ESTCP

FINAL REPORT

Thermal In Situ Sustainable Remediation to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

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14. ABSTRACT
Thermal In-Situ Sustainable Remediation (TISR®) is an innovative and sustainable remediation technology designed to enhance the degradation of contaminants in the subsurface by increasing the temperature of the target treatment zones. TISR utilizes renewable energy sources, such as solar radiation and waste heat, to heat the subsurface, thereby accelerating both biotic (microbial) and abiotic (chemical) reactions that degrade contaminants.

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ACRONYMS AND ABBREVIATIONS

1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
1,1,2,2-TeCA	1,1,2,2-tetrachloroethane
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
3D	three-dimensional
ρ_R	rock grain density
ρ_w	water density
φ	porosity
λ	thermal conductivity
θ	theta value
°C	degree Celsius
°F	degree Fahrenheit
µg/L	microgram per liter
µmol/L	micromole per liter
AMIBA	Aqueous and Mineral Intrinsic Bioremediation Assessment
Arcadis	Arcadis U.S., Inc.
AS	air sparge
bgs	below ground surface
BHE	borehole heat exchanger
CA	chloroethane
CF	chloroform
cis-1,2-DCE	cis-1,2-dichloroethene
COC	constituent of concern
C_R	rock grain heat capacity
CSIA	compound-specific isotope analysis
CVOC	chlorinated volatile organic compound
C_w	water heat capacity
d^{-1}	per day
DCM	dichloromethane
DGR	directed groundwater recirculation
DoD	U.S. Department of Defense
DTS	distributed temperature sensing
EISB	enhanced in situ bioremediation
erfc	complementary error function
ESTCP	Environmental Security and Technology Certification Program
EVS	Earth Volumetric Studio

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FSGW	filter sterilized groundwater
GHG	greenhouse gas
Gal	gallon
gpm	gallon per minute
HSA	hollow-stem auger
k_d	rate of dichlorination
kJ/mol	kilojoule per mole
MCL	maximum contaminant level
mg/L	milligram per liter
MI	Microbial Insights
mL	milliliter
NTU	nephelometric turbidity unit
O&M	operation and maintenance
OMM	operation, maintenance, and monitoring
PCE	tetrachloroethene
PeCA	polyethylcyanoacrylate
PVC	polyvinyl chloride
qPCR	quantitative polymerase chain reaction
RWQCB	San Francisco Bay Regional Water Quality Control Board
SEM-EDS	scanning electron microscopy with energy dispersive X-ray spectroscopy
site	Installation Restoration Program Site SD015, located at Vandenberg Space Force Base
SVE	soil vapor extraction
TCE	trichloroethene
TED	thermal-enhanced decay
TISR	Thermal In Situ Sustainable Remediation
TOC	total organic carbon
VC	vinyl chloride
V_d	groundwater Darcy velocity (flux)
VOC	volatile organic compound
VSFB	Vandenberg Space Force Base

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ABSTRACT

INTRODUCTION AND OBJECTIVES

Remediation of contaminants in low-permeability zones can be challenging, resulting in long and costly remedial timeframes. Thermal In-Situ Sustainable Remediation (TISR®) can provide improved remedial outcomes for these challenging sites for a wide range of contaminants, including chlorinated solvents and aromatic hydrocarbons. By leveraging the principles of sustainable energy and advanced heat transfer technologies, TISR offers a promising solution for accelerating the remediation of contaminated sites while minimizing environmental impact.

The goal of this project was to field-validate the TISR technology at a geologically challenging site impacted by chlorinated solvents. The field demonstration helped to validate TISR design and technical performance parameters and their limitations and therefore serves as a basis for a wider application at other sites with challenging hydrogeology and prolonged chlorinated impacts.

TECHNOLOGY DESCRIPTION

TISR is an innovative and sustainable remediation technology designed to enhance the degradation of contaminants in the subsurface by increasing the temperature of the target treatment zones. TISR uses renewable energy sources (such as solar radiation and waste heat) to heat the subsurface, thereby accelerating both biotic (microbial) and abiotic (chemical) reactions that degrade contaminants. TISR systems transfer energy to the subsurface through a closed-loop heat transfer fluid system. Subsequently, the heated fluid is circulated via insulated manifolds and process piping to the borehole heat exchangers (BHEs) located in the targeted treatment area.

PERFORMANCE AND COST ASSESSMENT

This project (ER20-5028) demonstrated the TISR technology to treat a chlorinated volatile organic compound (CVOC) groundwater source zone at site SD015 at Vandenberg Space Force Base (VSFB), located near Lompoc, California. Prior to TISR, the source zone and downgradient groundwater plume at site SD015 was managed with enhanced in situ bioremediation (EISB) and a dynamic groundwater recirculation (pump, treat, and reinject) approach. The TISR system included 8 BHEs and was designed to treat a subset of site SD015 near monitoring well 15-MW-41. The system operated from May 2022 to February 2025 and increased temperatures from an ambient average background of 17°C to a peak above 50°C at the BHEs and between 20°C and 35°C in other areas. In April – May 2024, a 2% molasses substrate was injected into the TISR footprint as total organic carbon had been depleted since the previous injection event. This heating and enhanced biodegradation resulted in accelerated CVOC treatment, including a reduction of CVOCs by 2 to 4 orders of magnitude, and a decrease in the total remedial treatment time by approximately 5 years (assuming a 5-year TISR system run time). A simple regression analysis was used to estimate the net remedial timeframe reduction, and is presented in **Appendix A**.

The specific requirements, scale, and geometry of each TISR application will vary. The monitoring infrastructure may also vary based on existing site infrastructure. However, the primary components include above-grade equipment such as solar collectors, heat pump, pump station, conveyance manifold and piping, and power connection, as well as below grade BHEs and monitoring infrastructure. The design and installation of the TISR system are the primary cost drivers, with a total capital cost of $724,000 for the demonstration project described herein.

Annual operation and maintenance will vary depending on the energy source used in the TISR design but was approximately $40,000 per year for this demonstration project. When considered against the reduced source zone remedial timeline, TISR implementation would lead to cost avoidance of approximately $1,080,000 from reduced EISB scope at SD015. Therefore, implementation of TISR for a 5-year period is estimated to reduce the total source zone remedial timeline by approximately 5 years for comparable cost as EISB, suggesting an overall benefit in liability reduction associated with this technology.

IMPLEMENTATION CONSIDERATIONS

When implementing TISR, it is important to recognize TISR isan enhancement strategy for optimizing source zone remedies like EISB. A critical early step is evaluating the treatment volume, as economies of scale directly influence the design and selection of energy resources needed to achieve target subsurface temperatures within a practical timeframe. This evaluation also supports a cost-benefit analysis, where accelerated contaminant degradation can shorten the remedial timeline and improve return on investment (ROI). To ensure TISR is the appropriate remedy, upfront assessments of the treatment area, energy source viability, and ROI must be completed. Lessons learned from the demonstration project further emphasize the importance of sustainable energy assessments, site-specific thermal modeling, power reliability planning, and robust in-situ temperature monitoring to support effective and resilient system performance.

PUBLICATIONS

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Ornelles, A., Falta, R.W., Divine, C., 2023. A design tool for solar thermal remediation using borehole heat exchangers. Groundwater 61(2):245–254. https://doi.org/10.1111/gwat.13265

EXECUTIVE SUMMARY

Thermal In Situ Sustainable Remediation (TISR®) is a novel remediation technology for accelerating treatment primarily by enhancing biotic and abiotic contaminant degradation rates through a modest increase in subsurface temperature. It is applicable in a broad range of hydrogeologic settings; requires moderate capital and low operational costs, minimal consumptive water and energy requirements; and can potentially lower lifecycle costs with shortened remedial timeframes.

TISR systems primarily use solar radiation or waste heat capture (although other energy sources are possible) to transfer heat to the subsurface via solar thermal collectors (i.e., solar collectors) connected to an array of borehole heat exchangers (BHEs). Solar collectors concentrate solar radiation from the sun to heat a transfer fluid circulating through the collectors. Solar collectors are widely used for household hot water needs or swimming pool heating (note that by contrast, a solar panel generally refers to an array of photovoltaic cells used to generate electricity). The BHEs are designed to maximize conductive heat transfer to the subsurface through a closed loop recirculation system (i.e., no groundwater pumping or discharge). Custom BHEs are fabricated for a project site based on the depth to water, extent of contamination, water and soil chemistry, and constructability. Typically, BHEs are installed in a vertical orientation within the contaminated saturated zone. Multiple BHEs are oriented in parallel to optimize the conductive heat transfer by maintaining a maximum change in temperature between the subsurface and all BHE locations at depth.

This project (ER20-5028) demonstrated the TISR technology from May 2022 to February 2025 to treat a chlorinated volatile organic compound (CVOC) groundwater plume at Vandenberg Space Force Base (VSFB), located near Lompoc, California. The overall objectives were to quantify technical performance and costs, ultimately providing a basis for wider application at U.S. Department of Defense and other sites with remedial objectives consistent with the strengths of the TISR technology. The dominant treatment mechanisms were corroborated using multiple lines of evidence including, but not limited to, high-resolution temperature data, constituent of concern trends, biogeochemistry analysis, microbiological analysis, stable isotopic analysis, and laboratory measurement of degradation rates. Successful demonstration of the TISR technology for CVOC treatment invites wider stakeholder acceptance as a holistic remedy for chlorinated plumes by reducing the conventional utility demand required and developing guidelines on scalability of the sustainable low-temperature approach.

OBJECTIVES

The goal of this project was to field-validate the TISR technology at a geologically challenging site impacted by chlorinated solvents. Increasing subsurface temperatures with TISR aids and/or accelerates the treatment of chlorinated solvent mass by enhancing biotic and abiotic degradation rates. The field demonstration helped to validate TISR design and technical performance parameters and their limitations and therefore serves as a basis for a wider application at other sites with challenging hydrogeology and prolonged chlorinated impacts. The performance objectives for this project are presented in **Table ES-1**, below.

Table ES-1. Key Performance Objectives and Success Criteria

Performance Objective	Data Requirements	Success Criteria	Success Criteria Achieved?
Quantitative Performance Objectives			
1. Validate temperature increases and uniformity of temperature distribution vertically and horizontally.	Temperature measurements from multiple horizontal and vertical points.	Of the DTS locations within the target treatment volume (DTS-2 through DTS-9), 75 percent will achieve a minimum temperature of 30°C within 1 year of initiating operations. Once this standard is achieved, temperatures within the active treatment volume will be maintained between 30 and 35°C for a minimum of 120 days. Temperature sensors outside the actively heated treatment volume (DTS-1, DTS-10, DTS-11, DTS-12) will not be used to assess compliance with this performance standard.	This performance objective is considered achieved. However, the success criteria were not met within the initial target timeframes due to unforeseen site weather patterns. Extended and supplemental heating was required to reach and maintain the specified temperature ranges and achieve this performance objective.
2. Determine influence of solar insolation and geographical variations on optimal design.	Solar insolation, borehole spacing, subsurface temperature changes, and rate of heat distribution in the subsurface.	Average of field temperature measurements within an average of 25 percent of location-specific design prediction ranges and reliable equipment sizing guidelines.	This performance objective is considered achieved. However, the average field temperature measurements did not fall within 25 percent of the location-specific design prediction ranges due to seasonal variations and higher-than-normal precipitation events. As a result, additional heating via a heat pump was required to meet the location-specific design predictions and achieve this performance objective.
3. Temperature-driven increase in microbial degradation activity.	a) Microbial community composition; b) Abundance of gene targets involved in reductive dechlorination; c) Organic carbon consumption rate from push-pull tracer tests; d) Isotopic fractionation of parent compound and daughter products; and e) CVOC concentration.	a) Statistically significant shifts in dominant microbial genera, as measured via the Shannon-Weaver Index, as heating proceeds; b) Increased abundance of gene targets associated with CVOC degradation to more than 10^6 gene copies per mL; c) Carbon consumption increases approximately two times per 10°C increase, up to approximately 35 to 40°C; d) Statistically significant increase in isotopic fractionation of CVOCs as heating proceeds, and e) Statistically significant decrease in chlorine number (the average total chlorine atoms per total ethene molar concentration) as heating proceeds.	This performance objective is considered achieved. A significant shift in microbial community composition (and dominant microbial genera) was observed with heating, as evidenced by a decrease in the Shannon Weaver Index from 2.1 at 18°C to 1.25 at 30°C. The abundance of gene targets associated with CVOC degradation increased with heating but remained below 10^6 gene copies per mL. Significant decreases in chlorine numbers were observed with heating, as evidenced by a drop from 2.42 to 0.35 at well TISR-4D.

Table ES-1. Key Performance Objectives and Success Criteria (Continued)

Performance Objective	Data Requirements	Success Criteria	Success Criteria Achieved?
Quantitative Performance Objectives			
4. Temperature-driven increases in abiotic degradation activity.	a) Measure abiotic rate constants for six temperatures from ^{14}C assay with site soils and groundwater; b) Reactive iron mineral composition measured in Min-Trap™ samples; c) Dissolved acetylene concentrations; and analysis of AHY gene target.	a) At least 0.01 percent of the contaminant is oxidized in the assay tests, resulting in a temperature correlation trend that consistent with the Arrhenius equation; b) Observed co-located iron and sulfur (SEM-EDS data) on Min-Trap™ matrix; and c) Presence of dissolved acetylene and/or AHY gene target.	This performance objective is considered achieved. AMIBA and SEM-EDS data collected from Min-Trap samples confirm the presence of reactive iron sulfide minerals within the target treatment area
5. Verify capital, operation and maintenance, and lifecycle cost benefit of TISR.	Historical remediation system operational costs, TISR equipment, construction, and operational costs, contaminant concentration trends, relative daughter generation, contaminant mass flux.	a) Reductions in projected active remediation phase costs exceed TISR system costs by more than two times; b) Reduction in project remedial timeline by > 2 years.	This performance objective is considered largely achieved. However, the lifecycle benefits were primarily associated with reduction of remedial timeline and associated project liability. The net cost difference was negligible, and thus did not meet the criteria in this case. However, cost reductions are site-specific and may be more favorable for other sites.
6. Sustainability benefits	Energy use data from existing site remedy and TISR system.	Projected greater than 25 percent lifecycle reduction in energy use compared to baseline EISB operations.	This performance objective is considered achieved.
Qualitative Performance Objectives			
7. Identify implementation and operational challenges.	Surveys from installation and project personnel.	No significant implementation or operational challenges identified.	This performance objective is considered achieved.

TECHNOLOGY DESCRIPTION

TISR offers an inexpensive and practical method of heating target treatment areas via BHEs drilled to specific depth intervals below grade. During operation, solar radiation is harnessed by solar collectors that transfer heat subsurface via a closed loop circulation system connected to the BHEs (**Figure ES-1**, below). While heating, thermal conduction and some advection help boost physical, biological, and chemical processes within the treatment zones that attenuate, degrade, and remove contaminants (Dettmer 2002; Horst et al. 2018) from the subsurface.

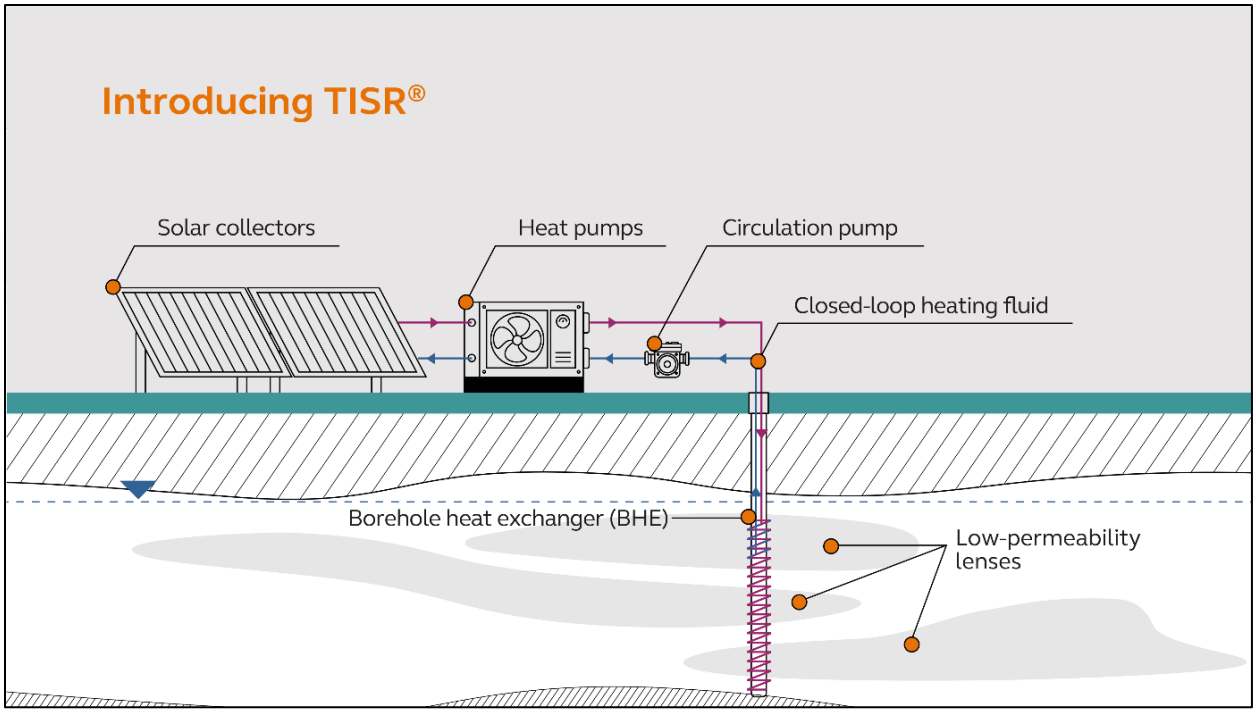


Figure ES-1. TISR Process Flow Diagram

TISR system schematic displaying solar collectors, heat pumps, circulation pump, and BHEs connected by a closed loop filled with propylene glycol and distilled water solution.

TISR systems that are intended to enhance in situ bioremediation and are typically designed to increase the subsurface temperature by approximately 10 to 20°C to reach an average groundwater temperature of up to approximately 35°C (optimal temperature for target microbial communities). Increasing the subsurface temperature by 10 to 20°C may also enhance the performance of other active technologies including air sparge (AS) and soil vapor extraction (SVE), and chemical oxidation. For other applications where maximizing abiotic hydrolysis mechanisms is targeted (e.g., for some chlorinated alkanes), TISR systems have been designed to target a final groundwater temperature of up to 60°C.

Therefore, TISR is an appropriate treatment method for enhancing the treatment of dissolved-phase mass located in low-permeable zones. Also, because it can be readily incorporated into existing remediation systems, TISR is particularly well-suited for accelerating treatment rates for existing in situ remediation systems designed to promote bioremediation of chlorinated solvents.

Performance Assessment 1: Validate Temperature Increases and Uniformity of Temperature Distribution Vertically and Horizontally

The data collected as part of this project were evaluated to determine if the success criteria for specific quantitative and qualitative performance objectives presented in **Table ES-1**, above, were achieved. This section discusses the assessment of each performance objective.

Data Collected

To validate temperature increases and the uniformity of temperature distribution both vertically and horizontally, temperature measurements were collected from multiple points within the target treatment volume. The primary data sources included DTS systems and HOBO TidbiT sensors. The DTS system provided continuous temperature data from various locations, while the TidbiT sensors offered point source temperature data at specific monitoring wells.

The DTS locations within the target treatment volume included DTS-2 through DTS-9. These locations were monitored to ensure that the temperature criteria were met. Additionally, TidbiT sensors were placed in select monitoring wells (15-15-MW-8, 15-MW-41, TISR-3S, TISR-3D, TISR-2S, and TISR-4D) to validate the DTS data and provide supplementary temperature measurements.

Data Interpretation

The original success criteria stated that 75 percent of the DTS locations within the target treatment volume (DTS-2 through DTS-9) should achieve a minimum temperature of 30°C within one year of initiating operations. Once this level was achieved, temperatures within the active treatment volume were to be maintained between 30 and 35°C for a minimum of 120 days. Temperature sensors outside the actively heated treatment volume (DTS-1, DTS-10, DTS-11, and DTS-12) were not used to assess compliance with this performance standard.

The data collected from the DTS system indicated that the majority of DTS locations within the target treatment volume achieved a minimum temperature of approximately 23°C (an increase of approximately 5°C) within the first year of operation. Therefore, 75 percent of the DTS locations (DTS-2 through DTS-9) did not reach or exceed the 30°C threshold outlined in the initial success criteria. However, during this operational period, temperature data demonstrated a uniform distribution of heat above ambient groundwater temperatures both vertically and horizontally within the target treatment volume. The DTS system provided high-resolution temperature profiles, showing consistent temperature increases across different depths and horizontal distances. The TidbiT sensors further validated these findings, with point source temperature data confirming the uniformity of temperature distribution.

After the initial year of operations, following a summer of consistent solar irradiation and sustained subsurface heating, the temperature cross-section observed on November 10, 2023 (Figure 5.12), showcased significant thermal elevation. Temperatures at the BHEs peaked above 50°C, while other areas ranged from 20°C to 35°C. Specifically, maximum temperatures observed at DTS-5 and DTS-7 were 27°C and 24°C respectively. These points, situated approximately 5 and 7 feet from the nearest BHE, indicate the radius of heating influence.

Although not all temperatures throughout the heated volume were within the specified 30 and 35°C range, the system successfully maintained elevated temperatures above ambient and in some locations above 30°C for a minimum of 120 days. This was evidenced by continuous temperature monitoring data from the DTS system and TidbiT sensors, which showed stable temperature readings within the specified range during the maintenance period.

The data also highlighted the impact of seasonal variations on subsurface temperatures. For instance, there was an observed decrease in temperatures after winter 2024, followed by sustained heating through the spring. To address these fluctuations and enhance the heating capability, a heat pump was introduced in September 2024. The heat pump maintained a set temperature of 120°F (approximately 49°C) to the BHEs, providing continuous heat input regardless of solar irradiation. This resulted in a significant temperature increase at the monitoring locations, with an approximate rise of 4°C in three months. The maximum temperature observed at 15-MW-41 was 29.5°C on January 27, 2025, which is approximately 11°C greater than the ambient groundwater temperature.

The data collected and analyzed for this performance objective demonstrated that the TISR system effectively increased and maintained subsurface temperatures within the target treatment volume. The uniformity of temperature distribution both vertically and horizontally was achieved, even though the original success criteria were not met. The introduction of the heat pump further enhanced the system's capability to maintain elevated temperatures, ensuring the effectiveness of the thermal treatment process. As such, this is considered a successful implementation of the TISR system and the broad goal of the performance objective was attained.

Performance Objective 2: Determine Influence of Solar Insolation and Geographical Variations on Optimal Design

Data Collected

Solar energy is a sustainable energy source, but its effectiveness depends on adequate solar radiation and sufficient space for installing the necessary number of solar collectors. The magnitude and duration of radiation vary based on site characteristics such as cloud cover, elevation, latitude, and seasonal changes due to sun angle and daylight length.

In addition to the thermal modeling evaluation outlined in Section 5.1.2, which considered temperature monitoring data, operational parameters (e.g., flow rates of the closed-loop system, heat efficiency based on solar collectors, and BHE temperature measurements for the site and other TISR sites in New York, Colorado, Mexico City, and various areas in Canada), empirical data accumulated to date were combined with learnings from the modeling task to refine the TISR design and cost assumptions.

The installed TISR system at the site utilized Apricus ETC-30 solar collectors (**Appendix B**). During the design phase, it was assumed that each collector could produce approximately 30,000 BTU per day based on the certified Solar Rating & Certification Corporation (SRCC) OG-100 Category C medium radiation climate category. The system was installed in a remote field on the central California coast, with an average solar irradiance of approximately 5 kilowatt hours per square meter per day (Solargis, 2024), equating to roughly 1,585 Btu/ft²/day, placing the site just above the SRCC medium radiation category (1,500 Btu/ft²/day). Given the site's solar energy rating and Climate Category C conditions, was assumed that the collectors would provide approximately 30,000 BTU of solar hot water heating per day per collector.

However, after installation and subsequent operation of the system, Autodesk Forma (Forma) was utilized to conduct a solar energy potential analysis for the site. Forma provided a more site-specific energy potential than the previous region-based data used to design the system.

Forma indicated that the site could provide an average of 193 kilowatt-hours per square foot (kWh/ft²) of solar energy potential. Given that the system consisted of eight Apricus ETC-30 solar collectors with a total surface area of approximately 250 square feet, this corresponds to an estimated annual solar energy potential of approximately 48,500 kilowatt-hours (kWh).

Forma assumes that photovoltaic (PV) panels are utilized for electricity generation with typical efficiency ratings between 15-20%. PV panels convert solar radiation directly into electricity, generally achieving an efficiency of less than 20%. In contrast, solar thermal collectors are designed to convert solar radiation into heat, with significantly higher efficiencies, typically reaching up to 70-75%. Given that solar collector efficiency is triple that of PV panels, the estimated annual thermal energy output from the eight collectors would be approximately 29,000 kWh, equivalent to roughly 99 million BTUs. This equates to an average daily thermal output of around 34,000 BTU per collector at this site.

Data Interpretation

The primary performance objective was to determine the influence of solar insolation and geographical variations on the optimal design of the TISR system. This involved analyzing key data such as solar insolation, heating equipment efficiency and transfer rate, borehole spacing, subsurface temperature changes, and the rate of heat distribution in the subsurface. Based on the solar collector certification rating falling within range of the site-specific solar energy potential analysis produced from Forma it was assumed that the solar collectors would provide roughly 34,000 BTU/day/collector. The target temperature of the TISR system aimed to heat the targeted treatment volume of soil to a temperature of 35°C. Based on the BHE spacing of 20 feet the TISR system would cover approximately a treatment area of 2,512 square feet. The vertical interval to be heated was 12.5 feet, resulting in a total soil volume of approximately 31,400 cubic feet. Assuming a 30% porosity the heated volume would comprise of 21,980 cubic feet of soil and 9,420 cubic feet of water. This equates to a total mass soil being 5,193,954 pounds, while the mass of the water being 587,995 pounds. The heat capacities assumed to be 1,298,489 BTU/°F for the soil and 587,995 BTU/°F for the water, leading to a total heat capacity of the heated volume of 1,886,483 BTU/°F. The starting temperature of the targeted heating volume was 18°C (64°F), and the target temperature is 35°C (95°F), resulting in a temperature change (ΔT) of 17°C (31°F). The total heat demand to achieve this temperature change is 57,726,394 BTU. Assuming an efficiency of 34,000 BTU/day per collector and utilizing 8 collectors, the adjusted total power input is 272,000 BTU/day. After accounting for a heat loss factor of 50%, the net power input rate is 5,667 BTU/hr. Based on this net power input rate, the estimated time to meet the subsurface target temperature was approximately 424 days, or approximately 1.2 years.

This analysis validated the use and design assumptions of the proposed solar thermal collectors were accurate and that target temperatures in the subsurface could be achieved approximately 1.2 years after system startup. However, the average of observed field temperature measurements did not fall within an average of 25 percent of the location-specific design prediction ranges as specified in the success criteria for this performance objective. This demonstrates that the site-specific influence of heat limiting factors due to seasonal variations resulting in reduced run time due to overcast and subsurface heat losses due to higher-than-normal precipitation events at the site had an effect on the system performing outside of the expected design criteria used.

Based on this observation it was determined that supplemental energy supply from heat pump would be needed to overcome these site limiting factors to achieve the targeted subsurface heating requirements within the period of performance specified for the project. This underscores the importance of the design parameters and engineering safety factors used and ensuring reliable equipment sizing guidelines and specification are established to ensure that the solar collectors and other TISR system components are appropriately sized for the specific site conditions.

Performance Objective 3: Temperature-Driven Increase in Microbial Degradation Activity

Data Collected

Microbial data were collected prior to and throughout TISR system operation. These data included assessments of microbial community composition and quantification of gene targets involved in reductive dichlorination. Additional data relevant to microbial degradation activity, such as organic carbon consumption rates from push-pull tracer tests, isotopic fractionation of parent compound and daughter products, and CVOC concentrations were also collected for TISR performance evaluation.

Data Interpretation

As described in Section 5.5, the increase in subsurface temperature within the TISR treatment area, from approximately 18°C (baseline, 2021) to approximately 30°C (January 2025), resulted in a significant reduction in CVOC concentrations in both the shallow and deep intervals monitored. Specifically, total CVOC concentrations decreased by an average of 95% and 83% in the shallow and deep zones, respectively, over the TISR demonstration period. Also concomitant with subsurface heating and decreasing CVOC concentrations, a significant shift in microbial community composition was observed: a higher abundance of key microorganisms and functional genes for the reductive dechlorination of CVOCs was quantified within the TISR system ROI as TISR treatment progressed. The criteria for this performance objective are considered achieved.

Performance Objective 4: Temperature-Driven Increase in Abiotic Degradation Activity

Data Collected

Abiotic degradation rate constants were derived for TCE from treatability bench-scale testing (i.e., ^{14}C-TCE assay) with microcosms prepared with site soils and groundwater and incubated at six temperatures (18, 25, 30, 35, 40, and 50°C), Additional in situ data relevant to abiotic degradation activity were also collected. The in situ data included reactive iron mineral composition measured in Min-Trap™ samples, dissolved acetylene concentrations, and analysis of the AHY gene target.

Data Interpretation

The rates of TCE degradation attributable mainly to abiotic activity were approximately two orders of magnitude less than the rates of TCE degradation attributable to biotic reductive dechlorination. However, treatability bench-scale testing confirmed increased temperatures increased abiotic rates, in accordance with the Arrhenius equation. Furthermore, the results suggests that prior electron donor injections at the site have created reactive minerals in the groundwater that are active in abiotic dichlorination. The presence of said reactive minerals in site groundwater was evidenced by the AMIBA and SEM-EDS results from Min-Trap samples collected from wells within the TISR system ROI. The criteria for this performance objective are considered achieved.

Performance Objective 5: Verify Capital, Operation and Maintenance, and Lifestyle Cost Benefit of Thermal In Situ Sustainable Remediation

This performance objective is intended to verify capital, operation and maintenance, and lifecycle cost benefit of TISR.

Data Collected

Historical remediation system operational costs, TISR equipment, construction and operational costs, contaminant concentration trends, relative daughter generation, and contaminant mass flux.

Data Interpretation

Costing data was tabulated for the installation and operation of the TISR system for 5 years. These costs were compared against projected costs for continuation of the EISB approach historically implemented at SD015. Remedial timeframe projects were informed by linear regression and analysis of groundwater data trends and responses to current and historical remedial activities (Appendix A).

Performance Objective 6: Sustainability Benefits

This performance objective is intended to demonstrate the sustainability benefits.

Data Collected

Data relevant to the lifecycle sustainability analysis of the baseline EISB remedy and the TISR remedy were collected. This data included the quantities, sources, and transportation of consumable materials and equipment; number of field personnel and vehicle commute metrics; energy and equipment use associated with field activities and operation of systems; and quantities, transportation, and end management approach associated with waste materials.

Data Interpretation

As described in Section 5.7, the data were interpreted in line with USEPA guidance using the SiteWise™ software for green and sustainable remediation developed by Battelle Corporation and the DoD. The results indicated that GHG emissions associated with TISR were 62 percent less than continuing the EISB approach at SD015, which used a DGR system, and approximately 32 percent less than implementing EISB with an injection trailer. Thus, TISR meets the performance objective of a having a GHG footprint that is 25 percent less than baseline EISB operations.

Performance Objective 7: Identify Implementation and Operational Challenges

This performance objective is intended to identify implementation and operational challenges.

Data Collected

Surveys from installation contractors and project personnel were conducted to capture insights and feedback regarding the practical challenges and operational experiences encountered during the implementation and operation phases. These surveys included detailed questions on system performance, ease of installation, maintenance issues, and suggestions for improvement, contributing to a comprehensive understanding of the project's sustainability benefits and operational hurdles.

Data Interpretation

During TISR implementation and operations, the field crews experienced challenges which yielded lessons learned. These lessons learned are summarized below:

- *Maintaining system operational pressure.* Upon startup, small leaks in the above-grade piping were identified and sealed. The original design called for soldered copper connections. While most of these connections held with no further effort, some in particularly difficult to access areas were persistent or required several repairs before holding long-term pressure. At this specific job location, soldering required hot work permits from the local fire department. In future modifications, press-fitting copper connections were used to a high degree of success.

- *Wellfield temperature monitoring.* TidBit submersible temperature monitoring dataloggers were deployed in several monitoring wells in the TISR treatment area. These dataloggers were selected for their size, temperature range, accessibility, and cost. Throughout the study, the TidBits would fail and require replacement, potentially with a loss of data. Other temperature dataloggers were assessed during and after the heat pump installation, but similar challenges arose. The frequency of replacement was greater for wells that were used for carbon or iron amendment, such as in push-pull studies or EISB injections, but the issue was not limited to those wells.

- *Intermittent power loss.* The location of the TISR system suffered from intermittent power losses due to antiquated infrastructure supplying the on-site remediation system. These intermittent interruptions led to significant downtime and operational challenges. When power was lost during the day, the circulation pump was not able to continue passing the heating fluid through the solar collectors. The stagnant fluid would quickly exceed its boiling temperature and evaporate through the pressure- and air-relief valves. This lead to added field effort to recharge the system and restart operations when power was restored. Given the minimal power requirements of the circulation pump, future systems could be designed with a battery contingency to maintain operations through short power interruptions.

- *Record rain and cloud cover in winter and spring 2022 and 2023.* The Central Coast of California experienced significant rainfall during the rainy seasons in 2022 and 2023. This excessive rainfall resulted in lower solar insolation during the winter months, increased infiltration cooling the subsurface, and power loss (mentioned in the previous bullet). The rainy season extended into late spring and was followed by a summer characterized by an unusually high number of overcast and cloudy days. This combination led to reduced heat input for the solar-only heating setup at the beginning of the performance period. The heat pump installation in September 2024 provided additional and more consistent heat input to the subsurface, helping to achieve the target temperature range efficiently despite the initial loss of heat input due to rainy conditions at the start of the performance period.

COST ASSESSMENT

Although the specific requirements, scale, and geometry of TISR applications will vary, the typical and scalable design from the project is shown below and may be adapted to different site conditions.

Design variations at other sites may be due to different levels of solar insolation, treatment volume, or site infrastructure than those at the demonstration site. The cost model for the design at the VSFB demonstration site included additional equipment for the installation of new monitoring wells and temperature sensing fiber (DTS) locations to provide a robust, high-resolution performance monitoring dataset during system operations.

The equipment used in the TISR design at the demonstration site is described below:

- Above-grade equipment:
  - *Solar collectors.* Eight units arranged in a 4x4 array.
  - *Heat pump skid.* One unit for efficient heat transfer.
  - *Pump station.* 1 unit, including instrumentation and controls.
  - *Conveyance manifold.* 1 unit for distributing the heated fluid.
  - *Insulated above grade conveyance piping branches.* Eight branches to minimize heat loss.
  - *Power connection.* One connection to the existing electrical source.
- Below-grade equipment:
  - *BHEs.* Eight units with a heating interval from 20 to 40 below ground surface (bgs).
  - *New performance monitoring wells.* Eight wells with the following screen intervals:
    - Shallow screen interval at 17.5 to 27.5 feet below ground surface (bgs).
    - Deep screen interval at 30 to 40 feet bgs.
  - *Existing monitoring wells.* Two wells with the following screen intervals:
    - Screen interval at 19 to 39 feet bgs.
    - Screen interval at 25 to 35 feet bgs.
  - *New soil vapor probes.* Two probes with a total depth of 17.5 feet bgs.
  - *DTS locations (Optional).* Twelve locations with a monitoring interval from the surface to 40 feet bgs.

Table ES-2, below, presents an estimate of the costs associated with the TISR system over a 5-year lifecycle. It includes one-time capital costs for system design and installation, as well as ongoing operation and maintenance (O&M) and sampling costs. This simple cost model is for a typical design and system size presented above. This cost breakdown serves as general guidance for estimating the costs of installing the TISR system. However, these costs can vary significantly depending on site conditions and specific project objectives.

Table ES-2. Cost Model for TISR System

Cost Element	Description	Unit Cost	Unit	Quantity	Cost
System design and procurement	Design, permitting, procurement	$120,000	Lump sum	1	$120,000
BHE and wellfield drilling	Drilling and installation of BHE and wellfield	$146,000	Lump sum	1	$146,000
Process mechanical construction and startup	Construction and startup of the solar system	$408,000	Lump sum	1	$408,000
EISB injection event	Injection of EISB substrate into five wells	$50,000	Lump sum	1	$50,000
				Subtotal: System Design and Installation	**$724,000**
Annual O&M costs	O&M costs per year	$40,000	Per year	5	$200,000
Cost Element	**Description**	**Unit Cost**	**Unit**	**Quantity**	**Cost**
Sampling event costs	Groundwater sampling event costs per year	$18,000	Per event	5	$90,000
				Subtotal: O&M and Sampling Costs (5 Years)	**$290,000**
				Total Cost (5-Year Lifecycle)	**$1,014,000**

Understanding and assessing key cost drivers during the design phase is crucial for effective planning and budgeting of TISR systems. By identifying these cost drivers early on, project planners can make informed decisions that optimize both performance and cost-efficiency. This proactive approach helps in anticipating potential challenges and managing resources more effectively, ensuring the successful implementation of the TISR system. The key cost drivers are summarized below:

- *Number of BHEs.* The number of BHEs required for a project significantly impacts the overall cost. Each BHE involves drilling, installation, and materials costs.
- *Heating interval size and depth.* As these parameters increase, so do the drilling and materials costs for TISR. Further, the waste disposal costs have a direct relationship to these design parameters due to the larger volume of waste generated during drilling and reaming operations, and well development.
- *Lithology.* Difficult drilling conditions such as dense soils and cobbles result in higher directional drilling costs. Coarser grained formations that are prone to flowing sand conditions and resultant borehole instability will also cause costs to increase. Drilling through bedrock is significantly more costly.
- *Solar collectors.* The number and type of solar collectors used in the system affect the initial capital costs. Solar collectors are essential for harnessing solar energy to heat the subsurface. The installation method, such as mounting solar collectors in a field versus on roofs, can also impact costs. Field installations may require more land and infrastructure, while roof installations might involve additional structural considerations.

- *Supplemental heating sources.* In some cases, additional heating sources like electric heat pumps or inline heaters might be needed to reach target temperatures. While these increase initial and operational costs, they can also shorten the project's lifecycle, leading to long-term savings. A cost-benefit analysis should be conducted to compare the extra upfront and operational costs with potential lifecycle savings. Consider energy consumption, maintenance costs, and equipment lifespan. This helps in making informed decisions that balance initial investments with long-term benefits for a cost-efficient TISR system.
- *Site-specific conditions.* Factors such as local geology, hydrogeology, and site accessibility can influence the cost of drilling, installation, and operation. For example, conveyance piping can be installed above grade or trenched below, with each method having different cost implications.
- *Monitoring and maintenance.* Regular monitoring and maintenance are essential to ensure the system's performance and longevity. Costs for sampling, laboratory analysis, and system inspections should be considered.
- *Permitting and regulatory compliance.* Obtaining necessary permits and ensuring compliance with local, state, and federal regulations can add to the overall project costs.

Implementation Considerations

This report presents the findings from the demonstration of TISR as a method to accelerate source zone treatment of chlorinated solvents. TISR enhances technologies such as EISB by increasing subsurface temperatures to promote more effective contaminant degradation.

Successful implementation of TISR requires early evaluation of treatment volume, energy source availability, and return on investment (ROI). These factors influence system design, energy delivery strategies, and overall feasibility. The demonstration highlighted the importance of assessing sustainable energy sources—such as solar, geothermal, or waste heat—and identifying when supplemental systems like heat pumps or inline heaters may be necessary.

Site-specific hydrogeologic conditions, including groundwater velocity and infiltration rates, must be considered to ensure effective heat transfer. In regions with limited solar input or extreme climates, supplemental heating and robust thermal modeling are essential. Power reliability and sensor durability also emerged as critical design considerations, with recommendations for battery backups and IoT-enabled temperature monitoring to ensure operational continuity and data integrity.

TISR is best applied in saturated zones and may require integration with other technologies—such as biostimulation, air sparging, or in situ chemical oxidation—depending on site-specific conditions and contaminant profiles. These insights provide a framework for future TISR applications, supporting more informed design decisions and improved remediation outcomes.

1.0 INTRODUCTION

This Final Report describes the field deployment and performance monitoring associated with Environmental Security Technology Certification Program (ESTCP) Project ER20-5028. *Thermal In Situ Sustainable Remediation to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes*. The overall objective of the project is to field-validate the patented Thermal In-Situ Sustainable Remediation (TISR®) technology (US Pat. Nos. 10,384,246 and 10,688,545) at a U.S. Department of Defense (DoD) site. TISR is a novel remediation technology for accelerating treatment primarily through enhancing biotic and abiotic contaminant degradation rates by a modest increase in subsurface temperature. It is applicable in a broad range of contaminants and hydrogeologic settings; requires moderate capital and low operational costs, and minimal consumptive water and energy requirements; and can potentially lower lifecycle costs with shortened remedial timeframes.

TISR systems primarily use solar radiation or waste heat capture (although other energy sources are possible) to transfer heat to the subsurface via solar thermal collectors (i.e., solar collectors) connected to an array of borehole heat exchangers (BHEs). BHEs are solid-filled boreholes without any casing connecting to the near-ground wellhead and with no potential direct path to the ground surface. Solar collectors concentrate solar radiation from the sun to heat a transfer fluid circulating through the collectors. Solar collectors are widely used for household hot water needs or swimming pool heating (note that by contrast, a solar panel generally refers to an array of photovoltaic cells used to generate electricity). The BHEs are designed to maximize conductive heat transfer to the subsurface through a closed loop recirculation system (i.e., no groundwater pumping or discharge). Custom BHEs are fabricated for a project site based on the depth to water, extent of contamination, water and soil chemistry, and constructability. Typically, BHEs are installed in a vertical orientation within the contaminated saturated zone. Multiple BHEs are oriented in parallel to optimize the conductive heat transfer by maintaining a maximum change in temperature between the subsurface and all BHE locations at depth.

This project demonstrated the TISR technology at a field site with operation from May 2022 to February 2025. The system was designed to treat a chlorinated volatile organic compound (CVOC) groundwater plume at Vandenberg Space Force Base (VSFB), located near Lompoc, California. The overall objectives were to quantify technical performance and limitations and provide a basis for wider application at DoD and other sites with remedial objectives consistent with the strengths of the TISR technology. The dominant treatment mechanisms were corroborated using multiple lines of evidence including but not limited to high-resolution temperature data, constituent of concern (COC) concentration trends, biogeochemistry analysis, microbiological analysis, stable isotopic analysis, and laboratory measurement of degradation rates. The project team consists of Arcadis U.S., Inc. (Arcadis); Clemson University; California State University, Long Beach; VSFB; and ESTCP.

1.1 BACKGROUND

Groundwater COCs such as chlorinated solvents can be effectively treated with many existing remedial technologies, but sites characterized by complex geological environments and persistent groundwater plumes continue to be a challenge, limiting the pace of remediation and therefore controlling overall remediation timeframes and costs. These sites can benefit from

new methods and technologies that are cost-effective accelerators of remediation pace, can be used as transition technology between active remediation and passive approaches, and can enhance ongoing attenuation processes. Heat transfer properties of a subsurface soil matrix do not vary considerably and are relatively independent of sediment grain size, unlike hydraulic properties that can vary many orders of magnitude. Consequently, thermal remediation can address contaminant mass present in both high- and low-permeability aquifer settings, including silts, clays, and sedimentary rock. Traditional high-temperature thermal technologies, which are designed to remove contaminants primarily through volatilization, are commercially available and widely demonstrated. However, they require significant infrastructure, have high capital costs and energy demands, and have significant operation and maintenance (O&M) requirements.

Lower-temperature electrical resistive heating has shown laboratory-scale success (e.g., Strategic Environmental Research and Development [SERDP] Project ER-1458) due to azeotropic boiling and collateral benefits associated with in situ chemical oxidation (e.g., Johnson et al. 2011). Project ER-1419 provided insights into the fate of chlorinated ethene under thermal treatment and concluded that although thermal treatment can increase mass transfer of trichloroethene (TCE) and tetrachloroethene (PCE) from contaminated soils to groundwater, a substantial fraction of contaminant mass may persist in fine-grained soils (Pennell et al. 2009). Laboratory studies performed as part of ESTCP Project ER-200719 demonstrated that the rate of dechlorination increased at least four-fold by increasing the temperature from 10 to 30 degrees Celsius (°C) (Macbeth et al. 2012). Also, the project team has substantial related experience with closed-loop BHEs from the ESTCP EW-201013 project (Falta et al. 2016). This demonstration project (ER20-5028) complements these previous laboratory studies and further addressed field-scale issues and the challenges posed by low-permeability soils in the real-world application. This project operated in the mesophilic temperature range (15 to 40°C) with a focus on biotic and abiotic benefits. Successful demonstration of the TISR technology for CVOC treatment invites wider stakeholder acceptance as a holistic remedy for chlorinated plumes by reducing the conventional utility demand required and developing guidelines on scalability of the sustainable low-temperature approach.

1.2 OBJECTIVE OF THE DEMONSTRATION

The goal of this project was to field-validate the TISR technology at a geologically challenging site impacted by chlorinated solvents. Increasing subsurface temperatures with TISR aids and/or accelerates treatment of chlorinated solvent mass by enhancing degradation rates. Project objectives included:

- Demonstrate subsurface heating efficiency and treatment enhancement at a chlorinated solvent source zone undergoing active enhanced in situ bioremediation (EISB);
- Confirm and characterize dominant treatment mechanisms (e.g., biodegradation, multiphase mass partitioning, chemical hydrolysis); and
- Collect high-resolution temperature data to calibrate qunatitative modeling and, ultimately develop a practical guidance document and Excel-based TISR design tool.

The field demonstration helped to validate TISR design and technical performance parameters and their limitations, and therefore, serves as a basis for a wider application at other sites with challenging hydrogeology and prolonged chlorinated impacts. This Final Report was prepared to document the outcomes of the demonstration, including a final cost assessment, key implementation factors necessary for successful deployment of TISR, key lessons learned, and future research or recommended design changes.

1.3 REGULATORY DRIVERS

For many DoD sites, the presence of residual-phase and high CVOC contaminant concentrations in the subsurface near the original release location functions as a long-term secondary source. Even decades after ongoing releases have stopped, these zones can still contain large amounts of contaminant mass, resulting in contaminant concentrations in groundwater in the tens to hundreds of parts per million range. Plume strength and associated migration risk is a function of source strength and, therefore, in many cases, the overall remediation timeframe and remediation lifecylce costs, is governed by the remediation pace of these zones. Consequently, many regulatory agencies and stakeholders prioritize remediation of these source zones. For this project's demonstration site, contaminants were approximately four orders of magnitude greater than cleanup goals despite decades of active remediation due to the presenece of persistent residual-phase contamination and geologic heterogeneity. Cleanup criteria for the demonstration site established by the Central California Regional Water Quality Control Board (RWQCB) consisted of the California Maximum Contaminant Levels (MCLs). The relevant MCLS were 5 µg/L, 6 µg/L, and 0.5 µg/L for TCE, cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride (VC), respectively.

In situ technologies for chlorinated solvents are well-demonstrated and accepted by regulatory agencies; however, complex geological environments and persistent groundwater plumes continue to be a challenge for treatment of chlorinated solvents, limiting the pace of remediation. Several proven in situ treatment technologies are prevalent, but are still limited by hydraulic properties and distribution of treatment reagents. Low-temperature heating in the mesophilic range of 15 to 40°C is an economical option to implement at these complex sites and can significantly increase the rates for biotic and abiotic treatment processes. Heat transfer properties of subsurface soil matrices do not vary considerably and are relatively independent of sediment grain size, unlike hydraulic properties that can vary many orders of magnitude. Consequently, low-temperature thermal remediation can readily address contaminant mass present in both high- and low-permeability aquifer settings, including fractured rock, while keeping the capital and operational costs relatively low. Given the large variety of contaminants and treatment approaches employed at DoD and other federal sites, TISR provides a unique and versatile tool for shortening remedial timeframes and lowering lifecycle costs. TISR holds much potential to benefit hundreds of current DoD sites where either active remediation or natural attenuation is ongoing. In addition to the sustainable nature of TISR operation through the use of solar energy collection, the enhanced degradation rates can help the DoD save significant costs by employing this "add-on" technology that is compatible with many other remediation technologies that are currently in operation. The return on investment is expected to be 1 to 3 years for most sites and the potential exists for significant overall remediation lifecycle cost reductions for many sites. It is expected that as TISR becomes further demonstrated, regulatory agencies will view it favorably and readily permit its incorporation into existing remediation systems to more quickly and reliably achieve remediation endpoints.

2.0 TECHNOLOGY DESCRIPTION

This section provides an overview of TISR, which is a novel approach designed to shorten remedial timeframes and lower lifecycle costs in a broad range of hydrogeologic settings. Because of the relative ease of thermal energy propagating through geologic materials compared to advective flow, TISR is particularly well-suited for low-permeability and heterogeneous sites. Most commonly, TISR uses solar energy for heating and no groundwater pumping is involved; therefore, its consumptive energy and water requirements are very low.

2.1 OVERVIEW

TISR offers an inexpensive and practical method of heating target treatment areas via BHEs drilled to specific depth intervals below grade. During operation, solar radiation is harnessed by solar collectors that transfer heat subsurface via a closed loop circulation system connected to the BHEs (**Figure 2.1**, below). While heating, thermal conduction and some advection help boost physical, biological, and chemical processes within the treatment zones that attenuate, degrade, and remove contaminants from the subsurface (Dettmer 2002; Horst et al. 2018).

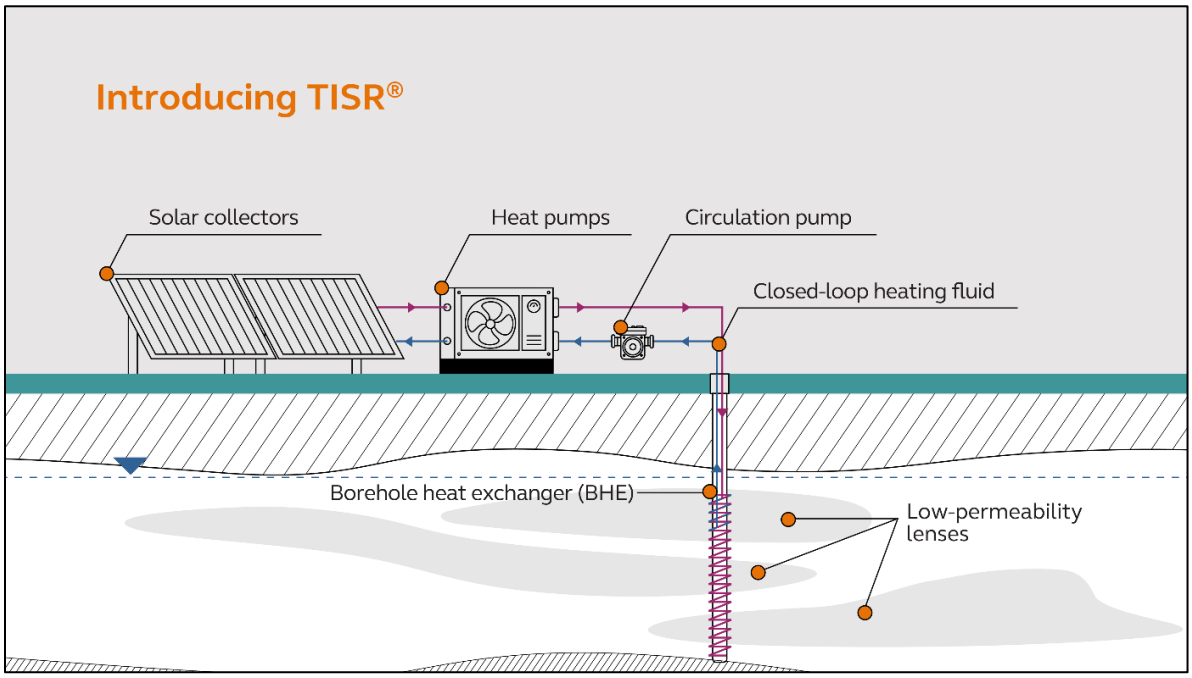


Figure 2.1. TISR Process Flow Diagram

TISR system schematic displaying solar collectors, heat pumps, circulation pump, and BHEs connected by a closed loop filled with propylene glycol and distilled water solution.

TISR systems that are intended to enhance in situ bioremediation are typically designed to increase the subsurface temperature by approximately 10 to 20°C to reach an average groundwater temperature of up to approximately 35°C (optimal temperature for target microbial communities). Increasing the subsurface temperature by 10 to 20°C may also enhance the performance of other active technologies including air sparge (AS), soil vapor extraction (SVE), and chemical oxidation.

For other applications where maximizing abiotic hydrolysis mechanisms is targeted (e.g., for some chlorinated alkanes), TISR systems have been designed to target a final groundwater temperature of up to 60°C.

It is well-demonstrated that modest increases in temperature can enhance treatment system performance by several mechanisms as discussed below:

- Primary dechlorinating bacteria (e.g., *Dehalococcoides* and *Dehalogenimonas*) are known to be mesophilic; therefore, microbial activity and biodegradation can be enhanced by multiple orders of magnitude by increasing temperature. For example, laboratory studies performed as part of ESTCP Project ER-200719 demonstrated that the rate of dechlorination increased (at least) four-fold by increasing the temperature from 10 to 30°C (Macbeth et al. 2012). Treatability testing completed as part of this project yielded similar results.
- Reduced iron minerals, particularly iron sulfides, can participate in the abiotic degradation of chlorinated ethenes and other contaminants. The rates of these reactions are generally temperature dependent according to the Arrhenius equation.
- Hydrolysis rates are highly temperature dependent for some compounds. For example, a 10°C increase will reduce the 1,1,1-trichloroethane (1,1,1-TCA) half-life by approximately 50 percent (Suthersan et al. 2012). **Figure 2.2**, below, shows the calculated temperature-dependent hydrolysis rates for 13 common CVOCs (pH = 7). The additional CVOCs shown on **Figure 2.2**, below, include 1,2-dichloroethene (1,2-DCE), PCE, dichloromethane (DCM), TCE, chloroform (CF), 1,1,2-trichloroethane (1,1,2-TCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethane (1,1-DCA), chloroethane (CA), 1,1,2,2-tetrachloroethane (1,1,2,2-TeCA), PeCA, and VC. Note that, while all rates are influenced by temperature, the half-lives are less than 300 days at 50°C for only four chlorinated ethanes.

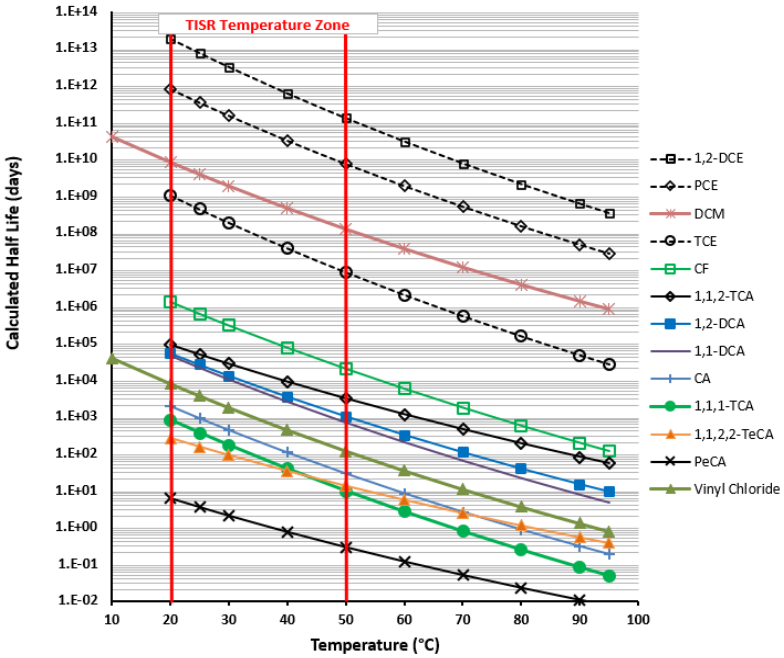


Figure 2.2. Hydrolysis Rates of Chlorinated Compounds

- Henry's Law constant, vapor pressure, solubility, and viscosity values are also temperature dependent. For example, the Henry's Law constant values for several volatile organic compounds (VOCs), specifically PCE, TCE, CF, 1,1,1-TCA, 1,1-DCA, DCM, carbon tetrachloride, 1,2-DCA, cis-1,2-DCE, chloromethane, chloroethane, and VC, have been found to double between 8 and 24°C (Chen et al. 2012b). Increased temperature, therefore, will result in increased recovery from AS/SVE systems (note that due to kinetic rate limitations, it is not anticipated that vadose zone concentrations will increase substantially at sites where an AS system is not in operation).
- Rates of other processes that often limit remediation pace, such as dissolution, desorption, and back diffusion are positively correlated with temperature. Although the magnitude of enhancement of these processes will generally be relatively modest for the temperature increases associated with typical TISR systems, this enhancement will result in the bioavailability of contaminant mass that otherwise may be inaccessible.

Therefore, TISR is an appropriate treatment method for enhancing treatment of dissolved-phase mass located in low-permeable zones. Also, because it can be readily incorporated into existing remediation systems, TISR is particularly well-suited for accelerating treatment rates for existing in situ remediation systems designed to promote bioremediation of chlorinated solvents.

2.2 DEVELOPMENT

TISR was first implemented in 2015 and has since been patented (US Pat. Nos. 10,384,246 and 10,688,545) and successfully deployed (pilot and full scale) at more than 25 sites across diverse hydrogeologic settings and climates. These systems have primarily been used to treat petroleum hydrocarbon contaminants, functioning both as standalone treatment solutions and as enhancements to existing remedial technologies such as AS/SVE systems. In addition to the original solar collectors, TISR has also effectively used waste heat as a sustainable energy source through steam recovery and heat exchangers. Notably, no technology development was conducted under the ESTCP program prior to this field demonstration.

2.3 ADVANTAGES AND LIMITATIONS

TISR is particularly well-suited for accelerating treatment rates for existing in situ remediation systems designed to promote bioremediation of chlorinated solvents, offering several key features:

- *Cost savings and reduced energy and water use*. Substantial cost savings compared to conventional remediation technologies and the potential to significantly replace or supplement/ enhance many existing remedial strategies.
- *Enhanced contaminant bioremediation, reactive iron mineral-facilitated abiotic degradation, chemical hydrolysis, and volatilization*. Biological degradation rates commonly double for every ~10°C rise in temperature under mesophilic conditions. Reactive iron mineral-facilitated abiotic degradation rates also generally increase with temperature, according to the Arrhenius equation. Chlorinated alkanes and carbon tetrachloride (but not chlorinated ethenes) undergo hydrolysis reactions at relatively high rates that increase with elevated temperatures.

- *Application in tandem*. Application in conjunction with source zone AS/SVE, multiphase extraction systems could significantly reduce treatment timeframes and complement natural attenuation.
- *Effective in complex geology*. Heat transfer and consequent treatment benefits are not limited by challenging hydrogeology (e.g., heterogeneous strata, tight clays).
- *Application in remote areas*. Remote areas present a challenge for traditional remedial approaches due to the lack of availability of conventional energy sources. Through its primary reliance on use of solar energy, TISR can help overcome that challenge.

Specific to the selected site, EISB was in operation for nearly a decade prior to TISR installation. However, the hydrogeology is complex and heterogenous, with lower permeability materials in the former source area. The current dominant source area treatment mechanism is EISB that has been enhanced with carbon substrate addition and groundwater recirculation. Uniform reagent distribution has historically been difficult to achieve at the site due to local heterogeneities. While reducing geochemical conditions are established and bioremediation mechanisms are demonstrably occurring, treatment performance has been mixed. TISR presented an opportunity to accelerate the remediation pace. Additional information on the site is provided in Section 4.

As with any novel technology, there may be limitations to TISR. The design of a TISR system is dependent on adequate solar radiation, which can vary based on geographic location and weather conditions. This dependency on solar radiation affects the number of required solar collectors and can impact the performance of the technology. Additionally, the design and implementation of TISR systems require careful consideration of site-specific factors, such as local geology, hydrogeology, and contaminant distribution. These site-specific considerations influence the feasibility, effectiveness, and actual costs of TISR applications.

Another important consideration is the existing power infrastructure. TISR systems can be powered by existing grid power or by photovoltaic (solar) power. However, in both cases, a loss of power to the system means that the pump will not circulate the heating fluid, resulting in the pressure relief safety system kicking in to purge expanded fluid into a containment tank. This "closed system" then must be recharged, incurring extra site visits to recharge the system. Therefore, potential backup power units may be advantageous to avoid this situation and should be evaluated based on the specific site conditions.

Less than optimal heating due to BHEs installed a low spatial density or lower-than-expected solar insolation at a selected site, caused by seasonal variations, could adversely affect the ability to heat the subsurface and achieve the desired temperature range within the treatment area. This is a manageable risk and can be mitigated by incorporating supplemental heating from an inline heater or heat pump if lower-than-normal solar insolation is encountered in the first year of TISR operation. A similar approach can be applied during the night and the winter months, if needed.

The installation and operation of TISR systems may necessitate regulatory approvals and cooperation from local authorities, potentially adding complexity and causing delays in the implementation process. It is essential to engage with regulatory agencies and stakeholders early in the planning stages to address any concerns and obtain the necessary approvals.

Laboratory studies performed by Fletcher et al. (2011) demonstrated that *Dehalococcoides* biomarker gene abundance and dechlorination rates were significantly greater at 30°C than at 35 and 40°C. Complete dechlorination to nontoxic end products (i.e., ethene) was also observed at 30°C, but dechlorination activity seemed to stall, at least transiently, at intermediate daughter products (i.e., cis-1,2-DCE and VC) at 35 and 40°C. Nemeeek et al. (2018) confirmed a similar response to heating at a real chlorinated solvent-contaminated site. At the site studied by Nemeeek et al. (2018), an increase in dechlorinating bacteria and reductive dehalogenase genes occurred after the addition of a fermentable organic carbon substrate and heating of a treated zone from 17 to 30°C. Further laboratory microcosm studies completed as a part of this project further confirm an ideal target temperature range of 30 to 35°C for microbial communities responsible for reductive dechlorination (see **Section 5.3.1**). TISR operational data collected so far have affirmed that TISR can increase groundwater temperature to 30°C and higher; therefore, achieving the optimal dechlorination conditions noted above should be achievable with TISR. If the enhanced solar insolation and potential overheating (greater than 40°C) of the subsurface become an issue, then one or more of the modular solar collectors can be taken offline to balance the subsurface temperatures back to the optimal range.

3.0 PERFORMANCE OBJECTIVES

The overall objectives of this TISR field demonstration were to field-validate the technology for use at CVOC sites, quantify technical performance and limitations, and provide a basis for wider application. Quantitative and qualitative performance objectives were established in the Demonstration Plan (Divine et al. 2021b) to provide the basis for evaluating the performance and costs of the TISR technology. The specific performance objectives, criteria that were used to evaluate success, and a summary of the results are presented in **Table 3.1**, below. Detailed evaluations of each performance objective are presented in Section 6.

Table 3.1. Key Performance Objectives and Success Criteria

Performance Objective	Data Requirements	Success Criteria	Success Criteria Achieved?
Quantitative Performance Objectives			
1. Validate temperature increases and uniformity of temperature distribution vertically and horizontally.	Temperature measurements from multiple horizontal and vertical points.	Of the DTS locations within the target treatment volume (DTS-2 through DTS-9), 75 percent will achieve a minimum temperature of 30°C within 1 year of initiating operations. Once this standard is achieved, temperatures within the active treatment volume will be maintained between 30 and 35°C for a minimum of 120 days. Temperature sensors outside the actively heated treatment volume (DTS-1, DTS-10, DTS-11, DTS-12) will not be used to assess compliance with this performance standard.	This performance objective is considered achieved. However, the success criteria were not met within the initial target timeframes due to unforeseen site weather patterns. Extended and supplemental heating was required to reach and maintain the specified temperature ranges and achieve this performance objective.
2. Determine influence of solar insolation and geographical variations on optimal design.	Solar insolation, borehole spacing, subsurface temperature changes, and rate of heat distribution in the subsurface.	Average of field temperature measurements within an average of 25 percent of location-specific design prediction ranges and reliable equipment sizing guidelines.	This performance objective is considered achieved. However, the average field temperature measurements did not fall within 25 percent of the location-specific design prediction ranges due to seasonal variations and higher-than-normal precipitation events. As a result, additional heating via a heat pump was required to meet the location-specific design predictions and achieve this performance objective.

Table 3-1. Key Performance Objectives and Success Criteria (Continued)

Performance Objective	Data Requirements	Success Criteria	Success Criteria Achieved?
Quantitative Performance Objectives			
3. Temperature-driven increase in microbial degradation activity.	a) Microbial community composition; b) Abundance of gene targets involved in reductive dechlorination; c) Organic carbon consumption rate from push-pull tracer tests; d) Isotopic fractionation of parent compound and daughter products; and e) CVOC concentration.	a) Statistically significant shifts in dominant microbial genera, as measured via the Shannon-Weaver Index, as heating proceeds; b) Increased abundance of gene targets associated with CVOC degradation to more than 10^6 gene copies per mL; c) Carbon consumption increases approximately two times per 10°C increase, up to approximately 35 to 40°C; d) Statistically significant increase in isotopic fractionation of CVOCs as heating proceeds, and e) Statistically significant decrease in chlorine number (the average total chlorine atoms per total ethene molar concentration) as heating proceeds.	This performance objective is considered achieved. A significant shift in microbial community composition (and dominant microbial genera) was observed with heating, as evidenced by a decrease in the Shannon Weaver Index from 2.1 at 18°C to 1.25 at 30°C. The abundance of gene targets associated with CVOC degradation increased with heating but remained below 10^6 gene copies per mL. Significant decreases in chlorine numbers were observed with heating, as evidenced by a drop from 2.42 to 0.35 at well TISR-4D.
4. Temperature-driven increases in abiotic degradation activity.	a) Measure abiotic rate constants for six temperatures from ^{14}C assay with site soils and groundwater; b) Reactive iron mineral composition measured in Min-Trap™ samples; c) Dissolved acetylene concentrations; and analysis of AHY gene target.	a) At least 0.01 percent of the contaminant is oxidized in the assay tests, resulting in a temperature correlation trend that consistent with the Arrhenius equation; b) Observed co-located iron and sulfur (SEM-EDS data) on Min-Trap™ matrix; and c) Presence of dissolved acetylene and/or AHY gene target.	This performance objective is considered achieved. AMIBA and SEM-EDS data collected from Min-Trap samples confirm the presence of reactive iron sulfide minerals within the target treatment area
5. Verify capital, operation and maintenance, and lifecycle cost benefit of TISR.	Historical remediation system operational costs, TISR equipment, construction, and operational costs, contaminant concentration trends, relative daughter generation, contaminant mass flux.	a) Reductions in projected active remediation phase lifecycle costs exceed TISR system costs by more than two times; b) Reduction in project remedial timeline by > 2 years.	This performance objective is considered achieved. However, the lifecycle benefits were primarily associated with reduction of remedial timeline and associated project liability. The net cost difference was negligible, and thus did not meet the criteria in this case. However, cost reductions are site-specific and may be more favorable for other sites.
6. Sustainability benefits	Energy use data from existing site remedy and TISR system.	Projected greater than 25 percent lifecycle reduction in energy use compared to baseline EISB operations.	This performance objective is considered achieved.

Table 3-1. Key Performance Objectives and Success Criteria (Continued)

Performance Objective	Data Requirements	Success Criteria	Success Criteria Achieved?
Qualitative Performance Objectives			
7. Identify implementation and operational challenges.	Surveys from installation and project personnel.	No significant implementation or operational challenges identified.	This performance objective is considered achieved.

Notes:
DTS = distributed temperature sensing
mL = milliliter
SEM-EDS = scanning electron microscopy with energy dispersive X-ray spectroscopy

4.0 SITE DESCRIPTION

This section describes the site setting, subsurface conditions, and contaminant distribution.

4.1 LOCATION AND HISTORY

Based on the evaluation presented in the Site Selection Memorandum (Divine et al. 2021a), TISR field testing was conducted at Installation Restoration Program Site SD015, located at Vandenberg Space Force Base (site) from April 2022 to December 2024. SD015 encompasses the Advanced Ballistic Re-Entry Systems-B Launch Complex and is located approximately 1.5 miles east of the Pacific Ocean and 3,500 feet north of San Antonio Creek (**Figures 4.1** and **4.2**, below). The TISR treatment area is shown north of the Tethys Road on **Figure 4.2**, below, with detailed BHE and DTS locations provided in **Appendix B**, Drawing G-3. The SD015 groundwater VOC plume extends downgradient to and into San Antonio Creek surface water.

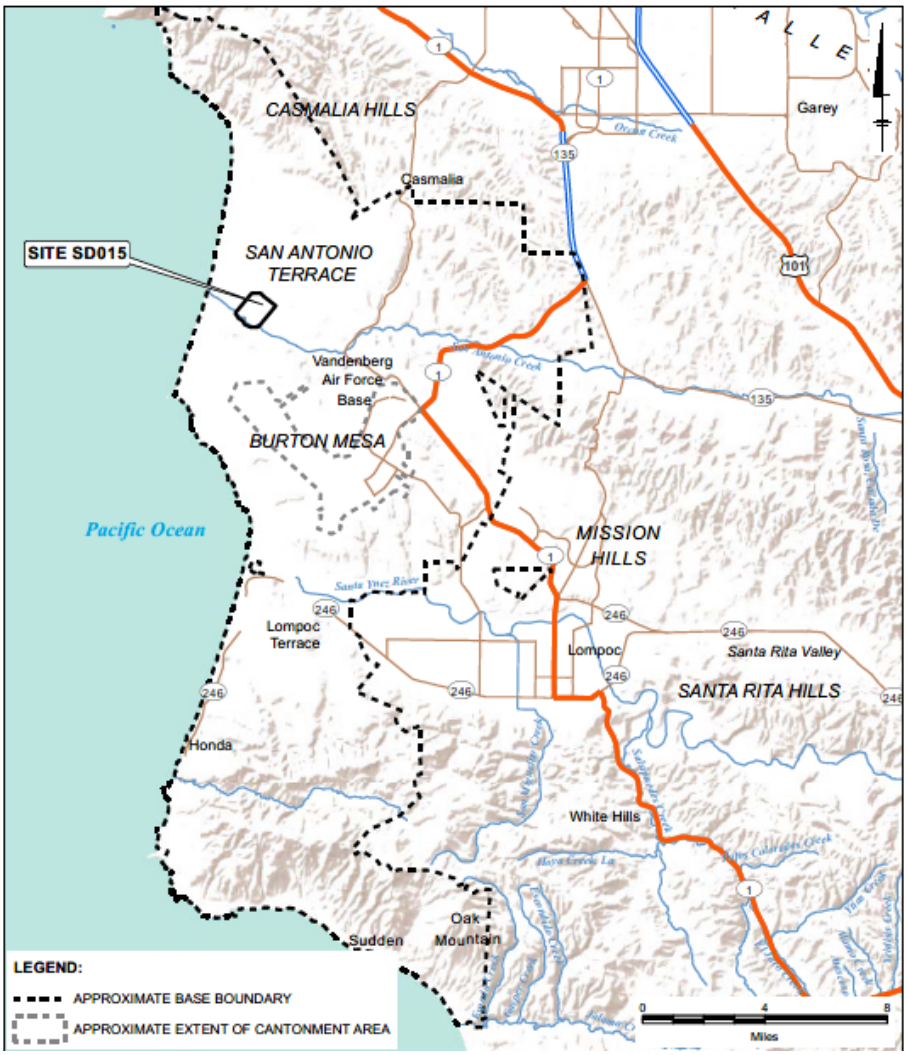


Figure 4.1. Site Location

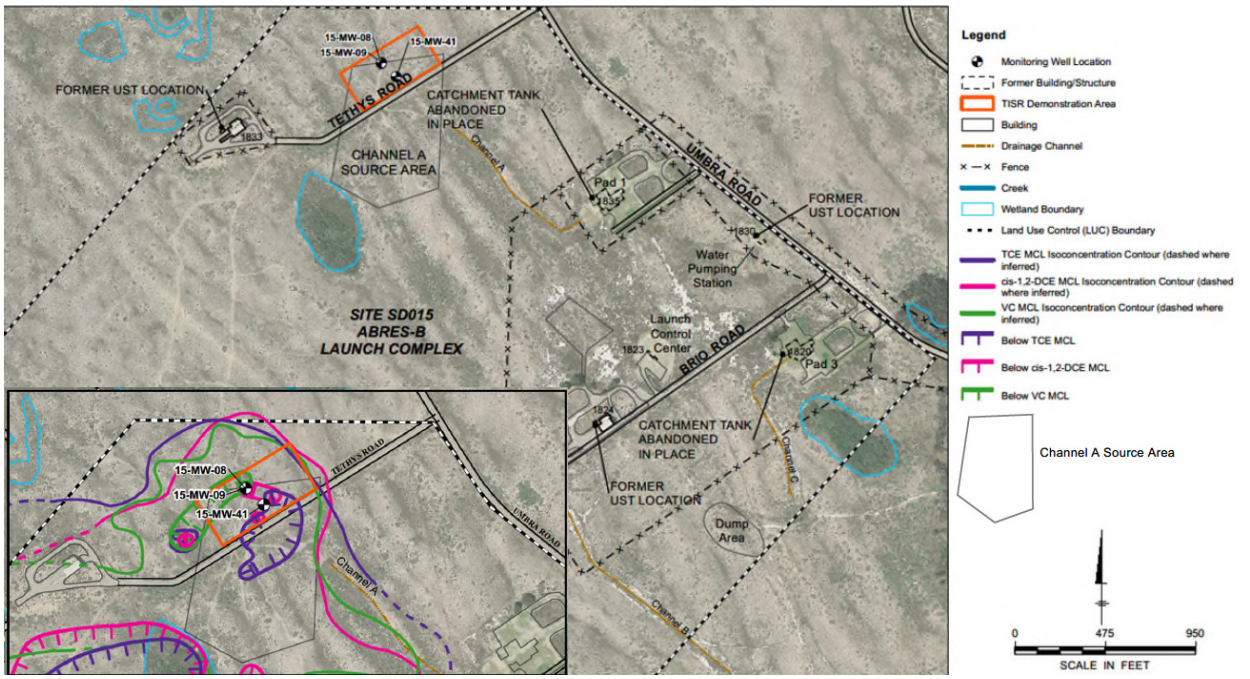


Figure 4.2. Site Layout Showing TISR Target Area Channel A (north of Tethys Road)

SD015 was constructed in 1959 and was used to launch Atlas D and Atlas F missiles from 1960 to 1967. The launch complex included a control center (Building 1823), a water pump station (Building 1830), a maintenance facility building (Building 1824), three abandoned launch pads (Pads 1, 2, and 3), and associated building structures (Buildings 1835, 1825, and 1820). Building 1833 was an experimental missile stage processing facility located outside the boundary of SD015 as defined by Battelle Corporation (1986). Each launch pad was constructed with a concrete-lined deluge channel extending from the pad to a drainage channel (Channels A, B, and C) through which deluge water from the launch pad was discharged. TISR field testing took place near the Channel A area, north of Tethys Road.

Prior to launches, TCE solvent was used to degrease rocket engines and fueling system components at the launch pads. This chemical substance, and at times along with tens to hundreds of thousands of gallons of deluge water, was washed down the drainage channels and discharged to the ground surface. Channel A extends approximately 800 feet northwest from Pad 1, Channel B extends approximately 1,200 feet southeast from Pad 2, and Channel C extends approximately 600 feet south from Pad 3. Channels A and B were identified in subsequent investigations as the potential source areas of VOC contamination in groundwater beneath SD015, which extends to the south-southwest and impacts surface water in San Antonio Creek. Primary COCs for the site include TCE, as well as degradation products of TCE, including cis-1,2-DCE and VC. The TISR treatment area aligned with the Channel A source COC plume.

Environmental and logistical conditions at the site (specifically surrounding 15-MW-41) made this an appropriate candidate site, including:

- The site geology and hydrogeology are well-understood but the persistence of the plume, despite significant remediation activity already completed, is largely the result of complex geologic heterogeneity, including lower-permeable zones.
- The existing site characterization data are extensive and additional characterization needs for TISR are minor.
- EISB has been applied in the former source area for more than a decade. The extensive existing dataset indicated bioremediation is occurring, but rates are relatively low. TISR was expected to significantly accelerate treatment rates and future remediation performance. EISB performance can be monitored in tandem with the application of TISR.
- The upgradient source area around 15-MW-41 had high contaminant concentrations prior to the TISR demonstration, with historical total CVOC concentrations exceeding 10,000 micrograms per liter [µg/L] in some samples.
- Total treatment depth was less than 50 feet below ground surface (bgs) and less than 20 feet in saturated thickness. Hydraulic conductivity estimates using slug tests in Channel A outfall area wells near 15-MW-41 (15-MW-7, 15-15-MW-8, 15-MW-9) range from 2.2 to 50.5 feet per day, with a geometric mean of 7.3 feet per day (Arcadis 2017). Previous remediation activities in this general area confirm that sustainable injection rates averaging approximately 2 gallons per minute are achievable. These relatively shallow depths and focused target zone allowed for economic application of TISR. The relationship between VOC concentrations and groundwater levels adds a variable to assessing EISB/TISR performance.
- Although the current EISB system had been operating for more than 1 decade prior to TISR demonstration, concentrations were still relatively high (total CVOCs of 4,881 µg/L at 15-MW-41 in January 2022), which is at least partially a consequence of the challenging local geologic and hydrogeologic setting. Stakeholder support and access considerations also played an important role in site selection. TISR was applied at the site to compliment the ongoing EISB system to accelerate treatment primarily by enhancing biotic contaminant degradation rates. Because EISB treatment is ongoing (which is currently enhancing contaminant dissolution and biodegradation), the system performance prior to the TISR install was defined as the baseline condition. As discussed further in the Performance Objectives section and presented in **Table 3.1**, the demonstration evaluated enhancements in EISB performance by measuring several parameters, including changes in target microbial communities, increases relative daughter product formation, and shifts in carbon isotopes.

4.2 GEOLOGY AND HYDROGEOLOGY

The site source areas are located approximately 3,500 feet northeast of San Antonio Creek and are designated as the San Antonio hydrologic planning area (watershed) and the San Antonio Creek Valley groundwater basin (Central Coast Regional Water Quality Control Board 2019). The VOC groundwater plumes extend from the source areas, and the Channel A plume discharges into San Antonio Creek. Localized wetlands have formed in small areas south of Tethys Road. A wetland located west of Pad 1 contains surface water most of the year. The water levels in these wetlands are above the surrounding water table (Shaw Environmental, Inc. 2004). It is assumed that organic clay in the surface soil holds water within the wetlands. The aquifer is relatively thin in the source area, and transitions to a thick aeolian sand sequence in the distal-plume area.

The alluvial aquifer is primarily sandy but contains a greater amount of fine-grained soil in the source area, transitioning to a greater relative sand content in the mid-plume area. The aquifer is underlain by an irregular bedrock surface in the source area and mid-plume area, and by a thick estuarine clay in the distal-plume area. Both the underlying marine shale bedrock (Sisquoc Formation) and the estuarine clay are low-permeability deposits and function as aquitards. To the south, the subsurface water-bearing zone encounters a boundary against the shale outcrop of Burton Mesa and flows into San Antonio Creek, which ultimately flows into the Pacific Ocean (Earth Tech 2008). Site cross sections are provided in Site Selection Memorandum (Divine et al. 2021a).

The ambient groundwater gradient direction at the site is generally to the southwest toward San Antonio Creek. In general, the gradient is steeper at the source areas located at the northeastern portion of the site. The calculated gradient is approximately 1 order of magnitude greater between the source area (near 15-MW-41) and the mid-plume area, compared to the distal plume area, under ambient conditions.

The lithology of the aquifer at the site is well-defined with a high degree of lithologic variation in bedrock surface, aquifer lithology, and saturated thickness across the site. Site lithology can be grouped into three areas based on observed lithology:

- *Source area*. This area consists of heterogeneous alluvial sediments (i.e., sands and silty sands with localized silts and clays) underlain by bedrock and overlain by relatively thin dune deposits. TISR implementation will be in this area, corresponding with 15-MW-41.
- *Mid-plume*. This area consists of a transition between alluvium and dune deposits, underlain to the northeast by bedrock, and by basal clay to the west and southwest.
- *Distal plume*. This area consists primarily of thick, more homogeneous dune sand deposits underlain by basal clays. The alluvial sediments are not present in the distal-plume area.

Bedrock elevation and saturated thickness are variable in the source area and mid-plume area due to the presence of the irregular bedrock surface; in the distal-plume area, the aquifer is primarily underlain by a flatter basal clay, which results in a more regular surface and less lateral variability in saturated thickness. A large laterally extensive bedrock is present in the central part of the site. This area is generally defined as the area immediately surrounding the wetland and areas immediately to the west and southwest. The bedrock high results in a thinning of the aquifer in the mid-plume area, including the complete disappearance of the saturated zone in a portion of the central part of the site.

4.3 CONTAMINANT DISTRIBUTION

Sitewide CVOC concentrations have decreased since EISB activities began. However, they have varied widely because of the likely presence of residual-phase CVOCs adsorbed on site soil, injected reagent distribution, and local geologic heterogeneity. Specifically, total CVOC concentrations in 15-MW-41 in the former source area have decreased since the onset of EISB activities in 2011; however, CVOC concentrations fluctuated with a general increasing trend since 2017 (Arcadis 2021; **Figure 4.3**, below). Between January 2017 and October 2022, TCE concentrations ranged from 550 µg/L (4.11 micromoles per liter [µmol/L]) to 0.29 µg/L (0.002 µmol/L), with a concentration of 550 µg/L (4.19 µmol/L) in January 2022, the last sampling point before TISR system startup. Between January 2017 and October 2020, cis-1,2-DCE concentrations ranged from 11,000 µg/L (113 µmol/L) to 13 µg/L (0.13 µmol/L), with a concentration of 3,500 µg/L (36.1 µmol/L) in January 2022.

Total CVOC concentrations (including VC) vary significantly during this period, ranging from 14,300 µg/L (150 µmol/L) to 25.9 µg/L (0.27 µmol/L), with the most recent concentration of 4,880 µg/L (53.6 µmol/L) in January 2022 prior to start up the TISR system.

It should be noted the high historical concentration variability at well 15-MW-41, in part due to GWE variability, adds uncertainty when assessing TISR performance. However, the changes in CVOC composition, as quantified by the reduction in chlorine number, confirm enhanced biodegradation.

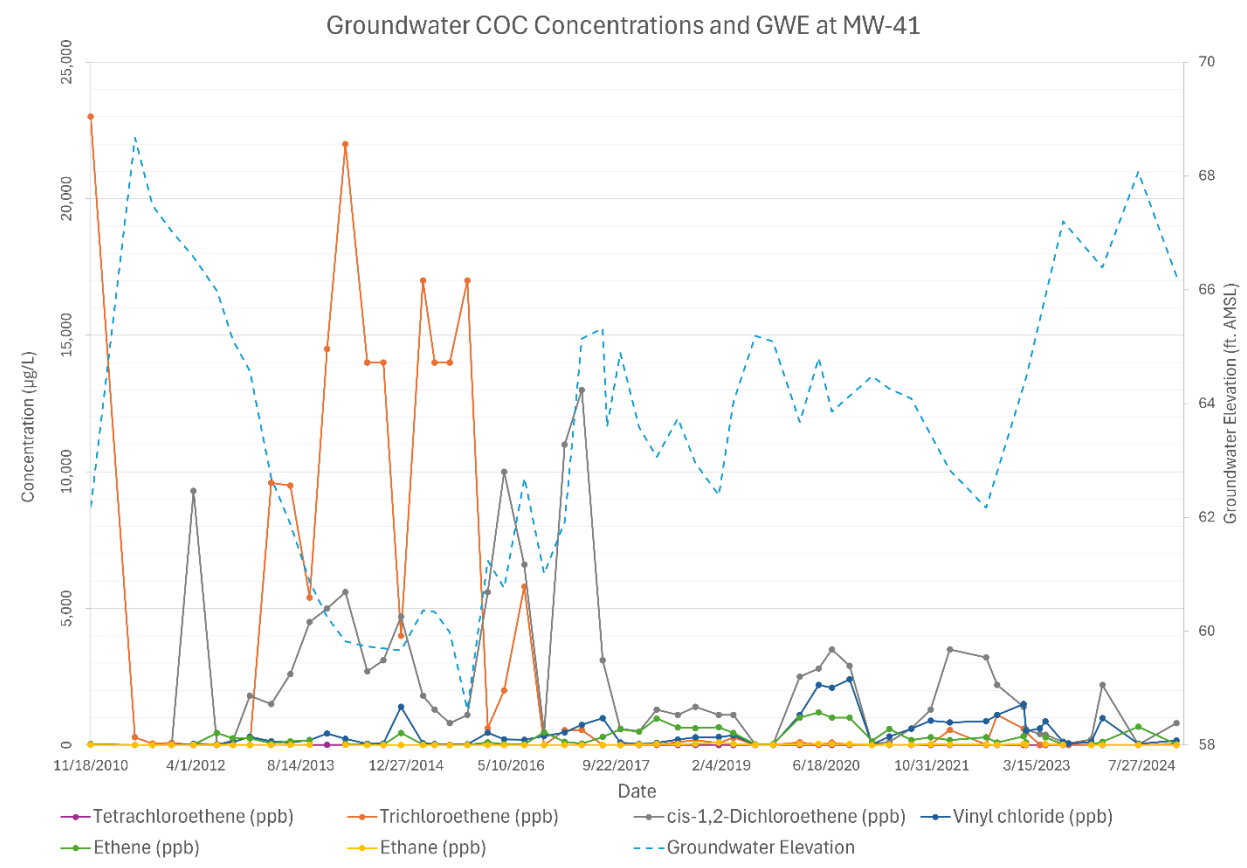


Figure 4.3. Historical COC Concentrations and GWE for Monitoring Well 15-MW-41

(a) Injection/Operational History at Well of Influence

Event Name	Event Start	Event End
EISB Recirculation 1 – Phase I	05/04/11	01/13/12
EISB Recirculation 1 – Phase II	02/02/12	03/28/13
EISB Recirculation 1 – Phase III	09/09/14	11/17/14
EISB Recirculation 1 – Phase IV	10/13/15	01/12/16
EISB Recirculation 1 – Phase V	06/27/16	08/19/16
EISB Recirculation 1 – Phase VI	04/03/19	06/11/19
EISB Recirculation 1 – Phase VII	10/05/20	01/19/21

(b) EISB recirculation events at the well have occurred in seven phases.

Additionally, VOC, ethene, ethane, total organic carbon (TOC), and methane concentrations decreased following the second quarter 2019 reagent injection event but rebounded. Overall, elevated VOC concentrations in 15-MW-41 suggest the presence of residual mass (i.e., immobile nonaqueous phase liquid) in the surrounding area (Arcadis 2021). Site remediation goals involve attainment of California maximum contaminant levels of 5.0, 6.0, and 0.5 µg/L for TCE, cis-1,2-DCE, and VC, respectively. After 1 decade of EISB, the presence of COCs several orders of magnitude greater than cleanup goals indicate that the likely continued presence of residual-phase contamination and geologic heterogeneity in the Channel A source area is limiting the pace of remediation and progress toward the site remedial goals.

5.0 DEMONSTRATION DESIGN AND IMPLEMENTATION

This section describes the TISR field demonstration conducted to meet the performance objectives discussed in Section 3.

5.1 CONCEPTUAL EXPERIMENTAL DESIGN

5.1.1 Target Treatment Area

The Demonstration Plan (Divine et al. 2021b) details the installation, operation, and performance monitoring of a TISR system near monitoring well 15-MW-41, which was selected based on its location within the source zone, treatment history, and specific historical soil and groundwater data. The system was installed in a remote field on the central California coast, with an average solar irradiance of approximately 5 kilowatt hours per square meters per day. The heated zone encompassed approximately 3,700 square feet and 2,750 cubic yards of saturated soil. The monitoring infrastructure was adapted to existing site conditions, involving the installation of new monitoring wells and temperature sensing fiber (DTS) locations to provide comprehensive performance monitoring data.

The above-grade equipment included eight solar collectors arranged in a 4x4 array, a heat pump skid for efficient heat transfer, a pump station with instrumentation and controls, a conveyance manifold for distributing heated fluid, and eight branches of insulated above-grade conveyance piping to minimize heat loss, connected to the existing electrical source.

Below grade, eight BHEs were installed with a heating interval from 20 to 40 feet bgs, along with eight new performance monitoring wells with screen intervals of 17.5 to 27.5 feet bgs (shallow) and 30 to 40 feet bgs (deep). Additionally, two existing monitoring wells with screen intervals of 19 to 39 feet bgs and 25 to 35 feet bgs were used, along with two new soil vapor probes at a depth of 17.5 feet bgs and 12 DTS locations from the surface to 40 feet bgs. The target treatment area and system infrastructure are shown on **Figure 5.1**, below. Specifications for system infrastructure and as build drawings is provided in **Appendix B**. Documentation of the system installation and associated boring logs are provided in **Appendix C**.

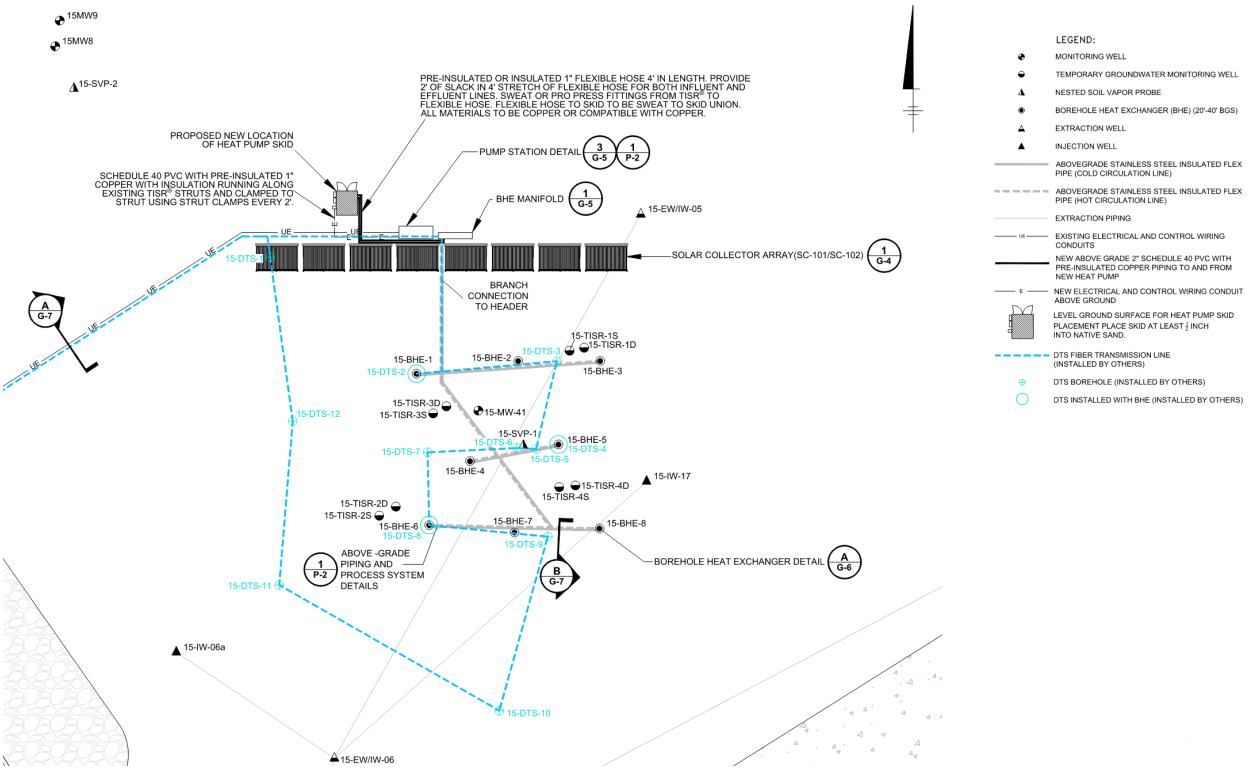


Figure 5.1. Target Treatment Area and TISR System Elements

Final TISR layout showing BHEs and DTS locations. Solar collectors shown as gray boxes.

5.1.2 Heat Transport Model Development

A new design tool was developed by adapting an analytical solution for simulating BHE geothermal heating processes. The initial model output predicted heat propagation and determined the necessary BHE spacing to meet temperature objectives within the project timeline. These predictions were estimates and were refined during system operations. The model involves the governing partial differential equation for transient heat conduction with convection due to groundwater flow (in three dimensions):

$$[\phi\rho_w C_w + (1-\phi)C_R\rho_R]\frac{\partial T}{\partial t} = -V_d\rho_w C_w\frac{\partial T}{\partial x} + \lambda\frac{\partial^2 T}{\partial x^2} + \lambda\frac{\partial^2 T}{\partial y^2} + \lambda\frac{\partial^2 T}{\partial z^2} \qquad \text{(Equation 5.1)}$$

Where:

C_R = rock grain heat capacity

C_w = water heat capacity

ρ_R = rock grain density

ρ_w = water density

φ = porosity

V_d = groundwater Darcy velocity (flux)

λ = thermal conductivity.

T = temperature

t = time

Treating a BHE as a continuous line source of heat of Q watts over a vertical thickness that extends from a depth of *a* to a depth of *b*, with an initial temperature of T_0, and a location of x_0, y_0, the temperature distribution can be adapted from a solution given by Molina-Giraldo et al. (2011):

$$T = T_0 + \frac{Q}{2\pi\lambda(b-a)} \exp\left\{\frac{v_T x}{2\alpha}\right\}\left[\int_a^b f(x,y,z,t)dz' - \int_{-b}^{-a} f(x,y,z,t)dz'\right] \quad \text{(Equation 5.2)}$$

Where:

$$r = \sqrt{(x-x_0)^2 + (y-y_0)^2 + (z-z')^2}\ ; \quad \alpha = \frac{\lambda}{\phi\rho_w C_w + (1-\phi)\rho_R C_R}$$

And:

$$v_T = \frac{V_d \rho_w C_w}{\phi\rho_w C_w + (1-\phi)\rho_R C_R}$$

The function *f* appearing in the integrals in Equation 5.2 is defined as:

$$f(x,y,z,t) = \frac{1}{4r}\left[\exp\left(\frac{-v_T r}{2\alpha}\right) erfc\left(\frac{r - v_T t}{2\sqrt{\alpha t}}\right) + \exp\left(\frac{v_T r}{2\alpha}\right) erfc\left(\frac{r + v_T t}{2\sqrt{\alpha t}}\right)\right] \quad \text{(Equation 5.3)}$$

Where:

erfc = complementary error function.

This solution applies to a single BHE in a semi-infinite system, with the ground surface maintained at a constant temperature of T_0. The case of an insulated ground surface boundary condition can be obtained by replacing the minus sign in front of the second integral in Equation 5.2 with a positive sign. The integrals in Equation 5.2 are easily evaluated numerically using, for example, Gaussian Quadrature (Press et al. 1986).

The solution can be extended to the case of multiple BHEs by superimposing the sources in space. This is done by summing the temperature contribution from each BHE using Equation 5.2 with the appropriate well locations, depths, and thermal power. For a system consisting of *nheater* BHEs, the composite solution becomes:

$$T = T_0 + \sum_{m=1}^{nheater}\left\{\frac{Q_m}{2\pi\lambda(b_m - a_m)} \exp\left\{\frac{v_T x}{2\alpha}\right\}\left[\int_{a_m}^{b_m} f_m(x,y,z,t)dz' - \int_{-b_m}^{-a_m} f_m(x,y,z,t)dz'\right]\right\} \quad \text{(Equation 5.4)}$$

Where:

$$r_m = \sqrt{(x-x_{0m})^2 + (y-y_{0m})^2 + (z-z')^2}$$

The function f_m becomes:

$$f_m(x,y,z,t) = \frac{1}{4r_m}\left[\exp\left(\frac{-v_T r_m}{2\alpha}\right) erfc\left(\frac{r_m - v_T t}{2\sqrt{\alpha t}}\right) + \exp\left(\frac{v_T r_m}{2\alpha}\right) erfc\left(\frac{r_m + v_T t}{2\sqrt{\alpha t}}\right)\right] \quad \text{(Equation 5.5)}$$

The thermal power delivered to each borehole is constant with respect to time in this formulation, but this could easily be extended to a variable thermal input by using superposition of the sources in time.

This solution applies to cases where the groundwater flow direction is in the x-direction. In map coordinates, the x-direction corresponds to the eastern direction. As a matter of convenience, the solution can be rotated with respect to the map axes to allow for groundwater flow in any direction. If the groundwater flow direction makes an angle θ with the x-axis (east), measured counterclockwise, the coordinates can be transformed to a new system *x', y'*:

$$\begin{aligned} x' &= x\cos\theta + y\sin\theta \\ y' &= -x\sin\theta + y\cos\theta \end{aligned} \quad \text{(Equation 5.6)}$$

Once the heat exchanger and *x,y* evaluation locations have been transformed to the rotated coordinate system, the temperature at that transformed location is computed using Equation 5.4. Then the results can be transformed back to the original coordinate system using the inverse transformation:

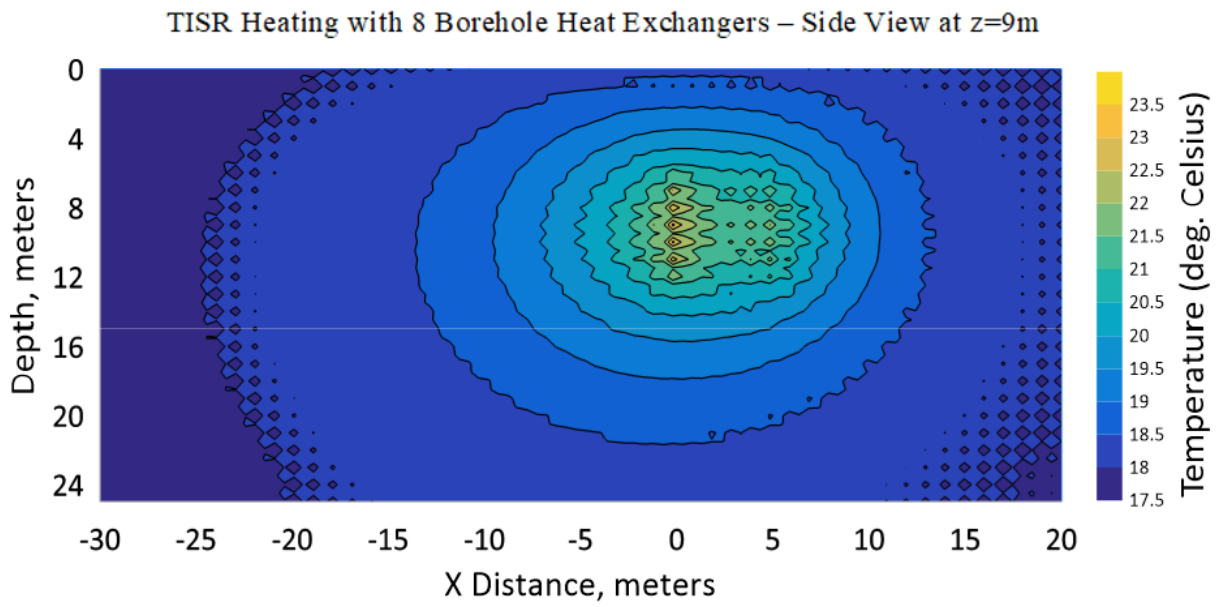
$$\begin{aligned} x &= x'\cos\theta - y'\sin\theta \\ y &= x'\sin\theta + y'\cos\theta \end{aligned} \quad \text{(Equation 5.7)}$$

The BHE analytical solution was programmed in an Excel spreadsheet using a Visual Basic program. This program was used to perform a preliminary analysis of the degree of heating expected from the proposed borehole array at the site. The array consists of eight heat exchangers that extend from a depth of approximately 20 to 40 feet (approximately 6 to 12 meters). The boreholes are arranged in a triangular spacing at a distance of 16 feet (4.9 meters) between boreholes. Based on Arcadis' experience on previous solar thermal heating projects, the average thermal power to each borehole was assumed to be ranging from 320 to 400 watts.

The groundwater Darcy velocity at the test location is expected to be low, on the order of 0.1 foot per day (0.03 meter per day), and the flow is in the westerly direction. For the purpose of this preliminary model, the porosity was assumed to be 0.3, the rock grain density was set to 2,650 kilograms per cubic meter, the rock grain heat capacity was 1,000 joules per kilogram per °C, and the thermal conductivity was 2.5 watts per meter °C. The simulation was run for a total time of 1.5 years.

Figures 5.2 and **5.3**, below, show a map view of the predicted temperature increase (in °C) after 1.5 years of heating. Each contour line represents 1 °C of temperature increase over background. The effect of groundwater flow to the southwest is evident, and the predicted temperature increase inside the pattern is approximately 5 to 8 °C (for 320-watt average thermal power to each BHE), and 6 to 9 °C (for 400-watt average thermal power to each BHE) except near the BHEs, where the temperature increase may be as high as 15 to 20 °C.

(a)



(b)

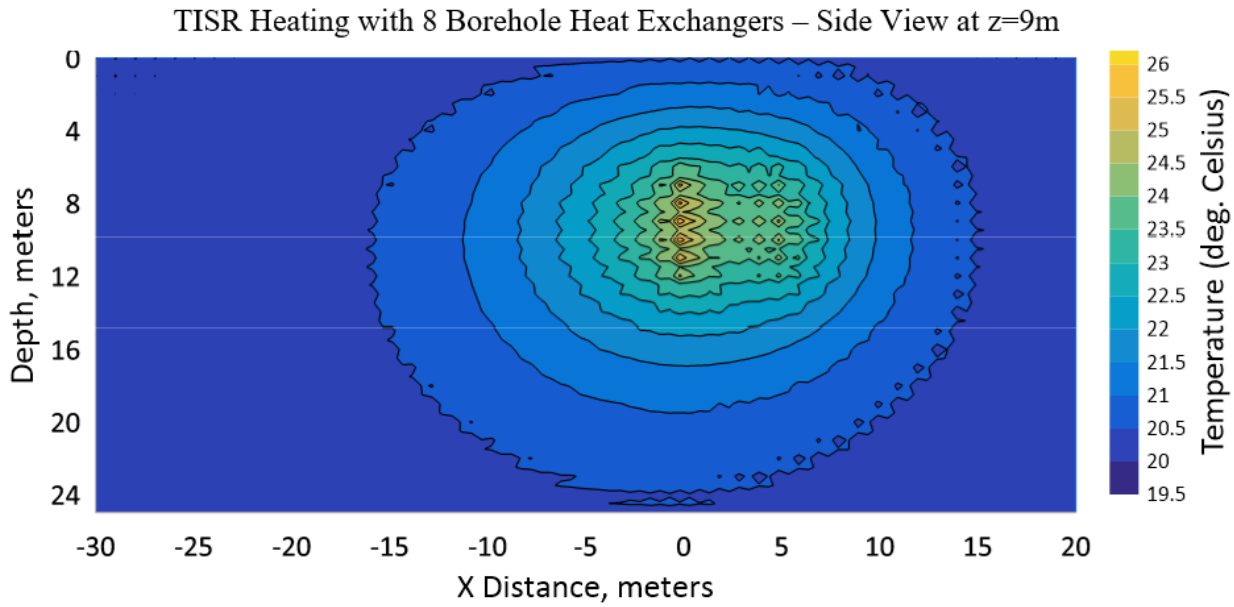
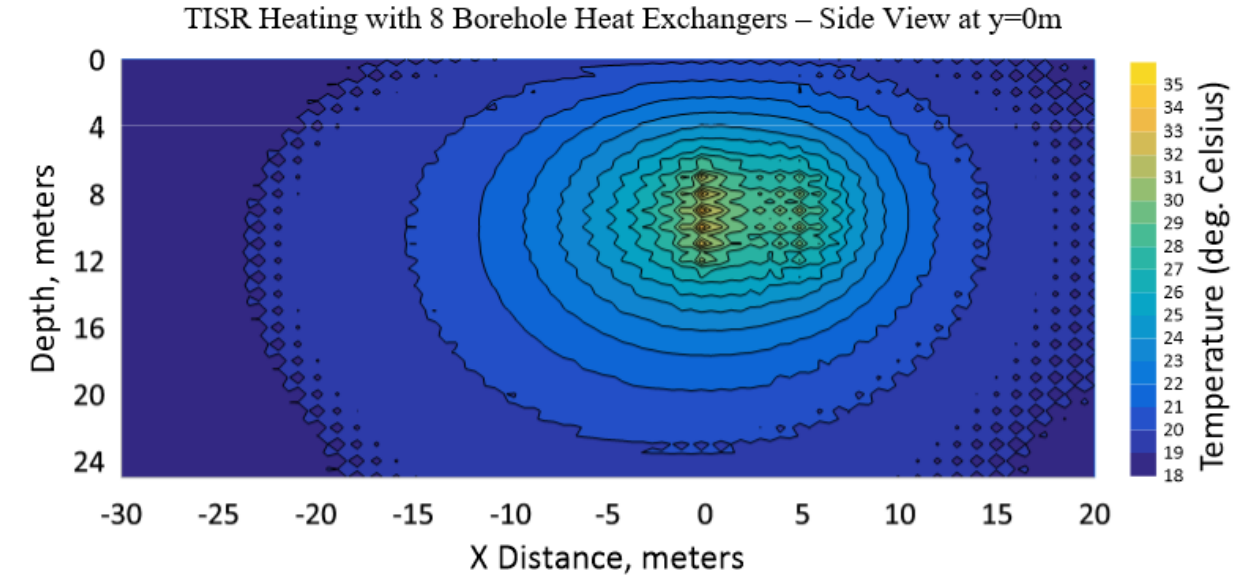


Figure 5.2. Map View of Simulated Temperature Increase (°C)

(a) After 1.5 years of heating with a thermal power of 320 watts per heater.
(b) After 1.5 years of heating with a thermal power of 400 watts per heater. The depth is 29.5 ft (9 meters), which is in the center of the heated zone.

A cross-sectional view of the predicted temperature increase is shown on **Figure 5.3**, below. This cross-section extends in the East-West direction and passes through the southern-most three BHEs (y=0 in the map view figure).

(a)



(b)

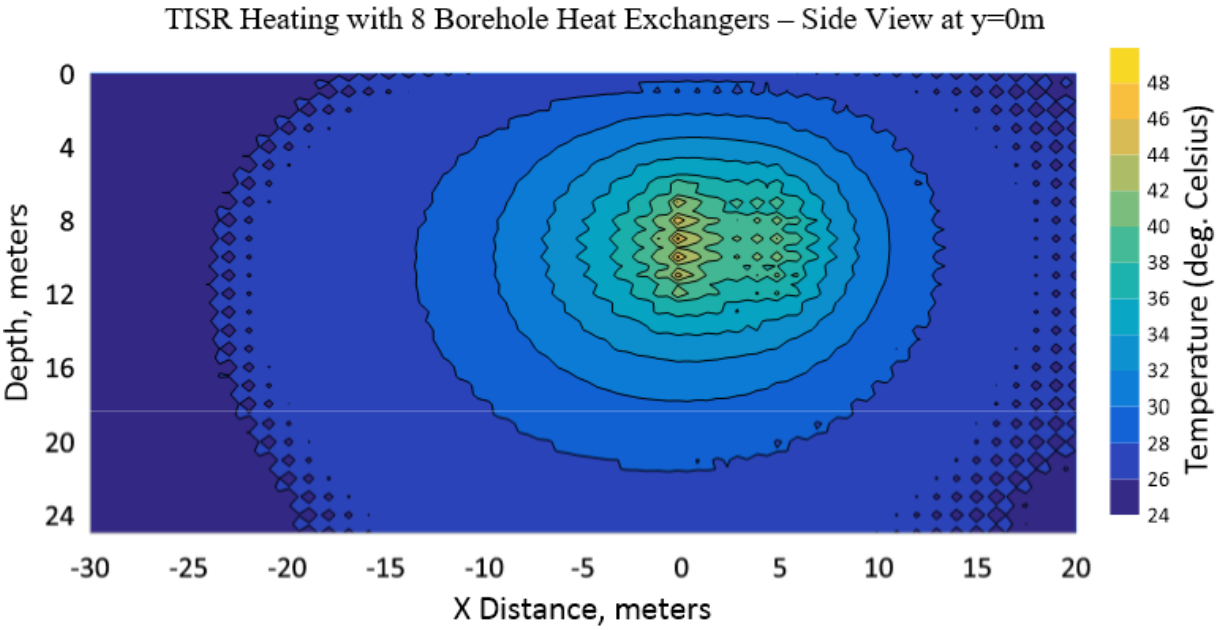


Figure 5.3. Cross-Sectional View of Simulated Temperature Increase (°C)

(a) After 1.5 years of heating with a thermal power of 320 watts per heater.
(b) After 1.5 years of heating with a thermal power of 400 watts per heater. The cross-section passes through the three southernmost heaters. The ground surface is maintained at constant average temperature.

The heat transfer is dominated by thermal conduction, with a possible contribution from thermal convection with groundwater flow. With the solar collectors, the heat energy input to each borehole can be measured by tracking the inlet and outlet temperatures along with the flow rate. The product of the temperature difference and the flow rate gives the instantaneous thermal power; this was averaged for longer time periods to get the average thermal power (watts) delivered to the borehole. At longer times, it may be possible to replace more detailed heat conduction models with a lumped energy balance model. The TISR design model was programmed in Visual Basic (which is part of Excel) and is available as a spreadsheet tool for easier technology transfer.

This modeling was used to refine the design tool, verify appropriate parameter value ranges, and simplifying assumptions. We performed these simulations using the U.S. Department of Energy TMVOC multiphase flow code (Pruess 2002). The code considers the three-dimensional (3D) compositional flow of a gas, aqueous, and nonaqueous phase liquid phase with full partitioning of contaminants between the phases. The thermodynamic effects of evaporation and condensation are included in the energy balance, and the chemical properties (vapor pressure, Henry's constant, solubility) are temperature dependent. This model has been used to simulate thermal remediation of chlorinated solvents (e.g., Baston et al. 2010; Chen et al. 2012a; Chen et al. 2015) and was ideally suited for the work. The detailed TMVOC model of the site was used to identify and validate simplifying assumptions that can be made in the design tool, and to evaluate sensitivity of the system to parameter values. The development and validation of the design tool is further detailed in Ornelles et al. (2022).

5.1.3 Treatability Bench-Scale Testing Setup

As described in the Demonstration Plan (Divine et al. 2021b), laboratory-scale microcosm tests were conducted using composite soil samples collected from locations TISR-2 and TISR-4, as well as groundwater collected from location 15-MW-41 in May 2022. During drilling of the monitoring wells, soil samples were collected from the surface of the water table to the target depth of the monitoring well (40 feet bgs). The soil samples were immediately refrigerated and shipped via overnight carrier to Clemson University for preparation of the microcosms used in the bench-scale study. Groundwater was obtained from the monitoring well closest to the boreholes (15-MW-41) and shipped on ice to Clemson University. The soil and groundwater were stored at 4°C pending analyses. Soil core samples were collected before installing the monitoring well components to preserve the soil integrity and ensure a fully representative sample. Approximately 3 kilograms of soil from the cores of two locations were used for the laboratory experiments.

Two sets of microcosms were prepared: one set received ^{14}C-TCE, the other set did not. Within each set, the treatments prepared were live and unamended, live and lactate amended, autoclaved controls, and filter sterilized groundwater (FSGW) controls. Both sets were incubated at different temperatures (18, 25, 30, 35, 40, and 50°C). The target temperatures were reached by changing the temperature from ambient (approximately 22°C) to the target at a rate of 1°C per day, to allow the indigenous microbial population time to acclimate. TCE and ^{14}C-TCE were added once the target temperatures were reached. TCE was added using a water-saturated stock solution; ^{14}C-TCE was added using a gas chromatography purification method. The resulting initial TCE concentration was approximately 4.5 milligrams per liter (mg/L).

The lactate-amended, non-^{14}C microcosms achieved complete dechlorination to ethene at 18, 25, 30, and 35°C (**Figure 5.4, Panel A**). No dechlorination occurred at 40 and 50°C, implying that these temperatures exceed the optimal range. ***The rate of dechlorination (k_d) doubled for each 8°C rise in temperature from 18 to 30°C, from 0.13 to 0.43 d^{-1} (per day)***, yielding a theta value (θ) of 1.092 (i.e., $k_{T1} = k_{T2}\theta^{T1-T2}$). At 35°C the rate constant also increased (0.46 d^{-1}) but less significantly, indicating that the optimal temperature is approximately 30 to 35°C. Vinyl chloride increased transiently and eventually decreased to less than 2 µg/L. The results indicate that the microbes needed for complete dechlorination are present. The absence of biotic reductive dechlorination at 40 and 50°C is consistent with the expected decrease in microbial activity in the transition from mesophilic to thermophilic conditions.

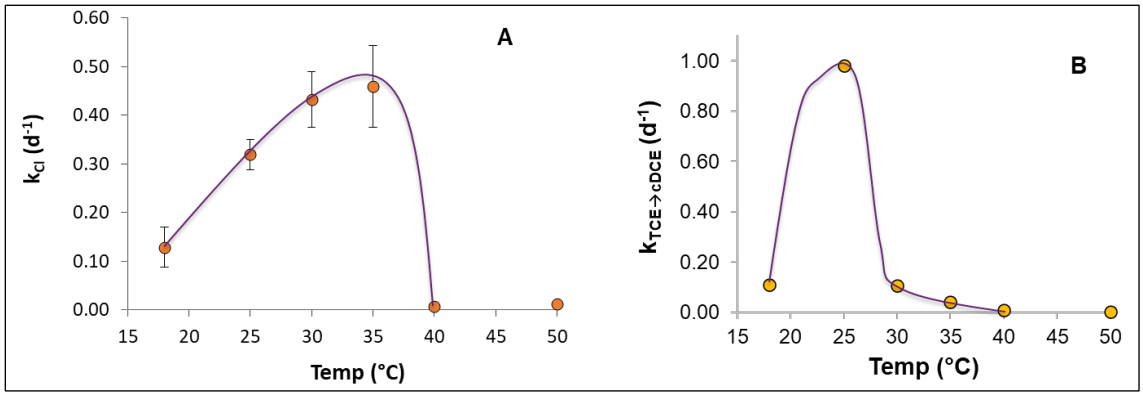


Figure 5.4. Dechlorination and Reduction Rate Constants in Microcosms

A) Complete dechlorination rate constants in lactate-amended microcosms without ^{14}C-TCE added.
(B) Rate constants for TCE reduction to cis-1,2-DCE in the unamended microcosms without ^{14}C-TCE added.

On February 27, 2023, one of the microcosms incubated at each of the different temperatures was submitted to Microbial Insights (MI) for compound-specific isotope analysis (CSIA) and microbiological analyses. The results confirm the presence of *Dehalococcoides* (greater than 10^5 copies per mL) and the *vcr* gene (greater than 10^4 copies per mL) needed to achieve complete dechlorination in the lactate-amended microcosms.

In the unamended, non-^{14}C microcosms, TCE was reduced to cis-1,2-DCE but no further. In this case, heating resulted in a nine-fold increase in the rate constant ($k_{TCE \rightarrow cDCE}$) from 18°C (0.11 d^{-1}) to 25°C (0.98 d^{-1}), followed by a drop back to baseline rate constants at 30°C (0.11 d^{-1}) and a further drop at 35°C (0.043 d^{-1}) (**Figure 5.4, Panel B**). As with the lactate-amended microcosms, there was no dechlorination at 40 and 50°C. The decrease in the rate constants at more than 25°C may have been an artifact of how the microcosms were prepared (i.e., by heating them at a slow rate before adding the TCE). In that interval, the available electron donor may have been exhausted. Regardless, results for the unamended microcosms confirmed that the aquifer system (as represented by these samples) is electron donor deficient. When the electron donor is limited, the primary benefit of heating alone (heating without the addition electron donor) will be to enhance TCE reduction to cis-1,2-DCE.

Methane production was consistent with the dechlorination activity (**Figure 5.5**). The 18°C microcosms were the fastest to respond, as was expected because this temperature is similar to in situ conditions where the samples were collected; therefore, there is no lag in microbial activity

due to acclimation. After several months of acclimation, methane production increased according to the increase in temperature (i.e., 35°C responded fastest, followed by the microcosms at 30 and 25°C). There was no methane production in the 40 and 50°C lactate-amended microcosms, and none in the unamended microcosms at any temperature.

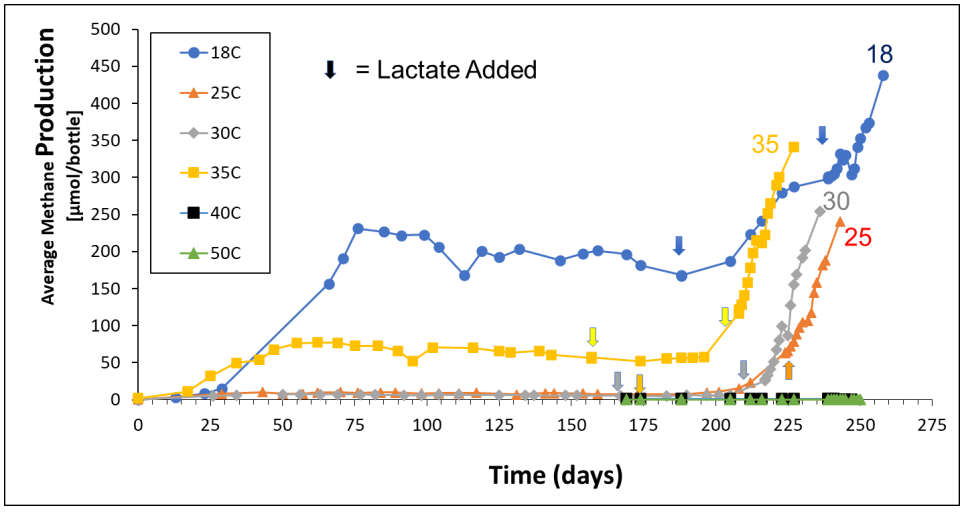


Figure 5.5. Accumulation of Methane in Lactate-Amended Microcosms without ^{14}C-TCE Added

The intent of the ^{14}C-TCE microcosms was to capture the rate of TCE degradation attributable mainly to abiotic activity. Of the treatments prepared, the only one that exhibited the most consistent trend with temperature was the FSGW (**Figure 5.6, Panel A**). The first-order rate constants vary from nondetect to 0.28 year^{-1} (half life = 2.5 years); this is approximately two orders of magnitude less than biotic reductive dechlorination. For the FSGW controls in the temperature range of 25 to 40°C, there was a doubling in the rate constant with each 8°C. It is not clear why the rate constants at 18 and 50°C deviated from this trend. Based on the FSGW results for 25 to 40°C, an Arrhenius activation constant of -69.0 kilojoule per mole (kJ/mol) was determined (**Figure 5.6, Panel B**).

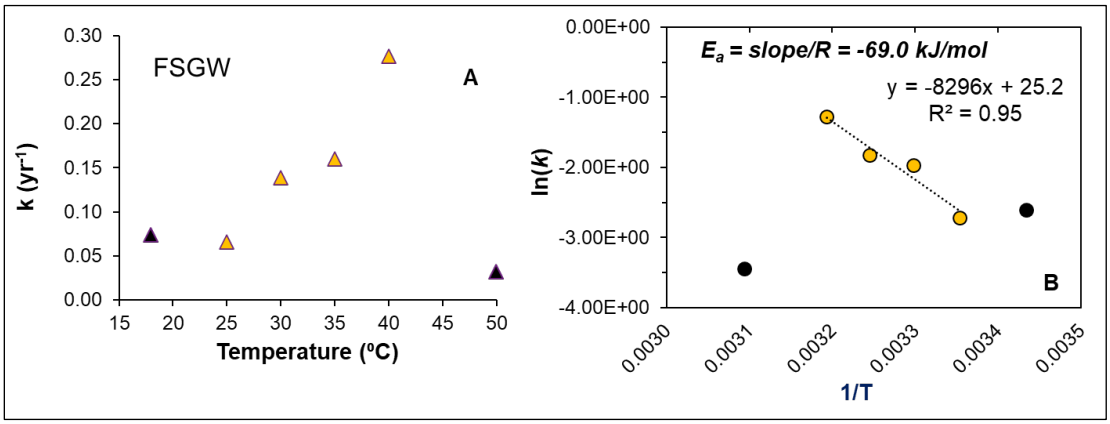


Figure 5.6. Rate Constants and Arrhenius Calculations in FSGW Microcosms

(A) Rate constants for the FSGW microcosms based on accumulation of 14C degradation products.
(B) Calculation of the Arrhenius constant using the data in Panel A.

It is not clear why the ^{14}C-TCE microcosms with soil present did not produce consistent trends with temperature. In other studies, we have also observed that the presence of soil may sometimes quench the ^{14}C activity, especially in soils with low abiotic reactivity. That appears to be the case with the soil at this site. However, the FSGW results indicate that prior electron donor injections at the site have created reactive minerals in the groundwater that are active in abiotic dechlorination.

5.2 THERMAL IN SITU SUSTAINABLE REMEDIATION SYSTEM IMPLEMENTATION

5.2.1 Borehole Heat Exchanger Installation

BHE-1 through BHE-8 were installed surrounding existing monitoring well 15-MW-41 (at the center of the treatment area) and upgradient of background monitoring well 15-MW-08 (screened from 26.5 to 36.5 feet bgs). All BHEs were installed with a planned approximate 10-foot radius of influence, based on empirical data collected to date at other sites and the preliminary modelling described in Section 5.1.2. Given the site geology and contaminant distribution outlined above, the BHEs were installed to a total depth of approximately 40 feet bgs, with a targeted heating interval between approximately 20 and 40 feet bgs. Additional details on the construction and installation of the TISR system, including BHEs, is included in **Appendix B**.

Soil borings for the BHEs were advanced by a licensed driller under the supervision of Arcadis personnel, using a 10-inch hollow-stem auger (HSA) drill rig. After clearing the top 5 feet, borings were advanced to the target depth of approximately 40 feet bgs. During hand clearing and drilling, Arcadis personnel visually observed soil cuttings and screened the boring with a photoionization detector. Soil samples were collected for lithologic logging and laboratory analysis (grain size and thermal conductivity) during drilling.

Once the boring was advanced to the target depth, the pre-constructed heat exchanger components were lowered inside the HSA to the target heating depth of 40 feet bgs. Each BHE consisted of approximately a 20-foot length of 3-inch-diameter stainless-steel casing wrapped with flexible stainless-steel corrugated conveyance piping. The conveyance piping was wrapped around the outside of the casing. At the bottom of the casing, the piping entered the casing and returned to the surface. The solution-return piping was insulated between the top of the casing and ground surface (i.e., from approximately 20 feet bgs to ground surface). At each BHE, approximately 150 feet of heat exchange flexible piping was wrapped around every 20-foot section of 3-inch steel casing.

After placing the BHE in the center of the borehole, the annular space both around and inside the casing was backfilled with silica sand, which, once saturated, is sufficiently thermally conductive to transmit heat from the BHE to the surrounding formation. Each BHE was finished at the surface with stickup well monuments. This construction helps minimize any heat losses and short-circuiting of fugitive vapors from the deeper treatment zone to the ground surface. The top 20 feet of conveyance piping were insulated and surrounded by a bentonite seal and concrete. Details of the BHEs are provided in **Appendix B**, Drawing G-6. Detailed boring logs can also be found in **Appendix C**.

5.2.2 Fiber Optic Distributed Temperature Sensing

Subsurface heating and system performance were documented and validated using multiple types of monitoring data, including high-resolution temperature data. Thermocouple-based temperature monitoring has been conducted at several TISR sites to date. While thermocouples are sufficient for point data collection to support general TISR operation and performance assessment for typical

applications, they do not produce a sufficiently detailed thermal profile to measure temperature changes in highly heterogenous geologic materials. Temperature rise is expected to be greater in low permeable water-bearing units where back-diffusion and the resulting asymptotic dissolved CVOC concentrations have posed challenges. Fiber optic DTS allows for a 25-centimeter depth resolution with a precision of less than 0.02°C. **Figure 5.7** shows an installation performed by California State University Long Beach on a monitoring well in an alluvial aquifer at another site. The fiber optic cable was lowered along with the deepest screen/riser assembly. The temperature profile indicates the impact of injection water from a seawater barrier installation.

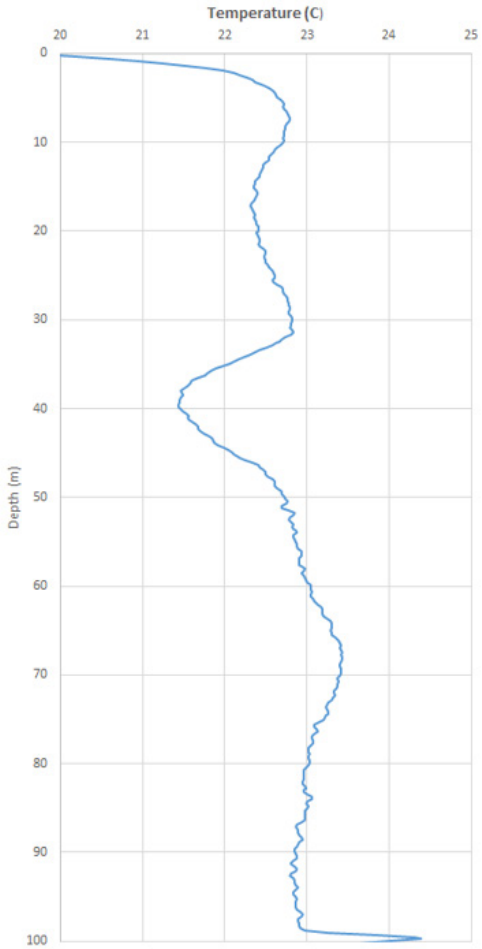


Figure 5.7. Example Fiber Optic DTS Installation

Advective heat loss occurring in the zones of enhanced groundwater flow results in deflections in the profile.

The 12 DTS locations (DTS-1 through DTS-12) were installed at varying distances from the BHEs to evaluate horizontal and vertical heating influences. At each location, fiber optic DTS were installed to monitor temperature from ground surface to a total depth of 40 feet bgs (5 feet below the heating interval). DTS-1, DTS-3, DTS-5, DTS-6, DTS-7, DTS-9, and DTS-10 were advanced using direct-push technology. DTS-11 and DTS-12 encountered refusal at 28 feet bgs and required use of an 8-inch HSA for installation. Once the sensor was lowered to the target depth, the drilling crew allowed the formation to collapse around the sensor/fiber optics cable. For borings drilled with an HSA, the hole was also backfilled with the soil generated during drilling.

DTS-1, DTS-4, and DTS-8 were installed as part of BHE-1, BHE-5, and BHE-6 respectively, attached to the inside of the 3-inch steel pipe and lowered to 40 feet bgs. DTS locations that were not part of a BHE installation were completed with a 1.5-inch galvanized pipe attached to a plastic electrical junction box. The DTS locations were arranged to provide adequate coverage and temperature monitoring across the TISR treatment area. Measurements were recorded in existing monitoring wells as part of the existing groundwater monitoring program.

Each fiber optic cable contained two fibers that could fuse to produce a U configuration. This allowed all of the fibers to be fused into a single circuit running through the BHE and monitoring locations. At the bottom of each fiber optic cable, a fiber "mini-bend" was fused to allow the U configuration while preventing photon loss through around the bend. At the surface, fiber optic cable was networked through polyvinyl chloride (PVC) electrical conduits to deter rodent attack and prevent a trip hazard. The DTS interrogator (Silixa™ XT-DTS https://silixa.com/products/xt-dts/) was installed in a separate panel attached to the existing directed groundwater recirculation (DGR) system control panel. Details of the DTS boring installations are provided in **Appendix B**, Drawing G-6. The DGR system was not operated near the TISR system during baseline operations or during the TISR demonstration. The DGR system continued to be operated further downgradient; however, this did not affect the hydraulics within the demonstration area. To document overall groundwater elevation changes and dynamics during the demonstration period, a pressure transducer with onboard datalogger was installed in 15-MW-41.

The DTS locations were selected in order to:

1. Measure the upgradient (background) temperature profile. This documented fluctuations in seasonal temperature changes and surface heat fluxes.
2. Measure the temperature profile or energy input at select BHEs. This documented the heating distribution of the system within the target zone.
3. Measure the temperature profile in the treatment zone. These data were used to identify how enthalpy is transferred relatively to low- and high-permeability strata. It supported an assessment of temperature increase in the strata that is more likely to show back-diffusion.
4. Measure the temperature profile downgradient of the treatment zone. These data are used to assess the extended treatment zone footprint.

5.2.3 Monitoring Well Installation and Development

Eight new monitoring points (TISR-1S, TISR-1D, TISR-2S, TISR-2D, TISR-3S, TISR-3D, TISR-4S, and TISR-4D) were installed within the target treatment zone. These points were installed to evaluate CVOC, geochemical and microbial community conditions and changes. The monitoring points were cleared to 5 feet bgs using hand tools prior to drilling. Drilling was conducted using an HSA drill rig to advance the borings to approximately 27.5 feet bgs for the shallow wells (TISR-1S through TISR-4S) and to approximately 40 feet bgs for the deep wells (TISR-1D through TISR-4D) for each well installation based on the monitoring well 15-MW-41 screened interval of 19 to 39 feet bgs. Based on a June 7, 2021 RWQCB comment on the Demonstration Plan (Divine et al. 2021b), a 20-foot well screen would be insufficient to account for the stratified CVOC distribution observed at SD015. Therefore, eight wells were installed, with the shallow wells screened from approximately 17.5 to 27.5 feet bgs and the deep wells screened from approximately 30 to 40 feet bgs.

The monitoring point well installations were constructed using 2-inch-diameter, Schedule 40 PVC casing and 0.010-inch slotted PVC screen (17.5 to 27.5 feet bgs and 30 to 40 feet bgs screened intervals). The monitoring wells were completed with an above-grade wellhead and developed using standard surge/bail/pump methods approximately 24 hours after installation of the grout seal.

Well development was performed on December 7, 8, and 9, 2021. The wells were surged manually due to technical considerations that prevented the use of a skid steer and hydraulic winch. The well development responses for each TISR well are detailed below:

- *TISR-1S.* Approximately 50 gallons were pumped in total at 1 gallon per minute (gpm). The well was finished with a 2.33-foot stickup monument. Depth to water was 23.62 feet bgs and total depth was 30.13 feet bgs.
- *TISR-1D.* Approximately 70 gallons were pumped in total at a rate of 0.5 to 0.75 gpm. The well was finished with a 2.3-foot stickup monument. Depth to water was 22.97 feet bgs and total depth was 42.67 feet bgs. TISR-1D had the best performance of all deep wells.
- *TISR-2S.* Approximately 56 gallons were pumped at a rate of 0.4 gpm. The well was finished with a 2.4-foot stickup monument. Depth to water was 23.17 feet bgs and total depth was 29.89 feet bgs.
- *TISR-2D.* Approximately 36 gallons were pumped at 0.25 gpm. The well was finished with a 2.08-foot stickup monument. Depth to water was 24.40 feet bgs and total depth was 42.90 feet bgs.
- *TISR-3S.* Approximately 33 gallons were pumped at 0.75 gpm. The well was finished with a 2.6-foot stickup monument. Depth to water was 23.35 feet bgs and total depth was 30.20 feet bgs.
- *TISR-3D.* Well development started on December 7, 2021. After pumping for 1 hour, turbidity remained greater than 1,000 nephelometric turbidity units (NTUs). Pumping was stopped and the well development was re-evaluated. It was decided to finish the development if the well could not recharge pumping at 0.25 gpm. On December 10, the well was bailed one more time and pumped dry for cleaning. After the well recharged, it was pumped at 0.25 gpm; after 2 hours, the water level lowered to below the pump and development was completed. Turbidity readings did not decrease to less than 1,000 NTUs. Approximately 56 gallons were pumped at 0.25 to 0.4 gpm. The well was finished with a 2.25-foot stickup monument. Depth to water was 22.90 feet bgs and total depth was 42.04 feet bgs.
- *TISR-4S.* Approximately 95 gallons were pumped at 1 gpm. The well was finished with a 2.25-foot stickup monument. Depth to water was 22.75 feet bgs and total depth was 30.08 feet bgs.
- *TISR-4D.* Well development was started on December 8, 2021 and completed on December 10, 2021 due to issues with the water quality meter. On December 10, 2021, the well recharged after previous pumping attempts and pumped at 0.25 gpm for more than 1.5 hours until turbidity readings were less than 170 NTUs. In total, approximately 46 gallons were pumped at 0.25 gpm. The well was finished with a 2.25-foot stickup monument. Depth to water was 22.87 feet bgs and total depth was 42.42 feet bgs.

Detailed boring logs, well construction and development information are provided in **Appendix C**.

5.2.4 Soil Vapor Probe Installation

Soil vapor probes SVP-1 and SVP-2 were advanced to 20 feet bgs using an 8-inch HSA drill rig. These probes consisted of dual-nested vapor sampling probes, with the centers set at 4.5 and 17.5 feet bgs. Each soil vapor probe was completed with a 2- by 2-foot concrete pad and a well monument.

5.2.5 Thermal In Situ Sustainable Remediation Process Components

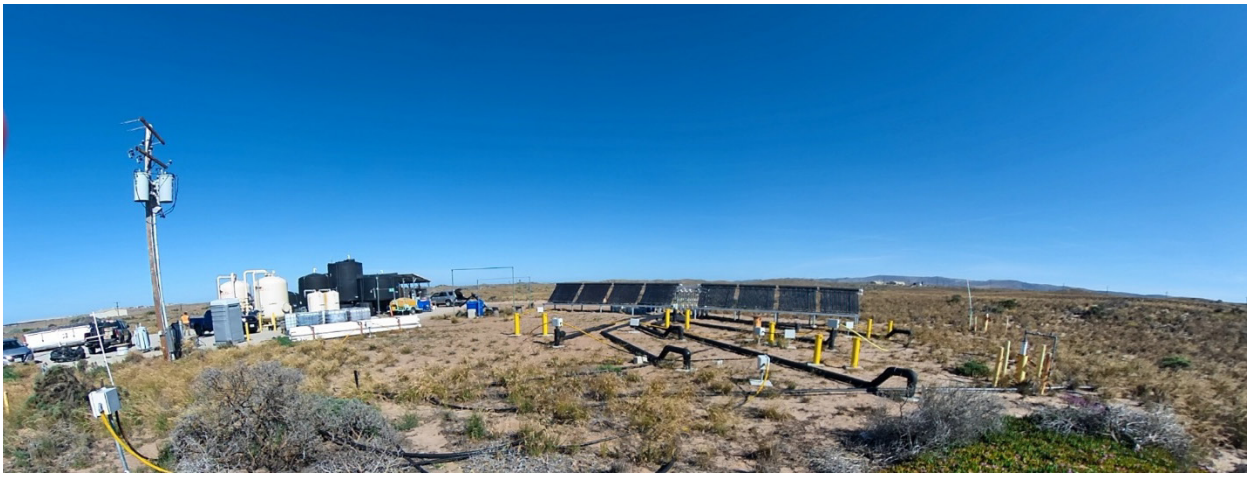
In addition to the wellfield infrastructure discussed above, installation of the TISR remedy included the deployment of solar collectors, a heat pump skid, conveyance piping, circulation pump components, operational sensors, and control wiring. The process flow diagram and piping and instrumentation diagrams is provided in **Appendix B**, Drawing P-1 and Drawing P-2, respectively. The TISR system equipment layout in displayed in Drawing G-4 (**Appendix B**).

The above-grade system equipment included:

- Eight solar collectors, arranged into two parallel groups of four collectors. These were mounted on a frame anchored into the ground.
- A heat pump skid introduced during the final 6 months of system operations for supplemental heating of the solar collectors. This skid comprised a 60,000 British thermal unit air-to-liquid heat pump unit, a 13-gallon buffer tank, a dedicated heating fluid circulation pump, and influent/effluent temperature and flow sensors.
- A pumping station housing the recirculation pump, complete with influent/effluent temperature and flow sensors, safety relief valves, expansion tanks, and containment tanks.
- Above-grade conveyance piping and manifolds, approximately 2,000 linear feet of 0.75-inch insulated stainless steel corrugated pipe within a high-density polyethylene conduit.
- Electrical connections and trenching to the existing DGR power drop.

Each solar collector comprises 30 evacuated tubes **(Figure 5.8),** oriented southward, to maximize solar insolation. The array was mounted atop a steel A-frame supported by concrete base anchors below grade. The heat pump skid was installed inline on the effluent side of the solar collector array to ensure the desired target temperature was achieved and distributed to the BHE network.

(a)



(b)



Figure 5.8. Setup of TISR System Equipment

(a) Front view of system
(b) Side view of system

The expansion tank was designed to accommodate thermal expansion and contraction of the fluid volume within the solar collector system. The containment tank was directly connected to the pressure-relief valve to capture any released circulation fluid. Both tanks were installed following the manufacturer's recommendations for the solar collectors.

Following BHE installations, the BHEs were connected to the treatment equipment via above-grade insulated tubing and conduit. Conveyance piping circulating the propylene glycol and distilled water heat transfer fluid consisted of insulated ¾-inch-diameter, flexible stainless-steel corrugated piping, which is further protected and aesthetically enhanced by a larger conduit. The eight BHEs were connected to the eight solar collector arrays in a parallel flow configuration to ensure consistent fluid temperatures across each BHE. Details regarding the manifold and above-grade conveyance are provided in Drawing G-5 and Drawing G-7 of **Appendix B**.

5.3 THERMAL IN SITU SUSTAINABLE REMEDIATION SYSTEM STARTUP, OPERATIONS, MAINTENANCE

Following completion of system installation, the conveyance piping was filled with food-grade propylene glycol and distilled water (50 percent solution) for use as the heat transfer solution. Propylene glycol is food grade and has a half-life of a few hours on the surface (in light) and a few days in groundwater. It was not an environmental concern given the small volume (40 gallons) used in the circulation loop. By design, any joints or connection in the loop were placed above ground or in the vaults for visible inspection. All pumping components, valving, and associated closed-loop conveyance piping were pressure tested prior to system startup. Circulation pressures were closely observed after system install and shakedown. A pressure-relief valve installed at the pump station is connected to a spill containment. If it is suspected that system fluid is being lost through a leak, BHEs can be individually pressure tested to confirm. A BHE replacement, while unlikely, can be completed if a malfunctioning BHE is confirmed after system startup. Similarly, the trenched supply lines can be segregated and pressure tested to confirm integrity and replaced if needed.

The post-startup monitoring and the routine operation, maintenance, and monitoring (OMM) were completed to track system performance parameters during operation of the TISR system. Following initial system startup, the system was inspected twice per week for first 2 weeks, followed by weekly monitoring for 4 weeks, and then twice a month for the first quarter. Subsequent monitoring was decreased based on remote data collection and observed maintenance needs. Datalogger readings were also collected from the solar collector influent/effluent temperature sensors to assess heat input to the BHEs throughout the day. The monitoring and inspection frequencies were modified based on field observations. Realtime system adjustments (e.g., circulation flow rates, circulation fluid refill, pump operation, datalogger, telemetry) were evaluated, and field OMM events were completed as needed.

Based on experience with TISR systems at other sites, subsurface temperatures (due to available heat sinks in the subsurface) were anticipated to increase gradually. Therefore, unlike traditional high-temperature thermal remedies, TISR progress was monitored in a controlled and adaptive way. BHEs were turned on or off to incoming heated fluid to manipulate subsurface temperature gradients. Circulation pump flow rates and numbers of active solar collectors are other parameters that were modified to optimize heat flow within the system.

A log of issues and troubleshooting steps for TISR operation was maintained as part of routine OMM. Fluid replacement is typically needed as temperature increases and the dissolved air is released from the circulation fluid. On average, circulation fluid is replaced twice per year. Any abnormal loss of circulation fluid can be detected at the BHEs where most of the plumbing connection was placed. These connections in the circulation tubing were available for visible inspection at any given time.

5.4 BASELINE AND PERFORMANCE MONITORING DATA COLLECTION

The site is currently undergoing active EISB and has a robust remediation and monitoring well network installed. No significant site-specific data gaps surrounding the TISR treatment area were identified. However, pre-construction baseline data collection was conducted prior to system installation in summer 2021. Specifically, site lithology, baseline geochemistry, baseline microbial community composition, and baseline temperature assessment were conducted (discussed below).

Lithologic assessments were performed during installation of the eight BHEs and the eight new monitoring points (TISR-1S, TISR-1D, TISR-2S, TISR-2D, TISR-3S, TISR-3D, TISR-4S, and TISR-4D) discussed in Section 5.2.3. New proposed monitoring points were installed within and outside of the TISR treatment area and were constructed similar to the existing monitoring wells at the site.

The dominant treatment mechanisms were confirmed using multiple lines of evidence including, but not limited to, high-resolution temperature data, COC trends, biogeochemical analysis, stable isotopic analysis, and laboratory measurement of degradation rates. Specifically, COC trends (i.e., CVOC concentration data) were evaluated at all groundwater monitoring wells located within the treatment zone. In addition to CVOC data, groundwater samples were analyzed for light dissolved gases (i.e., ethene, ethane) to confirm production of nontoxic end products. Groundwater samples were collected bimonthly for the first year of operations, quarterly for the second year of treatment, and semiannually for the remainder of treatment. Biogeochemical evaluation via analysis of geochemical indicator parameters were collected quarterly for the first year and semiannually for the remainder of treatment. Likewise, 16S rDNA profiling of the microbial community and stable isotopic analysis were performed for groundwater samples collected at various steps of increase in subsurface temperatures at monitoring wells 15-MW-41, 15-MW-08, TISR-1S/1D through TISR-4S/4D.

5.4.1 Temperature Monitoring

Historical temperature data since 2010 suggest that the average background groundwater temperature in at the site is approximately 17°C, with a maximum temperature of 22.4°C in third quarter 2019. The DTS network was installed 2 weeks prior to activating the TISR system to establish baseline temperature profiles and determine the depth of surface heating across the treatment zone. During this pre-treatment period, temperatures were collected at 30-minute intervals. During the initiation of the treatment system, temperatures were collected every 30 minutes for the first week and then at 60-minute intervals thereafter. The DTS system was meant to continuously run for the first 90 days; however, monitoring was initiated in December 2021 and temperature was collected until February 2022 when a power outage shut down the DTS logger and remote monitoring. DTS temperature monitoring was restored on May 10, 2022, prior to system startup. On May 13, 2022, temperature sensors/loggers were installed in TISR-1S/1D, TISR-4S/4D, and 15-MW-8 for background and additional temperature monitoring in the wellfield.

Two previously existing monitoring wells (15-MW-41 and 15-MW-08) were equipped with automated temperature loggers at three equal intervals consistent with the screened intervals of these locations, approximately 20 to 40 feet bgs. Measured temperature from the automated loggers was used to compare and validate temperatures recorded by the DTS system.

5.4.2 Soil Vapor Monitoring

Henry's Law constant values for site VOCs approximately double between 8 and 24°C (Chen et al. 2012b). While temperature-driven increases in Henry's Law constant values would be expected to increase recovery from an AS/SVE system, a significant increase in soil gas VOC concentrations is not expected at this site because there is no AS system at the site. Therefore, the volatilization mass transfer rate was expected to be very low. To confirm this, two soil vapor locations were constructed to quantify the effect of heating on soil gases.

Each soil vapor location was constructed as a nested unit with two vapor sampling points within; one vapor point at each location extended into the heated zone (approximately 2 feet above the depth to water, at 17.5 feet bgs) and one was shallow (approximately 15 feet above the depth to water, at 4.5 feet bgs). Probes at both depths have a 2-foot screen length. The locations of the soil vapor points are shown on **Figure 5.1**. The soil vapor points are monitored semiannually for VOCs, carbon dioxide, and methane.

Table 5.1. Recommended Data Collection Activities

Data Type	Project Phase	Priority and Purpose	Specific Analyses/Techniques
Soil Sampling	Pre-design	Optional; characterizes subsurface conditions and identify contaminant distribution	Collect if data gaps in CSM; analyze for COCs, soil type logging, moisture content
Temperature Monitoring	Performance monitoring	Required; used to assess and predict system performance and identify need for modifications.	Collect using TidBits or similar monitoring unit.
Groundwater Monitoring	Pre-design (baseline), performance monitoring	Required; assess groundwater conditions and inform remedial mechanisms	Analyze for site COCs, pH, Temperature, DO, oxidation reduction potential (ORP), Conductivity, Nitrate (NO_3), Total Iron (FE) and Manganese (Mn), Sulfate (SO_4^{-2}), Methane (CH_4), Ethene (C_2H_4), Ethane (C_2H_6), TOC
Microbial Assessments	Pre-design (baseline), performance monitoring	Optional; understand biological processes contributing to contaminant degradation	QuantArray-Chloro, QuantArray-Petro, Next-generation Sequencing (NGS)
CSIA	Pre-design (baseline), performance monitoring	Optional; provides direct evidence of contaminant degradation	Analyze $^{13}C/^{12}C$ ratio for CVOCs
Reactive Iron Formation	Pre-design (baseline), performance monitoring	Optional; measures reactive iron minerals be treated with TISR	Min-Trap™ sampling of total iron, aqueous and mineral intrinsic bioremediation assessment (AMIBA), and SEM-EDS analyses.
Soil Vapor Monitoring	Pre-design (baseline)	Optional; assess Soil Vapor at Baseline	Analyze for volatile organic compounds (VOCs), carbon dioxide (CO_2) and methane (CH_4)
Push-Pull Tracer Testing	Pre-design (baseline), performance monitoring	Optional; measures groundwater flux and carbon consumption rates as a general proxy for microbiological activity	Uses fermentable carbon (sodium lactate) and conservative tracer (bromide)
Topographic Surveys & GPR	Pre-design	Required; identify presence and location of buried utilities	Conduct topographic surveys and use GPR to map subsurface utilities

Baseline soil vapor sampling was performed in January 2022 at locations SVP-1S, SVP-1D, SVP-2S, and SVP-2D. Following TISR system startup, soil vapor sampling for performance monitoring at the same four locations was conducted in September 2022, April 2023, October/November 2023, June/July 2024, and January 2025. Soil vapor samples were analyzed for CVOCs and fixed gases (methane and carbon dioxide).

5.4.3 Groundwater Sampling

Baseline groundwater sampling was conducted in October 2021 (for existing wells 15-15-MW-8 and 15-MW-41) and January 2022 (for new wells TISR-1S/1D through TISR 4S/4D). Baseline groundwater sampling included analysis of COC concentrations (i.e., CVOCs), geochemical indicator parameters (i.e., total and dissolved manganese and iron, nitrate, sulfate, chloride, total sulfides, dissolved gasses [ethene, ethane, and methane], TOC, and alkalinity), microbial community assessment, CSIA, and reactive iron formation. In addition, field parameters such as pH, conductivity, dissolved oxygen, and oxidation-reduction potential were measured during the baseline groundwater sampling event.

Following TISR system startup in May 2022, groundwater sampling events to monitor TISR performance were conducted in September 2022; January, March/April, July/August, and November 2023; July 2024; and January 2025. CVOC concentrations were assessed during every performance monitoring event at wells 15-MW-08, 15-MW-41, and TISR-1S/1D through TISR-4S/4D. Geochemical indicator parameter concentrations were assessed during all but one of the performance monitoring events. In addition, field parameters such as pH, conductivity, dissolved oxygen, and oxidation-reduction potential were measured during each performance monitoring event.

5.4.4 Microbial Community Assessment

Groundwater samples collected during the baseline sampling event at monitoring wells 15-MW-08, 15-MW-41, TISR-2S, and TISR-2D were subjected to microbial community assessment. Notably well 15-MW-08 is located outside of the TISR treatment area, while wells 15-MW-41, TISR-2S, and TISR-2D are located within the target TISR treatment area. The baseline microbial community assessment entailed 16S rDNA profiling using next-generation DNA sequencing technologies and quantification of gene targets associated with reductive dechlorination using quantitative polymerase chain reaction (qPCR) quantification. Next-generation DNA sequencing is a high-throughput, DNA-based technique that allows for the comprehensive identification of microorganisms present in an environmental sample down to the genus level; therefore, the resulting data provide an assessment of the background (pre-TISR system operation) microbial community composition. Although function cannot always be predicted from phylogenetic information, next-generation DNA sequencing data also provide insight into the potential microbial processes occurring in situ. In addition to next-generation DNA sequencing, specific gene targets associated with reductive dechlorination were quantified via MI's QuantArray®-Chlor. The QuantArray®-Chlor is a qPCR method that allows for the quantification of key microorganisms (e.g., *Dehalococcoides*, *Dehalobacter*) and functional genes (e.g., TCE reductase, VC reductase) to assess the potential for reductive dechlorination of chlorinated solvents such as TCE in situ. Together, the data resulting from next-generation DNA sequencing and QuantArray®-Chlor are used to identify the makeup of the microbial community down to the genus level and to assess the presence and abundance of key microorganisms and functional genes for the reductive dechlorination of chlorinated solvents.

Characterization of the microbial community within the TISR treatment zone prior to treatment served as a baseline against which to compare microbial community composition and function at different time points as TISR treatment progressed.

Two post-TISR implementation microbial community assessment events were conducted with groundwater collected from monitoring wells 15-MW-08, 15-MW-41, TISR-2S, and TISR-2D during January 2023 and January 2025, when the average subsurface temperature within the TISR treatment area reached 24 and 30°C, respectively. Similar to the baseline event, these assessments entailed 16S rDNA profiling using next-generation DNA sequencing technologies and quantification of specific gene targets associated with reductive dechlorination via MI's QuantArray®-Chlor.

Microbiological data collected within the TISR treatment zone throughout treatment were compared to baseline microbiological data, as well as similar data collected from the monitoring wells located outside of the TISR treatment zone (i.e., 15-MW-08).

5.4.5 Compound-Specific Isotope Analysis

The isotopic fractionation of the primary COCs was also quantified prior to the TISR demonstration via ^{13}C CSIA. ^{13}C CSIA allows for measurement of the ratio of $^{13}C/^{12}C$ of the primary COCs. The ratio of stable isotopes $^{13}C/^{12}C$ changes in a predictable way as a compound is degraded; however, physical processes such as volatilization, sorption, and dilution do not significantly alter isotopic ratios. Therefore, ^{13}C CSIA can provide direct evidence of degradation of the primary COCs within the TISR treatment zone. Quantification of the isotopic fractionation of the primary COCs within the TISR treatment zone prior to treatment provides a baseline against which to compare isotopic fractionation measurements for the primary COCs at different time points as TISR treatment progresses.

Accompanying the microbial community assessment samples collected during the baseline sampling event, as well as in January 2023 and January 2025, additional groundwater samples were collected from monitoring wells 15-MW-08, 15-MW-41, TISR-2S, and TISR-2D to evaluate the isotopic fractionation of the primary COCs (i.e., TCE, cis-1,2-DCE, and VC) via ^{13}C CSIA. As mentioned above, the average groundwater temperature during the baseline sampling event was approximately 18°C; whereas, the average groundwater temperatures within the TISR treatment area in January 2023 and January 2025 were 24 and 30°C, respectively.

^{13}C enrichment data collected within the TISR treatment zone throughout treatment were compared to baseline data, as well as similar data collected from the monitoring wells located outside of the TISR treatment zone (i.e., 15-MW-08).

5.4.6 Reactive Iron Mineral Formation

Several reactive iron mineral species are important in the abiotic degradation of CVOCs (e.g. Horst est al., 2019). Through ESTCP project ER19-5190, a passive reactive mineral sampler (the Min-Trap™), was developed and validated for documenting the formation of these minerals within conventional monitoring wells. One baseline Min-Trap™ sampling event was conducted inside the TISR treatment area at monitoring well 15-MW-41, as well as from outside the treatment area at monitoring well 15-MW-08. Min-Trap™ samplers were deployed at the two monitoring locations approximately 2 months prior to TISR implementation, and baseline Min-Trap™ sampling included total iron, AMIBA, and SEM-EDS analyses. These analyses allowed for an assessment of reactive iron minerals residing within the area to be treated with TISR. Evaluation of reactive iron minerals within the TISR treatment zone prior to treatment served as a baseline against which to compare the formation of these minerals after TISR implementation.

One post-TISR implementation Min-Trap™ sampling event was conducted in December 2024, toward the end of TISR treatment, at the three monitoring wells where Min-Trap™ samplers were deployed prior to the baseline sampling event (i.e., 15-MW-41 and 15-MW-08). As during the baseline sampling event, Min-Trap™ sampling included total iron, AMIBA, and SEM-EDS analyses. The results from Min-Trap™ sampling within the TISR treatment zone toward the end of TISR treatment were compared to baseline Min-Trap™ results, as well as similar data collected from the monitoring wells located outside of the TISR treatment zone.

5.4.7 Push-Pull Testing

Point-dilution and push-pull (e.g., Istok 2013; **Figure 5.9**) tracer tests were conducted in April 2022 before TISR startup and in January 2023 to measure groundwater flux and the change in organic carbon consumption rates as a general proxy for microbiological activity. This information supports the overall quantification of the increase. Single-well tracer tests involved injection of a small volume of distilled water in a well and monitoring its washout through time (using specific conductivity as a proxy), which was analyzed to determine local groundwater flux. The push-pull tests involved the injection of a known solution of fermentable carbon (sodium lactate) and conservative tracer (bromide) into both shallow and deep locations TISR-1S, TISR-1D, TISR-4S, and TISR-4D. Most of this injected solution was then pumped back out of the aquifer after 2 to 4 days and the relative recovery of organic carbon to bromide was used to quantify carbon consumption rate. Approximately 500-gallon solutions containing approximately 100 mg/L of both dissolved organic carbon and bromide were injected for each test at each location. The source of the water was groundwater, which was treated with granular activated carbon to remove VOCs.

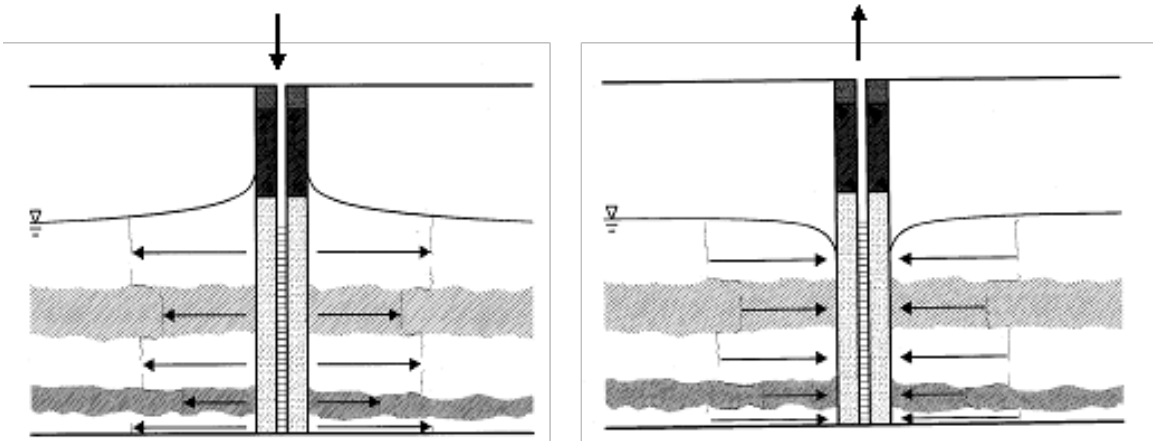


Figure 5.9. Push-Pull Experimental Diagram from Istok (2013)

5.4.8 Injection Event

An injection event was performed in April 2024 to supplement available carbon and iron in the subsurface. Approximately 56,200 gallons of a 2% molasses by volume and 64.08 mg/L of iron injected using an aqueous ferrous sulphate mixture was injected across wells TISR-1D, TISR-3D, and TISR-4D, with a focus on upgradient wells (TISR-1D, TISR-3D). TISR-1D, TISR-3D, and TISR-4D received approximate volumes of 23,500 gal, 27,400 gal, and 5,300 gal respectively.

Subsequent sampling events (3Q 2024 and 1Q 2025) show that this injection event successfully supplemented carbon and iron available for reductive dechlorination via biological and biotic processes.

5.5 RESULTS

5.5.1 Temperature and Monitoring Results

5.5.1.1 Distributed Temperature Sensing Temperature Data

This section presents the high-resolution temperature data collected using the DTS system, displayed through an Earth Volumetric Studio (EVS) model. EVS is a powerful software tool used for visualizing and analyzing subsurface data in three dimensions. It allows for the integration of various data types to create detailed and accurate models of the subsurface environment.

EVS performs parameter estimation (in this case, temperature) using expert system-driven two-dimensional and 3D kriging algorithms with best-fit variograms. Kriging is a geostatistical interpolation technique that provides the best linear unbiased prediction of intermediate values. The best-fit variograms are used to model the spatial correlation of the temperature data, ensuring accurate and reliable estimations. The kriging method minimizes the estimated variance of a predicted point (node) by using a weighted moving average of its neighbors. The weighting factors and the variance are calculated using a semi-variogram model that describes the differences versus distance for pairs of samples in the input dataset.

Additionally, EVS supports four-dimensional data visualizations, which include the dimension of time, allowing for high-level animation support. This capability enables the visualization of changes in temperature through time, providing a dynamic and comprehensive understanding of subsurface thermal conditions. The interactive 3D fence diagrams (cross sections) shown below are a key feature of EVS, allowing for detailed and interactive exploration of the temperature data across different points in the treatment zone.

The subsequent figures illustrate the temperature monitoring results obtained through the EVS model. These cross-sections provide a detailed visualization of temperature data collected from specific points: DTS-1, DTS-2 (BHE-1), DTS-7, DTS-5, and DTS-4 (BHE-5). Historical records since 2010 indicate that the average background groundwater temperature at the site is approximately 17°C, with a maximum of 22.4°C noted in the third quarter of 2019.

Temperatures displayed in **Figure 5.10** presents the background conditions at these designated locations before the installation of the TISR system. To establish these baseline temperature profiles, the DTS network was installed two weeks prior to the activation of the TISR system on May 13, 2022. The figure provides a crucial comparison point for subsequent temperature data, demonstrating that the maximum temperatures recorded at DTS-1 (downgradient), DTS-2 (BHE-1), DTS-7, DTS-5, and DTS-4 (BHE-5) were all approximately 18 - 19°C.

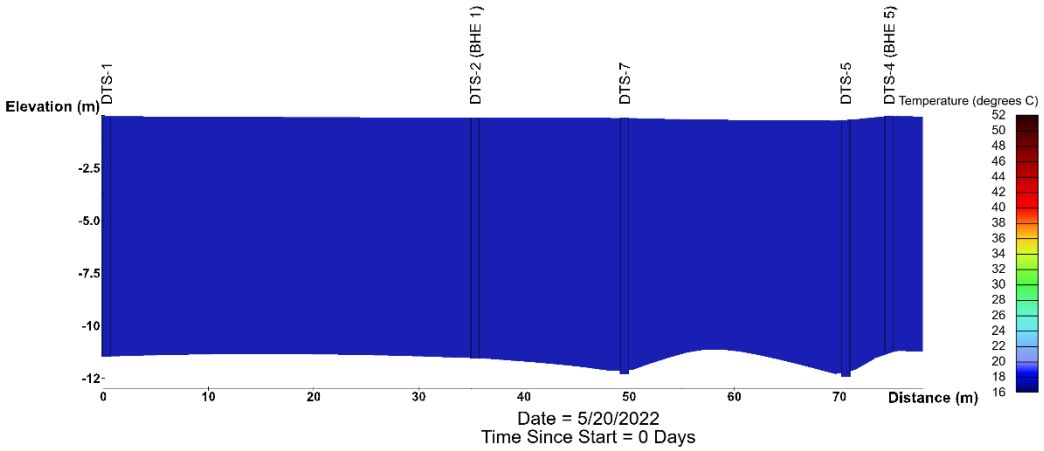


Figure 5.10. Background Temperature Prior to TISR System Installation

After 180 days of startup, the temperature cross section data from November 16, 2022, indicate significant heating of the subsurface. Temperatures were collected at 60-minute intervals from all DTS locations presented. As shown in **Figure 5.11**, the data demonstrate that temperatures have been raised above ambient groundwater levels, showcasing the effectiveness of the TISR system. The maximum temperatures recorded at DTS-1, DTS-2 (BHE-1), DTS-7, DTS-5, and DTS-4 (BHE-5) during this period were 20°C, 34 °C, 24 °C, 22 °C, and 25 °C, respectively.

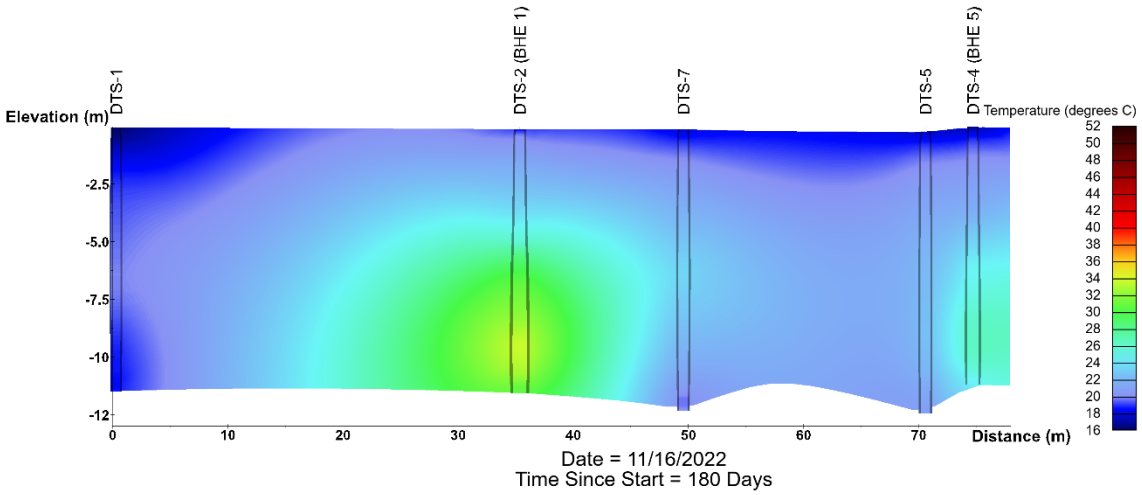


Figure 5.11. Temperature Cross Section 180 Days Since Startup (11/16/2022)

The temperature cross section from March 10, 2023, following a rainy and cold winter, reveals surface water infiltration cooling the top approximately 19.7 feet (6 meters) of the subsurface back to less than the starting ambient groundwater temperatures. This period's data highlights the impact of seasonal variations and weather conditions on subsurface temperatures, as illustrated in **Figure 5.12**. The maximum temperatures recorded at DTS-1, DTS-2 (BHE-1), DTS-7, DTS-5, and DTS-4 (BHE-5) during this time were 21°C, 30 °C, 23 °C, 26 °C, and 31 °C respectively.

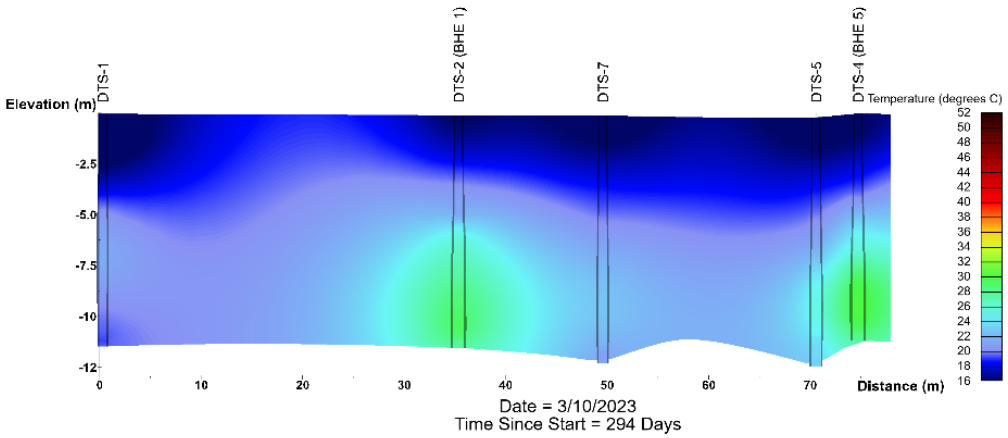


Figure 5.12. Temperature Cross Section Showing Heat Loss Due to Surface Water Infiltration (03/10/2023)

Following a summer of consistent solar irradiation and sustained subsurface heating, the temperature cross section observed on November 10, 2023, showcased significant thermal elevation. Temperatures at the BHEs peaked above 50°C, while other areas ranged from 20°C to 35°C. Specifically, maximum temperatures observed at DTS-5 and DTS-7 were 27°C and 24°C respectively. These points, situated approximately 5 and 7 feet from the nearest BHE, indicate the radius of heating influence.

The solar-based system shows the capability to achieve and maintain subsurface temperatures necessary for remediation when consistent solar irradiation is available. The spatial distribution of heat around the BHEs indicates the system's ability to provide a significant radius, enhancing the treatment zone's effectiveness.

Continuous heating during the summer demonstrates the system's ability to meet thermal conditions. This ongoing temperature increase aids in the degradation of contaminants and speeds up the remediation process. Temperature profiles, as shown in **Figure 5.13**, offer useful data for optimizing the TISR system's operational parameters, ensuring performance objectives are met and the subsurface environment is treated.

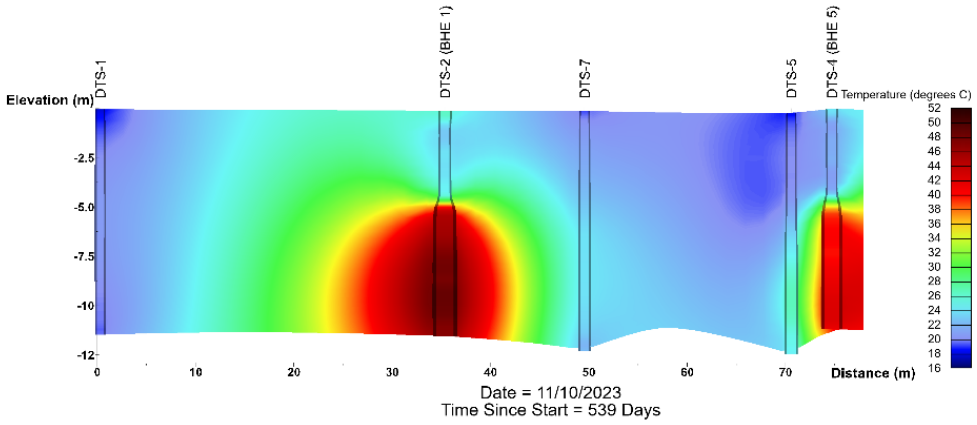


Figure 5.13. Temperature Cross Section After Sustained Heating during the Summer (11/10/2023)

5.5.1.2 TidbiT Temperature Data

HOBO TidbiT temperature sensors were strategically placed in select monitoring wells since the start of the TISR system to validate the temperatures observed from the DTS system. The TISR system was initiated on May 13, 2022, and TidbiT data were collected periodically during operations. Figure 5.14, below, shows the temperature data from 15-MW-8 (background), 15-MW-41, TISR-3S, TISR-3D, TISR-2S, and TISR-4D from July 2023 to January 2025. Notably, the DTS system was taken offline in November 2023.

In September 2024, a heat pump was introduced to provide an additional heating source to the solar system. This heat pump maintained a set temperature of 120 degrees Fahrenheit (°F; approximately 49°C) to the BHEs, regardless of solar irradiation. This addition allowed for continuous runtime and heat input through the night, ensuring that heating was not solely dependent on daytime solar energy. The robust heat input from the heat pump resulted in a significant increase in temperatures at the monitoring locations, with an approximate rise of 4°C in 3 months. Notably, the maximum temperature observed at 15-MW-41 was 29.5°C on January 27, 2025, which equates to approximately 11°C greater than the ambient groundwater temperature. This rate of heat increase was more than the standalone solar setup, which provided a 4 to 5°C increase throughout a year.

It is important to note that most TidbiT monitoring points were located at the centroid of the BHE radius of influence. This positioning means that the temperatures displayed would be considered the coldest areas of the heating zone, because heat would be transferring conductively away from the BHEs and higher temperatures would be observed nearer to the BHEs.

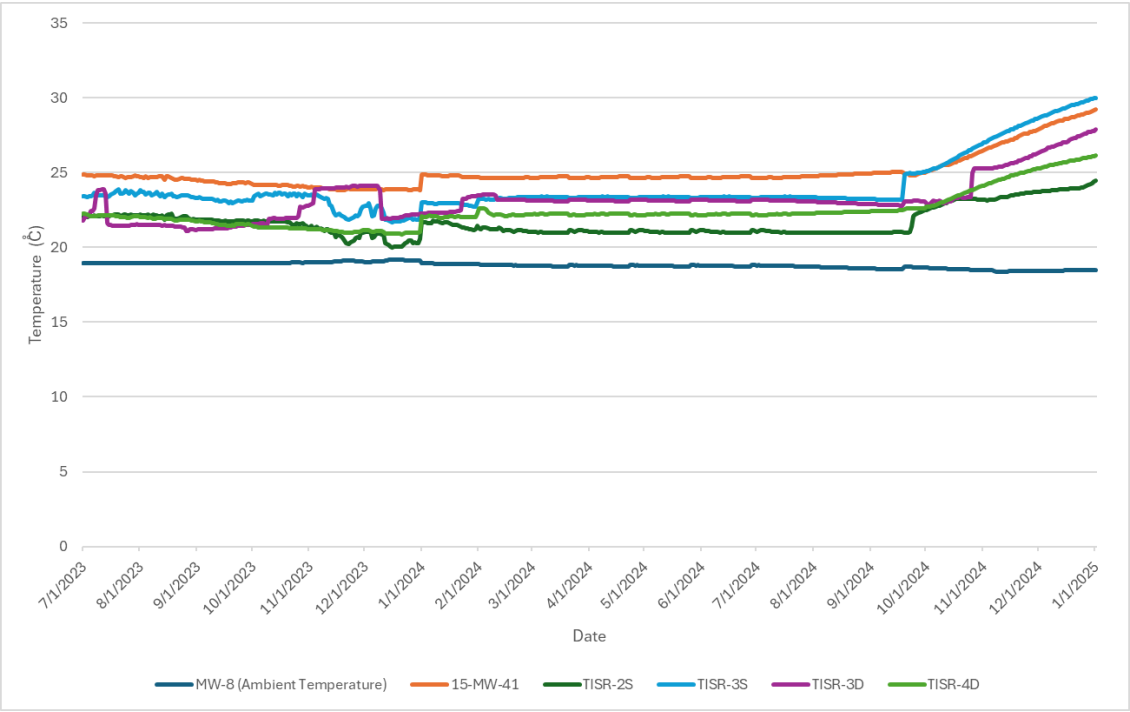


Figure 5.14. Point Source Temperature Data Collected with HOBO TidbiT Sensors from 15-MW-8, 15-MW-41, TISR-3S, TISR-3D, TISR-2S, and TISR-4D from July 2023 to January 2025

Temperatures shown in **Figure 5.13** illustrate the TISR system's effectiveness in distributing heat through the subsurface and heat pump's impact. The addition of the heat pump provides a more constant heat input, offering heating during the night and compensating for seasonal changes that affect solar radiation. This supplementary heating helps negate the large swings in temperature increases and decreases commonly observed with solar-only based TISR systems. The data shows that consistent heat input maintains higher subsurface temperatures and allows the system to adapt to seasonal changes and improve thermal conditions with extra heating, as illustrated in **Figure 5.14**.

5.5.2 Groundwater Analytical Results

Baseline groundwater sampling was conducted between October 2021 and January 2022, prior to TISR system startup (in May 2022), and groundwater sampling events to monitor TISR performance were conducted in September 2022; January, March/April, July/August, and November 2023; July 2024; and January 2025. Groundwater samples collected from 15-15-MW-8, 15-MW-41, TISR-1S, TISR-1D, TISR-2S, TISR-2D, TISR-3S, TISR-3D, TISR-4S, and TISR-4D were analyzed for CVOC concentrations and geochemical indicator parameters (i.e., total and dissolved manganese and iron, nitrate, sulfate, chloride, total sulfides, dissolved gasses [ethene, ethane, and methane], TOC, and alkalinity), in addition to field parameters (i.e., pH, conductivity, dissolved oxygen, and oxidation-reduction potential). The data resulting from the TISR performance monitoring events were compared to the data resulting from the baseline groundwater sampling event.

In general, groundwater samples collected from the TISR monitoring locations screened within the shallow portion of the aquifer (i.e., TISR-1S, TISR-2S, TISR-3S, and TISR-4S) exhibited decreasing CVOC concentrations throughout TISR operation (**Appendix A**). The data resulting from the final TISR performance monitoring event (i.e., January 2025) confirmed insignificant concentrations of CVOCs within the shallow portion of the aquifer. For example, monitoring well TISR-3S exhibited a significant decrease in TCE and cis-1,2-DCE concentrations between September 2022 (shortly after TISR system startup) and March 2023 (after almost 1 year of TISR operation); from 1,100 µg/L of each TCE and cis-1,2-DCE, to 0.28 µg/L TCE and 0.63 µg/L cis-1,2-DCE. TCE and cis-1,2-DCE concentrations in well TISR-3S remained minimal as TISR operation continued, between March 2023 and January 2025, when groundwater sampling and analysis yielded 0.36 µg/L TCE and 1.90 µg/L cis-1,2-DCE. Following the TISR system startup, VC concentrations in well TISR-3S increased from 40 µg/L in September 2022 to 260 µg/L in January 2023, while TCE and cis-1,2-DCE concentrations decreased. By January 2025, the VC concentrations had decreased to 2.10 µg/L at TISR. This trend is consistent with the expected behavior of VC as an intermediate product of CVOC biodegradation, aligning with observations at many successful EISB sites.

Significant CVOC concentration decreases were observed in wells TISR-1S and TISR-4S due to TISR operations. Data from the four shallow TISR monitoring locations, showing ethene and ethane detections, suggests ongoing reductive dechlorination. Additionally, with elevated subsurface temperatures, the additional carbon substrate injection event in April-May 2024 and geochemical data from 2025 (including dissolved methane and elevated TOC levels) create and indicate conducive subsurface conditions for continued CVOC degradation within the treatment footprint.

In the deep portion of the aquifer (15-MW-41, TISR-1D, TISR-2D, TISR-3D, and TISR-4D), significant (between 2 and 4 orders of magnitude) decreases in CVOC concentrations were observed at TISR-1D, TISR-2D, TISR-3D, and TISR-4D between the TISR system startup and January 2025 monitoring events. For example, TCE and cis-1,2-DCE concentrations in monitoring

well TISR-4D decreased from 11,000 and 3,900 µg/L, respectively, in September 2022 to 4.9 and 26 µg/L, respectively, in March 2023. TCE and cis-1,2-DCE concentrations in well TISR-4D still remained low, at non-detect (<1 µg/L) and 10 µg/L, respectively, in January 2025. Over the demonstration period, total CVOC concentrations decreased by an average of 83.4% and 92.5% in the deep and shallow zones, respectively.

The chlorine number for a well represents the average number of chlorine atoms for the total molar concentration of ethenes (e.g., PCE = 4, ethene = 0), and therefore can be used to assess changes in the relative concentration of CVOCs over time as a result of EISB. The chlorine number for TISR-4D decreased from 2.42 in September 2022, indicating higher TCE and cis-1,2-DCE molar fractions, to 0.35 in January 2025, indicating the predominance of ethene/ethane. Importantly, carbon substrate and iron were delivered into wells TISR-1D and TISR-3D between April and May 2024; therefore, the significantly decreased CVOC concentrations observed at these locations during the June/July 2024 and January 2025 TISR performance monitoring events can be attributed to reducing conditions enhanced by the increased TOC and iron concentrations detected at these locations since the carbon substrate injection was performed. Location 15-MW-41, which is within the highest observed temperature increase in the TISR system radius of influence, also exhibited decreases in TCE, DCE, and VC concentrations throughout TISR operation.

Comprehensive groundwater monitoring data tables are provided in **Appendix A.**

5.5.3 Soil Vapor Analytical Results

As mentioned in Section 5.4.2, soil vapor sampling was performed at sampling points SVP-1S, SVP-1D, SVP-2S, and SVP-2D during the baseline sampling event (January 2022), as well as during the TISR performance monitoring events (September 2022, April 2023, October/November 2023, June/July 2024, and January 2025). Soil vapor samples were analysed for CVOCs and fixed gases (methane and carbon dioxide) to evaluate whether volatilization became a significant mass transfer process as a result of TISR operation and subsurface heating. The soil vapor data resulting from the TISR performance monitoring events were compared against the data resulting from the baseline soil vapor sampling event **(Appendix A**).

The resulting soil vapor data show insignificant concentrations of CVOCs in soil vapor at all four sampling locations during January 2022 (baseline), April 2023, June/July 2024, and January 2025. During the October/November 2023 sampling event, PCE concentrations in soil vapor yielded a significant spike at locations SVP-1S and SVP-2S, with 460 and 5,700 µg/m^3, respectively. Notably, methane remained undetected in soil vapor samples collected during the October/ November 2023 sampling event. Since concentrations returned to baseline during the next soil vapor sampling event, in June/July 2024, and given the undetectable methane, the spike in PCE concentrations during the October/November 2023 sampling event is thought to be related to significant rain events that occurred at the Site during the same timeframe. Uncharacteristically heavy rainfall can result in an uncharacteristically high water table, which, in turn, can introduce CVOC mass from impacted groundwater into shallower/typically vadose zone areas, leading to spikes in CVOC concentrations in soil vapor. The soil vapor dataset suggests that the punctual spike in PCE concentration during October/November 2023 is not the result of enhanced CVOC volatilization due to increased subsurface temperatures during TISR operation.

Comprehensive soil vapor sampling data is provided in **Appendix A**.

5.5.4 Microbial Community Assessment Results

Groundwater samples were collected from wells 15-MW-08, 15-MW-41, TISR-2S, and TISR-2D during baseline sampling (average temperature 18°C), January 2023 (24°C), and January 2025 (30°C) for microbial community assessment.

The microbial community assessment entailed 16S rDNA profiling using next-generation DNA sequencing technologies and quantification of specific gene targets associated with reductive dechlorination via MI's QuantArray®-Chlor. Notably well 15-MW-08 is located outside of the TISR treatment area and remained at an average subsurface temperature of 18°C, and therefore serves as a control. Wells 15-MW-41, TISR-2S, and TISR-2D are located within the target TISR treatment area. Microbial community composition and function data from different time points as TISR treatment progressed were compared against baseline microbial community and function. Similarly, microbial community composition and function data from within the TISR treatment area (i.e., wells 15-MW-41, TISR-2S, and TISR-2D) were compared against microbial community composition and function data from background well 15-MW-08.

The results from next-generation DNA sequencing show significant shifts in diversity and abundance of bacterial groups as a function of temperature increase from 18°C to 30°C (**Figure 5.15**). Specifically, the abundance of bacteria within the Proteobacteria phylum at monitoring well 15-MW-41 increased from 30.5% at baseline (18°C in October 2021) to 66.7% at 30°C in January 2025. Several bacteria within the Proteobacteria phylum, particularly those in the delta and epsilon subgroups, are known for their ability to perform reductive dechlorination. Some of the dechlorinating Proteobacteria are *Dehalococcoides*, *Desulfitobacterium*, *Geobacter*, and *Shewanella*. The abundance of bacteria within the Proteobacteria phylum remained relatively stable, between 25.0% and 30.2%, at background well 15-15-MW-8 throughout TISR system operation. As mentioned above, well 15-MW-08 is outside of the TISR system ROI and remained at a stable, baseline temperature. However, the TOC concentration at this location was comparable to that at well 15-MW-41. These data indicate that the shift in microbial community composition observed at wells located within the TISR treatment area is directly related to the subsurface heating caused by TISR operation.

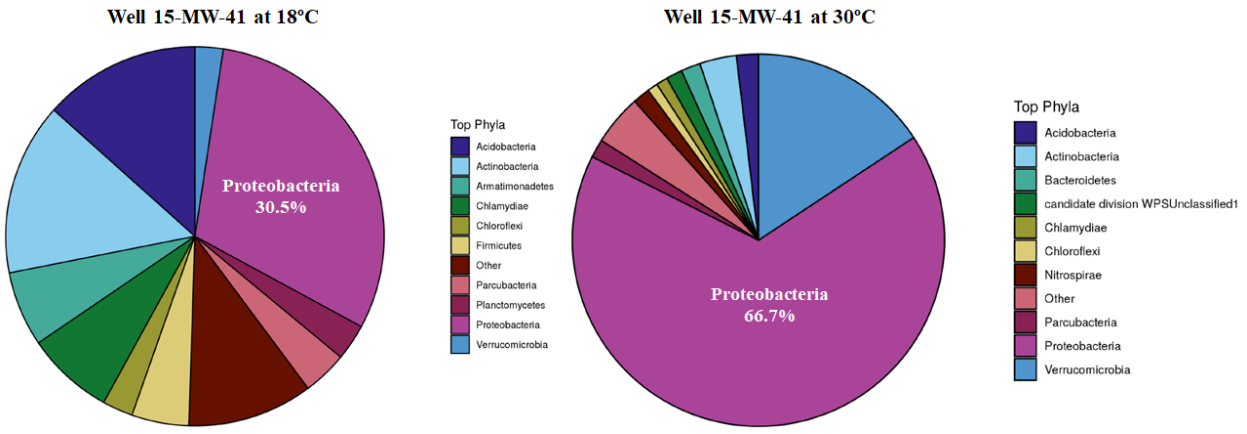
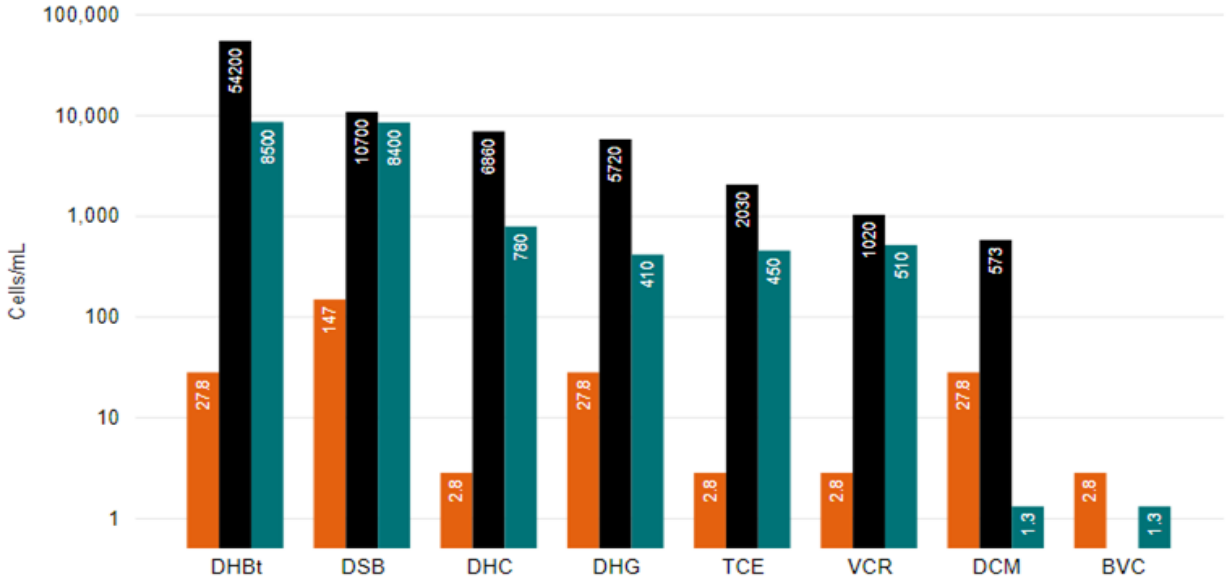


Figure 5.15. Next Generation Sequencing (NGS) Data Collected at 15-MW-41 During the Baseline (2021) and January 2025 Groundwater Sampling Events

Further, the results from the QuantArray-Chlor assays show increases in the abundance of key microorganisms (e.g., *Dehalococcoides*) and functional genes (e.g., tceA and vcrA) for the reductive dechlorination of chlorinated solvents. For example, *Dehalococcoides* abundance at well 15-MW-41 increased from below laboratory detection (2.8 cells per milliliter [cell/mL]) at baseline (18°C in October 2021) to 780 cells per mL at 30°C in January 2025. Similarly, the abundance of tceA and vcrA functional gene markers increased from below laboratory detection (both 2.8 cells/mL) to 450 and 510 cells/mL, respectively, at 30°C in January 2025 (**Figure 5.16**). Albeit the increases in *Dehalococcoides*, tceA, and vcrA abundance at well 15-MW-41 (within the TISR treatment area) were not considered significant (i.e., below 10^6 cells/mL), these data still indicate an increase in the abundance of key dichlorination bacteria and functional genes as a direct result of the subsurface heating caused by TISR operation. The abundance of *Dehalococcoides*, tceA, and vcrA at control well 15-MW-08 actually decreased between October 2021 and January 2025.



DHBt = *Dehalobacter* spp., DSB = *Desulfitobacterium* spp., DHC = *Dehalococcoides* spp., DGH = *Dehalogenimonas* spp., TCE = tceA Reductase, VCR = vcrA (Vinyl Chloride) Reductase, DCM = *Dehalobacter* DCM, BVC = BAV1 Vinyl Chloride Reductase

Figure 5.16. QuantArray-Chlor Data Collected at 15-MW-41 During the Baseline (18°C in 2021, orange-colored bars), January 2023 (24°C, black-colored bars), and January 2025 (30°C, teal-colored bars) groundwater sampling events.

5.5.5 Compound-Specific Isotope Analytical Results

As mentioned in **Section 5.4.5**, accompanying the microbial community assessment samples collected during the baseline sampling event, as well as in January 2023 and January 2025, additional groundwater samples were collected from monitoring wells 15-MW-08, 15-MW-41, TISR-2S, and TISR-2D to evaluate the isotopic fractionation of the primary COCs (i.e., TCE, cis-1,2-DCE, and VC) via ^{13}C CSIA. In theory, the ratio of stable isotopes $^{13}C/^{12}C$ changes in a predictable way as a compound is degraded; however, physical processes such as volatilization, sorption, and dilution do not significantly alter isotopic ratios. Therefore, ^{13}C CSIA can provide direct evidence of degradation of the primary COCs within the TISR treatment zone. A minimum COC concentration per sample is required for the laboratory to be able to effectively calculate the ratio of stable isotopes $^{13}C/^{12}C$.

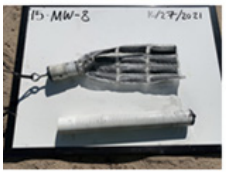
Unfortunately, many of the groundwater samples collected for ^{13}C CSIA did not contain sufficient TCE, cis-1,2-DCE, and/or VC concentrations and, hence, were not subjected to ^{13}C CSIA. The results of the few samples that exceeded the minimum COC concentrations to be subjected to ^{13}C CSIA did not show significant changes in the ratio of stable isotopes $^{13}C/^{12}C$ as TISR implementation progressed. These limited data do not imply the absence of degradation of COCs within the TISR treatment area; rather, the fact that such few samples contained sufficient TCE, cis-1,2-DCE, and/or VC concentrations to be able to be subjected to ^{13}C CSIA is a direct effect of decreased COC concentrations due to TISR-enhanced degradation.

5.5.6 Reactive Iron Mineral Formation Results

As mentioned in Section 5.4.6, Min-Trap™ samplers were deployed at monitoring wells 15-MW-41 (within the TISR treatment area) and 15-MW-08 (outside the TISR system ROI) approximately 2 months prior to TISR implementation. Min-Trap™ sampling was conducted in October 2021 (baseline) and December 2024, and included total iron, AMIBA, and SEM-EDS analyses.

Results from both the baseline and December 2024 Min-Trap™ sampling events confirm the presence of iron sulfide minerals within the TISR treatment area. There was no notable increase in the amount of iron sulfide minerals encountered during the December 2024 sampling event when compared to baseline; however, the presence of iron sulfide minerals, which can react and degrade CVOCs via biologically-mediated abiotic reactions, indicates that subsurface conditions are conducive to the continued attenuation (via both biological and abiotic mechanisms) of the residual, dissolved CVOC impacts at the Site.

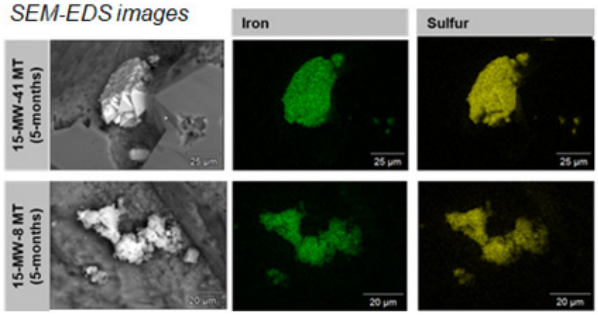




AMIBA results

Sample	WAS Fe				SAS Fe				
	Total Fe (mg/kg)	Fe2+ (mg/kg)	Fe3+ (mg/kg)	Total Fe (mg/kg)	Fe2+ (mg/kg)	Fe3+ (mg/kg)	Total Fe (mg/kg)	AVS (mg/kg)	CrES (mg/kg)
MW-41	100	38	0.0	38	44	18	62	13	41
MW-8	114	14	1.8	15	18	23	42	1.2	24

SEM-EDS images





Min-Trap collected Dec 2024

Fe = iron, WAS Fe = weak acid soluble iron, SAS Fe = strong acid soluble iron; mg/kg = milligrams per kilogram, AVS = acid volatile sulfide; CrES = chromium extractable sulfide

Figure 5.17. Total Iron, AMIBA, and SEM-EDS Data Collected from Min-Traps™ at 15-MW-41 and 15-MW-08 during the Baseline (18°C in 2021) Sampling Event.

The Min-Trap™ retrieved from well 15-MW-41 in December 2024 is also shown (bottom right).

5.5.7 Push-Pull Testing Results

Baseline push-pull tracer testing was conducted in April 2022. Tracer tests use a conservative and a reactive tracer (bromide and TOC, respectively) to assess the decay rate in the subsurface. The April event represented the baseline event, indicating the reaction rate prior to heat application. Five hundred gallons each of sodium lactate- and bromine-dosed injectate were injected at TISR-1S, TISR-1D, TISR 4S, and TISR-4D. After a 75-hour residence time, 500 gallons were extracted from each location. Samples were collected when 150, 300, and 500 gallons had been extracted. Analysis of the push-pull baseline data showed a projected average decay rate of 0.058 per day from subsurface heating, as shown on **Figure 5.18**, below.

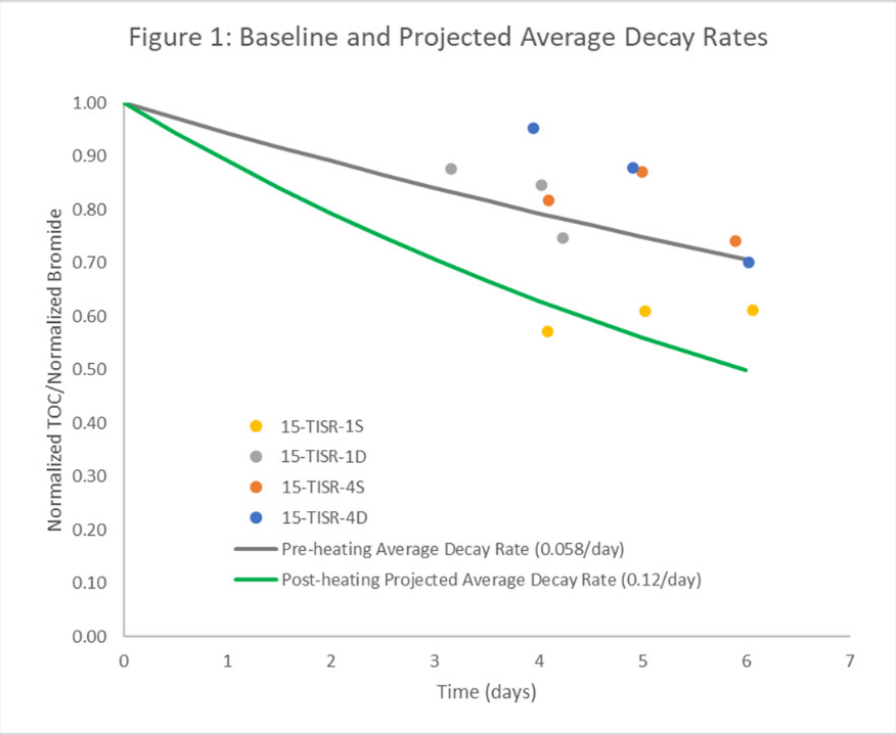


Figure 5.18. Baseline and Projected Average Decay Rates

The results from the January 2023 push-pull testing event were compared against the baseline push-pull testing results to further assess TISR system performance. During data review it was determined that the shallow wells screens were insufficiently submerged during both push-pull events. As a result, the injectate in the shallow wells was primarily delivered within the vadose zone, where geochemistry is different and ability to "pull" is limited. To ensure data that is representative of biogeochemistry within the heating zone, additional shallow push-pull testing events were not performed. The average decay rate in the deep wells was 0.088 per day in April 2023, compared with 0.042 per day during the baseline event in January 2022 (**Figure 5.19**). This significant increase (~2x) is indicative of enhanced decay due to TISR system operation. The difference in decay rate (and subsequent half-lives) between locations (e.g., TISR-1D and TISR-4D) may be the result of inhibitory effects on the overall microbial population from lower TOC, sulfate, and TCE concentrations at TISR-1D.

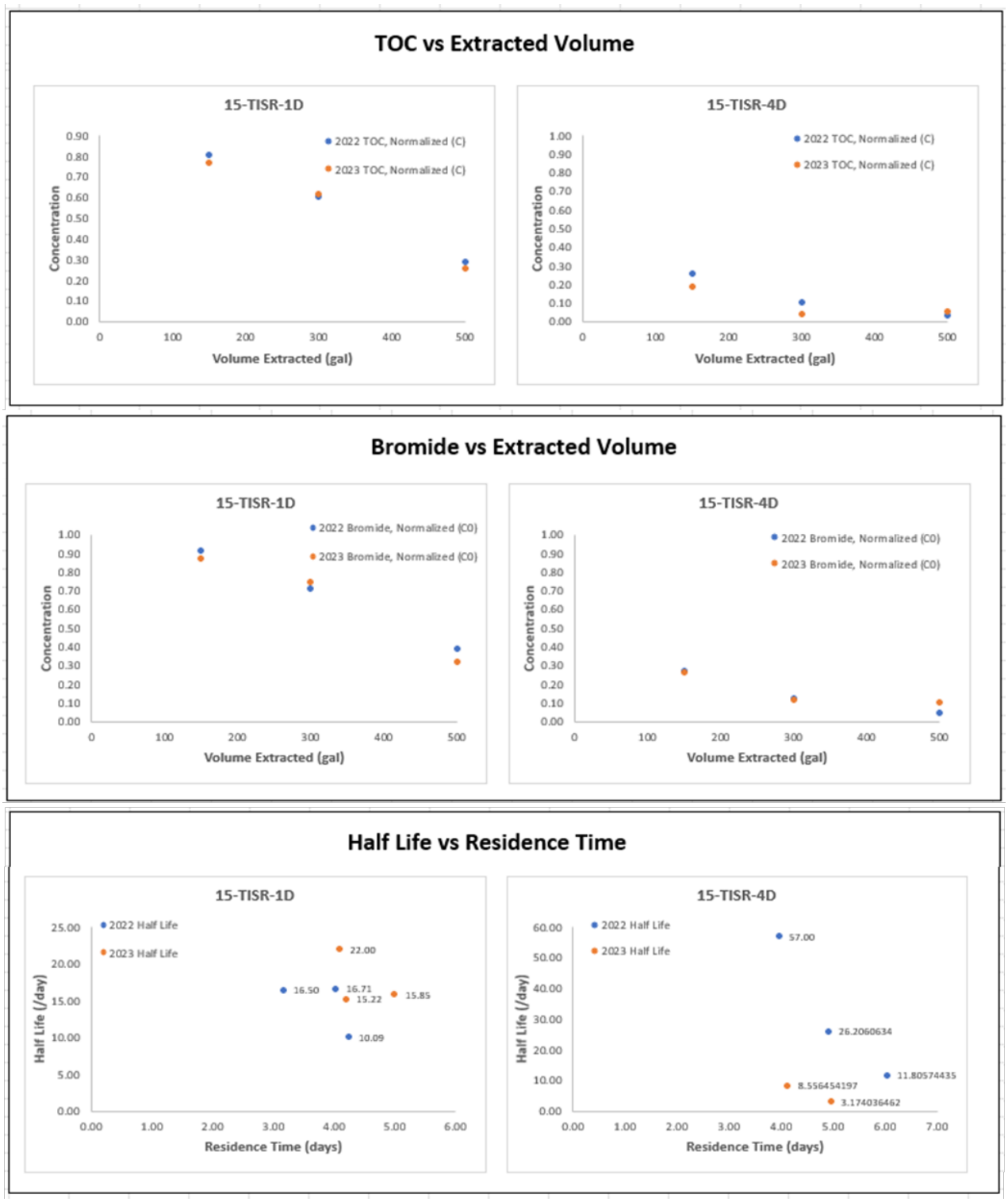


Figure 5.19. Comparison of TOC, Bromide, and Half-life between the January 2022 and April 2023 Push Pull Events.

5.6 HEAT TRANSPORT MODEL RESULTS AND VALIDATION

Temperature data were collected from DTS points DTS-5, DTS-7, and DTS-9 between August 2022 and January 2023. Subsurface temperatures steadily increased following the start of heating in June, with peak increases of 3.7 to 6.4 °C; however, sharp declines were observed in late December at shallow depths, likely due to weather. The analytical model accurately predicted trends at DTS-7 and DTS-9, but underestimated temperatures at DTS-5. The analytical design tool, using an initial Darcy velocity of 37 feet per year (11 meters per year), effectively reproduced temperature trends at DTS-7 and DTS-9 (Figure 5.20, below). However, lower groundwater velocities (20 to 27 feet per year) significantly improved accuracy at DTS-5, highlighting site-specific heterogeneity. Sharp temperature declines at shallow depths 16 to 23 feet (5 to 7 meters) were recorded, likely due to environmental (cold weather) factors indicating depth-dependent cooling.

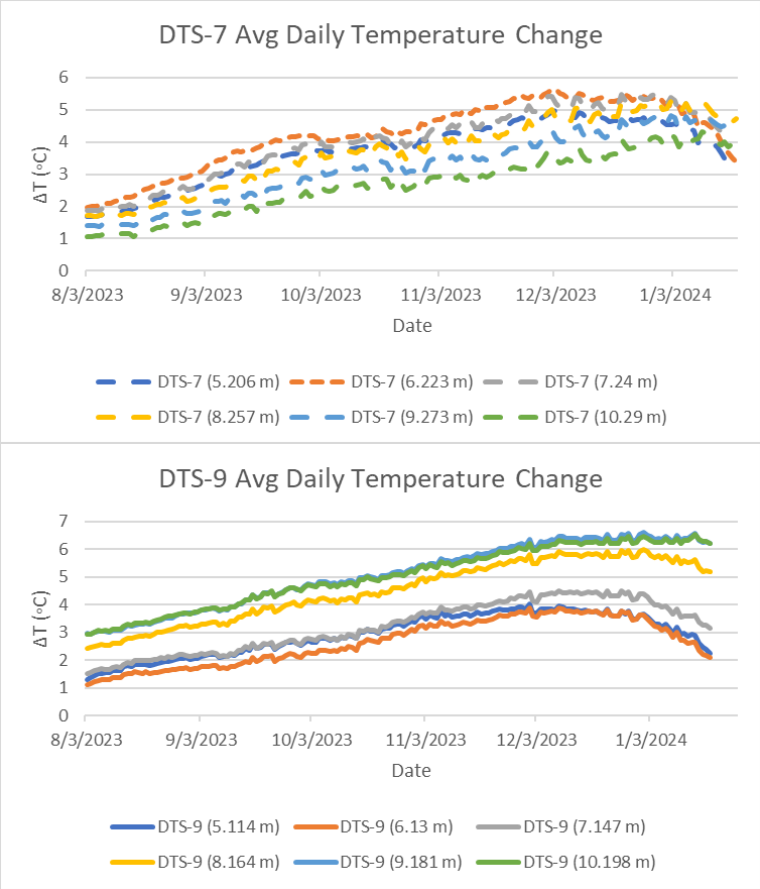


Figure 5.20. Average Daily Temperature Change Sampled from 6 Different Depths along DTS-7 and DTS-9

Throughout the monitoring period, spatial variability in temperature response became apparent. DTS-7 and DTS-9, which were situated near reliably functioning heaters, displayed more consistent heating trends, whereas DTS-5 experienced a less uniform temperature profile. The differences across sensors reflected both the impacts of heating interruptions and inherent heterogeneity in subsurface thermal behavior. Nonetheless, all sensors recorded long-term upward trends in temperature, especially below 22 feet (7 meters), indicating sustained energy delivery to target treatment zones.

The system showed the capacity to maintain elevated subsurface temperatures suitable for accelerating both biotic and abiotic degradation processes. With average borehole power ranging from 164 to 361 watts per month during the first year, the system could achieve meaningful thermal enhancement in key locations.

After 3 years of continuous solar thermal heating, the system achieved a significant enhancement in contaminant degradation, with up to 52 percent enhanced decay occurring in areas immediately surrounding the BHEs. Even at the outer edges of the BHE array, a 22 percent increase in decay was observed, indicating effective thermal influence beyond the core heating zone. As heating continued through time, the effect became even more pronounced. The thermal-enhanced decay (TED) reached 95 to 100 percent in the central regions of the array. These results demonstrate the long-term effectiveness of solar thermal remediation in promoting substantial contaminant breakdown, particularly in areas with sustained elevated temperatures.

Validation of the analytical solar thermal remediation design tool was critical in establishing the accuracy and reliability of the heat propagation and TED modeling. Validation focused primarily on DTS systems near the BHEs and the quality of their recorded temperature profiles. The model effectively reproduced observed trends at DTS-7 and DTS-9, capturing seasonal variations and the general shape of the temperature-time series. A velocity of 10 feet per year (3 meters per year) yielded the best match to observed data at DTS-5, improving the coefficient of determination from -0.77 to +0.29. These results highlighted the sensitivity of model output to groundwater velocity and suggested localized hydraulic heterogeneity at the site. Further validation was conducted by simulating known system anomalies by reducing power input to zero for those units while proportionally redistributing power to the remaining BHEs. Overall, the validation process confirmed that the analytical design tool, when properly calibrated, can reliably simulate subsurface temperature changes under varying field conditions, showing strong agreement with field data and demonstrating the ability to account for system irregularities. Ultimately, the analytical design tool offers a robust framework for predicting long-term heating and optimizing remediation system design.

The assumptions and parameters utilized for the heat model are provided in **Appendix D**.

5.7 SUSTAINABILITY ANALYSIS AND RESULTS

A sustainability analysis was performed to assess the anticipated lifecycle footprint of the remedial implementation at SD015. The analysis was conducted in accordance with USEPA guidance using the SiteWise™ software for green and sustainable remediation developed by Battelle Corporation and the DoD. The lifecycle footprint for remediation using the TISR system (including historical EISB injection events performed between 2015 and 2020) was compared to the anticipated lifecycle implementation of EISB without TISR (baseline). The baseline scenario was scaled to match the vicinity immediately surrounding 15-MW-41, consistent with the treatment footprint of the TISR system, and assumed that an additional 20 injection events would be required to address CVOC concentrations. Consistent with past events, it was assumed that the remedy at SD015 would continue to use the DGR system during injections. To provide a broader point of comparison between TISR and EISB at other sites, a third scenario (traditional EISB) was also analyzed that assumed the use of injection trailers.

The results indicated that implementing a TISR system at SD015 instead of continuing the baseline EISB approach would result in reductions in lifecycle total energy usage and GHG emissions (defined as emissions carbon dioxide equivalents comprised of carbon dioxide, methane, and nitrous oxide) of 66 and 62 percent less, respectively. The reduction in GHG is primarily attributable to the carbon emissions associated with manufacture and regeneration of GAC for the DGR system, which is an energy- and carbon-intensive process. In addition to reduced energy usage and GHG emissions, TISR also resulted in the reduced usage of water and produced lower emissions of nitrogen oxide (NO_x), sulfur oxide (SO_x), and particulate matter less than 10 microns in diameter (PM_{10}). These metrics are presented in **Table 5.2**. As shown on **Figure 5.16**, below, the historical EISB injection events comprise the majority of the SD015 GHG footprint, followed by installation of the system. As expected, the footprint associated with TISR system OMM and waste is negligible.

Table 5.2. Summary of Lifecycle Sustainability Metrics for TISR vs EISB

		GHG Emissions[1]	Total Energy[2]	Water[3]	Electricity[4]	Total Air Emissions[1]
Scenario 1: EISB using DGR System	Scenario 1A: EISB Only	403	7,460	201,960	396	1.10
	Scenario 1B: EISB + TISR	154	2,555	44,923	88	0.39
Scenario 2: Traditional EISB	Scenario 2A: EISB Only	148	5,296	153,000	300	1.00
	2B: EISB + TISR	101	2,105	34,723	68	0.38
Sustainability Impact of TISR	Scenario 1A vs 1B (DGR)	-62%	-66%	-78%	-78%	-64%
	Scenario 2A vs. 2B (Traditional)	-32%	-60%	-77%	-77%	-63%

Notes:
[1] GHG emissions are presented in metric tons of carbon dioxide equivalents. Total air emissions are presented in metric tons of NO_x, SO_x, and PM_{10}.
[2] Energy is reported in metric million British thermal units.
[3] Water is reported in gallons.
[4] Electricity is reported in megawatt hours.

The table below does not include energy use associated with the heat pump, which was considered separately. A power study to ascertain the energy use from the heat pump was not performed, however a conservative estimate was made assuming that the heat pump operated for 14 hours per day, or approximately 60% of the time. Using these assumptions, operation of the heat pump for 6 months would have an additional GHG footprint of 10 metric tons of carbon dioxide equivalents and 242 metric million British thermal units.

These results meet the performance objective success criteria, which was defined as energy usage and GHG footprint of the TISR system to be at least 25 percent less than the baseline EISB operations. While not the approach at SD015, implementation of a TISR system would have a 32 percent lower GHG footprint and 60 percent lower energy footprint than the traditional EISB implementation using injection trailers, which would still meet the performance objective. The results continue to meet performance objectives when considering the footprint of the heat pump, with a 25 percent lower GHG footprint and 56 percent lower energy footprint than the traditional EISB implementation using injection trailers.

Water use is also significantly lower for the TISR approach when compared to either EISB implementation scenarios, with nearly an 80% reduction in footprint.

6.0 PERFORMANCE ASSESSMENT

The data collected as part of this project were evaluated to determine if the specific quantitative and qualitative performance objectives presented in **Table 3.1** were met. Assessment of each performance objective is discussed in detail in the following sections.

6.1 PERFORMANCE OBJECTIVE 1: VALIDATE TEMPERATURE INCREASES AND UNIFORMITY OF TEMPERATURE DISTRIBUTION VERTICALLY AND HORIZONTALLY

6.1.1 Data Collected

To validate temperature increases and the uniformity of temperature distribution both vertically and horizontally, temperature measurements were collected from multiple points within the target treatment volume. The primary data sources included DTS systems and HOBO TidbiT sensors. The DTS system provided continuous temperature data from various locations, while the TidbiT sensors offered point source temperature data at specific monitoring wells.

The DTS locations within the target treatment volume included DTS-2 through DTS-9. These locations were monitored to ensure that the temperature criteria were met. Additionally, TidbiT sensors were placed in select monitoring wells (15-MW-8, 15-MW-41, TISR-3S, TISR-3D, TISR-2S, and TISR-4D) to validate the DTS data and provide supplementary temperature measurements.

6.1.2 Data Interpretation

The original success criteria required that 75 percent of the DTS locations within the target treatment volume (DTS-2 through DTS-9) achieve a minimum temperature of 30°C within one year of initiating operations. Once this level was achieved, temperatures within the active treatment volume were to be maintained between 30 and 35°C for a minimum of 120 days. Temperature sensors outside the actively heated treatment volume (DTS-1, DTS-10, DTS-11, and DTS-12) were not used to assess compliance with this performance standard.

The data collected from the DTS system indicated that the majority of DTS locations within the target treatment volume achieved a minimum temperature of approximately 23°C within the first year of operation. Therefore, 75 percent of the DTS locations (DTS-2 through DTS-9) did not reach or exceed the 30°C threshold outlined in the initial success criteria. However, during this operational period, temperature data demonstrated a uniform distribution of heat above ambient groundwater temperatures both vertically and horizontally within the target treatment volume. The DTS system provided high-resolution temperature profiles, showing consistent temperature increases across different depths and horizontal distances. The TidbiT sensors further validated these findings, with point source temperature data confirming the uniformity of temperature distribution.

The data collected from the DTS system indicated that the majority of DTS locations within the target treatment volume achieved a minimum temperature of approximately 23°C within the first year of operation. Therefore, 75 percent of the DTS locations (DTS-2 through DTS-9) did not reach or exceed the 30°C threshold outlined in the initial success criteria. However, during this operational period, temperature data demonstrated a uniform distribution of heat above ambient groundwater temperatures both vertically and horizontally within the target treatment volume.

The DTS system provided high-resolution temperature profiles, showing consistent temperature increases across different depths and horizontal distances. The TidbiT sensors further validated these findings, with point source temperature data confirming the uniformity of temperature distribution. Future designs can benefit from more informed upfront heat transfer modeling by utilizing site-specific climate data such as solar irradiation and precipitation data. This can be accomplished via better geolocated data from online sources or onsite weather station data. Additionally, incorporating design contingencies such as tighter BHE spacings and supplemental heat sources can mitigate the impact of unexpected weather conditions or subsurface heat losses. These tools can be assessed during the system design planning phase to determine which contingencies to include based on site uncertainties. This helps adjust the heating level to address heating challenges, ensuring efficient and dependable thermal treatment processes.

After the initial year of operations, following a summer of consistent solar irradiation and sustained subsurface heating, the temperature cross-section observed on November 10, 2023 (Figure 5.12), showcased significant thermal elevation. Temperatures at the BHEs peaked above 50°C, while other areas ranged from 20°C to 35°C. Specifically, maximum temperatures observed at DTS-5 and DTS-7 were 27°C and 24°C respectively. These points, situated approximately 5 and 7 feet from the nearest BHE, indicate the radius of heating influence.

Although not all temperatures throughout the heated volume were within the specified 30 and 35°C range, the system successfully maintained elevated temperatures above ambient and in some locations above 30°C for a minimum of 120 days. This was evidenced by continuous temperature monitoring data from the DTS system and TidbiT sensors, which showed stable temperature readings within the specified range during the maintenance period.

The data also highlighted the impact of seasonal variations on subsurface temperatures. For instance, there was an observed decrease in temperatures after winter 2024, followed by sustained heating through the spring. To address these fluctuations and enhance the heating capability, a heat pump was introduced in September 2024. The heat pump maintained a set temperature of 120°F (approximately 49°C) to the BHEs, providing continuous heat input regardless of solar irradiation. This resulted in a significant temperature increase at the monitoring locations, with an approximate rise of 4°C in three months. The maximum temperature observed at 15-MW-41 was 29.5°C on January 27, 2025, which is approximately 11°C greater than the ambient groundwater temperature.

The data collected and analyzed for this performance objective demonstrated that the TISR system effectively increased and maintained subsurface temperatures within the target treatment volume. The uniformity of temperature distribution both vertically and horizontally was achieved, even though the original success criteria were not met. The introduction of the heat pump further enhanced the system's capability to maintain elevated temperatures, ensuring the effectiveness of the thermal treatment process. As such, this is considered a successful implementation of the TISR system and the broad goal of the performance objective was attained.

6.2 PERFORMANCE OBJECTIVE 2: DETERMINE INFLUENCE OF SOLAR INSOLATION AND GEOGRAPHICAL VARIATIONS ON OPTIMAL DESIGN

6.2.1 Data Collected

Solar energy is a sustainable energy source, but its effectiveness depends on adequate solar radiation and sufficient space for installing the necessary number of solar collectors. The magnitude and duration of radiation vary based on site characteristics such as cloud cover, elevation, latitude, and seasonal changes due to sun angle and daylight length.

In addition to the thermal modeling evaluation outlined in Section 5.1.2, which considered temperature monitoring data, operational parameters (e.g., flow rates of the closed-loop system, heat efficiency based on solar collectors, and BHE temperature measurements for the site and other TISR sites in New York, Colorado, Mexico City, and various areas in Canada), empirical data accumulated to date were combined with learnings from the modeling task to refine the TISR design and cost assumptions.

The installed TISR system at the site utilized Apricus ETC-30 solar collectors (**Appendix B**). During the design phase, it was assumed that each collector could produce approximately 30,000 BTU per day based on the certified Solar Rating & Certification Corporation (SRCC) OG-100 Category C medium radiation climate category. The system was installed in a remote field on the central California coast, with an average solar irradiance of approximately 5 kilowatt hours per square meter per day (Solargis, 2024), equating to roughly 1,585 Btu/ft²/day, placing the site just above the SRCC medium radiation category (1,500 Btu/ft²/day). Given the site's solar energy rating and Climate Category C conditions, was assumed that the collectors would provide approximately 30,000 BTU of solar hot water heating per day per collector.

However, after installation and subsequent operation of the system, Autodesk Forma (Forma) was utilized to conduct a solar energy potential analysis for the site. Forma provided a more site-specific energy potential than the previous region-based data used to design the system. Forma indicated that the site could provide an average of 193 kilowatt-hours per square foot (kWh/ft²) of solar energy potential. Given that the system consisted of eight Apricus ETC-30 solar collectors with a total surface area of approximately 250 square feet, this corresponds to an estimated annual solar energy potential of approximately 48,500 kilowatt-hours (kWh).

Forma assumes that photovoltaic (PV) panels are utilized for electricity generation with typical efficiency ratings between 15-20%. PV panels convert solar radiation directly into electricity, generally achieving an efficiency of less than 20%. In contrast, solar thermal collectors are designed to convert solar radiation into heat, with significantly higher efficiencies, typically reaching up to 70-75%. Given that solar collector efficiency is triple that of PV panels, the estimated annual thermal energy output from the eight collectors would be approximately 29,000 kWh, equivalent to roughly 99 million BTUs. This equates to an average daily thermal output of around 34,000 BTU per collector at this site.

6.2.2 Data Interpretation

The primary performance objective was to determine the influence of solar insolation and geographical variations on the optimal design of the TISR system. This involved analyzing key data such as solar insolation, heating equipment efficiency and transfer rate, borehole spacing, subsurface temperature changes, and the rate of heat distribution in the subsurface.

Based on the solar collector certification rating falling within range of the site-specific solar energy potential analysis produced from Forma it was assumed that the solar collectors would provide roughly 34,000 BTU/day/collector. The target temperature of the TISR system aimed to heat the targeted treatment volume of soil to a temperature of 35°C. Based on the BHE spacing of 20 feet the TISR system would cover approximately a treatment area of 2,512 square feet. The vertical interval to be heated was 12.5 feet, resulting in a total soil volume of approximately 31,400 cubic feet. Assuming a 30% porosity the heated volume would comprise of 21,980 cubic feet of soil and 9,420 cubic feet of water. This equates to a total mass soil being 5,193,954 pounds, while the mass of the water being 587,995 pounds. The heat capacities assumed to be 1,298,489 BTU/°F for the soil and 587,995 BTU/°F for the water, leading to a total heat capacity of the heated volume of 1,886,483 BTU/°F. The starting temperature of the targeted heating volume was 18°C (64°F), and the target temperature is 35°C (95°F), resulting in a temperature change (ΔT) of 17°C (31°F). The total heat demand to achieve this temperature change is 57,726,394 BTU. Assuming an efficiency of 34,000 BTU/day per collector and utilizing 8 collectors, the adjusted total power input is 272,000 BTU/day. After accounting for a heat loss factor of 50%, the net power input rate is 5,667 BTU/hr. Based on this net power input rate, the estimated time to meet the subsurface target temperature was approximately 424 days, or roughly 1.2 years.

This analysis validated the use and design assumptions of the proposed solar thermal collectors were accurate and that target temperatures in the subsurface could be achieved approximately 1.2 years after system startup. However, the average of observed field temperature measurements did not fall within an average of 25 percent of the location-specific design prediction ranges as specified in the success criteria for this performance objective. This demonstrates that the site-specific influence of heat limiting factors due to seasonal variations resulting in reduced run time due to overcast and subsurface heat losses due to higher-than-normal precipitation events at the site had an effect on the system performing outside of the expected design criteria used. Based on this observation it was determined that supplemental energy supply from heat pump would be needed to overcome these site limiting factors to achieve the targeted subsurface heating requirements within the period of performance specified for the project. This underscores the importance of the design parameters and engineering safety factors used and ensuring reliable equipment sizing guidelines and specification are established to ensure that the solar collectors and other TISR system components are appropriately sized for the specific site conditions.

6.3 PERFORMANCE OBJECTIVE 3: TEMPERATURE-DRIVEN INCREASE IN MICROBIAL DEGRADATION ACTIVITY

6.3.1 Data Collected

Microbial data were collected prior to and throughout TISR system operation. These data included assessments of microbial community composition and quantification of gene targets involved in reductive dichlorination. Additional data relevant to microbial degradation activity, such as organic carbon consumption rates from push-pull tracer tests, isotopic fractionation of parent compound and daughter products, and CVOC concentrations were also collected for TISR performance evaluation.

6.3.2 Data Interpretation

As described in Section 5.5, the increase in subsurface temperature within the TISR treatment area, from approximately 18°C (baseline, 2021) to approximately 30°C (January 2025), resulted in a significant reduction in CVOC concentrations in both the shallow and deep intervals monitored. Specifically, total CVOC concentrations decreased by an average of 95.2% and 83.4% in the shallow and deep zones, respectively, over the TISR demonstration period. Also concomitant with subsurface heating and decreasing CVOC concentrations, a significant shift in microbial community composition was observed: a higher abundance of key microorganisms and functional genes for the reductive dechlorination of CVOCs was quantified within the TISR system ROI as TISR treatment progressed. The criteria for this performance objective are considered achieved.

6.4 PERFORMANCE OBJECTIVE 4: TEMPERATURE-DRIVEN INCREASE IN ABIOTIC DEGRADATION ACTIVITY

6.4.1 Data Collected

Abiotic degradation rate constants were derived for TCE from treatability bench-scale testing (i.e., ^{14}C-TCE assay) with microcosms prepared with site soils and groundwater and incubated at six temperatures (18, 25, 30, 35, 40, and 50°C), Additional in situ data relevant to abiotic degradation activity were also collected. The in situ data included reactive iron mineral composition measured in Min-Trap™ samples, dissolved acetylene concentrations, and analysis of the AHY gene target.

6.4.2 Data Interpretation

The rates of TCE degradation attributable mainly to abiotic activity were approximately two orders of magnitude less than the rates of TCE degradation attributable to biotic reductive dechlorination. However, treatability bench-scale testing suggests that prior electron donor injections at the site have created reactive minerals in the groundwater that are active in abiotic dichlorination. The presence of said reactive minerals in site groundwater was evidenced by the AMIBA and SEM-EDS results from Min-Trap samples collected from wells within the TISR system ROI. The criteria for this performance objective are considered achieved.

6.5 PERFORMANCE OBJECTIVE 5: VERIFY CAPITAL, OPERATION AND MAINTENANCE, AND LIFESTYLE COST BENEFIT OF THERMAL IN SITU SUSTAINABLE REMEDIATION

This performance objective is intended to verify capital, operation and maintenance, and lifecycle cost benefit of TISR.

6.5.1 Data Collected

Historical remediation system operational costs including labor, TISR equipment, construction and operational costs, contaminant concentration trends, relative daughter generation, and contaminant mass flux.

6.5.2 Data Interpretation

Costing data was tabulated for the installation and operation of the TISR system for 5 years. These costs were compared against projected costs for continuation of the EISB approach historically implemented at SD015, which was projected to require an additional 10 years of remedy if TISR had not been utilized. Remedial timeframe projects were informed by linear regression and analysis of groundwater data trends and responses to current and historical remedial activities (Appendix A).

6.6 PERFORMANCE OBJECTIVE 6: SUSTAINABILITY BENEFITS

This performance objective is intended to demonstrate the sustainability benefits.

6.6.1 Data Collected

Data relevant to the lifecycle sustainability analysis of the baseline EISB remedy and the TISR remedy were collected. This data included the quantities, sources, and transportation of consumable materials and equipment; number of field personnel and vehicle commute metrics; energy and equipment use associated with field activities and operation of systems; and quantities, transportation, and end management approach associated with waste materials.

6.6.2 Data Interpretation

As described in Section 5.7, the data were interpreted in line with USEPA guidance using the SiteWise™ software for green and sustainable remediation developed by Battelle Corporation and the DoD. The results indicated that GHG emissions associated with TISR were 62 percent less than continuing the EISB approach at SD015, which used a DGR system, and approximately 32 percent less than implementing EISB with an injection trailer. Thus, TISR meets the performance objective of a having a GHG footprint that is 25 percent less than baseline EISB operations.

6.7 PERFORMANCE OBJECTIVE 7: IDENTIFY IMPLEMENTATION AND OPERATIONAL CHALLENGES

This performance objective is intended to identify implementation and operational challenges.

6.7.1 Data Collected

Surveys from installation contractor and project personnel were conducted to capture insights and feedback regarding the practical challenges and operational experiences encountered during the implementation and operation phases. These surveys included detailed questions on system performance, ease of installation, maintenance issues, and suggestions for improvement, contributing to a comprehensive understanding of the project's sustainability benefits and operational hurdles.

6.7.2 Data Interpretation and Lessons Learned

During TISR implementation and operations, the field crews experienced challenges which yielded lessons learned. These lessons learned are summarized below:

- *Maintaining system operational pressure.* Upon startup, small leaks in the above-grade piping were identified and sealed. The original design called for soldered copper connections. While most of these connections held with no further effort, some in particularly difficult to access areas were persistent or required several repairs before holding long-term pressure. At this specific job location, soldering required hot work permits from the local fire department. In future modifications, press-fitting copper connections were used to a high degree of success.
- *Wellfield temperature monitoring.* TidBit submersible temperature monitoring dataloggers were deployed in several monitoring wells in the TISR treatment area. These dataloggers were selected for their size, temperature range, accessibility, and cost. Throughout the study, the TidBits would fail and require replacement, potentially with a loss of data. Other temperature dataloggers were assessed during and after the heat pump installation, but similar challenges arose. The frequency of replacement was greater for wells that were used for carbon or iron amendment, such as in push-pull studies or EISB injections, but the issue was not limited to those wells.
- *Intermittent power loss.* The location of the TISR system suffered from intermittent power losses due to antiquated infrastructure supplying the on-site remediation system. These intermittent interruptions led to significant downtime and operational challenges. When power was lost during the day, the circulation pump was not be able to continue passing the heating fluid through the solar collectors. The stagnant fluid would quickly exceed its boiling temperature and evaporate through the pressure- and air-relief valves. This lead to added field effort to recharge the system and restart operations when power was restored. Given the minimal power requirements of the circulation pump, future systems could be designed with a battery contingency to maintain operations through short power interruptions.
- *Record rain and cloud cover in winter and spring 2022 and 2023.* The Central Coast of California experienced significant rainfall during the rainy seasons in 2022 and 2023. This excessive rainfall resulted in lower solar insolation during the winter months, increased infiltration cooling the subsurface, and power loss (mentioned in the previous bullet). The rainy season extended into late spring and was followed by a summer characterized by an unusually high number of overcast and cloudy days. This combination led to reduced heat input for the solar-only heating setup at the beginning of the performance period. The heat pump installation in September 2024 provided additional and more consistent heat input to the subsurface, helping to achieve the target temperature range efficiently despite the initial loss of heat input due to rainy conditions at the start of the performance period.

7.0 COST ASSESSMENT

This section is intended to provide sufficient cost information such that a remediation professional can reasonably estimate costs for installation of a TISR system at a site.

7.1 TYPICAL AND SCALABLE THERMAL IN SITU SUSTAINABLE REMEDIATION SYSTEM COST MODEL

Although the specific requirements, scale, and geometry of TISR applications will vary, the typical and scalable design from the VSFB project is shown below and may be adapted to different site conditions. Design variations at other sites may be due to different levels of solar insolation, treatment volume, or site infrastructure than those at the demonstration site. The cost model for the design at the VSFB demonstration site included additional equipment for the installation of new monitoring wells and temperature sensing fiber (DTS) locations to provide a robust, high-resolution performance monitoring dataset during system operations.

The equipment used in the TISR design at the demonstration site is described below:

- Above-grade equipment:
  - *Solar collectors.* Eight units arranged in a 4x4 array.
  - *Heat pump skid.* One unit for efficient heat transfer.
  - *Pump station.* One unit, including instrumentation and controls.
  - *Conveyance manifold.* One unit for distributing the heated fluid.
  - Insulated above-grade conveyance piping branches. Eight branches to minimize heat loss.
  - *Power connection.* One connection to the existing electrical source.
- Below-grade equipment:
  - *BHEs.* Eight units with a heating interval from 20 to 40 bgs.
  - *New performance monitoring wells.* Eight wells with the following screen intervals:
    - Shallow screen interval at 17.5 to 27.5 feet bgs.
    - Deep screen interval at 30 to 40 feet bgs.
  - *Existing monitoring wells.* Two wells with the following screen intervals:
    - Screen interval at 19 to 39 feet bgs.
    - Screen interval at 25 to 35 feet bgs.
  - *New soil vapor probes.* Two probes with a total depth of 17.5 feet bgs.
  - *DTS locations (optional).* Twelve locations with a monitoring interval from the surface to 40 feet bgs.

Table 7.1, below, provides estimated costs associated with the TISR system targeting approximately 1,200 cubic yards of saturated soil through a 5-year lifecycle. It includes one-time capital costs for system design and installation, as well as ongoing O&M and sampling costs. This simple cost model is for a typical design and system size presented above. This cost breakdown serves as general guidance for estimating the costs of installing TISR. However, these costs can vary significantly depending on site conditions and specific project objectives.

Table 7.1. Cost Model for TISR System

Cost Element	Description	Unit Cost	Unit	Quantity	Cost
System design and procurement	Design, permitting, procurement	$120,000	Lump sum	1	$120,000
BHE and wellfield drilling	Drilling and installation of BHE and wellfield	$146,000	Lump sum	1	$146,000
Process mechanical construction and startup	Construction and startup of the solar system	$408,000	Lump sum	1	$408,000
EISB injection event	Injection of EISB substrate into five wells	$50,000	Lump sum	1	$50,000
Subtotal: System Design and Installation					**$724,000**
Annual O&M costs	O&M costs per year	$40,000	Per year	5	$200,000
Sampling event costs	Groundwater sampling event costs per year	$18,000	Per event	5	$90,000
Subtotal: O&M and Sampling Costs (5 Years)					**$290,000**
Total Cost (5-Year Lifecycle)					**$1,014,000**

7.2 COST DRIVERS

Understanding and assessing key cost drivers during the design phase is crucial for effective planning and budgeting for TISR systems, regardless of the climate or site scenario. By identifying these cost drivers early on, project planners can make informed decisions that optimize both performance and cost-efficiency across diverse conditions. This proactive approach helps in anticipating potential challenges and managing resources more effectively, ensuring the successful implementation of the TISR system. Key cost drivers are summarized below:

- *Number of BHEs.* The number of BHEs required for a project significantly impacts the overall cost. Each BHE involves drilling, installation, and materials costs.
- *Heating interval size and depth.* As these parameters increase, so do the drilling and materials costs for TISR. Further, the waste disposal costs have a direct relationship to these design parameters due to the larger volume of waste generated during drilling and reaming operations and well development.
- *Lithology.* Difficult drilling conditions such as dense soils and cobbles result in higher directional drilling costs. Coarser grained formations that are prone to flowing sand conditions and resultant borehole instability will also cause costs to increase. Drilling through bedrock is significantly more costly.
- *Solar collectors.* The number and type of solar collectors used in the system affect the initial capital costs. Solar collectors are essential for harnessing solar energy to heat the subsurface. The installation method, such as mounting solar collectors in a field versus on roofs, can also impact costs. Field installations may require more land and infrastructure, while roof installations might involve additional structural considerations.

- *Supplemental heating sources.* In some cases, additional heating sources like electric heat pumps or inline heaters might be needed to reach target temperatures. While these increase initial and operational costs, they can also shorten the project's lifecycle, leading to long-term savings. A cost-benefit analysis should be conducted to compare the extra upfront and operational costs with potential lifecycle savings. Consider energy consumption, maintenance costs, and equipment lifespan. This helps in making informed decisions that balance initial investments with long-term benefits for a cost-efficient TISR system.
- *Site-specific conditions.* Factors such as local geology, hydrogeology, and site accessibility can influence the costs of drilling, installation, and operation. For example, conveyance piping can be installed above grade or trenched below, with each method having different cost implications.
- *Monitoring and maintenance.* Regular monitoring and maintenance are essential to ensure the system's performance and longevity. Costs for sampling, laboratory analysis, and system inspections should be considered.
- *Permitting and regulatory compliance.* Obtaining necessary permits and ensuring compliance with local, state, and federal regulations can add to the overall project costs.

7.3 COST ANALYSIS

The specific requirements, scale, and geometry of each TISR application will vary based on COC concentrations, treatment objectives, and site conditions. TISR is intended to shorten remedial timeframes by increasing the rate of biotic and abiotic COC degradation mechanisms. Regression analysis of groundwater data from 15-MW-41 indicated that implementation of TISR at SD015 shortened the remedial timeframe for TCE concentration to achieve protective screening levels (5 μg/L) by about 2 years. However, the cis-1,2-DCE concentrations were stable or increasing at the site prior to installation of the TISR system, making the remedial timeline difficult to quantify. During operation of the TISR system the concentrations of cis-1,2-DCE have decreased, including a reduction in both frequency and magnitude of peaks. Additionally, the treatment of residual mass that was likely not reflected in groundwater concentrations prior to system install is expected to have further shortened the treatment period. Thus, the overall reduction in the remedial timeframe is believed to be higher than indicated by TCE concentrations alone. Using the factors above and the rebound degradation patterns observed at 15-MW-41 throughout the historical EISB implementation, the remedial time frame of the source zone is estimated to have been approximately 10 years prior to the added heat enhancement via TISR operations (Appendix A). By implementing TISR, comparable treatment could be accomplished in approximately 5 years, reducing the net remedial timeline by 5 years.

Based on the groundwater analysis and the cost model presented in Section 7.1, the cost savings from avoiding an additional 10 years of EISB implementation are estimated as follows:

- *EISB injection events avoided*. Cost estimated at $50,000 per event and approximately one injection event avoided per year for 10 years; cost savings estimated at $500,000.
- *Annual O&M costs avoided*. Cost estimated at $40,000 per year for 10 years, for a total cost savings of $400,000.

- *Sampling event costs avoided*. Cost estimated at $18,000 per year for 10 years, for a total cost savings of $180,000.

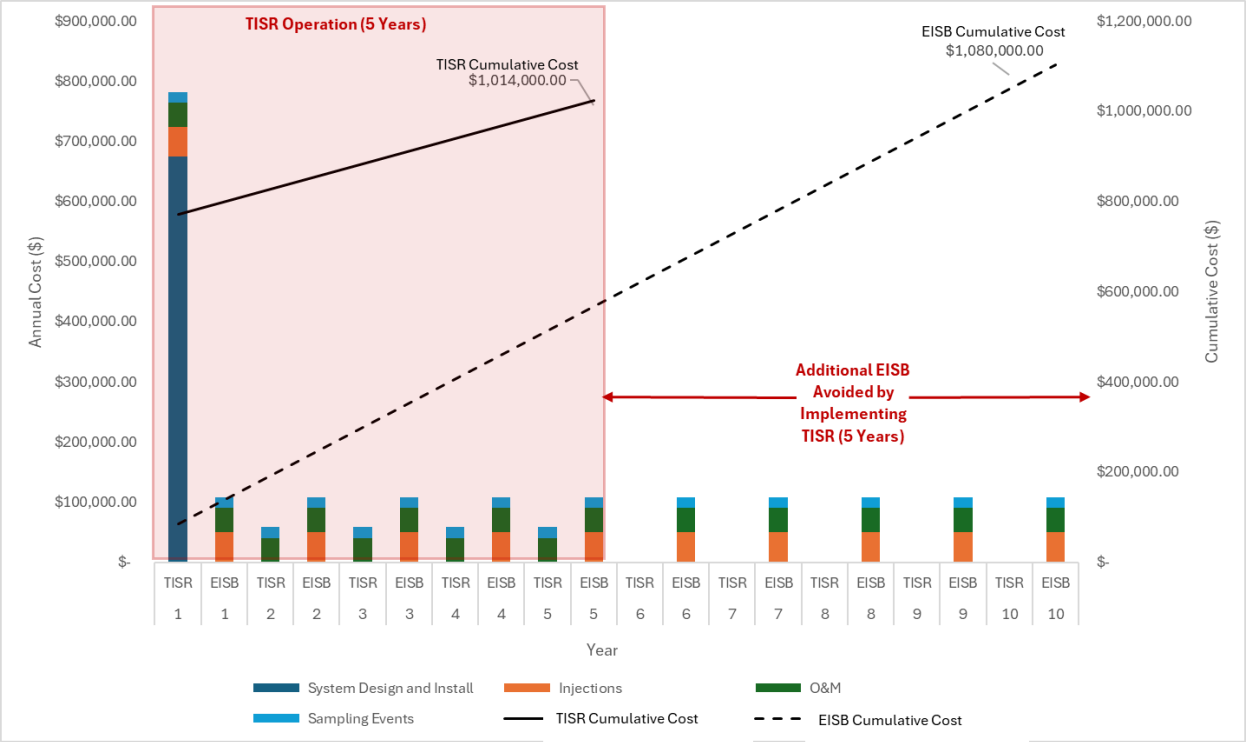


Figure 7.1. Cost and Remedial Timeline Comparison, TISR vs. EISB

Based on the costss identified above, the total costs avoided from reduced EISB scope at SD015 are $1,080,000. However, the cost of implementing a TISR system instead of continuing the EISB approach was comparable (Table 7.1). Therefore, full-scale implementation of TISR for a 5-year period is estimated to reduce the total site remedial timeline by approximately 5 years for comparable cost, suggesting an overall benefit in liability reduction associated with this technology.

8.0 IMPLEMENTATION CONSIDERATIONS

The successful implementation of a TISR system depends on a thorough understanding of both above- and below-grade site conditions, as well as the operational and logistical realities of deploying a sustainable thermal system. Lessons learned from the demonstration project at VSFB and other field applications have provided valuable insights that can inform future TISR designs and deployments.

8.1 SUSTAINABLE ENERGY ASSESSMENT

Evaluating the availability and reliability of sustainable energy sources—such as solar, geothermal, or waste heat—is a foundational step in TISR planning. If these sources are insufficient, supplemental heating (e.g., heat pumps or inline heaters) may be required to maintain target subsurface temperatures. This introduces cost and performance implications that must be carefully assessed during the design phase.

Above-grade conditions such as precipitation, cloud cover, and shading from infrastructure or vegetation can significantly affect solar collector performance. A comprehensive site assessment should include:

- Solar insolation mapping and seasonal variability analysis
- Evaluation of shading and collector orientation
- Assessment of local infrastructure reliability and grid stability
- Consideration of regulatory and permitting requirements

At the VSFB demonstration site, prolonged cloud cover and record rainfall in 2022–2023 reduced solar input, necessitating the installation of a heat pump to maintain a consistent 120°F fluid temperature to the BHEs.

8.2 SITE-SPECIFIC ENERGY TRANSFER MODELING

A site-specific energy transfer model is essential to simulate expected temperature profiles and determine whether supplemental heating is needed. The model should incorporate:

- Local solar irradiation and seasonal variability
- Subsurface thermal properties (thermal conductivity, specific heat, bulk density)
- Groundwater flow characteristics (velocity, direction)
- Above-grade conditions (e.g., shading, precipitation)

Tools such as the Excel-based model developed by Falta et al. or more advanced geothermal modeling software can be used for this purpose. These models help estimate energy demand, heating duration, and system sizing.

8.3 SUBSURFACE LITHOLOGY AND HYDROGEOLOGIC CONDITIONS

Subsurface conditions are among the most critical factors influencing TISR performance. Key considerations include:

- **Lithology:** Fine-grained or heterogeneous formations (e.g., silts, clays, interbedded sands) are ideal due to their low permeability and high thermal retention. Coarse-grained or fractured media may require tighter BHE spacing or supplemental heating.
- **Groundwater Velocity:** Ideal conditions are <1 ft/day. Higher velocities can dissipate heat through advection, reducing thermal retention and requiring design modifications.
- **Surface Water Infiltration:** Infiltration from rainfall or nearby surface water bodies can introduce cooler water into the treatment zone, reducing heating efficiency. Sites with shallow water tables or recharge zones may require thermal buffering or isolation strategies.
- **Areal Extent of Contamination:** The horizontal and vertical footprint of the treatment zone directly affects the number, spacing, and depth of BHEs. Larger or deeper plumes may require phased implementation or modular system expansion.

8.4 BHE PLACEMENT AND SYSTEM DESIGN

Placement of BHEs should be guided by CSM, including contaminant distribution, lithologic layering, and infrastructure constraints. Optimal heating intervals are typically 10–20 feet thick and located <50 feet bgs, where thermal control is more manageable, and drilling costs are lower. BHEs should be positioned to maximize thermal overlap and minimize cold zones, particularly in areas of high contaminant mass or limited natural attenuation. Additionally, wells should be designed to have sufficient transmissivity (screened saturated thickness and hydraulic conductivity) for push-pull testing. If saturated thickness is low, extraction yield and flow rates may be too low to be practical.

8.5 CONTAMINANT DESORPTION AND REBOUND

While thermal treatment enhances bioavailability and degradation potential, contaminant concentration "rebound" can occur as a result of back diffusion from low permeability materials, desorption, and NAPL dissolution and can be a challenge for any remediation technology. However, as noted by Horst et al. (2022) significant rebound is rarely observed with EISB applications for several reasons, including the coincident formation of reduced iron minerals which maintain enhanced CVOC attenuation rates for many years. This effect should be anticipated and managed through:

- Extended performance monitoring to track post-heating trends
- Integration with complementary technologies (e.g., EISB, SVE) to capture or degrade mobilized contaminants
- Adaptive system operation (e.g., pulsed heating or staged shutdown) to mitigate rebound and optimize treatment duration; once turned off, the TISR system should remain in a standby/mothball phase for 6 to 12 months, or until subsurface temperatures have returned to ambient conditions. If significant rebound is observed, the TISR system can be restarted.

8.6 EXTREME REGIONAL CLIMATE CONDITIONS

In colder climates (e.g., Fairbanks, Alaska or Keflavik Air Base, Iceland), where winter daylight is limited to 4–5 hours, reliance on supplemental heating is expected. However, these regions also typically have lower baseline groundwater temperatures. A modest increase of 5–10°C can significantly enhance biotic and abiotic degradation rates, potentially offsetting the increased energy costs and infrastructure requirements. The evaluation of this trade-off should be conducted using thermal modeling tools to inform design decisions.

8.7 POWER RELIABILITY

Power reliability is a critical consideration during both design and operations. At the VSFB demonstration site, intermittent power outages caused the circulation pump to stop, leading to fluid stagnation and overheating in the solar collectors. This activated pressure relief valves and required manual recharging of the system. Given the low power requirements of the circulation pump, future designs should consider:

- Battery backups
- Uninterruptible power supplies (UPS)
- Secondary photovoltaic power units

These measures can help maintain circulation during short-term outages and prevent system disruptions.

8.8 IN-SITU TEMPERATURE MONITORING

Reliable temperature monitoring is essential for evaluating system performance. During the demonstration, failures in DTS fiber and Tidbit sensors resulted in data loss. Future projects should consider:

- IoT-enabled temperature sensors for remote logging and real-time review
- Redundant sensor networks to ensure data continuity
- Cost-effective, easily replaceable sensors
- Early planning for data resolution, volume, and visualization needs

These improvements can reduce the need for on-site inspections and optimize operational efficiency.

By incorporating these implementation considerations—grounded in field experience and technical modeling—future TISR projects can be more effectively designed, deployed, and managed. A well-informed approach that balances site-specific constraints, energy availability, and contaminant behavior will maximize the performance and sustainability of TISR systems.

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APPENDIX A COMPREHENSIVE MONITORING DATA TABLES

Appendix A
Soil Vapor Analytical Data
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Carbon Dioxide	Carbon Monoxide	Hydrogen	Methane	Nitrogen	Oxygen
SD015-SVP-1D	9/8/2022	N	SD015-SVP-1D(09082022)	1.35	<0.10 U	<0.10 U	<0.10 U	78.5	20.1
SD015-SVP-1D	1/8/2025	N	SD015-SVP-1D(01082025)	<0.10 UH1	--	--	<0.10 UH1	--	--
SD015-SVP-1S	9/7/2022	N	SD015-SVP-1S(09072022)	0.360	<0.10 U	<0.10 U	<0.10 U	77.9	21.7
SD015-SVP-1S	4/26/2023	N	SD015-SVP-1S(042023)	--	--	--	<0.10 U	--	--
SD015-SVP-1S	10/12/2023	N	SD015-SVP-1S(10122023)	0.188	--	--	<0.10 U	--	--
SD015-SVP-1S	6/26/2024	N	SD015-SVP-1S(06262024)	1.61	--	--	<0.10 U	--	--
SD015-SVP-1S	1/8/2025	N	SD015-SVP-1S(01082025)	1.25 H1	--	--	<0.10 UH1	--	--
SD015-SVP-2D	1/8/2025	N	SD015-SVP-2D(01082025)	<0.10 UH1	--	--	<0.10 UH1	--	--
SD015-SVP-2S	9/7/2022	N	SD015-SVP-2S(09072022)	0.187	<0.10 U	<0.10 U	<0.10 U	77.9	21.9
SD015-SVP-2S	4/26/2023	N	SD015-SVP-2S(042023)	--	--	--	<0.10 U	--	--
SD015-SVP-2S	10/12/2023	N	SD015-SVP-2S(10122023)	0.125	--	--	<0.10 U	--	--
SD015-SVP-2S	6/26/2024	N	SD015-SVP-2S(06262024)	0.191	--	--	<0.10 U	--	--
SD015-SVP-2S	1/8/2025	N	SD015-SVP-2S(01082025)	0.206 H1	--	--	<0.10 UH1	--	--

Appendix A
Soil Vapor Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-trichloro-1,2,2-trifluoroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,2,4-Trichlorobenzene
SD015-SVP-1D	1/5/2022	N	SD015-SVP-1D(01052022)	<6.9 U	<6.9 U	<7.2 U	<6.9 U	<7.1 U	<7.2 U	<15 U
SD015-SVP-1D	9/8/2022	N	SD015-SVP-1D(09082022)	<5.2 U	<5.2 U	<5.4 U	<5.2 U	<5.3 U	<5.4 U	<11 U
SD015-SVP-1D	1/8/2025	N	SD015-SVP-1D(01052025)	<5.3 UJ-H1	<5.3 UJ-H1	<5.4 UJ-H1	<5.3 UJ-H1	<5.4 UJ-H1	<5.4 UJ-H1	<11 UJ-H1
SD015-SVP-1S	1/5/2022	N	SD015-SVP-1S(01052022)	<5.2 U	<5.2 U	<5.4 U	<5.2 U	<5.3 U	<5.4 U	<11 U
SD015-SVP-1S	9/7/2022	N	SD015-SVP-1S(09072022)	<5.2 U	<5.2 U	<5.4 U	<5.2 U	<5.3 U	<5.4 U	<11 U
SD015-SVP-1S	4/26/2023	N	SD015-SVP-1S(042023)	<5.3 U	<5.3 U	<5.4 U	<5.3 U	<5.4 U	<5.4 U	<11 U
SD015-SVP-1S	10/12/2023	N	SD015-SVP-1S(10122023)	<5.3 U	<5.3 U	<5.4 U	<5.3 U	<5.4 U	<5.4 U	<11 U
SD015-SVP-1S	6/26/2024	N	SD015-SVP-1S(06262024)	<5.3 U	<5.3 U	<5.4 U	<5.3 U	<5.4 U	<5.4 U	<11 U
SD015-SVP-1S	1/8/2025	N	SD015-SVP-1S(01052025)	<5.3 UJ-H1	<5.3 UJ-H1	<5.4 UJ-H1	<5.3 UJ-H1	<5.4 UJ-H1	<5.4 UJ-H1	<11 UJ-H1
SD015-SVP-2D	1/5/2022	N	SD015-SVP-2D(01052022)	<5.2 U	<5.2 U	<5.4 U	<5.2 U	<5.3 U	<5.4 U	<11 U
SD015-SVP-2D	1/8/2025	N	SD015-SVP-2D(01052025)	<5.3 U	<5.3 U	<5.4 U	<5.3 U	<5.4 U	<5.4 U	<11 U
SD015-SVP-2S	1/5/2022	N	SD015-SVP-2S(01052022)	<5.2 U	<5.2 U	<5.4 U	<5.2 U	<5.3 U	<5.4 U	<11 U
SD015-SVP-2S	9/7/2022	N	SD015-SVP-2S(09072022)	<5.2 U	<5.2 U	<5.4 U	<5.2 U	<5.3 U	<5.4 U	<11 U
SD015-SVP-2S	4/26/2023	N	SD015-SVP-2S(042023)	<5.3 U	<5.3 U	<5.4 U	<5.3 U	<5.4 U	<5.4 U	<11 U
SD015-SVP-2S	10/12/2023	N	SD015-SVP-2S(10122023)	<53 U	<53 U	<54 U	<53 U	<54 U	<54 U	<110 U
SD015-SVP-2S	6/26/2024	N	SD015-SVP-2S(06262024)	<5.3 U	<5.3 U	<5.4 U	<5.3 U	<5.4 U	<5.4 U	<11 U
SD015-SVP-2S	1/8/2025	N	SD015-SVP-2S(01052025)	<5.3 U	<5.3 U	<5.4 U	<5.3 U	<5.4 U	<5.4 U	<11 U

Appendix A
Soil Vapor Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,2,4-Trimethylbenzene	1,2-Dibromoethane	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,2-Dichlorotetrafluoroethane	1,3,5-Trimethylbenzene
SD015-SVP-1D	1/5/2022	N	SD015-SVP-1D(01052022)	**1.6 J**	<6.9 U	<7.1 U	<7.1 U	<6.7 U	<7.2 U	<6.9 U
SD015-SVP-1D	9/8/2022	N	SD015-SVP-1D(09082022)	<5.2 U	<5.2 U	<5.3 U	<5.3 U	**3.1 J**	<5.4 U	<5.2 U
SD015-SVP-1D	1/8/2025	N	SD015-SVP-1D(01052025)	<5.3 UJ-H1	<5.2 UJ-H1	<5.4 UJ-H1	<5.4 UJ-H1	<5.3 UJ-H1	<5.2 UJ-H1	<5.3 UJ-H1
SD015-SVP-1S	1/5/2022	N	SD015-SVP-1S(01052022)	**1.4 J**	<5.2 U	<5.3 U	<5.3 U	<5.0 U	<5.4 U	<5.2 U
SD015-SVP-1S	9/7/2022	N	SD015-SVP-1S(09072022)	<5.2 U	<5.2 U	<5.3 U	<5.3 U	**2.9 J**	<5.4 U	<5.2 U
SD015-SVP-1S	4/26/2023	N	SD015-SVP-1S(042023)	<5.3 U	<5.2 U	<5.4 U	<5.4 U	**1.8 J**	<5.2 U	<5.3 U
SD015-SVP-1S	10/12/2023	N	SD015-SVP-1S(10122023)	**1.5 J**	<5.2 U	<5.4 U	<5.4 U	**0.67 J**	<5.2 U	<5.3 U
SD015-SVP-1S	6/26/2024	N	SD015-SVP-1S(06262024)	**1.0 J**	<5.2 U	<5.4 U	<5.4 U	<5.3 U	<5.2 U	<5.3 U
SD015-SVP-1S	1/8/2025	N	SD015-SVP-1S(01052025)	**0.84 J-H1**	<5.2 UJ-H1	<5.4 UJ-H1	<5.4 UJ-H1	<5.3 UJ-H1	<5.2 UJ-H1	<5.3 UJ-H1
SD015-SVP-2D	1/5/2022	N	SD015-SVP-2D(01052022)	**1.2 J**	<5.2 U	<5.3 U	<5.3 U	**1.8 J**	<5.4 U	<5.2 U
SD015-SVP-2D	1/8/2025	N	SD015-SVP-2D(01052025)	**0.74 J**	<5.2 U	<5.4 U	<5.4 U	<5.3 U	<5.2 U	<5.3 U
SD015-SVP-2S	1/5/2022	N	SD015-SVP-2S(01052022)	**2.8 J**	<5.2 U	<5.3 U	<5.3 U	**4.2 J**	<5.4 U	<5.2 U
SD015-SVP-2S	9/7/2022	N	SD015-SVP-2S(09072022)	<5.2 U	<5.2 U	<5.3 U	<5.3 U	**3.4 J**	<5.4 U	<5.2 U
SD015-SVP-2S	4/26/2023	N	SD015-SVP-2S(042023)	<5.3 U	<5.2 U	<5.4 U	**0.61 J**	**2.8 J**	<5.2 U	<5.3 U
SD015-SVP-2S	10/12/2023	N	SD015-SVP-2S(10122023)	**14 J**	<52 U	<54 U	<54 U	<53 U	<52 U	<53 U
SD015-SVP-2S	6/26/2024	N	SD015-SVP-2S(06262024)	<5.3 U	<5.2 U	<5.4 U	<5.4 U	**0.89 J**	<5.2 U	<5.3 U
SD015-SVP-2S	1/8/2025	N	SD015-SVP-2S(01052025)	<5.3 U	<5.2 U	<5.4 U	<5.4 U	<5.3 U	<5.2 U	<5.3 U

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Location ID	Sample Date	Sample Type	Sample Name	1,3-Butadiene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	1,4-Dioxane	2-Butanone (MEK)	4-Ethyltoluene	4-Methyl-2-Pentanone	Acetone	Acrolein	Benzene	Benzyl Chloride
SD015-SVP-1D	1/5/2022	N	SD015-SVP-1D(01052022)	<6.9 U	<6.9 U	<6.9 U	<6.9 U	<13 U	<7.1 U	<15 U	<69 U	<13 U	**1.4 J**	<15 U
SD015-SVP-1D	9/8/2022	N	SD015-SVP-1D(09082022)	<5.2 U	<5.2 U	<5.2 U	<5.2 U	**3.4 J**	<5.3 U	<11 U	**23 J**	**2.8 J**	**1.5 J**	<11 U
SD015-SVP-1D	1/8/2025	N	SD015-SVP-1D(01052025)	<5.3 UJ-H1	<5.3 UJ-H1	<5.3 UJ-H1	<5.3 UJ-H1	<10 UJ-H1	<5.5 UJ-H1	<11 UJ-H1	**23 J-H1**	<10 UJ-H1	**2.4 J-H1**	<21 UJ-H1
SD015-SVP-1S	1/5/2022	N	SD015-SVP-1S(01052022)	<5.2 U	<5.2 U	<5.2 U	<5.2 U	<10 U	<5.3 U	<11 U	<52 U	<10 U	**0.77 J**	<11 U
SD015-SVP-1S	9/7/2022	N	SD015-SVP-1S(09072022)	<5.2 U	<5.2 U	<5.2 U	<5.2 U	**6.8 J**	<5.3 U	<11 U	**28 J**	**3.2 J**	**1.1 J**	<11 U
SD015-SVP-1S	4/26/2023	N	SD015-SVP-1S(042023)	<5.3 U	<5.3 U	<5.3 U	<5.3 U	**2.8 J**	<5.5 U	<11 U	**67**	**2.2 J**	**1.4 J**	<21 U
SD015-SVP-1S	10/12/2023	N	SD015-SVP-1S(10122023)	<5.3 U	<5.3 U	<5.3 U	<5.3 U	**7.3 J**	<5.5 U	<11 U	**130**	**4.6 J**	**4.7 J**	<21 U
SD015-SVP-1S	6/26/2024	N	SD015-SVP-1S(06262024)	<5.3 U	<5.3 U	<5.3 U	<5.3 U	**3.0 J**	<5.5 U	<11 U	**120**	<10 U	**2.8 J**	<21 U
SD015-SVP-1S	1/8/2025	N	SD015-SVP-1S(01052025)	<5.3 UJ-H1	<5.3 UJ-H1	<5.3 UJ-H1	<5.3 UJ-H1	<10 UJ-H1	<5.5 UJ-H1	<11 UJ-H1	**28 J-H1**	<10 UJ-H1	**1.4 J-H1**	<21 UJ-H1
SD015-SVP-2D	1/5/2022	N	SD015-SVP-2D(01052022)	<5.2 U	<5.2 U	<5.2 U	<5.2 U	**3.9 J**	<5.3 U	<11 U	**34 J**	**2.0 J**	**2.4 J**	<11 U
SD015-SVP-2D	1/8/2025	N	SD015-SVP-2D(01052025)	<5.3 U	<5.3 U	<5.3 U	<5.3 U	<10 U	<5.5 U	<11 U	**26 J**	<10 U	**2.7 J**	<21 U
SD015-SVP-2S	1/5/2022	N	SD015-SVP-2S(01052022)	<5.2 U	<5.2 U	<5.2 U	<5.2 U	**2.4 J**	<5.3 U	<11 U	**16 J**	<10 U	**1.2 J**	<11 U
SD015-SVP-2S	9/7/2022	N	SD015-SVP-2S(09072022)	<5.2 U	<5.2 U	<5.2 U	<5.2 U	**6.7 J**	<5.3 U	<11 U	**28 J**	**3.3 J**	**1.2 J**	<11 U
SD015-SVP-2S	4/26/2023	N	SD015-SVP-2S(042023)	<5.3 U	<5.3 U	<5.3 U	<5.3 U	**5.8 J**	<5.5 U	<11 U	**87**	**3.3 J**	**2.0 J**	<21 U
SD015-SVP-2S	10/12/2023	N	SD015-SVP-2S(10122023)	<53 U	<53 U	**8.3 J**	<53 U	**15 J**	<55 U	<110 U	<530 U	<100 U	**24 J**	<210 U
SD015-SVP-2S	6/26/2024	N	SD015-SVP-2S(06262024)	<5.3 U	<5.3 U	<5.3 U	<5.3 U	**4.6 J**	<5.5 U	<11 U	**110**	<10 U	**1.4 J**	<21 U
SD015-SVP-2S	1/8/2025	N	SD015-SVP-2S(01052025)	<5.3 U	<5.3 U	<5.3 U	<5.3 U	<10 U	<5.5 U	<11 U	**21 J**	<10 U	**1.7 J**	<21 U

Appendix A
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Location ID	Sample Date	Sample Type	Sample Name	Bromodichloromethane	Bromoform	Bromomethane	Carbon Disulfide	Carbon Tetrachloride	CFC-11	CFC-12	Chlorobenzene	Chlorodibromomethane	Chloroethane	Chloroform
SD015-SVP-1D	1/5/2022	N	SD015-SVP-1D(01052022)	<7.1 U	<6.9 U	<6.8 U	<15 U	<6.7 U	**1.2 J**	**2.5 J**	<6.9 U	<7.1 U	<6.8 U	**10**
SD015-SVP-1D	9/8/2022	N	SD015-SVP-1D(09082022)	<5.3 U	<5.2 U	<5.1 U	<11 U	<5.0 U	**0.92 J**	**2.1 J**	<5.2 U	<5.3 U	<5.1 U	**2.0 J**
SD015-SVP-1D	1/8/2025	N	SD015-SVP-1D(01052025)	<5.4 UJ-H1	<5.4 UJ-H1	<5.1 UJ-H1	<11 UJ-H1	<5.2 UJ-H1	**1.2 J-H1**	**2.2 J-H1**	**1.9 J-H1**	<5.4 UJ-H1	<5.2 UJ-H1	<5.3 UJ-H1
SD015-SVP-1S	1/5/2022	N	SD015-SVP-1S(01052022)	<5.3 U	<5.2 U	<5.1 U	<11 U	<5.0 U	**1.2 J**	**2.4 J**	<5.2 U	<5.3 U	<5.1 U	**2.7 J**
SD015-SVP-1S	9/7/2022	N	SD015-SVP-1S(09072022)	<5.3 U	<5.2 U	<5.1 U	<11 U	<5.0 U	**1.0 J**	**2.1 J**	**1.7 J**	<5.3 U	<5.1 U	**0.72 J**
SD015-SVP-1S	4/26/2023	N	SD015-SVP-1S(042023)	<5.4 U	<5.4 U	<5.1 U	<11 U	<5.2 U	**1.0 J**	**2.3 J**	**5.0 J**	<5.4 U	<5.2 U	<5.3 U
SD015-SVP-1S	10/12/2023	N	SD015-SVP-1S(10122023)	<5.4 U	<5.4 U	<5.1 U	**9.0 J+**	<5.2 U	**1.1 J**	**2.2 J**	**6.1**	<5.4 U	<5.2 U	<5.3 U
SD015-SVP-1S	6/26/2024	N	SD015-SVP-1S(06262024)	<5.4 U	<5.4 U	<5.1 U	<11 U	<5.2 U	**0.90 J**	**1.9 J**	**3.3 J**	<5.4 U	<5.2 U	**0.71 J**
SD015-SVP-1S	1/8/2025	N	SD015-SVP-1S(01052025)	<5.4 UJ-H1	<5.4 UJ-H1	<5.1 UJ-H1	<11 UJ-H1	<5.2 UJ-H1	**1.1 J-H1**	**2.2 J-H1**	<5.3 UJ-H1	<5.4 UJ-H1	<5.2 UJ-H1	**0.91 J-H1**
SD015-SVP-2D	1/5/2022	N	SD015-SVP-2D(01052022)	<5.3 U	<5.2 U	<5.1 U	<11 U	<5.0 U	**1.3 J**	**2.6 J**	**1.1 J**	<5.3 U	<5.1 U	<5.4 U
SD015-SVP-2D	1/8/2025	N	SD015-SVP-2D(01052025)	<5.4 U	<5.4 U	<5.1 U	<11 U	<5.2 U	**1.1 J**	**2.2 J**	**2.0 J**	<5.4 U	<5.2 U	<5.3 U
SD015-SVP-2S	1/5/2022	N	SD015-SVP-2S(01052022)	<5.3 U	<5.2 U	<5.1 U	<11 U	<5.0 U	**1.2 J**	**2.5 J**	<5.2 U	<5.3 U	<5.1 U	<5.4 U
SD015-SVP-2S	9/7/2022	N	SD015-SVP-2S(09072022)	<5.3 U	<5.2 U	<5.1 U	<11 U	<5.0 U	**0.97 J**	**2.1 J**	**0.86 J**	<5.3 U	<5.1 U	<5.4 U
SD015-SVP-2S	4/26/2023	N	SD015-SVP-2S(042023)	<5.4 U	<5.4 U	<5.1 U	<11 U	<5.2 U	**1.1 J**	**2.4 J**	**3.6 J**	<5.4 U	<5.2 U	<5.3 U
SD015-SVP-2S	10/12/2023	N	SD015-SVP-2S(10122023)	<54 U	<54 U	<51 U	<110 U	<52 U	<52 U	**26 J**	<53 U	<54 U	<52 U	<53 U
SD015-SVP-2S	6/26/2024	N	SD015-SVP-2S(06262024)	<5.4 U	<5.4 U	<5.1 U	<11 U	<5.2 U	**1.0 J**	**2.3 J**	**0.99 J**	<5.4 U	<5.2 U	<5.3 U
SD015-SVP-2S	1/8/2025	N	SD015-SVP-2S(01052025)	<5.4 U	<5.4 U	<5.1 U	<11 U	<5.2 U	**1.0 J**	**2.0 J**	<5.3 U	<5.4 U	<5.2 U	<5.3 U

Appendix A
Soil Vapor Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Chloromethane	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	Cyclohexane	Dichloromethane	Ethyl Acetate	Ethylbenzene	Hexachloro-1,3-butadiene	Hexane
SD015-SVP-1D	1/5/2022	N	SD015-SVP-1D(01052022)	<6.8 U	**6.7 J**	<6.7 U	<15 U	**2.4 J**	<28 U	<6.9 U	<6.9 U	<7.1 U
SD015-SVP-1D	9/8/2022	N	SD015-SVP-1D(09082022)	<5.1 U	**24**	<5.0 U	<11 U	<5.2 U	**4.4 J**	**1.2 J**	<5.2 U	<5.3 U
SD015-SVP-1D	1/8/2025	N	SD015-SVP-1D(01052025)	**1.0 J-VH1**	<5.3 UJ-H1	<5.4 UJ-H1	<11 UJ-H1	**3.4 J-H1**	**11 J-H1**	<5.3 UJ-H1	<5.3 UJ-H1	**2.0 J-H1**
SD015-SVP-1S	1/5/2022	N	SD015-SVP-1S(01052022)	<5.1 U	<5.2 U	<5.0 U	<11 U	<5.2 U	<21 U	**0.86 J**	<5.2 U	<5.3 U
SD015-SVP-1S	9/7/2022	N	SD015-SVP-1S(09072022)	<5.1 U	<5.2 U	<5.0 U	**1.7 J**	**1.6 J**	**5.1 J**	**1.6 J**	<5.2 U	<5.3 U
SD015-SVP-1S	4/26/2023	N	SD015-SVP-1S(042023)	<5.2 U	<5.3 U	<5.4 U	<11 U	**2.0 J**	**3.9 J**	**1.4 J**	<5.3 U	<5.3 U
SD015-SVP-1S	10/12/2023	N	SD015-SVP-1S(10122023)	**1.7 J**	**1.3 J**	<5.4 U	**14**	**3.5 J**	**6.6 J**	**2.5 J**	<5.3 U	**12**
SD015-SVP-1S	6/26/2024	N	SD015-SVP-1S(06262024)	<5.2 U	<5.3 U	<5.4 U	<11 U	<5.3 U	<21 U	**1.9 J**	<5.3 UV	**2.8 J**
SD015-SVP-1S	1/8/2025	N	SD015-SVP-1S(01052025)	<5.2 UJ-VH1	<5.3 UJ-H1	<5.4 UJ-H1	<11 UJ-H1	**4.3 J-H1**	**18 J-H1**	<5.3 UJ-H1	<5.3 UJ-H1	**2.7 J-H1**
SD015-SVP-2D	1/5/2022	N	SD015-SVP-2D(01052022)	**1.6 J**	<5.2 U	<5.0 U	<11 U	**4.0 J**	**3.5 J**	**1.8 J**	<5.2 U	<5.3 U
SD015-SVP-2D	1/8/2025	N	SD015-SVP-2D(01052025)	**1.1 JV**	<5.3 U	<5.4 U	<11 U	**4.2 J**	**14 J**	<5.3 U	<5.3 U	**2.3 J**
SD015-SVP-2S	1/5/2022	N	SD015-SVP-2S(01052022)	<5.1 U	<5.2 U	<5.0 U	<11 U	**2.9 J**	**3.7 J**	**1.7 J**	<5.2 U	<5.3 U
SD015-SVP-2S	9/7/2022	N	SD015-SVP-2S(09072022)	<5.1 U	<5.2 U	<5.0 U	<11 U	<5.2 U	**4.3 J**	**1.3 J**	<5.2 U	<5.3 U
SD015-SVP-2S	4/26/2023	N	SD015-SVP-2S(042023)	<5.2 U	<5.3 U	<5.4 U	**2.8 J**	**2.3 J**	**11 J**	**1.9 J**	<5.3 U	<5.3 U
SD015-SVP-2S	10/12/2023	N	SD015-SVP-2S(10122023)	<52 U	**110**	<54 U	**35 J**	**17 J**	<210 U	**27 J**	<53 U	**33 J**
SD015-SVP-2S	6/26/2024	N	SD015-SVP-2S(06262024)	<5.2 U	<5.3 U	<5.4 U	**2.1 J**	<5.3 U	<21 U	**1.7 J**	<5.3 UV	**3.2 J**
SD015-SVP-2S	1/8/2025	N	SD015-SVP-2S(01052025)	<5.2 UV	<5.3 U	<5.4 U	<11 U	**2.9 J**	**12 J**	<5.3 U	<5.3 U	**1.5 J**

Appendix A
Soil Vapor Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Isopropyl alcohol	m&p-Xylenes	Methyl N-Butyl Ketone (2-Hexanone)	Methyl-tert-butylether	Naphthalene	n-Heptane	o-Xylene	Styrene (Monomer)	Tetrachloroethene
SD015-SVP-1D	1/5/2022	N	SD015-SVP-1D(01052022)	**3.1 J**	**2.6 J**	<15 U	<7.1 U	<6.9 U	<7.1 U	**1.4 J**	<6.7 U	<6.9 U
SD015-SVP-1D	9/8/2022	N	SD015-SVP-1D(09082022)	**36**	**3.4 J**	<11 U	<5.3 U	<5.2 U	**1.6 J**	**1.8 J**	**0.91 J**	<5.2 U
SD015-SVP-1D	1/8/2025	N	SD015-SVP-1D(01052025)	**37 J-H1**	**1.8 J-H1**	<11 UJ-H1	<5.4 UJ-H1	<5.5 UJ-H1	**0.85 J-H1**	**0.79 J-H1**	<5.3 UJ-H1	**17 J-H1**
SD015-SVP-1S	1/5/2022	N	SD015-SVP-1S(01052022)	<10 U	**3.1 J**	<11 U	<5.3 U	<5.2 U	<5.3 U	**1.4 J**	<5.0 U	<5.2 U
SD015-SVP-1S	9/7/2022	N	SD015-SVP-1S(09072022)	**37**	**4.4 J**	<11 U	<5.3 U	<5.2 U	**3.7 J**	**3.1 J**	**2.9 J**	**2.0 J**
SD015-SVP-1S	4/26/2023	N	SD015-SVP-1S(042023)	**13**	**3.7 J**	<11 U	<5.4 U	<5.5 U	**42**	**1.9 J**	**0.93 J**	<5.3 U
SD015-SVP-1S	10/12/2023	N	SD015-SVP-1S(10122023)	**58**	**6.3 J**	<11 U	<5.4 U	<5.5 U	**7.1**	**2.7 J**	**6.8**	**460**
SD015-SVP-1S	6/26/2024	N	SD015-SVP-1S(06262024)	**9.8 J**	**4.5 J**	<11 U	<5.4 U	<5.5 U	**11**	**1.6 J**	**0.92 J**	**0.79 J**
SD015-SVP-1S	1/8/2025	N	SD015-SVP-1S(01052025)	**74 J-H1**	**2.3 J-H1**	<11 UJ-H1	<5.4 UJ-H1	<5.5 UJ-H1	**1.0 J-H1**	**0.97 J-H1**	<5.3 UJ-H1	**2.3 J-H1**
SD015-SVP-2D	1/5/2022	N	SD015-SVP-2D(01052022)	**9.8 J**	**4.7 J**	<11 U	<5.3 U	<5.2 U	**2.2 J**	**2.1 J**	**3.7 J**	<5.2 U
SD015-SVP-2D	1/8/2025	N	SD015-SVP-2D(01052025)	**23**	**1.9 J**	<11 U	<5.4 U	<5.5 U	<5.3 U	**0.81 J**	<5.3 U	**16**
SD015-SVP-2S	1/5/2022	N	SD015-SVP-2S(01052022)	**14**	**6.3 J**	<11 U	<5.3 U	<5.2 U	**2.4 J**	**2.8 J**	<5.0 U	<5.2 U
SD015-SVP-2S	9/7/2022	N	SD015-SVP-2S(09072022)	**32**	**3.1 J**	<11 U	<5.3 U	<5.2 U	**3.0 J**	**1.7 J**	**0.90 J**	**1.0 J**
SD015-SVP-2S	4/26/2023	N	SD015-SVP-2S(042023)	**41**	**5.1 J**	<11 U	<5.4 U	<5.5 U	**22**	**2.3 J**	**1.1 J**	<5.3 U
SD015-SVP-2S	10/12/2023	N	SD015-SVP-2S(10122023)	**69 J**	**34 J**	<110 U	<54 U	<55 U	**19 J**	**14 J**	<53 U	**5700**
SD015-SVP-2S	6/26/2024	N	SD015-SVP-2S(06262024)	**10 J**	**4.6 J**	<11 U	<5.4 U	<5.5 U	**9.8**	**1.3 J**	**1.4 J**	<5.3 U
SD015-SVP-2S	1/8/2025	N	SD015-SVP-2S(01052025)	**52**	**1.6 J**	<11 U	<5.4 U	<5.5 U	<5.3 U	<5.3 U	<5.3 U	**1.8 J**

Appendix A
Soil Vapor Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Tetrahydrofuran	Toluene	trans-1,2-Dichloroethene	trans-1,3-Dichloropropene	Trichloroethene	Vinyl acetate	Vinyl chloride
SD015-SVP-1D	1/5/2022	N	SD015-SVP-1D(01052022)	<13 U	**4.2 J**	<7.1 U	<6.8 U	**890**	<67 U	<6.9 U
SD015-SVP-1D	9/8/2022	N	SD015-SVP-1D(09082022)	**1.1 J**	**30**	<5.3 U	<5.1 U	**230**	<50 U	<5.2 U
SD015-SVP-1D	1/8/2025	N	SD015-SVP-1D(01052025)	**2.6 J-H1**	**7.8 J-H1**	<5.4 UJ-H1	<5.1 UJ-H1	**2.5 J-H1**	<50 UJ-H1	<5.1 UJ-H1
SD015-SVP-1S	1/5/2022	N	SD015-SVP-1S(01052022)	<10 U	**3.4 J**	<5.3 U	<5.1 U	**150**	<50 U	<5.2 U
SD015-SVP-1S	9/7/2022	N	SD015-SVP-1S(09072022)	**3.4 J**	**26**	<5.3 U	<5.1 U	**23**	--	<5.2 U
SD015-SVP-1S	4/26/2023	N	SD015-SVP-1S(042023)	**4.6 J**	**24**	<5.4 U	<5.1 U	**1.1 J**	<50 U	<5.1 U
SD015-SVP-1S	10/12/2023	N	SD015-SVP-1S(10122023)	**4.8 J**	**100**	<5.4 U	<5.1 U	**1.9 J**	<50 U	<5.1 U
SD015-SVP-1S	6/26/2024	N	SD015-SVP-1S(06262024)	**5.3 J**	**13**	<5.4 U	<5.1 U	**0.79 J**	<50 U	<5.1 U
SD015-SVP-1S	1/8/2025	N	SD015-SVP-1S(01052025)	<10 UJ-H1	**9.2 J-H1**	<5.4 UJ-H1	<5.1 UJ-H1	**2.1 J-H1**	<50 UJ-H1	<5.1 UJ-H1
SD015-SVP-2D	1/5/2022	N	SD015-SVP-2D(01052022)	**2.2 J**	**26**	<5.3 U	<5.1 U	**15**	<50 U	<5.2 U
SD015-SVP-2D	1/8/2025	N	SD015-SVP-2D(01052025)	**2.2 J**	**9.0**	<5.4 U	<5.1 U	**1.6 J**	<50 U	<5.1 U
SD015-SVP-2S	1/5/2022	N	SD015-SVP-2S(01052022)	**1.4 J**	**35**	<5.3 U	<5.1 U	**6.7**	<50 U	<5.2 U
SD015-SVP-2S	9/7/2022	N	SD015-SVP-2S(09072022)	**1.5 J**	**28**	<5.3 U	<5.1 U	<5.2 U	--	<5.2 U
SD015-SVP-2S	4/26/2023	N	SD015-SVP-2S(042023)	**4.7 J**	**34**	<5.4 U	<5.1 U	<5.3 U	<50 U	<5.1 U
SD015-SVP-2S	10/12/2023	N	SD015-SVP-2S(10122023)	**22 J**	**330**	<54 U	<51 U	**34 J**	<500 U	**120**
SD015-SVP-2S	6/26/2024	N	SD015-SVP-2S(06262024)	**3.8 J**	**11**	<5.4 U	<5.1 U	<5.3 U	<50 U	<5.1 U
SD015-SVP-2S	1/8/2025	N	SD015-SVP-2S(01052025)	<10 U	**6.7**	<5.4 U	<5.1 U	<5.3 U	<50 U	<5.1 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,1,1,2-Tetrachloroethane	1,1,1,2-Tetrachloroethane (Total)	1,1,1-Trichloroethane	1,1,1-Trichloroethane (Total)	1,1,2,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane (Total)	1,1,2-trichloro-1,2,2-trifluoroethane	1,1,2-trichloro-1,2,2-trifluoroethane (Total)	1,1,2-Trichloroethane	1,1,2-Trichloroethane (Total)
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.28 J	--
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	0.37 J	--
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.18 J	--
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	<0.50	--	<1.0	--	<1.0	--	<1.0	--	<1.0	--
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	--	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U
15-MW-48	3/18/2024	FD	SD015-DUP1	--	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15MW8	1/12/2023	N	SD015-15MW8(01122023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15MW8	4/26/2023	N	SD015-15MW8(04262023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	<0.50	--	<1.0	--	<1.0	--	<1.0	--	<1.0	--
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	<0.50 U	--	<1.0 U	--	0.12 J	--	<1.0 U	--	<1.0 U	--
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.22 J	--
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.31 J	--
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	0.65 J	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.54 J	--
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.55 J	--
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.60 J	--
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.52 J	--
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.52 J	--
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.43 J	--
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.38 J	--
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	0.17 J	--
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.66 J	--
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.86 J	--
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.83 J	--
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	<0.50	--	<1.0	--	<1.0	--	<1.0	--	<1.0	--
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	<0.50	--	<1.0	--	<1.0	--	<1.0	--	<1.0	--
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,1,1,2-Tetrachloroethane	1,1,1,2-Tetrachloroethane (Total)	1,1,1-Trichloroethane	1,1,1-Trichloroethane (Total)	1,1,2,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane (Total)	1,1,2-trichloro-1,2,2-trifluoroethane	1,1,2-trichloro-1,2,2-trifluoroethane (Total)	1,1,2-Trichloroethane	1,1,2-Trichloroethane (Total)
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.19 J	--
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.23 J	--
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.92 J	--
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.81 J	--
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.55 J	--
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	<0.50 U	--	0.22 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.31 J	--
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.25 J	--
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.47 J	--
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	<2.5 U	--	<5 U	--	<5 U	--	<5 U	--	<5 U	--
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.96 J	--
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	<0.5 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.44 J	--
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	<0.50 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	0.67 J	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,1-Dichloroethane	1,1-Dichloroethane (Total)	1,1-Dichloroethene	1,1-Dichloroethene (Total)	1,1-Dichloropropene	1,1-Dichloropropene (Total)	1,2,3-Trichlorobenzene	1,2,3-Trichlorobenzene (Total)	1,2,3-Trichloropropane	1,2,3-Trichloropropane (Total)	1,2,4-Trichlorobenzene	1,2,4-Trichlorobenzene (Total)
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	<1.0 U	--	2.5	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	<1 U	--	1.5	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	<1.0 U	--	0.64 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	<1.0 U	--	0.42 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	<1.0 U	--	0.19 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	<1.0 U	--	0.33 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	<1.0	--	0.59 J	--	<1.0	--	<1.0	--	<2.0	--	<1.0	--
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	--	<1.0 U	--	0.13 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U
15-MW-48	3/18/2024	FD	SD015-DUP1	--	<1.0 U	--	0.13 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	<1.0 U	--	0.10 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15MW8	1/12/2023	N	SD015-15MW8(01122023)	<1 U	--	0.13 J	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15MW8	4/26/2023	N	SD015-15MW8(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<2.0	--	<1.0	--
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	<1.0 U	--	2.4	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	<1.0 U	--	9.5	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	<1 U	--	11	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	<1.0 U	--	9.6	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	<1.0 U	--	9.6	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	<1.0 U	--	8.3	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	<1.0 U	--	9.9	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	<1.0 U	--	10	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	<1.0 U	--	5.1	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	<1.0 U	--	0.10 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	<1.0 U	--	0.17 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	<1.0 U	--	0.39 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	<1 U	--	0.67 J	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	<1.0 U	--	0.81 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	<1.0 U	--	0.22 J	--	<1.0 U	--	<1.0 U	--	0.81 J	--	<1.0 U	--
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	<1.0 U	--	0.28 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	<1.0 U	--	0.21 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	<1.0 U	--	3.0	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	<1.0 U	--	0.30 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	<1.0 U	--	0.76 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	<1 U	--	1.1	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	<1.0 U	--	5.2	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	<1.0 U	--	5.8	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	<1.0 U	--	2.0	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	<1.0 U	--	5.7	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	<1.0 U	--	5.7	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	<1.0	--	12	--	<1.0	--	<1.0	--	<2.0	--	<1.0	--
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	<1.0	--	13	--	<1.0	--	<1.0	--	<2.0	--	<1.0	--
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,1-Dichloroethane	1,1-Dichloroethane (Total)	1,1-Dichloroethene	1,1-Dichloroethene (Total)	1,1-Dichloropropene	1,1-Dichloropropene (Total)	1,2,3-Trichlorobenzene	1,2,3-Trichlorobenzene (Total)	1,2,3-Trichloropropane	1,2,3-Trichloropropane (Total)	1,2,4-Trichlorobenzene	1,2,4-Trichlorobenzene (Total)
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	<1.0 U	--	0.12 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	<1.0 U	--	2.1	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	<1.0 U	--	2.7	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	<1.0 U	--	2.2	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	<1 U	--	3.2	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	<1.0 U	--	7.9	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	<1.0 U	--	5.8	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	<1.0 U	--	6.2	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	<1.0 U	--	6.9	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	<1.0 U	--	0.19 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	<1.0 U	--	0.63 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	<1.0 U	--	2.4	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	<1 U	--	2.8	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	<1.0 U	--	5.2	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	<1.0 U	--	6.5	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	<5 U	--	7.2	--	<5 U	--	<5 U	--	<10 U	--	<5 U	--
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	<1.0 U	--	0.15 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	<1.0 U	--	0.24 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	<1.0 U	--	0.71 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	<1.0 U	--	0.11 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	<1.0 U	--	0.22 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<2 U	--	<1 U	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	<1.0 U	--	0.88 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	<1.0 U	--	0.21 J	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	<1.0 U	--	5.8	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	<1.0 U	--	5.8	--	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,2,4-Trimethylbenzene	1,2,4-Trimethylbenzene (Total)	1,2-Dibromo-3-chloropropane	1,2-Dibromo-3-chloropropane (Total)	1,2-Dibromoethane	1,2-Dibromoethane (Total)	1,2-Dichlorobenzene	1,2-Dichlorobenzene (Total)	1,2-Dichloroethane	1,2-Dichloroethane (Total)	1,2-Dichloropropane	1,2-Dichloropropane (Total)
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	0.11 J	--	<1 U	--
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.12 J	--	<1.0 U	--
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	<1.0	--	<2.0	--	<1.0	--	<1.0	--	<0.50	--	<1.0	--
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U
15-MW-48	3/18/2024	FD	SD015-DUP1	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15MW8	1/12/2023	N	SD015-15MW8(01122023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	<0.5 U	--	<1 U	--
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15MW8	4/26/2023	N	SD015-15MW8(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	<1.0	--	<2.0	--	<1.0	--	<1.0	--	<0.50	--	<1.0	--
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.12 J	--	<1.0 U	--
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.11 J	--	<1.0 U	--
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	0.15 J	--	<1 U	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.14 J	--	<1.0 U	--
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.13 J	--	<1.0 U	--
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.15 J	--	<1.0 U	--
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.17 J	--	<1.0 U	--
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	<0.5 U	--	<1 U	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	0.38 J	--
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	<0.5 U	--	<1 U	--
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	<1.0	--	<2.0	--	<1.0	--	<1.0	--	<0.50	--	<1.0	--
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	<1.0	--	<2.0	--	<1.0	--	<1.0	--	<0.50	--	<1.0	--
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	<0.5 U	--	<1 U	--
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	<0.5 U	--	<1 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,2,4-Trimethylbenzene	1,2,4-Trimethylbenzene (Total)	1,2-Dibromo-3-chloropropane	1,2-Dibromo-3-chloropropane (Total)	1,2-Dibromoethane	1,2-Dibromoethane (Total)	1,2-Dichlorobenzene	1,2-Dichlorobenzene (Total)	1,2-Dichloroethane	1,2-Dichloroethane (Total)	1,2-Dichloropropane	1,2-Dichloropropane (Total)
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	0.10 J	--	<1 U	--
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.12 J	--	<1.0 U	--
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.13 J	--	<1.0 U	--
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	0.14 J	--	<1 U	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	<5 U	--	<10 U	--	<5 U	--	<5 U	--	<2.5 U	--	<5 U	--
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	<1 U	--	<2 U	--	<1 U	--	<1 U	--	<0.5 U	--	<1 U	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.21 J	--	<1.0 U	--
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<0.50 U	--	<1.0 U	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,3,5-Trimethylbenzene	1,3,5-Trimethylbenzene (Total)	1,3-Dichlorobenzene	1,3-Dichlorobenzene (Total)	1,3-Dichloropropane	1,3-Dichloropropane (Total)	1,4-Dichlorobenzene	1,4-Dichlorobenzene (Total)	2,2-Dichloropropane	2,2-Dichloropropane (Total)	2-Butanone (MEK)	2-Butanone (MEK) (Total)	2-Chlorotoluene
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	7.8 J	--	<1.0 U
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	29	--	<1.0 U
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<20	--	<1.0
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--
15-MW-48	3/18/2024	FD	SD015-DUP1	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	6.0 J	--	<1.0 U
15MW8	1/12/2023	N	SD015-15MW8(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15MW8	4/26/2023	N	SD015-15MW8(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<20	--	<1.0
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	210	--	<1.0 U
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	1300	--	<1.0 U
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	310	--	<1.0 U
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	140	--	<1.0 U
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	6.5 J	--	<1.0 U
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<20	--	<1.0
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<1.0	--	<20	--	<1.0
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	1,3,5-Trimethylbenzene	1,3,5-Trimethylbenzene (Total)	1,3-Dichlorobenzene	1,3-Dichlorobenzene (Total)	1,3-Dichloropropane	1,3-Dichloropropane (Total)	1,4-Dichlorobenzene	1,4-Dichlorobenzene (Total)	2,2-Dichloropropane	2,2-Dichloropropane (Total)	2-Butanone (MEK)	2-Butanone (MEK) (Total)	2-Chlorotoluene
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	2800	--	<1.0 U
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	460	--	<1.0 U
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	15 J	--	<1.0 U
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	19 J	--	<1.0 U
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	3400	--	<1.0 U
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	45	--	<1.0 U
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	<5 U	--	<5 U	--	<5 U	--	<5 U	--	<5 U	--	<100 U	--	<5 U
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	1800	--	<1.0 U
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	5.1 J	--	<1.0 U
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<1 U	--	<20 U	--	<1 U
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	160	--	<1.0 U
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	9.9 J	--	<1.0 U
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<20 U	--	<1.0 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	2-Chlorotoluene (Total)	4-Chlorotoluene	4-Chlorotoluene (Total)	4-Methyl-2-Pentanone	4-Methyl-2-Pentanone (Total)	Acetone	Acetone (Total)	Acetylene	Alkalinity (as CaCO3)	Benzene	Benzene (Total)	Bromide	Bromobenzene	Bromobenzene (Total)	Bromochloromethane	Bromochloromethane (Total)
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	--	<1.0 U	--	<20 U	--	11 J	--	<2.0 U	113000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	105000	<1 U	--	1640 J	<1 U	--	<1 U	--
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	65400	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	--	<1.0 U	--	<20 U	--	8.5 J	--	<2.0 U	25000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	--	<1.0 U	--	<20 U	--	38	--	<2.0 U	185000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	--	<1.0	--	<20	--	<20	--	<2.0	249000	<1.0	--	--	<1.0	--	<1.0	--
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	<1.0 U	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U
15-MW-48	3/18/2024	FD	SD015-DUP1	<1.0 U	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	--	<1.0 U	--	<20 U	--	5.2 J	--	<2.0 U	112000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15MW8	1/12/2023	N	SD015-15MW8(01122023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	72700	<1 U	--	448 J	<1 U	--	<1 U	--
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15MW8	4/26/2023	N	SD015-15MW8(04262023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	26800	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	91000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	--	<1.0 U	--	<20 U	--	25	--	<2.0 U	120000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	--	<1.0	--	<20	--	<20	--	<2.0	119000	<1.0	--	--	<1.0	--	<1.0	--
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	238000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	215000	<1 U	--	1940 J	<1 U	--	<1 U	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	146000	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	125000	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	54300	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	139000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	--	<1.0 U	--	<20 U	--	18 J	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	--	<1.0 U	--	<20 U	--	5.4 J	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	242000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	--	<1.0 U	--	9.2 J	--	<20 U	--	<2.0 U	<5000 U	<1.0 U	--	--	<1.0 U	--	0.22 J	--
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	--	<1.0 U	--	88	--	860	--	<2.0 U	<5000 U	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	294000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	134000	<1 U	--	<2500 U	<1 U	--	<1 U	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	2820	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	3620	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	3920	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	12700	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	--	<1.0 U	--	<20 U	--	7.9 J	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	--	<1.0 U	--	<20 U	--	5.4 J	--	<2.0 U	28700	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	--	<1.0 U	--	<20 U	--	78	--	<2.0 U	432000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	--	<1.0 U	--	<20 U	--	120	--	<2.0 U	194000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	115000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	96900	<1 U	--	479 J	<1 U	--	<1 U	--
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	49500	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	--	<1.0 U	--	<20 U	--	8.6 J	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	--	<1.0 U	--	<20 U	--	12 J	--	<2.0 U	108000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	--	<1.0 U	--	<20 U	--	6.0 J	--	<2.0 U	74100	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	--	<1.0	--	<20	--	<20	--	<2.0	436000	<1.0	--	--	<1.0	--	<1.0	--
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	--	<1.0	--	<20	--	190	--	<2.0	430000	<1.0	--	--	<1.0	--	<1.0	--
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	76800	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	58400	<1 U	--	436 J	<1 U	--	<1 U	--
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	57400	<1 U	--	436 J	<1 U	--	<1 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	13100	<1.0 U	--	--	<1.0 U	--	<1.0 U	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	2-Chlorotoluene (Total)	4-Chlorotoluene	4-Chlorotoluene (Total)	4-Methyl-2-Pentanone	4-Methyl-2-Pentanone (Total)	Acetone	Acetone (Total)	Acetylene	Alkalinity (as CaCO3)	Benzene	Benzene (Total)	Bromide	Bromobenzene	Bromobenzene (Total)	Bromochloromethane	Bromochloromethane (Total)
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	11600	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	--	<1.0 U	--	<20 U	--	6.3 J	--	<2.0 U	92600	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	--	<1.0 U	--	<20 U	--	350	--	<2.0 U	762000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	92600	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	104000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	--	<1.0 U	--	<20 U	--	5.7 J	--	<2.0 U	100000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	154000	<1 U	--	948 J	<1 U	--	<1 U	--
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	107000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	81400	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	<5000 U	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	--	<1.0 U	--	28	--	32	--	<2.0 U	2600000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	204000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	--	<1 U	--	<20 U	--	170	--	<2 U	90300	<1 U	--	476 J	<1 U	--	<1 U	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	36400	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	14400	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	--	<1.0 U	--	8.1 J	--	1100	--	<2.0 U	<5000 U	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	--	<1.0 U	--	<20 U	--	57	--	<2.0 U	723000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	--	<1.0 U	--	<20 U	--	6.1 J	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	297000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	--	<5 U	--	<100 U	--	<100 U	--	<2 U	175000	<5 U	--	2090 J	<5 U	--	<5 U	--
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	45900	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	21300	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	18900	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	--	<1.0 U	--	<20 U	--	21	--	<2.0 U	136000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	84000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	--	<1.0 U	--	5.6 J	--	450	--	<2.0 U	406000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	--	<1.0 U	--	<20 U	--	16 J	--	<2.0 U	926000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	73200	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	--	<1 U	--	<20 U	--	<20 U	--	<2 U	37200	<1 U	--	479 J	<1 U	--	<1 U	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	3810	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	6040	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	3980	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	--	<1.0 U	--	<20 U	--	<20 U	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	24800	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	--	<1.0 U	--	<20 U	--	6.9 J	--	--	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	--	<1.0 U	--	<20 U	--	6.4 J	--	<2.0 U	20400	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	--	<1.0 U	--	<20 U	--	20 J	--	<2.0 U	152000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	--	<1.0 U	--	<20 U	--	12 J	--	<2.0 U	70500	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	162000	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	166000	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	167000	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	169000	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	165000	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	168000	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	--	<1.0 U	--	<20 U	--	<20 U	--	<2.0 U	237000	<1.0 U	--	--	<1.0 U	--	<1.0 U	--
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	--	<1.0 U	--	<20 U	--	5.0 J	--	<2.0 U	9610	<1.0 U	--	--	<1.0 U	--	<1.0 U	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Bromodichloromethane	Bromodichloromethane (Total)	Bromoform	Bromoform (Total)	Bromomethane	Bromomethane (Total)	Carbon Dioxide	Carbon Disulfide	Carbon Disulfide (Total)	Carbon Tetrachloride	Carbon Tetrachloride (Total)	CFC-11	CFC-11 (Total)	CFC-12	CFC-12 (Total)	Chloride	Chlorobenzene
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	0.55 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	92100	<1.0 U
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	<1 U	--	<1 U	--	<1 U	--	190000	0.60 J	--	<1 U	--	<1 U	--	<1 U	--	94600	<1 U
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	100000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	69800	<1.0 U
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	70000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	54600	<1.0 U
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	140000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	88800	<1.0 U
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	<1.0	--	<1.0	--	<1.0	--	230000	<1.0	--	<1.0	--	<1.0	--	<1.0	--	96300	<1.0
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
15-MW-48	3/18/2024	FD	SD015-DUP1	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	68000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	65900	<1.0 U
15MW8	1/12/2023	N	SD015-15MW8(01122023)	<1 U	--	<1 U	--	<1 U	--	47000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	60800	<1 U
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
15MW8	4/26/2023	N	SD015-15MW8(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	87000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	56900	<1.0 U
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	44000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	56900	<1.0 U
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	50000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	58800	<1.0 U
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	<1.0	--	<1.0	--	<1.0	--	51000	<1.0	--	<1.0	--	<1.0	--	<1.0	--	53000	<1.0
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	0.50 J	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	0.13 J	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	2.8	--	6.0	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	1.4	--	3.6	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	1.2	--	2.8	--	<1.0 U	--	--	0.29 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	1.1	--	0.95 J	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	0.93 J	--	0.34 J	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	1.1	--	0.70 J	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	230000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	105000	<1.0 U
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	0.58 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	100000	<1.0 U
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	120000	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	<1 U	--	<1 U	--	<1 U	--	220000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	92000	<1 U
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	130000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	85800	<1.0 U
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	250000	0.56 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	86700	<1.0 U
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	890000	1.4	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	217000	<1.0 U
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	620000	1.5	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	278000	<1.0 U
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	240000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	95100	<1.0 U
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	0.26 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	101000	<1.0 U
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	390000	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	<1 U	--	<1 U	--	<1 U	--	150000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	94500	<1 U
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	34000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	44100	<1.0 U
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	30000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	47200	<1.0 U
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	340000	0.70 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	93800	<1.0 U
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	330000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	62800	<1.0 U
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	150000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	110000	<1.0 U
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	88000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	72300	<1.0 U
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	<1 U	--	<1 U	--	<1 U	--	120000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	68800	<1 U
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	380000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	99500	<1.0 U
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	300000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	96400	<1.0 U
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	350000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	90800	<1.0 U
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	<1.0	--	<1.0	--	<1.0	--	550000	1.4	--	<1.0	--	<1.0	--	<1.0	--	132000	<1.0
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	<1.0	--	<1.0	--	<1.0	--	620000	1.5	--	<1.0	--	<1.0	--	<1.0	--	138000	<1.0
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	100000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	73600	<1.0 U
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	72000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	61500	<1.0 U
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	<1 U	--	<1 U	--	<1 U	--	70000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	66900	<1 U
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	<1 U	--	<1 U	--	<1 U	--	61000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	70900	<1 U
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	34000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	30300	<1.0 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Bromodichloromethane	Bromodichloromethane (Total)	Bromoform	Bromoform (Total)	Bromomethane	Bromomethane (Total)	Carbon Dioxide	Carbon Disulfide	Carbon Disulfide (Total)	Carbon Tetrachloride	Carbon Tetrachloride (Total)	CFC-11	CFC-11 (Total)	CFC-12	CFC-12 (Total)	Chloride	Chlorobenzene
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	28000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	28800	<1.0 U
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	120000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	59100	<1.0 U
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	310000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	225000	<1.0 U
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	160000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	60700	<1.0 U
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	190000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	96800	<1.0 U
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	290000	0.37 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	91600	<1.0 U
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	260000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	85500	<1.0 U
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	<1 U	--	<1 U	--	<1 U	--	260000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	90600	<1 U
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	360000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	106000	<1.0 U
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	240000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	86300	<1.0 U
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	720000	1.9	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	214000	<1.0 U
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	430000	2.3	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	499000	<1.0 U
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	100000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	79300	<1.0 U
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	91000	0.88 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	63200	<1.0 U
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	<1 U	--	<1 U	--	<1 U	--	110000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	68100	<1 U
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	76000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	66700	<1.0 U
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	47000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	44200	<1.0 U
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	440000	0.73 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	151000	<1.0 U
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	380000	0.42 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	309000	<1.0 U
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	750000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	237000	<1.0 U
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	0.32 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	180000	<1.0 U
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	620000	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	<5 U	--	<5 U	--	<5 U	--	440000	<5 U	--	<5 U	--	<5 U	--	<5 U	--	117000	<5 U
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	74000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	76900	<1.0 U
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	97000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	61400	<1.0 U
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	550000	0.43 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	148000	<1.0 U
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	770000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	244000	<1.0 U
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	87000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	70600	<1.0 U
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	75500	<1.0 U
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	330000	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	<1 U	--	<1 U	--	<1 U	--	59000	<1 U	--	<1 U	--	<1 U	--	<1 U	--	62800	<1 U
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	45000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	62700	<1.0 U
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<1.0 U
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	24000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	40600	<1.0 U
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	310000	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	60100	<1.0 U
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	<1.0 U	--	<1.0 U	--	<1.0 U	--	150000	0.28 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	57600	<1.0 U
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	260000	0.64 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	88800	<1.0 U
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	<1.0 U	--	<1.0 U	--	<1.0 U	--	290000	0.35 J	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	93700	<1.0 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Chlorobenzene (Total)	Chlorodibromomethane	Chlorodibromomethane (Total)	Chloroethane	Chloroethane (Total)	Chloroform	Chloroform (Total)	Chloromethane	Chloromethane (Total)	cis-1,2-Dichloroethene	cis-1,2-Dichloroethene (Total)	cis-1,3-Dichloropropene	cis-1,3-Dichloropropene (Total)	Conductivity (uS/cm)
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	410.000000
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	393.000000
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--	656.000000
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	--	<1.0 U	--	15	--	<1.0 U	--	<1.0 U	--	2200	--	<1.0 U	--	--
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	--	<1 U	--	26	--	<1 U	--	<1 U	--	1400	--	<1 U	--	--
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	--	<1.0 U	--	10	--	<1.0 U	--	<1.0 U	--	400	--	<1.0 U	--	--
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	--	<1.0 U	--	12	--	<1.0 U	--	<1.0 U	--	380	--	<1.0 U	--	--
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	--	<1.0 U	--	2.3	--	<1.0 U	--	<1.0 U	--	62	--	<1.0 U	--	--
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	--	<1.0 U	--	2.2	--	<1.0 U	--	<1.0 U	--	200	--	<1.0 U	--	--
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	--	<1.0 U	--	7.3	--	<1.0 U	--	<1.0 U	--	15	--	<1.0 U	--	--
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	--	<1.0	--	<2.0	--	<1.0	--	<1.0	--	800	--	<1.0	--	--
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.14 J	--	<1.0 U	565.000000
15-MW-48	3/18/2024	FD	SD015-DUP1	<1.0 U	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.16 J	--	<1.0 U	--
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	52	--	<1.0 U	--	--
15MW8	1/12/2023	N	SD015-15MW8(01122023)	--	<1 U	--	<2 U	--	<1 U	--	<1 U	--	74	--	<1 U	--	--
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	5.9	--	<1.0 U	--	--
15MW8	4/26/2023	N	SD015-15MW8(04262023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	2.6	--	<1.0 U	--	--
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	--	<1.0 U	--	6.5	--	<1.0 U	--	0.32 J	--	21	--	<1.0 U	--	--
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	--	<1.0 U	--	2.0	--	<1.0 U	--	<1.0 U	--	15	--	<1.0 U	--	--
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	--	<1.0 U	--	1.2 J	--	<1.0 U	--	<1.0 U	--	32	--	<1.0 U	--	--
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	--	<1.0	--	<2.0	--	<1.0	--	<1.0	--	0.17 J	--	<1.0	--	--
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	--	0.34 J	--	<2.0 U	--	0.33 J	--	<1.0 U	--	2.9	--	<1.0 U	--	--
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.18 J	--	<1.0 U	--	--
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	--	<1.0 U	--	<2.0 U	--	0.14 J	--	<1.0 U	--	0.43 J	--	<1.0 U	--	--
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	--	5.9	--	<2.0 U	--	0.56 J	--	<1.0 U	--	12	--	<1.0 U	--	--
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	--	3.0	--	<2.0 U	--	0.26 J	--	<1.0 U	--	21	--	<1.0 U	--	--
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	--	2.6	--	<2.0 U	--	0.33 J	--	<1.0 U	--	20	--	<1.0 U	--	--
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	--	1.8	--	<2.0 U	--	0.38 J	--	<1.0 U	--	19	--	<1.0 U	--	--
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	--	1.0	--	<2.0 U	--	0.38 J	--	<1.0 U	--	8.8	--	<1.0 U	--	--
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	--	1.5	--	<2.0 U	--	0.41 J	--	<1.0 U	--	14	--	<1.0 U	--	--
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	800	--	<1.0 U	--	--
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	--	<1.0 U	--	3.9	--	<1.0 U	--	<1.0 U	--	3700	--	<1.0 U	--	--
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	--	<1 U	--	12	--	<1 U	--	<1 U	--	5500	--	<1 U	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	--	<1.0 U	--	4.4	--	<1.0 U	--	<1.0 U	--	4300	--	<1.0 U	--	--
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	--	<1.0 U	--	3.9	--	<1.0 U	--	<1.0 U	--	4200	--	<1.0 U	--	--
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	--	<1.0 U	--	6.3	--	<1.0 U	--	<1.0 U	--	5000	--	<1.0 U	--	--
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	--	<1.0 U	--	14	--	<1.0 U	--	<1.0 U	--	4300	--	<1.0 U	--	--
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	--	<1.0 U	--	14	--	<1.0 U	--	<1.0 U	--	4300	--	<1.0 U	--	--
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	--	<1.0 U	--	13	--	<1.0 U	--	<1.0 U	--	1600	--	<1.0 U	--	--
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	--	<1.0 U	--	<2.0 U	--	0.15 J	--	1.1	--	44	--	<1.0 U	--	--
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	78	--	<1.0 U	--	--
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	--	<1.0 U	--	5.6	--	<1.0 U	--	<1.0 U	--	97	--	<1.0 U	--	--
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	--	<1.0 U	--	5.1	--	<1.0 U	--	<1.0 U	--	160	--	<1.0 U	--	--
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	--	<1 U	--	3.5	--	<1 U	--	<1 U	--	640	--	<1 U	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	--	<1.0 U	--	7.3	--	<1.0 U	--	<1.0 U	--	430	--	<1.0 U	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	6.7	--	<1.0 U	--	--
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	8.8	--	<1.0 U	--	--
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	120	--	<1.0 U	--	--
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	94	--	<1.0 U	--	--
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	--	<1.0 U	--	2.8	--	<1.0 U	--	<1.0 U	--	130	--	<1.0 U	--	--
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	--	<1.0 U	--	4.2	--	<1.0 U	--	<1.0 U	--	38	--	<1.0 U	--	--
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	--	<1.0 U	--	32	--	<1.0 U	--	<1.0 U	--	1000	--	<1.0 U	--	--
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	--	<1.0 U	--	2.6	--	<1.0 U	--	<1.0 U	--	95	--	<1.0 U	--	--
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	--	<1.0 U	--	8.3	--	<1.0 U	--	<1.0 U	--	320	--	<1.0 U	--	--
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	--	<1 U	--	3.8	--	<1 U	--	<1 U	--	330	--	<1 U	--	--
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	--	<1.0 U	--	10	--	<1.0 U	--	<1.0 U	--	1100	--	<1.0 U	--	--
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	--	<1.0 U	--	12	--	<1.0 U	--	<1.0 U	--	1700	--	<1.0 U	--	--
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	--	<1.0 U	--	6.5	--	<1.0 U	--	<1.0 U	--	650	--	<1.0 U	--	--
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	--	<1.0 U	--	38	--	<1.0 U	--	<1.0 U	--	1900	--	<1.0 U	--	--
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	--	<1.0 U	--	41	--	<1.0 U	--	<1.0 U	--	2800	--	<1.0 U	--	--
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	--	<1.0	--	<2.0	--	<1.0	--	<1.0	--	8700	--	<1.0	--	--
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	--	<1.0	--	<2.0	--	<1.0	--	<1.0	--	8400	--	<1.0	--	--
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	6.9	--	<1.0 U	--	--
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	7.5	--	<1.0 U	--	--
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	1.3	--	<1.0 U	--	--
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	--	<1 U	--	<2 U	--	<1 U	--	<1 U	--	3.1	--	<1 U	--	--
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	--	<1 U	--	<2 U	--	<1 U	--	<1 U	--	2.9	--	<1 U	--	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Chlorobenzene (Total)	Chlorodibromomethane	Chlorodibromomethane (Total)	Chloroethane	Chloroethane (Total)	Chloroform	Chloroform (Total)	Chloromethane	Chloromethane (Total)	cis-1,2-Dichloroethene	cis-1,2-Dichloroethene (Total)	cis-1,3-Dichloropropene	cis-1,3-Dichloropropene (Total)	Conductivity (uS/cm)
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	6.4	--	<1.0 U	--	--
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	2.5	--	<1.0 U	--	--
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	36	--	<1.0 U	--	--
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	26	--	<1.0 U	--	--
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	--	<1.0 U	--	35	--	<1.0 U	--	<1.0 U	--	870	--	<1.0 U	--	--
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	--	<1.0 U	--	77	--	<1.0 U	--	<1.0 U	--	1100	--	<1.0 U	--	--
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	--	<1.0 U	--	68	--	<1.0 U	--	<1.0 U	--	1100	--	<1.0 U	--	--
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	--	<1 U	--	83	--	<1 U	--	<1 U	--	1600	--	<1 U	--	--
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	--	<1.0 U	--	54 J	--	<1.0 U	--	<1.0 U	--	2800	--	<1.0 U	--	--
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	--	<1.0 U	--	76	--	<1.0 U	--	<1.0 U	--	2300	--	<1.0 U	--	--
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	--	<1.0 U	--	99	--	<1.0 U	--	<1.0 U	--	2500	--	<1.0 U	--	--
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	--	<1.0 U	--	60	--	<1.0 U	--	<1.0 U	--	2500	--	<1.0 U	--	--
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	1.3	--	50	--	<1.0 U	--	--
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	--	<1.0 U	--	1.9 J	--	<1.0 U	--	<1.0 U	--	2.8	--	<1.0 U	--	--
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	180	--	<1.0 U	--	--
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	1100	--	<1.0 U	--	--
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	--	<1 U	--	0.69 J	--	<1 U	--	<1 U	--	2300	--	<1 U	--	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.53 J	--	<1.0 U	--	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.63 J	--	<1.0 U	--	--
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.70 J	--	<1.0 U	--	--
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.86 J	--	<1.0 U	--	--
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	17	--	<1.0 U	--	--
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	0.46 J	--	16	--	<1.0 U	--	--
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	--	<1.0 U	--	1.2 J	--	<1.0 U	--	<1.0 U	--	1.9	--	<1.0 U	--	--
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	4200	--	<1.0 U	--	--
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	--	<1.0 U	--	3.4	--	<1.0 U	--	<1.0 U	--	3900	--	<1.0 U	--	--
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	--	<5 U	--	<10 U	--	<5 U	--	<5 U	--	4600	--	<5 U	--	--
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	--	<1.0 U	--	0.51 J	--	<1.0 U	--	<1.0 U	--	26	--	<1.0 U	--	--
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	--	<1.0 U	--	0.55 J	--	<1.0 U	--	<1.0 U	--	73	--	<1.0 U	--	--
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	78	--	<1.0 U	--	--
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	--	<1.0 U	--	1.8 J	--	<1.0 U	--	<1.0 U	--	210	--	<1.0 U	--	--
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	--	<1.0 U	--	1.9 J	--	<1.0 U	--	<1.0 U	--	10	--	<1.0 U	--	--
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	18	--	<1.0 U	--	--
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	93	--	<1.0 U	--	--
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	--	<1 U	--	<2 U	--	<1 U	--	<1 U	--	56	--	<1 U	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	0.31 J	--	<1.0 U	--	--
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	4.1	--	<1.0 U	--	--
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	12	--	<1.0 U	--	--
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	180	--	<1.0 U	--	--
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	<1.0 U	--	88	--	<1.0 U	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	--	<1.0 U	--	16	--	<1.0 U	--	<1.0 U	--	1900	--	<1.0 U	--	--
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	--	<1.0 U	--	41	--	0.13 J	--	<1.0 U	--	2900	--	<1.0 U	--	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Cymene (p-Isopropyltoluene)	Cymene (p-Isopropyltoluene) (Total)	Dichloromethane	Dichloromethane (Total)	Di-isopropyl ether	Di-isopropyl ether (Total)	Dissolved Oxygen (Total)	Ethane	Ethene	Ethyl tert-butyl ether	Ethyl tert-butyl ether (Total)	Ethylbenzene	Ethylbenzene (Total)	Hexachloro-1,3-butadiene
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	10500.000	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	5200.000	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	3140.000	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	4.6	88	<1.0 U	--	<1.0 U	--	<1.0 U
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	<1 U	--	<2 U	--	<1 U	--	--	32	320	<1 U	--	<1 U	--	<1 U
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	40	280	<1.0 U	--	<1.0 U	--	<1.0 U
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.9 J	13	<1.0 U	--	<1.0 U	--	<1.0 U
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	8.2	670	<1.0 U	--	0.12 J	--	<1.0 U
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	<1.0	--	<2.0	--	<1.0	--	--	1.9 J	22	<1.0	--	<1.0	--	<1.0
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	--	<1.0 U	--	<2.0 U	--	<1.0 U	1710.000	--	--	--	<1.0 U	--	<1.0 U	--
15-MW-48	3/18/2024	FD	SD015-DUP1	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.9 J	2.0	<1.0 U	--	<1.0 U	--	<1.0 U
15MW8	1/12/2023	N	SD015-15MW8(01122023)	<1 U	--	<2 U	--	<1 U	--	--	1.1 J	2.1	<1 U	--	<1 U	--	<1 U
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
15MW8	4/26/2023	N	SD015-15MW8(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.2 J	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	13	2.2	<1.0 U	--	<1.0 U	--	<1.0 U
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	16	5.6	<1.0 U	--	<1.0 U	--	<1.0 U
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	<1.0	--	<2.0	--	<1.0	--	--	6.4	<2.0	<1.0	--	<1.0	--	<1.0
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	92	310	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	58	260	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	<1 U	--	0.51 J	--	<1 U	--	--	35	220	<1 U	--	<1 U	--	<1 U
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	26	180	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	59	180	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	<1.0 U	--	2.3	--	<1.0 U	--	--	2.4	3.3	<1.0 U	--	0.38 J	--	<1.0 U
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.3 J	2.8	<1.0 U	--	0.34 J	--	<1.0 U
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	28	5.2	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	23	5.5	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	<1 U	--	<2 U	--	<1 U	--	--	47	43	<1 U	--	<1 U	--	<1 U
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<2.0 U	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.8 J	2.6	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	2.0 J	5.9	<1.0 U	--	0.11 J	--	<1.0 U
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	5.8	4.8	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	6.7	56	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	13	23	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	<1 U	--	<2 U	--	<1 U	--	--	14	29	<1 U	--	<1 U	--	<1 U
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	16	100	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	36	280	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	28	150	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	<1.0	--	<2.0	--	<1.0	--	--	7.9	98	<1.0	--	1.2	--	<1.0
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	<1.0	--	<2.0	--	<1.0	--	--	7.5	96	<1.0	--	0.94 J	--	<1.0
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	5.5	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.0 J	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	<1 U	--	<2 U	--	<1 U	--	--	1.7 J	<2 U	<1 U	--	<1 U	--	<1 U
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	<1 U	--	<2 U	--	<1 U	--	--	1.6 J	<2 U	<1 U	--	<1 U	--	<1 U
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	<1.0 U	--	0.63 J	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<2.0 U	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Cymene (p-Isopropyltoluene)	Cymene (p-Isopropyltoluene) (Total)	Dichloromethane	Dichloromethane (Total)	Di-isopropyl ether	Di-isopropyl ether (Total)	Dissolved Oxygen (Total)	Ethane	Ethene	Ethyl tert-butyl ether	Ethyl tert-butyl ether (Total)	Ethylbenzene	Ethylbenzene (Total)	Hexachloro-1,3-butadiene
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<2.0 U	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.8 J	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<2.0 U	1.8 J	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	17	9.1	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	8.2	180	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	7.4	210	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	7.2	250	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	<1 U	--	<2 U	--	<1 U	--	--	36	170	<1 U	--	<1 U	--	<1 U
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	20	300	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	7.1	140	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	<1.0 U	--	1.5 J	--	<1.0 U	--	--	2.2	4.8	<1.0 U	--	0.43 J	--	<1.0 U
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	0.69 J	<2.0 U	<1.0 U	--	0.27 J	--	<1.0 U
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.4 J	5.8	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.4 J	12	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	<1 U	--	<2 U	--	<1 U	--	--	13	23	<1 U	--	<1 U	--	<1 U
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	1.1 J	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	0.69 J	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	<1.0 U	--	0.60 J	--	<1.0 U	--	--	0.77 J	0.74 J	<1.0 U	--	0.51 J	--	<1.0 U
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	6.2	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	29	120	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	55	140	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	<5 U	--	<10 U	--	<5 U	--	--	49	120	<5 U	--	<5 U	--	<5 U
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	45	31	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	47	3.4	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	<1.0 U	--	1.1 J	--	<1.0 U	--	--	1.5 J	4.8	<1.0 U	--	0.88 J	--	<1.0 U
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	<1.0 U	--	0.61 J	--	<1.0 U	--	--	15	3.4	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	2.7	1.3 J	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	4.0	6.9	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	<1 U	--	<2 U	--	<1 U	--	--	1.9 J	2.4	<1 U	--	<1 U	--	<1 U
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<2.0 U	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	--	--	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<2.0 U	<2.0 U	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	6.0	3.0	<1.0 U	--	0.30 J	--	<1.0 U
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	16	13	<1.0 U	--	<1.0 U	--	<1.0 U
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	<1.0 U	--	0.55 J	--	<1.0 U	--	--	59	180	<1.0 U	--	<1.0 U	--	<1.0 U
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	27	140	<1.0 U	--	<1.0 U	--	<1.0 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Hexachloro-1,3-butadiene (Total)	Iron (Dissolved)	Iron (Total)	Isopropylbenzene	Isopropylbenzene (Total)	m&p-Xylenes	m&p-Xylenes (Total)	Manganese (Dissolved)	Manganese (Total)	Methane	Methyl N-Butyl Ketone (2-Hexanone)	Methyl N-Butyl Ketone (2-Hexanone) (Total)	Methyl-tert-butylether
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	--	36100	26700	<1.0 U	--	--	--	775	785	510	<20 U	--	<1.0 U
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	--	36400	40800	<1 U	--	<2 U	--	617	637	2100	<20 U	--	<1 U
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	--	15200	24700	<1.0 U	--	--	--	379	389	1800	<20 U	--	<1.0 U
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	--	80.0 J	14000	<1.0 U	--	--	--	294	331	670	<20 U	--	<1.0 U
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	--	8440	74400	<1.0 U	--	--	--	1090	1210	11000	<20 U	--	<1.0 U
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	--	<200	11300	<1.0	--	--	--	1820	1820	9600	<20	--	<1.0
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	<1.0 U	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--
15-MW-48	3/18/2024	FD	SD015-DUP1	<1.0 U	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	--	12100	12000	<1.0 U	--	--	--	911	951	4100	<20 U	--	<1.0 U
15MW8	1/12/2023	N	SD015-15MW8(01122023)	--	14100	13600	<1 U	--	--	--	1080	1040	940	<20 U	--	<1 U
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
15MW8	4/26/2023	N	SD015-15MW8(04262023)	--	1380	5020	<1.0 U	--	--	--	329	414	2400	<20 U	--	<1.0 U
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	--	2550	4290	<1.0 U	--	--	--	1330	1290	2300	<20 U	--	<1.0 U
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	--	394	11400	<1.0 U	--	--	--	1040	1160	1900	<20 U	--	<1.0 U
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	--	341	14000	<1.0	--	--	--	1450	1700	4200	<20	--	<1.0
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	--	48500	61700	<1.0 U	--	<2.0 U	--	667	768	15000	<20 U	--	<1.0 U
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	--	58200	51600	<1.0 U	--	--	--	547	527	8100	<20 U	--	<1.0 U
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	--	57600	56900	<1 U	--	--	--	530	520	4300	<20 U	--	<1 U
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	--	51900	55100	<1.0 U	--	--	--	360	368	1800	<20 U	--	<1.0 U
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	--	18700	87200	<1.0 U	--	--	--	546	570	2700	<20 U	--	<1.0 U
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	--	453000	559000	<1.0 U	--	--	--	6300	6450	460	<20 U	--	<1.0 U
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	--	602000	682000	<1.0 U	--	--	--	4230	4250	8300	23	--	<1.0 U
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	--	117000	115000	<1.0 U	--	<2.0 U	--	3020	3040	16000	<20 U	--	<1.0 U
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	--	103000	103000	<1.0 U	--	--	--	1770	1690	18000	<20 U	--	<1.0 U
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	--	38400	39400	<1 U	--	--	--	1050	1060	15000	<20 U	--	<1 U
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	--	151 J	973	<1.0 U	--	--	--	18.6	38.5	10	<20 U	--	<1.0 U
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	--	<200 U	11700	<1.0 U	--	--	--	5.61 J	786	50	<20 U	--	<1.0 U
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	--	128000	203000	<1.0 U	--	--	--	14600	15100	14000	<20 U	--	<1.0 U
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	--	22000	53600	<1.0 U	--	--	--	492	512	8200	<20 U	--	<1.0 U
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	--	2420	11500	<1.0 U	--	<2.0 U	--	794	1290	2200	<20 U	--	<1.0 U
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	--	23900	24500	<1.0 U	--	--	--	2310	2360	1700	<20 U	--	<1.0 U
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	--	20900	20700	<1 U	--	--	--	2240	2190	1200	<20 U	--	<1 U
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	--	12300	8470	<1.0 U	--	--	--	1210	513	1900	<20 U	--	<1.0 U
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	--	8130	13800	<1.0 U	--	--	--	580	643	3500	<20 U	--	<1.0 U
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	--	5210	11200	<1.0 U	--	--	--	458	455	3000	<20 U	--	<1.0 U
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	--	19400	40000	<1.0	--	--	--	1750	1740	4300	<20	--	<1.0
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	--	20000	44100	<1.0	--	--	--	1700	1780	4100	<20	--	<1.0
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	--	46000	47600	<1.0 U	--	<2.0 U	--	1430	1370	13000	<20 U	--	<1.0 U
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	--	--	--	<1.0 U	--	<2.0 U	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	--	28100	24400	<1.0 U	--	--	--	703	700	670	<20 U	--	<1.0 U
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	--	25700	25800	<1 U	--	--	--	665	668	350	<20 U	--	<1 U
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	--	25700	26000	<1 U	--	--	--	660	661	320	<20 U	--	<1 U
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	--	4680	15600	<1.0 U	--	--	--	184	203	1.7 J	<20 U	--	<1.0 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Hexachloro-1,3-butadiene (Total)	Iron (Dissolved)	Iron (Total)	Isopropylbenzene	Isopropylbenzene (Total)	m&p-Xylenes	m&p-Xylenes (Total)	Manganese (Dissolved)	Manganese (Total)	Methane	Methyl N-Butyl Ketone (2-Hexanone)	Methyl N-Butyl Ketone (2-Hexanone) (Total)	Methyl-tert-butylether
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	--	3780	13600	<1.0 U	--	--	--	182	193	2.5	<20 U	--	<1.0 U
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	--	1500	43500	<1.0 U	--	--	--	816	1180	1100	<20 U	--	<1.0 U
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	--	130000	412000	<1.0 U	--	--	--	15000	16100	9200	<20 U	--	<1.0 U
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	--	7830	46400	<1.0 U	--	--	--	1710	1890	12000	<20 U	--	<1.0 U
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	--	3250	4150	<1.0 U	--	<2.0 U	--	559	565	1600	<20 U	--	<1.0 U
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	--	32000	24900	<1.0 U	--	--	--	415	424	1500	<20 U	--	<1.0 U
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	--	18000	11500	<1.0 U	--	--	--	487	476	1700	<20 U	--	<1.0 U
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	--	30800	31700	<1 U	--	--	--	606	602	2800	<20 U	--	<1 U
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	--	22600	18600	<1.0 U	--	--	--	414	426	3400	<20 U	--	<1.0 U
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	--	13100	40700	<1.0 U	--	--	--	398	423	1200	<20 U	--	<1.0 U
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	--	568000	682000	<1.0 U	--	--	--	7960	7700	2800	<20 U	--	<1.0 U
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	--	4150	177000	<1.0 U	--	--	--	2630	3620	3200	<20 U	--	<1.0 U
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	--	47400	54300	<1.0 U	--	<2.0 U	--	3650	3800	1300	<20 U	--	<1.0 U
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	--	108000	115000	<1.0 U	--	--	--	3730	4140	17000	<20 U	--	<1.0 U
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	--	40400	45600	<1 U	--	--	--	1830	1880	17000	<20 U	--	<1 U
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	--	30500	33800	<1.0 U	--	--	--	1650	1430	680	<20 U	--	<1.0 U
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	--	2870	118000	<1.0 U	--	--	--	648	1330	290	<20 U	--	<1.0 U
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	--	332000	451000	<1.0 U	--	--	--	16700	16800	11000	<20 U	--	<1.0 U
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	--	3690	40500	<1.0 U	--	--	--	699	1420	8400	<20 U	--	<1.0 U
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	--	65600	73300	<1.0 U	--	<2.0 U	--	1900	1940	2800	<20 U	--	<1.0 U
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	--	68200	64700	<1.0 U	--	--	--	990	1030	10000	<20 U	--	<1.0 U
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	--	45100	45700	<5 U	--	--	--	699	713	6200	<100 U	--	<5 U
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	--	5870	12500	<1.0 U	--	--	--	965	1030	3900	<20 U	--	<1.0 U
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	--	1210	12800	<1.0 U	--	--	--	1120	1230	6700	<20 U	--	<1.0 U
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	--	229000	276000	<1.0 U	--	--	--	5000	5010	9900	<20 U	--	<1.0 U
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	--	12700	123000	<1.0 U	--	--	--	2940	3400	3800	<20 U	--	<1.0 U
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	--	14400	14700	<1.0 U	--	<2.0 U	--	1760	1620	1000	<20 U	--	<1.0 U
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	--	12900	10900	<1.0 U	--	--	--	1010	1080	500	<20 U	--	<1.0 U
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	--	5950	6080	<1 U	--	--	--	658	657	180	<20 U	--	<1 U
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	--	<200 U	998	<1.0 U	--	--	--	20.9	26.7	4.7	<20 U	--	<1.0 U
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	--	--	--	<1.0 U	--	--	--	--	--	--	<20 U	--	<1.0 U
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	--	103 J	6020	<1.0 U	--	--	--	262	708	7.9	<20 U	--	<1.0 U
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	--	13600	32900	<1.0 U	--	--	--	249	264	13000	<20 U	--	<1.0 U
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	--	<200 U	18100	<1.0 U	--	--	--	295	311	11000	<20 U	--	<1.0 U
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	--	27800	86800	<1.0 U	--	--	--	547	566	2600	<20 U	--	<1.0 U
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	--	6300	19100	<1.0 U	--	--	--	462	490	2800	<20 U	--	<1.0 U

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Methyl-tert-butylether (Total)	Naphthalene	Naphthalene (Total)	n-Butylbenzene	n-Butylbenzene (Total)	Nitrate-N	n-Propylbenzene	n-Propylbenzene (Total)	o,p-Xylene	Oxidation Reduction Potential (Total)(mV)	o-Xylene	o-Xylene (Total)	pH (Total) (pH units)	sec-Butylbenzene	sec-Butylbenzene (Total)	Selenium (Total)
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	--	--	--	35.000000	--	--	4.430000	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	--	--	--	212.000000	--	--	4.250000	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	--	--	--	-3.000000	--	--	4.300000	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	--	<2 U	--	<1 U	--	<500 U	<1 U	--	--	--	<1 U	--	--	<1 U	--	--
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	--	<2.0 U	--	<1.0 U	--	<100 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	--	<2.0 U	--	<1.0 U	--	56.4 J	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	--	<2.0 U	--	<1.0 U	--	<4000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	--	<2.0	--	<1.0	--	<1000	<1.0	--	<2.0	--	<1.0	--	--	<1.0	--	--
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	6.750000	--	<1.0 U	--
15-MW-48	3/18/2024	FD	SD015-DUP1	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15MW8	1/12/2023	N	SD015-15MW8(01122023)	--	<2 U	--	<1 U	--	1400	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15MW8	4/26/2023	N	SD015-15MW8(04262023)	--	<2.0 U	--	<1.0 U	--	<100 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	--	<2.0 U	--	<1.0 U	--	<2000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	--	<2.0	--	<1.0	--	<4000	<1.0	--	<2.0	--	<1.0	--	--	<1.0	--	--
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	589 J
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	--	<2 U	--	<1 U	--	<500 U	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	--	<2.0 U	--	<1.0 U	--	<100 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	--	<2.0 U	--	<1.0 U	--	<2000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	--	<2.0 U	--	<1.0 U	--	5050 J	<1.0 U	--	0.23 J	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	--	<2.0 U	--	<1.0 U	--	<100000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	--	<2 U	--	<1 U	--	1450	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	--	<2.0 U	--	<1.0 U	--	5950	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	--	<2.0 U	--	<1.0 U	--	3870	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	--	<2.0 U	--	<1.0 U	--	<2000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	--	<2.0 U	--	<1.0 U	--	<20000 U	<1.0 U	--	0.24 J	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	--	<2.0 U	--	<1.0 U	--	<100 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	--	<2 U	--	<1 U	--	<100 U	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	--	<2.0 U	--	<1.0 U	--	<100 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	--	<2.0 U	--	<1.0 U	--	<4000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	--	<2.0	--	<1.0	--	<20000	<1.0	--	<2.0	--	<1.0	--	--	<1.0	--	--
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	--	<2.0	--	<1.0	--	<20000	<1.0	--	<2.0	--	<1.0	--	--	<1.0	--	--
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	--	<2.0 U	--	<1.0 U	--	<100 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	--	<2 U	--	<1 U	--	<100 U	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	--	<2 U	--	<1 U	--	71.9 J	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	--	<2.0 U	--	<1.0 U	--	3340	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Methyl-tert-butylether (Total)	Naphthalene	Naphthalene (Total)	n-Butylbenzene	n-Butylbenzene (Total)	Nitrate-N	n-Propylbenzene	n-Propylbenzene (Total)	o,p-Xylene	Oxidation Reduction Potential (Total)(mV)	o-Xylene	o-Xylene (Total)	pH (Total) (pH units)	sec-Butylbenzene	sec-Butylbenzene (Total)	Selenium (Total)
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	--	<2.0 U	--	<1.0 U	--	3750	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	--	<2.0 U	--	<1.0 U	--	122 J	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	--	<2.0 U	--	<1.0 U	--	<10000 U	<1.0 U	--	0.25 J	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	--	<2.0 U	--	<1.0 U	--	<4000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	--	<2 U	--	<1 U	--	<200 U	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	--	<2.0 U	--	<1.0 U	--	<200 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	--	<2.0 U	--	<1.0 U	--	<500 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	--	<2.0 U	--	<1.0 U	--	5020 J	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	--	<2.0 U	--	<1.0 U	--	<100000 U	<1.0 U	--	0.70 J	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	--	<2.0 U	--	<1.0 U	--	46.0 J	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	--	<2 U	--	<1 U	--	1930	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	--	<2.0 U	--	<1.0 U	--	235	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	--	<2.0 U	--	<1.0 U	--	460	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	--	<2.0 U	--	<1.0 U	--	<10000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	--	<2.0 U	--	<1.0 U	--	<100000 U	<1.0 U	--	0.34 J	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	--	<2.0 U	--	<1.0 U	--	217 J	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	--	<10 U	--	<5 U	--	654	<5 U	--	<10 U	--	<5 U	--	--	<5 U	--	--
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	--	<2.0 U	--	<1.0 U	--	<100 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	--	<2.0 U	--	<1.0 U	--	137 J	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	--	<2.0 U	--	<1.0 U	--	<10000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	--	<2.0 U	--	<1.0 U	--	<40000 U	<1.0 U	--	0.79 J	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	--	<2.0 U	--	<1.0 U	--	352	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	--	<2 U	--	<1 U	--	5270	<1 U	--	<2 U	--	<1 U	--	--	<1 U	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	--	<2.0 U	--	<1.0 U	--	2000	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	--	<2.0 U	--	<1.0 U	--	4230	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	--	<2.0 U	--	<1.0 U	--	<2000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	--	<2.0 U	--	<1.0 U	--	<2000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	--	<2.0 U	--	<1.0 U	--	<1000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	--	<2.0 U	--	<1.0 U	--	<2000 U	<1.0 U	--	<2.0 U	--	<1.0 U	--	--	<1.0 U	--	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Styrene (Monomer)	Styrene (Monomer) (Total)	Sulfate	Sulfide	Temperature (C°)	tert-Amyl methyl ether	tert-Amyl methyl ether (Total)	tert-Butyl alcohol	tert-Butyl alcohol (Total)	tert-Butylbenzene	tert-Butylbenzene (Total)	Tetrachloroethene	Tetrachloroethene (Total)	Toluene	Toluene (Total)	Total Organic Carbon
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	19.820000	--	--	--	--	--	--	--	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	19.660000	--	--	--	--	--	--	--	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	19.770000	--	--	--	--	--	--	--	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	<1.0 U	--	105000	88.1 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	17500
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	<1 U	--	116000	131	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	<1 U	--	21000
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	<1.0 U	--	67900	71.2 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	13800
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	<1.0 U	--	37900	46.3 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	4350
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	<1.0 U	--	12500 J	970	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	77100
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	<1.0	--	37200	<100	--	<1.0	--	<20	--	<1.0	--	<1.0	--	<1.0	--	13900 J
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	--	<1.0 U	--	--	18.700000	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	3.3	--
15-MW-48	3/18/2024	FD	SD015-DUP1	--	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	3.5	--
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	<1.0 U	--	45500	133	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	13600
15MW8	1/12/2023	N	SD015-15MW8(01122023)	<1 U	--	60400	27.6 J	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	<1 U	--	10700
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
15MW8	4/26/2023	N	SD015-15MW8(04262023)	<1.0 U	--	67500	62.0 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	2950
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	<1.0 U	--	25300	29.3 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	12300
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	<1.0 U	--	28000	121	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	11400
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	<1.0	--	17000 J	<100	--	<1.0	--	<20	--	<1.0	--	<1.0	--	<1.0	--	14400 J
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	<1.0 U	--	126000	83.2 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.41 J	--	--
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	<1.0 U	--	141000	371	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.18 J	--	31200
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	<1 U	--	121000	48.8 J	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	0.12 J	--	25100
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	243000
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	200000
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	97500
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	<1.0 U	--	113000	463	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.13 J	--	13700
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	<1.0 U	--	56900	50.2 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	10700
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	0.33 J	--	919000	1780	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.59 J	--	6330000
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	<1.0 U	--	361000 J	2950	--	<1.0 U	--	1000	--	<1.0 U	--	<1.0 U	--	0.35 J	--	5040000
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	<1.0 U	--	13000	549	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.95 J	--	--
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	<1.0 U	--	20200	223	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.55 J	--	71800
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	<1 U	--	45700	204	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	0.15 J	--	31000
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	35900
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	23200
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	21200
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	<1.0 U	--	15800	23.3 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	3280
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	<1.0 U	--	27400	25.4 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	2750
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	<1.0 U	--	5530 J	323	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	662000
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	<1.0 U	--	127000	32.4 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.68 J	--	45000 J
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	<1.0 U	--	132000	5120	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.33 J	--	<1.0 U	--	--
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	<1.0 U	--	40100	50.3 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	15000
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	<1 U	--	44900	36.1 J	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	<1 U	--	12500
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.51 J	--	<1.0 U	--	--
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	<1.0 U	--	173000	142	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.67 J	--	<1.0 U	--	16000
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	<1.0 U	--	126000	3120	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.33 J	--	0.10 J	--	18500
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	<1.0 U	--	148000	334	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.26 J	--	<1.0 U	--	20400
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	<1.0	--	56200 J	116	--	<1.0	--	<20	--	<1.0	--	<1.0	--	<1.0	--	262000
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	<1.0	--	62800 J	88.0 J	--	<1.0	--	<20	--	<1.0	--	<1.0	--	<1.0	--	263000
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	<1.0 U	--	14600	122	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	<1.0 U	--	37900	127	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	9560
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	<1 U	--	33900	72.8 J	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	<1 U	--	8120
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	<1 U	--	36000	62.9 J	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	<1 U	--	8330
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	<1.0 U	--	31500	<100 U	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	6820

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	Styrene (Monomer)	Styrene (Monomer) (Total)	Sulfate	Sulfide	Temperature (C°)	tert-Amyl methyl ether	tert-Amyl methyl ether (Total)	tert-Butyl alcohol	tert-Butyl alcohol (Total)	tert-Butylbenzene	tert-Butylbenzene (Total)	Tetrachloroethene	Tetrachloroethene (Total)	Toluene	Toluene (Total)	Total Organic Carbon
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	<1.0 U	--	27500	<100 U	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	5430
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	<1.0 U	--	31600	<100 U	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	13100
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	<1.0 U	--	28000 J	144	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.19 J	--	539000
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	<1.0 U	--	23000	<100 U	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.53 J	--	21600 J
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	<1.0 U	--	147000	267	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	<1.0 U	--	142000	40.5 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	27300
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	<1.0 U	--	137000	76.9 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	20100
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	<1 U	--	157000	<100 U	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	<1 U	--	25300
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.15 J	--	<1.0 U	--	--
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	<1.0 U	--	155000	319	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.25 J	--	<1.0 U	--	31500
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	<1.0 U	--	130000	78.9 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	26000
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	<1.0 U	--	823000	1630	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.41 J	--	6530000
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	<1.0 U	--	357000 J	93.4 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.29 J	--	402000
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	<1.0 U	--	49100	242	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	<1.0 U	--	8090	1320 1660	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	627000
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	<1 U	--	18800	237	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	<1 U	--	21800
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	<1.0 U	--	19700	<100 U	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	5000
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	<1.0 U	--	29100	<100 U	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	11400
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	0.35 J	--	508000	1670	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.21 J	--	3850000
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	<1.0 U	--	924000	199	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	1.6	--	171000
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	<1.0 U	--	238000	510	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.18 J	--	0.72 J	--	--
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	<1.0 U	--	373000	148	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.59 J	--	0.52 J	--	88400
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	<5 U	--	224000	151	--	<5 U	--	<100 U	--	<5 U	--	<5 U	--	<5 U	--	53500
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	85500
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	43900
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	49400
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	<1.0 U	--	33500	35.0 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	9290
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	<1.0 U	--	22500	29.3 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	10000
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	<1.0 U	--	62000	273	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.36 J	--	2270000
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	<1.0 U	--	393000	<100 U	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.54 J	--	283000
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	<1.0 U	--	31500	123	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	<1.0 U	--	33200	92.3 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	4600
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	<1 U	--	32900	71.4 J	--	<1 U	--	<20 U	--	<1 U	--	<1 U	--	<1 U	--	2480
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12400
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14600
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9780
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	<1.0 U	--	23500	41.9 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	2790
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	<1.0 U	--	--	--	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	--
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	<1.0 U	--	15500	22.8 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	2090
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	<1.0 U	--	4160 J	189	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	93000
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	<1.0 U	--	27300	<100 U	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	0.23 J	--	9730 J
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	303000
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	304000
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300000
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	309000
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	316000
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	314000
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	<1.0 U	--	58600	35.8 J	--	<1.0 U	--	<20 U	--	<1.0 U	--	<1.0 U	--	<1.0 U	--	10600
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	<1.0 U	--	149000	597	--	<1.0 U	--	<20 U	--	<1.0 U	--	0.27 J	--	<1.0 U	--	20200

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	trans-1,2-Dichloroethene	trans-1,2-Dichloroethene (Total)	trans-1,3-Dichloropropene	trans-1,3-Dichloropropene (Total)	Trichloroethene	Trichloroethene (Total)	Turbidity (ntu)	Vinyl acetate	Vinyl acetate (Total)	Vinyl chloride	Vinyl chloride (Total)
15-EW-50	1/19/2024	N	SD015-15-EW-50(1Q24)	--	--	--	--	--	--	7.770000	--	--	--	--
15-EW-51	1/19/2024	N	SD015-15-EW-51(1Q24)	--	--	--	--	--	--	3.940000	--	--	--	--
15-EW-52	1/19/2024	N	SD015-15-EW-52(1Q24)	--	--	--	--	--	--	1.690000	--	--	--	--
15-MW-41	9/8/2022	N	SD015-15-MW-41(09082022)	16	--	<1.0 U	--	1100	--	--	<2.0 U	--	1100	--
15-MW-41	1/12/2023	N	SD015-15-MW-41(01122023)	15	--	<1 U	--	600	--	--	<2 U	--	1500	--
15-MW-41	3/30/2023	N	SD015-15-MW-41(03302023)	6.4	--	<1.0 U	--	20	--	--	<2.0 U	--	610	--
15-MW-41	4/26/2023	N	SD015-15-MW-41(04262023)	8.0	--	<1.0 U	--	19	--	--	<2.0 U	--	860	--
15-MW-41	8/14/2023	N	SD015-15-MW-41(08142023)	0.71 J	--	<1.0 U	--	12	--	--	<2.0 U	--	50	--
15-MW-41	11/29/2023	N	SD015-15-MW-41(11292023)	1.7	--	<1.0 U	--	7.0	--	--	<2.0 U	--	110	--
15-MW-41	7/11/2024	N	SD015-15-MW-41(07112024)	9.4	--	<1.0 U	--	0.17 J	--	--	<2.0 U	--	45	--
15-MW-41	1/8/2025	N	SD015-15-MW-41(01082025)	8.1	--	<1.0	--	21	--	--	<2.0	--	160	--
15-MW-48	3/18/2024	N	SD015-15-MW-48(031824)	--	<1.0 U	--	<1.0 U	--	28	97.000000	--	<2.0 U	--	<0.50 U
15-MW-48	3/18/2024	FD	SD015-DUP1	--	<1.0 U	--	<1.0 U	--	28	--	--	<2.0 U	--	<0.50 U
15MW8	9/8/2022	N	SD015-15-MW-8(09082022)	0.32 J	--	<1.0 U	--	5.1	--	--	<2.0 U	--	19	--
15MW8	1/12/2023	N	SD015-15MW8(01122023)	0.27 J	--	<1 U	--	12	--	--	<2 U	--	9.8	--
15MW8	3/30/2023	N	SD015-15-MW-8(03302023)	<1.0 U	--	<1.0 U	--	0.34 J	--	--	<2.0 U	--	1.5	--
15MW8	4/26/2023	N	SD015-15MW8(04262023)	<1.0 U	--	<1.0 U	--	0.21 J	--	--	<2.0 U	--	0.52	--
15MW8	8/14/2023	N	SD015-15-MW-8(08142023)	0.48 J	--	<1.0 U	--	2.1	--	--	<2.0 U	--	16	--
15MW8	11/29/2023	N	SD015-15-MW-8(11292023)	0.31 J	--	<1.0 U	--	3.8	--	--	<2.0 U	--	9.0	--
15MW8	7/11/2024	N	SD015-15-MW-8(07112024)	0.46 J	--	<1.0 U	--	0.91 J	--	--	<2.0 U	--	21	--
15MW8	1/8/2025	N	SD015-15-MW-8(01082025)	<1.0	--	<1.0	--	0.12 J	--	--	<2.0	--	0.44 J	--
SD015-CHB	6/27/2024	N	SD015-GACCHB-2(062724)	--	--	--	--	--	--	--	--	--	--	--
SD015-EFF	7/25/2022	N	SD015-DGR-GAC-EFF(07252022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	0.62	--
SD015-EFF	8/1/2022	N	SD015-DGR-GAC-EFF(08012022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	0.15 J	--
SD015-EFF	8/8/2022	N	SD015-DGR-GAC-EFF(08082022)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	0.60	--
SD015-INF	7/25/2022	N	SD015-DGR-GAC-INF(07252022)	1.6	--	<1.0 U	--	52	--	--	<2.0 U	--	<0.50 U	--
SD015-INF	8/1/2022	N	SD015-DGR-GAC-INF(08012022)	1.8	--	<1.0 U	--	52	--	--	<2.0 U	--	<0.50 U	--
SD015-INF	8/8/2022	N	SD015-DGR-GAC-INF(08082022)	2.1	--	<1.0 U	--	45	--	--	<2.0 U	--	<0.50 U	--
SD015-MIDPOINT	7/25/2022	N	SD015-DGR-GAC-MID(07252022)	0.21 J	--	<1.0 U	--	9.0	--	--	<2.0 U	--	0.73	--
SD015-MIDPOINT	8/1/2022	N	SD015-DGR-GAC-MID(08012022)	<1.0 U	--	<1.0 U	--	0.85 J	--	--	<2.0 U	--	0.92	--
SD015-MIDPOINT	8/8/2022	N	SD015-DGR-GAC-MID(08082022)	0.45 J	--	<1.0 U	--	3.7	--	--	<2.0 U	--	1.1	--
SD015-TISR-1D	1/4/2022	N	SD015-TISR-1D(01042022)	15	--	<1.0 U	--	41	--	--	<2.0 U	--	940	--
SD015-TISR-1D	9/7/2022	N	SD015-TISR-1D(09072022)	25	--	<1.0 U	--	13	--	--	<2.0 U	--	1800	--
SD015-TISR-1D	9/8/2022	N	SD015-TISR-1D(09082022)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/12/2023	N	SD015-TISR-1D(01122023)	32	--	<1 U	--	13	--	--	<2 U	--	2300	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-150(0117023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/17/2023	N	SD015-TISR-1D-300(01172023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	1/18/2023	N	SD015-TISR-1D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1D	3/30/2023	N	SD015-TISR-1D(03302023)	21	--	<1.0 U	--	1.7	--	--	<2.0 U	--	1400	--
SD015-TISR-1D	3/30/2023	FD	SD015-DUP1(03302023)	22	--	<1.0 U	--	1.8	--	--	<2.0 U	--	1200	--
SD015-TISR-1D	4/26/2023	N	SD015-TISR-1D(04262023)	26	--	<1.0 U	--	4.2	--	--	<2.0 U	--	1600	--
SD015-TISR-1D	8/14/2023	N	SD015-TISR-1D(08142023)	26	--	<1.0 U	--	3.8	--	--	<2.0 U	--	2400	--
SD015-TISR-1D	8/14/2023	FD	SD015-DUP1(08142023)	26	--	<1.0 U	--	3.5	--	--	<2.0 U	--	2800	--
SD015-TISR-1D	11/29/2023	N	SD015-TISR-1D(11292023)	19	--	<1.0 U	--	4.9	--	--	<2.0 U	--	1600	--
SD015-TISR-1D	7/11/2024	N	SD015-TISR-1D(07112024)	0.87 J	--	<1.0 U	--	0.39 J	--	--	<2.0 U	--	64	--
SD015-TISR-1D	1/9/2025	N	SD015-TISR-1D(01092025)	2.5	--	<1.0 U	--	3.7	--	--	<2.0 U	--	31	--
SD015-TISR-1S	1/4/2022	N	SD015-TISR-1S(01042022)	1.7	--	<1.0 U	--	7.6	--	--	<2.0 U	--	63	--
SD015-TISR-1S	9/7/2022	N	SD015-TISR-1S(09072022)	2.4	--	<1.0 U	--	28	--	--	<2.0 U	--	95	--
SD015-TISR-1S	9/8/2022	N	SD015-TISR-1S(09082022)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/11/2023	N	SD015-TISR-1S(01112023)	6.0	--	<1 U	--	32	--	--	<2 U	--	230	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/17/2023	N	SD015-TISR-1S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	1/18/2023	N	SD015-TISR-1S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)	3.1	--	<1.0 U	--	36	--	--	<2.0 U	--	110	--
SD015-TISR-1S	3/30/2023	N	SD015-TISR-1S(03302023)-HB	<1.0 U	--	<1.0 U	--	0.57 J	--	--	<2.0 U	--	1.7	--
SD015-TISR-1S	4/25/2023	N	SD015-TISR-1S(04252023)	0.10 J	--	<1.0 U	--	2.2	--	--	<2.0 U	--	1.1	--
SD015-TISR-1S	8/14/2023	N	SD015-TISR-1S(08142023)	0.70 J	--	<1.0 U	--	17	--	--	<2.0 U	--	6.8	--
SD015-TISR-1S	11/29/2023	N	SD015-TISR-1S(11292023)	0.79 J	--	<1.0 U	--	40	--	--	<2.0 U	--	23	--
SD015-TISR-1S	7/11/2024	N	SD015-TISR-1S(07112024)	2.0	--	<1.0 U	--	3.7	--	--	<2.0 U	--	77	--
SD015-TISR-1S	1/9/2025	N	SD015-TISR-1S(01092025)	4.7	--	<1.0 U	--	3.5	--	--	<2.0 U	--	31	--
SD015-TISR-2D	1/5/2022	N	SD015-TISR-2D(01052022)	12	--	<1.0 U	--	5400	--	--	<2.0 U	--	440	--
SD015-TISR-2D	1/5/2022	FD	SD015-DUP2(01052022)	1.0	--	<1.0 U	--	580	--	--	<2.0 U	--	38	--
SD015-TISR-2D	9/8/2022	N	SD015-TISR-2D(09082022)	2.8	--	<1.0 U	--	980	--	--	<2.0 U	--	130	--
SD015-TISR-2D	1/12/2023	N	SD015-TISR-2D(01122023)	2.9	--	<1 U	--	1200	--	--	<2 U	--	120	--
SD015-TISR-2D	3/30/2023	N	SD015-TISR-2D(03302023)	11	--	<1.0 U	--	7500	--	--	<2.0 U	--	240	--
SD015-TISR-2D	4/26/2023	N	SD015-TISR-2D(04262023)	15	--	<1.0 U	--	14000	--	--	<2.0 U	--	370	--
SD015-TISR-2D	8/14/2023	N	SD015-TISR-2D(08142023)	5.6	--	<1.0 U	--	1900	--	--	<2.0 U	--	150	--
SD015-TISR-2D	11/29/2023	N	SD015-TISR-2D(11292023)	22	--	<1.0 U	--	3400	--	--	<2.0 U	--	580	--
SD015-TISR-2D	7/11/2024	N	SD015-TISR-2D(07112024)	26	--	<1.0 U	--	4400	--	--	<2.0 U	--	1600	--
SD015-TISR-2D	1/8/2025	N	SD015-TISR-2D(01082025)	45	--	<1.0	--	11	--	--	<2.0	--	1100	--
SD015-TISR-2D	1/8/2025	FD	SD015-DUP1(01082025)	46	--	<1.0	--	13	--	--	<2.0	--	1100	--
SD015-TISR-2S	1/5/2022	N	SD015-TISR-2S(01052022)	<1.0 U	--	<1.0 U	--	0.44 J	--	--	<2.0 U	--	1.7	--
SD015-TISR-2S	1/5/2022	FD	SD015-DUP1(01052022)	<1.0 U	--	<1.0 U	--	0.42 J	--	--	<2.0 U	--	1.9	--
SD015-TISR-2S	9/8/2022	N	SD015-TISR-2S(09082022)	<1.0 U	--	<1.0 U	--	0.17 J	--	--	<2.0 U	--	0.52	--
SD015-TISR-2S	1/12/2023	N	SD015-TISR-2S(01122023)	<1 U	--	<1 U	--	1.2	--	--	<2 U	--	2.2	--
SD015-TISR-2S	1/12/2023	FD	SD015-DUP1(01122023)	<1 U	--	<1 U	--	1.2	--	--	<2 U	--	2.0	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	<0.50 U	--
SD015-TISR-2S	3/30/2023	N	SD015-TISR-2S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	<0.50 U	--
SD015-TISR-2S	4/25/2023	N	SD015-TISR-2S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	<0.50 U	--

Appendix A
Groundwater Analytical Data - CVOCs
Final Report, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes

Location ID	Sample Date	Sample Type	Sample Name	trans-1,2-Dichloroethene	trans-1,2-Dichloroethene (Total)	trans-1,3-Dichloropropene	trans-1,3-Dichloropropene (Total)	Trichloroethene	Trichloroethene (Total)	Turbidity (ntu)	Vinyl acetate	Vinyl acetate (Total)	Vinyl chloride	Vinyl chloride (Total)
SD015-TISR-2S	4/25/2023	FD	SD015-DUP1(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	<0.50 U	--
SD015-TISR-2S	8/14/2023	N	SD015-TISR-2S(08142023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	2.1	--
SD015-TISR-2S	11/29/2023	N	SD015-TISR-2S(11292023)	0.11 J	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	3.0	--
SD015-TISR-2S	7/11/2024	N	SD015-TISR-2S(07112024)	0.56 J	--	<1.0 U	--	0.13 J	--	--	<2.0 U	--	43	--
SD015-TISR-2S	1/9/2025	N	SD015-TISR-2S(01092025)	0.68 J	--	<1.0 U	--	1.5	--	--	<2.0 U	--	31	--
SD015-TISR-3D	1/5/2022	N	SD015-TISR-3D(01052022)	11	--	<1.0 U	--	1600	--	--	<2.0 U	--	980	--
SD015-TISR-3D	9/8/2022	N	SD015-TISR-3D(09082022)	13	--	<1.0 U	--	1900	--	--	<2.0 U	--	1800	--
SD015-TISR-3D	9/8/2022	FD	SD015-DUP1(09082022)	13	--	<1.0 U	--	1400	--	--	<2.0 U	--	1700	--
SD015-TISR-3D	1/11/2023	N	SD015-TISR-3D(01112023)	18	--	<1 U	--	1500	--	--	<2 U	--	1200	--
SD015-TISR-3D	3/30/2023	N	SD015-TISR-3D(03302023)	25	--	<1.0 U	--	1800	--	--	<2.0 U	--	1100	--
SD015-TISR-3D	4/26/2023	N	SD015-TISR-3D(04262023)	25	--	<1.0 U	--	4200	--	--	<2.0 U	--	1900	--
SD015-TISR-3D	8/14/2023	N	SD015-TISR-3D(08142023)	19	--	<1.0 U	--	2300	--	--	<2.0 U	--	2500	--
SD015-TISR-3D	11/29/2023	N	SD015-TISR-3D(11292023)	20	--	<1.0 U	--	750	--	--	<2.0 U	--	1700	--
SD015-TISR-3D	7/11/2024	N	SD015-TISR-3D(07112024)	0.69 J	--	<1.0 U	--	38	--	--	<2.0 U	--	90	--
SD015-TISR-3D	1/9/2025	N	SD015-TISR-3D(01092025)	1.2	--	<1.0 U	--	0.64 J	--	--	<2.0 U	--	5.5	--
SD015-TISR-3S	1/5/2022	N	SD015-TISR-3S(01052022)	1.4	--	<1.0 U	--	920	--	--	<2.0 U	--	13	--
SD015-TISR-3S	9/8/2022	N	SD015-TISR-3S(09082022)	3.1	--	<1.0 U	--	1100	--	--	<2.0 U	--	40	--
SD015-TISR-3S	1/12/2023	N	SD015-TISR-3S(01122023)	7.6	--	<1 U	--	6.0	--	--	<2 U	--	260	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)	<1.0 U	--	<1.0 U	--	0.28 J	--	--	<2.0 U	--	0.13 J	--
SD015-TISR-3S	3/30/2023	N	SD015-TISR-3S(03302023)-HB	<1.0 U	--	<1.0 U	--	0.25 J	--	--	<2.0 U	--	0.19 J	--
SD015-TISR-3S	4/25/2023	N	SD015-TISR-3S(04252023)	<1.0 U	--	<1.0 U	--	0.54 J	--	--	<2.0 U	--	0.18 J	--
SD015-TISR-3S	8/14/2023	N	SD015-TISR-3S(08142023)	<1.0 U	--	<1.0 U	--	0.33 J	--	--	<2.0 U	--	0.29 J	--
SD015-TISR-3S	11/29/2023	N	SD015-TISR-3S(11292023)	<1.0 U	--	<1.0 U	--	3.6	--	--	<2.0 U	--	1.6	--
SD015-TISR-3S	7/11/2024	N	SD015-TISR-3S(07112024)	0.34 J	--	<1.0 U	--	5.8	--	--	<2.0 U	--	9.8	--
SD015-TISR-3S	1/9/2025	N	SD015-TISR-3S(01092025)	0.97 J	--	<1.0 U	--	0.36 J	--	--	<2.0 U	--	2.1	--
SD015-TISR-4D	1/4/2022	N	SD015-TISR-4D(01042022)	54	--	<1.0 U	--	7200	--	--	<2.0 U	--	390	--
SD015-TISR-4D	9/7/2022	N	SD015-TISR-4D(09072022)	59	--	<1.0 U	--	11000	--	--	<2.0 U	--	630	--
SD015-TISR-4D	9/8/2022	N	SD015-TISR-4D(09082022)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/11/2023	N	SD015-TISR-4D(01112023)	51	--	<5 U	--	8600	--	--	<10 U	--	490	--
SD015-TISR-4D	1/17/2023	N	SD015-TISR-4D-150(01172023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-300(01182023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	1/18/2023	N	SD015-TISR-4D-500(01182023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4D	3/30/2023	N	SD015-TISR-4D(03302023)	0.29 J	--	<1.0 U	--	4.9	--	--	<2.0 U	--	10	--
SD015-TISR-4D	8/14/2023	N	SD015-TISR-4D(08142023)	1.3	--	<1.0 U	--	3.8	--	--	<2.0 U	--	41	--
SD015-TISR-4D	11/29/2023	N	SD015-TISR-4D(11292023)	1.0	--	<1.0 U	--	6.1	--	--	<2.0 U	--	13	--
SD015-TISR-4D	7/11/2024	N	SD015-TISR-4D(07112024)	5.1	--	<1.0 U	--	82	--	--	<2.0 U	--	43	--
SD015-TISR-4D	1/9/2025	N	SD015-TISR-4D(01092025)	5.6	--	<1.0 U	--	1.0	--	--	<2.0 U	--	3.1	--
SD015-TISR-4S	1/4/2022	N	SD015-TISR-4S(01042022)	0.18 J	--	<1.0 U	--	480	--	--	<2.0 U	--	2.0	--
SD015-TISR-4S	9/7/2022	N	SD015-TISR-4S(09072022)	0.89 J	--	<1.0 U	--	770	--	--	<2.0 U	--	13	--
SD015-TISR-4S	9/8/2022	N	SD015-TISR-4S(09082022)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/12/2023	N	SD015-TISR-4S(01122023)	0.31 J	--	<1 U	--	87	--	--	<2 U	--	14	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-150(01172023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/17/2023	N	SD015-TISR-4S-300(01172023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	1/18/2023	N	SD015-TISR-4S-500(01182023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)	<1.0 U	--	<1.0 U	--	0.23 J	--	--	<2.0 U	--	<0.50 U	--
SD015-TISR-4S	3/30/2023	N	SD015-TISR-4S(03302023)-HB	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	<0.50 U	--
SD015-TISR-4S	4/25/2023	N	SD015-TISR-4S(04252023)	<1.0 U	--	<1.0 U	--	<1.0 U	--	--	<2.0 U	--	0.25 J	--
SD015-TISR-4S	8/14/2023	N	SD015-TISR-4S(08142023)	<1.0 U	--	<1.0 U	--	0.94 J	--	--	<2.0 U	--	0.38 J	--
SD015-TISR-4S	11/29/2023	N	SD015-TISR-4S(11292023)	<1.0 U	--	<1.0 U	--	3.8	--	--	<2.0 U	--	0.56	--
SD015-TISR-4S	7/11/2024	N	SD015-TISR-4S(07112024)	0.90 J	--	<1.0 U	--	7.7	--	--	<2.0 U	--	13	--
SD015-TISR-4S	1/9/2025	N	SD015-TISR-4S(01092025)	1.0	--	<1.0 U	--	4.6	--	--	<2.0 U	--	30	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B1	1/13/2023	N	SD015-TISR-B1-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ1(01132023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ2(01132023)	--	--	--	--	--	--	--	--	--	--	--
SD015-TISR-B2	1/13/2023	N	SD015-TISR-B2-INJ3(01132023)	--	--	--	--	--	--	--	--	--	--	--
UNKNOWN DUPLICATE	11/29/2023	FD	SD015-DUP1(11292023)	22	--	<1.0 U	--	5.9	--	--	<2.0 U	--	1900	--
UNKNOWN DUPLICATE	7/11/2024	FD	SD015-DUP1(07112024)	24	--	<1.0 U	--	4800	--	--	<2.0 U	--	1600	--

APPENDIX B TISR SYSTEM SPECIFICATIONS AND VENDOR INFORMATION

Submittal Data Information

ETC-30 Solar Collector

USA Version
A11-01.2.1.3-PB-V3 - June 2015

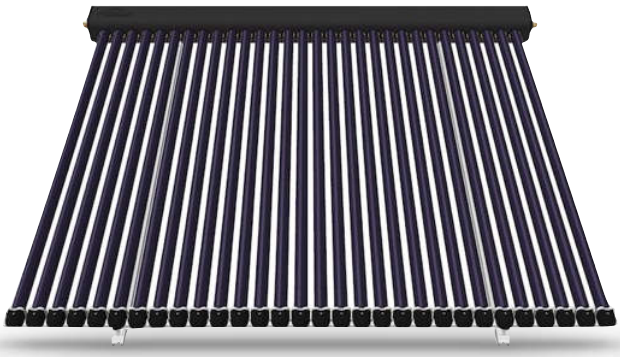
Job: _____ **Engineer:** _____ **Contractor:** _____ **Rep:** _____

Part Codes

ETC-30 Solar Collector Complete is comprised of:
1 x ETC-30-KIT (Manifold and standard frame)
3 x BOX-ET/HP-10/10 (Tubes and heat pipes)

Applications

The Apricus ETC-30 collector is designed to be used in a wide variety of solar thermal (heat) applications in almost any climate. The evacuated tube and heat pipe technology provides very efficient and reliable solar thermal production in a simple to install design.



Materials of Construction

Evacuated Tubes:	Borosilicate 3.3 Glass
Absorber:	Cu-AL/N-SS
Heat Pipes:	High purity copper
Rubber Components:	HTV Silicone Rubber
Mounting Frame:	6005-T5 Anodized Aluminum 316 SS Fasteners
Manifold Casing:	3003 AL, PVDF coating

Flow Guidelines

Recommended Flow Rate:	0.5 gpm
Max Flow Rate:	4 gpm
Heat Transfer Liquid:	Water or 50% Glycol/water

Physical Specifications

Dimensions (WxHxD):	78.9" x 86.4" x 5.35"
Aperture Area:	30.77 ft²
Gross Area:	47.33 ft²
Gross Dry Weight:	209 lbs
Fluid Capacity:	0.2 gal
Max Operating Pressure:	116 psi
Stagnation Temperature:	442°F

Warranty

- 10 year limited warranty on tubes and heat pipes
- 15 year limited warranty on copper header and mounting frame

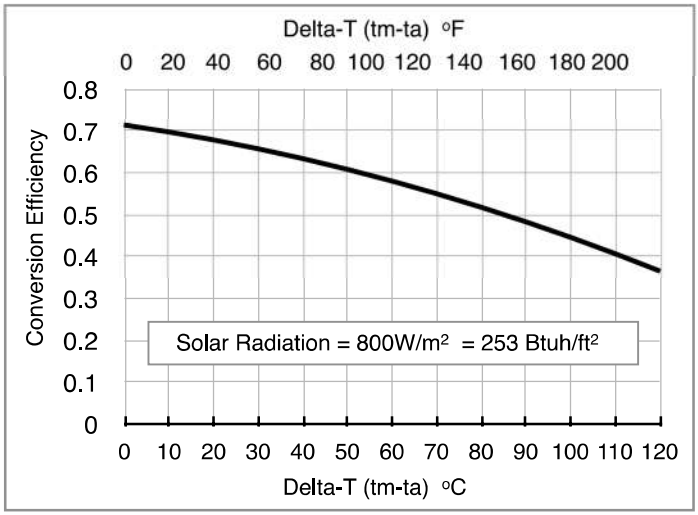
Certifications

SRCC OG-100:	10001909
USEC:	S-5995
NSF-61 Tested:	17248

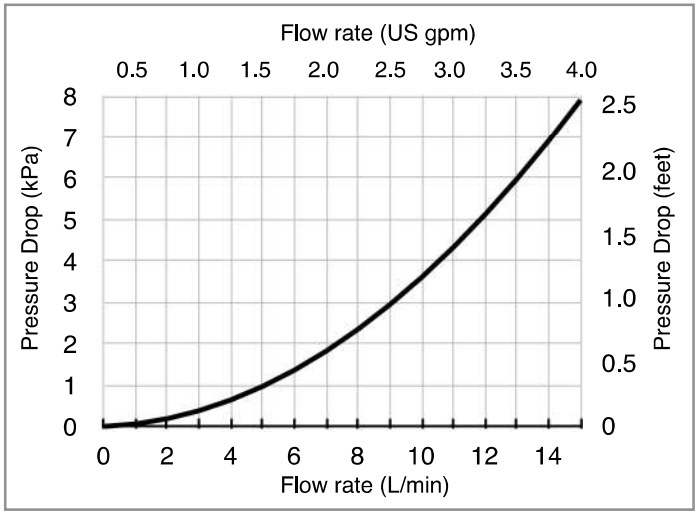
OG-100 Performance Ratings

Climate Category (Ti-Ta)	High Radiation (2000 Btu/ft²/day)	Medium Radiation (1500 Btu/ft²/day)
A (-9°F)	45.3	34.2
B (9°F)	43.7	32.6
C (36°F)	40.9	29.8
D (90°F)	34.4	23.5
E (144°F)	26.7	15.8

Collector Performance (aperture area)



Pressure Drop



Sustainable HOT WATER Solutions, Delivered by APRICUS

Apricus Inc | 1150 S Milliken Ave, Ontario, CA, USA | inquiry-usa@apricus.com | +1 877 458 2634 | www.apricus.com

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Description

1" Press Full Port Brass Ball Valve

Specs

Size:	1"
Approvals:	cUPC NSF61 AB1953 NSF372
Lead Free:	Yes
Max Pressure (PSI):	250 PSI (CWP) 150 PSI (WSP)
Temperature Range (F):	-20°F to 300°F
Connection Method:	Press
Connection Type:	Press x Press
Material:	Brass
Lead Free:	Yes

Automatic air vent and shut-off valve for solar systems

250 series





Function

Automatic air vents are used in the closed circuits of solar heating systems. They allow air contained in the fluid to be released automatically during the filling process, through a valve operated by a float in contact with fluid in the system.
The shut-off valves are used in combination with the automatic air vents to isolate them after filling the circuit of solar heating systems.

These series of products have been specially made to work at high temperatures with a glycol medium.

Product range

Code 250041A Automatic air vent for solar systems ..... size 1/2" M NPT
Code NA29284 Shut-off valve for automatic air vent ..... size 1/2" M NPT x 1/2" F NPT

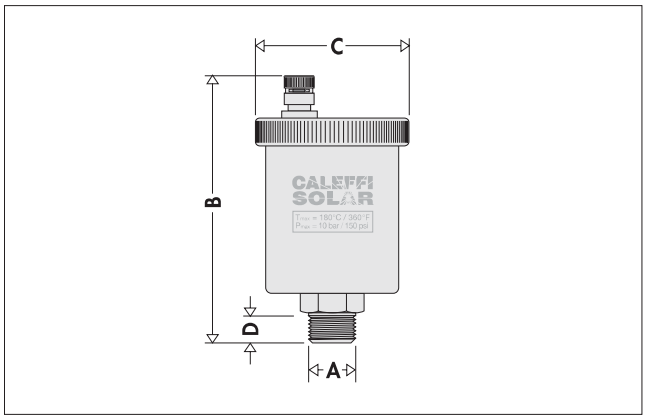
Technical specifications of 250 series valve

Materials: - body:	brass chrome plated
- cover:	brass chrome plated
- control spindle:	stainless steel
- float:	high resistance polymer
- seals:	EPDM
Medium:	water, glycol solutions
Max. percentage of glycol:	50%
Working temperature range:	-20 to 360°F (-30 to 180°C)
Max. working pressure:	150 psi (10 bar)
Max. discharge pressure:	75 psi (5 bar)
Connection:	1/2" M NPT

Technical specifications of valve NA29284

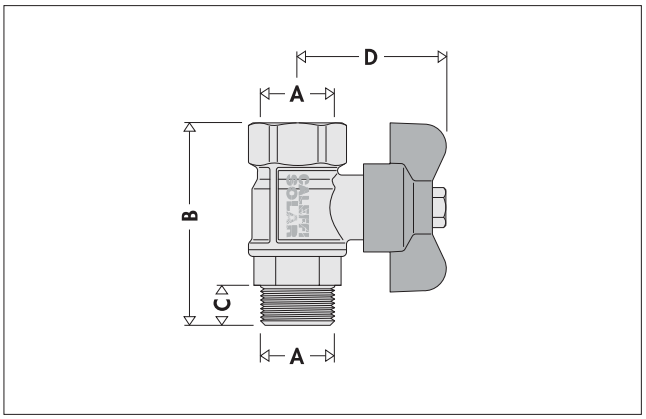
Materials: - body:	brass chrome plated
- ball:	brass chrome plated
- seals:	P.T.F.E.
Medium:	water, glycol solutions
Max. percentage of glycol:	50%
Working temperature range:	-20 to 360°F (-30 to 180°C)
Max. working pressure:	150 psi (10 bar)
Connection:	1/2" F x 1/2" M NPT

Dimensions



Code	A	B	C	D	Weight (lb)
250041A	1/2"	4"	∅2 1/8"	1/2"	0.7

Dimensions

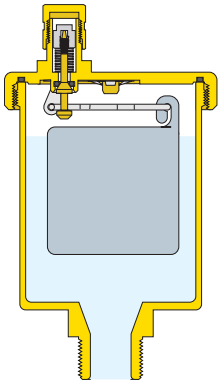


Code	A	B	C	D	Weight (lb)
NA29284	1/2"	2 7/8"	1/2"	1 1/2"	0.5

Operating principle

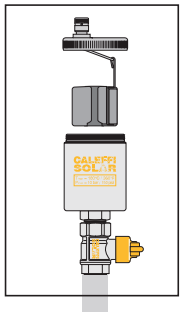
The accumulation of air bubbles in the valve body causes the float to drop so the air vent valve opens.

This phenomenon occurs, and consequently, the valve functions correctly, as long as the water pressure remains below the maximum discharge pressure.



Maintenance

The 250 series automatic air vent is made to allow checking of the internal mechanism.
Access to the moving parts that govern the air vent is attained by simply removing the top cover.
A shut-off valve must be installed before the 250 series device to allow shut off to simplify any maintenance work and for shutting off after the filling phase.

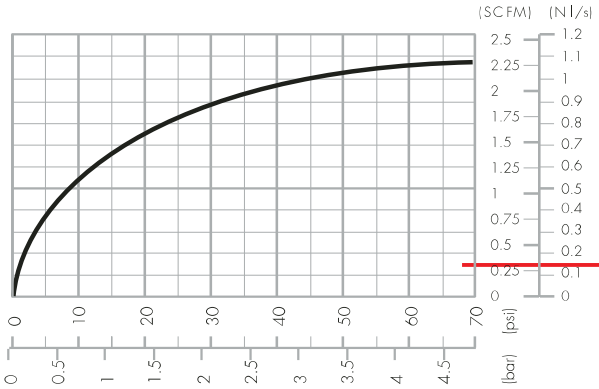


Construction details

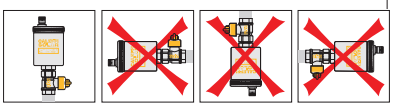
Resistance to temperature
The high performance level of this series of automatic air vent valves, required in solar heating systems, is ensured by using materials that are highly resistant to temperature. The materials allow the vent function with glycol water temperatures up to 360°F (180°C).

Hydraulic characteristics

Discharge capacity when the system is being filled

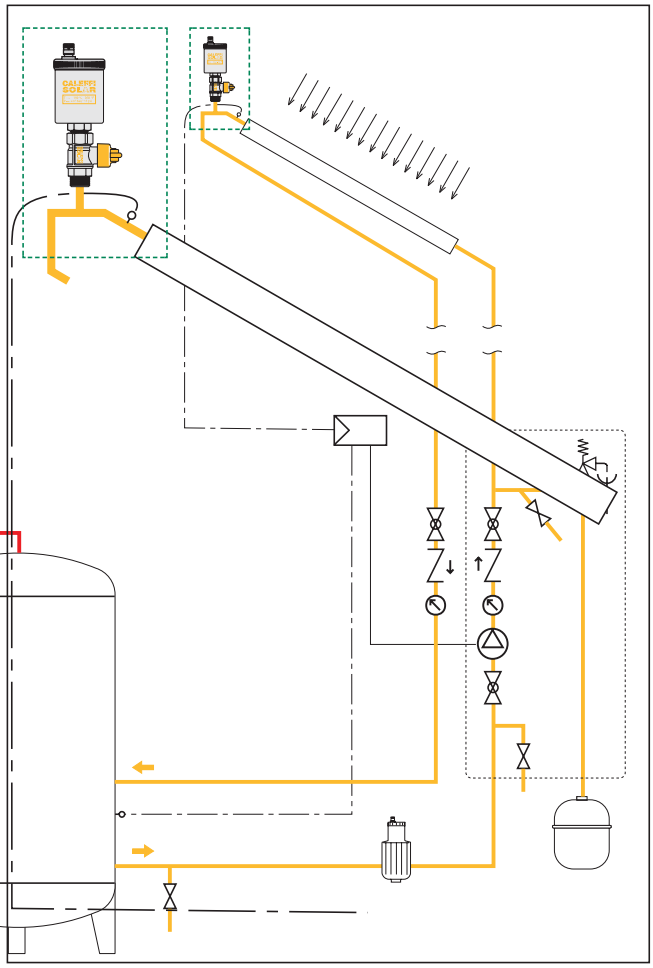


Installation



250 series automatic air vents must be installed in a vertical position, typically on the top of the solar heating system panels and at points in the circuit where air bubbles gather that need to be discharged.
They must always be installed in combination with a shut-off valve. This is necessary since the vent valves must be shut off after use to remove the air during the filling and starting up phase of the system.

Application diagram



SPECIFICATION SUMMARIES

250 series
Automatic air vent for solar heating systems. 1/2" Male NPT connections. Brass body and cover. Chrome plated. Float in high resistance polymer. Seals in high resistance elastomer. Medium: water and glycol solutions. Maximum percentage of glycol: 50%. Working temperature range: -20 to 360°F. Maximum working pressure: 150 psi. Maximum discharge pressure: 75 psi.

Code NA29284
Shut-off valve for automatic air vent for solar heating systems. 1/2" F NPT x 1/2" M NPT connections. Chrome plated brass body and ball. Seals in high resistance elastomer. Medium: water and glycol solutions. Maximum percentage of glycol: 50%. Working temperature range: -20 to 360°F. Maximum working pressure: 150 psi.

○ Galvanized Sch. 40 Pipe

21 ft. stock lengths

ASTM A53 • Tensile Strength: 60 ksi • Yield Point: 35 ksi

Nominal Inside Dimension (in.)	Nominal Wall Thickness (in.)	Inside Dimension (in.)	Outside Dimension (in.)	Weight per ft. (lb./ft.)
3/4	.113	0.824	1.050	1.24
1	.133	1.049	1.315	1.76
1-1/4	.140	1.380	1.660	2.38
1-1/2	.145	1.610	1.900	2.86
2	.154	2.067	2.375	3.83
2-1/2	.203	2.469	2.875	6.38
3	.216	3.068	3.500	8.34
4	.237	4.026	4.500	11.39
6	.280	6.065	6.625	19.92

○ Sch. 80 Pipe

21 and 42 ft. stock lengths

ASTM A53 • Tensile Strength: 60 ksi • Yield Point: 35 ksi
ASTM A500 • Tensile Strength: 62 ksi • Yield Point: 46 ksi

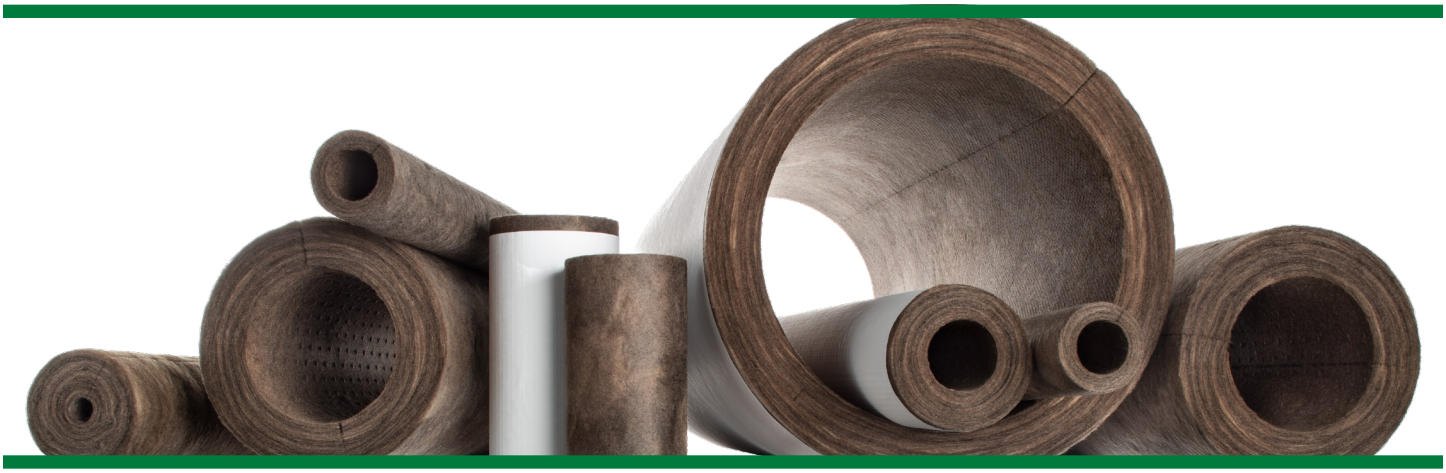
Nominal Inside Dimension (in.)	Nominal Wall Thickness (in.)	Inside Dimension (in.)	Outside Dimension (in.)	Weight per ft. (lb./ft.)
1/2	.147	.546	.840	1.09
3/4	.154	.742	1.050	1.47
1	.179	.957	1.315	2.17
1-1/4	.191	1.278	1.660	3.00
1-1/2	.200	1.500	1.900	3.63
2	.218	1.939	2.375	5.02
2-1/2	.276	2.323	2.875	7.66
3	.300	2.900	3.500	10.25
3-1/2	.318	3.344	4.000	12.51
4	.337	3.826	4.500	14.98
5	.375	4.813	5.563	20.78
6	.432	5.761	6.625	28.57
8	.500	7.625	8.625	43.39
10	.500	9.750	10.750	54.74

MANSON INSULATION

CONTRACTOR

JOB NAME

DATE



ALLEY-K®

Operating Temperature: 0° F – 1000° F (-18° C – 538° C)

DESCRIPTION

Alley-K pipe insulation is a preformed insulation product composed of high quality glass fibers bonded together with a thermosetting resin. The 36" pipe sections are available with or without the all service jacket (ASJ). Our all service vapor retarder jacket (ASJ) reinforced with glass fibers comes with a factory-applied, pressure-sensitive self-sealing lap closure system (SSL). Butt strips are also supplied.

ECOSE® TECHNOLOGY

ECOSE Technology is a revolutionary binder chemistry that enhances the sustainability of our products. The "binder" is the bond that holds our fiberglass product together and gives the product its shape and brown color. ECOSE Technology is a plant-based, sustainable chemistry that replaces the phenol/formaldehyde (PF) binder traditionally used in fiberglass products. Products using ECOSE Technology are formaldehyde-free and have reduced global warming potential when compared to our products of the past.

SUSTAINABILITY

Manson Insulation's products used for thermal insulating purposes recover the energy that it took to make them in just hours or days, depending on the application. Once installed, the product continues to save energy and reduce carbon generation as long as it is in place.

Fiberglass insulation with ECOSE Technology contains three key ingredients:

- Recycled glass content, verified annually by UL Environment
- Sand, one of the world's most abundant resources
- Our green chemistry initiative ECOSE Technology, which is validated to be formaldehyde-free

APPLICATION

Manson Insulation pipe insulation is intended as a thermal insulation product for hot and cold service piping. Typical uses include domestic hot and cold water, hot water heating, high temperature, dual temperature, steam, condensate and refrigerated lines. As a component of a suitable insulation system, plain pipe insulation may be used for light industrial applications, while pipe insulation with ASJ jacket may be used for commercial and institutional usage.

INSTALLATION

Manson Insulation pipe insulation should be installed in accordance with the procedure in the publication "Commercial & Industrial Standards" by the National Insulation Association (NIA).

INDOOR AIR QUALITY

- UL Environment
  - GREENGUARD Certified
  - GREENGUARD Gold Certified
  - Validated to be Formaldehyde-Free
- EUCEB certified

SPECIFICATION COMPLIANCE

- ASTM C547; Type I, Type IV
- ASTM C585
- MIL-DTL-32585; Type I, Form 4, Facing A and D
- UL/ULC Classified

- ASTM C795
- MIL-I-24244
- NRC Reg. Guide 1.36
  (Certification needs to be specified at the time of the order)

Jacketing

- UL 723/ASTM E84
- CGSB 51-GP-52M
- ASTM C1136; Type I, II
- NFPA 90A and 90B

MANSON INSULATION

ALLEY-K®

Operating Temperature: 0° F – 1000° F (-18° C – 538° C)

PRODUCT FORMS AND SIZES

- Produced in 3' (914 mm) sections
- For iron pipe ½" – 24" (15 mm – 610 mm) nominal pipe size
- For copper tube ⅝" – 6⅛" (16 mm – 156 mm)
- All insulation inner and outer diameters comply with ASTM C585.
- Wall thicknesses from ½" to 6" (13 mm to 152 mm) in single layer for most sizes
- With or without a white, factory-applied jacket, ASJ (allservice jacket) is composed of aluminum foil, reinforced with a glass scrim bonded to a white kraft paper
- A matching ASJ butt strip is supplied for each section
- The longitudinal lap of the jacket has the SSL self-sealing lap that creates a strong and lasting bond

PRECAUTIONS

Hot Pipe

- May be installed while the system is in operation, at all temperatures up to 1000° F (538° C).
- Manson Insulation recommends, for insulation thicknesses greater than 6" (152 mm), the temperature must be increased from 500° F (260° C) to maximum temperature at a rate not exceeding 100° F (37.8° C) per hour.
- During initial heat-up to operating temperatures above 350° F (177° C), a slight odor and some smoke may be given off as a portion of the bonding material used in the insulation begins to undergo a controlled decomposition.
- If natural convection is not adequate in confined areas, forced ventilation should be provided in order to protect against any harmful fumes and vapors that might be generated.
- Care must also be taken when using sealants, solvents or flammable adhesive during installation.
- A maximum of 6" (152 mm) wall thickness is recommended.

Cold Pipe

- Use a continuous vapor retarder on piping operating below ambient temperatures.
- Seal all joints, surfaces, seams and fittings to prevent condensation.
- On below freezing applications, and in high-abuse areas, the ASJ jacket shall be protected with a PVC vapor retarding outer jacket. In addition, exposed ends of insulation shall be sealed with vapor barrier mastic installed per the mastic manufacturer's instructions. Vapor seals at butt joints shall be applied at 12' to 21' intervals; at the Engineer's discretion and at each fitting to isolate any water incursion.
- On chilled water systems operating in high humidity conditions, it is recommended that the same guidelines be followed as listed above for below freezing applications.
- Exterior hanger supports are recommended.

Outside Application

- Do not expose pipe insulation to weather. It must be covered with appropriate jacketing, mastic or vapor retardant coatings.
- All exposed surfaces must be protected. Proto® Indoor/Outdoor PVC Jacketing is recommended. See Manson Insulation Guide Specifications for recommended PVC jacketing application guidelines.
- Apply jacketing, mastics or vapor retardant adhesives per manufacturer's instructions.
- For metallic jackets, factory-applied moisture retarders are recommended.

ASJ SSL

- Keep adhesive and contact surfaces free from dirt and water. Seal immediately once adhesive is exposed.
- Apply when ambient and insulation temperatures are between 20° F and 130° F (-6.7° C and 54° C).
- If stored below 20° F or above 130° F, allow insulation cartons to stand within recommended temperature range for 24 hours prior to application.
- Do not store product below -20° F (-29° C) or above 150° F (66° C).
- When using Manson Insulation's SSL Advanced Closure System, make sure the longitudinal and circumferential joints are properly sealed by rubbing the closure firmly with a squeegee. Use of staples is not recommended.
- When using Alley-K® pipe insulation, the surface temperature of the ASJ facing should not exceed 150° F (66° C).

Fittings and Hangers

- Use Proto 25/50 Rated (ASTM E84) PVC Fitting Covers, applying PVC fittings per Proto's Data Sheet.
- Fittings should be insulated to same thickness as the adjoining insulation.
- Apply fittings per manufacturer's instructions.
- When required by specification, a hard insert of sufficient length should be used to avoid compression of the insulation.

ADDITIONAL PRECAUTIONS

- Fiberglass may cause temporary skin irritation. Wear long-sleeved, loose-fitting clothing, head covering, gloves and eye protection when handling and applying material.
- Wash with soap and warm water after handling.
- Wash work clothes separately and rinse washer afterwards.
- Use a disposable mask/respirator designed for nuisance-type dusts where sensitivity to dust and airborne particles may cause irritation to the nose or throat.

MANSON INSULATION

ALLEY-K®

Operating Temperature: 0° F – 1000° F (-18° C – 538° C)

APPLICATION GUIDELINES

Storage

- Protect insulation from water damage or other abuse, welding sparks and open flame.
- Cartons are not designed for outside storage.

Preparation

- Apply only on clean, dry surfaces
- Pipe or vessel should be tested and released before insulation is applied.

General Guidelines

- All sections should be firmly butted.
- Seal circumferential joint with a minimum 3" (76 mm) wide butt strip.
- Jackets, coating and adhesives should have a comparable F.H.C. rating.
- ASJ may be painted. As with traditional ASJ, Manson Insulation does not encourage the painting of ASJ because the application of any paint may change the surface burning characteristics and will void the UL Classification and Manson Insulation Limited Warranty.

Insulation Limited Warranty

Where painting is necessary use common water, oil, or solvent-based paints. All paints should be tested for compatibility and adhesion before use.

- All piping should have continuous insulation.
- Position longitudinal lap downward to avoid dirt and moisture infiltration.
- Do not expose pipe insulation to excessive vibration or physical abuse.
- Faced insulation should not have a facing temperature above 150° F (66° C).

SSL Installation Instructions:

- To install SSL, first remove the kraft release liner to expose adhesive.
- Carefully align the jacketing. Starting in the center of the insulation section, begin initial SSL tack using pressure in the direction of the overlap. Again, starting in the center of the insulation section, with a plastic squeegee begin to apply firm pressure to the bonded lap area swiping from the center of the insulation section toward each end.
- **NOTE:** After initial SSL adhesive tack, it is critical that the closure is not re-opened and repositioned on the facing. Doing so will delaminate the jacket and adhesive, diminishing the bond strength.

Butt Strip Installation Instructions:

- To install Butt Strips, remove the kraft release liner by separating the butt strip from the kraft using the convenient, easy release kiss cut.
- Simply wrap the butt strip, centered around the joint, and apply firm pressure with a squeegee.
- **NOTE:** After initial Butt Strip adhesive tack, it is critical that the closure is not re-opened and repositioned on the facing. Doing so will weaken the adhesive and diminish bond strength.

FIBERGLASS AND MOLD

Fiberglass insulation will not sustain mold growth. However, mold can grow on almost any material when it becomes wet and contaminated. Carefully inspect any insulation that has been exposed to water. If it shows any sign of mold, it must be discarded. If the material is wet but shows no evidence of mold, it should be dried rapidly and thoroughly. If it shows signs of facing degradation from wetting, it should be replaced.

NOTES

The chemical and physical properties of Manson Insulation Alley-K insulation represent average values determined in accordance with accepted test methods. The data is subject to normal manufacturing and testing variations. The data is supplied as a technical service and is subject to change without notice. References to numerical flame spread ratings are not intended to reflect hazards presented by these or any other materials under actual fire conditions.

Check with your Manson Insulation Area Manager to ensure information is current.

TECHNICAL DATA

PROPERTY (UNIT)	TEST	PERFORMANCE
Corrosiveness	ASTM C665	Does not accelerate corrosion of steel
Linear Shrinkage	ASTM C356	Less than 0.3%
Maximum Service Temperature	C411	1000° F (538° C)
Water Vapor Sorption (by weight)	ASTM C1104	Less than 5%
Water Vapor Permeance	ASTM E96	0.02 perms
Puncture Resistance	TAPPI T803, Beach Units	Min. rating of 50
Microbial Growth	ASTM C1338	Pass
Surface Burning Characteristics (flame spread/smoke developed)	ASTM E84, UL 723, CAN/ULC S102	UL/ULC Classified FHC 25/50

MANSON INSULATION

ALLEY-K®

Operating Temperature: 0° F – 1000° F (-18° C – 538° C)

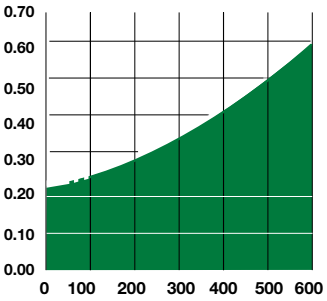
ASHRAE 90.1-2016 REQUIREMENTS

MINIMUM PIPE INSULATION THICKNESS

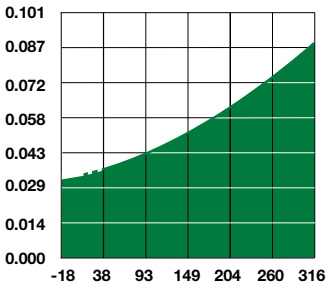
FLUID OPERATING TEMPERATURE RANGE AND USAGE	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE				
	CONDUCTIVITY RANGE BTU-IN./(HR · FT² · °F)	MEAN TEMPERATURE RATING	<1"	1"–<1½"	1½"–<4"	4"–<8"	≥8"
HEATING AND HOT WATER SYSTEMS (STEAM, STEAM CONDENSATE, HOT-WATER HEATING AND DOMESTIC WATER SYSTEMS)A, B, C, D							
Above 350° F	0.32–0.34	250° F	4½"	5"	5"	5"	5"
251–350° F	0.29–0.31	200° F	3"	4"	4½"	4½"	4½"
201–250° F	0.27–0.30	150° F	2½"	2½"	2½"	3"	3"
141–200° F	0.25–0.29	125° F	1½"	1½"	2"	2"	2"
105–140° F	0.22–0.28	100° F	1"	1"	1½"	1½"	1½"
COOLING SYSTEMS (CHILLED WATER, BRINE, REFRIGERANT) [A, B, C, D]							
40–60° F	0.21–0.27	75° F	½"	½"	1"	1"	1"
Below 40° F	0.20–0.26	50° F	½"	1"	1"	1"	1½"

a. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T=r\{(1+t/r)^{K/k}-1\}$, where T=minimum insulation thickness (in.), r=actual outside radius of pipe (in.), t=insulation thickness listed in this table for applicable fluid temperature and pipe size, K=conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature {Btu · in. (h · ft² · °F)}; and k=the upper value of the conductivity range listed in this table for the applicable fluid temperature.
b. These thicknesses are based on energy efficiency considerations only.
c. For piping smaller than 1½" and located in partitions within conditioned spaces, reduction of these thicknesses by 1" shall be permitted (before thickness adjustment required in footnote a) but not to thicknesses below 1". These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.
d. The table is based on steel pipe. Non-metallic pipes schedule 80 thickness or less shall use the table values. For other non-metallic pipes having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown on the table.

THERMAL CONDUCTIVITY BTU · IN/FT² · HR. · °F



METRIC THERMAL CONDUCTIVITY | W/M · °C



THERMAL CONDUCTIVITY | ASTM C335

MEAN TEMPERATURE		BTU · IN/FT² · HR. · °F	W/M · °C
75° F	24° C	0.23	0.033
100° F	38° C	0.24	0.035
200° F	93° C	0.28	0.040
300° F	149° C	0.34	0.049
400° F	204° C	0.42	0.061
500° F	260° C	0.51	0.074
600° F	316° C	0.62	0.089

FIRE HAZARD CLASSIFICATION

FACING	FLAME SPREAD	SMOKE DEVELOPED
Plain	25	50
ASJ	25	50

Manson Insulation | **www.imanson.com**
One Knauf Drive, Shelbyville, IN 46176
Sales (317) 398-4434, ext. 8485
Technical Support (317) 398-4434, ext. 8727

03-21

SKU: TDA25-BM

2.5" Tridicator Temperature and Pressure Gauge, Back Mount





Features:

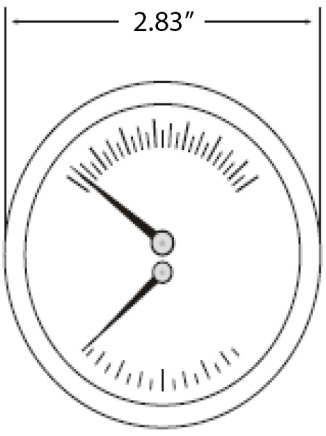
Measures both pressure and temperature on the same dial
2.5" dial
Dual scale (kPa & psi) (°F & °C)
Back mount connection
Brass wetted parts
1/4" NPT connection
2.5% Accuracy

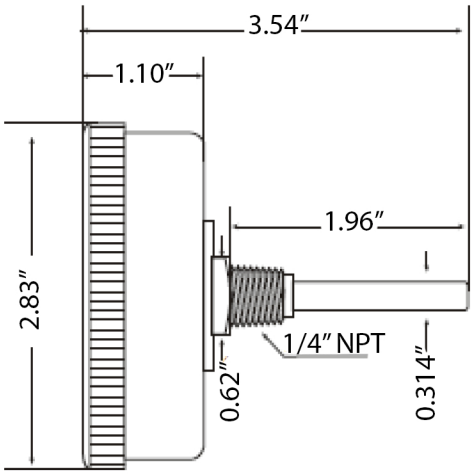
Applications:

ot water and steam pressure for boilers.

Specifications:

Pressure Scale	0-75psi / 0-500kPa
Temperature Scale	20-160 °C / 70-320 °F
Dial	2.5" black & red markings
Case	Black painted steel
Lens	Thread-in plastic
Connection	1/4" NPT, back
Movement	Brass
Socket	Brass
Stem	Brass
Pointer	Aluminum, painted black
Temp Sensing Element	Bi-metallic element
Pressure Element	Bourdon tube
Temp accuracy	2.5% of full scale
Pressure accuracy	2.5% of full scale
Enclosure Rating	IP45





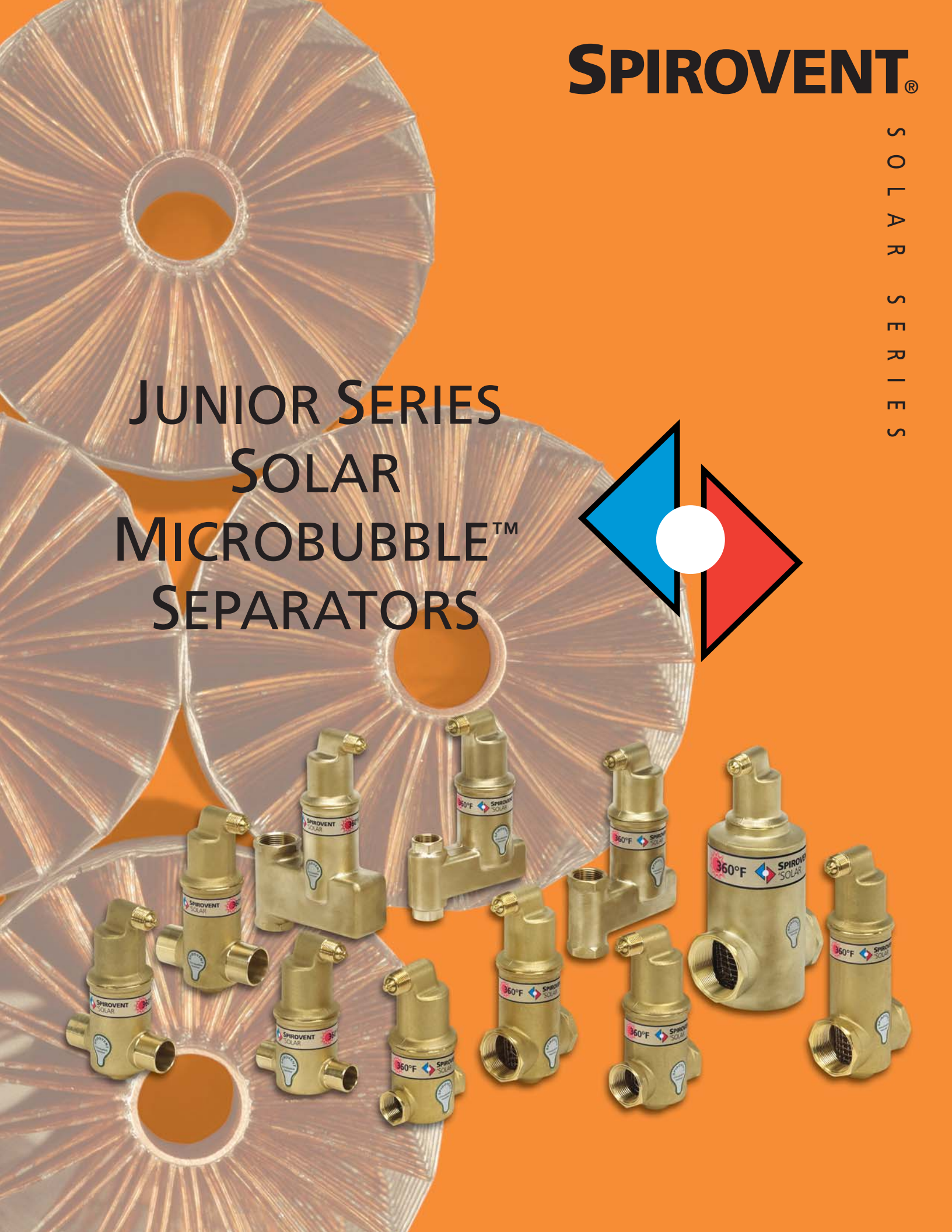


Example Pump Station

SPIROVENT®

SOLAR SERIES

JUNIOR SERIES SOLAR MICROBUBBLE™ SEPARATORS



Air in system water causes many problems.

Noisy pipes, valves, and other air-related noises are often accepted as the signs of a functioning system. Excessive pump noise, cavitation, and cascading in terminal units are considered normal.

But… air in system water can cause corrosion, reduced efficiency, poorly heated or inadequately cooled rooms, accelerated component wear and on-going complaints.

There is a device that will keep your system free of air … permanently. Less maintenance, quiet operation, fewer costs!

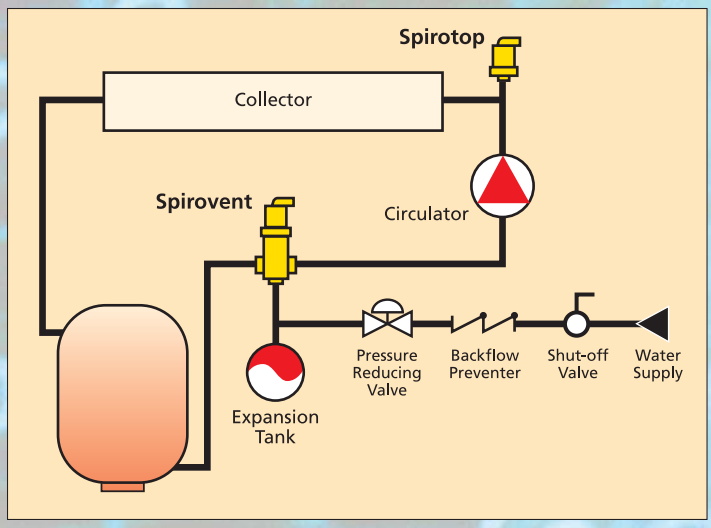
The name:

SPIROVENT®

Unlike conventional air eliminators or air scoops, the Spirovent completely eliminates 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system. Consisting of woven copper wire soldered to a copper tube, the patented Spirotube® creates a low velocity area in the Spirovent that scrubs the bubbles from the water. The air bubbles rise and collect in the air chamber before they are vented from the system via an integral automatic valve. Air problems become a thing of the past.

Install the Spirovent for optimum performance

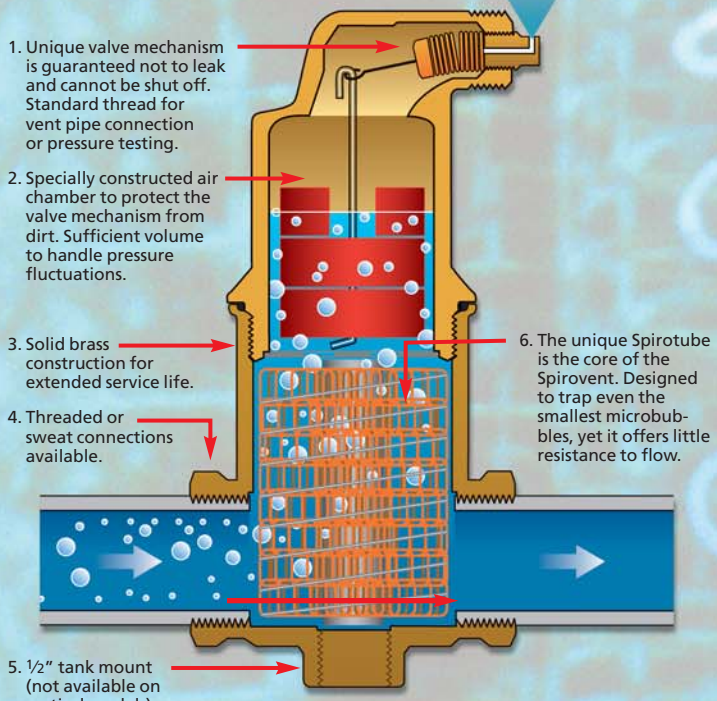
Ideal placement of the Spirovent Junior is based on microbubble separation and Henry's Law. Simply put, Henry's Law states that air is released from water as the temperature increases or the pressure decreases. In solar systems, the Spirovent should be installed in the supply line where the temperature is highest. Should the circulator be located on the supply line as well, the Spirovent should be installed between the tank and the circulator where pressure is also the lowest.



ADVANTAGES TO THE INSTALLER AND END-USER

- High temperature design for solar applications ("HT" models only)
- Maintenance free.
- No venting required.
- Vent head is designed to stay dry. Dirt and leak resistant.
- ½" male thread port for pressure testing or remote venting of unwanted gases.
- Quiet operation.
- Increased component life.
- Reduced oxygen-based corrosion and pump cavitation.

The Principal Difference



The Spirotube is the core of the Spirovent. It allows the Spirovent to scrub out 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system. Even the smallest microbubbles coalesce and rise. Air is eliminated, component life and heat transfer abilities are increased; oxygen-based corrosion and pump cavitation are reduced; and annoying gurgling, cascading, and other air-related system noises are eliminated.

Technical Specification — Spirovent Junior Air Eliminator

SPIROVENT		JUNIOR				
Threaded Part Number		**VJR075HT**	**VJR100HT**	**VJR125HT**	**VJR150HT**	**VJR200HT**
Sweat Part Number		**VJS075HT**	**VJS100HT**	**VJS125HT**	**N/A**	**N/A**
Vertical Part Number		**VJV075HT**	**VJV100HT**	**VJV125HT**	**N/A**	**N/A**
Pipe Size		¾"	1"	1¼"	1½"	2"
Thread	NPT	¾"	1"	1¼"	1½"	2"
D	Inch	2.6	2.6	2.6	2.6	4.0
H1 (Threaded)	Inch	6.0	7.0	7.8	9.1	10.8
H1 (Sweat)	Inch	6.0	7.0	7.8	N/A	N/A
H1 (Vertical)	Inch	6.0	7.0	9.1	N/A	N/A
h1 (Threaded)	Inch	0.8	1.4	1.5	1.6	2.3
h1 (Sweat)	Inch	0.8	1.4	1.5	N/A	N/A
B (Vertical)	Inch	4.8	4.8	5.4	N/A	N/A
L (Threaded)	Inch	3.4	3.5	3.5	3.5	5.2
L (Sweat)	Inch	4.1	4.5	4.5	N/A	N/A
L (Vertical)	Inch	3.4	3.5	3.8	N/A	N/A
Plug (e)*		½"	½"	½"	½"	½"
Wt. Threaded	Lbs.	3.0	3.5	4	4.5	8.5
Wt. Sweat	Lbs.	3.0	3.0	3.5	N/A	N/A
Wt. Vertical	Lbs.	4.8	5.0	6.0	N/A	N/A
Recommended Flow**	GPM	6	10	15	30	40

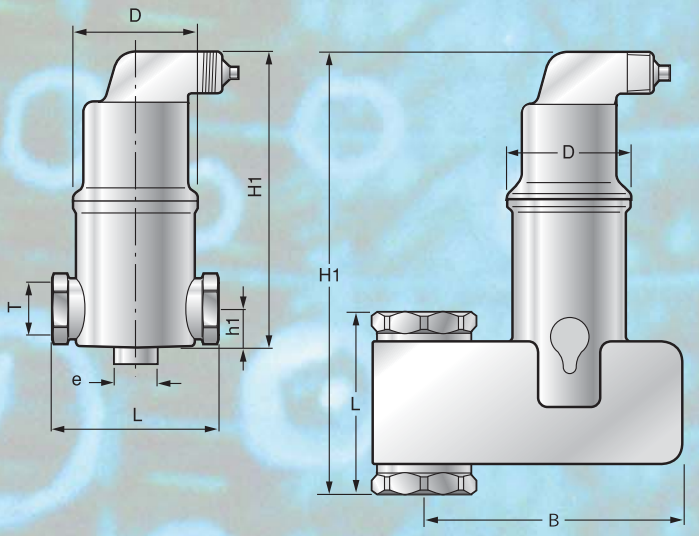
* Not available on Vertical units.

**Approximately 4 ft. per second inlet velocity

Consult Senior Air Brochure for larger Senior units.

Maximum Temperature: 360°F

Maximum Pressure: 150 psig



Insulation Kits Available



Horizontal Insulation Kit **Vertical Insulation Kit**

Part No. PJR000IK includes Insulation and Trimming Knife
Fits all ¾" through 1½" models.

When you first start up your solar system, you'll find that many air bubbles are large enough to rise to the top on their own. There is an automatic air vent that will quickly gather and release these bubbles. You won't have to manually bleed hard-to-reach areas, such as the tops of risers, tanks, unit heaters, and horizontal lines near the ceiling.

The result?

Hydronic and solar systems start up in much less time with no aggravation.

Known for its reliability, this unique automatic air vent can be found in millions of installations around the world.

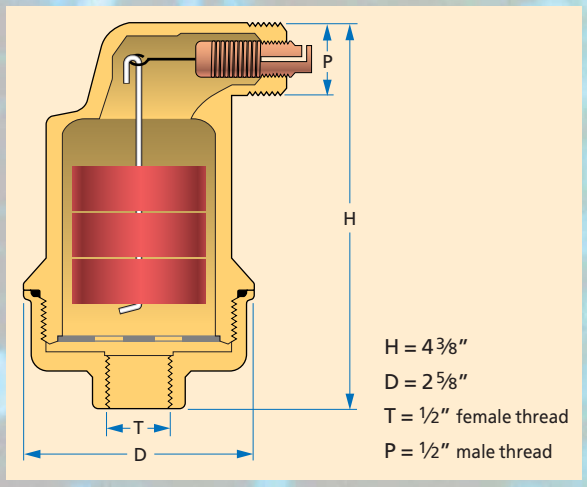
The name:

SPIROTOP®

Spirotop's low profile and high-compression valve combine to give you a leak-resistant, high point vent that fits just about anywhere. Moreover, Spirotop resists dirt particles and sudden pressure shocks, which can cause ordinary vents to leak.

When filling or draining a system, venting high points, or eliminating air locks, the Spirotop automatic air vent is the only choice for those who want reliable, problem-free results every time.

Try a Spirotop. We think you'll find it's much more than an air vent. It's a problem solver!

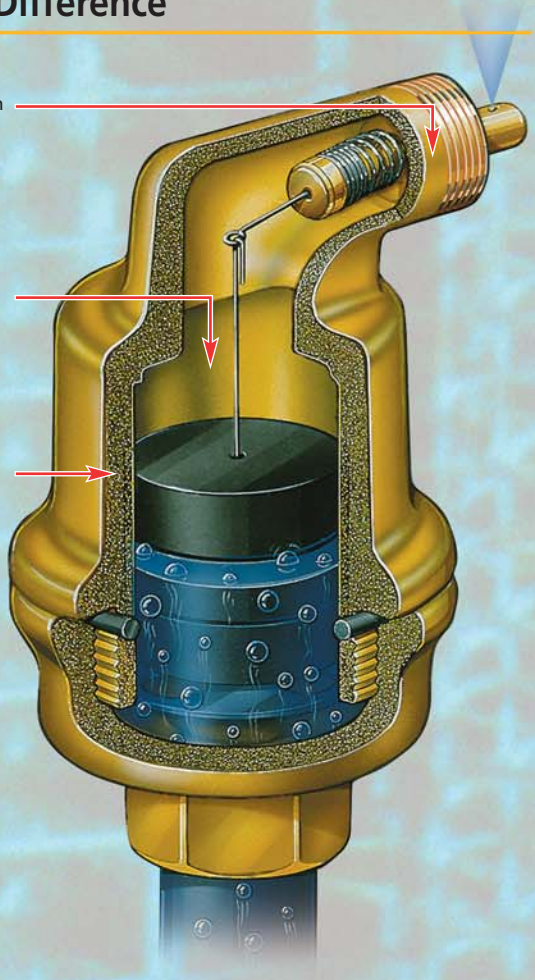


ADVANTAGES TO THE INSTALLER AND END-USER

- 360° F maximum temperature (Model VTP050HT only).
- Maintenance free.
- Continuous air venting.
- 150 psig standard working pressure.
- Sized to fit almost anywhere.
- Dirt resistant.
- Leak resistant.
- ½" male tread at vent point for pressure testing or remote venting of unwanted gasses.
- Quick removal of large air bubbles.
- Reliable vacuum breaker for system draining.

The Principal Difference

1. Unique valve mechanism is guaranteed not to leak and cannot be shut off. Standard thread for vent pipe connection or pressure testing.
2. Specially constructed air chamber to protect the valve mechanism from dirt. Sufficient volume to handle pressure fluctuations.
3. Solid brass construction for extended service life.



Model VTP050HT for Solar Applications

SPIROTHERM
A Spiro Enterprises Company

Spirotherm, Inc.
25 N. Brandon Drive
Glendale Heights, IL 60139

Tel.: 630-307-2662
Fax: 630-307-3773

Website: www.spirotherm.com
E-mail: info@spirotherm.com

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GRUNDFOS

Company name: -
Created by: -
Phone: -
Fax: -
Date: -

Position	Count	Description	Unit price
	-1	**UPS 26-150**	On request



Product photo could vary from the actual product

Product No.: 95906630
The pump is of the canned rotor type, i.e. pump and motor form an integral unit without shaft seal and with only two gaskets for sealing.
The bearings are lubricated by the pumped liquid.
The pump is characterized by:

* Ceramic shaft and radial bearings.
* Carbon axial bearing.
* Stainless steel rotor can and bearing plate.
* Corrosion-resistant impeller, Composite, PES.
* Cast iron pump housing.

The motor is a 1-phase motor.
No additional motor protection is required.

Liquid:

Liquid temperature range:	32 .. 230 °F
Density:	62.4 lb/ft³

Technical:

Maximum operating pressure:	145 psi
Approvals on nameplate:	ETL, CSA

Materials:

Pump housing:	Cast iron EN-GJL-200
Impeller:	Composite, PES

Installation:

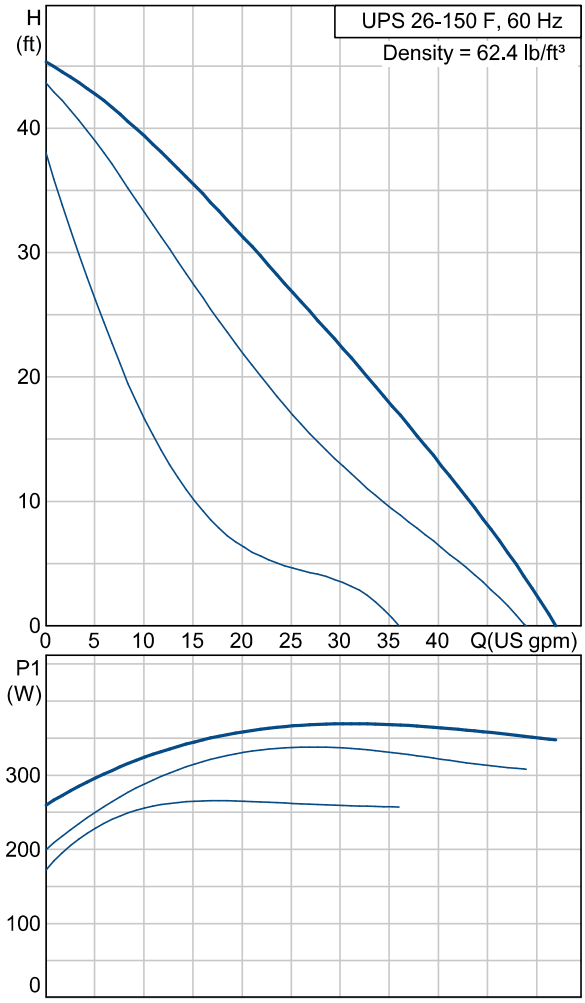
Maximum ambient temperature:	104 °F
Ambient max at 176°F liquid:	176 °F
Maximum operating pressure:	145 psi
Flange standard:	USA Oval
Type of connection:	C.I. Flange
Pipe connection:	2 - Bolt Flange
Pressure stage:	10

Position	Count	Description		Unit price
		Port-to-port length:	6 1/2 in	
		Electrical data:		
		Number of poles:	2	
		Power input in speed 1:	265 W	
		Power input in speed 2:	335 W	
		Max. power input:	370 W	
		Rated power - P2:	0.335 HP	
		Main frequency:	60 Hz	
		Rated voltage:	1 x 115 V	
		Current in speed 1:	2.5 A	
		Current in speed 2:	3.1 A	
		Current in speed 3:	3.5 A	
		Capacitor size - run:	40 µF/180 V	
		Insulation class (IEC 85):	H	
		Others:		
		Gross weight:	17.4 lb	

GRUNDFOS

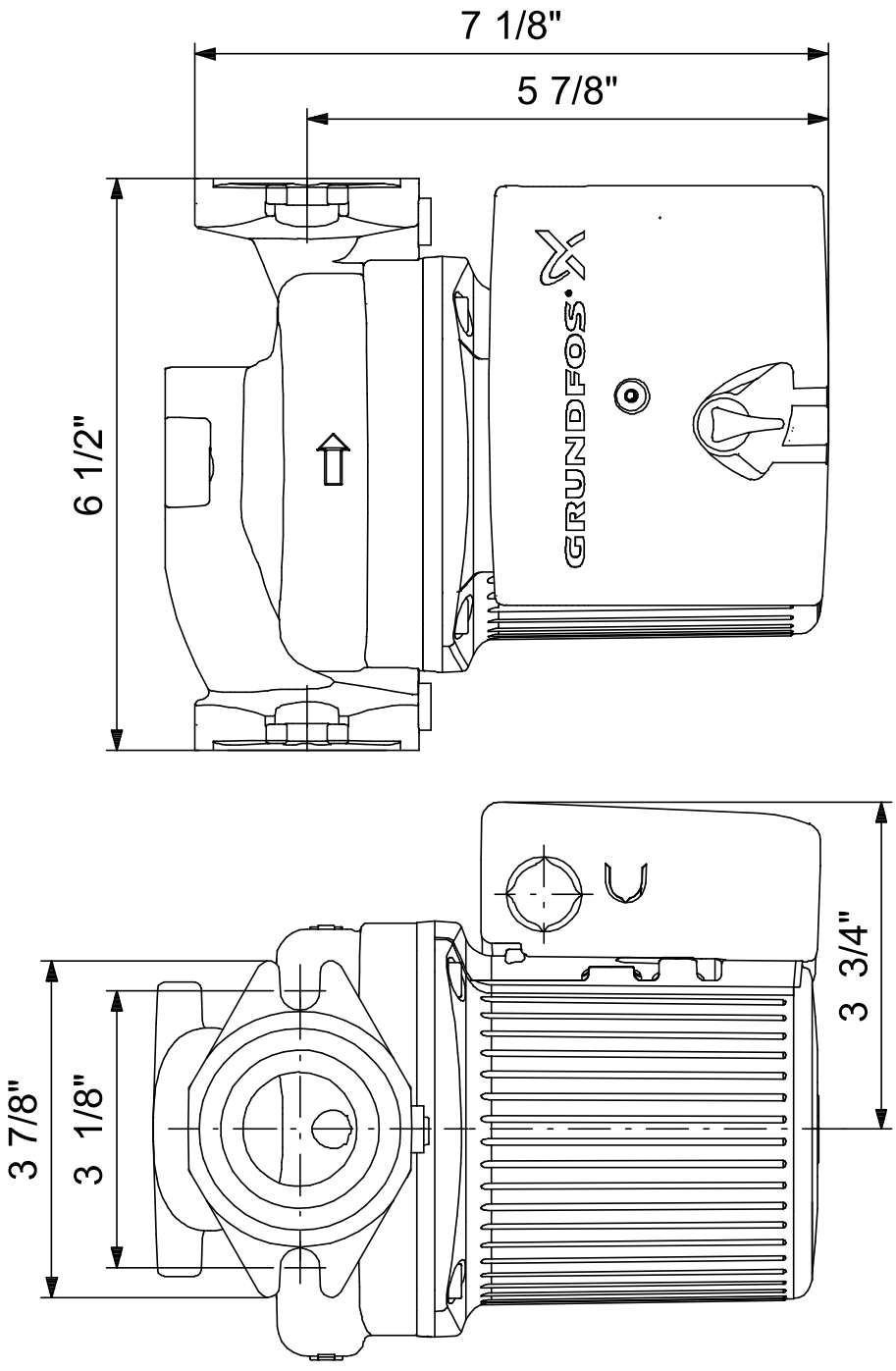
Company name: -
Created by: -
Phone: -
Fax: -
Date: -

Description	Value
Product name:	UPS 26-150 F
Product Number:	95906630
EAN number:	5700313291670
Technical:	
Speed Number:	3
Max flow:	52 US gpm
Head max:	45.3 ft
Maximum operating pressure	145 psi
Approvals on nameplate:	ETL, CSA
Materials:	
Pump housing:	Cast iron
	EN-GJL-200
Impeller:	Composite, PES
Installation:	
Maximum ambient temperature:	104 °F
Ambient max at 176°F liquid	176 °F
Maximum operating pressure	145 psi
Flange standard:	USA Oval
Type of connection:	C.I. Flange
Pipe connection:	2 - Bolt Flange
Pressure stage:	10
Port-to-port length:	6 1/2 in
Liquid:	
Liquid temperature range	32 .. 230 °F
Density:	62.4 lb/ft³
Electrical data:	
Number of poles:	2
Power input in speed 1:	265 W
Power input in speed 2:	335 W
Max. power input:	370 W
Rated power - P2:	0.335 HP
Main frequency:	60 Hz
Rated voltage:	1 x 115 V
Current in speed 1	2.5 A
Current in speed 2	3.1 A
Current in speed 3	3.5 A
Capacitor size - run	40 µF/180 V
Insulation class (IEC 85):	H
Motor protection:	CONTACT
Thermal protec:	internal
Controls:	
Pos term box:	9H
Others:	
Gross weight:	17.4 lb



Company name: -
Created by: -
Phone: -
Fax: -
Date: -

95906630 UPS 26-150 F 60 Hz



Note! All units are in [mm] unless others are stated.
Disclaimer: This simplified dimensional drawing does not show all details.

Steel Drum - 55 Gallon, Closed Top, Lined



More Images

Store and ship liquids or solids.

- Withstands extreme temperatures of -30° to 250°F.
- Epoxy/Phenolic coating resists corrosion.
- **Closed Top:** Features 2" opening to pour and 3/4" opening to vent.
- FDA compliant.

MEETS TITLE 49 CODE

MODEL NO.	DESCRIPTION	CAP.	UN RATING	THICKNESS (mm) TOP/BODY/BOTTOM	WT. (LBS.)	PRICE EACH 1	PRICE EACH 4+	ADD TO CART
S-16914	Closed Top	55 Gal.	1A1/X1.8/300	1.2/0.9/1.2	38	$110	$104	1 ADD

SHIPS VIA MOTOR FREIGHT

Additional Info | Shopping Lists | Request a Catalog

DIMENSIONS:
- Diameter:
  - Opening (Inside): 22 1/4"
  - Outside: 23"
- Height: 34 1/4"

MATERIAL:
- Made from cold rolled steel.
- Top and Bottom: 18 gauge steel
- Body and Lid: 20 gauge steel
- Lining:
  - Epoxy: 70%
  - Phenolic: 30%

COMPATIBILITY:
- Compatible with H-1552 Drum Plug Opener.

FEATURES:
- Vent hole plugs have gaskets.
- Lid Openings:
  - (1) 3/4" Fine/NPS threaded
  - (1) 2" Fine/NPS threaded

CAPACITY:
- 825 lbs

STYLE:
- Lid is not removable.

USAGE:
- Can be Used to Store:
  - Gasoline/Diesel fuel
  - Drinking water

Ships Via Motor Freight

Availability: In Stock
Unit Weight: 38 lbs.

Instructions

Test Report

Catalog Page 554

Email Item

Country of Origin: USA

VFS 5-100

Vortex Flowsensor Standard, 5-100 l/min



TM03 8211 0807

Fig. 1 VFS 5-100 sensor

Technical overview

Grundfos Direct Sensors™, type VFS, is a series of combined flow- and temperature sensors (two-in-one) based on the principle of vortex shedding behind a bluff body. The VFS sensors are designed for high-volume production and are fully compatible with wet, aggressive media. The VFS sensor utilises MEMS sensing technology in combination with a novel packaging concept using corrosion-resistant coating on the MEMS sensor element. This makes the VFS sensor very robust and ideal for high-volume OEM applications. VFS sensors are available for flow ranges of 1-12, 1-20, 2-40, 5-100, 10-200 and 20-400 l/min.

The trademark Grundfos Direct Sensors™ is owned and controlled by the Grundfos group.

Applications

- thermal management in solar heating systems
- industrial process flow control
- flow rate detection for pump controls
- monitoring of pumps, valves and filters
- cooling and temperature control
- domestic hot-water systems
- heat metering (solar - heat pumps).

Features

- flow ranges: 1-12, 1-20, 2-40, 5-100, 10-200 and 20-400 l/min.
- based on vortex shedding
- voltage output (ratiometric, ideal for use with microprocessor and PLC)
- compact and robust design
- approved for potable water: WRAS, KTW, W270, ACS.

Benefits

- no moving parts
- flow and temperature sensor in one package (two-in-one sensor)
- fast temperature response (direct media contact)
- compatible with wet, aggressive media
- cost-effective and robust construction.

Specifications

Flow	
Measuring range	5 to 100 l/min
Accuracy (±1σ), 0 to 100 °C	±1.5 % FS
Response time (63.2 %)	< 1 s
Resolution	0.5 l/min
Temperature	
Measuring range	0 to 100 °C
Accuracy (±1σ), 25 to 80 °C	±1 °C
Accuracy (±1σ), 0 to 100 °C	±2 °C
Response time (63.2 % at 50 % FS flow)	< 1 s
Resolution	0.5 °C
Media and environment	
Media types	The sensor is compatible with liquids (kinematic viscosity ≤ 2 mm^2/s)
Media temperature (operation)	0 to 100 °C
Media temperature (peak)	–25 to 120 °C, non-freezing
Ambient air temp. (operation)	–25 to 60 °C
Ambient air temp. (peak)	–55 to 90 °C
Humidity	0 - 95 % (relative), non-condensing
System burst pressure	> 16 bar
Electrical data	
Power supply	5 V DC (±5 %). Grounding of the sensor supply is required (PELV)
Output signals	Ratiometric
Flow signal	0.5 - 3.5 V (Zero at 0.35 V)
Temperature signal	0.5 - 3.5 V
Power consumption	< 50 mW
Load impedance	> 10 kΩ
Sensor materials	
Sensing element	Silicon-based MEMS sensor
Seal (sensor to housing)	EPDM rubber
Housing	Composites (PPS, PA66)
Flow pipe	PPA 40-GF
Wetted materials	Corrosion-resistant coating EPDM, PPS, PPA 40-GF
Environmental standards	
Enclosure class	IP44 (Non overmolded IP20)
Temperature cycling	IEC 68-2-14
Vibration (non-destructive)	20 - 2000 Hz, 10G, 4h
Electromagnetic compatibility	EN 61326-1
Dimensions	
Sensing element	47 x 40 x 20 mm, see drawing
Flow pipe	129 x 37 x 32 mm

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Dimensions (in mm)

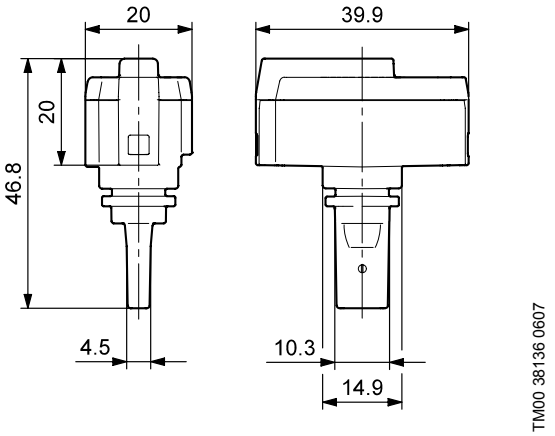


Fig. 2 Dimensional sketches of sensing element

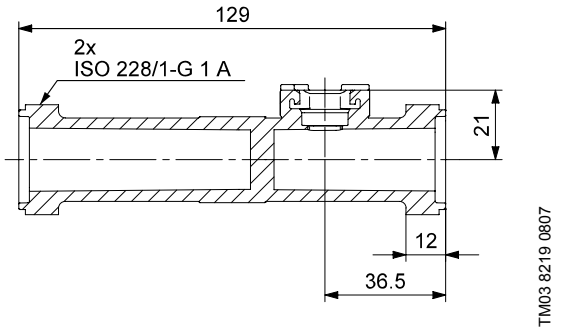


Fig. 3 Dimensional sketch of flow pipe

Type key

The sensor is labelled with a type designation.

	96	- XX	- XXX	XXXXX
Product number				
Revision				
Production year and week				
Consecutive number				

For more information, see
http://www.grundfos.com/directsensors.

Electrical connections

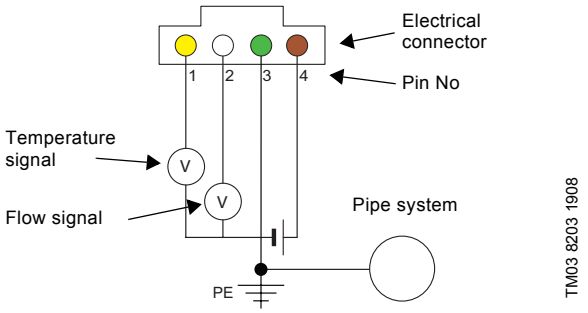


Fig. 4 Electrical connections

Pin configuration		Colour
1	Temperature signal (0.5 to 3.5 V relative to pin 3)	Yellow
2	Flow signal (0.5 to 3.5 V relative to pin 3)	White
3	GND (0 V)	Green
4	Power supply (+5 VDC), PELV	Brown

Power supply requirements

- 5 VDC
- separated from hazardous live circuitry by double or reinforced insulation
- power limitation:150 VA; current limitation: 8 A.

Sensor output signals

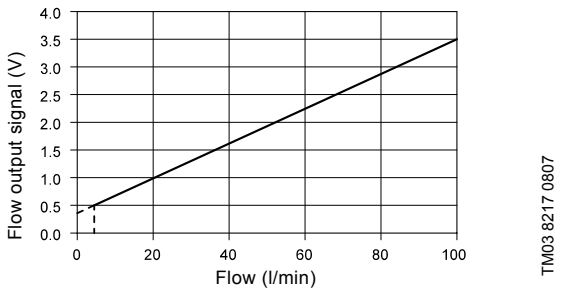


Fig. 5 Flow response

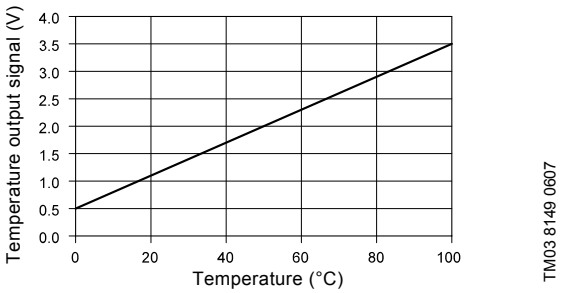


Fig. 6 Temperature response

96702084 1008
Repl. 96702084 0108
GB

Subject to alterations.

Grundfos Sensor A/S
Poul Due Jensens Vej 7. DK-8850 Bjerringbro. Denmark
Telephone: +45 87 50 14 00

www.grundfos.com/directsensors

GRUNDFOS

Submittal Package

viega

ProPress® System

- ☐ Potable Water
- ☐ Hydronic Heating
- ☐ Chilled Water
- ☐ Compressed Air
- ☐ Nitrogen N_2
- ☐ Argon
- ☐ Low Pressure Steam
- ☐ Fire Protection
- ☐ Vacuum
- ☐ Corgon
- ☐ Oxygen 0_2 (non medical)
- ☐ _____

Viega LLC, 100 N. Broadway, 6th Floor • Wichita, KS 67202 • Ph: 800-976-9819 • Fax: 316-425-7618

Submittal Package

System Data Sheet

System Description
Viega ProPress and Viega ProPress XL (copper) are safe, reliable and economical copper pipe installation systems that use modern cold press connection technology for a wide assortment of more than 600 fittings in dimensions ranging from ½" to 4". ProPress utilitizes an EPDM sealing element to provide permanent leak-proof connections.
Tubing: K, L and M hard copper tubing from ½" to 4" and soft copper tubing in ½" to 1¼" diameters.

Applications
All tubing must comply with the ASTM B88 standard. Viega ProPress fittings are approved for installations in both above- and below-ground applications. Per code, local inspector approval must be obtained prior to installation below ground.

Operating Parameters
Operating Pressure: 200 psi Max.
Test Pressure: 600 psi Max.
Low-Pressure Steam: 15 psi Max.
Vacuum: 29.2" Mercury Max. @ 68°F
Operating Temperature: 0°F to 250°F

Approved Applications
- Potable Water
- Hydronic Heating (w/ Glycol)
- Chilled Water
- Compressed Air (200 psi max.)
- Non-medical Gases (140 psi maximum)
- Fire Sprinkler (175 psi maximum)
- Low Pressure Steam (15 psi maximum)
- Vacuum (29.2" Mercury maximum @ 68°F)

System Benefits
- Fast and Easy to Use
- Flameless
- Permanent Connections
- Large Selection of Fittings from ½" to 4"
- Consistent Professional Appearance
- Less Equipment Required
- Environmentally Friendly Connection System
- Versatility of Fittings and Tools for Variety of Applications

Fittings
There are more than 600 Viega ProPress fittings including: Elbows, Couplings, Reducers, Tees, Reducing Tees, Threaded Adapters, Unions, Caps and Flanges. All threaded ½" - 2" fittings are bronze. Viega ProPress and Viega ProPress XL (copper) fittings conform to NSF 61 Annex G.

Smart Connect Feature
The Smart Connect feature is a special indentation in the inside surface of the fitting near the sealing element. This indentation assures leakage of liquids and/or gases from inside the system past the sealing element of an unpressed connection. The indentation is removed during the pressing process, creating a leak-free, permanent connection. This feature provides quick and easy identification of connections that have not been pressed prior to putting the system into operation.

Tools
RIDGID offers pressing tools for connecting Viega ProPress fittings.
- RIDGID RP 200-B (½" to 1¼")
- RIDGID RP 210-B (½" to 1¼")
- RIDGID RP 320-B
- RIDGID RP 330-B
- RIDGID RP 340-B
- RIDGID CT-400

History
Viega ProPress has been used in Europe since the late 1980s and in the U.S. since the late 1990s for a variety of applications.

Warranty
Viega ProPress products carry a 50-year warranty against defects in material and workmanship. ProPress valves carry a 2-year warranty against defects in material and workmanship.

Listings and Certificates
- NSF 61G
- IAPMO PS117
- UL 213
- FM Class 1920
- ICC-ES PMG 1037
- CSA MSE-13
- ABS
- CRN OA4541.5

International Listings and Certificates
- Deutsch Verein des Gas-und Wasserfachese.V. (DVGW)
- Lloyd's Register (LLOYD'S)
- Det Norske Veritas (DNV)
- Registro Italiano Navale (RINA)
- Bureau Veritas (BV)
- KIWA

Compliant with:
- ICC International Plumbing Code
- IAPMO Uniform Plumbing Code
- PHCC National Standard Plumbing Code
- NFPA 13, 13D and 13R
- ASME B16.51
- U.S. Coast Guard

Contact your local Viega representative for details on local approvals

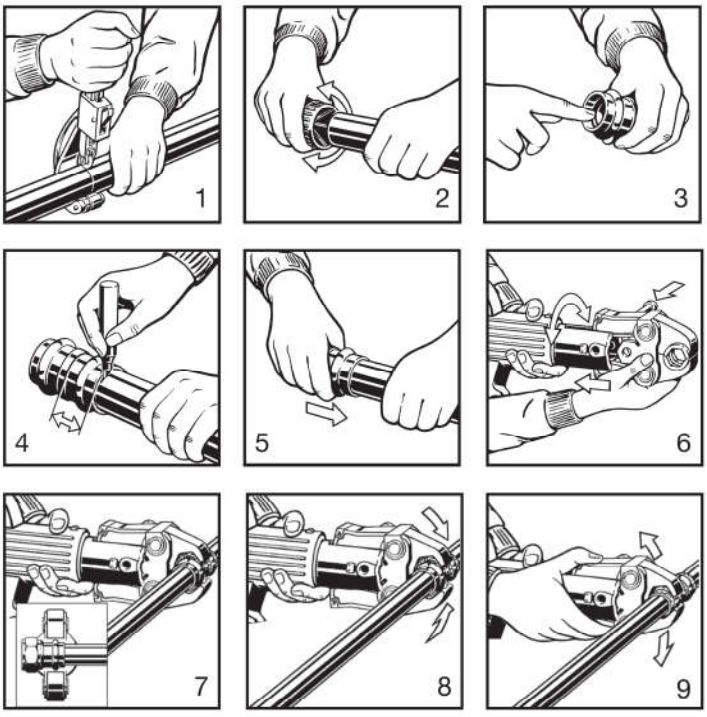
For more information on RIDGID products, contact:
Ridge Tool Company
400 Clark Street, Elyria, Ohio 44036
Demos, Literature: 800-769-7743
Technical inquiries: 800-519-3456
Availability: 888-743-4333
Web: www.ridgid.com

Submittal Package

viega

Viega ProPress®

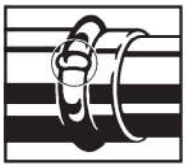
For Types K, L and M Hard Copper Tubing in ½" to 2" and Soft Copper Tubing in ½" to 1¼"



Viega ProPress Insertion Depth Chart						
Tube Size	½"	¾"	1"	1¼"	1½"	2"
Insertion Depth	¾"	⅞"	⅞"	1"	1 7/16"	1 9/16"

⚠ WARNING Read and understand all instructions for installing Viega ProPress fittings. Failure to follow all instructions may result in extensive property damage, serious injury or death.

1. Cut copper tubing at right angles using displacement-type cutter or fine-toothed steel saw.
2. Remove burr from inside and outside of tubing to prevent cutting sealing element.
3. Check seal for correct fit. Do not use oils or lubricants. Use only Viega ProPress Shiny Black EPDM or Dull Black FKM sealing elements.
   Note: For applications requiring Viega ProPress with FKM sealing elements, remove the factory-installed EPDM sealing element and replace with FKM sealing element.
4. Mark proper insertion depth as indicated by the Viega ProPress Insertion Depth Chart. Improper insertion depth may result in improper seal.
5. While turning slightly, slide press fitting onto tubing to the marked depth.
   Note: End of tubing must contact stop.
6. Insert appropriate Viega jaw into the pressing tool and push in, holding pin until it locks in place.
7. Open the jaw and place at right angles on the fitting. Visually check insertion depth using mark on tubing.
8. Start pressing process and hold the trigger until the jaw has engaged the fitting.
9. After pressing, the jaw can be opened again.



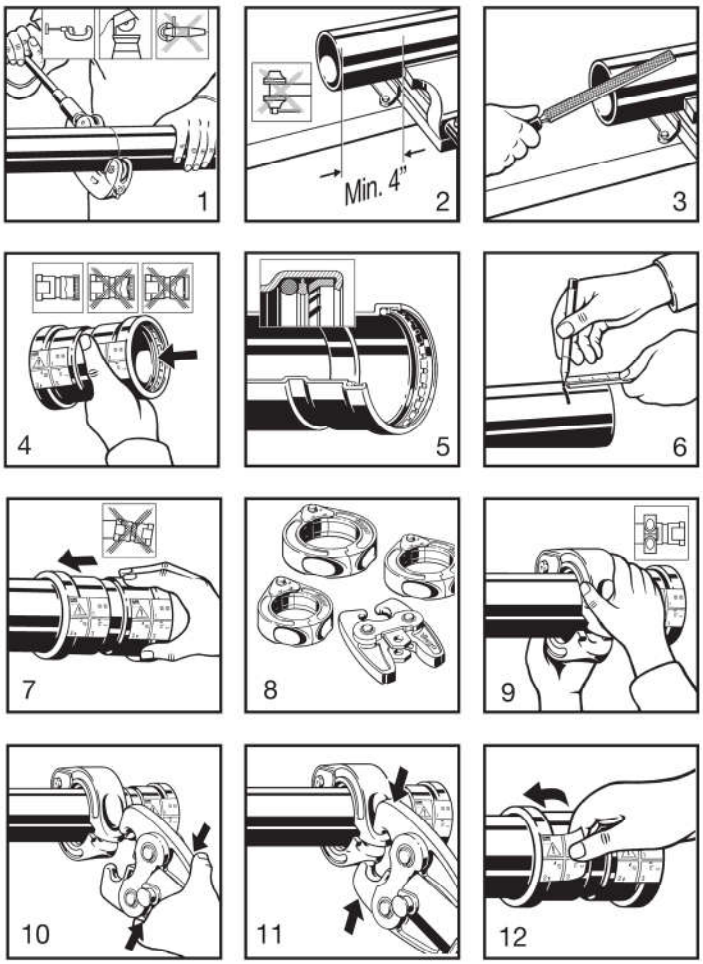
Leak Testing with Smart Connect®: Unpressed connections are located by pressurizing the system with air or water. When testing with water the proper pressure range is 15 psi to 85 psi maximum. Leak testing with air can be dangerous at high pressures. When testing with compressed air the proper pressure range is ½ psi to 45 psi maximum. Following a successful leak test, the system may be pressure tested up to 200 psi with air, or up to 600 psi with water, if required by local code requirements or project specifications.

Submittal Package

viega

Viega ProPress® XL (Copper)

For Types K, L and M Hard Copper Tubing in 2½" to 4"



ProPress XL (copper) Insertion Depth Chart			
Tube Size	2½"	3"	4"
Insertion Depth	1⅝"	1⅞"	2⅜"

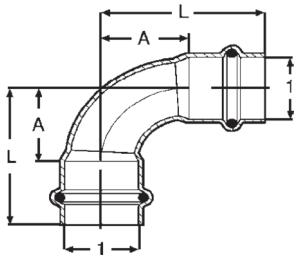
⚠ WARNING Read, understand and follow all instructions for installing ProPress XL (copper) fittings. Failure to follow all instructions may result in extensive property damage, serious injury or death.

1. Cut copper tubing at right angles using displacement-type cutter or fine-toothed steel saw.
2. Keep end of tubing a minimum of 4" away from the contact area of the vise to prevent possible damage to the tubing in the press area.
3. Remove burr from inside and outside of tubing to prevent cutting sealing element.
4. Check seal and grip ring for correct fit. Do not use oils or lubricants. Use only ProPress Shiny Black EPDM sealing elements.
5. Illustration demonstrates proper fit of grip ring, separation ring and sealing element.
6. Mark proper insertion depth as indicated by the ProPress XL (copper) Insertion Depth Chart. Improper insertion depth may result in an improper seal.
7. While turning slightly, slide press fitting onto tubing to the marked depth. End of tubing must contact stop.
8. ProPress XL (copper) fitting connections must be performed with ProPress XL-C Rings and V2 ACTUATOR. Use of ProPress XL Rings and/or Actuator (for Bronze fittings) will result in an improper connection. See Ridgid Operator's Manual for proper tool instructions.
9. Open XL-C Ring and place at right angles on the fitting. XL-C Ring must be engaged on the fitting bead. Check insertion depth.
10. With V2 ACTUATOR inserted into the tool, open the V2 ACTUATOR as shown and connect V2 ACTUATOR to the XL-C Ring.
11. Place V2 ACTUATOR onto XL-C Ring and start pressing process. Hold the trigger until the Actuator has engaged the XL-C Ring. Keep extremities and foreign objects away from XL-C Ring and V2 ACTUATOR during pressing operation to prevent injury or incomplete press.
12. Release V2 ACTUATOR from XL-C Ring and then remove the XL-C Ring from the fitting on completion of press. Remove tag from fitting, indicating press has been performed.

Leak Testing with Smart Connect®: Unpressed connections are located by pressurizing the system with air or water. When testing with water the proper pressure range is 15 psi to 85 psi maximum. Leak testing with air can be dangerous at high pressures. When testing with compressed air the proper pressure range is ½ psi to 45 psi maximum. Following a successful leak test, the system may be pressure tested up to 200 psi with air, or up to 600 psi with water, if required by local code requirements or project specifications.

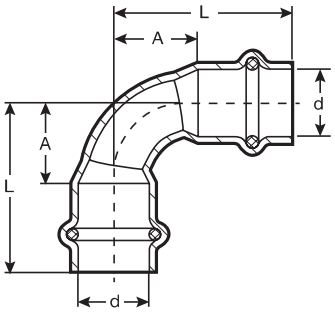
Submittal Package

ProPress® Dimensional Documentation



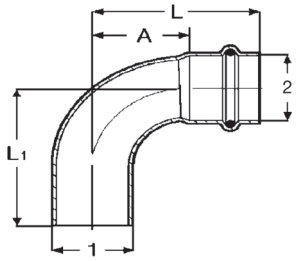
Viega ProPress 90° Elbow Copper P x P - Model 2916

Part No.	Size	A (in)	L (in)
	1		
77317	½"	0.75	1.50
77322	¾"	1.04	1.94
77327	1"	1.32	2.23
77332	1¼"	1.65	2.68
77337	1½"	1.98	3.40
77342	2"	2.54	4.13



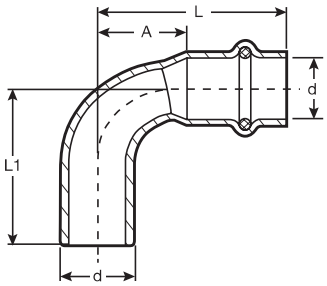
Viega ProPress 90° Elbow Copper P x P - Model 2916 Short

Part No.	Size	A (in)	L (in)
	1		
77317	½"	0.75	1.50
77022	¾"	0.76	1.67
77027	1"	1.28	2.19
77032	1¼"	1.28	2.31
77037	1½"	1.29	2.72
77042	2"	2.16	3.74



Viega ProPress 90° Street Elbow Copper P x FTG - Model 2916.1

Part No.	Size	A (in)	L (in)	L1 (in)
	1 2			
77347	½" x ½"	0.75	1.50	1.54
77352	¾" x ¾"	1.04	1.94	1.98
77357	1" x 1"	1.32	2.23	2.27
77362	1¼" x 1¼"	1.65	2.68	2.76
77367	1½" x 1½"	1.98	3.40	3.48
77372	2" x 2"	2.54	4.13	4.20

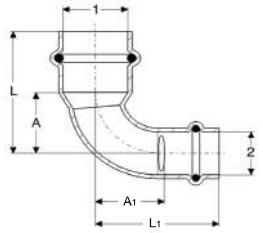


Viega ProPress 90° Elbow Copper P x FTG - Model 2916.1 Short

Part No.	Size	A (in)	L (in)	L1 (in)
	1			
77347	½"	0.75	1.50	1.54
77052	¾"	0.76	1.67	1.83
77057	1"	1.28	2.19	2.27
77062	1¼"	1.28	2.31	2.48
77067	1½"	1.29	2.72	2.80
77072	2"	2.16	3.74	3.78

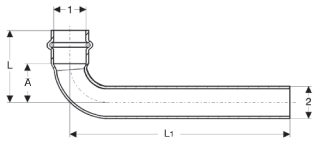
Submittal Package

viega



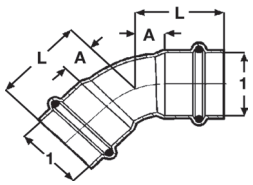
Viega ProPress 90° Reducing Elbow Copper P x P - Model 2916.3

Part No.	Size	A (in)	A1 (in)	L (in)	L1 (in)
	1 2				
77325	¾" x ½"	0.91	0.94	1.81	1.69
77330	1" x ¾"	1.20	1.30	2.11	2.21



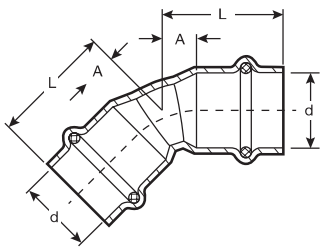
Viega ProPress 90° Extended Street Elbow Copper P x FTG - Model 2947

Part No.	Size	A (in)	L (in)	L1 (in)
	1 2			
77353	¾" x ¾"	1.02	1.93	5.98



Viega ProPress 45° Elbow Copper P x P - Model 2926

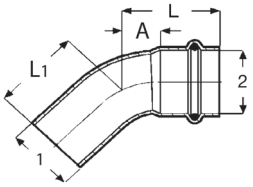
Part No.	Size	A (in)	L (in)
	1		
77607	½"	0.30	1.04
77612	¾"	0.43	1.34
77617	1"	0.55	1.46
77622	1¼"	0.68	1.71
77627	1½"	0.81	2.24
77632	2"	0.81	2.63



Viega ProPress 45° Elbow Copper P x P - Model 2926 Short

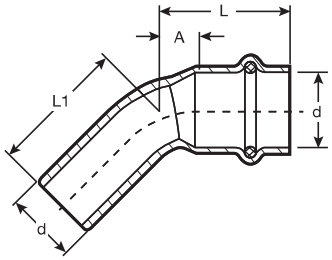
Part No.	Size	A (in)	L (in)
	1		
77607	½"	0.30	1.04
77023	¾"	0.36	1.26
77028	1"	0.47	1.38
77033	1¼"	0.58	1.61
77038	1½"	0.65	2.08
77043	2"	0.86	2.44

Submittal Package



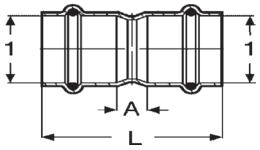
Viega ProPress 45° Street Elbow Copper P x FTG - Model 2926.1

Part No.	Size	A (in)	L (in)	L1 (in)
	1 2			
77637	½" x ½"	0.31	1.06	1.10
77642	¾" x ¾"	0.43	1.34	1.37
77647	1" x 1"	0.55	1.46	1.49
77652	1¼" x 1¼"	0.68	1.71	1.79
77657	1½" x 1½"	0.81	2.24	2.32
77662	2" x 2"	1.05	2.63	2.71



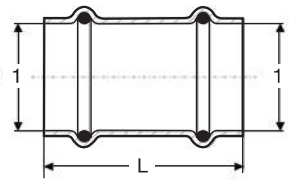
Viega ProPress 45° Elbow Copper P x FTG - Model 2926.1 Short

Part No.	Size	A (in)	L (in)	L1 (in)
	1			
77637	½"	0.31	1.06	1.10
77053	¾"	0.36	1.26	1.30
77058	1"	0.47	1.38	1.49
77063	1¼"	0.58	1.61	1.67
77068	1½"	0.65	2.08	2.04
77073	2"	0.86	2.44	2.54



Viega ProPress Coupling with Stop Copper P x P - Model 2915

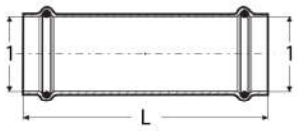
Part No.	Size	A (in)	L (in)
	1		
78047	½"	0.12	1.61
78052	¾"	0.20	2.01
78057	1"	0.16	1.97
78062	1¼"	0.14	2.20
78067	1½"	0.14	2.99
78072	2"	0.14	3.31



Viega ProPress Coupling No Stop Copper P x P - Model 2915.3

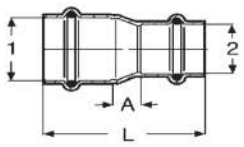
Part No.	Size	L (in)
	1	
78172	½"	1.61
78177	¾"	2.01
78182	1"	1.97
78187	1¼"	2.20
78192	1½"	2.99
78197	2"	3.31

Submittal Package



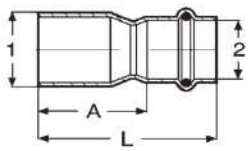
Viega ProPress Extended Coupling Copper P x P - Model 2915.5

Part No.	Size	L (in)
	1	
79005	½"	2.99
79010	¾"	3.50
79015	1"	3.74
79020	1¼"	4.13
79025	1½"	4.72
79030	2"	5.31



Viega ProPress Reducer Copper P x P - Model 2915.2

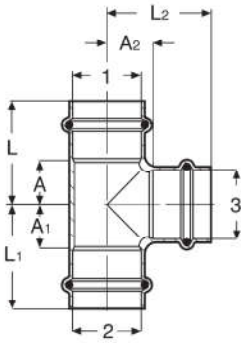
Part No.	Size	A (in)	L (in)
	1 2		
78147	¾" x ½"	0.42	2.07
15603	1" x ½"	0.71	2.36
78152	1" x ¾"	0.48	2.29
15593	1¼" x ¾"	0.70	2.64
78157	1¼" x 1"	0.55	2.48
18473	1½" x ¾"	0.98	3.33
15588	1½" x 1"	0.74	3.07
78162	1½" x 1¼"	0.50	2.96
18468	2" x ¾"	1.54	4.02
15608	2" x 1"	1.29	3.78
22328	2" x 1¼"	0.81	3.43
78167	2" x 1½"	0.74	3.75



Viega ProPress Reducer Copper FTG x P - Model 2915.1

Part No.	Size	A (in)	L (in)
	1 2		
78077	¾" x ½"	1.42	2.17
78082	1" x ½"	1.69	2.44
78087	1" x ¾"	1.42	2.32
22333	1¼" x ½"	1.89	2.64
78092	1¼" x ¾"	1.85	2.76
78097	1¼" x 1"	1.57	2.48
14543	1½" x ¾"	2.56	3.46
78102	1½" x 1"	2.28	3.19
78107	1½" x 1¼"	2.04	3.07
78112	2" x 1"	3.03	3.94
78117	2" x 1¼"	2.79	3.82
78122	2" x 1½"	2.63	4.06

Submittal Package

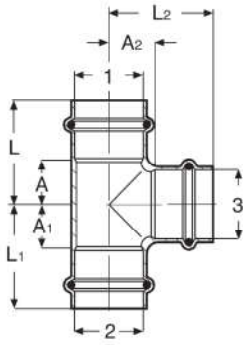


Viega ProPress Tee Copper P x P x P - Model 2918

Part No.	Size 1 2 3	A (in)	A1 (in)	A2 (in)	L (in)	L1 (in)	L2 (in)
77377	½"	0.75	0.75	0.50	1.50	1.50	1.25
77382	½" x ½" x ¾"	0.91	0.91	0.59	1.65	1.65	1.50
15493	½" x ½" x 1"	1.10	1.10	0.55	1.85	1.85	1.46
77387	¾"	0.85	0.85	0.59	1.75	1.75	1.50
77392	¾" x ½" x ½"	0.69	0.98	0.63	1.59	1.73	1.38
77397	¾" x ½" x ¾"	0.85	1.14	0.59	1.75	1.89	1.50
77402	¾" x ¾" x ½"	0.69	0.69	0.63	1.59	1.59	1.38
77407	¾" x ¾" x 1"	0.97	0.97	0.63	1.87	1.87	1.54
77412	1"	0.97	0.97	0.79	1.87	1.87	1.69
22263	1" x ½" x ¾"	0.85	1.24	0.75	1.76	1.99	1.66
94767	1" x ½" x 1"	0.97	1.52	0.79	1.87	2.26	1.69
77417	1" x ¾" x ½"	0.69	0.89	0.79	1.59	1.79	1.54
77422	1" x ¾" x ¾"	0.85	1.04	0.75	1.75	1.95	1.65
77427	1" x ¾" x 1"	0.97	1.18	0.78	1.87	2.07	1.69
77432	1" x 1" x ½"	0.69	0.69	0.79	1.59	1.59	1.54
77437	1" x 1" x ¾"	0.85	0.85	0.75	1.75	1.75	1.65
15488	1" x 1" x 1 ¼"	1.16	1.16	0.84	2.07	2.07	1.87
77442	1 ¼"	1.02	1.02	0.86	2.05	2.05	1.89
22253	1¼" x ½" x 1¼"	1.02	1.77	0.87	2.05	2.52	1.89
22243	1¼" x ¾" x ½"	0.64	1.13	0.93	1.68	2.03	1.68
22258	1¼" x ¾" x ¾"	0.76	1.30	0.87	1.80	2.21	1.78
22268	1¼" x ¾" x 1"	0.88	1.40	0.91	1.91	2.31	1.82
22248	1¼" x ¾" x 1¼"	1.02	1.54	0.86	2.05	2.45	1.89
22238	1¼" x 1" x ½"	0.64	0.91	0.93	1.68	1.82	1.68
94762	1¼" x 1" x ¾"	0.76	1.14	0.87	1.79	2.05	1.77
14568	1¼" x 1" x 1"	0.88	1.28	0.91	1.91	2.19	1.81
94757	1¼" x 1¼" x ½"	0.65	0.65	0.93	1.67	1.67	1.67
77452	1¼" x 1¼" x ¾"	0.77	0.77	0.89	1.79	1.79	1.77
77447	1¼" x 1¼" x 1"	0.88	0.88	0.90	1.91	1.91	1.81
77457	1½"	1.13	1.13	1.13	2.56	2.56	2.56
79660	1½" x 1" x ¾"	0.67	1.39	1.16	2.17	2.44	2.05
15458	1½" x 1" x 1"	0.74	1.54	1.06	2.17	2.44	1.97
15463	1½" x 1" x 1½"	1.13	1.83	1.13	2.56	2.74	2.56
22233	1½" x 1¼" x ¾"	0.67	1.08	1.15	2.09	2.11	2.05
15453	1½" x 1¼" x 1"	0.74	1.29	1.18	2.17	2.32	2.09
15483	1½" x 1¼" x 1¼"	0.86	1.33	1.13	2.28	2.36	2.17
15448	1½" x 1½" x ½"	0.47	0.47	1.10	1.89	1.89	1.85
77462	1½" x 1½" x ¾"	0.66	0.66	1.14	2.09	2.09	2.05
77467	1½" x 1½" x 1"	0.74	0.74	1.18	2.17	2.17	2.09
77472	1½" x 1½" x 1¼"	0.86	0.86	1.13	2.28	2.28	2.17
77477	2"	1.37	1.37	1.37	2.95	2.95	2.95
15518	2" x 1¼" x 1¼"	0.94	1.84	1.33	2.52	2.87	2.36
15513	2" x 1½" x ¾"	0.70	1.25	1.38	2.28	2.68	2.28
15498	2" x 1½" x 1"	0.82	1.45	1.38	2.40	2.87	2.28
15508	2" x 1½" x 1¼"	0.94	1.55	1.49	2.52	2.97	2.52

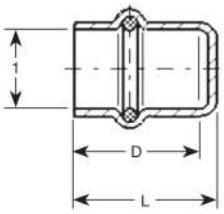
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Submittal Package



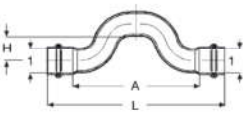
Copper Tee P x P x P - Model 2918 (continued)

Part No.	Size	A (in)	A1 (in)	A2 (in)	L (in)	L1 (in)	L2 (in)
	1 2 3						
15503	2" x 1½" x 1½"	1.13	1.65	1.37	2.72	3.07	2.80
22228	2" x 1½" x 2"	1.38	1.89	1.38	2.95	3.33	2.95
15538	2" x 2" x ½"	0.54	0.54	1.30	2.13	2.13	2.05
94777	2" x 2" x ¾"	0.79	0.79	1.26	2.37	2.37	2.17
94772	2" x 2" x 1"	0.91	0.91	1.30	2.49	2.49	2.21
77487	2" x 2" x 1¼"	1.04	1.04	1.37	2.62	2.62	2.40
77482	2" x 2" x 1½"	1.13	1.13	1.37	2.72	2.72	2.80



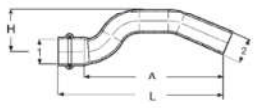
Viega ProPress Cap Copper P - Model 2956

Part No.	Size	L (in)	D (in)
	1		
77712	½"	0.92	0.79
77717	¾"	1.07	0.94
77722	1"	1.11	0.99
77727	1¼"	1.32	1.20
77732	1½"	1.62	1.49
77737	2"	1.81	1.69



Viega ProPress Cross-Over Copper P x P - Model 2928

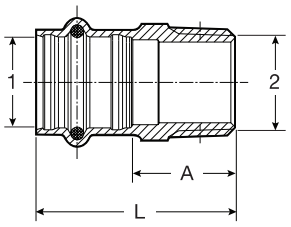
Part No.	Size	A (in)	L (in)	H (in)
	1			
77742	½"	3.62	5.12	0.77
77747	¾"	4.49	6.30	0.90



Viega ProPress Cross-Over Copper P x FTG - Model 2927

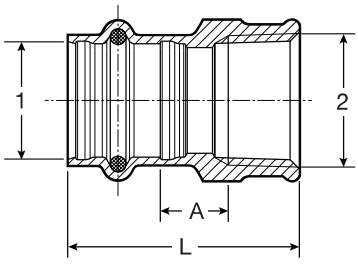
Part No.	Size	A (in)	L (in)	H (in)
	1 2			
78137	½" x ½"	3.83	4.58	1.10
78142	¾" x ¾"	4.64	5.54	1.54

Submittal Package



Viega ProPress Adapter Zero Lead Bronze P x MPT - Model 2911ZL

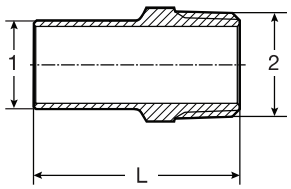
Part No.	Size	A (in)	L (in)
	1 2		
79210	½" x ⅜" MPT	0.77	1.59
79215	½" x ½" MPT	0.89	1.71
79220	½" x ¾" MPT	1.00	1.83
79225	¾" x ½" MPT	1.02	1.93
79230	¾" x ¾" MPT	1.02	1.93
79235	¾" x 1" MPT	1.18	2.09
79240	1" x ¾" MPT	1.18	2.09
79245	1" x 1" MPT	1.26	2.17
79250	1" x 1¼" MPT	1.54	2.44
79255	1¼" x 1" MPT	1.22	2.24
79260	1¼" x 1¼" MPT	1.34	2.36
79265	1¼" x 1½" MPT	1.48	2.50
79270	1½" x 1¼" MPT	1.34	2.76
79275	1½" x 1½" MPT	1.28	2.70
79280	1½" x 2" MPT	1.65	3.07
79285	2" x 1½" MPT	1.54	3.11
79290	2" x 2" MPT	1.50	3.07



Viega ProPress Adapter Zero Lead Bronze P x FPT - Model 2912ZL

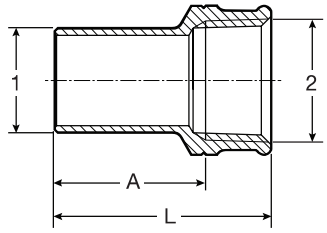
Part No.	Size	A (in)	L (in)
	1 2		
79295	½" x ⅜" FPT	0.19	1.42
79300	½" x ½" FPT	0.25	1.61
79305	½" x ¾" FPT	0.27	1.65
79310	¾" x ½" FPT	0.33	1.77
79315	¾" x ¾" FPT	0.35	1.81
79320	1" x ½" FPT	0.41	1.85
79325	1" x ¾" FPT	0.39	1.85
79330	1" x 1" FPT	0.44	2.01
79335	1" x 1¼" FPT	0.50	2.09
79340	1¼" x ½" FPT	0.37	1.93
79345	1¼" x 1" FPT	0.24	1.93
79350	1¼" x 1¼" FPT	0.34	2.05
79355	1¼" x 1½" FPT	0.42	2.13
79360	1½" x 1¼" FPT	0.26	2.36
79365	1½" x 1½" FPT	0.34	2.44
79370	2" x 2" FPT	0.41	2.68

Submittal Package



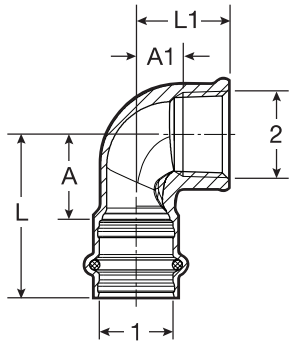
Viega ProPress Adapter Zero Lead Bronze FTG x MPT - Model 2911.1ZL

Part No.	Size	L (in)
	1 2	
79375	½" x ⅜" MPT	1.75
79380	½" x ½" MPT	1.95
79385	½" x ¾" MPT	2.05
79390	¾" x ½" MPT	1.93
79395	¾" x ¾" MPT	2.05
79400	1" x ¾" MPT	2.05
79405	1" x 1" MPT	2.22
79410	1¼" x 1¼" MPT	2.54
79415	1½" x 1½" MPT	2.89
79420	2" x 2" MPT	3.33



Viega ProPress Adapter Zero Lead Bronze FTG x FPT - Model 2912.1ZL

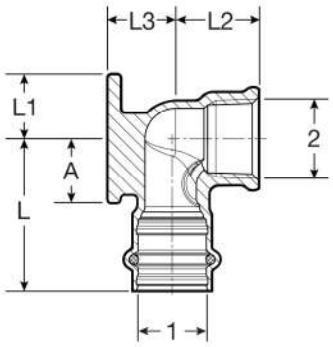
Part No.	Size	A (in)	L (in)
	1 2		
79425	½" x ⅜" FPT	1.10	1.54
79430	½" x ½" FPT	1.22	1.75
79435	½" x ¾" FPT	1.30	1.83
79440	¾" x ½" FPT	1.26	1.79
79445	¾" x ¾" FPT	1.28	1.83
79455	1" x ½" FPT	1.35	1.99
79450	1" x 1" FPT	1.33	1.99
79460	1¼" x ½" FPT	1.65	2.19
79465	1¼" x 1¼" FPT	1.50	2.19
79470	1½" x 1½" FPT	1.88	2.56
79475	2" x 2" FPT	2.13	2.95



Viega ProPress 90° Elbow Zero Lead Bronze P x FPT - Model 2914.2ZL

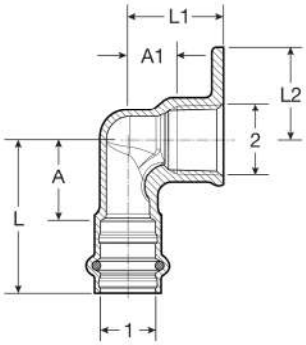
Part No.	Size	A (in)	A1 (in)	L (in)	L1 (in)
	1 2				
79520	½" x ⅜" FPT	0.94	0.42	1.77	0.83
79525	½" x ½" FPT	0.94	0.57	1.77	1.10
79530	½" x ¾" FPT	1.06	0.51	1.89	1.06
79535	¾" x ½" FPT	1.06	0.65	1.97	1.18
79540	¾" x ¾" FPT	1.06	0.57	1.97	1.12
79545	1" x ½" FPT	1.06	0.72	1.97	1.26
79550	1" x 1" FPT	1.34	0.76	2.24	1.42
79560	1¼" x 1¼" FPT	1.54	0.89	2.56	1.57
79565	1½" x 1½" FPT	1.69	1.05	3.11	1.73
79570	2" x 2" FPT	2.17	1.35	3.74	2.05

Submittal Package



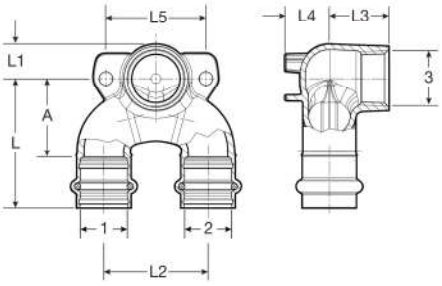
Viega ProPress 90° Drop Ear Elbow Zero Lead Bronze P X FPT - Model 2925.5ZL

Part No.	Size	A (in)	L (in)	L1 (in)	L2 (in)	L3 (in)
	1 2					
79185	½" x ⅜" FPT	0.94	1.77	0.74	0.83	0.67
79190	½" x ½" FPT	0.94	1.77	0.74	1.10	0.67
79195	¾" x ¾" FPT	1.06	1.97	0.83	1.12	0.83



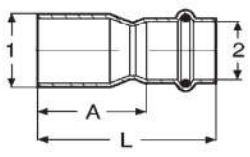
Viega ProPress 90° Hi Ear Elbow Zero Lead Bronze P x FPT - Model 2925.2ZL

Part No.	Size	A (in)	A1 (in)	L (in)	L1 (in)	L2 (in)
	1 2					
79205	½" x ½" FPT	0.94	0.57	1.77	1.10	1.07



Viega ProPress Double Drop Elbow Zero Lead Bronze P x P x FPT - Model 2928.7ZL

Part No.	Size	A (in)	L (in)	L2 (in)	L3 (in)	L4 (in)	L5 (in)
	1 2 3						
78800	½" x ½" x ½" FNPT	1.34	2.17	1.97	1.10	0.67	1.57
78801	¾" x ¾" x ¾" FNPT	1.54	2.44	1.97	1.12	0.83	1.89
78802	¾" x ¾" x ½" FNPT	1.54	2.44	1.97	1.10	0.83	2.05
78803	1" x 1" x ½" FNPT	1.77	2.68	2.36	1.10	0.87	2.52

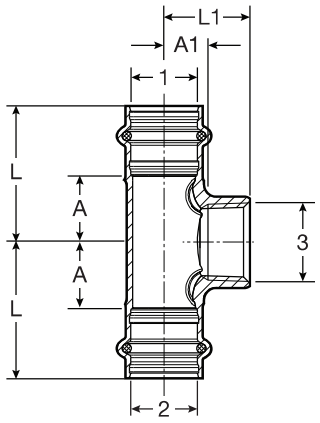


Viega ProPress Reducer Zero Lead Bronze FTG x P - Model 2915.1ZL

Part No.	Size	A (in)	L (in)
	1 2		
79850	1½" x ½"	1.95	2.78
79855	2" x ½"	2.38	3.21
79860	2" x ¾"	2.42	3.33

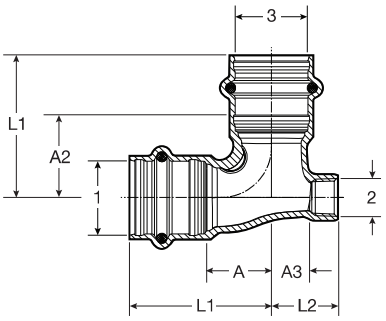
Submittal Package

viega



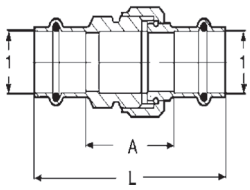
Viega ProPress Tee Zero Lead Bronze P x P x FPT - Model 2917.2ZL

Part No.	Size	A (in)	A1 (in)	L (in)	L1 (in)
	1 2 3				
79580	½" x ½" x ½" FPT	0.79	0.69	1.61	1.30
79585	¾" x ¾" x ¼" FPT	0.67	0.79	1.57	1.18
79590	¾" x ¾" x ½" FPT	0.79	0.88	1.69	1.42
79595	¾" x ¾" x ¾" FPT	0.91	0.59	1.81	1.14
79760	1" x 1" x ½" FPT	0.79	1.04	1.69	1.57
79765	1" x 1" x ¾" FPT	0.91	1.06	1.81	1.61
79770	1¼" x 1¼" x ½" FPT	0.83	1.16	1.85	1.69
79775	1¼" x 1¼" x ¾" FPT	0.95	1.18	1.97	1.73
79780	1½" x 1½" x ½" FPT	0.87	1.24	2.28	1.77
79785	1½" x 1½" x ¾" FPT	0.94	1.30	2.36	1.85
79790	2" x 2" x ½" FPT	0.98	1.59	2.56	2.13
79795	2" x 2" x ¾" FPT	1.06	1.65	2.64	2.20



Viega ProPress Tee Vent Zero Lead Bronze P x FPT x P - Model 2917.3ZL

Part No.	Size	A (in)	A2 (in)	A3 (in)	L (in)	L1 (in)	L2 (in)
	1 2 3						
79635	½" x ⅛" FPT x ½"	0.67	0.67	0.44	1.50	1.50	0.71
79640	¾" x ⅛" FPT x ¾"	0.83	0.83	0.54	1.73	1.73	0.81

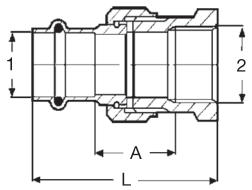


Viega ProPress Union Zero Lead Bronze P x P - Model 2960ZL

Part No.	Size	A (in)	L (in)
	1		
79125	½"	1.19	2.84
79130	¾"	1.34	3.15
79135	1"	1.83	3.65
79140	1¼"	1.64	3.69
79145	1½"	2.13	4.96
79150	2"	2.07	5.22

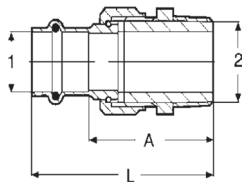
Submittal Package

viega



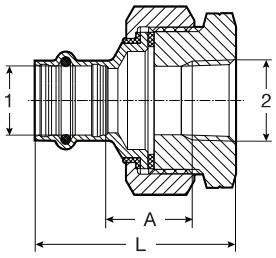
Viega ProPress Union Zero Lead Bronze P x FPT - Model 2962ZL

Part No.	Size	A (in)	L (in)
	1 2		
79700	½" x ½" FPT	0.91	2.27
79705	¾" x ¾" FPT	0.96	2.42
79710	1" x 1" FPT	1.31	2.88
79715	1¼" x 1¼" FPT	1.27	2.97
79720	1½" x 1½" FPT	1.77	3.87
79725	2" x 2" FPT	1.65	3.92



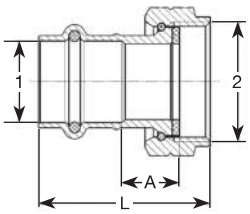
Viega ProPress Union Zero Lead Bronze P x MPT - Model 2965ZL

Part No.	Size	A (in)	L (in)
	1 2		
79730	½" x ½" MPT	1.86	2.69
79735	¾" x ¾" MPT	2.00	2.90
79740	1" x 1" MPT	2.54	3.45
79745	1¼" x 1¼" MPT	2.49	3.52
79750	1½" x 1½" MPT	3.05	4.47
79755	2" x 2" MPT	2.99	4.57



Viega ProPress Union Zero Lead Bronze P x FPT - Model 2967ZL

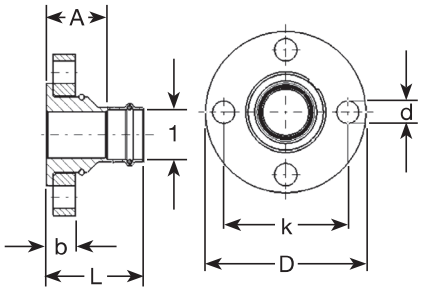
Part No.	Size	A (in)	L (in)
	1 2		
79155	½" x ½" FPT	0.88	2.24
79160	¾" x ¾" FPT	1.11	2.57
79165	1" x 1" FPT	1.00	2.57
79170	1¼" x 1¼" FPT	0.97	2.68
79175	1½" x 1½" FPT	1.01	3.11
79180	2" x 2" FPT	1.26	3.53



Viega ProPress Tailpiece Zero Lead Bronze P x F BSP - Model 2957ZL

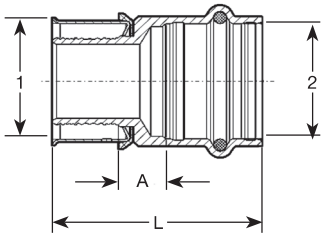
Part No.	Size	A (in)	L (in)
	1 2		
79800	½" x 1" BSP	0.39	1.57
79805	¾" x 1" BSP	0.63	1.87
79810	1" x 1" BSP	0.91	2.14
79815	1" x 1¼" BSP	0.73	2.04

Submittal Package



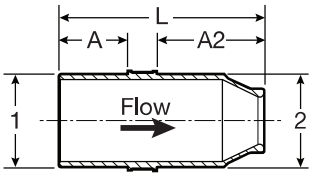
Viega ProPress Adapter Flange Zero Lead Bronze P x Flange - Model 2959.5ZL

Part No.	Size	L (in)	A (in)	b (in)	D (in)	k (in)	d (in)
	1						
79680	1"	2.76	1.85	0.84	4.33	3.11	0.63
79685	1¼"	2.76	1.73	0.84	4.53	3.50	0.63
79690	1½"	3.07	1.65	0.84	4.92	3.86	0.63
79695	2"	3.66	2.09	0.84	5.91	4.76	0.75



Viega PEX Press Adapter Zero Lead Bronze P x P - Model 2813PZL

Part No.	Size	A (in)	L (in)
	1 2		
99620	½"x ½"	0.29	1.61
99626	½" x ¾"	0.43	1.83
99630	¾" x ½"	0.23	1.56
99640	¾"x ¾"	0.33	1.73
99660	1" x 1"	0.45	1.97
99670	1¼" x 1¼"	0.49	2.38
99680	1½" x 1½"	0.59	2.87
99690	2" x 2"	0.58	3.21

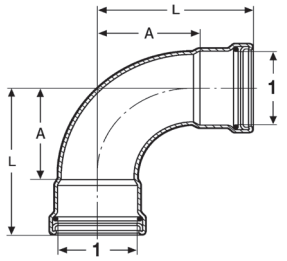


Viega ProPress Venturi Insert Zero Lead Bronze - Model 2911.5ZL

Part No.	Size	A (in)	A2 (in)	L (in)
	1 2			
78810	1¼" x 1¼"	1.02	1.60	3.07
78811	1½" x 1½"	1.43	2.10	3.98
78812	2" x 2"	1.58	2.45	4.48

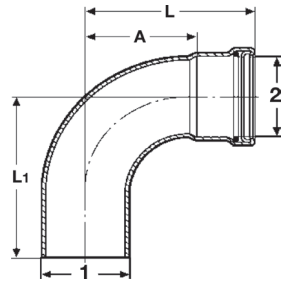
Submittal Package

ProPress® XL (Copper) Dimensional Documentation



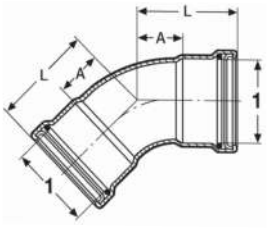
XL 90° Elbow P x P - Model 0916XL

Part Number	Size	A (in)	L (in)
	1		
20623	2½"	3.19	4.88
20628	3"	3.76	5.73
20633	4"	4.90	7.26



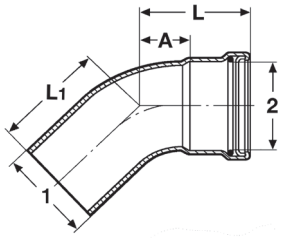
XL 90° Street Elbow P x FTG - Model 0916.1XL

Part Number	Size	A (in)	L (in)	L1 (in)
	1 2			
20638	2½" x 2½"	3.19	4.88	4.80
20643	3" x 3"	3.76	5.73	5.63
20648	4" x 4"	4.90	7.26	7.13



XL 45° P x P - Model 0926XL

Part Number	Size	A (in)	L (in)
	1		
20653	2½"	1.48	3.18
20658	3"	1.73	3.70
20663	4"	1.96	4.63

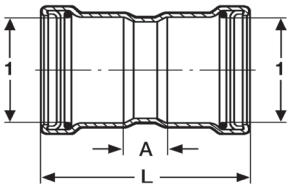


XL 45° Street Elbow P x FTG - Model 0926.1XL

Part Number	Size	A (in)	L (in)	L1 (in)
	1 2			
20668	2½" x 2½"	1.48	3.18	3.10
20673	3" x 3"	1.73	3.70	3.60
20678	4" x 4"	2.23	4.59	4.45

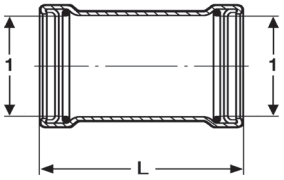
Submittal Package

viega



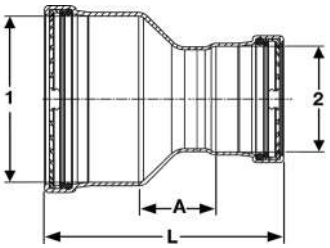
XL Coupling with Stop P x P - Model 0915XL

Part Number	Size	A (in)	L (in)
	1		
20728	2½"	0.95	4.33
20733	3"	0.98	4.92
20738	4"	1.06	5.79



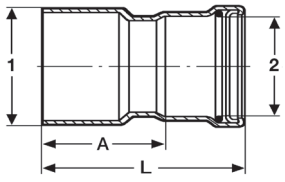
XL Coupling No Stop P x P - Model 0915.5XL

Part Number	Size	L (in)
	1	
20743	2½"	4.33
20748	3"	4.92
20753	4"	5.79



XL Reducer P x P - Model 0915.2XL

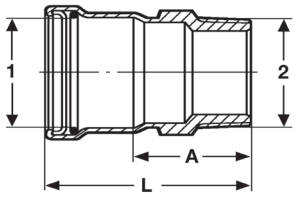
Part Number	Size	A (in)	L (in)
	1 2		
20685	2½" x 1"	1.76	4.36
20690	2½" x 1¼"	1.61	4.34
20695	2½" x 1½"	1.52	4.64
20700	2½" x 2"	1.41	4.69
20705	3" x 1½"	1.78	5.17
20710	3" x 2"	1.53	5.08
20715	3" x 2½"	1.41	5.07
20720	4" x 2"	2.06	6.00
20725	4" x 2½"	1.93	5.99
20730	4" x 3"	1.70	6.03



XL Reducer FTG x P - Model 0915.1XL

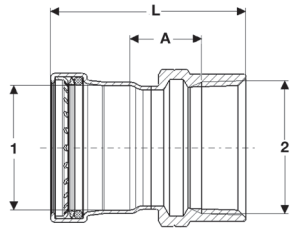
Part Number	Size	A (in)	L (in)
	1 2		
20814	2½" x 1"	3.61	4.52
20815	2½" x 1¼"	3.47	4.51
20813	2½" x 1½"	3.41	4.84
20758	2½" x 2"	2.35	3.94
20817	3" x 1¼"	3.96	5.00
20818	3" x 1½"	3.91	5.34
20763	3" x 2"	2.98	4.57
20768	3" x 2½"	2.76	4.45
20773	4" x 2"	4.58	6.17
20778	4" x 2½"	4.45	6.15
20783	4" x 3"	4.17	6.14

Submittal Package



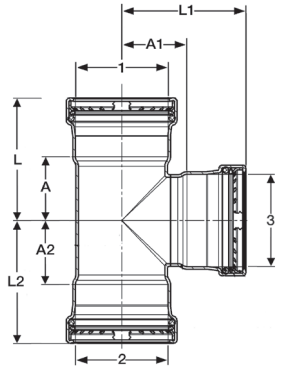
XL Adapter P x MPT - Model 0911XL

Part Number	Size	A (in)	L (in)
	1 2		
20823	2½"x 2½" MPT	2.76	4.45
20828	3"x 3" MPT	2.84	4.80
20838	4"x 4" MPT	3.10	5.46



XL Adapter P x FPT - Model 0912XL

Part Number	Size	A (in)	L (in)
	1 2		
20819	2½" x 2½" FPT	1.53	4.15
20829	3" x 3" FPT	1.84	4.82
20839	4" x 4" FPT	2.09	5.55

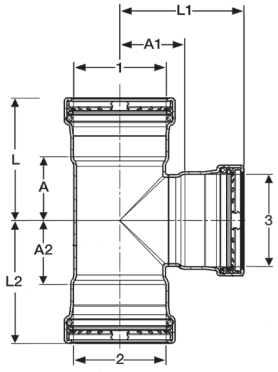


XL Tee P x P x P - Model 0918XL

Part Number	Size	A (in)	A1 (in)	A2 (in)	L (in)	L1 (in)	L2 (in)
	1 2 3						
20684	2½" x ¾" x 2½"	1.83	1.91	3.23	3.52	3.60	4.13
20689	2½" x 1" x 2½"	1.83	1.91	3.25	3.52	3.60	4.15
20694	2½" x 1¼" x 2½"	1.83	1.91	3.20	3.52	3.60	4.23
20699	2½" x 1½" x 2½"	1.83	1.91	3.14	3.52	3.60	4.57
20704	2½" x 2" x ¾"	1.04	1.61	1.59	2.74	2.52	3.17
20709	2½" x 2" x 1"	1.04	1.77	1.65	2.74	2.67	3.24
22283	2½" x 2" x 1½"	1.30	1.78	2.07	2.99	3.20	3.66
22278	2½" x 2" x 2"	1.50	1.78	2.25	3.19	3.36	3.83
20714	2½" x 2" x 2½"	1.83	1.91	2.41	3.52	3.60	4.00
22303	2½" x 2½" x ½"	0.91	1.52	0.91	2.60	2.27	2.60
22298	2½" x 2½" x ¾"	0.91	1.58	0.91	2.60	2.48	2.60
22293	2½" x 2½" x 1"	1.04	1.77	1.04	2.74	2.68	2.74
22288	2½" x 2½" x 1¼"	1.16	1.76	1.16	2.85	2.79	2.85
20803	2½" x 2½" x 1½"	1.30	1.78	1.30	2.99	3.21	2.99
20688	2½" x 2½" x 2"	1.54	1.75	1.54	3.23	3.34	3.23
20683	2½" x 2½" x 2½"	1.83	1.87	1.83	3.52	3.57	3.52
20719	3" x ¾" x 3"	2.07	2.15	3.82	4.04	4.11	4.72
20724	3" x 1" x 3"	2.07	2.15	3.96	4.04	4.11	4.86
20729	3" x 1¼" x 3"	2.07	2.15	3.83	4.04	4.11	4.86

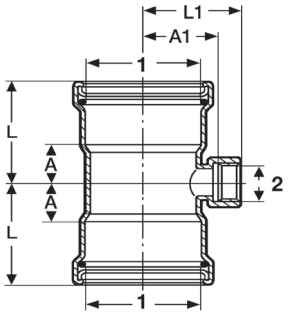
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Submittal Package



XL Tee P x P x P - Model 0918XL (continued from previous page)

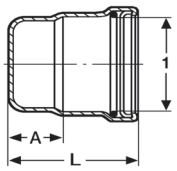
Part Number	Size	A (in)	A1 (in)	A2 (in)	L (in)	L1 (in)	L2 (in)
	1 2 3						
20727	3" x 1½" x 3"	2.07	2.15	3.71	4.04	4.11	5.14
20732	3" x 2" x 2"	1.56	2.03	2.33	3.52	3.61	3.92
20734	3" x 2" x 2½"	1.85	2.15	2.63	3.82	3.85	4.21
20739	3" x 2" x 3"	2.07	2.15	2.84	4.04	4.11	4.43
20744	3" x 2½" x 2"	1.56	2.03	2.07	3.52	3.61	3.76
20749	3" x 2½" x 2½"	1.85	2.15	2.56	3.82	3.85	4.25
20754	3" x 2½" x 3"	2.07	2.15	2.78	4.04	4.11	4.47
20759	3" x 3" x ½"	0.93	1.76	0.93	2.89	2.50	2.89
22323	3" x 3" x ¾"	0.93	1.80	0.93	2.89	2.71	2.89
22308	3" x 3" x 1"	1.06	2.02	1.06	3.03	2.92	3.03
22313	3" x 3" x 1¼"	1.18	2.01	1.18	3.15	3.04	3.15
20798	3" x 3" x 1½"	1.32	2.03	1.32	3.29	3.45	3.29
20698	3" x 3" x 2"	1.56	2.00	1.56	3.52	3.59	3.52
20703	3" x 3" x 2½"	1.85	2.15	1.85	3.82	3.85	3.82
20693	3" x 3" x 3"	2.07	2.21	2.07	4.04	4.18	4.04
20774	4" x 3" x 2"	1.59	2.57	3.33	3.96	4.15	5.22
20784	4" x 3" x 3"	2.11	2.66	3.84	4.47	4.63	5.81
20788	4" x 4" x ½"	1.08	2.24	1.08	3.45	2.99	3.45
20793	4" x 4" x ¾"	1.08	2.32	1.08	3.45	3.22	3.45
20794	4" x 4" x 1"	1.36	2.52	1.36	3.72	3.42	3.72
20795	4" x 4" x 1¼"	1.36	2.50	1.36	3.72	3.54	3.72
20808	4" x 4" x 1½"	1.36	2.52	1.36	3.72	3.95	3.72
20713	4" x 4" x 2"	1.59	2.53	1.59	3.96	4.11	3.96
20718	4" x 4" x 2½"	1.89	2.65	1.89	4.25	4.35	4.25
20723	4" x 4" x 3"	2.11	2.69	2.11	4.47	4.65	4.47
20708	4" x 4" x 4"	2.60	2.72	2.60	4.96	5.09	4.96



XL Tee P x P x FPT - Model 0917.2XL

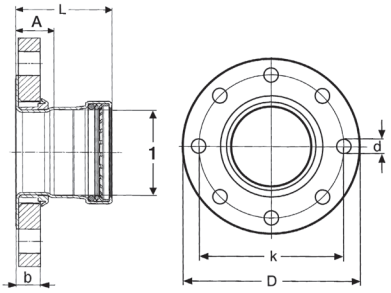
Part Number	Size	A (in)	A1 (in)	L (in)	L1 (in)
	1 2				
20883	2½" x ¾" FPT	1.02	1.78	2.72	2.34
20878	2½" x 2" FPT	1.54	1.90	3.23	2.60
20893	3" x ¾" FPT	1.04	2.03	3.01	2.59
20888	3" x 2" FPT	1.56	2.16	3.52	2.85
20873	4" x ¾" FPT	1.08	2.53	3.34	3.09
20868	4" x 2" FPT	1.59	2.69	3.96	3.38

Submittal Package



XL Cap P - Model 0956XL

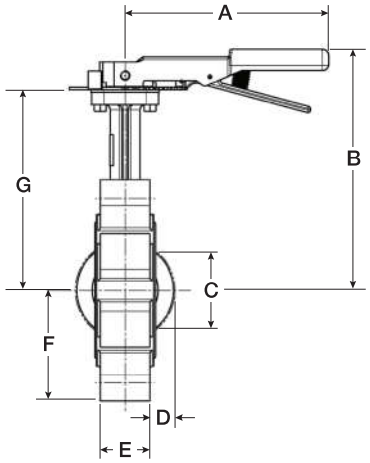
Part Number	Size	A (in)	L (in)
	1		
20833	2½"	0.39	2.11
20843	3"	0.39	2.36
20848	4"	0.39	2.76

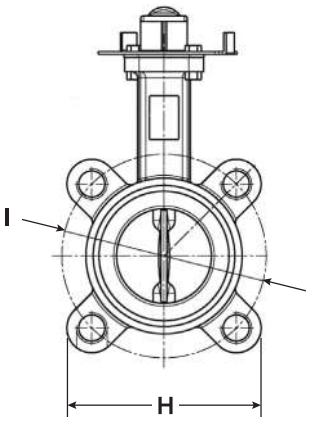


XL Adapter Flange P x Flange - Model 0959.5XL

Part Number	Size	A (in)	L (in)	b (in)	k (in)	D (in)	d (in)
	1						
20853	2½"	1.09	2.79	0.70	5.51	7.09	0.75
20858	3"	1.20	3.17	0.79	5.98	7.48	0.75
20863	4"	1.29	3.66	0.86	7.52	9.06	0.75

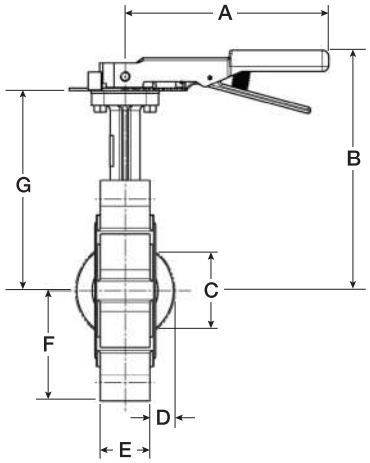
Submittal Package

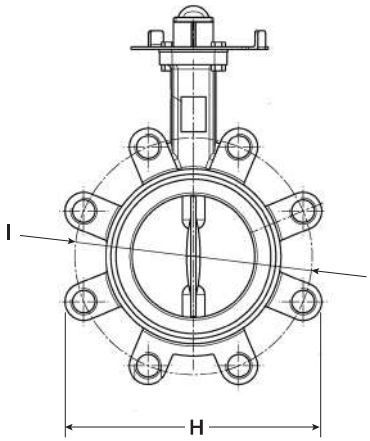




Butterfly Valve - Model 2873.81

Part No.	Size	A (in)	B (in)	C (in)	D (in)	E (in)	F (in)	G (in)	H (in)	I (in)
22074	2½"	6.50	7.40	2.17	0.43	1.81	2.64	5.35	5.20	5.51
22075	3"	7.28	7.64	2.80	0.67	1.81	2.82	5.59	7.01	5.98





Butterfly Valve - Model 2873.81

Part No.	Size	A (in)	B (in)	C (in)	D (in)	E (in)	F (in)	G (in)	H (in)	I (in)
22076	4"	9.06	8.47	3.54	0.91	2.05	3.62	6.42	8.27	7.48

Submittal Package

Viega Limited Warranty ProPress® Fittings And Valves

Subject to the conditions and limitations in this Limited Warranty, Viega LLC (VIEGA) warrants to wholesalers and licensed plumbing and mechanical contractors in the United States and Canada that its PROPRESS fittings, when properly installed in non industrial and non marine applications and under normal conditions of use, will be free of failure from manufacturing defect for a period of fifty (50) years from date of installation and that its PROPRESS valves, when properly installed in non industrial and non marine applications and under normal conditions of use, will be free of failure from manufacturing defect for a period of two (2) years from date of installation.

Under this Limited Warranty, you only have a right to a remedy if the failure or leak resulted from a manufacturing defect in the products covered by this warranty and the failure or leak occurred during the warranty period. You do not have a remedy under this warranty and the warranty does not apply if the failure or any resulting damage is caused by (1) components other than those manufactured or sold by Viega; (2) not designing, installing, inspecting, or testing the ProPress fittings or valves in accordance with Viega's installation instructions in effect at the time of the installation; applicable code requirements; and accepted industry practice; (3) improper handling and protection of the product prior to and during installation, inadequate freeze protection, exposure to water pressures or temperatures or in applications outside acceptable operating conditions; (4) acts of nature such as, but not limited to, earthquakes, fire, flood, or lightning, or (5) external environmental causes, such as water quality variations, aggressive water, or other external chemical or physical conditions.

In the event of a leak or other failure of the parts covered by this warranty, it is the responsibility of the property owner to obtain and pay for repairs. Only if the warranty applies will Viega be responsible for the remedy under this warranty. The part or parts which you claim failed should be kept and Viega contacted by writing to the address below or telephoning 1-800-976-9819 within thirty (30) days after the leak or other failure and identifying yourself as having a warranty claim. You should be prepared to ship, at your expense, the product which you claim failed due to a manufacturing defect and document the date of installation. Within a reasonable time after receiving the product, Viega will investigate the reasons for the failure, which includes the right to inspect the product at Viega. Viega will notify you in writing of the results of its review.

In the event that Viega determines that the failure or leak was the result of a manufacturing defect in the part covered by this warranty and that this warranty applies, the EXCLUSIVE AND ONLY REMEDY under this warranty shall be the reimbursement for repair and/or replacement of the part. VIEGA SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL OR OTHER DAMAGE (FOR EXAMPLE, WATER OR PROPERTY OR MOLD REMEDIATION) UNDER ANY LEGAL THEORY AND WHETHER ASSERTED BY DIRECT ACTION, FOR CONTRIBUTION OR INDEMNITY OR OTHERWISE.

THE ABOVE WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. If a limited warranty shall be found to apply, such warranty is limited to four years. Other than this Limited Warranty, Viega does not authorize any person or firm to create for it any other obligation or liability in connection with its products.

This Limited Warranty gives you specific legal rights and you also may have other rights which may vary from state to state. This warranty shall be interpreted and applied under the law of the state in which the product is installed and is intended as a Commercial Warranty.

*Zero Lead identifies Viega® products meeting the lead free requirements of NSF 61-G through testing under NSF/ANSI 372 (0.25% or less maximum weighted average lead content).

This document subject to updates. For the most current Viega technical literature please visit www.viega.us.
Click Services -> Click Electronic Literature Downloads -> Select Product Line -> Select Desired Document

Viega LLC, 100 N. Broadway, 6th Floor • Wichita, KS 67202 • Ph: 800-976-9819 • Fax: 316-425-7618

viega

Tech Data

Seals and Gaskets Information

FKM Sealing Elements Will Be Used On This Project

This document is subject to updates. For the most current Viega technical literature please visit www.viega.us.

Viega products are designed to be installed by licensed and trained plumbing and mechanical professionals who are familiar with Viega products and their installation. **Installation by non-professionals may void Viega LLC's warranty.**

WARNING! Product line application guides and chemical compatibility matrix are not all inclusive.

All sealing elements are installed using an H-1 food grade silicone oil lubricant registered with NSF, USDA and approved for use under FDA 21 CFR.

Refer to product line application guides or chemical compatibility matrix for general information, or call Viega® Tech Services at 1-800-976-9819.

ProPress 2½" to 4" formerly ProPress XL.

FKM Sealing Element

Operating temperature:
14°F to 284°F (-10°C to 140°)

Resistant to thermal spikes to 356°F (thermal spikes are temperature increases above maximum defined operating temperature for a duration of 24 hours or less).

FKM, is a fluoroelastomer or synthetic fluorinated rubber, specialty purpose elastomer.

FKM sealing elements are dull black in color, and possess excellent resistance to chemicals, higher temperatures, aging, ozone, sunlight, weathering, environmental influences, oils, and petroleum-based additives.

FKM's resistance to aggressive chemicals and higher operating temperatures makes it ideal for seals and gaskets in solar and industrial process applications.

HNBR Sealing Element

Operating temperature:
-40°F to 180°F (-40°C to 82°C)

HNBR, or Hydrogenated Nitrile Butadiene Rubber, is a speciality purpose compound used where resistance to petroleum-based additives are required.

HNBR sealing elements are yellow in color, and possess excellent physical strength and retention properties after long-term exposure to heat, oil, and chemicals.

HNBR sealing elements are used for applications of natural, propane, mixed, and manufactured gases as well as oils and lubricants.

HNBR's unique properties have resulted in wide adoption in automotive, industrial, and assorted high performance applications.

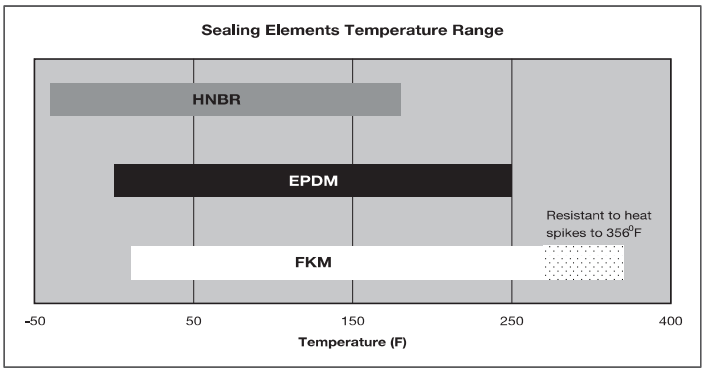
EPDM Sealing Element

Operating temperature:
0°F to 250°F (-18°C to 120°C)

EPDM, or ethylene-propylene-diene rubber, is a synthetically manufactured and peroxidically cured all-purpose elastomer.

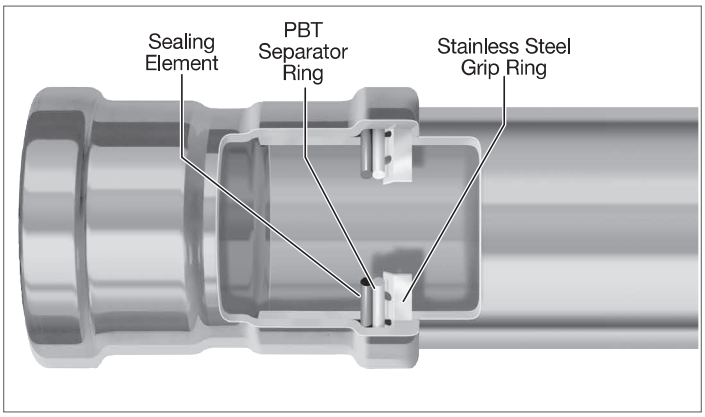
EPDM sealing elements are shiny black in color and possess excellent resistance to aging, ozone, sunlight, weathering, environmental influences, alkalis and most alkaline solutions along with chemicals used in a broad range of applications, including ketones. EPDM has particularly good resistance to hot water, making it ideal for seals and gaskets.

Viega Press Systems are manufactured with high quality sealing elements, installed at the factory.



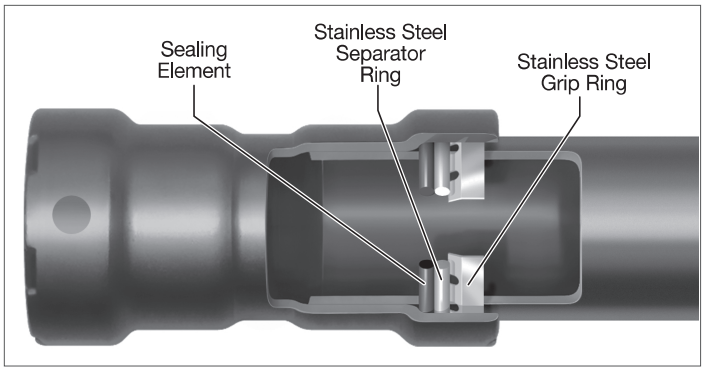
ProPress Exclusive Grip and Separator Ring

The grip ring is made of 420 (1.4021) stainless steel. The grip ring ensures the ProPress 2½" to 4" fittings create a positive cold press mechanical joint. The PBT (Polybutylene Terephthalate) separator ring ensures that sealing element and grip ring perform at maximum capacity by providing a positive physical separation.



MegaPress Exclusive Grip and Separator Ring

The MegaPress grip ring is made of 420 (1.4021) stainless steel. The grip ring ensures the MegaPress fittings create a positive cold press mechanical joint. For MegaPress ½" to 2" fittings, a 304 stainless steel separator ring ensures that sealing element and grip ring perform at maximum capacity by providing a positive physical separation. For MegaPress 2½" to 4" fittings, a PBT (Polybutylene Terephthalate) separator ring protects the sealing element. For MegaPressG 2½" to 4" fittings, a graphite separator ring protects the sealing element.



Viega LLC
585 Interlocken Blvd.
Broomfield, CO 80021

Phone (800) 976 9819
www.viega.us

4. Vortex Flow sensor, Standard (VFS and VFS QT)

General data



TM05 4745 2412

Fig. 32 VFS and VFS QT sensors

Technical overview

The VFS is a combined flow and temperature sensor (two-in-one) from Grundfos Direct Sensors™. The sensor is based on the principle of vortex shedding behind a bluff body.

The VFS sensor is fully compatible with wet, aggressive liquids. The sensor is based on MEMS sensing technology in combination with the corrosion-resistant Silicoat® coating technology on the sensor chip.

The sensor is supplied with a flow pipe.

Applications

- Pump control
- HVAC systems
- temperature control and chiller systems
- renewable energies such as heat pumps, solar thermals, fresh water and micro-CHP systems
- monitoring and control systems
- water treatment plants
- water utility and distribution systems
- HPC (High-Performance Computing) and IT cooling systems.

Features and benefits

- Measurement principle with no movable parts, resulting in no wear and tear
- flow and temperature measurement in one sensor (two-in-one solution) for easy and cost-efficient installation
- MEMS technology
- direct contact with the aqueous media resulting in a fast response time
- plug and play for quick setup
- smart system solution with Grundfos pump controls
- compact and robust design
- compatible with aqueous media
- suitable for a wide temperature range
- suitable for a wide range of applications.
- For aqueous media below 2 µS/cm contact your local Grundfos sensor representative.

Flow range

l/min	gpm
1-18	0.26 - 4.76
1.3 - 20	0.34 - 5.28
2-40	0.53 - 10.57
5-100	1.32 - 26.42
10-200	2.64 - 52.83
20-400	5.28 - 105.67

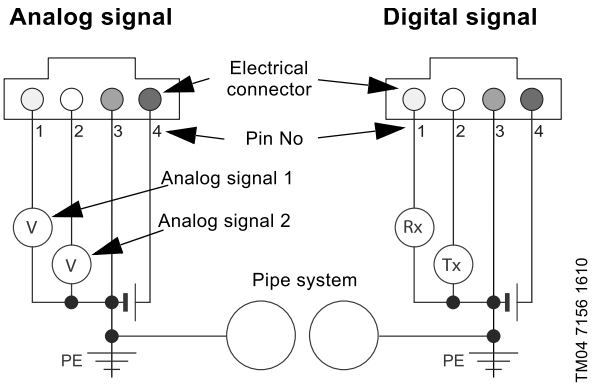
Approvals (w/EPDM O-rings)

- WRAS
- KTW
- AS4020
- ACS.

Certificates

CE	C, CSA, US	EAC

Electrical connections



TM04 7156 1610

Fig. 33 Electrical connections

Pin	Description Analogue signal	Description Digital signal	Colour
1	Temperature signal	Rx	Yellow
2	Pressure signal	Tx	White
3	GND, 0 V PELV	GND, 0 V PELV	Green
4	Voltage supply, +5 VDC	Power supply, +5 VDC	Brown

Power supply requirements

- 5 VDC ± 5 %, PELV
- Ratiometric
- Max. 10 mV ripple: 50 Hz
- Min. output current: 25 mA
- Separated from hazardous live circuitry by double or reinforced insulation.
- Grounding of the sensor supply is required.

Directives

The Grundfos Direct Sensors™ are in conformity with these council directives on the approximation of the laws of the EC member states:

- Low Voltage Directive (2014/35/EU)
  - Standards used: EN 61010-1:2010
- EMC Directive (2014/30/EU).
  - Standards used: EN 61326-1:2013 and EN 61326-2-3:2013

The Grundfos Direct Sensors™ are exempted from the Pressure Equipment Directive (PED) according to Article 4, paragraph 3 in the PED 2014/68/EU.

VFS sensors



Fig. 34 The VFS family

The VFS flow sensor consists of a composite flow pipe and a sensor fitted with cable.

The VFS flow sensor is available in 1-20, 2-40, 5-100, 10-200, 20-400 l/min versions.

VFS QT sensors



Fig. 35 The VFS QT family

The VFS QT flow sensor consists of a composite insert, a stainless steel flow pipe and a sensor fitted with cable.

The VFS QT flow sensor is available in 1-18, 2-40, 5-100, 10-200 l/min versions.

Snap-on sensor



Fig. 36 Snap-on sensor

Differential Temperature

The differential temperature is between two standard Direct Sensors™ from Grundfos.

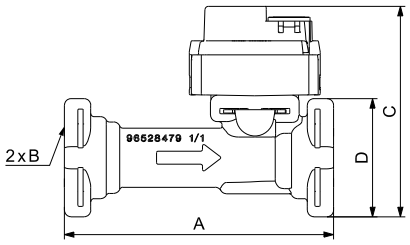
VFS, 1-20 l/min (0.2 - 5.3 gpm)



TM05 4751 2512

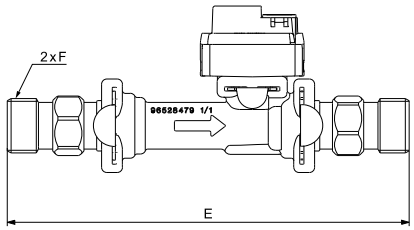
Fig. 37 VFS, 1-20 l/min

Dimensions



TM06 3420 0314

Fig. 38 Dimensions, VFS, 1-20 l/min, without adapter

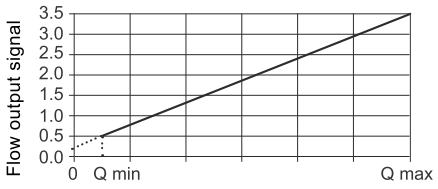


TM06 3425 0314

Fig. 39 Dimensions, VFS, 1-20 l/min, with adapters

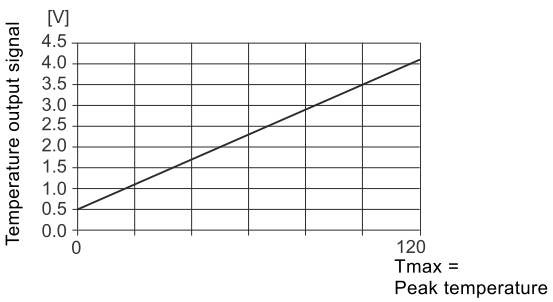
	A	B	C	D	E	F
mm	82	∅19.8	65	36	153.6	ISO 228 - G 1/2 A
in	3.23	∅0.78	2.56	1.42	6.05	1/2" NPT

Sensor output signals



TM07 2484 3618

Fig. 40 Flow response in Analogue mode



TM06 3354 5214

Fig. 41 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	1.3-20 l/min (0.34 to 5.3 gpm)
Accuracy (± 1 σ) in water, 0-120 °C (32-248 °F)	± 1 % FS
Response time (63.2 %)	Less than 1 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.006 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-100 °C (32-212 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F) for 5 minutes, up to 3 weeks in sensor lifetime
Ambient temperature, operation	-25 to +60 °C (-13 to -140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to 194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	24 bar (348 psig)
Burst Pressure	30 bar (435 psig)
Maximum system pressure examples	Max 10 bar (145 psig) at 100 °C (212 °F)
Electrical data	
Power supply	5 VDC (± 5 %), PELV Grounding of sensor supply required
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 3.5 V for flow (zero at 0.35 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM O-rings, FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	PPA 40-GF
Wetted materials	Corrosion-resistant coating, EPDM or FKM, PPS, PPA 40-GF
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

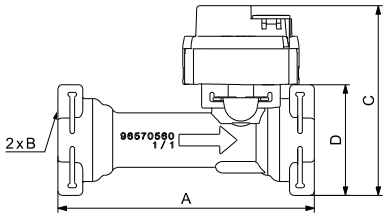
VFS, 2-40 l/min (0.5 - 10.6 gpm)



TM05 4749 2512

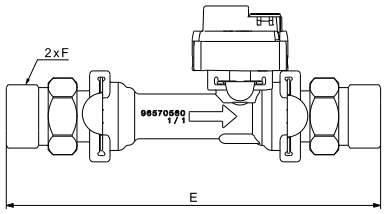
Fig. 42 VFS, 2-40 l/min

Dimensions



TM06 3421 0314

Fig. 43 Dimensions, VFS, 2-40 l/min, without adapter

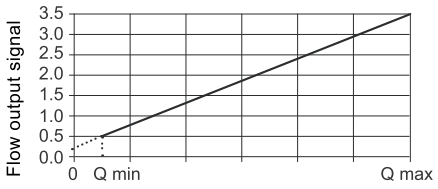


TM06 3426 0314

Fig. 44 Dimensions, VFS, 2-40 l/min, with adapters

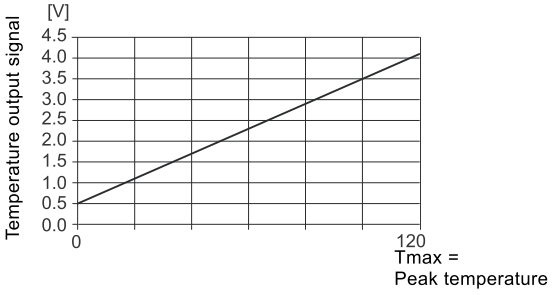
	A	B	C	D	E	F
mm	88	∅22.8	66	38	157.4	ISO 228/1 - G 3/4 A
in	3.46	∅0.19	2.60	1.50	6.20	3/4" NPT

Sensor output signals



TM07 2484 3618

Fig. 45 Flow response in Analogue mode



TM06 3354 5214

Fig. 46 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	2-40 l/min (0.5 - 10.6 gpm)
Accuracy (± 1 σ) in water, 0-100 °C (32-212 °F)	± 1 % FS
Response time (63.2 %)	Less than 1 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.006 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than or equal to 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-100 °C (32-212 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F) for 5 minutes, up to 3 weeks in sensor lifetime
Ambient temperature, operation	-25 to +60 °C (-13 to +140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to +194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	24 bar (348 psig)
Burst Pressure	30 bar (435 psig)
Maximum system pressure examples	Max 10 bar (145 psig) at 100 °C (212 °F)
Electrical data	
Power supply	5 VDC (± 5 %), PELV Grounding of sensor supply required
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 3.5 V for flow (zero at 0.35 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM-O-rings or FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	PPA 40-GF
Wetted materials	Corrosion-resistant coating, EPDM or FKM, PPS, PPA 40-GF
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

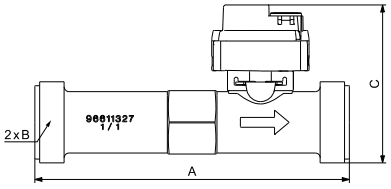
VFS, 5-100 l/min (1.3 - 26 gpm)



TM05 4748 2512

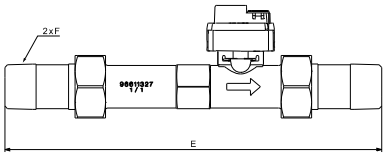
Fig. 47 VFS, 5-100 l/min

Dimensions



TM06 3422 0314

Fig. 48 Dimensions, VFS, 5-100 l/min, without adapter

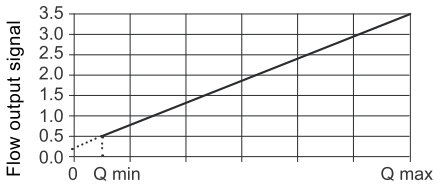


TM06 3427 0314

Fig. 49 Dimensions, VFS, 5-100 l/min, with adapters

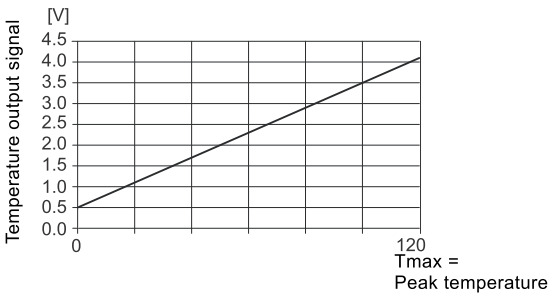
	A	B	C	D	E	F
mm	129	ISO 228/1 - G 1 A	65	-	223	ISO 7/1 - Rc 3/4
in	5.08		2.56	-	8.78	3/4" NPT

Sensor output signals



TM07 2484 3618

Fig. 50 Flow response in Analog mode



TM06 3354 5214

Fig. 51 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	5-100 l/min (1.3 to 26.4 gpm)
Accuracy (± 1 σ) in water, 0-100 °C (32-212 °F)	± 1 % FS
Response time (63.2 %)	Less than 1 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.006 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than or equal to 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-100 °C (32-212 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F) for 5 minutes, up to 3 weeks in sensor lifetime
Ambient temperature, operation	-25 to +60 °C (-13 to +140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to +194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	24 bar (348 psig)
Burst Pressure	30 bar (435 psig)
Maximum system pressure examples	Max 10 bar (145 psig) at 100 °C (212 °F)
Electrical data	
Power supply	5 VDC (± 5 %), PELV Grounding of sensor supply required
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 3.5 V for flow (zero at 0.35 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM O-rings, FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	PPA 40-GF
Wetted materials	Corrosion-resistant coating, EPDM or FKM, PPS, PPA 40-GF
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

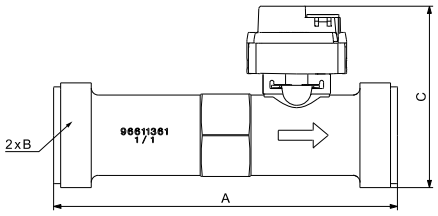
VFS, 10-200 l/min (2.6 - 53 gpm)



TM05 4747 2512

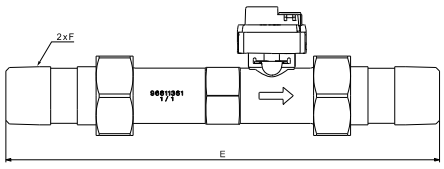
Fig. 52 VFS, 10-200 l/min

Dimensions



TM06 3423 0314

Fig. 53 Dimensions, VFS, 10-200 l/min, without adapter

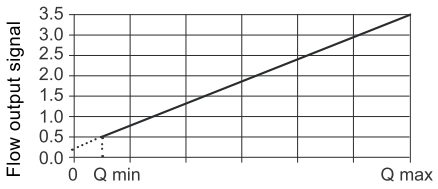


TM06 3428 0314

Fig. 54 Dimensions, VFS, 10-200 l/min, with adapters

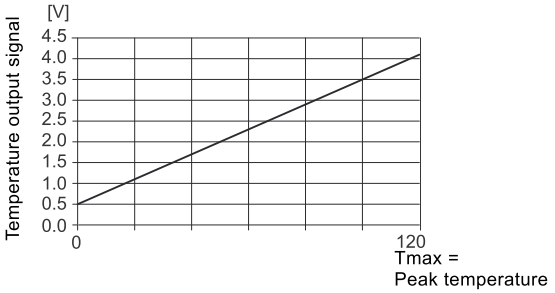
	A	B	C	D	E	F
mm	137.5	ISO 228/1 - G 1 1/4 A	73	-	252	ISO 7/1-R 1
in	5.41		2.87	-	9.92	1" NPT

Sensor output signals



TM07 2484 3618

Fig. 55 Flow response in Analogue mode



TM06 3354 5214

Fig. 56 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	10-200 l/min (2.6 to 52.8 gpm)
Accuracy (± 1 σ) in water, 0-100 °C (32-212 °F)	± 1 % FS
Response time (63.2 %)	Less than 1 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.35 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than or equal to 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-100 °C (32-212 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F) for 5 minutes, up to 3 weeks in sensor lifetime
Ambient temperature, operation	-25 to +60 °C (-13 to +140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to +194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	24 bar (348 psig)
Burst Pressure	30 bar (435 psig)
Maximum system pressure examples	Max 10 bar (145 psig) at 100 °C (212 °F)
Electrical data	
Power supply	5 VDC (± 5 %), PELV Grounding of sensor supply required
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 3.5 V for flow (zero at 0.35 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM-O-rings or FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	PPA 40-GF
Wetted materials	Corrosion-resistant coating, EPDM or FKM, PPS, PPA 40-GF
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

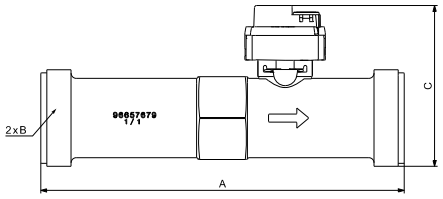
VFS, 20-400 l/min (5.3 - 106 gpm)



TM05 4746 2512

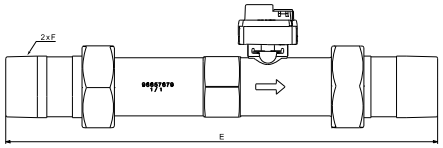
Fig. 57 VFS, 20-400 l/min

Dimensions



TM06 3424 0314

Fig. 58 Dimensions, VFS, 20-400 l/min, without adapter

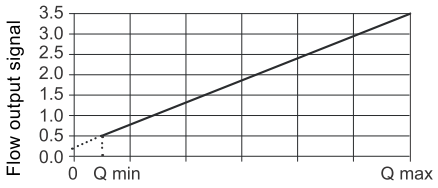


TM06 3429 0314

Fig. 59 Dimensions, VFS 20-400 l/min, with adapters

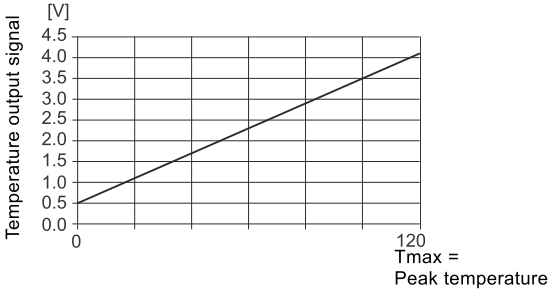
	A	B	C	D	E	F
mm	180	ISO 228/1 - G 1 1/2 A	80	-	293	ISO 7/1- R 1 1/4
in	7.09		3.15	-	11.54	1 1/4" NPT

Sensor output signals



TM07 2484 3618

Fig. 60 Flow response in Analogue mode



TM06 3354 5214

Fig. 61 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	20-400 l/min (5.3 to 105.7 gpm)
Accuracy (± 1 σ) in water, 0-120 °C (32-248 °F)	± 1 % FS
Response time (63.2 %)	Less than 1 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.006 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than or equal to 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-100 °C (32-212 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F) for 5 minutes, up to 3 weeks in sensor lifetime
Ambient temperature, operation	-25 to +60 °C (-13 to +140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to +194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	24 bar (348 psig)
Burst Pressure	30 bar (435 psig)
Maximum system pressure examples	Max 10 bar (145 psig) at 100 °C (212 °F)
Electrical data	
Power supply	5 VDC (± 5 %), PELV Grounding of sensor supply required
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 3.5 V for flow (zero at 0.35 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM O-rings, FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	PPA 40-GF
Wetted materials	Corrosion-resistant coating, EPDM or FKM, PPS, PPA 40-GF
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

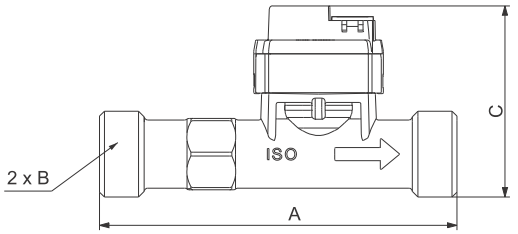
VFS QT, 1-18 l/min (0.2 - 4.8 gpm)



TM05 4741 2512

Fig. 62 VFS QT, 1-18 l/min

Dimensions

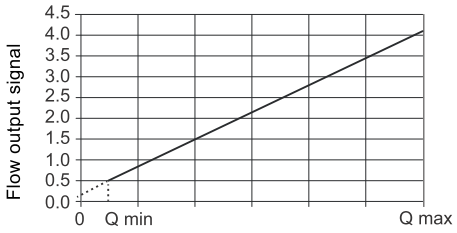


TM05 4671 2512

Fig. 63 Dimensions, VFS QT, 1-18 l/min, with threads

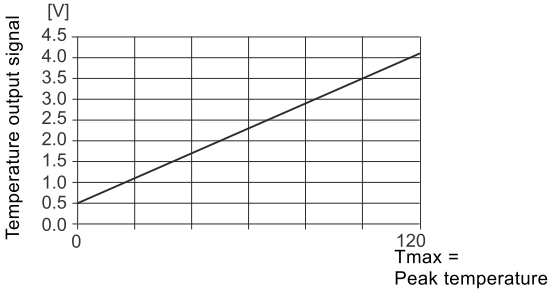
	A	B	C
mm	110	ISO 228/1 - G3/4 A	58.8
in	4.33		2.31

Sensor output signals



TM07 2747 4118

Fig. 64 Flow response in Analogue mode



TM06 3354 5214

Fig. 65 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	1-18 l/min (0.2 to 4.8 gpm)
Accuracy (± 1 σ) in water, 0-120 °C (32-248 °F)	± 1 % FS
Response time (63.2 %)	Less than 1 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.006 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than or equal to 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-120 °C (32-248 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F)
Ambient temperature, operation	-25 to +60 °C (-13 to +140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to +194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	30 bar (435 psig)
Burst Pressure	40 bar (580 psig)
Maximum system pressure examples	Max 16 bar (232 psig) at 100 °C (212 °F) Max 8 bar (116 psig) at 120 °C (248 °F)
Electrical data	
Power supply	5 VDC (± 5 %), PELV Grounding of sensor supply required
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 4.1 V for flow (zero at 0.28 V and 15 l/m at 3.5 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM O-rings, FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	Stainless steel AISI 316 EN 1.4408
Insert	PPA 40 GF
Wetted materials	Corrosion-resistant coating EPDM or FKM, PPS, PPA 40-GF, 1.4408
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

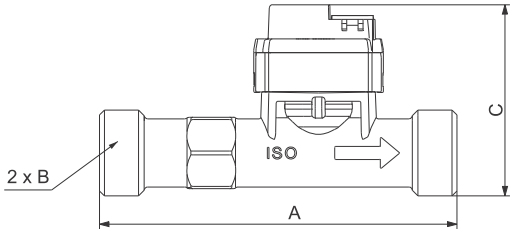
VFS QT, 2-40 l/min (0.5 - 10.6 gpm)



TM05 4741 2512

Fig. 66 VFS QT, 2-40 l/min

Dimensions

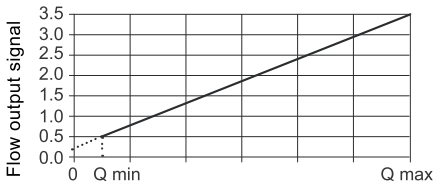


TM05 4671 2512

Fig. 67 Dimensions, VFS QT, 2-40 l/min, with threads

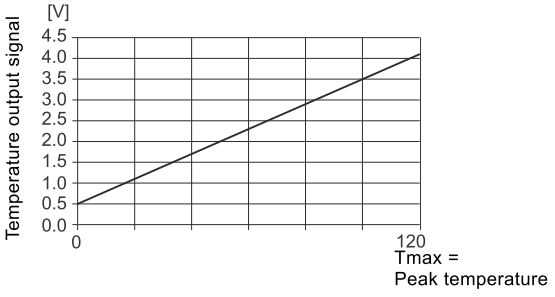
	A	B	C
mm	110	ISO 228/1 - G3/4 A	58.8
in	4.33		2.31

Sensor output signals



TM07 2484 3618

Fig. 68 Flow response in Analogue mode



TM06 3354 5214

Fig. 69 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	2-40 l/min (0.5 - 10.6 gpm)
Accuracy (± 1 σ) in water, 0-120 °C (32-248 °F)	± 1 % FS
Response time (63.2 %)	Less than 3 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.006 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than or equal to 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-100 °C (32-212 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F)
Ambient temperature, operation	-25 to +60 °C (-13 to +140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to +194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	30 bar (435 psig)
Burst Pressure	40 bar (580 psig)
Maximum system pressure examples	Max 16 bar (232 psig) at 100 °C (212 °F) Max 8 bar (116 psig) at 120 °C (248 °F)
Electrical data	
Power supply	5 VDC (± 5 %), PELV Grounding of sensor supply required
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 3.5 V for flow (zero at 0.35 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM O-rings, FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	Stainless steel AISI 316 EN 1.4408
Insert	PPA 40 GF
Wetted materials	Corrosion-resistant coating, EPDM or FKM, PPS, PPA 40-GF, 1.4408
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

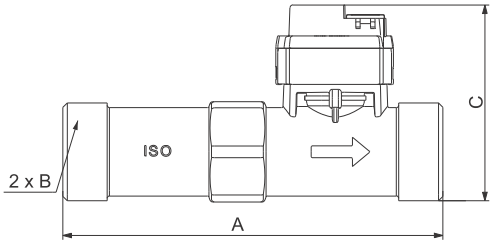
VFS QT, 5-100 l/min (1.3 - 26 gpm)



TM05 4740 2512

Fig. 70 VFS QT, 5-100 l/min

Dimensions

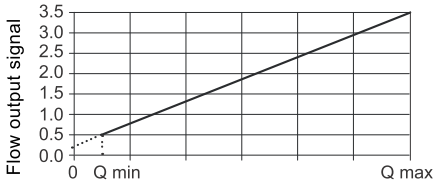


TM05 4672 2512

Fig. 71 Dimensions, VFS QT, 5-100 l/min, with threads

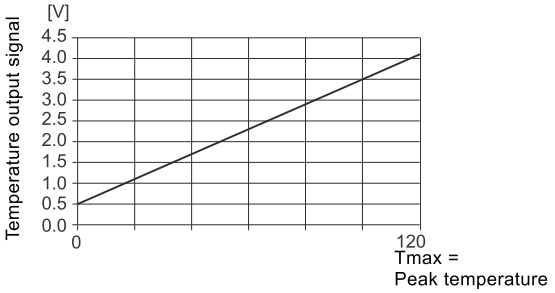
	A	B	C
mm	129	ISO 228/1 - G1A	66.5
in	5.08		2.62

Sensor output signals



TM07 2484 3618

Fig. 72 Flow response in Analogue mode



TM06 3354 5214

Fig. 73 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	5-100 l/min (1.3 to 26.4 gpm)
Accuracy (± 1 σ), 0-100 °C (32-212 °F)	± 1 % FS
Response time (63.2 %)	Less than 1 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.006 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than or equal to 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-120 °C (32-248 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F)
Ambient temperature, operation	-25 to +60 °C (-13 to +140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to +194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	30 bar (435 psig)
Burst Pressure	40 bar (580 psig)
Maximum system pressure examples	Max 16 bar (232 psig) at 100 °C (212 °F) Max 8 bar (116 psig) at 120 °C (248 °F)
Electrical data	
Power supply	5 VDC (± 5 %). We recommend grounding of the sensor supply (PELV).
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 3.5 V for flow (zero at 0.35 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM O-rings, FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	Stainless steel AISI 316 EN 1.4408
Insert	PPA 40-GF
Wetted materials	Corrosion-resistant coating, EPDM or FKM, PPS, PPA 40-GF, 1.4408
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

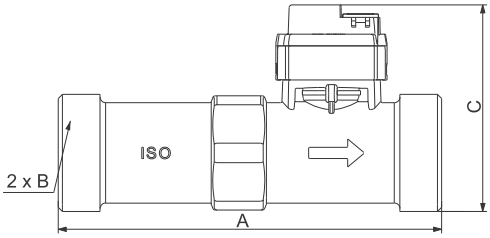
VFS QT, 10-200 l/min (2.6 - 53 gpm)



TM05 4739 2512

Fig. 74 VFS QT, 10-200 l/min

Dimensions

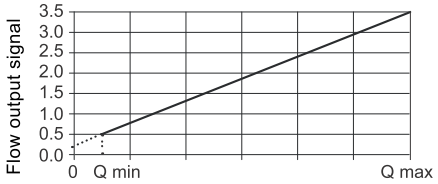


TM05 4673 2512

Fig. 75 Dimensions, VFS QT, 10-200 l/min, with threads

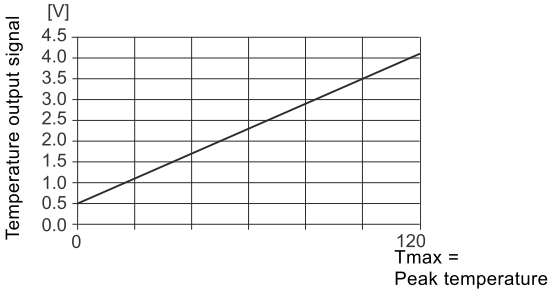
	A	B	C
mm	137.5	ISO 228/1 - G1 1/4 A	74.1
in	5.41		2.92

Sensor output signals



TM07 2484 3618

Fig. 76 Flow response in Analogue mode



TM06 3354 5214

Fig. 77 Temperature response in Analogue mode

Specifications

Flow	
Measuring range	10-200 l/min (2.6 to 52.8 gpm)
Accuracy (± 1 σ) in water, 0-100 °C (32-212 °F)	± 1 % FS
Response time (63.2 %)	Less than 1.0 s
Resolution	max flow/16384 l/min or gpm
Temperature	
Measuring range	0-120 °C (32-248 °F)
Accuracy (± 1 σ), 15-90 °C (59-194 °F)	± 0.5 K
Accuracy (± 1 σ), 0-120 °C (32-248 °F)	± 1 K
Response time (63.2 % at 50 % FS flow)	250 ms
Resolution	0.006 K
Differential Temperature	
Accuracy 15-90 °C (59-194 °F)	0.3 K
Accuracy 0-120 °C (32-248 °F)	0.5 K
System conditions and environment	
Liquid types	Aqueous media compatible with wetted materials. Kinematic viscosity less than or equal to 2 mm^2/s (cSt)
Liquid temperature, operation	Water: 0-120 °C (32-248 °F)
Liquid temperature, peak	-25 °C (-13 °F), non-freezing 120 °C (248 °F)
Ambient temperature, operation	-25 to +60 °C (-13 to +140 °F)
Ambient temperature, peak	-55 to +90 °C (-67 to +194 °F)
Humidity, relative	0-95 %, non-condensing
Maximum System Pressure	30 bar (435 psig)
Burst Pressure	40 bar (580 psig)
Maximum system pressure examples	Max 16 bar (232 psig) at 100 °C (212 °F) Max 8 bar (116 psig) at 120 °C (248 °F)
Electrical data	
Power supply	5 VDC (± 5 %), PELV Grounding of sensor supply required
Output signals	Ratiometric
Digital output signals	Grundfos open data protocol
Analog output signals	0.5 - 3.5 V for flow (zero at 0.35 V) 0.5 - 4.1 V for temperature (zero at 0.5 V and 100 °C at 3.5 V)
Power consumption	Appr. 75 mW
Load impedance	> 47 kΩ
Maximum cable length	3 m (9.10 ft)
Materials	
Sensing element	Silicon-based MEMS
Sealing	EPDM O-rings, FKM O-rings or EPDM sealing cap with FKM O-rings
Housing	Composite (PPS, PA66)
Flow pipe	Stainless steel 1.4408 (AISI 316)
Insert	PPA 40-GF
Wetted materials	Corrosion-resistant coating, EPDM or FKM, PPS, PPA 40-GF, 1.4408
Environmental standards	
Enclosure class	IP44, cable connected
Temperature cycling	IEC 68-2-14
Vibration, non-destructive	20-2000 Hz, 10G, 4 h
Electromagnetic compatibility	EN 61326-1

For Residential, Commercial, Industrial and Solar Applications

Job Name _____ Contractor _____

Job Location _____ Approval _____

Engineer _____ Contractor's P.O. No. _____

Approval _____ Representative _____

LEAD FREE*

Series LF600

Lead Free* Silent Check Valves

Sizes: ¼"– 2"

Series LF600 Lead Free* silent check valves efficiently perform all of the functions of a swing check or vertical lift check valves and at the same time operate silently to prevent the effects of water hammer. The Series LF600 check valves feature Lead Free* construction to comply with Lead Free* installation requirements.



LF600

Features

- Conical Lead Free* check for full fluid flow
- PTFE seat
- Install in horizontal or vertical position with upward flow (consult factory for proper use in vertical installations)
- Low pressure drop equivalent to a swing check
- Stainless steel guide, rod and spring (1¼" to 2")
- Silent operation
- Threaded ends

Specifications

A Lead Free* silent check valve shall be installed as indicated on the plans. The valve shall have a conical Lead Free* check, PTFE seat and silent operation. Pressure rating no less than 400psi (27.6 bar) WOG non-shock and 15psi (1 bar) WSP. The silent check valve shall be constructed using Lead Free* copper silicon alloy. Lead Free* silent check valves shall comply with state codes and standards, where applicable, requiring reduced lead content. Valve shall be a Watts Series LF600.

NOTICE

These valves are not suggested for installation in sewage ejector piping.

NOTICE

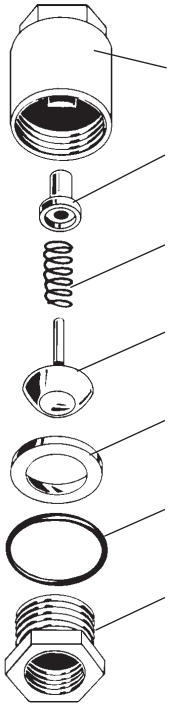
Do not use for reciprocating air compressor service.

NOTICE

Inquire with governing authorities for local installation requirements

***The wetted surface of this product contacted by consumable water contains less than 0.25% of lead by weight.**

Materials



Body
Lead Free* cast copper silicon alloy

Guide Bushing
Stainless Steel

Spring
Stainless Steel

Check
Lead Free* copper silicon alloy

Seat
PTFE

O-ring
Nitrile (1¼" – 2" only)

Adapter
¼" – 1" Lead Free* brass
1¼" – 2" Lead Free* brass

NSF
Certified to NSF/ANSI 372

NOTICE

The information contained herein is not intended to replace the full product installation and safety information available or the experience of a trained product installer. You are required to thoroughly read all installation instructions and product safety information before beginning the installation of this product.

Watts product specifications in U.S. customary units and metric are approximate and are provided for reference only. For precise measurements, please contact Watts Technical Service. Watts reserves the right to change or modify product design, construction, specifications, or materials without prior notice and without incurring any obligation to make such changes and modifications on Watts products previously or subsequently sold.

WATTS®

Pressure – Temperature

Maximum Working Pressure:

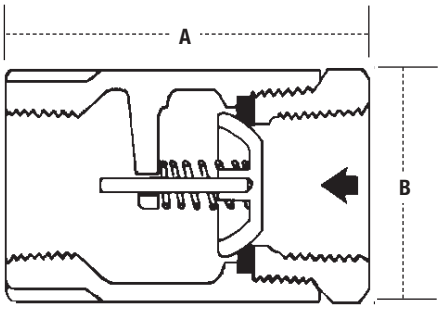
400psi (27.6 bar) WOG non-shock @ -20°F to 100°F
(-29°C to 38°C); 15psi (1 bar) WSP @ 250°F (121°C)

TEMPERATURE		PRESSURE	
Fahrenheit	Celsius	psi	bar
-20° to 100°	-29° to 38°	400	27.6
200°	93°	200	13.8
250°	121°	160	11.0

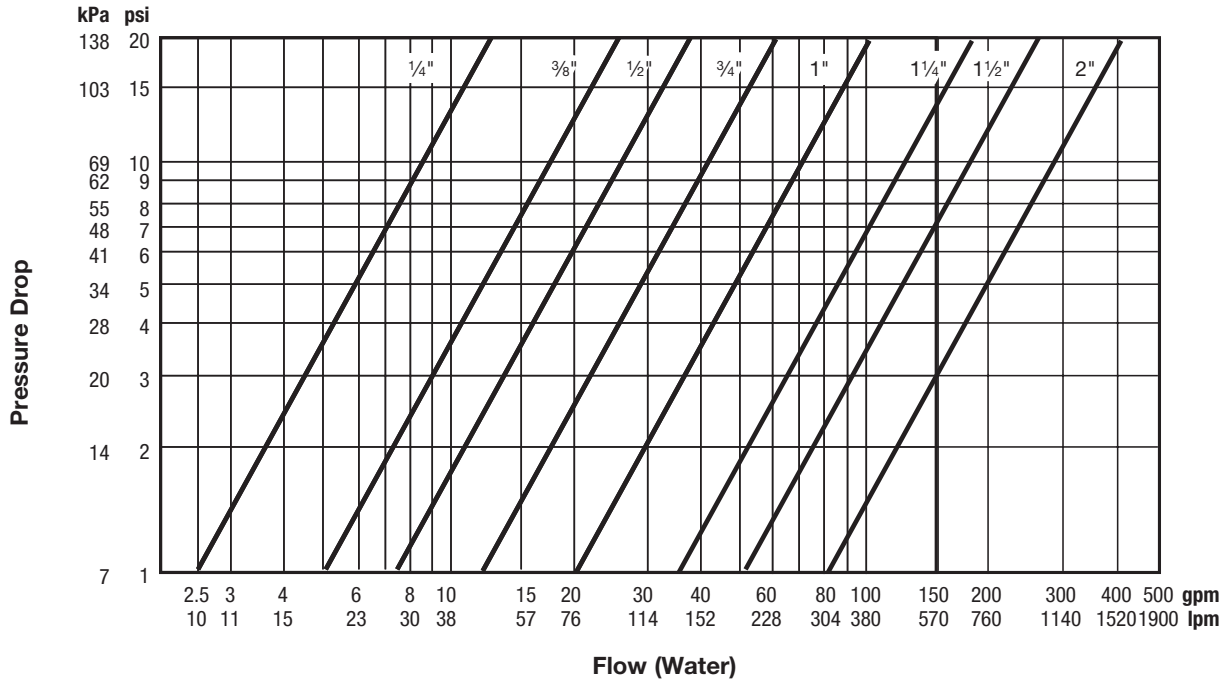
Dimensions – Weights

SIZE	DIMENSIONS				WEIGHT	
	A		B			
in.	*in.*	*mm*	*in.*	*mm*	*lbs.*	*kg*
¼	2⅛	54	1¼	32	.22	.1
⅜	2⅛	54	1¼	32	.5	.2
½	2⅛	54	1¼	32	.5	.2
¾	2½	64	1½	38	.75	.3
1	3⅛	79	2	50	1.38	.6
1¼	3¾	95	2½	64	2.13	1.0
1½	4	102	2¾	70	3.0	1.4
2	4½	114	3½	89	4.38	2.0

Series LF600



Pressure Drop vs. Flow



USA: T: (978) 689-6066 • F: (978) 975-8350 • Watts.com
Canada: T: (905) 332-4090 • F: (905) 332-7068 • Watts.ca
Latin America: T: (52) 81-1001-8600 • Watts.com

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THIS SPACE FOR DESIGNER/ENGINEER APPROVAL		
Job/Customer _____	Date _____	Contractor _____
Model Specified _____	Qty _____	Approved By _____
Designer/Engineer _____	Date _____	Contractor's PO# _____
Submitted by _____	Date _____	Other _____

4141 Series

Full Port Forged Brass Uni-Flange Ball Valves w/ Detachable Rotating Flange & Multi-Function Hi-Flow Hose Drain Adjustable Packing Gland, Nuts & Bolts IPS x Rotating Flange 600 WOG - ISO 9001

The ISOLATOR UNI-FLANGE BALL VALVE®

Lead free products are certified to NSF/ANSI 61 & NSF/ANSI 372

STANDARD BRASS ITEM #	LEAD FREE ITEM #	SIZE	CTN	CASE (Lead Free QTY)	A	B	C	D	E	F	G	H	I	J
41413	41413W	3/4"	2	20	3/4	2 3/4	2 3/8	2 1/2	3/8	1/2	1	2 11/16	4 3/16	2 3/4
41414	41414W	1"	2	20	1	2 15/16	2 5/8	2 1/2	3/8	1/2	1 1/4	2 11/16	4 3/16	2 3/4
41415	41415W	1 1/4"	2	20 (10)	1 1/4	3 5/16	3 3/16	3 3/16	3/8	1/2	1 9/16	2 11/16	4 3/16	3 1/4
41416	41416W	1 1/2"	2	10	1 1/2	4	3 3/8	3 13/16	3/8	1/2	1 15/16	2 11/16	4 3/16	3 1/2
HV MODELS FIT BOTH STANDARD & HIGH VELOCITY PUMPS														
41413HV	41413WHV	3/4"	2	20	3/4	2 3/4	2 3/8	2 1/2	3/8	5/8	1	2 11/16	4 3/16	2 3/4
41414HV	41414WHV	1"	2	20	1	2 15/16	2 5/8	2 1/2	3/8	5/8	1 1/4	2 11/16	4 3/16	2 3/4
41415HV	41415WHV	1 1/4"	2	20 (10)	1 1/4	3 5/16	3 3/16	3 3/16	3/8	5/8	1 9/16	2 11/16	4 3/16	3 1/4
41416HV	41416WHV	1 1/2"	2	10	1 1/2	4	3 3/8	3 13/16	3/8	5/8	1 15/16	2 11/16	4 3/16	3 1/2



PATENTED TECHNOLOGY

NO.	DESCRIPTION	MATERIAL
1	FLANGED BODY	BRASS
2	END CAP	BRASS
3	SEATS	PTFE
4	BALL	BRASS HCP
5	STEM	BRASS
6	STEM SEAL	PTFE
7	PACKING GLAND	BRASS
8	HANDLE	STEEL CP
9	HANDLE NUT	STAINLESS STEEL
10	HANDLE JACKET	VINYL
11	DRAIN VALVE SEATS	PTFE
12	DRAIN VALVE BALL	BRASS HCP
13	DRAIN VALVE STEM	BRASS
14	DRAIN VALVE STEM SEAL	PTFE
15	DRAIN VALVE HANDLE	ENAMEL COATED ALUMINUM
16	DRAIN VALVE HANDLE SCREW	BRASS
17	DRAIN VALVE CAP, WASHER & STRAP	BRASS W/ EPDM WASHER &STRAP
18	ROTATING FLANGE	BRASS
19	ROTATING FLANGE RING	STAINLESS STEEL
20	FLANGE BOLTS & NUTS	STEEL ZP

TEMP °F	PSI
100	600
150	490
200	470
250	439
300	411
350	294

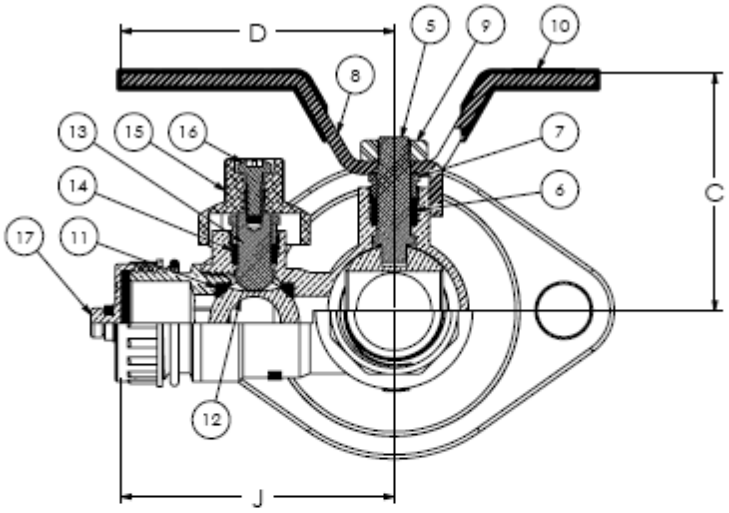
Webstone VALVE INNOVATION

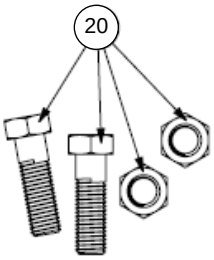
Quality and Commitment Since 1954

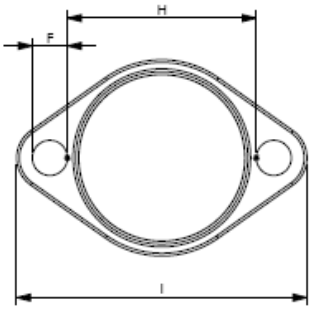
www.webstonevalves.com · P: (800) 225-9529 · F: (800) 336-5133

Webstone product specifications in U.S. customary units are approximate and are provided for reference only. Webstone reserves the right to change or modify product design, construction, specifications or materials without prior notice and without incurring any obligation to make such changes and modifications on Webstone products previously or subsequently sold.

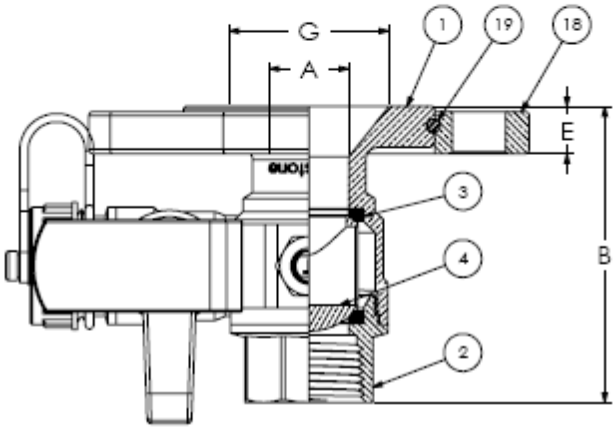
THIS SPACE FOR DESIGNER/ENGINEER APPROVAL		
Job/Customer _____	Date _____	Contractor _____
Model Specified _____	Qty _____	Approved By _____
Designer/Engineer _____	Date _____	Contractor's PO# _____
Submitted by _____	Date _____	Other _____

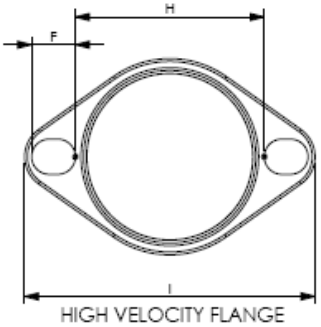






REGULAR FLANGE





HIGH VELOCITY FLANGE

Specifications: Designed for residential, commercial or industrial use with water or a glycol mixture. This approved Webstone valve is actuated by a blowout proof stem and features an adjustable packing gland. Flange features a conical inlet to minimize turbulence. The rotating flange is secured by a snug-fit snap-ring that provides greater control over positioning during installation. Multi-directional main valve allows for draining from either side of the pump. Threaded ends comply with ANSI B1.20.1.

Webstone product specifications in U.S. customary units are approximate and are provided for reference only. Webstone reserves the right to change or modify product design, construction, specifications or materials without prior notice and without incurring any obligation to make such changes and modifications on Webstone products previously or subsequently sold.

WIEGMANN

48 inH x 38 inW x 12 inD Metallic Enclosure, Silver, Knockouts: No, 1/4 Turn Latch Closure Method



Item #**487L29** Mfr. Model # **N412483812CDSS**

UNSPSC #**39121301** Catalog Page #**N/A**

Country of Origin USA. Country of Origin is subject to change.

Technical Specs

Item - Electrical Enclosure	Enclosure
Enclosure NEMA Rating	12, 3R, 4, 4X
Metallic / Non-Metallic	Metallic
Material of Enclosure	304 Stainless Steel
Nominal Enclosure Depth	12 in
Nominal Enclosure Height	48 in
Nominal Enclosure Width	38 in
Enclosure Cover Type	Hinged
Solid / Clear Cover	Solid
Closure Method	1/4 Turn Latch

Finish	Unfinished
Color	Silver
Depth	12.0 in
Enclosure Cover Features	Latch with 2 or 3 Internal Locking Points
Features	Mounting Holes, Poured in Place Gasket, Turn Semi-Flush Latches
Gasket	Seamless Foam-In-Place
Height	48.0 in
Interior Panel	Mfr. No. NP4836C, NP4836CG
Metal Gauge	14 ga
Mounting	Wall
Series	Ultimate

Your Price

$4,980.24 / each

This item requires special shipping, additional charges may apply.

Qty 1

Add to Cart

Setup Auto Reorder

Shipping Pickup

Ships from supplier. Expected to arrive by end of **Nov, 2021**.

Ship to **60601** | Change

Shipping Weight **164 lbs**

Ship Availability Terms

Add to List

Chat with an Agent

Knockouts	No
Usable Opening Depth	12.0 in
Width	38.0 in

Standards	cULus

Chat with an Agent

Glycols

Freez-Kontr'l® 95/5



INHIBITED PROPYLENE GLYCOL HEAT TRANSFER FLUID AND ANTI-FREEZE

- Formulated for chilled water, hydronic and other closed systems.
- Concentrated 95% propylene glycol formula provides optimum freeze and burst protection.
- Fully inhibited to prevent corrosion, non flammable.
- Low in acute oral toxicity. The ingredients used in its manufacture are GRAS (Generally Recognized as Safe), under Title 21, Part 182 of the US Code of Federal Regulation, where accidental or incidental contact with potable water could occur.

Application

Many commercial and industrial water systems, particularly closed systems, are required to operate while being exposed to varying extremes in temperature. These extremes may approach the freezing point of the water, making it necessary to suppress this freezing point in order to protect the system from freezing or bursting pipes. In other applications, it is necessary for the water to operate at temperatures below its freezing point (thermal storage, ice banks, etc.) or above its boiling point. As a result, suppression of the freezing point or raising of the boiling point becomes a matter of system design.

Description

Freez-Kontr'l 95/5 is made with propylene glycol, corrosion inhibitor and deionized water. It is formulated as a premixed or ready-to-use coolant for medium temperature secondary refrigeration systems, providing freeze protection to +2°F. The product provides the added advantage to be used direct from the drum without any on-site dilution steps to provide the required freeze protection and optimized corrosion inhibition.

Packaging

5 gallon pail: **4188-06**
55 gallon drum: **4188-03**
275 gallon tote: **4188-50**

Dilution Chart

Percent Volume of Freez-Kontr'l 95/5	Freeze Protection	Burst Protection
100%	Below -60°F	-100°F
75%	Below -60°F	-100°F
60%	-51°F	-100°F
50%	-24°F	-95°F
40%	-3°F	-62°F
30%	+10°F	-19°F

Read and understand the product's label and Safety Data Sheet ("SDS") for precautionary and first aid information. The SDS is available on the Nu-Calgon website at www.nucalgon.com.

HIGH TEMPERATURE FLOW METER

High Temperature Flow Meter enables flow monitoring of barrel heating fluids, thermal transfer fluids such as Sylltherm® coolant flows, hydraulic circuits and sub-circuits.



TECHNICAL SPECIFICATIONS

Measuring Accuracy
±2.0% of full scale

Repeatability
±1% of full scale

Flow Measuring Range
0.1–150 GPM (0.4–560 LPM)

Maximum Operating Pressure[1]
Liquids
Aluminum and brass meters: 3500 PSIG (240 Bar)
Stainless steel meters: 6000 PSIG (410 Bar)

Air/Gas
Aluminum and brass meters: 600 PSIG (40 Bar)
Stainless steel meters: 1000 PSIG (69 Bar)

Maximum Operating Temperature
H-Series 400°F (204°C)
J-Series 600°F (315°C)

Standard Calibration Fluids
Oil meters: DTE 25® @ 110°F (43°C), 0.873 sg
Water meters: water @ 70°F (21°C), 1.0 sg
Air meters: air @ 70°F (21°C), 1.0 sg & 100 PSIG (6.8 bar)

Filtration Requirements
74 micron filter or 200 mesh screen minimum

Viscosity
Standard viscosities up to 110 cSt. For viscosities between 110 to 430 cSt contact factory.

[1]Note: See Temperature/Pressure De-rating Chart on back. DTE 25 is a registered trademark of Exxon Mobil.

MATERIALS OF CONSTRUCTION (NON-WETTED COMPONENTS)

	Aluminum	Brass	Stainless Steel
Window Tube	Pyrex®	Pyrex®	Pyrex®
Window Seals	PTFE	PTFE	PTFE

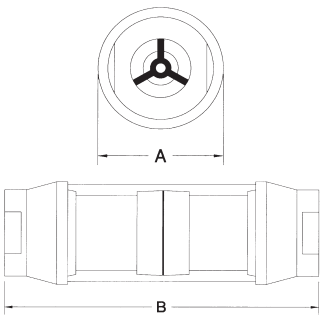
Pyrex is a registered trademark of Corning Incorporated.

MATERIALS OF CONSTRUCTION (WETTED COMPONENTS)

	Aluminum	Brass	Stainless Steel
Casing and End Ports	Anodized Aluminum	Brass	Stainless Steel
Seals H-Series (400°F) J-Series (600°F)	 FKM w/ PTFE backup FFKM w/ PTFE backup	 FKM w/ PTFE backup FFKM w/ PTFE backup	 FKM w/ PTFE backup FFKM w/ PTFE backup
Transfer Magnet	PTFE coated Alnico	PTFE coated Alnico	PTFE coated Alnico
All other internal parts	Stainless Steel	Stainless Steel	Stainless Steel

MECHANICAL - SIZE CODE

DIM	Series 3	Series 4	Series 5	Series 5 (2" port only)
A	1-7/8" (48mm)	2-3/8" (60mm)	3-1/2" (90mm)	3-1/2" (90mm)
B	6-9/16" (167 mm)	7-5/32" (182mm)	10-1/8" (258mm)	12-5/8" (322mm)



BENEFITS

Choice of Materials
Select from aluminum, brass or stainless steel to meet system and media compatibility requirements.

Unrestricted Mounting
Allows for horizontal, vertical or inverted installation and does not require straight plumbing on inlet or outlet.

Multiple Ports Available
Standard selection of NPT, SAE and BSPP ports reduces the amount of adapters required for installation.

Bi-Directional and Reverse Flow Option Offered
High temperature monitors are also available in bidirectional and reverse flow versions. Contact the factory for more information.

AW-LAKE
PROCESS FLOW MEASUREMENT

2440 W. Corporate Preserve Dr. #600, Oak Creek, WI 53154 | www.aw-lake.com

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HIGH TEMPERATURE FLOW METERS

High Temperature Flow Meter enables flow monitoring of barrel heating fluids, thermal transfer fluids such as Syltherm® coolant flows, hydraulic circuits and sub-circuits.

PART NUMBER GUIDE

☐☐☐ — ☐☐☐ — ☐☐☐☐ — ☐☐☐☐

METER STYLE

400°F In-line =	H
600°F In-line =	J

PORT SIZE RANGE

1/4" - 1/2" =	3
3/4" - 1" =	4
1-1/4 - 2" =	5

MATERIAL

Aluminum =	A
Brass =	B
Stainless Steel =	S

MAX. PRESSURE RATING

600 psig (air/gas, aluminum & brass) =	4
1000 psig (air/gas, stainless steel) =	5
3500 psig (liquids, aluminum & brass) =	6
6000 psig (liquids, stainless steel) =	7

FLUID MEDIA

Air & Gases =	A
Oil & 0.873 specific gravity =	H
Water & 1.0 specific gravity =	W

Note: For special scales consult the factory.

PORTING/THREAD TYPE

(all female)	Size	
1/4" NPTF, dry seal	3 only	S
3/8" NPTF, dry seal	3 only	A
1/2" NPTF, dry seal	3 only	B
3/4" NPTF, dry seal	4 only	C
1" NPTF, dry seal	4 only	D
#6 SAE, O-ring seal	3 only	E
#8 SAE, O-ring seal	3 only	F
#10 SAE, O-ring seal	3 only	G
#12 SAE, O-ring seal	4 only	H
#16 SAE, O-ring seal	4 only	J
1-1/4" NPTF, dry seal	5 only	K
1-1/2" NPTF, dry seal	5 only	L
2" NPTF, dry seal	5 only	M
#20 SAE, O-ring seal	5 only	N
#24 SAE, O-ring seal	5 only	P
#32 SAE, O-ring seal	5 only	Q
1/4" BSPP	3 only	&
3/8" BSPP	3 only	R
1/2" BSPP	3 only	T
3/4" BSPP	4 only	U
1" BSPP	4 only	V
1-1/4" BSPP	5 only	W
1-1/2" BSPP	5 only	Y
2" BSPP	5 only	X

Note: SAE porting not available in Brass. Consult factory for SAE brass monitor requirements.

SPECIAL SCALE/CUSTOM PRODUCT

OPTIONAL FLOW DIRECTIONS

Standard Flow, Uni-Directional =	☐☐
Reverse Flow =	RF
Bi-Directional Flow =	BI

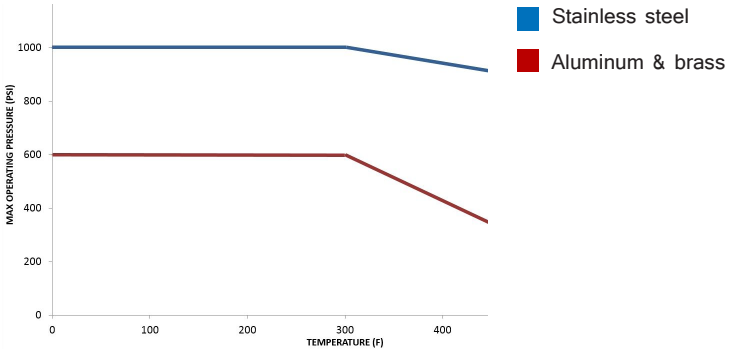
Note: See bi-directional datasheet for available bi-directional ranges.

FLOW RANGES

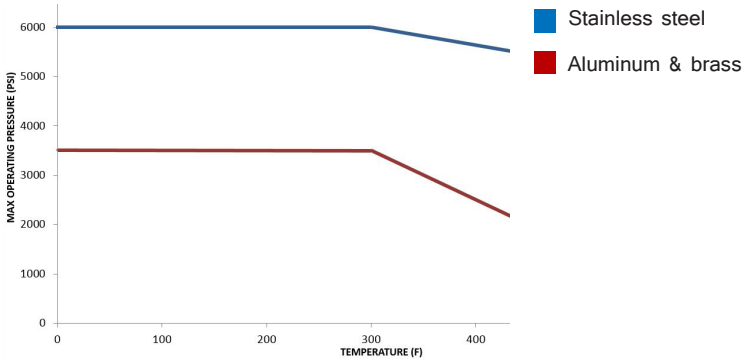
Liquid	Air	Size	
0.1-1.0 GPM	2-12 SCFM	3 only	01
0.2-2.0 GPM	4-23 SCFM	3 & 4	02
0.5-5.0 GPM	5-50 SCFM	3 & 4	05
1-10 GPM	10-100 SCFM	3 & 4	10
1-15 GPM	25-150 SCFM	3 & 4	15
2-20 GPM	20-215 SCFM	4 only	20
2-25 GPM	20-250 SCFM	4 & 5	25
3-30 GPM	30-330 SCFM	4 only	30
4-40 GPM	30-400 SCFM	4 only	40
5-50 GPM	40-500 SCFM	4 only	50
5-50 GPM	30-470 SCFM	5 only	50
8-75 GPM	30-750 SCFM	5 only	75
10-100 GPM	150-900 SCFM	5 only	88
20-150 GPM	150-1300 SCFM	5 only	99

TEMPERATURE DE-RATING FOR ALUMINUM & BRASS METERS

AIR & GAS



LIQUID



Products may be subject to change without notice - Contact factory for the most up-to-date product information.

AW-LAKE PROCESS FLOW MEASUREMENT

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Arcadis Logo BW.PNG

AS-BUILT DRAWINGS FOR

THERMAL IN-SITU SUSTAINABLE REMEDIATION (TISR®) SYSTEM



IMAGE: BING MAPS, © 2017 MICROSOFT CORPORATION

LOCATION MAP

0 2 4
MILES



VANDENBERG SPACE FORCE BASE
SITE SD015
LOMPOC, CALIFORNIA

DATE ISSUED / DATE REVISED

JANUARY 2022 / SEPTEMBER 2024

AS-BUILT DESIGN

ARCADIS

ARCADIS U.S., INC.

KEY CONTACTS:

PROJECT SITE:
VANDENBERG SPACE FORCE BASE
EL RANCHO ROAD AND ASTRAL ROAD/ASTRO ROAD
LOMPOC, CALIFORNIA 93436

ENGINEER:
ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401
TELEPHONE: 913.494.3799
CONTACT: BLAIR KINSER, P.E.

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4	FLITEWAY WIRING SCHEMATIC

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SCOPE OF WORK

1. THE CONTRACTOR SHALL MOBILIZE TO THE SITE AND PREPARE EQUIPMENT STORAGE AREAS AND MATERIALS LAYDOWN YARD. THE CONTRACTOR IS RESPONSIBLE FOR THE SECURITY OF THEIR EQUIPMENT AND ANY MATERIALS PURCHASED FOR THE PROJECT.
2. THE CONTRACTOR SHALL INSTALL NEW UNDERGROUND PIPING AND ELECTRICAL CONDUIT/CONDUCTORS FROM THE POWER DROP METER TO THE PUMPING STATION. ALSO, UNDERGROUND CONDUITS AND WIRING SHALL BE COMPLETED FOR ALL POWER AND CONTROL WIRING TO FOR THE PUMPING STATION. ADDITIONAL DETAILS AND SPECIFICATIONS FOR THE ELECTRICAL WORK ARE PRESENTED IN THE ELECTRICAL DRAWINGS.
3. EIGHT BOREHOLE HEAT EXCHANGERS (BHEs), TWELVE DISTRIBUTED TEMPERATURE SENSING POINTS (DTS), AND TWO SOIL VAPOR MONITORING POINTS (SVP) WILL BE INSTALLED BY OTHERS.
4. THE CONTRACTOR SHALL COMPLETE THE REMEDIATION SYSTEM SO THAT IT IS FULLY FUNCTIONAL. THIS INCLUDES ALL PIPING AND WIRING AND ANY NECESSARY CONNECTIONS. THE CONTRACTOR SHALL PARTICIPATE IN THE COMMISSIONING AND TESTING OF THE UNIT TO ASSURE THAT THE SYSTEM IS FUNCTIONING PER THE DESIGN AND THERE ARE NO LEAKS OR OPERATIONAL ISSUES.
5. THE CONTRACTOR SHALL KEEP THE WORK SITE CLEAN ON A DAILY BASIS AND ALL DEBRIS SHALL BE REMOVED AND THE SITE LEFT IN CLEAN CONDITION AFTER THE COMPLETION OF WORK.
6. ARCADIS WILL PROVIDE OVERSIGHT OF CONSTRUCTION ACTIVITIES. A FIELD ENGINEER/SUPERVISOR WILL BE DEFINED AT A LATER TIME. THE CONTRACTOR WILL ABIDE BY ARCADIS DIRECTION AND THE CONTRACTOR IS REQUIRED TO COMPLETE THE PROJECT TO THE SATISFACTION OF ARCADIS.

SITE HEALTH AND SAFETY

1. CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE LOCAL, STATE, AND FEDERAL HEALTH AND SAFETY CODES ALWAYS.
2. THE CONTRACTOR AND SUB-CONTRACTOR PERSONNEL ARE REQUIRED TO HAVE 40-HOUR OSHA HAZWOPER TRAINING AND 8-HOUR REFRESHER TRAINING, AND ALL EMPLOYEES MUST BE CURRENT IN THEIR CERTIFICATIONS. SOME SUBCONTRACTORS THAT DO NOT CONTACT IMPACTED SOILS OR GROUNDWATER MAY BE EXEMPT FROM THIS REQUIREMENT
3. THE CONTRACTOR SHALL PROVIDE A SITE-SPECIFIC HEALTH AND SAFETY PLAN (HASP) AND COMPLY WITH ALL ARCADIS AND/OR ARCADIS CLIENT HEALTH AND SAFETY GUIDELINES.
4. THE CONTAMINANTS OF CONCERN ARE CHLORINATED VOLATILE ORGANIC COMPOUNDS. ADDITIONAL DATA ON THESE COMPOUNDS CAN BE PROVIDED BY ARCADIS.
5. IT IS THE CONTRACTOR'S RESPONSIBILITY FOR EDUCATING ITS SUPERVISORS, EMPLOYEES, AND SUB-CONTRACTORS OF ALL HEALTH AND SAFETY REQUIREMENTS. CONTRACTOR IS RESPONSIBLE FOR WORKER SAFETY.
6. AT A MINIMUM, ALL ONSITE CONTRACTOR PERSONNEL SHALL BE IN LEVEL D PPE WHICH IS DEFINED AS HARD HAT, STEEL TOE BOOTS, AND SAFETY GLASSES.
7. ARCADIS OVERSIGHT PERSONNEL WILL ALSO BE ONSITE TO ASSURE THAT THE WORK IS BEING COMPLETED IN A SAFE MANNER.

PIPING AND PIPING APPURTENANCE MATERIALS

1. PIPING MATERIALS AND PIPING APPURTENANCES ARE IDENTIFIED ON THE CONSTRUCTION DRAWINGS. ADDITIONAL SPECIFICATIONS ARE PROVIDED IN THIS SECTION. IF THERE ARE ANY DISCREPANCIES BETWEEN THESE SPECIFICATIONS AND THE CONSTRUCTION DRAWINGS, THE ENGINEER SHALL BE CONSULTED TO RESOLVE THE DISCREPANCY.
2. NEW PIPING MATERIAL SHALL BE SCHEDULE 40 HDPE, STAINLESS STEEL AND COPPER AS SHOWN ON THE CONSTRUCTION DRAWINGS.
3. ALL HDPE GLUED CONNECTIONS SHALL USE WELD-ON P-70 PRIMER AND 711 PVC CEMENT PER THE MANUFACTURER'S SPECIFICATIONS.
4. ALL STAINLESS STEEL FLEXIBLE TUBING CONNECTIONS MUST BE MADE PER MANUFACTURES RECOMMENDATIONS TO PREVENT LEAKAGE.
5. ALL VALVES SHALL HAVE A MINIMUM RATING OF 150 PSI AND SHALL HAVE TEFLON SEALS UNLESS OTHERWISE SPECIFIED.
6. ALL OTHER MATERIALS NOT SPECIFICALLY DESCRIBED BUT REQUIRED FOR A COMPLETE AND PROPER INSTALLATION OF THE WORK OF THIS SECTION, SHALL BE NEW, FIRST QUALITY OF THEIR RESPECTIVE KIND, AND AS SELECTED BY CONTRACTOR SUBJECT TO THE APPROVAL OF ARCADIS.
7. PIPE AND PIPING APPURTENANCES THAT ARE ONSITE SHALL BE PROPERLY STORED TO PREVENT DAMAGE OR THEFT. ANY DAMAGED OR STOLEN MATERIALS WILL BE REPLACED BY THE CONTRACTOR.

PIPING INSTALLATION

1. THE PIPING INSTALLERS PROVIDED BY THE CONTRACTOR SHALL BE THOROUGHLY TRAINED AND
2. EXPERIENCED IN THE NECESSARY CRAFTS AND FAMILIAR WITH THE SPECIFICATIONS PROVIDED HERE.
3. CONSTRUCTION DRAWINGS SHOW GENERAL ARRANGEMENT, DIRECTION, AND SIZE OF PIPES AND ARE NOT INTENDED TO SHOW EVERY OFFSET, VALVE, AND FITTING, OR EVERY STRUCTURAL DIFFICULTY THAT MAY BE ENCOUNTERED. INSTALL THE PIPING AND APPURTENANCES TO SUIT. VERIFY ALL MEASUREMENTS AT THE SITE. INSTALL ALL PIPING IN STRICT ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND IN ACCORDANCE WITH ALL APPLICABLE STATE AND LOCAL CODES.
4. THE CONTRACTOR SHALL PROVIDE ADEQUATE PIPE SUPPORTS FOR ALL NECESSARY PIPES.
5. PRESSURE GAUGES, SAMPLE PORTS, AND OTHER INSTRUMENTATION SHALL BE INSTALLED IN LOCATIONS THAT ARE EASILY READABLE AND ACCESSIBLE FOR MAINTENANCE.
6. THE EXACT LOCATIONS AND TRENCHING APPURTENANCES SHALL BE DETERMINED IN THE FIELD DURING CONSTRUCTION AND DISCUSSED WITH THE ENGINEER'S REPRESENTATIVE.
7. ALL ABOVE-GROUND PIPING SHALL BE PERMANENTLY LABELED WITH DIRECTIONAL FLOW ARROWS AND LINE CONTENTS SHALL BE IDENTIFIED.
8. ALL 90-DEGREE BENDS INSTALLED UNDERGROUND OR WHERE OTHERWISE INDICATED ON THE CONSTRUCTION DRAWINGS SHALL BE CONSTRUCTED USING LONG-SWEEP ELBOWS TO ALLOW FOR CLEANING THE LINES IN THE FUTURE.
9. CONTRACTOR SHALL COMPLY WITH LOCAL PLUMBING PERMITS REQUIRED FOR THIS WORK AND WORK SHALL BE COMPLETED IN ACCORDANCE WITH THE CALIFORNIA PLUMBING CODE.

PRESSURE TESTING

1. THE CONTRACTOR SHALL COMPLETE PRESSURE TESTS FOR ALL PIPING. ARCADIS SHALL BE PRESENT DURING THE TESTS TO OBSERVE THE TESTS PROCEDURES AND VERIFY THE RESULTS OF THE TESTS. THE CONTRACTOR SHALL PROVIDE THE TEST FORMS TO DOCUMENT THE TEST CONDITIONS AND THE FORMS MUST BE SIGNED BY THE ENGINEER'S REPRESENTATIVE AT THE TIME OF THE TEST.
2. HYDROSTATIC TESTS (WITH WATER) FOR ALL WATER PIPING SHALL BE CONDUCTED USING CLEAN POTABLE WATER. PIPE SHALL BE CAPPED BEFORE TESTING AND EQUIPMENT SUCH AS FLOW METERS SHOULD BE ISOLATED TO PREVENT DAMAGE. THE PIPING SYSTEM MAY BE TESTED IN SECTIONS WITH APPROVAL FROM ARCADIS. HYDROSTATIC TESTS WILL BE COMPLETED AT A PRESSURE OF 50 PSI. ONCE THE TEST PRESSURE HAS BEEN ACHIEVED, THE TEST WILL LAST FOR A MINIMUM OF 1 HOUR OR AS MUCH TIME AS MAY BE REQUIRED TO PROPERLY INSPECT ALL JOINTS AND CONNECTIONS. HYDROSTATIC TEST ACCEPTANCE SHALL BE +/- 5% OF THE PRESSURE RATING DEVIATIONS REGARDING TEST PRESSURE AND TIMES SHALL REQUIRE APPROVALS BY ARCADIS.
3. DURING THE PIPE TESTS, THE PIPING SYSTEM SHALL BE INSPECTED FOR LEAKS AND SHALL BE DRIP TIGHT WITH NO SIGNS OF LEAKAGE.
4. IF THE TEST RESULTS ARE NOT CONSIDERED TO BE ACCEPTABLE BY ARCADIS, THEN THE CONTRACTOR SHALL IDENTIFY AND REPAIR THE LEAKS. THE PIPE MUST BE RE-TESTED AFTER THE REPAIRS UNTIL ACCEPTABLE TEST RESULTS ARE ACHIEVED.
5. WRITTEN RECORDS OF THE PIPE TEST SHALL BE MADE BY THE CONTRACTOR OF EACH PIPE SEGMENT AND SUBMITTED TO ARCADIS. THE TEST RECORDS SHALL INCLUDE THE FOLLOWING:
   a. DATE OF TEST
   b. PIPE SEGMENT TESTED
   c. TEST PRESSURE, AIR TEMPERATURE AND TIME BEFORE AND AFTER TEST
   d. REMARKS (INCLUDING DESCRIPTION OF TEST RESULTS, LEAKS, AND REPAIRS)
   e. SIGNATURE OF THE CONTRACTOR AND ARCADIS.

EXCAVATION/TRENCHING

1. PRIOR TO BEGINNING ANY EXCAVATION WORK, CONTRACTOR SHALL FORMALLY CONTACT THE REGIONAL UNDERGROUND UTILITY NOTIFICATION SERVICE SUCH AS UNDERGROUND SERVICE ALERT, AND OBTAIN ALL NECESSARY CLEARANCES BEFORE BREAKING GROUND. CONTRACTOR SHALL REVIEW AVAILABLE UTILITY MAPS AND VERIFY THE LOCATIONS OF ALL UTILITIES. ARCADIS WILL HIRE A THIRD-PARTY SERVICE PROVIDER TO CONDUCT A UTILITY SURVEY USING GROUND PENETRATING RADAR (GPR) AND METAL DETECTION AT A MINIMUM. ANY IDENTIFIED ANOMALIES WILL BE DETECTED WITH MARKED WITH ORANGE PAINT ON THE SIDE OF TRENCH.
2. THE CONTRACTOR SHALL HAND EXCAVATE OR SOFT DIG ALL TRENCHES PROPOSED IN AREAS 30" ADJACENT TO UNDERGROUND UTILITIES. ALL UNCOVERED UTILITIES ARE TO BE FULLY EXPOSED AND SHALL BE SUPPORTED, BEDDED, AND BACKFILLED IN ACCORDANCE WITH THE UTILITY OWNER'S REQUIREMENTS AND SPECIFICATIONS. DAMAGE TO UNDERGROUND UTILITIES OR PIPELINES CAUSED BY THE CONTRACTOR SHALL BE REPAIRED AT THE EXPENSE OF THE CONTRACTOR.
3. IT IS EXPECTED THAT ALL TRENCHES WILL BE INSTALLED USING A BACKHOE OR BY SOFT DIG METHODS. IF OTHER TRENCHING METHOD IS USED, THE CONTRACTOR SHALL OBTAIN APPROVAL FROM ARCADIS.
4. EXCAVATED SOILS SHALL BE STOCKPILED WITHIN A BERMED-AREA INSIDE THE WORK ZONE. SOIL STOCKPILES SHALL BE PLACED ON 10-MIL PLASTIC VISQUEEN AND COVERED WITH A MINIMUM OF 6-MIL PLASTIC VISQUEEN TO PREVENT CONTACT WITH RAINWATER AND/OR PREVENT DUST GENERATION. EARTHEN MATERIALS SHALL NOT BE USED TO SECURE THE VISQUEEN TOP COVER.
5. PIPING SHALL BE LAID IN THE TRENCHES IN AN ORDERLY MANNER. SAND BEDDING WILL BE PLACED BELOW, AROUND, AND ABOVE ALL PIPING FOR COMPACTION AND TO PREVENT DAMAGE WHEN BACKFILLING. SAND BEDDING WILL BE REQUIRED AS ILLUSTRATED ON THE CONSTRUCTION DRAWINGS.
6. ALL PIPING SHALL BE BURIED AT LEAST 24 INCHES DEEP. MAGNETIC LOCATION TAPE SHALL BE INSTALLED ABOVE THE PIPING AND CONDUIT WHEN BACKFILLING.
7. FOR TRENCHES GREATER THAN 18" WIDE, TWO LINES OF TAPE SHALL BE PLACED WITH EACH LINE 4" FROM THE SIDES OF THE TRENCH.
8. EXCAVATED MATERIAL CAN BE USED FOR TRENCH BACKFILL IF SOILS ARE GRANULATED AND LOOSE MATERIAL (NO ROCKS). WHEN BACKFILLING, THE CONTRACTOR SHALL PROPERLY COMPACT THE SOILS IN 6-INCH LIFTS USING A VIBRATORY COMPACTOR.
9. TRENCHES SHALL BE BACKFILLED IN 8" LOOSE LIFTS TO A MINIMUM 90% OF A MAXIMUM DRY-DENSITY AND WITHIN 95% OF AN OPTIMAL MOISTURE CONTENT FORM A MOISTURE-DENSITY RELATION REPRESENTATIVE OF LAB COMPACTION TEST. OBTAIN A NEW MOISTURE-DENSITY CURVE UPON EACH VARIATION IN SOIL INDEX PROPERTIES.

WELL MONUMENT INSTALLATION

1. WELL MONUMENTS FOR THE BHEs, DTS LOCATIONS, MONITORING WELLS AND SVPs ARE DETAILED WITH THE CONSTRUCTION DRAWINGS.
2. ALL WELL MONUMENTS WILL BE INSTALLED TO SPECIFICATIONS BY OTHERS AND ARE NOT INCLUDED IN THE CONTRACTOR'S SCOPE OF WORK.

ELECTRICAL INSTALLATION

1. MORE COMPLETE AND DETAILED ELECTRICAL SCOPE AND SPECIFICATIONS (DRAWING E-1) ARE INCLUDED WITH THE ELECTRICAL DRAWINGS.
2. THE CONTRACTOR SHALL COMPLETE THE INSTALLATION OF THE ELECTRIC POWER FROM THE EXISTING FEED TO THE PUMPING STATION CONTROL PANEL.
3. THE CONTRACTOR SHALL COMPLETE POWER AND CONTROL WIRING TO THE PUMPING STATION.
4. THE CONTRACTOR'S ELECTRICAL INSTALLATION SHALL MEET THE NATIONAL ELECTRIC CODE (NEC) AND ANY OTHER APPLICABLE FEDERAL, STATE, AND LOCAL CODE.
5. A LOCAL ELECTRICAL PERMIT IS REQUIRED TO COMPLETE THE WORK FOR THIS PROJECT AND A LICENSED ELECTRICIAN.

EROSION AND SEDIMENTATION CONTROLS

1. CONTRACTOR SHALL INSTALL MEASURES TO DIVERT STORMWATER FLOW AROUND THE WORK AREA AND AWAY FROM OPEN EXCAVATIONS (E.G., TEMPORARY BERMS, CURBING, HAY BALES, OR SIMILAR METHODS) IN PAVED AREAS AS NECESSARY DURING CONSTRUCTION.
2. CONTRACTOR SHALL INSTALL SEDIMENT FILTERS IN STORM DRAINS LOCATED WITHIN OR ADJACENT TO TRENCHING WORK AREAS THAT RECEIVE SURFACE WATER RUNOFF FLOWS FROM THE WORK AREA.
3. CONTRACTOR SHALL CONTROL FUGITIVE DUST GENERATED DURING CONSTRUCTION AS NECESSARY BY APPLYING A LIGHT SPRAY OF WATER OR OTHER APPROVED DUST CONTROL MEASURES.
4. CONTRACTOR SHALL EMPLOY CONTROLS TO PREVENT CONSTRUCTION VEHICLES FROM TRACKING EXCAVATED SOIL OUT OF THE WORK AREA AND SHALL DESIGN THE WORK AREA LAYOUT TO LIMIT THE POTENTIAL FOR TRACKING OF SOIL OFF-SITE. THE CONTRACTOR SHALL ALSO EMPLOY GOOD HOUSEKEEPING PRACTICES DURING CONSTRUCTION. RESIDUAL EXCAVATED SOIL SHALL BE CLEANED FROM PAVED SURFACES TO THE EXTENT PRACTICAL, TO PREVENT THIS MATERIAL FROM BECOMING ENTRAINED IN SURFACE WATER RUNOFF.

CLEANING

1. A CLEAN WORK AREA SHALL BE MAINTAINED THROUGHOUT AND AT THE END OF EACH WORKING DAY AND AT THE COMPLETION OF THE PROJECT.
2. ALL CONSTRUCTION DEBRIS SHALL BE DISPOSED OF AFTER THE COMPLETION OF WORK, INCLUDING BUT NOT LIMITED TO RUBBLE, CONCRETE AND PIPE. THE DISPOSAL OF ALL CONSTRUCTION DEBRIS SHALL BE AT A LICENSED WASTE DISPOSAL/TREATMENT FACILITY.
3. THE CONTRACTOR IS RESPONSIBLE FOR THE DISPOSAL OF ALL EXCAVATED SOIL THAT IS NOT RE-USED FOR TRENCH BACKFILL. SOILS SHALL BE CHARACTERIZED AND TAKEN OFF-SITE FOR DISPOSAL AT A LICENSED WASTE DISPOSAL FACILITY.

FINAL INSPECTION

1. A FINAL INSPECTION WILL BE COMPLETED BY ARCADIS. THE CONTRACTOR SHALL RESOLVE AND/OR CORRECT ANY DEFICIENCIES THAT ARE NOTED BY ARCADIS.

SUBMITTALS

1. THE FOLLOWING SUBMITTALS NEED TO BE PROVIDED BY THE CONTRACTOR TO THE ENGINEER AT THE SCHEDULE INDICATED BELOW:
   a. SCHEDULE - THE CONTRACTOR SHALL PROVIDE A DETAILED CONSTRUCTION SCHEDULE TO THE ENGINEER WITHIN 10 DAYS OF A NOTICE TO PROCEED. THE SCHEDULE SHALL INCLUDE A DAILY BREAKDOWN OF WORK TASKS FOR EACH PROPOSED WORKWEEK.
   b. CONTRACTOR HEALTH AND SAFETY PLAN (HASP) - THE CONTRACTOR SHALL PROVIDE THEIR HASP TO THE ENGINEER 15 DAYS AFTER AWARD OF THE CONTRACT. THE ENGINEER SHALL PROVIDE ACCEPTANCE OF THE HASP PRIOR TO THE START OF ON-SITE WORK ACTIVITIES.
   c. EQUIPMENT - CONTRACTOR SHALL PROVIDE SUBMITTALS FOR THE ENGINEER FOR REVIEW FOR ANY MATERIALS OR EQUIPMENT SELECTED THAT ARE NOT SPECIFIED IN THE DESIGN DRAWINGS, OR FOR ANY ALTERNATE MATERIALS OR EQUIPMENT PROPOSED. EQUIPMENT AND MATERIAL SUBMITTALS SHALL BE PROVIDED TO THE ENGINEER AND APPROVED PRIOR TO CONTRACTOR ORDERING.
   d. RECORD DRAWINGS - THE CONTRACTOR SHALL PROVIDE COMPLETE RECORD DRAWINGS OF THE PROJECT WORK. RECORD DRAWINGS SHALL INCLUDE HAND-WRITTEN MARKUPS OF THE CONSTRUCTION DRAWINGS AS PREPARED BY THE ENGINEER. THE RECORD DRAWINGS MUST BE SUBMITTED TO THE ENGINEER WITHIN 5 DAYS AFTER CONSTRUCTION COMPLETION.
   e. PIPE TEST RECORDS - THE CONTRACTOR SHALL PROVIDE TEST RECORDS FOR ALL PIPE TESTING AS SPECIFIED ABOVE. THE PASSING PIPE TEST FORMS MUST BE SIGNED BY THE ENGINEER. THE TEST RECORDS MUST BE SUBMITTED TO THE ENGINEER WITHIN 24 HOURS OF CONSTRUCTION COMPLETION.
   f. THE CONTRACTOR SHALL PROVIDE TO THE CLIENT COPIES OF ALL WASTE MANIFESTS AND/OR CERTIFICATIONS OF RECLAMATION FOR ALL MEDIA (SOIL, CONSTRUCTION DEBRIS, ETC.) REQUIRING DISPOSAL. THESE MANIFESTS AND/OR CERTIFICATES SHALL BE SUBMITTED TO THE CLIENT PRIOR TO INVOICING.

XREFS:
TISR AS-BUILT DWG-X-TITLE

No.	Date	Revisions	By	Ckd
5	03/25/2025	AS-BUILTS	BK	JM
4	08/23/2024	100% DESIGN	BK	JM
3	08/02/2024	90% DESIGN	BK	JM
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Professional Engineer's Name
BLAIR KINSER
Professional Engineer's No.
88162
State: CA | Date Signed: | Project Mgr.: HV
Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

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SPECIFICATIONS

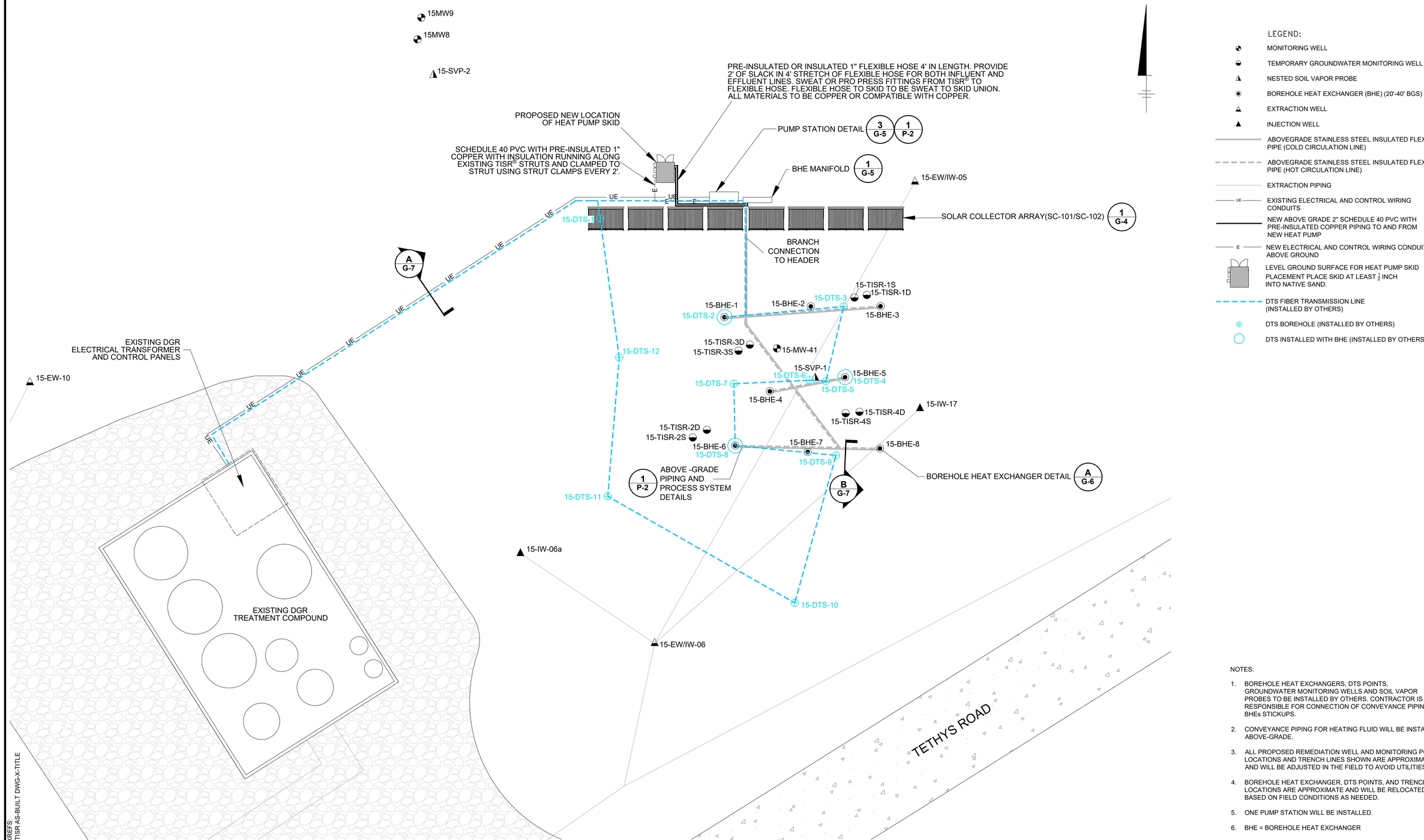
AS-BUILTS

ARCADIS Project No.
30027243

Date
SEPTEMBER 2024

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

G-2



XREFS:
TISR AS-BUILT DWG-X-TITLE

NOTES:

1. BOREHOLE HEAT EXCHANGERS, DTS POINTS, GROUNDWATER MONITORING WELLS AND SOIL VAPOR PROBES TO BE INSTALLED BY OTHERS. CONTRACTOR IS RESPONSIBLE FOR CONNECTION OF CONVEYANCE PIPING TO BHEs STICKUPS.
2. CONVEYANCE PIPING FOR HEATING FLUID WILL BE INSTALLED ABOVE-GRADE.
3. ALL PROPOSED REMEDIATION WELL AND MONITORING POINT LOCATIONS AND TRENCH LINES SHOWN ARE APPROXIMATE, AND WILL BE ADJUSTED IN THE FIELD TO AVOID UTILITIES.
4. BOREHOLE HEAT EXCHANGER, DTS POINTS, AND TRENCH LOCATIONS ARE APPROXIMATE AND WILL BE RELOCATED BASED ON FIELD CONDITIONS AS NEEDED.
5. ONE PUMP STATION WILL BE INSTALLED.
6. BHE = BOREHOLE HEAT EXCHANGER

0 10' 20'
GRAPHIC SCALE

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SD015 TISR® SITE PLAN MODIFICATION YEAR 4

AS-BUILTS

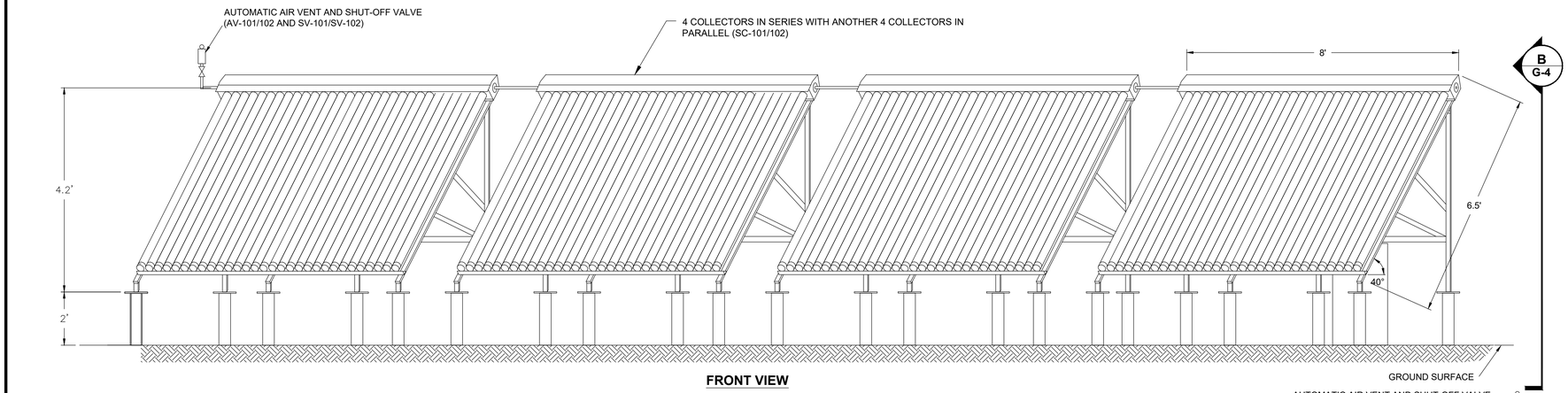
ARCADIS Project No.
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Date
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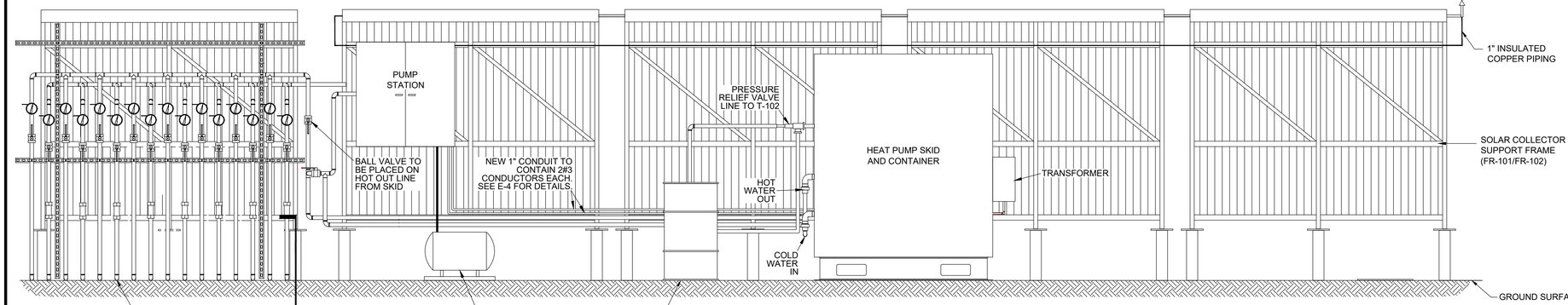
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G-3

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BY: HARRIS, JESS



FRONT VIEW



BACK VIEW

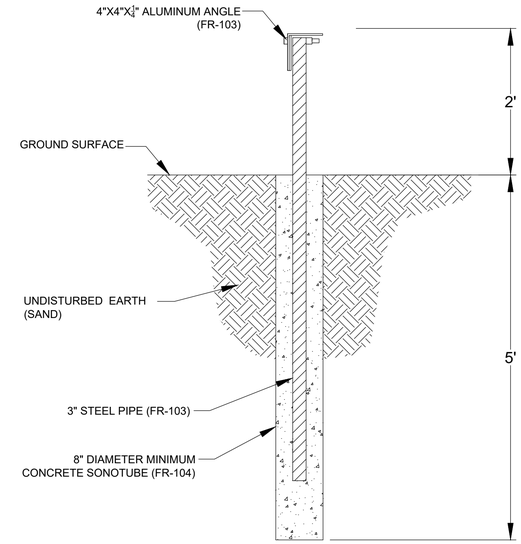
SOLAR TRANSECT DETAIL

1 / G-4

NOT TO SCALE

NOTES:

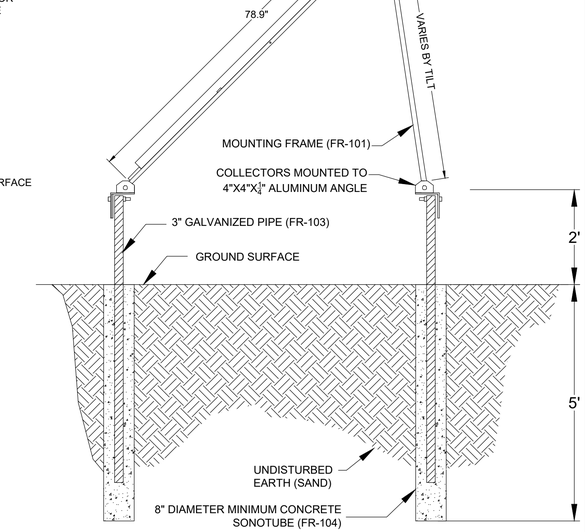
1. PUMP CONTROL, CIRCULATION PUMP, DATALOGGER, TELEMETRY MODEM ARE HOUSED IN THE CONTROL PANEL.
2. THE EXPANSION TANK AND CONTAINMENT DRUM WILL CONTAIN THE HEATING FLUID ONLY (50% FOOD-GRADE PROPYLENE GLYCOL AND 50% DEIONIZED WATER).



SUPPORT BASE ANCHORAGE DETAIL (TYP.)

A / G-4

NOT TO SCALE



SIDE VIEW DETAIL (TYP.)

B / G-4

NOT TO SCALE

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Professional Engineer's Name: **BLAIR KINSER**
Professional Engineer's No.: 88162

State	Date Signed	Project Mgr.
CA		HV

Designed by	Drawn by	Checked by
ARCADIS	JH	JM,WS,BK

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EQUIPMENT LAYOUT

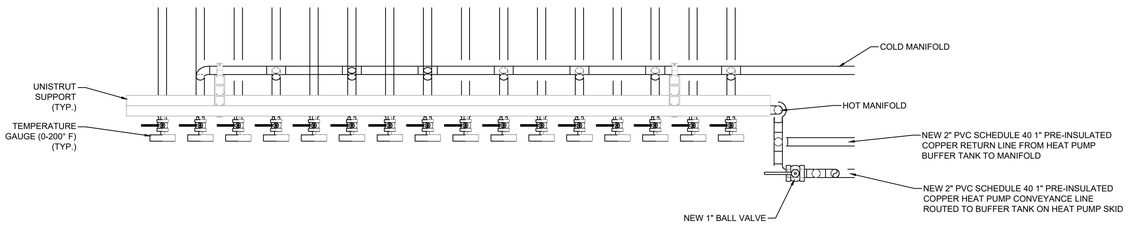
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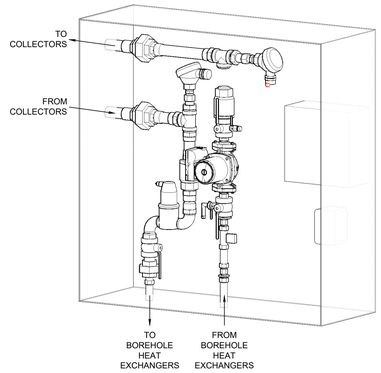
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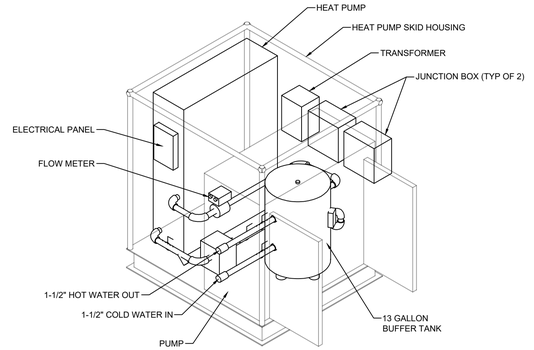
G-4





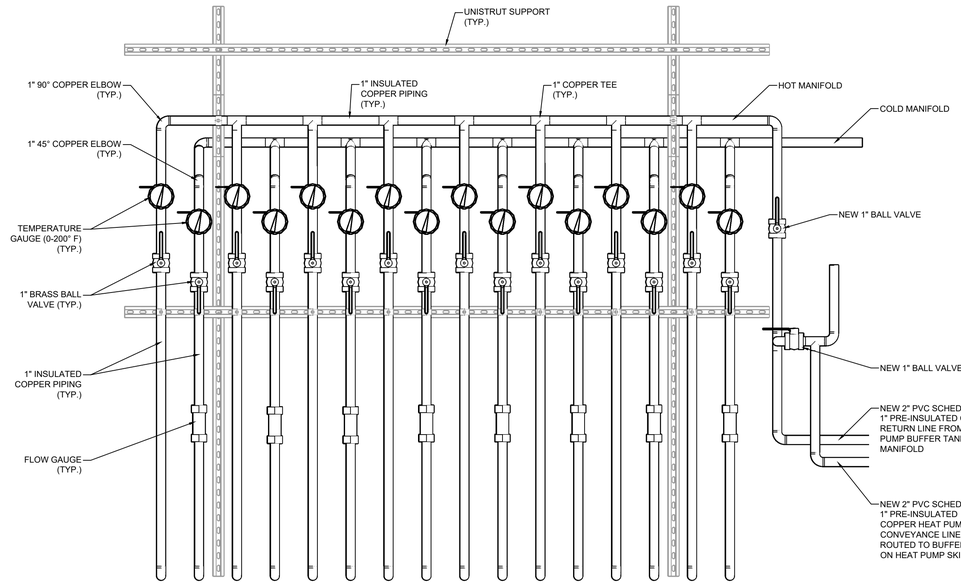
3 G-5 PUMPING STATION DETAILS

NOT TO SCALE



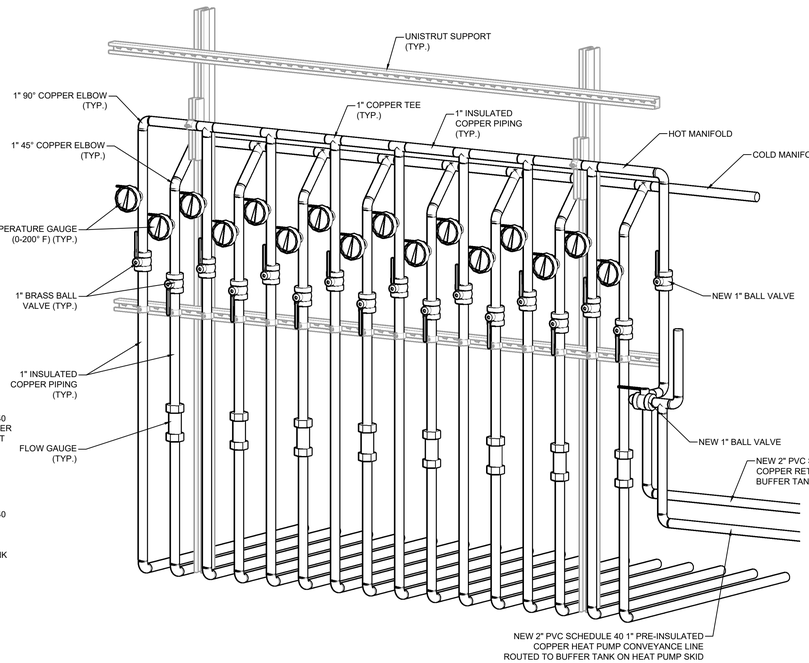
4 G-5 HEAT PUMP SKID DETAILS

NOT TO SCALE



1 G-5 MANIFOLD DETAILS

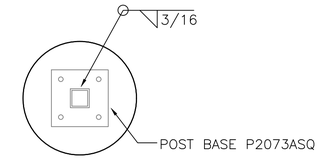
NOT TO SCALE



ISOMETRIC VIEW

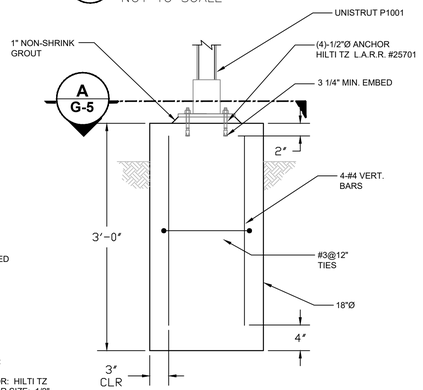
NOTES:

1. CONVEYANCE LINE TO BE FLEXIBLE STAINLESS STEEL ONE FOOT FROM THE MANIFOLD WITH 2 FEET OF SLACK.
2. PIPE AND FITTING INSULATION CONSIST OF 1" FIBERGLASS WITH ALUMINUM PROTECTIVE JACKETING. (INSULATION AND JACKETING NOT SHOWN FOR CLARITY)



A G-5 BASE PLATE SECTION

NOT TO SCALE



NOTES:

ANCHOR: HILTI TZ
ANCHOR SIZE: 1/2"
SPECIAL INSPECTION: YES
RATING BASIS: ESR-1817
SUBSTRATE: NORMAL WEIGHT CONCRETE
SUBSTRATE RATING: 4000 PSI

2 G-5 PIPE SUPPORT FOUNDATION DETAIL

NOT TO SCALE

XREFS:
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Professional Engineer's Name: **BLAIR KINSER**

Professional Engineer's No.: 88162

State	Date Signed	Project Mgr.
CA		HV
Designed by	Drawn by	Checked by
ARCADIS	JH	JM,WS,BK

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AS-BUILT DRAWINGS ● SD015

TRENCH CROSS SECTION AND MANIFOLD DETAILS

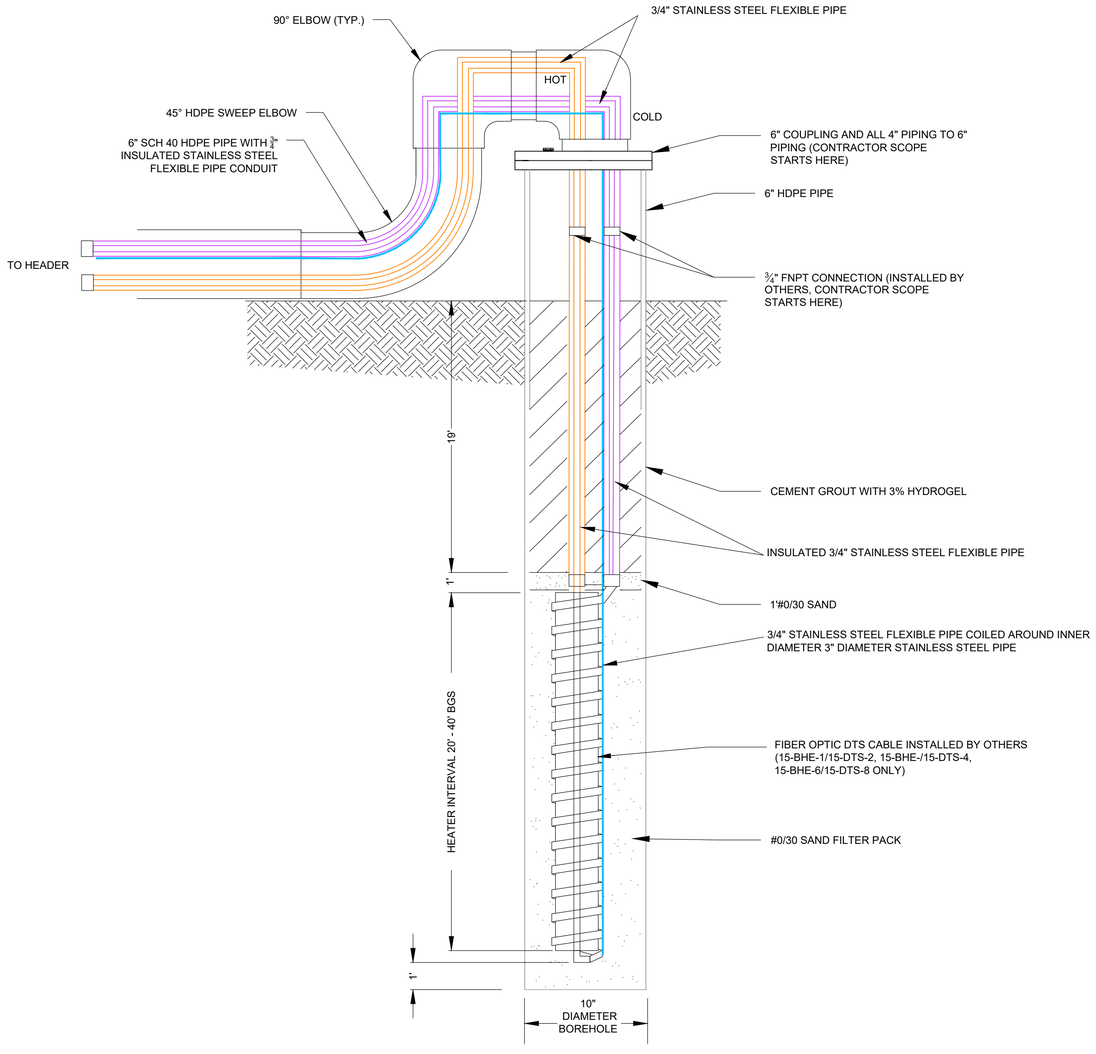
AS-BUILTS

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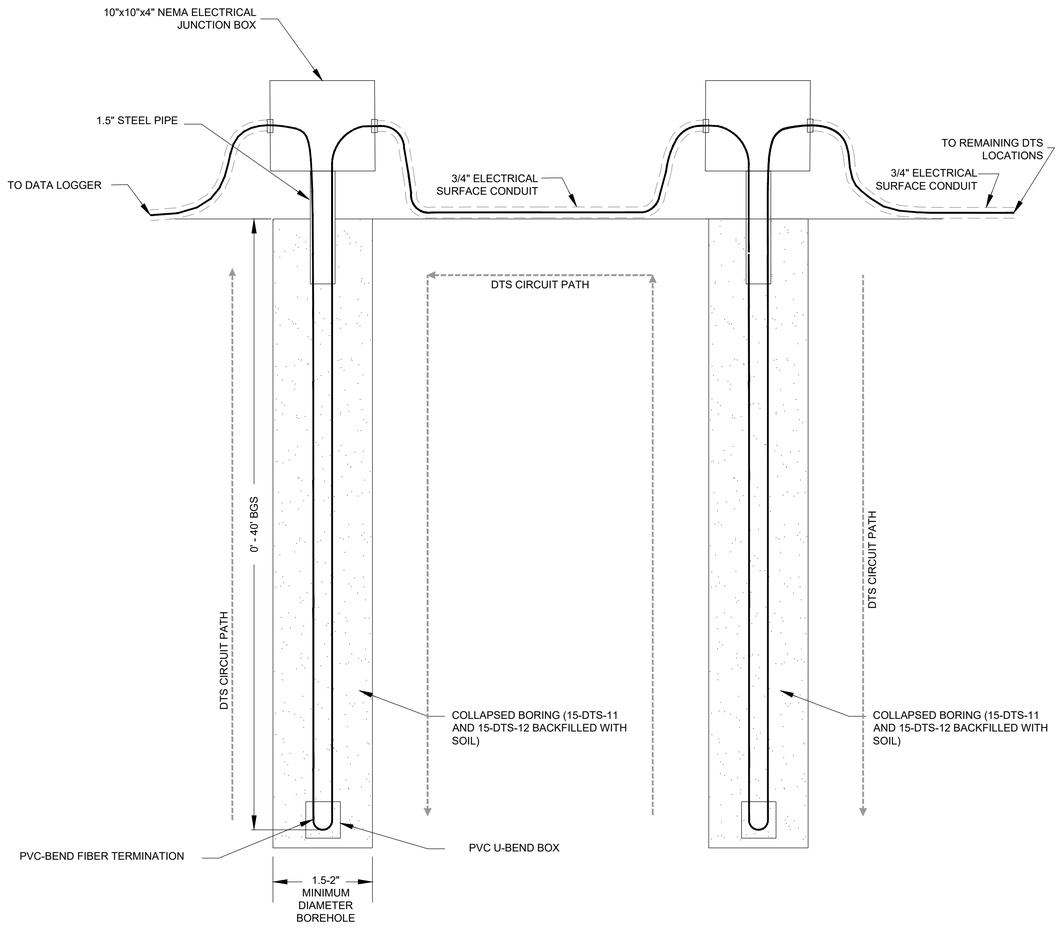
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G-5



A G-6 BOREHOLE HEAT EXCHANGER DETAIL (TYP.)

NOT TO SCALE



A G-6 DISTRIBUTED TEMPERATURE SENSING (DTS) (INSTALLED BY OTHERS) INSTALLATION NEW AND EXISTING MONITORING WELL DETAIL (TYP.)

NOT TO SCALE

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Professional Engineer's No.: 88162
State: CA | Date Signed: | Project Mgr.: HV
Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

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BOREHOLE HEAT EXCHANGER SCHEMATIC AND DTS POINT CONSTRUCTION DETAILS

AS-BUILTS

ARCADIS Project No. 30027243
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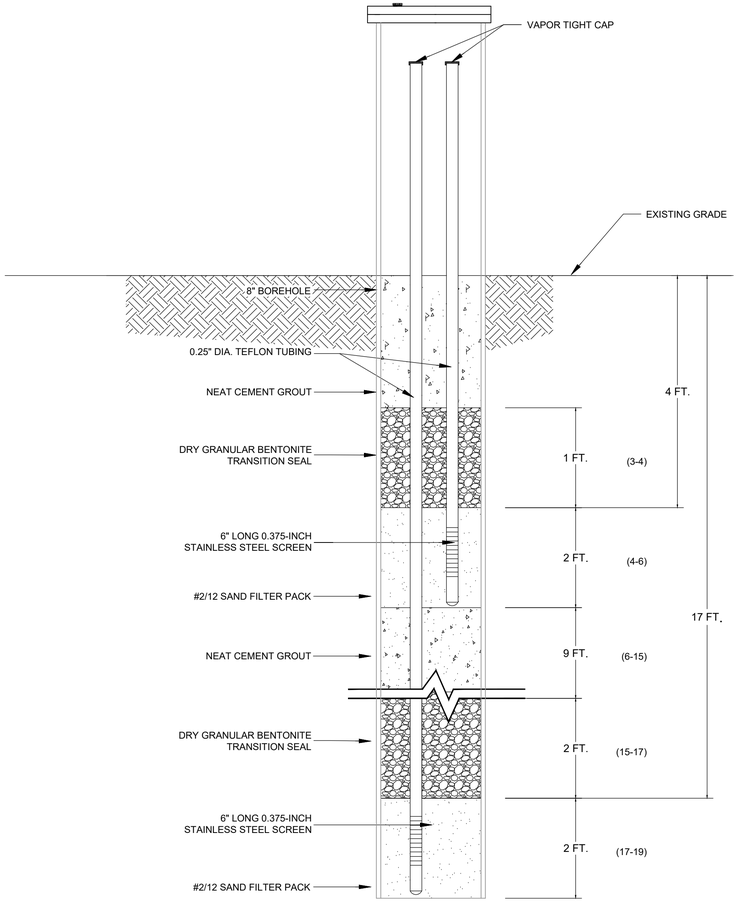
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G-6

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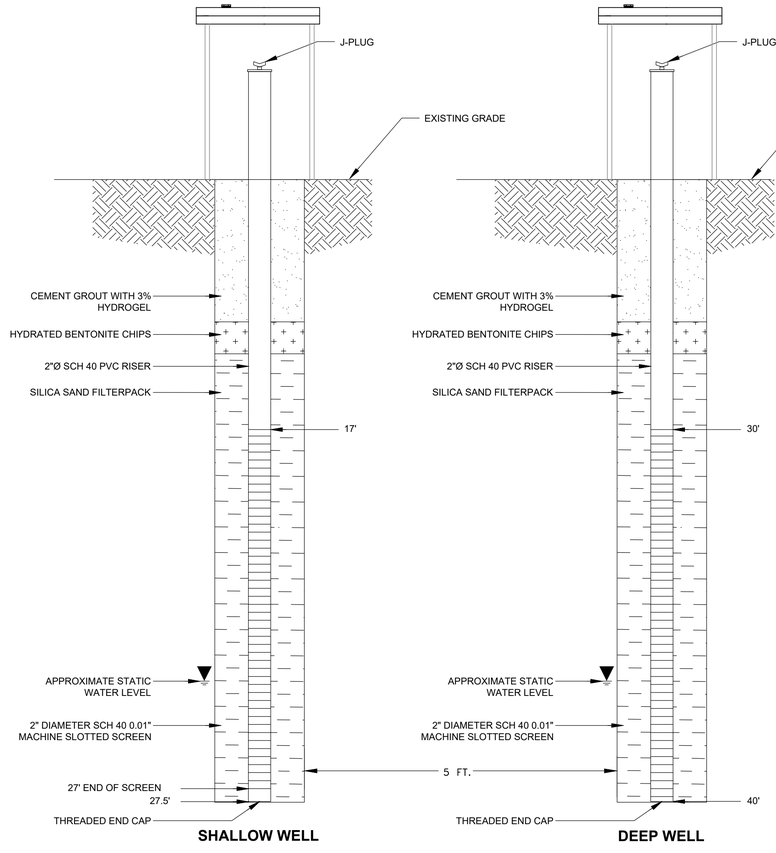
SOIL VAPOR AND GROUNDWATER MONITORING WELL CONSTRUCTION SCHEDULE

ID	Date Installed	Drillling method	Well Diameter (in)	Screening Interval (ft bgs)	Screen material	Screen slot	Sump	Total Depth (ft bgs)	Filter pack depth (ft bgs)	TOC elevation (ft msl)	Casing Material	Northing	Easting
TISR-1S	11/17/2021	8" HAS	2	17.5 to 27.5	2" SCH 40 SLOTTED PVC	0.01	NO	27.5	2/16 SAND 15.5 TO 27.5	88.88	SCH 40 PVC	2121784.75	5781522.80
TISR-1D	11/17/2021	8" HSA	2	30 to 40	2" SCH 40 SLOTTED PVC	0.01	NO	40	2/16 SAND 28 TO 40	88.95	SCH 40 PVC	2121785.31	5781525.54
TISR-2S	11/29/2021	8" HSA	2	17 to 27	2" SCH 40 SLOTTED PVC	0.01	NO	27.5	2/16 SAND 15.5 TO 27.5	88.88	SCH 40 PVC	2121753.96	5781487.24
TISR-2D	11/29/2021	8" HSA	2	30 to 40	2" SCH 40 SLOTTED PVC	0.01	NO	40	2/16 SAND 28 TO 40	88.67	SCH 40 PVC	2121755.65	5781490.34
TISR-3S	11/18/2021	8" HSA	2	17.5 to 27.5	2" SCH 40 SLOTTED PVC	0.01	NO	27.5	2/16 SAND 15.5 TO 27.5	89.01	SCH 40 PVC	2121773.06	5781497.30
TISR-3D	11/18/2021	8" HSA	2	30 to 40	2" SCH 40 SLOTTED PVC	0.01	NO	40	2/16 SAND 28 TO 40	88.72	SCH 40 PVC	2121774.38	5781499.78
TISR-4S	11/15/2021	8" HSA	2	17.5 to 27.5	2" SCH 40 SLOTTED PVC	0.01	NO	27.5	2/16 SAND 15.5 TO 27.5	88.72	SCH 40 PVC	2121759.31	5781520.87
TISR-4D	11/11/2021	8" HSA	2	30 to 40	2" SCH 40 SLOTTED PVC	0.01	NO	40	2/16 SAND 28 TO 40	88.75	SCH 40 PVC	2121759.62	5781523.90
SVP-1	11/11/2021	8" HSA	.25 in	PROBES AT 4.5 and 17.5	0.375" STAINLESS STEEL	-	NO	17.5	2/12 SAND 4 TO 6 AND 17 to 19	86.50	0.25 in TEFLON TUBING	2121767.07	5781514.16
SVP-2	11/15/2021	8" HSA	.25 in	PROBES AT 4.5 and 17.6	0.375" STAINLESS STEEL	-	NO	17.5	2/12 SAND 4 TO 6 AND 17 to 19	85.84	0.25 in TEFLON TUBING	2121833.69	5781430.17



1 G-6A SOIL VAPOR PROBE CONSTRUCTION DETAIL (INSTALLED BY OTHERS)

NOT TO SCALE



2 G-6A TEMPORARY MONITORING WELL CONSTRUCTION DETAIL (INSTALLED BY OTHERS)

NOT TO SCALE

NOTES:

1. ALL DEPTH INTERVALS ARE IN FEET BELOW GROUND SURFACE.

FT = FEET
FT BGS = FEET BELOW GROUND SURFACE
FT MSL = FEET MEAN SEA LEVEL
GPM = GALLONS PER MINUTE
HSA = HOLLOW STEM AUGER
IN = INCHES
PVC = POLYVINYL CHLORIDE
PVC SCH. 40 = SCHEDULE 40 PVC
S.S. = STAINLESS STEEL
TOC = TOP OF CASING

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CA		HV
Designed by	Drawn by	Checked by
ARCADIS	JH	JM,WS,BK

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MONITORING POINT CONSTRUCTION DETAILS

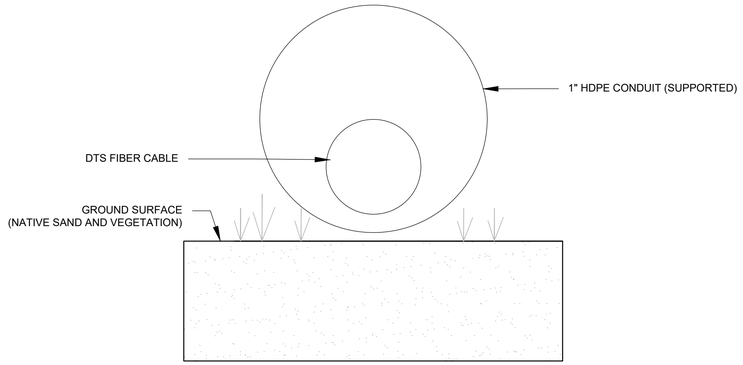
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ARCADIS Project No. 30027243

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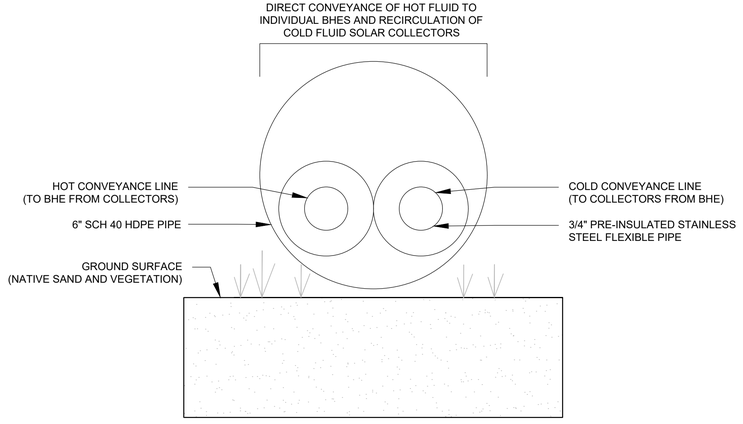
G-6A



1 G-7

CROSS SECTION - ABOVEGROUND DTS CONVEYANCE LINE (INSTALLED BY OTHERS)

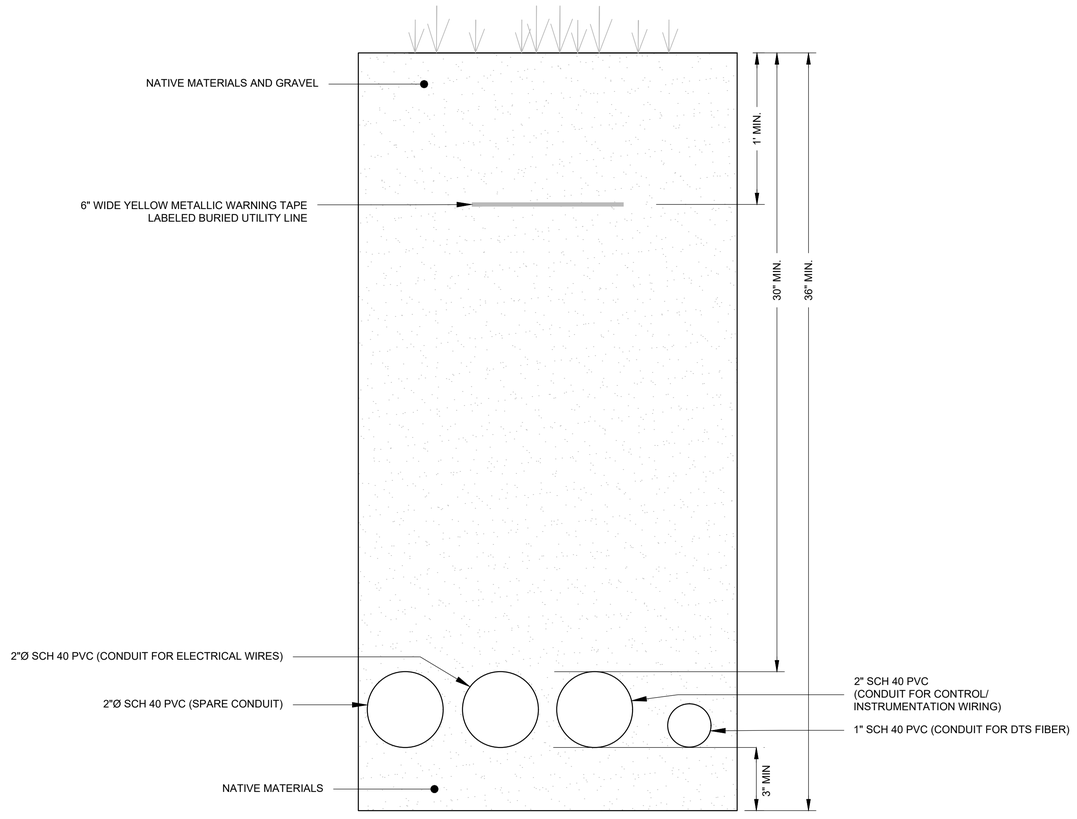
NOT TO SCALE



B G-7

CROSS SECTION - ABOVEGROUND BHE CONVEYANCE LINE 1 OF 8

NOT TO SCALE



A G-7

CROSS SECTION - ELECTRICAL TRENCH

NOT TO SCALE

NOTES:

1. CONTRACTOR SHALL PERFORM BACKFILL AND COMPACTION IN ACCORDANCE WITH THE SPECIFICATIONS IN THE BID SPECIFICATIONS PACKAGE.
2. ELECTRICAL CONDUITS WILL HAVE A DIAMETER SUITABLE FOR THE REQUIRED CONDUCTOR SIZE FOR THE ELECTRICAL POWER SERVICE TYPE (TO BE DETERMINED).

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Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE ● CALIFORNIA
AS-BUILT DRAWINGS ● SD015

CONDUIT CROSS SECTION DETAILS

AS-BUILTS

ARCADIS Project No.
30027243

Date
SEPTEMBER 2024

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

G-7

ELECTRICAL SPECIFICATIONS:

GENERAL

1. ALL ELECTRICAL EQUIPMENT SHALL BE U.L. LISTED AND LABELED. ELECTRICAL EQUIPMENT AND INSTALLATION COMPLY WITH NFPA 70 AND 70E.

2. ALL ELECTRICAL WORK SHALL BE COMPLETED IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS INCLUDING THE MOST 2019 EDITION OF THE CALIFORNIA ELECTRICAL CODE (CEC) AND OSHA REQUIREMENTS, ALL AS INTERPRETED BY THOSE HAVING JURISDICTION. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY COORDINATION REQUIRED WITH THE LOCAL FIRE DEPARTMENT. ANY DRAWINGS REQUIRED FOR PERMITS OTHER THAN THOSE PRESENTED HEREIN WILL BE THE RESPONSIBILITY OF THE CONTRACTOR AND SHALL BE REVIEWED BY THE ENGINEER PRIOR TO USE.

3. THERE SHALL BE NO SUBSTITUTIONS UNLESS THE CONTRACTOR HAS OBTAINED WRITTEN APPROVAL FROM THE OWNER AFTER HAVING SUBMITTED AN ALTERNATIVE PROPOSAL COMPLETE WITH A DESCRIPTION OF DEVIATION FROM THE SPECIFICATIONS AND A STATEMENT OF BENEFITS TO BE DERIVED SHOULD SUCH A PROPOSED SUBSTITUTE BE ACCEPTED.

4. THE ELECTRICAL DRAWINGS ARE DIAGRAMMATIC AND ARE INTENDED TO SHOW THE APPROXIMATE LOCATIONS OF OUTLETS, CONDUIT, JUNCTION BOXES, EQUIPMENT, ETC. DIMENSIONS PRESENTED ON THE DRAWINGS SHALL TAKE PRECEDENCE OVER SCALED DIMENSIONS AND ALL DIMENSIONS, WHETHER SHOWN ON THE DRAWINGS OR SCALED, SHALL BE VERIFIED IN THE FIELD.

5. ELECTRICAL PANEL BUILDER(S) SHALL PROVIDE DETAILED SHOP DRAWINGS OF PANEL FOR ENGINEER APPROVAL PRIOR TO CONSTRUCTION.

6. UNLESS OTHERWISE NOTED, CONDUIT USE SHALL BE AS FOLLOWS:

   A. CONDUIT ABOVE GRADE AND EXPOSED TO THE ELEMENTS SHALL BE RIGID GALVANIZED STEEL (RGS).

   B. FINAL CONNECTION TO MOVING EQUIPMENT (i.e. MOTORS, TRANSFORMERS, FREE STANDING EQUIPMENT, ETC.) SHALL BE BY LIQUID TIGHT FLEXIBLE METALLIC CONDUIT.

   C. INTERIOR LIGHTING CIRCUITS ABOVE 8'-0" AFF SHALL BE MC CABLE WITH A DEDICATED GROUNDING CONDUCTOR.

   D. DIRECT BURIED CONDUIT BELOW GRADE SHALL BE SCHEDULE 40 PVC. RIGID CONDUIT (RGS) SHALL BE USED ABOVE GRADE. PROVIDE SEAL OFF FITTINGS FOR ALL CONDUITS ENTERING AND EXITING CLASSIFIED AREAS.

7. INSTALL PULL BOXES, JUNCTION BOXES, SPLICE BOXES AND FITTINGS WHERE SHOWN AND AT OTHER LOCATIONS AS NECESSARY. PULL AND JUNCTION BOX MATERIAL SHALL MATCH THE CONDUIT SYSTEM ATTACHED.

8. ALL 120 VOLT, SINGLE PHASE 20 AMPERE RECEPTACLE OUTLETS USED BY THE CONTRACTOR SHALL BE GROUND FAULT CIRCUIT INTERRUPTER (GFCI) TYPE. ALL RECEPTACLES INSTALLED OUTDOORS SHALL BE WEATHER RESISTANT, GFCI TYPE RECEPTACLES, PER CEC 406.9.

9. IN COMPLIANCE WITH THE SAN JOSE MUNICIPAL CODE SECTION 24.02.330, THE ISSUANCE OF A PERMIT OR APPROVAL OF PLANS SHALL NOT BE CONSTRUED TO BE AN APPROVAL OF ANY VIOLATION TO THE ORDINANCE OR THE 2019 CEC TECHNICAL CODE.

RIGID METAL CONDUIT (RGS)

1. GALVANIZED STEEL, HOT-DIPPED ZINC, ANSI STANDARD C80.1 AND C80.4.

2. MANUFACTURER SHALL BE ALLIED TUBE & CONDUIT CORPORATION, TRIANGLE WIRE AND CABLE INC., OR EQUAL.

NONMETALLIC CONDUIT (PVC)

1. NONMETALLIC RIGID CONDUIT AND FITTINGS SHALL BE SCHEDULE 40, POLYVINYL CHLORIDE AND SHALL BE RESISTANT TO CORROSION.

2. CONDUIT AND FITTINGS SHALL BE IN ACCORDANCE WITH NEMA STANDARD TC-2 AND TC-3, LATEST REVISION.

3. MANUFACTURER SHALL BE CARLON ELECTRIC CONDUIT CO., TRIANGLE PWC CO., OR EQUAL.

LIQUID TIGHT FLEXIBLE METALLIC CONDUIT (LFMC)

1. FLEXIBLE CONDUIT SHALL BE AN INTERLINKED GALVANIZED STEEL CORE WITH A SMOOTH LIQUID TIGHT PVC COVER.

2. FITTINGS SHALL BE NEMA-3R RATED AND MATCH CONDUIT TYPE INSTALLED.

LIQUID TIGHT FLEXIBLE METALLIC CONDUIT (LFMC) (CONT.)

3. MANUFACTURER'S SHALL BE ANACONDA, LIQUATITE OR EQUAL.

JUNCTION BOXES

1. IN INDOOR, DRY LOCATIONS, JUNCTION BOXES AND FITTINGS SHALL BE OF GALVANIZED STEEL OR COPPER FREE ALUMINUM. IN EXTERIOR LOCATIONS, JUNCTION BOXES SHALL BE NEMA 4X STAINLESS STEEL.

WIRES AND CABLES

1. GENERAL

   A. ALL CONDUCTORS, UNLESS OTHERWISE NOTED, SHALL BE STRANDED COPPER, CONSTRUCTED OF SOFT DRAWN OR ANNEALED COPPER.

   B. CONDUCTORS INSULATION SHALL BE COLOR CODED. COLOR OF INSULATION SHALL BE ONE COLOR THROUGHOUT THE ENTIRE RUN.

   C. 277/480 VAC, THREE PHASE, 4 WIRE
      PHASE A - BROWN
      PHASE B - ORANGE
      PHASE C - YELLOW
      NEUTRAL - GRAY
      GROUND - GREEN

   D. 120/208 VAC, THREE PHASE, 4 WIRE
      PHASE A - BLACK
      PHASE B - RED
      PHASE C - BLUE
      NEUTRAL - WHITE
      GROUND - GREEN

2. LOW VOLTAGE CONDUCTORS

   A. ALL CONDUCTORS FOR POWER, LIGHTING AND 120 VAC CONTROL SHALL BE RATED FOR A MINIMUM OF 600 VAC.

   B. CONDUCTORS SHALL BE CONSTRUCTED OF UNCOATED CLASS C COPPER CONCENTRIC-LAY-STRANDED WIRES.

   C. POWER AND LIGHTING CONDUCTORS SHALL BE TYPE THWN-2-90C OR XHHW WITH PVC INSULATION AND NYLON JACKET.

3. INSTRUMENTATION CABLES

   A. TWISTED PAIR, WITH QUANTITY OF PAIRS AS SHOWN ON DRAWINGS, OF NO. 18 AWG TINNED COATED CLASS C COPPER CONCENTRIC LAY STRANDED WIRES WITH AN ALUMINUM POLYESTER SHIELD AND COPPER DRAIN. RATED FOR 600V AND COLOR CODED WITH PVC OUTER JACKET.

4. VARIABLE FREQUENCY DRIVE (VFD) CABLES

   A. SHALL HAVE A MINIMUM OF 45 MILS OF CROSS LINKED POLYETHYLENE INSULATION.

5. CONNECTORS

   A. PIGTAIL SPLICING #10 AND SMALLER, USE TAPERED SPRING WIRE NUTS. MANUFACTURER SHALL BE IDEAL WING NUT, BUCHANAN B-CAP, T&B PIGGIES, OR EQUAL.

   B. FOR TERMINATION OF #14 CONTROL WIRES TO TERMINALS, USE INSULATED COMPRESSION SPADE TYPE CONNECTORS. MANUFACTURER SHALL BE BURNDY HYDENT, T&B STA-KON, OR EQUAL.

   C. SPLICES AND TERMINALS FOR #8 AND LARGER SHALL BE COPPER COMPRESSION TYPE. MANUFACTURER SHALL BE BURNDY HYDENT OR HYLUG, T&B, STA-CON, OR EQUAL..

   D. FIXTURE CONNECTIONS MANUFACTURER SHALL BE T&B STA-KON SERIES PT-66M, IDEAL CRIMP SLEEVE NO. 410 WITH LONG BARREL, OR EQUAL.

   E. CONNECTORS IN OUTDOOR HANDHOLES (ABOVE GRADE OR IN GRADE) SHALL BE SUBMERSIBLE TYPE, RATED FOR USE IN UNDERGROUND AND EXTERIOR ENVIRONMENT.

6. METAL CLAD (MC) CABLE

   A. ALL MC CABLE SHALL BE OF TYPE FEEDER AND/OR BRANCH CIRCUIT DEPENDING ON THE APPLICATION.

   B. ALL MC CABLE SHALL BE UL LISTED, RATED AT 600 VOLTS, HAVE LIGHTWEIGHT ALUMINUM INTERLOCKED ARMOR, AND SHALL HAVE A PVC JACKET OVER THE ALUMINUM INTERLOCKED ARMOR.

   C. ALL MC CABLE SHALL BE PROVIDED BY MANUFACTURER SOUTHWIRE, ANIXTER, ENCORE, OR EQUAL.

GROUNDING

1. GROUNDING OF ELECTRICAL SYSTEMS AND EQUIPMENT SHALL, AT A MINIMUM, MEET THE REQUIREMENTS OF CEC ARTICLE 250 OR SHALL EXCEED ARTICLE 250 AS HEREIN SPECIFIED.

2. ALL CONDUITS SHALL HAVE AN INTERNAL GROUNDING CONDUCTOR. THIS GROUNDING CONDUCTOR SHALL BE PROVIDED ALTHOUGH IT MAY NOT BE SHOWN OR SCHEDULED ON THE PLANS.

3. GROUNDING ELECTRODE CONDUCTORS SHALL BE A MINIMUM OF NO. 6 AWG BARE STRANDED COPPER.

4. GROUND RODS SHALL BE 3/4" DIAMETER, 10 FEET LONG, STEEL CORE WITH COPPER MOLTEN WELDED OR ELECTROLYTICALLY BONDED TO EXTERIOR.

5. ALL CONNECTIONS SHALL BE MADE WITH COMPRESSION OR CADWELD CONNECTORS.

ENCLOSURES

1. ENCLOSURES SHALL BE NEMA 12 FOR DRY, INDOOR LOCATIONS UNLESS OTHERWISE NOTED.

2. WET LOCATIONS OR OUTDOORS, ENCLOSURES SHALL BE NEMA 4X STAINLESS STEEL.

3. ENCLOSURES SHALL HAVE A NAMEPLATE ON THE EXTERIOR IDENTIFYING THE APPLICATION OR FUNCTION OF THE EQUIPMENT ENCLOSED. COORDINATE NAMING IN THE FIELD.

HAND HOLES (HH)

1. PRECAST CONCRETE, SIZED AS SHOWN IN DRAWINGS, WITH TIER H-20 TRAFFIC RATING, MANUFACTURED BY JENSEN OR EQUAL.

WIRING DEVICES

1. RECEPTACLES MARKED AS GFCI SHALL BE OF THE GROUND FAULT CIRCUIT INTERRUPTER TYPE. MANUFACTURER SHALL BE GE TYPE TGTR 20, OR EQUAL.

2. WEATHER-PROOF (WP) RECEPTACLE COVERS SHALL BE IN-USE TYPE, CARLON E9UDVCRN, OR EQUAL, NON-METALLIC, NON-CONDUCTIVE CORROSION RESISTANT. COVER SHALL BE VERTICAL TYPE RATED FOR IN-USE PROTECTION WITH BOTTOM ENTRY CORD.

3. SWITCHES

   A. LIGHTING SWITCHES SHALL BE RATED 20 AMPERES AT 120 VAC, TOGGLE OPERATED, PLASTIC ENCLOSED, SINGLE POLE, THREE-WAY OR FOUR-WAY AS SHOWN OR REQUIRED. MANUFACTURER SHALL BE P&S SERIES 20AC1 SPECIFICATION GRADE, OR EQUAL.

   B. SWITCHES SHALL HAVE SILVER ALLOY CONTACTS AND PROVISIONS FOR SIDE AND BACK WIRING.

   C. EACH SWITCH SHALL BE SUITED FOR FULL-RATED CAPACITY ON TUNGSTEN FILAMENT AND FLUORESCENT LAMP LOADS.

4. FACEPLATE AND COVERS

   A. FINISHED AREAS SHALL HAVE STAINLESS STEEL TYPE 302 ALLOY COVERS.

   B. WET AND CORROSIVE AREAS SHALL BE WEATHERPROOF COVERS WITH GASKETS.

DISCONNECT SWITCHES

1. NON-FUSIBLE SWITCH ASSEMBLIES: NEMA KS 1, TYPE HD LOAD INTERRUPTER ENCLOSED KNIFE SWITCH WITH EXTERNALLY LOCKABLE HANDLE INTERLOCKED TO PREVENT OPENING FRONT COVER WITH SWITCH IN "ON" POSITION, HANDLE LOCKABLE IN "OFF" POSITION. INCLUDE ELECTRICAL INTERLOCK (N.C.) SNAP SWITCH TYPE.

2. FUSIBLE SWITCH ASSEMBLIES: SAME CONSTRUCTION AS NON-FUSED EXCEPT WITH FUSE CLIPS DESIGNED TO ACCOMMODATE CLASS R FUSES.

3. VOLTAGE AND AMPERE RATING: AS INDICATED ON DRAWINGS.

4. SHORT CIRCUIT RATING: 10 KA FOR NON-FUSIBLE DISCONNECTS,100 KA FOR FUSIBLE DISCONNECTS UNLESS OTHERWISE INDICATED.

5. SWITCHES USED AS MAIN DISCONNECTS FOR BUILDINGS AND STRUCTURES SHALL BE RATED FOR SERVICE ENTRANCE USE.

6. ENCLOSURE: NEMA 3R UNLESS OTHERWISE INDICATED

7. INSTALLATION

   A. INSTALL SWITCHES WHERE INDICATED.

DISCONNECT SWITCHES (CONT.)

   B. INSTALL SWITCHES 5 FEET FROM OPERATING HANDLE TO FLOOR OR FINISHED GRADE, UNLESS OTHERWISE NOTED.

COMBINATION MOTOR CONTROLLERS

1. COMBINE MOTOR CONTROLLERS AND OVERCURRENT PROTECTION DEVICE IN CONTROL PANEL.

2. OVERCURRENT PROTECTION DEVICES:

   A. MOTOR CIRCUIT PROTECTOR (MCP): NEMA AB 1; INTEGRAL INSTANTANEOUS MAGNETIC TRIP IN EACH POLE. PROVIDE MANUAL INSTANTANEOUS TRIP ADJUSTMENT TO ALLOW ADJUSTMENT FROM 400 PERCENT TO 1000 PERCENT OF MOTOR STARTING CURRENT.

   B. THERMAL-MAGNETIC CIRCUIT BREAKERS (T-M): NEMA AB 1. INTEGRAL THERMAL AND INSTANTANEOUS MAGNETIC TRIP IN EACH POLE.

   C. PROVIDE TRIP RATING AS SHOWN IN SCHEDULE ON DRAWINGS.

3. MAGNETIC MOTOR CONTROLLERS:

   A. NEMA ICS 2. RATED IN ACCORDANCE WITH NEMA STANDARD SIZES AND HORSEPOWER RATINGS.

   B. MINIMUM RATING: NEMA SIZE 1.

   C. COIL OPERATING VOLTAGE: 120 VOLTS, 60 HZ FOR SIZE 3 AND SMALLER. USE LINE-RATED VOLTAGE COILS FOR SIZE 4 AND LARGER MOTOR STARTERS.

4. OVERLOAD RELAY: NEMA ICS; THREE THERMAL OVERLOAD RELAYS OF THE AMBIENT-COMPENSATED BI-METAL MELTING ALLOY TYPE.

INSTRUMENTATION

1. TEMPERATURE TRANSMITTER MANU. AND MODEL (RTD):

   A. ROSEMOUNT 644 SERIES

   B. OR ENGINEER APPROVED EQUAL

2. PRESSURE TRANSMITTER MANU. AND MODEL:

   A. ENDRESS AND HAUSER CERABAR S MODEL

   B. OR ENGINEER APPROVED EQUAL

SUBMITTALS

1. SUBMIT APPLICABLE PRODUCT DATA AND MATERIALS FOR INSTALLATION TO ENGINEER FOR APPROVAL PRIOR TO INSTALLATION.

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XREFS:
TISR AS-BUILT DWG-X-TITLE

No.	Date	Revisions	By	Ckd
5	03/25/2025	AS-BUILTS	BK	JM
4	08/23/2024	100% DESIGN	BK	JM
3	08/02/2024	90% DESIGN	BK	JM
2	07/19/2024	60% DESIGN	BK	JM
1	05/17/2024	30% DESIGN	BK	JM

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Professional Engineer's Name: JEREMIAH SIMPSON
Professional Engineer's No.: 81211
State: CA | Date Signed: | Project Mgr.: HV
Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE ● CALIFORNIA
AS-BUILT DRAWINGS ● SD015

ELECTRICAL SPECIFICATIONS

AS-BUILTS

ARCADIS Project No.
30027243

Date
SEPTEMBER 2024

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

E-1

ELECTRICAL SYMBOL LEGEND

SINGLE LINE DIAGRAM

- SERVICE CONNECTION
- CIRCUIT BREAKER
- DISCONNECT SWITCH
- MOTOR (HP)
- COMBINATION MOTOR STARTER WITH MOTOR CIRCUIT PROTECTOR AND OVERLOADS
- METER (M)
- GROUND ROD
- FUSE
- DRY TYPE TRANSFORMER
- PANEL
- VFD — VARIABLE FREQUENCY DRIVE
- SPD — SURGE PROTECTION DEVICE
- RECEPTACLES
- LIGHTS

PLAN VIEW

- SERVICE CONNECTION
- MOTOR (HP)
- METER (M)
- GROUND ROD
- PANEL
- RECEPTACLES
- PROPOSED UTILITY POLE

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3	08/02/2024	90% DESIGN	BK	JM
2	07/19/2024	60% DESIGN	BK	JM
1	05/17/2024	30% DESIGN	BK	JM

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Professional Engineer's Name: **JEREMIAH SIMPSON**
Professional Engineer's No.: 81211
State: CA | Date Signed: | Project Mgr.: HV
Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE ● CALIFORNIA
AS-BUILT DRAWINGS ● SD015

ELECTRICAL SYMBOL LEGEND

AS-BUILTS

ARCADIS Project No. 30027243
Date SEPTEMBER 2024

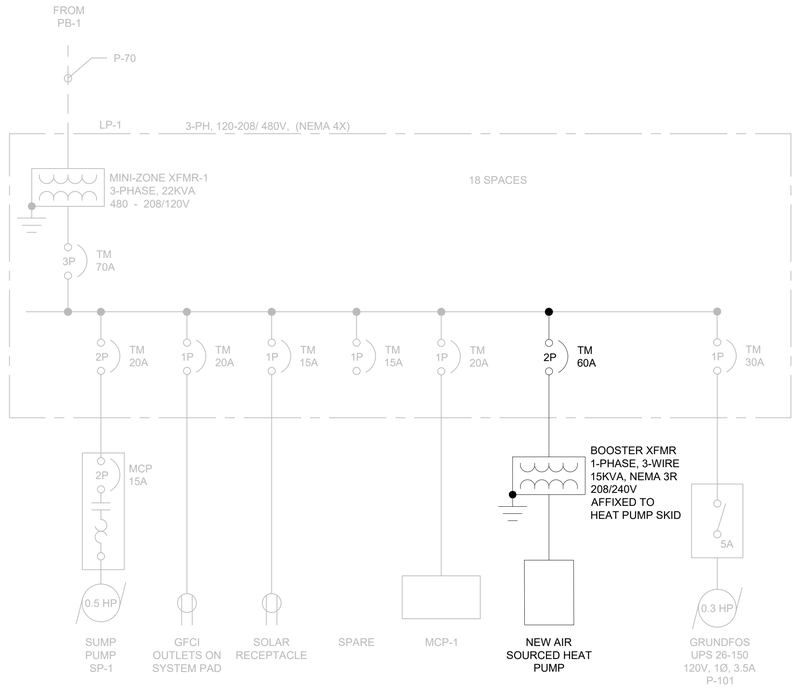
ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

E-2

PANEL "LP-1" SCHEDULE

SERVICE VOLTS: 208 / 120 PHASE (Ø): 3 MAIN BREAKER: 70A

	LOAD DESCRIPTION		WATTS A	WATTS B	WATTS C	POLE	AMP	WIRE SIZE		POLE	AMP	WATTS A	WATTS B	WATTS C	LOAD DESCRIPTION	
1	SUMP PUMP SP-1		561			2	20			2	20	750			(UNKNOWN LOAD)	2
3				561									750			4
5	MCP-1				960	1	20			1	30			864	GRUNDFOS UPS 26-150 (P-101)	6
7	SOLAR RECEPTACLE		360			1	15			1	15				SPARE	8
9										2	30				SPARE	10
11	NEW AIR SOURCED HEAT PUMP				4200	2	60	2#3, 1#8G								12
13			4200													14
15																18
17																18
SUB TOTAL WATTS:		10842	5121	561	5160							750	750	864	SUB TOTAL WATTS:	2364
PHASE A TOTAL WATTS =		5871										PHASE A TOTAL AMPS =				49
PHASE B TOTAL WATTS =		1311										PHASE B TOTAL AMPS =				11
PHASE C TOTAL WATTS =		6024										PHASE C TOTAL AMPS =				50
GRAND TOTAL WATTS =		13206										TOTAL CONNECTED LOAD AMPS:				37



NOTES:

1. EXISTING EQUIPMENT SHOWN IN GRAY, ONLY SHOWN FOR REFERENCE.
2. AS-BUILT OR ADJUSTED EQUIPMENT SHOWN IN BLACK.
3. PROVIDE NEW 60A, 2-POLE 208V BREAKER IN EXISTING LP-1, AND 2#3 w/ 1/8 GND IN EXISTING 2" CONDUIT TO NEW AIR SOURCED HEAT PUMP CONTROL PANEL AND MAY RUN THROUGH MCP-1 AS WELL.

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4	08/23/2024	100% DESIGN	BK	JM
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Professional Engineer's Name: **JEREMIAH SIMPSON**
Professional Engineer's No.: 81211
State: CA | Date Signed: | Project Mgr.: HV
Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE ● CALIFORNIA
AS-BUILT DRAWINGS ● SD015

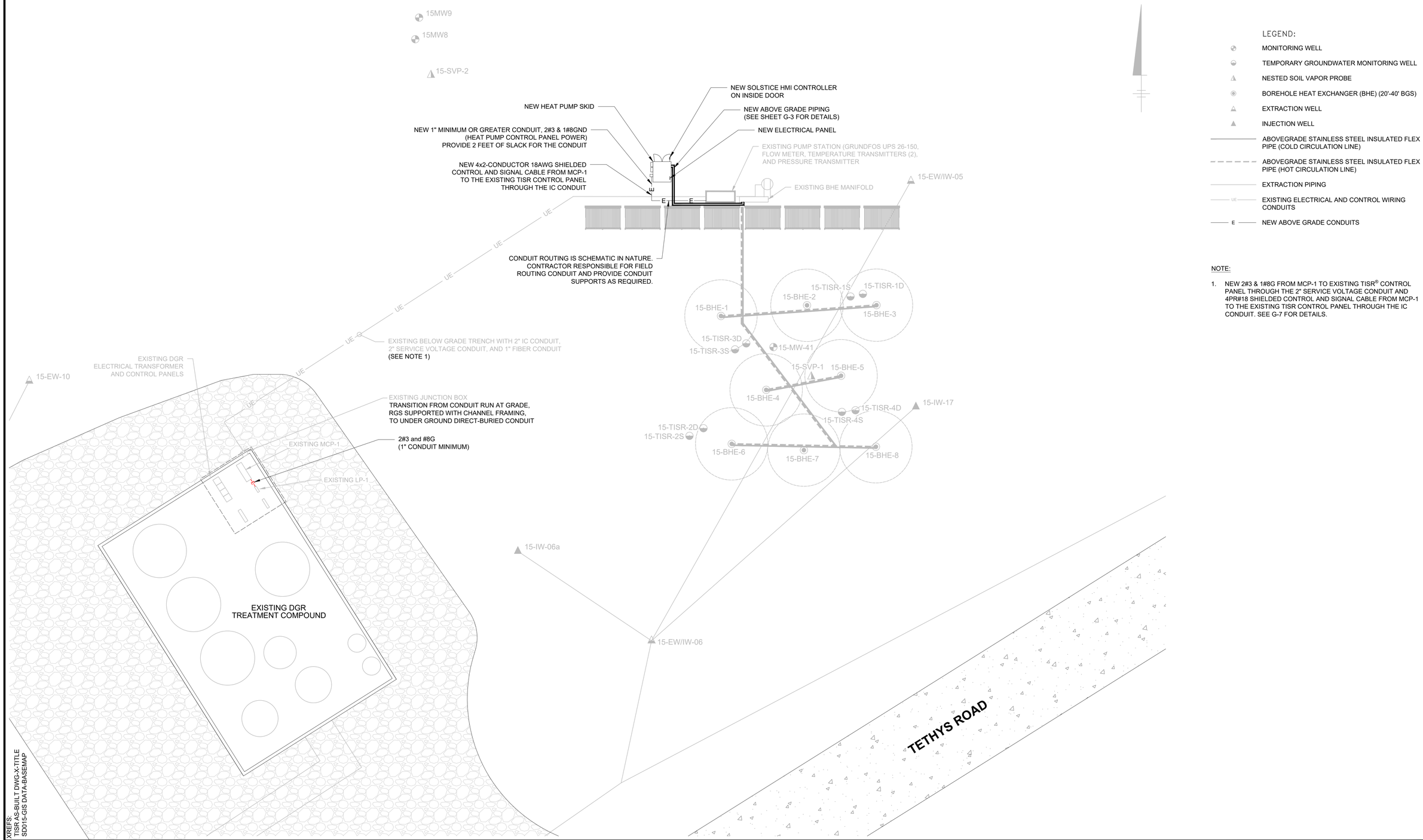
ELECTRICAL ONE LINE DIAGRAM AND PANEL SCHEDULE

AS-BUILTS

ARCADIS Project No. 30027243
Date SEPTEMBER 2024

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

E-3



NOTE:

1. NEW 2#3 & 1#8G FROM MCP-1 TO EXISTING TISR® CONTROL PANEL THROUGH THE 2" SERVICE VOLTAGE CONDUIT AND 4PR#18 SHIELDED CONTROL AND SIGNAL CABLE FROM MCP-1 TO THE EXISTING TISR CONTROL PANEL THROUGH THE IC CONDUIT. SEE G-7 FOR DETAILS.

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TISR AS-BUILT DWG-X-TITLE
SD015-GIS DATA-BASEMAP

0 10' 20'
GRAPHIC SCALE

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USE TO VERIFY FIGURE REPRODUCTION SCALE

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Professional Engineer's Name
JEREMIAH SIMPSON
Professional Engineer's No.
81211

State	Date Signed	Project Mgr.
CA		HV
Designed by	Drawn by	Checked by
ARCADIS	JH	JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE ● CALIFORNIA
AS-BUILT DRAWINGS ● SD015

SD015 TISR® ELECTRICAL SITE PLAN

AS-BUILTS

ARCADIS Project No.
30027243

Date
SEPTEMBER 2024

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

E-4

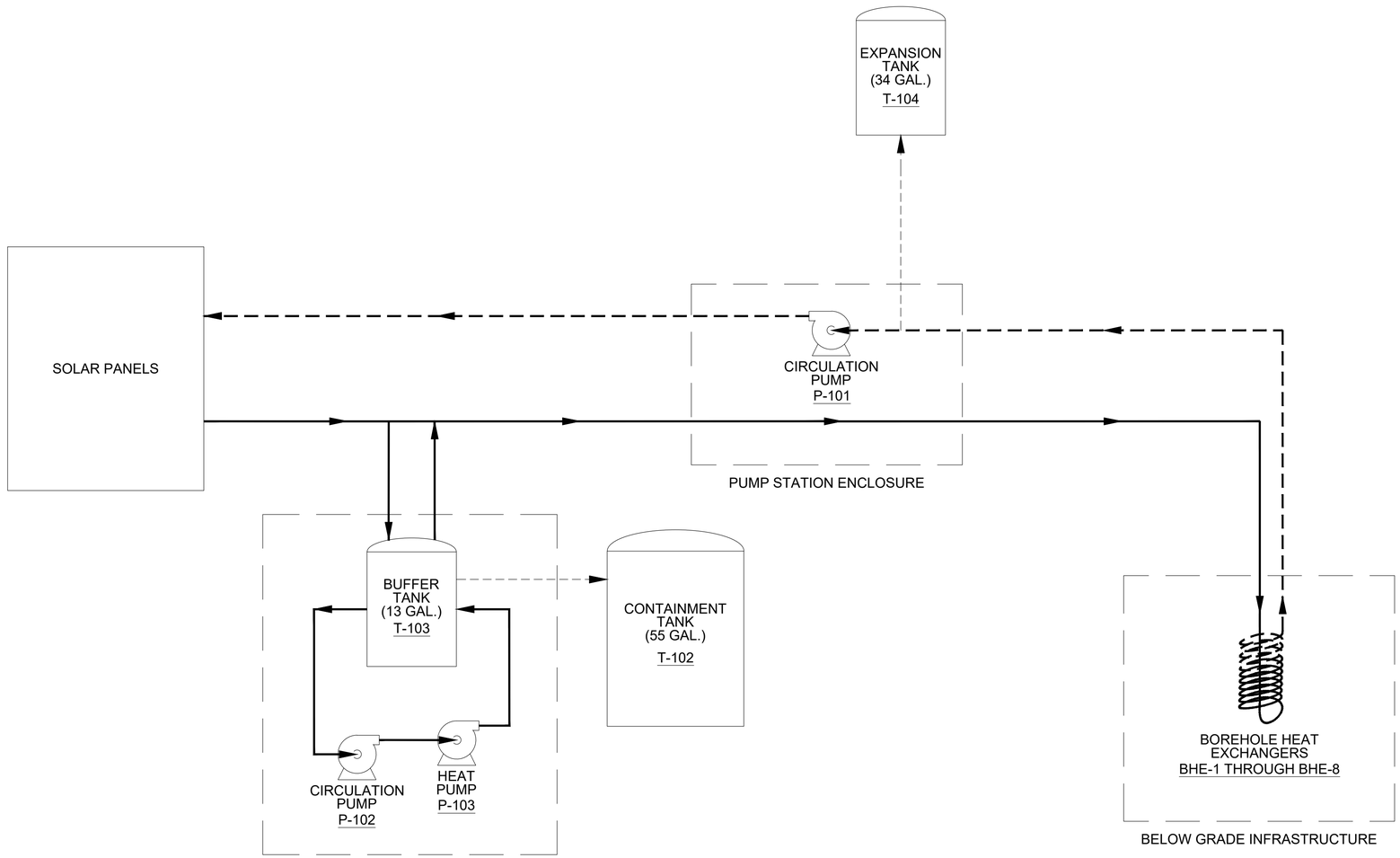
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LEGEND:

- HOT CIRCULATION LINE
- COLD CIRCULATION LINE
- INTERMITTENT MINOR PROCESS LINE

GAL. GALLON



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TISR AS-BUILT DWG-X-TITLE

NOT TO SCALE

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4	03/25/2025	AS-BUILTS	BK	JM
3	08/23/2024	100% DESIGN	BK	JM
2	08/16/2024	90% DESIGN, UPDATED FLOW PROCESS WITH REMOVAL OF OLD EXPANSION TANK AND MOVED CONTAINMENT TANK OFF OF BUFFER TANK	BK	JM
1	07/19/2024	60% DESIGN, FLOW DIAGRAM CREATED	BK	JM

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Professional Engineer's Name
BLAIR KINSER
Professional Engineer's No.
88162

State	Date Signed	Project Mgr.
CA		HV
Designed by	Drawn by	Checked by
ARCADIS	JH	JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE • CALIFORNIA
AS-BUILT DRAWINGS • SD015

PROCESS FLOW DIAGRAM
THERMAL IN-SITU SUSTAINABLE REMEDIATION (TISR®) SYSTEM

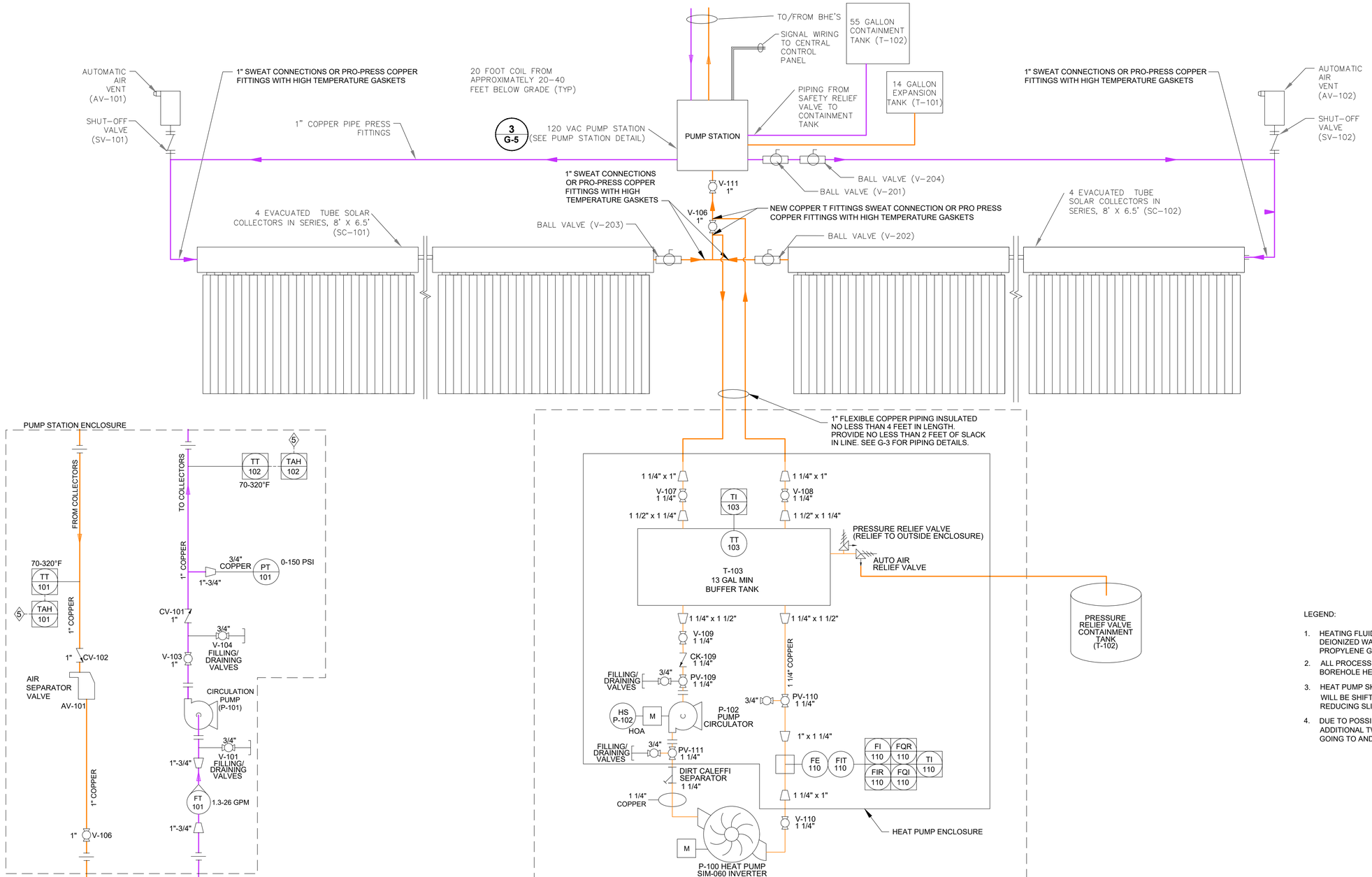
AS-BUILTS

ARCADIS Project No.
30027243

Date
SEPTEMBER 2024

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

P-1



LEGEND:

1. HEATING FLUID ONLY (50% FOOD-GRADE PROPYLENE GLYCOL AND 50% DEIONIZED WATER). AFTER MOD YEAR 4 MIX SHALL BE 30% FOOD-GRADE PROPYLENE GLYCOL AND 70% DEOIONIZED WATER
2. ALL PROCESS LINES SHALL BE INSULATED WITH THE EXCEPTION OF THE BOREHOLE HEAT EXCHANGER COIL.
3. HEAT PUMP SKID SHALL BE PLACED ON A LEVEL SURFACE. THE HEAT PUMP WILL BE SHIFTED INTO THE SAND AT LEAST ½" TO IMPROVE FRICTION AND REDUCING SLIDING.
4. DUE TO POSSIBLE SLIDING CAUSED BY WIND OR EARTHQUAKES AN ADDITIONAL TWO FEET OF SLACK WILL BE PROVIDED FOR THE LINES GOING TO AND FROM THE HEAT PUMP SKID.

C:\Users\jlharris\DC\ACCDocs\Arcadis ACC US\ANA-30027243-ESTCP TISR VSFB SD015\Project Files\10_WIP\10T_INS_Instrumentation\TISR AS-BUILT DWG-P2-TISR PID.dwg LAYOUT: P-2 SAVED: 3/26/2025 11:08 AM ACADVER: 24.3S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 3/26/2025 11:17 AM BY: HARRIS, JESS

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4	08/23/2024	100% DESIGN	BK	JM
3	08/16/2024	90% DESIGN, UPDATED NOTES, MINOR EDITS	BK	JM
2	07/19/2024	60% DESIGN, REMOVED OLD EXPANSION TANK, LINE , AND INCLUDED FLITEWAY P&ID	BK	JM
1	05/17/2024	30% DESIGN, ADDED HEAT PUMP SKID	BK	JM

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Professional Engineer's Name: **BLAIR KINSER**
Professional Engineer's No.: 88162
State: CA | Date Signed: | Project Mgr.: HV
Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE • CALIFORNIA
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PIPING AND INSTRUMENTATION DIAGRAM THERMAL IN-SITU SUSTAINABLE REMEDIATION (TISR®) SYSTEM

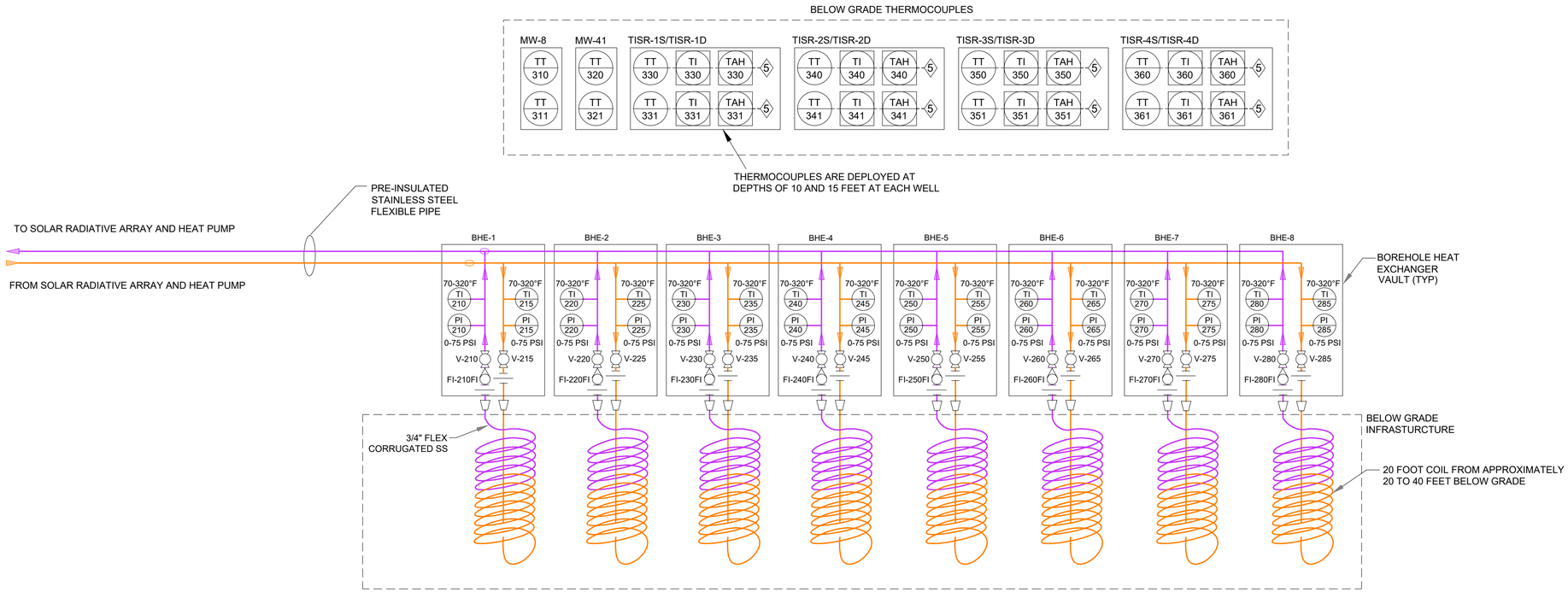
AS-BUILTS

ARCADIS Project No. 30027243
Date SEPTEMBER 2024

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SUITE 150
SAN LUIS OBISPO, CA 93401

P-2

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NOTES:
1. THE EXPANSION TANK AND CONTAINMENT DRUM WILL CONTAIN THE HEATING FLUID ONLY (30% FOOD-GRADE PROPYLENE GLYCOL AND 70% DEIONIZED WATER).
2. ALL PROCESS LINES SHALL BE INSULATED WITH THE EXCEPTION OF THE BOREHOLE HEAT EXCHANGER COIL.

LEGEND:
- HOT CIRCULATION LINE
- COLD CIRCULATION LINE

XREFS:
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2	07/19/2024	60% DESIGN	BK	JM
1	05/17/2024	30% DESIGN	BK	JM

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Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

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PIPING AND INSTRUMENTATION DIAGRAM BOREHOLE HEAT EXCHANGER DETAILS (TISR®) SYSTEM

AS-BUILTS

ARCADIS Project No. 30027243

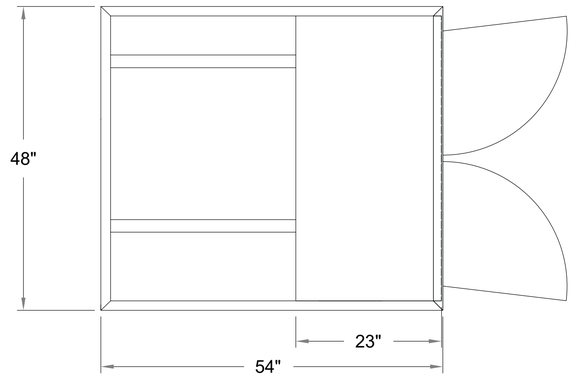
Date SEPTEMBER 2024

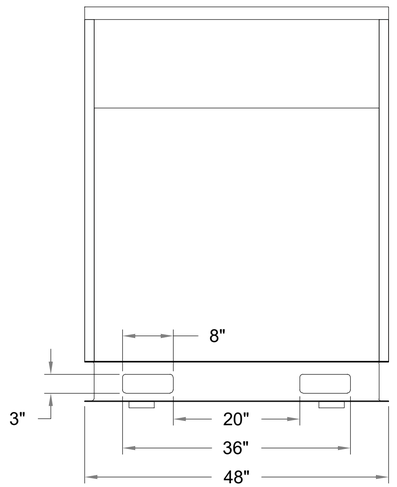
ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

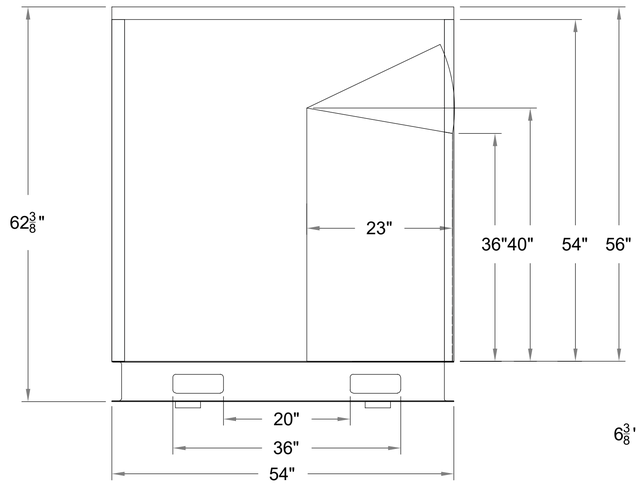
P-3

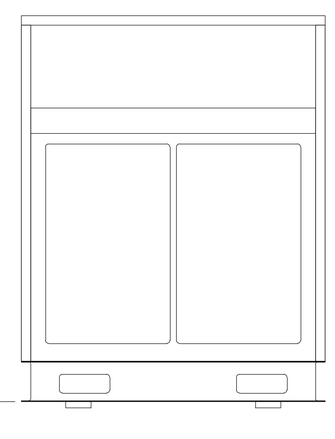
NOTES:

1. 304SS CONSTRUCTION FOR SKID & ENCLOSURE
2. ALL CONNECTIONS SHALL BE MIG WELDED 308SS. FILLET WELDS SHALL BE $\frac{5}{16}$"
3. ALL EQUIPMENT SHALL BE MOUNTED WITH 304SS FASTENERS. SIZE DETERMINED BY THE EQUIPMENT MOUNTING HOLES PROVIDED.
4. GALVANIZED STRUT & FASTENERS SHALL BE USED FOR SECURING PIPING & ELECTRICAL









XREFS:
TISR AS-BUILT DWG-X-TITLE

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0 1' 2'
GRAPHIC SCALE

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Professional Engineer's Name
BLAIR KINSER
Professional Engineer's No.
88162

State	Date Signed	Project Mgr.
CA		HV

Designed by	Drawn by	Checked by
ARCADIS	JH	JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE ● CALIFORNIA
AS-BUILT DRAWINGS ● SD015

FLITEWAY HEAT PUMP SKID DETAIL

AS-BUILTS

ARCADIS Project No.
30027243

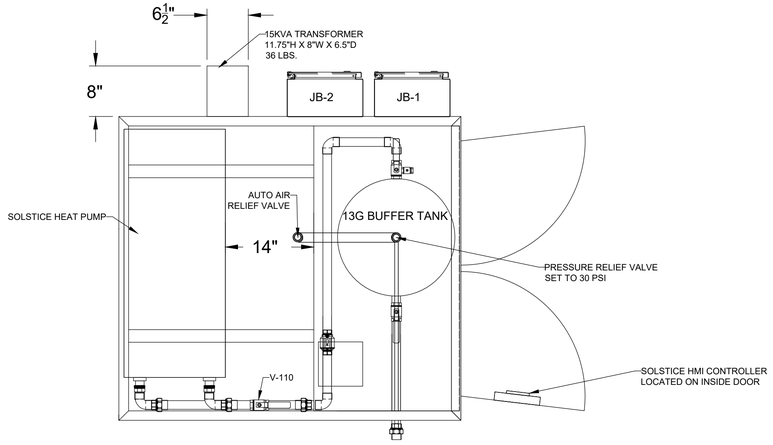
Date
SEPTEMBER 2024

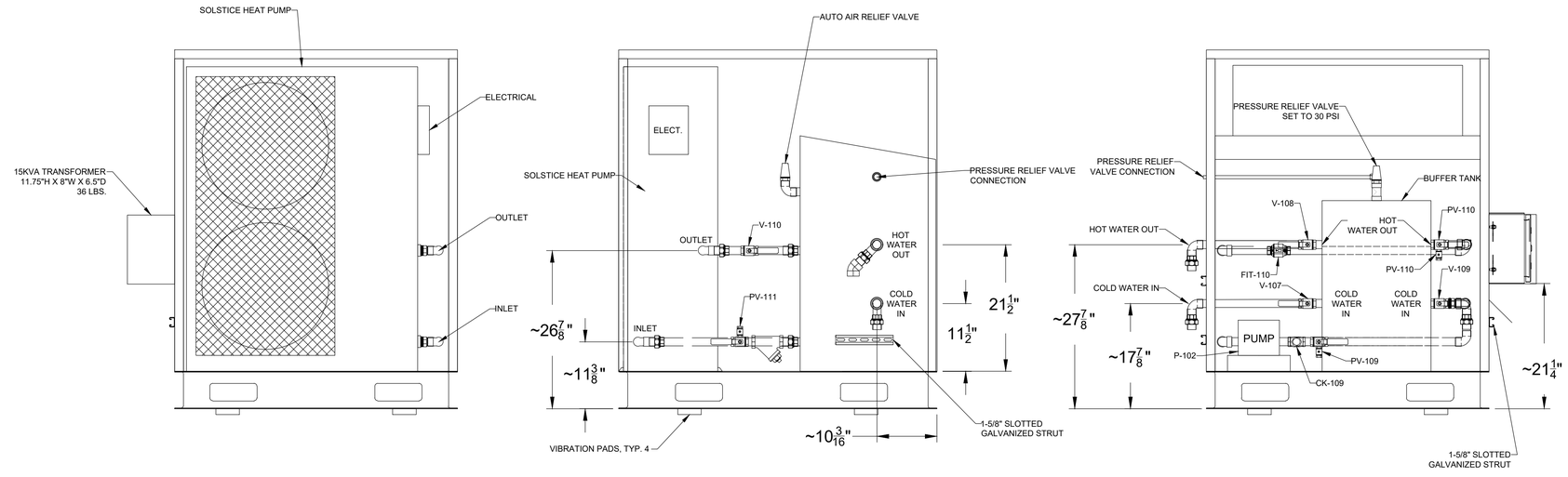
ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

1

NOTES:

1. FLOW METER SHALL HAVE UNIONS ON BOTH SIDES FOR EASE OF MAINTENANCE
2. PUMP SHALL HAVE UNIONS ON BOTH SIDES FOR EASE OF MAINTENANCE
3. STRUT TO BE FASTENED TO THE SKID FOR FIELD CONDUIT & PIPING CONNECTIONS.
4. TRANSFORMER SIZE TBD





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2	07/19/2024	60% DESIGN	BK	JM
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State: CA | Date Signed: | Project Mgr.: HV
Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

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VANDENBERG SPACE FORCE BASE ● CALIFORNIA
AS-BUILT DRAWINGS ● SD015

FLITEWAY HEAT PUMP SKID LAYOUT

AS-BUILTS

ARCADIS Project No. 30027243
Date SEPTEMBER 2024

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

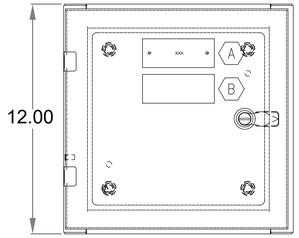
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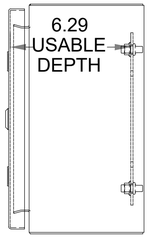
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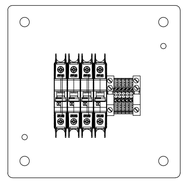
A — JUNCTION BOX
JB-1

COLOR: WHITE W/BLACK LETTERING,
SIZE: 2" TALL X 5" WIDE, 1/4" TALL LETTERS

B — 240 VOLTS



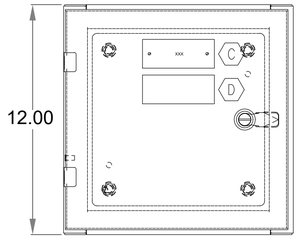


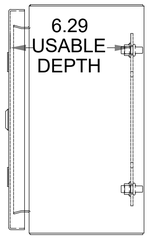


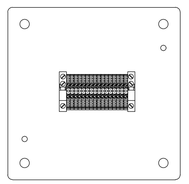
C — JUNCTION BOX
JB-2

COLOR: WHITE W/BLACK LETTERING,
SIZE: 2" TALL X 5" WIDE, 1/4" TALL LETTERS

D — 24 VOLTS







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1	05/17/2024	30% DESIGN	BK	JM

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Professional Engineer's Name: **BLAIR KINSER**
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State: CA | Date Signed: | Project Mgr.: HV
Designed by: ARCADIS | Drawn by: JH | Checked by: JM,WS,BK

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VANDENBERG SPACE FORCE BASE ● CALIFORNIA
AS-BUILT DRAWINGS ● SD015

FLITEWAY JUNCTION BOX LAYOUT

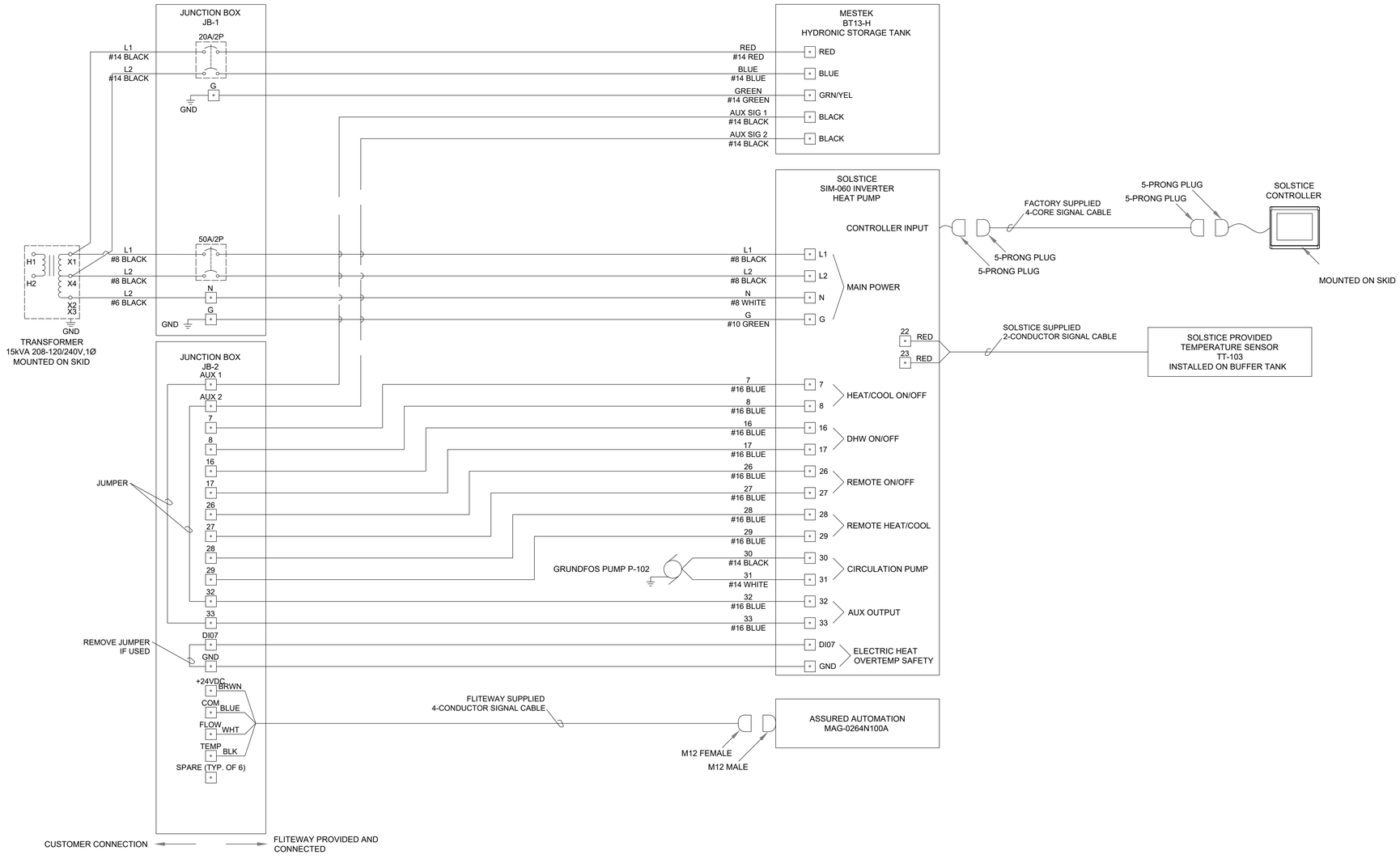
AS-BUILTS

ARCADIS Project No.
30027243

Date
SEPTEMBER 2024

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SUITE 150
SAN LUIS OBISPO, CA 93401

3



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2	07/19/2024	60% DESIGN	BK	JM
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Professional Engineer's Name
BLAIR KINSER
Professional Engineer's No.
88162

State	Date Signed	Project Mgr.
CA		HV

Designed by	Drawn by	Checked by
ARCADIS	JH	JM,WS,BK

ARCADIS U.S., INC.

VANDENBERG SPACE FORCE BASE • CALIFORNIA
AS-BUILT DRAWINGS • SD015

FLITEWAY WIRING SCHEMATIC

AS-BUILTS

ARCADIS Project No.
30027243

Date
SEPTEMBER 2024

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

4

APPENDIX C TISR SYSTEM FIELD COMPLETION MEMO

Memo

SUBJECT
ESTCP TISR Q4 2021 – Q1 2022 Field Completion Memo

DATE
18 February 2022

DEPARTMENT

COPIES TO
Carmen Vidal, Arcadis

TO
Erik Zardouzian, Arcadis
Craig Divine, Arcadis

OUR REF
Arcadis Project 30027243

PROJECT NUMBER
ESTCP Project ER20-5028

NAME
Julia Vidonish Aspinall, 724.317.4630
Mario Alcolea, 805.264.0570

Introduction

Activity:	TISR Drilling and Subsurface Infrastructure Installation
Client:	ESTCP
Site Name:	Site SD015
Site Location:	Vandenberg Space Force Base, California

The goal of the field event was to complete drilling and installation of below-ground components of a Thermal In-Situ Sustainable Remediation (TISR^{SM}) at Site SD015 (the Site) located at Vandenberg Space Force Base (VSFB) in central California. This work was the first phase of installation of a TISR^{SM} system at the site. TISR^{SM} is being demonstrated as part of a current Environmental Security Technology Certification Program (ESTCP) project (ER20-5028) and is being integrated as part of the overall remediation strategy for the Site to address chlorinated solvent impacted media within defined source areas. This ESTCP project is being conducted in partnership between Arcadis, Clemson University, and California State University, Long Beach. TISR^{SM} systems use solar radiation to transfer heat subsurface via solar collectors connected to an array of borehole heat exchangers (BHEs). Solar collectors concentrate solar radiation from the sun to heat a transfer fluid circulating through the collectors into the BHEs. The modest subsurface heating serves to accelerate treatment by enhancing both biotic and abiotic treatment rates.

Pre-Field Activities

A description of pre-field activities conducted to prepare for the drilling and subsurface infrastructure installation event are described below.

Health and Safety Plan

As required by the Occupational Safety and Health Administration Standard “Hazardous Waste Operations and Emergency Response” guidelines (29 Code of Federal Regulations Section 1910.120), field operations were performed under an appropriate health and safety plan (HASP). After discussing the scope of work with Arcadis

safety personnel, the existing Arcadis-VSFB Base-wide HASP was determined to be protective of worker safety. No modifications to the existing HASP were required. This HASP was reviewed by all Arcadis and subcontractor personnel onsite prior to work.

Permitting and Screening

In accordance with VSFB procedures, a VSFB Work Clearance Request (Form 103) and Work Request (Form 332) were completed prior to implementing subsurface disturbances and construction. These work permits identify potential constraints (e.g., natural, cultural, unexploded ordnance [UXO], etc.) and include utility clearance. Preliminary UXO screening was conducted by PenMaxX Consulting on November 5, November 9, and November 15, 2021 prior to the field event. A utility locate was conducted by SoCal locators using ground-penetrating radar screening methods prior to the start of work. VAFB biologists were notified of the intended work areas and approval was obtained prior to accessing the work area.

Utility and UXO Screening

On January 5, 2022, a survey of all monitoring wells, soil vapor probes, DTSs (Distributed Temperature Sensors) locations, and BHEs was completed by Cannon Surveying in compliance with VSFB requirements. Additionally, groundwater and soil vapor sampling were completed at the eight new TISR wells and two SVP locations on the first week of January 2022.

Scope of Work Completed

The drilling and well install activity was conducted in accordance with the Demonstration Plan (Divine et al., 2021) and completed from November 29 to December 9, 2021. Photographs and field forms from the event are provided as Attachments 1 and 2, respectively. Site layout maps and construction drawings are provided as Attachment 3.

Drilling

ABC Liovin mobilized two rigs to Site SD015 at VSFB, a CME 95 to drill using a hollow stem auger (HSA) and a Geoprobe 6712 on tracks to drill using direct push technology (DPT). Prior to drilling, the boring locations were manually cleared for subsurface utilities by advancing a hand auger to approximately 5.0 feet bgs. Boring logs from drilling activities are provided in Attachment 4.

Direct Push Technology Borings

DTS-1, DTS-3, DTS-5, DTS-6, DTS-7, DTS-9, and DTS-10 were installed by ABC Liovin using DPT under the oversight of Arcadis from November 8th to November 14th. These borings were advanced using a Geoprobe 6712 rig using rods to a total depth between 40 to 45 ft bgs. Two of the sensors, DTS-11 and DTS-12, hit refusal at 28 ft bgs and had to be installed using an eight-inch HSA between November 30th and December 1st.

Hollow Stem Auger Borings

Soil borings to install BHE-1 through BHE-8, TISR-1S, TISR-1D, TISR-2S, TISR-2D, TISR-3S, TISR_3D, TISR-4S, TISR_4D, SVP-1 SVP-22, DTS-11, and DTS-12, were advanced using a CME-95 rig by ABC Liovin from November 9th to December 1st. Soil borings for the heat exchangers BHE 1 through BHE-8 were advanced using a ten-inch auger, while the rest of the soil borings were advanced using an eight-inch auger.

Air monitoring was conducted during drilling, taking spot VOCs air samples of the breathing zone and from the soil samples every 5 ft while logging SVP-1, SVP-2, TISR-1D, TISR 2D, TISR-3D and TISR-4D. No VOCs values over 0.0 ppm were detected while drilling in the breathing zone.

TISR wells were initially planned as dual-nested shallow and deep wells but, after a revision from the water board, it was suggested to drill a 5-feet step-out in each location with the purpose of isolating the shallow and deep units and avoid bridging between screened sections. Each location was installed to the specifications described in Table 1 below.

TISR Wells

Borings for the TISR wells were advanced using an eight-inch HSA. TISR wells were installed as shallow and deep wells at a 5 ft step-out with the purpose of isolating the shallow section in one well (TISR-"X"S) and the deeper section in the other well (TISR-"X"D). Each location was installed to the specifications described in Table 1 below. No issues were encountered while drilling the TISR wells.

Table 1. TISR Well Construction and Sampling Specifications

ID	Total Depth (ft bgs)	Well Diameter (in)	Screening Interval (ft bgs)	Construction Details	Sampling Interval
TISR-1S	27.5	2	17.5 to 27.5	Sch 40 PVC, 0.010 slotted screen	-
TISR-1D	40	2	30 to 40	Sch 40 PVC, 0.010 slotted screen	Core sample 35-37.5 ft bgs
TISR-2S	27.5	2	17 to 27	Sch 40 PVC, 0.010 slotted screen	-
TISR-2D	40	2	30 to 40	Sch 40 PVC, 0.010 slotted screen	Core sample 37.5-40 ft bgs
TISR-3S	27.5	2	17.5 to 27.5	Sch 40 PVC, 0.010 slotted screen	Shelby Tube 22.5-25 ft bgs
TISR-3D	40	2	30 to 40	Sch 40 PVC, 0.010 slotted screen	Shelby tube 35-37.5 ft bgs
TISR-4S	27.5	2	17.5 to 27.5	Sch 40 PVC, 0.010 slotted screen	-

TISR-4D	40	2	30 to 40	Sch 40 PVC, 0.010 slotted screen	Core sample 35-37.5 ft bgs

TISR wells were completed with a 2ft x2ft concrete pad and a well monument.

Borehole Heat Exchangers

Borings to install the BHEs were advanced using a ten-inch HSA drill rig. Once the BHE was lowered to the bottom of the hole, the empty space, in sand around the BHE, was filled with 0/30 sand. BHEs were installed to the specifications detailed in Table 2. Photographs are provided in Attachment 1.

Table 2. BHE Construction Specifications

ID	Total Depth (ft bgs)	Well Diameter (in)	Heat exchanger Interval (ft bgs)	Construction Details
BHE-1*	40	10	20 to 40	¾ in stainless steel flexible tubing coiled around a 3 in (ID), 20ft long stainless-steel pipe. Insulated 3/4in stainless steel tubing from 0 to 20ft bgs. *DTS fiber optic cable attached to the inside of the BHE
BHE-2				
BHE-3				
BHE-4				
BHE-5*				
BHE-6*				
BHE-7				
BHE-8				

Soil Vapor Probes

Soil vapor probes were advanced to 20 ft bgs using an 8-inch HSA on November 11th and November 15th, respectively. Soil vapor probes were completed with a 2ft x 2ft concrete pad and a well monument. Soil vapor probes were installed to the specifications detailed in Table 3.

Table 3. Soil Vapor Probe Construction Specifications

ID	Total Depth (ft bgs)	Construction details
SVP-1	20	Dual nested vapor sampling probes with center of probes set at 4.5ft bgs and 17.5ft bgs
SVP-2		

Distributed Temperature Sensors

DTS-1, DTS-3, DTS-5, DTS-6, DTS-7, DTS-9, and DTS-10 were advanced using DPT from November 8th to November 14th. DTS-11 and DTS-12, hit refusal at 28 ft bgs and had to be installed using an eight-inch HSA between November 30th and December 1st. Once the sensor was lowered to the target depth, the drilling crew let the formation collapse around the sensor/fiber optics cable. In the case of the borings drilled with HSA, the hole was also back-filled with the soil generated while drilling. Photographs are provided in Attachment 1.

Table 4. DTS Construction Specifications

ID	Drilling details	Total Depth (ft bgs)
DTS-1	Drilled with DPT	40
DTS-2	Installed along with BHE-1	
DTS-3	Drilled with DPT	
DTS-4	Installed along with BHE-5	
DTS-5	Drilled with DPT	
DTS-6	Drilled with DPT	
DTS-7	Drilled with DPT	
DTS-8	Installed along with BHE-6	
DTS-9	Drilled with DPT	
DTS-10	Drilled with DPT	
DTS-11	Drilled with HSA due to refusal with DPT at 28 ft bgs	
DTS-12	Drilled with HSA due to refusal with DPT at 28 ft bgs	

DTS-1, DTS-4 and DTS-8 were installed as part of the BHE-1, BHE-5 and BHE-6 respectively, attached to the inside of the 3in steel pipe and lowered to 40ft bgs. DTS locations that were not part of a BHE installation were completed with a 1.5in galvanized pipe attached to a plastic electrical junction box. Fiber optics cables are protected by a 2in HDPE pipe and were fused on-site as part of the temperature monitoring system.

Sampling

Soil Sampling

Two different types of soil samples were collected from the TISR wells:

- Core samples: Collected from TISR-1D, TISR-2D and TISR-4D. These samples were double vacuum sealed with an oxygen absorbing packet between the bags and kept refrigerated until their destination.
- Shelby tubes: Collected from TISR-3S and TISR-3D. These samples were collected directly in a stainless-steel tube and protected with plastic end-caps. They were also refrigerated until they reached the laboratory.

Samples were submitted for the following analyses:

- Core samples: Laboratory measurement of degradation rates to be performed in different sets of microcosms prepared with samples from TISR-1D, TISR2-D and TISR-4D, and groundwater. Laboratory measurement of degradation rates will be performed in two sets of microcosms prepared with samples of site soil and groundwater. The first set will consist of three treatments: unamended (to simulate natural attenuation), electron donor amended (to simulate bio-stimulation) and killed controls (to simulate only abiotic activity). Analyses to be conducted at Clemson University in South Carolina.
- Shelby tubes: Hydraulic Properties Package (HPP) with rigid wall Ksat and Thermal properties: five to ten points. These laboratory measurements will be performed to help refine a detailed thermal and contaminant transport numerical model. Analyses to be conducted by Daniel B. Stephens & Associates, Inc.

Groundwater Sampling

Water samples from the TISR wells were collected on January 4th and 5th, 2022. The wells were purged using a whale pump in the shallow wells (TISR-"X"S) and a monsoon pump in the deep wells (TISR-"X"D). After purging, the samples were collected and sent to Microbial insights laboratory to perform the following tests:

- QuantArray-Chlor, to identify key microorganisms.
- CENSUS AHY to determine concentrations of contaminant degraders.
- 16S rDNA Profiling to determine gene sequencing profiles generated from bacterial communities.
- CSIA (TCE, cis-1,2-DCE, VC) analyses to determine presence of TCE and TCE degradation.

A second set of water samples was sent to EMAX laboratories to test for the following analytes: Sulfites, Fe and Mn, MEE and acetylene, TOC, Anions (Nitrate, Sulfate, Chloride), CVOCs, CO_2 and alkalinity.

Soil Vapor Sampling

Soil vapor samples were collected on January 5th from SVP-1 and SVP-2, both from the shallow and the deep probes. Both wells were purged 3 volumes before collecting the samples. The Tedlar bags with the samples were sent overnight to ALS laboratories to test for VOC's and fixed gases.

Well Development

Well development was performed from December 7 through 9, 2021. The wells were surged manually due to technical considerations that prevented the use of a skid steer and hydraulic winch. The well development responses for each TISR well are detailed below.

- **TISR-1S:** Approximately 50 gallons were pumped in total at 1 gallon per minute (gpm). The well was finished with a 2.33 ft stick-up monument. Depth to water was 23.62 ft bgs and total depth was 30.13 ft bgs.
- **TISR-1D:** Approximately 70 gallons were pumped in total at a rate of 0.5 to 0.75 gpm. The well was finished with a 2.3 ft stickup monument. Depth to water was 22.97 ft bgs and total depth was 42.67 ft bgs. TISR-1D had the best performance of all deep wells.
- **TISR-2S:** Approximately 56 gallons were pumped at a rate of 0.4 gpm. The well was finished with a 2.4 ft stickup monument. Depth to water was 23.17 ft bgs and total depth was 29.89 ft bgs.
- **TISR-2D:** Approximately 36 gallons were pumped at 0.25 gpm. The well was finished with a 2.08 ft stick up monument. Depth to water was 24.40 ft bgs and total depth was 42.90 ft bgs.
- **TISR-3S:** Approximately 33 gallons were pumped at 0.75 gpm. The well was finished with a 2.6 ft stick up monument. Depth to water was 23/35 ft bgs and total depth was 30.20 ft bgs.
- **TISR-3D:** Well development started on December 7, 2021. After pumping for one hour, turbidity remained above 1,000 NTU. Pumping was stopped to re-evaluate. It was decided to finish the development if the

well could not recharge pumping at 0.25 gpm. On December 10, the well was bailed one more time and pumped dry to clean it. After it recharged, it was pumped at 0.25 GPM and, after 2h, the water level got below the pump and development was completed. Turbidity readings did not decrease below 1,000 NTU.1000 NTU. Approximately 56 gallons were pumped at 0.25 to 0.4 gpm. The well was finished with a 2.25 ft stick up monument. Depth to water was 22.90 ft bgs and total depth was 42.04 ft bgs.

- **TISR-4S:** Approximately 95 gallons were pumped at 1 gpm. The well was finished with a 2.25 ft stick up monument. Depth to water was 22.75 ft bgs and total depth was 30.08 ft bgs.
- **TISR-4D:** Well development was started on December 8, 2021 and completed on December 10, 2021 due to issues with the water quality meter. On December 10, 2021 the well recharged after previous pumping attempts and pumped at 0.25 for over 1.5 hours until turbidity readings were below 170 NTU. In total, approximately 46 gallons were pumped at 0.25 gpm. The well was finished with a 2.25 ft stickup monument. Depth to water was 22.87 ft bgs and total depth was 42.42 ft bgs.

Copies of Field Forms are provided in Attachment 2 and Boring and Well Development Logs are provided in Attachment 4.

Issues Encountered

The following issues were encountered during the field event:

- On November 8th, the DPT and HSA rigs were mobilized to the SD015 site to install four TISR wells, eight BHEs and twelve DTSs, but only the DPT rig was able to start drilling due to the very loose sand present onsite that caused the HSA rig to get stuck while mobilizing to the first location. This issue was resolved the next day when the ABC crew brought mud mats to the site.
- During the well development phase, the water meter sensor, a Horiba U-54, malfunctioned and stopped working causing a data loss at TISR-1S, TISR-1D and TISR 4D. ABC Liovin was able to bring a new unit the next day to be able to gather data from the remaining wells. TISR-1D was partially re-developed to acquire water quality data from that location.
- During the January sampling event, 15-IW-17 was found to contain milky water evident of residual molasses from prior injection events and therefore was not sampled.

Deviations from Demonstration Plan

Several design considerations and field adaptations have occurred from the Demonstration Plan. These deviations, rationales, and expected impacts are detailed below.

On June 7, 2021, the Water Board submitted a comment to the Demonstration Plan suggesting that the 20-foot well screens at the four proposed TISR wells were insufficient to account for the stratified CVOC distribution observed at SD015. The presence of clean groundwater at the top end of the screen and CVOC-impacted water at the bottom could potentially confound understanding of concentration trends. Therefore, the TISR wells were installed as four well pairs, with one shallow well (screened approximately 17 to 27 ft bgs) and one deep well (screened 30-40 ft bgs), at each location. This well construction isolates the shallow and the deep units avoiding the possibility of bridging between two screen intervals. It will also allow for better insight into the stratified nature of impacts at SD015 and the subsequent impacts of subsurface heating.

Additionally, the Demonstration Plan stated that baseline groundwater sampling would be conducted from existing monitoring wells 15-MW-08 and 15-IW-17 outside of the treatment area. However, 15-IW-17 was found in January 2022 to contain milky water from residual molasses from previous injections and will not be sampled due to data quality and representativeness concerns. However, baseline concentrations in the area will be adequately represented by 15-MW-41 and 15-MW-08. Following system startup, 15-MW-08 will serve as the comparison well outside the heating area.

Waste Management

Investigation-derived waste (IDW) generated during field activities were handled, stored and profiled in accordance with all local State and Federal regulations, and the Arcadis Investigation-Derived Waste Handling and Storage Standard Operation Procedure, which is included in the Final Basewide UFP-QAPP (Arcadis 2015). Waste generated during this project includes solid drill cuttings, drilling slurry waste, decontamination water and well development water.

The solid wastes were containerized in 20-yard roll-off bin provided by Waste Management, Inc. and 55-gallon drums. One roll-off was filled at 2/3 capacity to store the drilling slurry/cuttings mixture from drilling. Tool decontamination was performed by ABC Liovin on-site. Soil cuttings in roll-off bins and drums, and wastewater, will be profiled and handled by an approved facility depending on the results.

The wastewater generated from tool decontamination was emptied in the wastewater tanks at Arcadis' drum yard at VSFB. These wastewater tanks are profiled regularly and disposed of in accordance with the above regulations. Liquid waste from the development phase of the TISR wells was left to settle overnight in 55-gallon drums to reduce the amount of solids in the liquid. The next day, the water was re-circulated into the DGR system at the site to be treated and injected back into the aquifer. Approximately 450 gallons of wastewater were generated during the development of the TISR wells.

Survey

In compliance with VSFB guidance, all TISR wells, DTS locations, SV points, and BHEs were surveyed on January 5th by Cannon Corp Engineering Consultants of San Luis Obispo, California, a state-licensed land surveying firm.

Ongoing and Upcoming Work

Baseline push-pull tracer tests to measure in situ biological activity are scheduled to be completed in February 2022. The installation of the remaining TISR^{SM} system infrastructure, including setup and connection of solar collectors, electrical trenching, and aboveground piping, is anticipated to be completed early in the second quarter of 2022. TISR^{SM} startup is also anticipated late in the second quarter of 2022.

References

Arcadis 2015. Final Basewide Uniform Federal Policy-Quality Assurance Project Plan, Performance-Based Remediation at Vandenberg Air Force Base, California. December 23.

Divine et al., 2021. Draft Demonstration Plan, Thermal In-Situ Sustainable Remediation (TISR^{SM}) to Enhance Biotic and Abiotic Reactions and Accelerate Remediation Timeframes, ESTCP Project ER20-5028, Version 3. May.

Attachments

Attachment 1 – Photo Log

Attachment 2 – Field Forms

Attachment 3 – Construction Drawings

Attachment 4 – Boring and Well Development Logs

Photograph Log

ESTCP TISR December 2021 Field Completion Memo
VSFB SD015



Photograph: 1

Description:
View of TISR area within site SD015



Photograph: 2

Description:
Drilling on mud mats

Photograph Log

ESTCP TISR December 2021 Field Completion Memo
VSFB SD015



Photograph: 3

Description:
Loose sand at SD015



Photograph: 4

Description:
Installation of BHE-5 and DTS-4

Photograph Log

ESTCP TISR December 2021 Field Completion Memo
VSFB SD015



Photograph: 5

Description:
Drilling of BHE-6



Photograph: 6

Description:
Installation of BHE-7

Photograph Log

ESTCP TISR December 2021 Field Completion Memo
VSFB SD015



Photograph: 7

Description:
Installation of BHE-8



Photograph: 8

Description:
Lifting of BHE-6

Photograph Log

ESTCP TISR December 2021 Field Completion Memo
VSFB SD015



Photograph: 9

Description:
Handling of BHE-8 prior to installation

ABC LIOVIN Rotary | Sonic | DPT | HSA | Air Knife

1180 E. Burnett Street, Signal Hill, CA 90755 (562) 981-8575 Fax (562) 981-9594 www.abcdrilling.com

INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis | DAY: Mon | DATE: 11-29-21

JOB LOCATION: Vandenberg AFB | CITY: Vandenberg AFB | CLIENT P.O.#

HOLE #		TISR-			TISR-		
SURFACE D/A/C		0			0		
# OF SOIL SAMPLES		35'			/		
FOOTAGE TODAY		40.5			28.0		
HOLE DIAMETER		8"			8"		
WELL DIAMETER		2"			2"		
TOTAL FOOTAGE		40.5			28.0		
CEMENT SEAL	FROM	2.0			2.0		
	TO	24.5		13.5			
BENT SEAL	FROM	24.5		13.5			
	TO	28			15.5		
SAND Type 2/16	FROM	28			15.5		
	TO	40.5			28.0		
CASING PVC Type Blank	FROM	0			0		
	TO	30			17.5		
SCREEN Type ____ Slot 010	FROM	30			17.5		
	TO	40			27.5		
WATER LEVEL							

DESCRIPTION OF WORK

START	STOP	HOURS TOTAL
400	430	
430	930	
930		

Loading - Fuel
Travel
Mob in - Pick up Equip
Mob to Drill Site
Setup - (TISR-20) MIS
Cont. Core from 5' to 40' Break down Equip - Install 2" Well @ 40' w/ 10 of 010 Screen - 2/16 Sand
Sand - Surge - Seal -
Lunch — 100 130
Tremie Portland - Pull out - top off - Move to (TISR-25) Setup - Drill to 28' w/ wood Plug - Install 2" Well - w/ 10' of 010 Screen
Sand - Surge - Seal -

TOTAL CHARGEABLE ONSITE RIG HOURS

RENTALS: | MILES/ HOURS: | INSPECTED? ☐ | DELIVERED FULL? ☐ | RETURNED FULL? ☐ | CALLED OFF? ☐

EQUIPMENT CM695

RIG #	A-8	JACK HAMMER	
FLATBED TRUCK #		AUX AIR COMPRESSOR	
FLATBED TRUCK #		FORKLIFT/ HOPPER	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE	YES 35'
# OF SAW CUTS		# OF WATER SAMPLES	
# OF CORE CUTS		A/C HOT PATCHES	
#BULL DOG CNCRT		LEVEL C HOURS	
BOBCAT			

CASING

DIAMETER	2"	4"
20 FT. SCREEN		
10 FT. SCREEN	2	
5 FT. SCREEN		
20 FT. BLANK		
10 FT. BLANK	5	
5 FT. BLANK	1	
SLIP CAP		
THREADED CAP	2	
LOCKING CAPS	2	

MATERIALS

ITEM	QTY.	ITEM	QTY
SAND (TYPE) 2/16 (1) 2/12 (8)		INSTALL (____") WELL COVER	
GRAVEL		REMOVE (____") WELL COVER	
READY MIX		MONUMENT CASING 6"	2
QUICK SET		BOLLARD POST	
PORTLAND CEMENT	20	SAMPLE LINERS SST/BRSS	
BENTONITE GROUT		HOLE COVER PLATES	
BENTONITE CHIPS	3	CONES/ DELINEATORS	
BENTONITE POWDER	1	CORE BOXES	
COATED PELLETS		DRUMS	
BENTONITE GRANULAR		NEW DRUMS	
ASPHALT PATCH		TUBING	
SAMPLER / SHOE		VAPOR PROBE (TYPE)	
BIT / AUGER REPAIR			
WOOD/ STEEL PLUGS 8"	1		
PLASTIC SHEETING	1		

REMARKS: Tremie Portland - Pull out - top off - Install Monuments - Clean up - Secure Site - Fill water Tank - Finish PM Shop Bank - Hotel

ENGINE HOURS	Start	Stop	Total

NAME (Print First & Last)	Per Diem	A.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	P.M. SHOP OUT
Jamie Moore	☐	400	430	430	930	930	100	130	JM	—	—	—	515	515	545	545	630
Jason Cotter	☐	400	430	430	930	930	100	130	JC	—	—	—	515	515	545	545	630
Luis Montes	☐	400	430	430	930	930	100	130	LM	—	—	—	515	515	545	545	630
	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

ABC LIOVIN Rotary | Sonic | DPT | HSA | Air Knife

1180 E. Burnett Street, Signal Hill, CA 90755 (562) 981-8575 Fax (562) 981-9594 www.abcdrilling.com

INVOICE NUMBER 392299

DAILY DRILL REPORT

CLIENT: Arcadis DAY: Tues DATE: 11-30-21

JOB LOCATION: Vandenberg AFB CITY: Vandenberg AFB CLIENT P.O.#

HOLE #	DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C	Loading -	600	615	
# OF SOIL SAMPLES	Travel	615	700	
FOOTAGE TODAY	HSS - Move - Chase	700		
HOLE DIAMETER	Truck - Check site - Move			
WELL DIAMETER	Rig to (BHE-6X) Setup -			
TOTAL FOOTAGE	Drill 10" Auger to 40' 11.7			
CEMENT SEAL FROM	Bedrock - Install Heat Exchange			
CEMENT SEAL TO	Sand up to 8' w/ 0/30 Sand	1230		
BENT SEAL FROM	Lunch	1230	100	
BENT SEAL TO	Tremie Pothead - Pull	100		
SAND Type ____ FROM	out - top off - Move to			
SAND Type ____ TO	(OTS-11) Drill to 40' Install			
CASING FROM	Sensor @ 40' Pull out - Clean			
CASING Type ____ TO	up - Move to (OTS-12) Setup			
SCREEN Type ____ FROM	Drill to 25' - Clean up -			
SCREEN Slot ____ TO	Loading - Install Concrete			
WATER LEVEL	# Forms on Wells -			

TOTAL CHARGEABLE ONSITE RIG HOURS:

RENTALS: MILES/ HOURS: INSPECTED? ☐ DELIVERED FULL? ☐ RETURNED FULL? ☐ CALLED OFF? ☐

EQUIPMENT CME 95

RIG #	R-8	JACK HAMMER		DIAMETER	2"	4"	
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			
FLATBED TRUCK #		FORKLIFT/ HOPPER	Yes	10 FT. SCREEN			
TRAILER #	T-8	CONT. SAMPLER FOOTAGE		5 FT. SCREEN			
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK			
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK			
BOBCAT				SLIP CAP			
				THREADED CAP			
REMARKS:	Pressure test Heat Exchange -			LOCKING CAPS			

MATERIALS

ITEM	QTY	ITEM	QTY
SAND (TYPE) 0/30 (22) 2/12 (4)		INSTALL (____") WELL COVER	
GRAVEL		REMOVE (____") WELL COVER	
READY MIX	10	MONUMENT CASING	
QUICK SET	2	BOLLARD POST	
PORTLAND CEMENT	10	SAMPLE LINERS SST/BRSS	
BENTONITE GROUT		HOLE COVER PLATES	
BENTONITE CHIPS		CONES/ DELINEATORS	
BENTONITE POWDER	1	CORE BOXES	
COATED PELLETS		DRUMS	
BENTONITE GRANULAR		NEW DRUMS	
ASPHALT PATCH		TUBING	
SAMPLER / SHOE		VAPOR PROBE (TYPE)	
BIT / AUGER REPAIR		6" X 5' Black Pipe (1)	
WOOD/ STEEL PLUGS 8" (2) 10" (1)			
PLASTIC SHEETING			

ENGINE HOURS	Start	Stop	Total

NAME (Print First & Last)	Per Diem	A.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	P.M. SHOP OUT
Jamie Moore	☐	600	615	615	700	700	1230	100	JM	-	-	JM	500	500	545	545	630
Luis Mendez	☐	600	615	615	700	700	1230	100	LM	-	-	LM	500	500	545	545	630
Juan Cortez	☐	600	615	615	700	700	1230	100	JC	-	-	JC	500	500	545	545	630
	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

ABC LIOVIN Rotary | Sonic | DPT | HSA | Air Knife

1180 E. Burnett Street, Signal Hill, CA 90755 (562) 981-8575 Fax (562) 981-9594 www.abcdrilling.com

INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis DAY: Wed DATE: 12-01-21

JOB LOCATION: Vandenberg AFB CITY: Vandenberg AFB CLIENT P.O.#

HOLE #	DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C	Loading -	600	615	
# OF SOIL SAMPLES	Travel	615	700	
FOOTAGE TODAY	Setup - (DTS-12) Drill	700		
HOLE DIAMETER	from 25' to 40'. Install			
WELL DIAMETER	probe - Pull out backfill			
TOTAL FOOTAGE	station - Cleanup - Install			
CEMENT SEAL FROM	Concrete forms on 5 -			
CEMENT SEAL TO	locations - Cleanup -			
BENT SEAL FROM	Loading -			
BENT SEAL TO	Secure site			
SAND Type ____ FROM				
SAND Type ____ TO	Lunch	1200	1230	
CASING Type ____ FROM				
CASING Type ____ TO				
SCREEN Type ____ FROM				
SCREEN Slot ____ TO				
WATER LEVEL		TOTAL CHARGEABLE ONSITE RIG HOURS		

RENTALS: MILES/ HOURS: INSPECTED? ☐ DELIVERED FULL? ☐ RETURNED FULL? ☐ CALLED OFF? ☐

EQUIPMENT				CASING			MATERIALS			
RIG #	D-8	JACK HAMMER	CME 95	DIAMETER	2"	4"	ITEM	QTY.	ITEM	QTY
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE)		INSTALL (___") WELL COVER	
FLATBED TRUCK #		FORKLIFT/ HOPPER	YES	10 FT. SCREEN			GRAVEL		REMOVE (___") WELL COVER	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE		5 FT. SCREEN			READY MIX		MONUMENT CASING	
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET	4	BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK			PORTLAND CEMENT		SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK			BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT				SLIP CAP			BENTONITE CHIPS		CONES/ DELINEATORS	
				THREADED CAP			BENTONITE POWDER		CORE BOXES	
REMARKS:				LOCKING CAPS			COATED PELLETS		DRUMS	
							BENTONITE GRANULAR		NEW DRUMS	
							ASPHALT PATCH		TUBING	
							SAMPLER / SHOE		VAPOR PROBE (TYPE)	
							BIT / AUGER REPAIR			

ENGINE HOURS	Start	Stop	Total

WOOD/ STEEL PLUGS

PLASTIC SHEETING

NAME (Print First & Last)	Per Diem	A.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	P.M. SHOP OUT
Jannie Moore	☐	600	615	615	700	700	1200	1230	JM	—	—	JM					
Juan Cortez	☐	600	615	615	700	700	1200	1230	JC	—	—	JC					
Luis Mateos	☐	600	615	615	700	700	1200	1230	LM	—	—	JC					
	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

Document Control Number:TGM - _____
TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

ARCADIS Design & Consultancy for natural and built assets

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SD15 TISR Installation			**Project Location:** VSFB CA
Date: 11/5/2021	**Time:** 0730	**Conducted by:** Marshall Brusa	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** Pennax

Initial Site Walk Comments:

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Clear DTS locations to 5' 3 clear solar array area to 2' 5 _____
2 Mount solar array locations 4 _____ 6 _____

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: NONE

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☒ If deviations, notify PM & client
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ All equipment checked & OK?
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L (M) H) STF, vegetation / sand	☒ Motion (i.e. traffic, moving water) (L M H)	☒ Mechanical (i.e., augers, motors) (L (M) H) hand auger - repetitive motion
☒ Electrical (i.e., utilities, lightning) (L (M) H) OH power lines	☐ Pressure (i.e. gas cylinders, wells) (L M H)	☒ Environment (i.e. heat, cold, ice) (L (M) H) cold
☐ Chemical (i.e., fuel, acid, paint) (L M H)	☒ Biological (i.e., ticks, poison ivy) (L (M) H) ticks, snakes, bees	☒ Radiation (i.e., alpha, sun, laser) (L (M) H)
☐ Sound (i.e., machinery, generators) (L M H)	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L (M) H) car / truck

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)

☐ Elimination	☐ Substitution	☐ Isolation
☐ Engineering controls	☐ Administrative controls	☐ Monitoring
☐ General PPE Usage	☐ Hearing Conservation	☐ Respiratory Protection
☐ Personal Hygiene	☐ Exposure Guidelines	☐ Decon Procedures
☐ Emergency Action Plan (EAP)	☐ Fall Protection	☐ Work Zones/Site Control
☐ JSA to be developed/used ***(specify)***	☐ TIP conducted ***(specify job/JSA)***	☐ Traffic Control
☐	☐	☐ Other ***(specify)***
☐	☐	☐

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand
Marshall Brasca / ANA /	0730		✓
Matt Sanders / Penmaxx /			
Dave & L Watkins / Penmaxx /			

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at 1.800.455.6155 and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

	In	Out
	In	Out
	In	Out
	In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- ☐ Lessons learned and best practices learned today: _____
- ☐ Incidents that occurred today: _____
- ☐ Any Stop Work interventions today? _____
- ☐ Corrective/Preventive Actions needed for future work: _____
- ☐ Any other H&S issues: _____

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

Document Control Number:TGM - _____

TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

ARCADIS Design & Consultancy for natural and built assets

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SDOIS TISR Install		**Project Location:** VSFB CA	
Date: 11/8/21	**Time:**	**Conducted by:** Marshall Brusca	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC & CSULB

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Mob/set-up equipment onsite 3 collect TISR soil samples 5 assemble BHE devices

2 begin drilling TISR/OTS points 4 install fiber optic cable 6 _____

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: none

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☒ If deviations, notify PM & client
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ All equipment checked & OK?
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L (M) H) STF-offroad, equipment	☒ Motion (i.e. traffic, moving water) (L (M) H) multiple vehicles onsite	☒ Mechanical (i.e., augers, motors) (L (M) H) pinch points; drill rigs
☒ Electrical (i.e., utilities, lightning) (L (M) H) OH power lines	☒ Pressure (i.e. gas cylinders, wells) (L (M) H) hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L (M) H)
☒ Chemical (i.e., fuel, acid, paint) (L (M) H) COCs in groundwater	☒ Biological (i.e., ticks, poison ivy) (L (M) H) ticks, snakes, bees	☒ Radiation (i.e., alpha, sun, laser) (L (M) H)
☒ Sound (i.e., machinery, generators) (L (M) H) DPT / HSA Rigs	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L (M) H) car; truck; forklift

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)
- [x] Elimination
- [x] Engineering controls
- [x] General PPE Usage
- [x] Personal Hygiene
- [x] Emergency Action Plan (EAP)
- [x] JSA to be developed/used ***(specify)***
- [x] Substitution
- [x] Administrative controls
- [x] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [x] Isolation
- [x] Monitoring
- [x] Respiratory Protection
- [x] Decon Procedures
- [x] Work Zones/Site Control
- [x] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Jamie Moore ABC	0715		
Marshall Brusca / ANA /	1030		
Chris Kim / ABC /	1030		
Chace Weck / ABC /	0930		
Megan Ward-Daranyay / CSULB /	0930		
Francine Cason / CSULB /	0930		
Matthew Reeder CSULB	0730		
Josh Markland / ANA /	1130		
Luis Mendoza / ABC /			

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

Juan Cortez ABC

In	Out
In	Out
In	Out
In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- [ ] Lessons learned and best practices learned today: _____
- [ ] Incidents that occurred today: _____
- [ ] Any Stop Work interventions today? _____
- [ ] Corrective/Preventive Actions needed for future work: _____
- [ ] Any other H&S issues: _____

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

Document Control Number:TGM - _____
TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

ARCADIS Design & Consultancy for natural and built assets

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SDOS TISR Installation		**Project Location:** VSFB CA	
Date: 11/9/21	**Time:** 0730	**Conducted by:** Marshall Barsa	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC, Pennex

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Continue DPT drilling & DTS installs; build BHEs & install
2 Mobilize HSA rig & begin drilling; install TISR & SVP
5 Sample TISR locations
6

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: none

If yes, describe them here:

How will they be controlled?

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☐ Any Stop Work Interventions yesterday?
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ If deviations, notify PM & client
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ All equipment checked & OK?
		☒ Staff knows gathering points?

Comments:

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L M H): STF, ppg, holes, offroad, equip.	☒ Motion (i.e., traffic, moving water) (L M H): many vehicles; repetitive motion	☒ Mechanical (i.e., augers, motors) (L M H): DPT/HSA rigs; building BHEs
☒ Electrical (i.e., utilities, lightning) (L M H): OH power lines; outlets → wet	☒ Pressure (i.e. gas cylinders, wells) (L M H): hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L M H): rain; covid
☒ Chemical (i.e., fuel, acid, paint) (L M H): cuts in gw	☒ Biological (i.e., ticks, poison ivy) (L M H): buckwheat; snakes; bees	☒ Radiation (i.e., alpha, sun, laser) (L M H)
☒ Sound (i.e., machinery, generators) (L M H): DPT/HSA Rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H): forklift, rig,

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

☒ **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)		
☒ Elimination	☒ Substitution	☒ Isolation
☒ Engineering controls	☒ Administrative controls	☒ Monitoring
☒ General PPE Usage	☐ Hearing Conservation	☒ Respiratory Protection
☐ Personal Hygiene	☐ Exposure Guidelines	☒ Decon Procedures
☐ Emergency Action Plan (EAP)	☐ Fall Protection	☒ Work Zones/Site Control
☐ JSA to be developed/used ***(specify)***	☐ TIP conducted ***(specify job/JSA)***	☒ Traffic Control
		☐ Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Marshall Brisco / ANA /			
Ram Meeda / ANA /	07:00		MA
Chace Lueck / ABC /			
Chris Kim / ABC /			

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

	In	Out
	In	Out
	In	Out
	In	Out

I **will STOP** the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I **will be** alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- ☐ Lessons learned and best practices learned today: _____
- ☐ Incidents that occurred today: _____
- ☐ Any Stop Work interventions today? _____
- ☐ Corrective/Preventive Actions needed for future work: _____
- ☐ Any other H&S issues: _____

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

Document Control Number:TGM - _____
TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

ARCADIS Design & Consultancy for natural and built assets

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SP015 TISR Installation		**Project Location:** VSFB, CA	
Date: 11/10/21	**Time:** 0700	**Conducted by:** Marshall Brusa	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Grout @ BHE-5
2 Move on to other HSA locations
3 Complete DPT, DTS install
4 construct BHEs
5 install TISR/SVE
6 sample TISR

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: None

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☐ Any Stop Work Interventions yesterday?
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ If deviations, notify PM & client
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ All equipment checked & OK?
		☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L M H) STF, offroad, equip.	☒ Motion (i.e., traffic, moving water) (L M H) moving vehicles; lifting	☒ Mechanical (i.e., augers, motors) (L M H) HSA; DPT; pinchpoints
☒ Electrical (i.e., utilities, lightning) (L M H) OH power lines; outlets	☒ Pressure (i.e. gas cylinders, wells) (L M H) pressure testing BHEs	☒ Environment (i.e., heat, cold, ice) (L M H) wind; heat; COVID
☒ Chemical (i.e., fuel, acid, paint) (L M H) loss in GW; gasoline	☒ Biological (i.e., ticks, poison ivy) (L M H) ticks snakes spiders bees	☒ Radiation (i.e., alpha, sun, laser) (L M H)
☒ Sound (i.e., machinery, generators) (L M H) DPT/HSA Rigs	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H) car; truck; forklift

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

☒ **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)		
☒ Elimination	☒ Substitution	☒ Isolation
☒ Engineering controls	☒ Administrative controls	☒ Monitoring
☒ General PPE Usage	☐ Hearing Conservation	☒ Respiratory Protection
☐ Personal Hygiene	☐ Exposure Guidelines	☒ Decon Procedures
☐ Emergency Action Plan (EAP)	☐ Fall Protection	☒ Work Zones/Site Control
☐ JSA to be developed/used ***(specify)***	☐ TIP conducted ***(specify job/JSA)***	☒ Traffic Control
☐	☐	☐ Other ***(specify)***
☐	☐	☐

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Matthew Bruce / DOE B	MB 0700		
Marshall Brasca / ANA	700 MA		
Hans Hladik / ANA	700 HH		
Juan Cortez / ABC	700 JC		
Luis Mendoza / ABC	700 LM		
Jamie Moore (ABC)	700 JM		
Josh Mehalland / ANA	700 JM		
Chace Weck / ABC	0700 CW		
Chris Fan / ABC	0700 CF		
Francine Cason / CSVLB			

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

	In	Out
	In	Out
	In	Out
	In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK;** and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- ☐ Lessons learned and best practices learned today: _____
- ☐ Incidents that occurred today: _____
- ☐ Any Stop Work interventions today? _____
- ☐ Corrective/Preventive Actions needed for future work: _____
- ☐ Any other H&S issues: _____

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

Document Control Number:TGM - _____
TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

ARCADIS Design & Consultancy for natural and built assets

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SD015 TISR Installation		**Project Location:** USFB, CA	
Date: 11/11/21	**Time:** 0700	**Conducted by:** Marshall Brusa	**Signature/Title:**
Client: AFCEC	**Client Contact:** -	**Subcontractor companies:** ABC	

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Backfill BHE-7
2 Drill TISRs & SVP
3 Sample / logging
4 MW / SVP installs
5
6

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: NONE

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☒ If deviations, notify PM & client
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ All equipment checked & OK?
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L M H) STF: offroad; equipment	☒ Motion (i.e., traffic, moving water) (L M H) moving vehicles	☒ Mechanical (i.e., augers, motors) (L M H) HSA pinch points; sharp tools
☒ Electrical (i.e., utilities, lightning) (L M H) OH power lines	☒ Pressure (i.e. gas cylinders, wells) (L M H) hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L M H) wind; heat; covid
☒ Chemical (i.e., fuel, acid, paint) (L M H) LCS in GW; gasoline	☒ Biological (i.e., ticks, poison ivy) (L M H) bees; buckwheat; snakes	☒ Radiation (i.e., alpha, sun, laser) (L M H)
☒ Sound (i.e., machinery, generators) (L M H) HSA rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H) car; rig; forklift

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)
- [x] Elimination
- [x] Engineering controls
- [x] General PPE Usage
- [x] Personal Hygiene
- [x] Emergency Action Plan (EAP)
- [x] JSA to be developed/used ***(specify)***
- [ ]
- [ ]
- [x] Substitution
- [x] Administrative controls
- [x] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [ ]
- [ ]
- [x] Isolation
- [x] Monitoring
- [x] Respiratory Protection
- [x] Decon Procedures
- [x] Work Zones/Site Control
- [x] Traffic Control
- [ ] Other ***(specify)***
- [ ]

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Marshall Brisa / AMA /	0700	1700	✓
Jamie Moore / ABC /	0700		✓
Luis Mendoza / ABC / Luis Mendoza	0700		✓
Juan Cortez / ABC /	0700		✓
Matt Becker / CSULB /	0800		
Francine Cason / CSULB / Francine Cason	0800		✓
Megan Ward-Baranyay / CSULB / Megan Ward-Baranyay	0800		✓

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

In	Out
In	Out
In	Out
In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- [ ] Lessons learned and best practices learned today: _____
- [ ] Incidents that occurred today: _____
- [ ] Any Stop Work interventions today? _____
- [ ] Corrective/Preventive Actions needed for future work: _____
- [ ] Any other H&S issues: _____

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

Document Control Number:TGM - _____
TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

ARCADIS Design & Consultancy for natural and built assets

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SD015 TISR Install		**Project Location:** VSFB, CA	
Date: 11/12/21	**Time:** 0715	**Conducted by:** Marshall Brusca	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Complete SUP-1 install
2 Drill TISR, DTS, BHE, SUP
3 Collect TISR samples
4 clean up & secure site for weekend
5

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: NONE

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☐ Any Stop Work Interventions yesterday?
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☐ If deviations, notify PM & client
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ All equipment checked & OK?
		☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L M H) STF, offroad, stickups, equip.	☒ Motion (i.e., traffic, moving water) (L M H) moving vehicles	☒ Mechanical (i.e., augers, motors) (L M H) HSA Rig pinch points, lifting
☒ Electrical (i.e., utilities, lightning) (L M H) OH lines, extension cables	☒ Pressure (i.e. gas cylinders, wells) (L M H) hydraulic lines, compressor	☒ Environment (i.e., heat, cold, ice) (L M H) heat, wind, COVID
☒ Chemical (i.e., fuel, acid, paint) (L M H) COCs in gw	☒ Biological (i.e., ticks, poison ivy) (L M H) snakes spiders bees	☒ Radiation (i.e., alpha, sun, laser) (L M H)
☒ Sound (i.e., machinery, generators) (L M H) HSA Rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H) car, forklift, mobilization

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)
- [x] Elimination
- [x] Engineering controls
- [x] General PPE Usage
- [x] Personal Hygiene
- [x] Emergency Action Plan (EAP)
- [x] JSA to be developed/used ***(specify)***
- [x] Substitution
- [x] Administrative controls
- [x] Hearing Conservation
- [x] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [x] Isolation
- [x] Monitoring
- [x] Respiratory Protection
- [x] Decon Procedures
- [x] Work Zones/Site Control
- [x] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Marshall Brusca / ANA /	0710		✓
Luis Mendoza / ABC / Luis Mendoza	0710	LM	
Jamie Moore ABC	700		
Ivan Cortez ABC	700	JC	

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

In	Out
In	Out
In	Out
In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK;** and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- [ ] Lessons learned and best practices learned today: _____
- [ ] Incidents that occurred today: _____
- [ ] Any Stop Work interventions today? _____
- [ ] Corrective/Preventive Actions needed for future work: _____
- [ ] Any other H&S issues: _____

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

ARCADIS Design & Consultancy for natural and built assets

Document Control Number:TGM - _____
TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SDOIS TISR Install		**Project Location:** VSFB, CA	
Date: 11/15/21	**Time:** 0800	**Conducted by:** Marshall Brisca	**Signature/Title:**
Client: AFCEC		**Client Contact:** –	**Subcontractor companies:** Penmax ; ABC

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 UXO clearance @ TISR 1-4
2 drillers to get base passes
3 Drill/install SUP, TISR, DHE
4 _____
5 _____
6 _____

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: NONE

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☐ Any Stop Work Interventions yesterday?
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ If deviations, notify PM & client
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ All equipment checked & OK?
		☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L (M) H) STF, unloading trucks	☒ Motion (i.e., traffic, moving water) (L (M) H) Moving vehicles : forklift ; rig	☒ Mechanical (i.e., augers, motors) (L (M) H) HSA rig pinch points
☒ Electrical (i.e., utilities, lightning) (L (M) H) OH power lines ; extension cords	☒ Pressure (i.e. gas cylinders, wells) (L (M) H) hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L (M) H) cold, wind
☒ Chemical (i.e., fuel, acid, paint) (L (M) H) COCs in gw	☒ Biological (i.e., ticks, poison ivy) (L (M) H) snakes, bees, spiders	☒ Radiation (i.e., alpha, sun, laser) (L (M) H)
☒ Sound (i.e., machinery, generators) (L (M) H) HSA Rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H) car, rig, forklift

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)
- [x] Elimination
- [x] Engineering controls
- [x] General PPE Usage
- [x] Personal Hygiene
- [x] Emergency Action Plan (EAP)
- [x] JSA to be developed/used ***(specify)***
- [x] Substitution
- [x] Administrative controls
- [x] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [x] Isolation
- [x] Monitoring
- [x] Respiratory Protection
- [x] Decon Procedures
- [x] Work Zones/Site Control
- [x] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Marshall Brisca / ANA /	0900		✓
Matt Sanders / PenMaxx /	0800		✓
Roman Gilliam / PenMaxx /	0800		✓
Hans Nicole / ANA /	08:00		✓
Jamie Moore ABC	10:30		—
PEDRO CAMACHO / ABC / P. Camacho	10:30		
Juan Cortez ABC	1030		

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

	In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

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Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- [ ] Lessons learned and best practices learned today:
- [ ] Incidents that occurred today:
- [ ] Any Stop Work interventions today?
- [ ] Corrective/Preventive Actions needed for future work:
- [ ] Any other H&S issues:

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

ARCADIS Design & Consultancy for natural and built assets

Document Control Number:TGM - _____

TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SDOIS TISR Install		**Project Location:** VSFB, CA	
Date: 11/16/21	**Time:** 0736	**Conducted by:** Marshall Bussa	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Install TISR, BHE, DTS
2 Sample TISRs
3 Install DTS infrastructure
4
5
6

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: NONE

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☒ If deviations, notify PM & client
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ All equipment checked & OK?
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L (M) H) STF, offroad	☒ Motion (i.e., traffic, moving water) (L (M) H) moving vehicles	☒ Mechanical (i.e., augers, motors) (L (M) H) pinchpoints: auger, Rig
☒ Electrical (i.e., utilities, lightning) (L (M) H) OH power lines, utilities	☒ Pressure (i.e. gas cylinders, wells) (L (M) H) hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L (M) H) fog, wind, COVID
☒ Chemical (i.e., fuel, acid, paint) (L (M) H) COCs in GW	☒ Biological (i.e., ticks, poison ivy) (L (M) H) Rattlesnake, spiders, bees	☒ Radiation (i.e., alpha, sun, laser) (L (M) H)
☒ Sound (i.e., machinery, generators) (L (M) H) HSA Rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e., car, ATV, boat, dozer) (L (M) H) car, forklift, Rig

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)
- [x] Elimination
- [x] Engineering controls
- [x] General PPE Usage
- [x] Personal Hygiene
- [x] Emergency Action Plan (EAP)
- [x] JSA to be developed/used ***(specify)***
- [x] Substitution
- [x] Administrative controls
- [x] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [x] Isolation
- [x] Monitoring
- [x] Respiratory Protection
- [x] Decon Procedures
- [x] Work Zones/Site Control
- [x] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Marshall Brasca / ANA /	MB		✓
Jamie Moore / ABC /	JM		✓
Juan Cortez / ABC /	JC		✓
PEDRO CARREON / ABC / P. Carreon			
Hans Ruder / ANA /	MT 7:15		✓

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

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In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

In	Out
In	Out
In	Out
In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

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I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- [ ] Lessons learned and best practices learned today:
- [ ] Incidents that occurred today:
- [ ] Any Stop Work interventions today?
- [ ] Corrective/Preventive Actions needed for future work:
- [ ] Any other H&S issues:

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

ARCADIS Design & Consultancy for natural and built assets

Document Control Number:TGM - _____

TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SD015 TISR Install		**Project Location:** VSFB CA	
Date: 11/17/21	**Time:** 0730	**Conducted by:** Marshall Brisca	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Backfill TISR
2 Drill shall TISR & BHE
3 Install surface completions @
4 BHEs & TISR & SUP
5
6

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: NONE

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☐ Any Stop Work Interventions yesterday?
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ If deviations, notify PM & client
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ All equipment checked & OK?
		☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L (M) H) STF - hoses, augers, wet surfaces	☒ Motion (i.e., traffic, moving water) (L (M) H) moving vehicles	☒ Mechanical (i.e., augers, motors) (L (M) H) HSA Rig - pinch points
☒ Electrical (i.e., utilities, lightning) (L (M) H) OH power lines	☒ Pressure (i.e. gas cylinders, wells) (L M H) hydraulic lines	☒ Environment (i.e. heat, cold, ice) (L (M) H)
☒ Chemical (i.e., fuel, acid, paint) (L (M) H) LOCs in GW	☒ Biological (i.e., ticks, poison ivy) (L (M) H) spiders, bees, buckwheat	☒ Radiation (i.e., alpha, sun, laser) (L (M) H)
☒ Sound (i.e., machinery, generators) (L (M) H) HSA Rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L (M) H) fork lift, Rig, truck

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - *(See statements below)*
- [x] Elimination
- [x] Engineering controls
- [x] General PPE Usage
- [x] Personal Hygiene
- [x] Emergency Action Plan (EAP)
- [x] JSA to be developed/used ***(specify)***
- [x] Substitution
- [x] Administrative controls
- [ ] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [x] Isolation
- [x] Monitoring
- [x] Respiratory Protection
- [x] Decon Procedures
- [x] Work Zones/Site Control
- [x] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Marshall Brisco / ANA /	0730 MB		✓
Dave Reade ANA /	0730 MB		✓
Jamie Moore ABC	730		✓
Ivan Cortez ABC	730		✓

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

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In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

	In	Out

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I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

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I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- [ ] Lessons learned and best practices learned today:
- [ ] Incidents that occurred today:
- [ ] Any Stop Work interventions today?
- [ ] Corrective/Preventive Actions needed for future work:
- [ ] Any other H&S issues:

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

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TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SQ015 TISR Install		**Project Location:** VSFB, CA	
Date: 11/18/21	**Time:** 0715	**Conducted by:** Marshall Brusca	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Backfill BHE location
2 drill TISR/BHEs
3 soil logging/sampling
4 install TISR/BHEs
5
6

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: NONE

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☐ Any Stop Work Interventions yesterday?
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ If deviations, notify PM & client
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ All equipment checked & OK?
		☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☐ Gravity (i.e., ladder, scaffold, trips) (L M H) SIF, standing on Rig to fillwater	☒ Motion (i.e., traffic, moving water) (L M H) Many vehicles	☒ Mechanical (i.e., augers, motors) (L M H) pinch points; bending/lifting
☒ Electrical (i.e., utilities, lightning) (L M H) OH lines, generator	☒ Pressure (i.e. gas cylinders, wells) (L M H) Hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L M H) wind; COVID
☒ Chemical (i.e., fuel, acid, paint) (L M H) cocs in GW, gasoline	☒ Biological (i.e., ticks, poison ivy) (L M H) snakes, spiders, bees	☒ Radiation (i.e., alpha, sun, laser) (L M H)
☒ Sound (i.e., machinery, generators) (L M H) HSA Rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H) car; Rig; forklift

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

☒ **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - *(See statements below)*		
☒ Elimination	☒ Substitution	☒ Isolation
☒ Engineering controls	☒ Administrative controls	☒ Monitoring
☒ General PPE Usage	☒ Hearing Conservation	☒ Respiratory Protection
☐ Personal Hygiene	☒ Exposure Guidelines	☒ Decon Procedures
☐ Emergency Action Plan (EAP)	☐ Fall Protection	☒ Work Zones/Site Control
☐ JSA to be developed/used ***(specify)***	☐ TIP conducted ***(specify job/JSA)***	☒ Traffic Control
☐	☐	☐ Other ***(specify)***
☐	☐	☐

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Marshall Brisca / ANA /	0715 MB		✓
Mario Alaba / ANA /	0715 MA		✓
Juan Cortez ABC	715		✓
Jamie Moore ABC	715		✓
PEDRO CARREON / ABC / P. Carreon	715		✓

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

	In	Out
	In	Out
	In	Out
	In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- ☐ Lessons learned and best practices learned today:
- ☐ Incidents that occurred today:
- ☐ Any Stop Work interventions today?
- ☐ Corrective/Preventive Actions needed for future work:
- ☐ Any other H&S issues:

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

Document Control Number:TGM - _____

TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SPOIS TISR Install		**Project Location:** VSFB, CA	
Date: 11/19/21	**Time:** 0715	**Conducted by:** Marshall Brosa	**Signature/Title:**
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Mob to BHE-1
2 Drill and install BHE-1
3 Clean up/secure site for weekend
4
5
6

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐ If there are none, write "None" here: NONE

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes :**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☒ Any Stop Work Interventions yesterday?
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ If deviations, notify PM & client
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ All equipment checked & OK?
		☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L M H) STF, offroad, equipment	☒ Motion (i.e., traffic, moving water) (L M H) moving vehicles	☒ Mechanical (i.e., augers, motors) (L M H) pinch points - HSA
☒ Electrical (i.e., utilities, lightning) (L M H) OH power lines	☒ Pressure (i.e. gas cylinders, wells) (L M H) hydraulic lines	☒ Environment (i.e. heat, cold, ice) (L M H) wind; COVID
☒ Chemical (i.e., fuel, acid, paint) (L M H) cocs in gw	☒ Biological (i.e., ticks, poison ivy) (L M H) spiders, bees, snakes	☒ Radiation (i.e., alpha, sun, laser) (L M H)
☒ Sound (i.e., machinery, generators) (L M H) HSA Rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H) car, forklift, Rig

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)
- [x] Elimination
- [x] Engineering controls
- [x] General PPE Usage
- [x] Personal Hygiene
- [x] Emergency Action Plan (EAP)
- [ ] JSA to be developed/used ***(specify)***
- [x] Substitution
- [x] Administrative controls
- [x] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [x] Isolation
- [x] Monitoring
- [x] Respiratory Protection
- [x] Decon Procedures
- [x] Work Zones/Site Control
- [x] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Marshall Bruza / ANA /	0700		✓
Juan Cortez / ABC /	0700		✓
Jamie Moore ABC	7:00		✓
Mau Na / ANA /	7:00		✓
PEDRO CARRION / ABC /	0700		—
Francesca Perrell / AECOM	0902		
Don Eley / RWQCB /	09:00		✓

Important Information and Numbers	Visitor Name/Co - not involved in work
All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns. In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager. In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager. In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.	In Out In Out In Out In Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- [ ] Lessons learned and best practices learned today:
- [ ] Incidents that occurred today:
- [ ] Any Stop Work interventions today?
- [ ] Corrective/Preventive Actions needed for future work:
- [ ] Any other H&S issues:

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

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TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SD015 TISA installation		**Project Location:** VSFB	
Date: 11/29/21	**Time:** 9:00	**Conducted by:** Hans Nicola	**Signature/Title:** [signature] / Geologist
Client: AFCEC	**Client Contact:** -	**Subcontractor companies:** ABC Drilling	

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Drive drill rig to site
2 Drill heating and temp wells
3
4
5
6

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations. ☐ If there are none, write "None" here: none

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes:**

☐ Topics from Corp H&S to cover?		
☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Any Stop Work Interventions yesterday?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☒ If deviations, notify PM & client
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ All equipment checked & OK?
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L M H) STF, mud mats, equipment	☒ Motion (i.e., traffic, moving water) (L M H) Traffic	☒ Mechanical (i.e., augers, motors) (L M H) HSA equipment
☒ Electrical (i.e., utilities, lightning) (L M H) power lines	☒ Pressure (i.e. gas cylinders, wells) (L M H) hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L M H) Weather (hot)
☐ Chemical (i.e., fuel, acid, paint) (L M H)	☒ Biological (i.e., ticks, poison ivy) (L M H) ticks, rattlers, bees	☒ Radiation (i.e., alpha, sun, laser) (L M H) clear skies
☒ Sound (i.e., machinery, generators) (L M H) drill rig	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H) driving rig to site, cars

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [X] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)
- [X] Elimination
- [X] Engineering controls
- [X] General PPE Usage
- [X] Personal Hygiene
- [X] Emergency Action Plan (EAP)
- [X] JSA to be developed/used ***(specify)***
- [X] Substitution
- [X] Administrative controls
- [X] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [X] Isolation
- [X] Monitoring
- [X] Respiratory Protection
- [X] Decon Procedures
- [X] Work Zones/Site Control
- [ ] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Pam Nail /ANAI	9:19	AN	✓
Jamie Moore ABC	9:20	—	—
Lucy Mendoza/ABC/Lucy Mendoza	9:20	LM	—
Juan Cortez ABC	9:20	JC	—

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1-888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

	In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain):

- [ ] Lessons learned and best practices learned today: _____
- [ ] Incidents that occurred today: _____
- [ ] Any Stop Work interventions today? _____
- [ ] Corrective/Preventive Actions needed for future work: _____
- [ ] Any other H&S issues: _____

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

ARCADIS Design & Consultancy for natural and built assets

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TGM + project number plus date as follows: xxxxxxxx.xxxxx.x - dd/mm/year

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SD015 TISR installation		**Project Location:** SD015 USFB	
Date: 11/30/21	**Time:** 7:00	**Conducted by:** Hans Mader	**Signature/Title:** / Geologist
Client: AFCEC	**Client Contact:** —	**Subcontractor companies:** ABC Liquid	

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Well drilling
2 Well installation
3 _____
4 _____
5 _____
6 _____

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations. ☐ If there are none, write "None" here: None

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes:**

☐ Incidents from day before to review?	☒ Lessons learned from the day before?	☐ Any Stop Work Interventions yesterday?
☒ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☒ If deviations, notify PM & client
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ All equipment checked & OK?
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ Staff knows gathering points?

☐ Topics from Corp H&S to cover?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L (M) H) STF/small pits	☒ Motion (i.e., traffic, moving water) (L (M) H) traffic	☒ Mechanical (i.e., augers, motors) (L (M) H) HSA equipment
☒ Electrical (i.e., utilities, lightning) (L (M) H) Power lines	☒ Pressure (i.e. gas cylinders, wells) (L (M) H) hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L M H) Hot weather
☐ Chemical (i.e., fuel, acid, paint) (L M H)	☒ Biological (i.e., ticks, poison ivy) (L (M) H) ticks, snakes, bees	☒ Radiation (i.e., alpha, sun, laser) (L (M) H) Sun
☒ Sound (i.e., machinery, generators) (L M (H)) Drill rig, forklift	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L (M) H) Commute

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [X] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - *(See statements below)*
- [X] Elimination
- [X] Engineering controls
- [X] General PPE Usage
- [X] Personal Hygiene
- [X] Emergency Action Plan (EAP)
- [X] JSA to be developed/used ***(specify)***
- [X] Substitution
- [X] Administrative controls
- [X] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [X] Isolation
- [X] Monitoring
- [X] Respiratory Protection
- [X] Decon Procedures
- [X] Work Zones/Site Control
- [ ] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Hans Alcala / ANA /	HA 706		—
Luis Mendoza / ABC / Luis Mendoza	LM 700		—
Juan Cortez ABC	JC 700		—
Jamie Moore ABC	~~JM~~ 700		—

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1-888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

In ____ Out ____

In ____ Out ____

In ____ Out ____

In ____ Out ____

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain):

- [ ] Lessons learned and best practices learned today: ____
- [ ] Incidents that occurred today: ____
- [ ] Any Stop Work interventions today? ____
- [ ] Corrective/Preventive Actions needed for future work: ____
- [ ] Any other H&S issues: ____

Keep H&S 1st in all things

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Document Control Number:TGM - _____
TGM + project number plus date as follows: xxxxxxxx.xxxxx.x - dd/mm/year

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name: SD015 TISA installation		**Project Location:** SD015 VSFB	
Date: 12/1/21	**Time:** 7:00	**Conducted by:** [illegible] Alaska	**Signature/Title:** [illegible] Geologist
Client: AFCEC		**Client Contact:** —	**Subcontractor companies:** ABC Crew

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 Well drilling
2 Well installation
3 Concrete work
4 Temperature sensors installation
5 _____
6 _____

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations. ☐ If there are none, write "None" here: _____

If yes, describe them here: _____

How will they be controlled? _____

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

	Doc #		Doc #		Doc #
☒ Not applicable		☐ Working at Height		☐ Confined Space	
☐ Energy Isolation (LOTO)		☐ Excavation/Trenching		☐ Hot Work	
☐ Mechanical Lifting Ops		☐ Overhead & Buried Utilities		☐ Other permit	

Discuss following questions (for some review previous day's post activities). **Check if yes:**

☐ Incidents from day before to review?	☐ Lessons learned from the day before?	☐ Topics from Corp H&S to cover?
☐ Any corrective actions from yesterday?	☐ Will any work deviate from plan?	☐ Any Stop Work Interventions yesterday?
☒ JSAs or procedures are available?	☒ Field teams to "dirty" JSAs, as needed?	☒ If deviations, notify PM & client
☒ Staff has appropriate PPE?	☒ Staff knows Emergency Plan (EAP)?	☒ All equipment checked & OK?
		☒ Staff knows gathering points?

Comments: _____

Recognize the hazards (check all those that are discussed) (Examples are provided) and **A**ssess the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☒ Gravity (i.e., ladder, scaffold, trips) (L M H) STP, fork lift	☒ Motion (i.e., traffic, moving water) (L M H) traffic	☒ Mechanical (i.e., augers, motors) (L M H) HSA,
☒ Electrical (i.e., utilities, lightning) (L M H) Power lines	☒ Pressure (i.e. gas cylinders, wells) (L M H) hydraulic lines	☒ Environment (i.e., heat, cold, ice) (L M H) Hot weather
☒ Chemical (i.e., fuel, acid, paint) (L M H) Concrete	☒ Biological (i.e., ticks, poison ivy) (L M H) Snakes, ticks, spiders	☒ Radiation (i.e., alpha, sun, laser) (L M H) Sun
☒ Sound (i.e., machinery, generators) (L M H) Drill rig, fork lift	☐ Personal (i.e. alone, night, not fit) (L M H)	☒ Driving (i.e. car, ATV, boat, dozer) (L M H) Commute, drive safely

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

- [x] **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)
- [x] Elimination
- [x] Engineering controls
- [x] General PPE Usage
- [x] Personal Hygiene
- [x] Emergency Action Plan (EAP)
- [x] JSA to be developed/used ***(specify)***
- [x] Substitution
- [x] Administrative controls
- [x] Hearing Conservation
- [ ] Exposure Guidelines
- [ ] Fall Protection
- [ ] TIP conducted ***(specify job/JSA)***
- [x] Isolation
- [x] Monitoring
- [x] Respiratory Protection
- [x] Decon Procedures
- [x] Work Zones/Site Control
- [ ] Traffic Control
- [ ] Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP
Dave Rich ANA	700		
Jamie Moore ABC	700		✓
Juan Cortez ABC	700		✓
Luis Mendoza / ABC / Luis Mendoza	700		—
Erik Zaderdahan / ANA	710		✓
Rob Rosales / ANA	730		—
Francine Cason / Francine Cason CSULB	8:30		✓
Megan Wardbarnard / Megan Wardbarnard CSULB			

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1-888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

In	Out
In	Out
In	Out
In	Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain):

- [ ] Lessons learned and best practices learned today: _____
- [ ] Incidents that occurred today: _____
- [ ] Any Stop Work interventions today? _____
- [ ] Corrective/Preventive Actions needed for future work: _____
- [ ] Any other H&S issues: _____

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

Site Visit Report

ARCADIS Project Number:	Date of Site Visit:
30027243.00002	11/5/2021
ARCADIS Project Name: SDIS TISR Installation	**Location of Project:** VSFB, CA
ARCADIS Personnel Present: Marshall Busca	**Other Persons Present:** Penmax (2)

Purpose of Site Visit: Clear DTS & solar Array locations of UXOs

Time:	Activities:
0715	Arrive @ field trailer ; prep equipment & mob to site
0745	H&S tailgate and scope discussion
0800	Begin marking out DTS locations based on distances in figure
1130	cleared all DTS locations to 5' legs w/ hand auger & Penmax uxo clearance
1200	Mob to trailer to pick up Trimble GPS unit
1300	Mob back to site ; Begin marking out solar array locations w/ coordinates → marked out each panel legs @ 6' x 7.5'
1400	Penmax cleared solar array area to 2' legs
1430	offsite for day
1500	Shipped out Trimble

Weather: Sunny | Signature & Date: 11/5/21

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Daily Log

Project Name SD015 TISR Installation Project Number 3002-7243 Page 1 of 2

Site Location USFB CA Date 11/8/2021

Field Personnel Marshall Brusca, Jonah Monholland, Benito Montez, CSULB (3), ABC (5)

Time	Description of Activities
0715	MB on site - begin ~~prep~~ prepping equipment
0730	JM on site & United Rentals arrives w/ forklift & pipe threader
0800	MB escorts United Rentals to SD015 to offload equipment
0900	CSULB crew on site ; load up sampling, logging, & HBS equipment
0945	Benito gives CSULB crew USFB HBS orientation
1000	Call w/ Sbandra to discuss sampling SOW
1030	DPT Rig crew on site ; mob to SD015 ; HBS tailgate on site
1115	HSA crew on site w/ Benito → need hose ramps for HDPE piping
	→ need mud mats for mobilizing on sand
1200	Benito offsite to grab hose ramps ; ABC will have mud mats
	delivered ASAP → can still mob to first location
1215	CSULB team begins assembling fiber optic cables
1230	DPT rig set up @ DTS-1
1240	Began DPT drilling @ DTS-1
1300	Reached 40' bgs ; unable to feed DTS sensor past ~30' bgs
	→ heaving sands through bottom of DPT rods
	→ water @ 28.6' bgs
1400	Pulled rod and redrove to 40' bgs
1400	Robert on site to drop off drum, WLM, & hose ramps
1415	Hand auger solar array locations to 2' bgs (Pennvax will clear to
	5' bgs on 11/9)
1430	Installed DTS-1 to TD ; placed 1.5" S.S. pipe as stick-up ; need
	to install concrete skirt
1500	Need to step out & clear SUP-1 & DTS-12 for rig accessibility
1536	DPT rig to DTS-7 ; begin drilling to 40' bgs

1600	Advanced PTS-7 to 40' bgs → will install cable tomorrow
1615	ABC offsite

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Daily Log

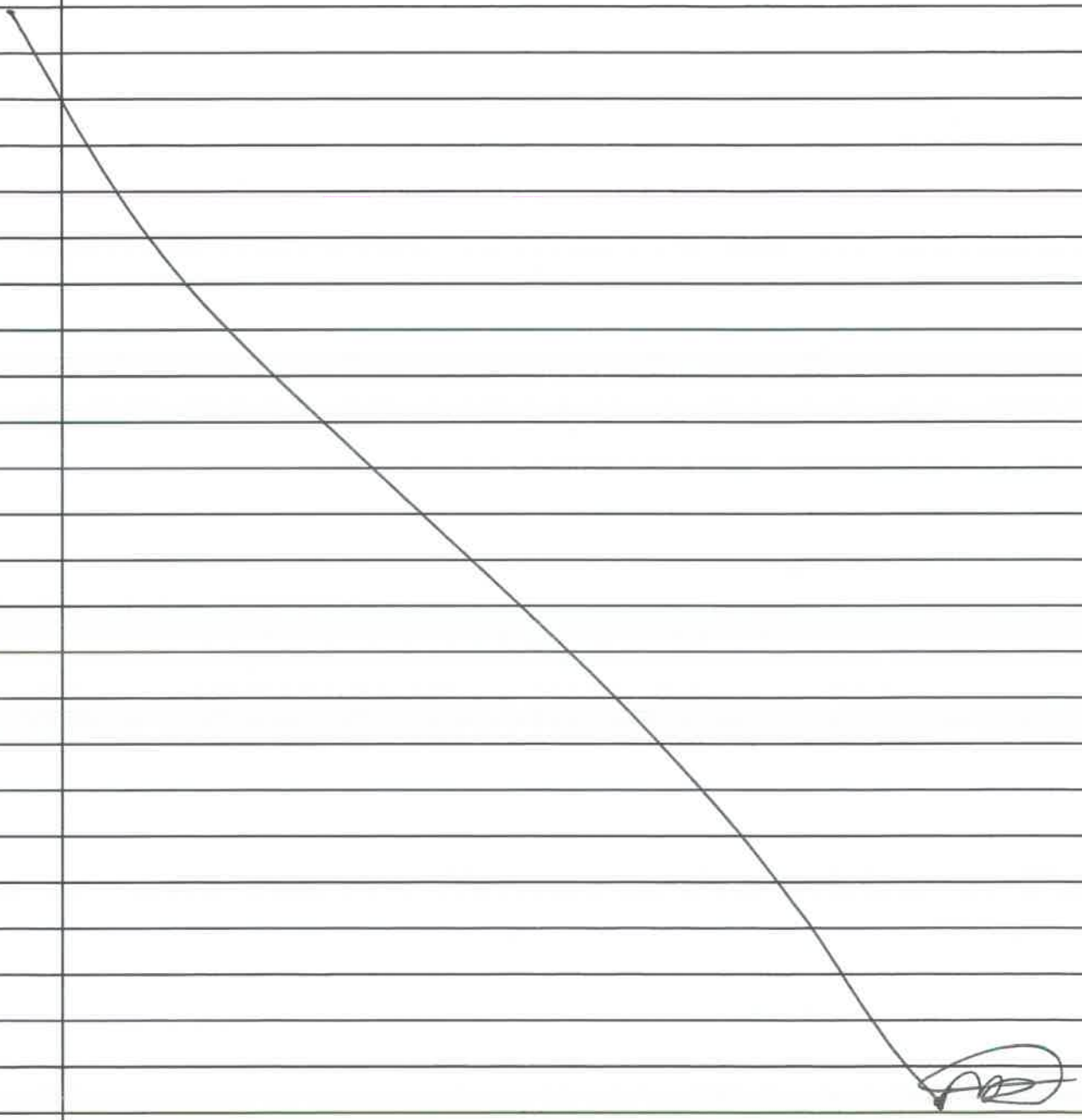
Project Name SDOS TISR Install Project Number 30027243 Page 1 of 2

Site Location USFB, CA Date 11/9/2021

Field Personnel MB, MA, JM

Time	Description of Activities
0700	MB & Mario @ AOS trailer ; load equipment & mob to site
0730	MB, Mario, JM, 2 ABC & SCSOUB on site @ SDOS
	→ Penmax (2) on site ; H&S discussion
0800	Deploy temp. sensor @ DTS-7
0830	Begin drilling @ DTS-12
	→ refusal @ 28' ; step-out ~5 N ; redrill for UXO
0900	Continue clearance of solar array locations w/ Penmax
0915	JM continues drilling BHE's
0930	3 ABC on site w/ mud mats, water tote, and wood frames
0945	Begin mobbing to BHE-5
	• Rhys Evans gave okay to take buckwheat if necessary
	→ need to document and email Rhys
	• Need to have spotter for red-legged frogs if mobbing off road
1000	Refusal @ DTS-12 → will need to auger
1015	DPT rig mob to DTS-3 ; reached 40' bgs ; Installed temp. sensor
1030	Began drilling @ BHE-5 ; TD: 41' bgs
1130	DPT rig mob to DTS-10 ; installed to 40' bgs
1230	bedrock / hardpan @ 40' bgs @ BHE-5
1300	had to bail mud out of BHE-5 before deploying BHE & sand
1330	installed BHE-5
1345	Mob to UXO training ; Mario & 2 ABC on site ; DTS-9 installed @ 40' bgs
1430	Back on site
1445	Refusal @ 28' bgs @ DTS-11
1450	Backfill w/ sand and grout @ BHE-5
1510	Tag 15-MW-41 : DTW: 21.2' bgs

1545	CSULB offsite
1600	installed sand from 4/1-20' bgs @ CHE-5
	→ heat exchanger pulled up ~2' : bottom sitting @ ~38' bgs
1610	Clean up & mob offsite
1630	OFFSITE



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Daily Log

Project Name SDOS TI SP Install Project Number 30027243 Page 1 of 1

Site Location USFB, CA Date 11/10/2021

Field Personnel Marshall Busch, Mario A., Jonah Marholland, Erik Zadazian

Time	Description of Activities
0645	MB & MA @ AUS trailer ; load equip. ; leave to site
0715	3 ABC, 3 ARC onsite @ SDOS ; HSS tailgate
0725	Complete sandpack (10 x 50lb bags) & begin grouting BHE-5 (50 gal.)
0830	Used rig to pull forklift out of sand ; ABC will exchange for a 4-wheel drive forklift
0900	second ABC crew stuck in sand ; sent another truck up to pull them out
0900	ABC DPT crew onsite
0915	DPT rig set up on DTS-5 ; ~~asbo~~ installed to 40' bgs
0930	HSA set up on BHE-8
	• adding water as drilling to mitigate heaving sands
	• used wooden plug on bottom auger to prevent sands/water from flooding augers
1000	DPT Rig set up on DTS-6 ; installed to 40' bgs
1015	installed BHE-8 to 41' bgs ; began 0/30 sand backfill
1120	DPT crew (2) offsite for event
1215	sand backfill from 41-18' bgs @ BHE-8 (23 x 50 lb bags)
1230	CSULB crew installing junction boxes and splicing @ completed DTS locations
1300	Grout BHE-8 (50 gal.) ; stick ups installed @ BHE-8 & -5
1330	Refilled water tank on HSA rig
1415	set-up and begin drilling @ BHE-7
1508	United Rentals onsite to swap out forklift for one w/ 4-wheel drive
1510	Reached 40' bgs @ BHE-7 ; hit bedrock @ 39'
1515	Begin sand backfill @ BHE-7 ; reached ~25' by EOD
1530	SM & EZ onsite
1600	Pressure test BHE w/ air compressor ; pass
1645	ABC offsite
1700	Arcadis & CSULB offsite

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Daily Log

Project Name SLC5 TISR Installation Project Number 30027243 Page 1 of 2

Site Location VSFB, CA Date 11/11/2021

Field Personnel Marshall Brusca, ABC (3), CSULB (3)

Time	Description of Activities
0700	Arrive on site ; HBS Tailgate
0715	Continue backfill @ BHE-7
0800	Completed sand backfill at BHE-7 (40-18' bgs ; 23 x 50lb bags)
0805	CSULB on site
0820	Grouted BHE-7 (50gal)
0900	Set-up & begin drilling TISR-4
0945	3 inches of moist soil core = 425 grams ; for 4kg sample, will need 28.2" of core
1030	Per discussion w/ Jonah, TISR wells need 2 screen intervals : will attempt to dual nest screens @ TISR locations @ 15-25' bgs & 30-40' bgs → not outlined in FIP/SOW ; if dual-nesting does not work, will need UXO clearance for secondary location • drill continuous core w/ 8" diameter for log/samples • redrill w/ 10" for dual-nested well
1200	Sample collected from 35-37.5' bgs (~4kg of soil) immediately vacuum-sealed twice w/ O_2 packet in between ; stored on ice • TISR-4
1220	Reached TD & logged TISR-4 (40' bgs)
1245	Per second discussion w/ Jonah ; well seal in between screens has to be grout → cannot get accurate grout seal and shallow screen set in a nested borehole, especially w/ heaving sands • New plan : set current borehole w/ a 30-40' well and seal/grout to grade, will need UXO support for shallow TISR-4

1300	Began well install at TISR-4 deep
1400	Completed install @ TISR-4 deep (6 bags sand, 1 bag bentonite, 55 gal grout)
1430	Clean up ; fill rig water tank ; CSULB done fusing for week
1500	Set up on SVP-1
1530	Reach TD (19' bgs) @ SVP-1
1545	install deep probe (17.5') @ SVP-1 ; grout up to ~7' bgs
1600	Tag TISR-4 deep : 18.84' bgs
1630	Will install shallow SVP-1 probe in AM
1645	clean up & demob

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Daily Log

Project Name SD015 TISR Install Project Number 30027943 Page 1 of 1

Site Location SD015 - VSFB, CA Date 11/12/2021

Field Personnel Marshall Brusa, ABC (3)

Time	Description of Activities
0710	Arrive on site ; HBS tailgate ; begin backfill @ SUP-1
0730	Install shallow SUP-1 and backfill
0740	Setup on BHE-4
0750	Begin drilling BHE-4 ; TD: 40' bgs
0900	Pressure test heat exchanger ; pass: held 140 psi
0915	install BHE-4
0920	Begin sand backfill @ BHE-4 (22 x 50lb bags)
1100	Grout BHE-4 (50 gal)
1200	Moved mud mats and set up Rig on SUP-2
1230	Secured site for the weekend

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Daily Log

Project Name SD015 TISR Install Project Number 30027243 Page 1 of 1

Site Location USFB, CA Date 11/15/2021

Field Personnel MB, MA

Time	Description of Activities
0715	Arrive @ AUS trailer ; prepare paperwork & equipment
0745	Mob to SD015
0810	Tailgate ; Penmax on site
0830	Clear shallow locations for TISR-1 through TISR-4 ; 3' step-outs
0930	Penmax offsite
1030	ABC onsite
1100	Begin drilling @ SVP-2
1145	Reach TD @ SVP-2 (19' bgs) ; begin install & backfill
1230	Get up to 6' bgs, ABC take lunch
1300	Return to SVP-2 and install shallow probe
1330	Clean up @ SVP-2 and Mob to TISR-4-S
1430	Begin drilling @ TISR-4-S & logging soil
1455	Per Jonah, do not have to log soils @ shallow step-outs
1515	Water encountered @ 20.5' bgs ; chert/shale @ 27.5' bgs
1530	Installed well @ TISR-4-S from 17.5-27.5' bgs, began backfill
1630	Cleaned up & Mob Rig ; offsite for day

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Daily Log

Project Name SD015 TISR Install Project Number 30027243 Page 1 of 1

Site Location SD015 USFB, CA Date 11/16/2021

Field Personnel Marshall Bruza Mario Alcolea

Time	Description of Activities
0700	Arrive @ AVS trailer, load equipment
0720	Arrive @ site, ABC onsite; HBS tailgate
0730	Begin mobbing Rig to BHE-3
0845	Begin drilling @ BHE-3
0910	Pressure test heat exchanger
0950	Install BHE-3, begin backfill
1100	ABC begins constructing concrete skirts (18"x18") for TISR2 & BHE locations
1230	Completed sand backfill up to 18' bgs @ BHE-3 (19 x 50lb bags)
1245	Lunch
1315	Grout BHE-3 (45 gal)
1320	Tag TISR-4-D : 22.22 btoc; TISR-4-S : 22.43 btoc
	↳ +2.62' stick-up ↳ +2.67' stick-up
1330	Mob to TISR-1-D
1400	Begin drilling TISR-1-D
1540	Sample collected from 35-37' & duble vacuumed @ TISR-1-D
1560	Reach TD: 40' @ TISR-1-D & begin well install; sand/bentonite up to 25'
	-will grout in AM
1630	Clean up for day
1645	Offsite for day

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Daily Log

Project Name SD015 TISR Install Project Number 30024037 Page 1 of 1

Site Location VSFB CA Date 11/17/2021

Field Personnel Marshall Brusca / Mario Alcalea

Time	Description of Activities
0645	Pick-up ABC from Lompoc due to truck issues, 1 ABC to santa Maria to get truck repaired
0730	Arrive @ SD015 ; HBS tailgate
0745	Begin grout backfill @ TISR-1-D (80 gallons)
09:15	Started drilling TISR-1-S with 8" auger with wood plug ; MB offsite to hand off miniRAE & pick up ABC RAE
09:50	Reached 27.5' (TD). Displaced wood plug. Started filling the well with 2/16 sand. after placing 2" pipe
1100	Completed grat backfill @ TISR-1-S (28 gallons) ; ABC truck repaired & on site
1130	Set-up rig @ BHE-2 ; begin drilling
1200	Conduct TIP on ABC drilling @ BHE-2
	+ always donned full PPE while drilling
	+ routine inspections of drill rig
	+ good communications w/ drilling & mobilization
	+ maintain tidy work area throughout the day
	- N95 should be worn during sand backfill and grout mixing
	- need to paint one of E-stops bright color
1230	Lunch
1300	Reach TD (40') @ BHE-2, begin sand backfill & pressure test
~~1400~~	
1615	Sand up to 30' @ BHE-2 ; clean up
1625	offsite for day

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Daily Log

Project Name SD015 TISR Install Project Number 30024237 Page 1 of 1

Site Location USFB, CA Date 11/18/2021

Field Personnel Marshall Brosca Mario Alcolea

Time	Description of Activities
0650	Arrive @ AVS trailer, load equipment
0715	Arrive @ SD015; HBS tailgate
0730	Set up and continue sand backfill @ BHE-2
0830	Completed sand up to 18' bgs @ BHE-2 (24x50lb bags)
0930	Completed install @ BHE-2 (50 gal. grout)
0945	Setup and begin drilling @ TISR-3-D
1100	Collected shelby tube sample @ TISR-3-D from 35-37.5' bgs
1130	Reach TD: 40' bgs @ TISR-3-D; begin backfill
1230	Sand & bentonite backfill complete; lunch
1300	Grout TISR-3-D
1330	Set-up and begin drilling @ TISR-3-S
1400	Inventory of DTS progress/equipment
	3 locations built w/ junct. box
	2 locations w/ flange, ready for junct. box
	2 locations w/o flange or junct. box
	2 not yet installed
	3 paired w/ BHE
	5 x junct. boxes drilled & ready
	4 x junct. boxes need drill holes
	3 x 1" flanges onsite
1440	Collect shelby tube sample @ TISR-3-S from 22.5-25' bgs
1500	Reach TD: 27.5' @ TISR-3-S; backfill location
1600	Complete install @ TISR-3-S
1630	OFFSITE FOR THE DAY

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Daily Log

Project Name SD015 TISR Install Project Number 30024237 Page 1 of 1

Site Location VSFB, CA Date 11/19/2021

Field Personnel Marshall Brusca / Mario Alcolea

Time	Description of Activities
0660	Arrive @ AUS trailer ; load equipment
0715	Arrive @ SD015 ; H&S tailgate
0730	Begin mobbing rig to BHE-1
0745	Begin drilling BHE-1 ; will place cuttings in drum per Jonah
0830	Reach TD : 40' @ BHE-1 , install BHE & begin sand backfill
0850	Don Eley & Francesca Perrell onsite ; H&S tailgate discussion
	• site walk and photos
	• discussed progress and upcoming work
	• observed ABC installing/backfilling BHE-1
	• looked @ TISR-3-D soil cores and "chert" layer @ 28'
0930	Don Eley and Francesca Perrell offsite
1100	Mario offsite for the day
1200	Completed install & back-fill @ BHE-1 / DTS-2
	· 18 x 50lb sand bags used
	· 50 gallons of grout
1230	Clean up and secure site for week's
1300	Approximate water usage by location during drilling
	Deep TISR : 30-40 gal
	Shallow TISR : 10-20 gal
	BHE : 100-200 gal
1300	Soil from BHE-1 containerized in labelled Drum
1815	OFFSITE

ABC LIOVIN Rotary | Sonic | DPT | HSA | Air Knife

1180 E. Burnett Street, Signal Hill, CA 90755 (562) 981-8575 Fax (562) 981-9594 www.abcdrilling.com

INVOICE NUMBER 892293

DAILY DRILL REPORT

CLIENT: Arcadis DAY: Mon DATE: 11-08-21

JOB LOCATION: VAFB CITY: Vandenberg CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							Unload & Load	400	445	
# OF SOIL SAMPLES							Travel	445	1030	
FOOTAGE TODAY							Checking - Pick up Passes	1030		
HOLE DIAMETER							Mob in - Fill water			
WELL DIAMETER							in Rig & Recon -			
TOTAL FOOTAGE										
CEMENT SEAL FROM							— Lunch —	1230	100	
CEMENT SEAL TO							Mob to site - off	100		
BENT SEAL FROM							Load Trucks - walk			
BENT SEAL TO							site - Prep Material			
SAND Type ___ FROM							Cover for Weather -			
SAND Type ___ TO										
CASING FROM							Secure site -			
CASING Type ___ TO										
SCREEN Type ___ FROM										
SCREEN Slot ___ TO										
WATER LEVEL										

TOTAL CHARGEABLE ONSITE RIG HOURS

RENTALS. MILES/ HOURS: INSPECTED? ☐ DELIVERED FULL? ☐ RETURNED FULL? ☐ CALLED OFF? ☐

EQUIPMENT				CASING			MATERIALS			
RIG #	R-8	JACK HAMMER	Comes	DIAMETER	2"	4"	ITEM	QTY.	ITEM	QTY
FLATBED TRUCK #	T-3	AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE)		INSTALL (____") WELL COVER	
FLATBED TRUCK #		FORKLIFT/ HOPPER	Yes	10 FT. SCREEN			GRAVEL		REMOVE (____") WELL COVER	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE		5 FT. SCREEN			READY MIX		MONUMENT CASING	
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET		BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK			PORTLAND CEMENT		SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK			BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT				SLIP CAP			BENTONITE CHIPS		CONES/ DELINEATORS	
				THREADED CAP			BENTONITE POWDER		CORE BOXES	
REMARKS:				LOCKING CAPS			COATED PELLETS		DRUMS	
							BENTONITE GRANULAR		NEW DRUMS	
							ASPHALT PATCH		TUBING	
PM Shop - Bank - Hotel							SAMPLER / SHOE		VAPOR PROBE (TYPE)	
							BIT / AUGER REPAIR			
ENGINE HOURS	Start	Stop	Total				WOOD/ STEEL PLUGS			
							PLASTIC SHEETING	1		

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break required if work more than 5 hrs IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break required if work more than 10 hrs IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Travis Mc...	☐	400	445	445	1030	1030	1230	100	TM	—	—	TM	445	445	530	530	600
Jason C...	☐	400	445	445	1030	1030	1230	100	JC	—	—	JC	445	445	530	530	600
Luis Mendez	☐	400	445	445	1030	1030	1230	100	LM	—	—	LM	445	445	530	530	600
	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

ABC LIOVIN Rotary | Sonic | DPT | HSA | Air Knife

1180 E. Burnett Street, Signal Hill, CA 90755 (562) 981-8575 Fax (562) 981-9594 www.abcdrilling.com

INVOICE NUMBER 89.2499

DAILY DRILL REPORT

CLIENT: Cargill's DAY: Monday DATE: 11-08-21

JOB LOCATION: Water well Station Ave CITY: Los Banos CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							DTS-1 Push to 40'			
# OF SOIL SAMPLES							Try to install clients			
FOOTAGE TODAY							Instrument sand			
HOLE DIAMETER							went up Rods to			
WELL DIAMETER							33' trip out and			
TOTAL FOOTAGE							clean rods go back			
CEMENT SEAL FROM							down to 40' Install			
CEMENT SEAL TO							Instrument. With 3/4			
BENT SEAL FROM							casing hold down			
BENT SEAL TO							Instrument while pulling			
SAND Type ____ FROM							UP			
SAND Type ____ TO							DTS-7 Push to 45'			
CASING Type ____ FROM							Install next day			
CASING Type ____ TO										
SCREEN Type ____ FROM										
SCREEN Slot ____ TO										
WATER LEVEL								TOTAL CHARGEABLE ONSITE RIG HOURS		

RENTALS: MILES/ HOURS: INSPECTED? ☐ DELIVERED FULL? ☐ RETURNED FULL? ☐ CALLED OFF? ☐

EQUIPMENT				CASING			MATERIALS			
RIG #	103	JACK HAMMER		DIAMETER	2"	4"	ITEM	QTY	ITEM	QTY
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE)		INSTALL (____") WELL COVER	
FLATBED TRUCK #		FORKLIFT/ HOPPER		10 FT. SCREEN			GRAVEL		REMOVE (____") WELL COVER	
TRAILER #		CONT. SAMPLER FOOTAGE		5 FT. SCREEN			READY MIX		MONUMENT CASING	
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET		BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK			PORTLAND CEMENT		SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK			BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT				SLIP CAP			BENTONITE CHIPS		CONES/ DELINEATORS	
				THREADED CAP			BENTONITE POWDER		CORE BOXES	
REMARKS:	1 QTY 3/4 casing			LOCKING CAPS			COATED PELLETS		DRUMS	
							BENTONITE GRANULAR		NEW DRUMS	
							ASPHALT PATCH		TUBING	
							SAMPLER / SHOE		VAPOR PROBE (TYPE)	
							BIT / AUGER REPAIR			
ENGINE HOURS	Start	Stop	Total				WOOD/ STEEL PLUGS			
							PLASTIC SHEETING			

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Chris L	☐	400	470	430	820	830	130	200	CL	—	—	CL	500				
Chase L	☐	400	430	430	820	830	130	200	CL	—	—	CL	500				
	☐																
	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

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INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis | DAY: Tues | DATE: 11 09 -21

JOB LOCATION: VAFB | CITY: Vandenberg | CLIENT P.O.#

HOLE #	BHE-5
SURFACE D/A/C	D
# OF SOIL SAMPLES	
FOOTAGE TODAY	
HOLE DIAMETER	10"
WELL DIAMETER	4.5" Heat Exchanger
TOTAL FOOTAGE	
CEMENT SEAL FROM	
CEMENT SEAL TO	
BENT SEAL FROM	
BENT SEAL TO	
SAND Type ____ FROM	
SAND Type ____ TO	
CASING Type ____ FROM	
CASING Type ____ TO	
SCREEN Type ____ FROM	
SCREEN Slot ____ TO	
WATER LEVEL	

DESCRIPTION OF WORK

START	STOP	HOURS TOTAL
600		
	830	
830	915	
915		
	130	
130	245	
245		

Fuel - Mob to Home Depot - Pick up supplies Wait for delivery of Mudd Matts & water tote

Mob to Base - off load Set up Mudd Matts - Set up - Rig - Drill to 40' w/ 10" Auger Had to Bail Mudd out of Auger - Install Heat Exchanger

Mob for Timing Ext

Sand up Well to 18'

Clean up Loading Secure site Mob fill Water tote -

TOTAL CHARGEABLE ONSITE RIG HOURS

RENTALS: | MILES/ HOURS: | INSPECTED? ☐ | DELIVERED FULL? ☐ | RETURNED FULL? ☐ | CALLED OFF? ☐

EQUIPMENT

RIG #	R8	JACK HAMMER	
FLATBED TRUCK #		AUX AIR COMPRESSOR	
FLATBED TRUCK #	T-3	FORKLIFT/ HOPPER	Yes
TRAILER #	T-8	CONT. SAMPLER FOOTAGE	Yes
# OF SAW CUTS		# OF WATER SAMPLES	
# OF CORE CUTS		A/C HOT PATCHES	
#BULL DOG CNCRT		LEVEL C HOURS	
BOBCAT		Service Rig	
		Mudd Matts	4

CASING

	2"	4"
DIAMETER		
20 FT. SCREEN		
10 FT. SCREEN		
5 FT. SCREEN		
20 FT. BLANK		
10 FT. BLANK		
5 FT. BLANK		
SLIP CAP		
THREADED CAP		
LOCKING CAPS		

MATERIALS

ITEM	QTY.	ITEM	QTY.
SAND (TYPE) 0/30	20	INSTALL (____") WELL COVER	
GRAVEL		REMOVE (____") WELL COVER	
READY MIX		MONUMENT CASING	
QUICK SET		BOLLARD POST	
PORTLAND CEMENT		SAMPLE LINERS SST/BRSS	
BENTONITE GROUT		HOLE COVER PLATES	
BENTONITE CHIPS		CONES/ DELINEATORS	
BENTONITE POWDER		CORE BOXES	
COATED PELLETS		DRUMS	
BENTONITE GRANULAR		NEW DRUMS	
ASPHALT PATCH		TUBING	
SAMPLER / SHOE		VAPOR PROBE (TYPE)	
BIT / AUGER REPAIR		6" Black Pipe 5'	(2)
WOOD/ STEEL PLUGS			
PLASTIC SHEETING			

REMARKS: Lunch - 100-130

ENGINE HOURS	Start	Stop	Total

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break required if work more than 5 hrs IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break required if work more than 10 hrs IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Jamie Moore	☑	600	830	830	915	915	100	130	JM	—	—	JM	530	530	615	615	645
Juan Cortez	☑	600	830	830	915	915	100	130	JC	—	—	JC	530	530	615	615	645
Luis Montes	☑	600	830	830	915	915	100	130	LM	—	—	LM	530	530	615	615	645
	☐																
	☐																
	☐																

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INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis | DAY: Tuesday | DATE: 11-09-21

JOB LOCATION: VAFB | CITY: Lompoc | CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							DTS-7 Install Instrument			
# OF SOIL SAMPLES							DTS-12 Refusal at 28' step cut 5' from Boring Pushed to 29' Refusal			
FOOTAGE TODAY							DTS-6 Push to 42' Install Instrument			
HOLE DIAMETER							DTS-10 Push to 40' Install Instrument			
WELL DIAMETER							DTS-11 Refusal at 28'			
TOTAL FOOTAGE							DTS-9 Advance to 40' Install Instrument			
CEMENT SEAL FROM										
CEMENT SEAL TO										
BENT SEAL FROM										
BENT SEAL TO										
SAND Type ____ FROM										
SAND Type ____ TO										
CASING Type ____ FROM										
CASING Type ____ TO										
SCREEN Type ____ FROM										
SCREEN Slot ____ TO										
WATER LEVEL								TOTAL CHARGEABLE ONSITE RIG HOURS		

RENTALS: | MILES/ HOURS: | INSPECTED? ☐ | DELIVERED FULL? ☐ | RETURNED FULL? ☐ | CALLED OFF? ☐

EQUIPMENT				CASING			MATERIALS			
RIG #	621	JACK HAMMER		DIAMETER	2"	4"	ITEM	QTY.	ITEM	QTY.
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE)		INSTALL (____") WELL COVER	
FLATBED TRUCK #		FORKLIFT/ HOPPER		10 FT. SCREEN			GRAVEL		REMOVE (____") WELL COVER	
TRAILER #		CONT. SAMPLER FOOTAGE		5 FT. SCREEN			READY MIX		MONUMENT CASING	
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET		BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK			PORTLAND CEMENT		SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK			BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT				SLIP CAP			BENTONITE CHIPS		CONES/ DELINEATORS	
				THREADED CAP			BENTONITE POWDER		CORE BOXES	
REMARKS:				LOCKING CAPS			COATED PELLETS		DRUMS	
							BENTONITE GRANULAR		NEW DRUMS	
							ASPHALT PATCH		TUBING	
							SAMPLER / SHOE		VAPOR PROBE (TYPE)	
							BIT / AUGER REPAIR			
ENGINE HOURS	Start		Stop		Total		WOOD/ STEEL PLUGS			
							PLASTIC SHEETING			

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break required if work more than 5 hrs IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break required if work more than 10 hrs IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Chris K	☐	——	——	615	700	700	100	130	CK	——	——	CK	930			——	
Chase L	☐	——															
	☐																
	☐																
	☐																
	☐																

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INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis | DAY: Wed | DATE: 11-10-21

JOB LOCATION: VAFB | CITY: Vandenberg | CLIENT P.O.#

HOLE #	BHE-8	BHE-7	DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C	D	D	Load up -	600	615	
# OF SOIL SAMPLES			Travel	615	700	
FOOTAGE TODAY			H&S - Set up - Tremie	700		
HOLE DIAMETER	10"	10"	Pot Hand on (BHE-5)			
WELL DIAMETER	4.5"	4.5"	Pull out - top off - Clean			
TOTAL FOOTAGE	40'	40'	up - Move to (BHE-8) Set up			
CEMENT SEAL FROM			Drill to 40' w/ wood Plug -			
CEMENT SEAL TO			Install Heat Exchanger			
BENT SEAL FROM			Sand up to 18'		115	
BENT SEAL TO			— Lunch —	115	145	
SAND Type ____ FROM			tremie, Pot Hand - Pull out	145		
SAND Type ____ TO			top off - Clean up -			
CASING Type ____ FROM			Move to (BHE-7) Set up			
CASING Type ____ TO			Drill w/ wood Plug to 40'			
SCREEN Type ____ FROM			Install Heat Exchanger			
SCREEN Slot ____ TO			Sand up to 25' Clean up - Load up - Secure site			
WATER LEVEL						

TOTAL CHARGEABLE ONSITE RIG HOURS

RENTALS: | MILES/ HOURS: | INSPECTED? ☐ | DELIVERED FULL? ☐ | RETURNED FULL? ☐ | CALLED OFF? ☐

EQUIPMENT CME 95

RIG #	B-8	JACK HAMMER		
FLATBED TRUCK #		AUX AIR COMPRESSOR		
FLATBED TRUCK #	T-3	FORKLIFT/ HOPPER	Yes	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE	Yes	
# OF SAW CUTS		# OF WATER SAMPLES		
# OF CORE CUTS		A/C HOT PATCHES		
#BULL DOG CNCRT		LEVEL C HOURS		
BOBCAT				

CASING

DIAMETER	2"	4"
20 FT. SCREEN		
10 FT. SCREEN		
5 FT. SCREEN		
20 FT. BLANK		
10 FT. BLANK		
5 FT. BLANK		
SLIP CAP		
THREADED CAP		
LOCKING CAPS		

MATERIALS

ITEM	QTY.	ITEM	QTY.
SAND (TYPE)	35	INSTALL (____") WELL COVER	
GRAVEL		REMOVE (____") WELL COVER	
READY MIX		MONUMENT CASING	
QUICK SET		BOLLARD POST	
PORTLAND CEMENT	12	SAMPLE LINERS SST/BRSS	
BENTONITE GROUT		HOLE COVER PLATES	
BENTONITE CHIPS		CONES/ DELINEATORS	
BENTONITE POWDER	1	CORE BOXES	
COATED PELLETS		DRUMS	
BENTONITE GRANULAR		NEW DRUMS	
ASPHALT PATCH		TUBING	
SAMPLER / SHOE		VAPOR PROBE (TYPE)	
BIT / AUGER REPAIR			
WOOD/ STEEL PLUGS	2		
PLASTIC SHEETING			

REMARKS: Mob fill water tote -

ENGINE HOURS	Start	Stop	Total

NAME (Print First & Last)	Per Diem	A.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	P.M. SHOP OUT
Jamie Moore	☐	600	615	615	700	~~700~~	115	145	JM	—	—	~~JM~~	515	515	600	~~515~~	~~600~~
Jason Carter	☐	600	615	615	700	700	115	145	JC	—	—	JC	515	515	600	/	/
Luis Mendoza	☐	600	615	615	700	700	115	145	LM	—	—	LM	515	515	600	/	/
	☐																
	☐																
	☐																

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INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis DAY: Wed DATE: 11 -10 -21

JOB LOCATION: VAFB CITY: Lompoc CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							DTS - 5 and 6			
# OF SOIL SAMPLES							Advance Rods to 40'			
FOOTAGE TODAY							Install Instrument at 40'			
HOLE DIAMETER										
WELL DIAMETER										
TOTAL FOOTAGE							Lompoc			
CEMENT SEAL FROM										
CEMENT SEAL TO										
BENT SEAL FROM										
BENT SEAL TO										
SAND Type ____ FROM										
SAND Type ____ TO										
CASING Type ____ FROM										
CASING Type ____ TO										
SCREEN Type ____ FROM										
SCREEN Slot ____ TO										
WATER LEVEL								TOTAL CHARGEABLE ONSITE RIG HOURS		

RENTALS: MILES/ HOURS: INSPECTED? ☐ DELIVERED FULL? ☐ RETURNED FULL? ☐ CALLED OFF? ☐

EQUIPMENT				CASING			MATERIALS			
RIG #	601	JACK HAMMER		DIAMETER	2"	4"	ITEM	QTY.	ITEM	QTY
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE)		INSTALL (____") WELL COVER	
FLATBED TRUCK #		FORKLIFT/ HOPPER		10 FT. SCREEN			GRAVEL		REMOVE (____") WELL COVER	
TRAILER #		CONT. SAMPLER FOOTAGE		5 FT. SCREEN			READY MIX		MONUMENT CASING	
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET		BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK			PORTLAND CEMENT		SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK			BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT				SLIP CAP			BENTONITE CHIPS		CONES/ DELINEATORS	
				THREADED CAP			BENTONITE POWDER		CORE BOXES	
REMARKS:				LOCKING CAPS			COATED PELLETS		DRUMS	
							BENTONITE GRANULAR		NEW DRUMS	
							ASPHALT PATCH		TUBING	
							SAMPLER / SHOE		VAPOR PROBE (TYPE)	
							BIT / AUGER REPAIR			
ENGINE HOURS	Start	Stop	Total				WOOD/ STEEL PLUGS			
							PLASTIC SHEETING			

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break required if work more than 5 hrs IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break required if work more than 10 hrs IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Chris K	☐	———	———	1015	700	700			CK	———	———	CK	1230				
Shane L	☐	———	———														
	☐																
	☐																
	☐																
	☐																

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INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis | DAY: Thur | DATE: 11-11-21

JOB LOCATION: VAFB | CITY: Vandenberg | CLIENT P.O.#

HOLE #				SUP-1		DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C				D		Loading -	600	615	
# OF SOIL SAMPLES				Cont. Core		TRAVEL	615	700	
FOOTAGE TODAY						H&S - Setup -	700		
HOLE DIAMETER				8"		Finish Sand Pack on			
WELL DIAMETER				¼" probe		(BHE-7) Sand up -			
TOTAL FOOTAGE		VAFB				Tremie Portland -			
CEMENT SEAL FROM						top off - Move to			
CEMENT SEAL TO						(T/SR-4) D/S Cont.			
BENT SEAL FROM						Core every 2.5' to			
BENT SEAL TO						40' [illegible]		1215	
SAND Type ____ FROM						——— lunch ———	1215	1245	
SAND Type ____ TO						Install 2" Well @ 40'	1245		
CASING Type ____ FROM						w/ 10' of 010 Screen -			
CASING Type ____ TO						Sand - Surge - Seal -			
SCREEN Type ____ FROM						Tremie Portland - Pull			
SCREEN Slot ____ TO						out - top off - Move			TOTAL CHARGEABLE ONSITE RIG HOURS
WATER LEVEL						to (SUP-1) Setup -			

RENTALS: | MILES/ HOURS: | INSPECTED? ☐ | DELIVERED FULL? ☐ | RETURNED FULL? ☐ | CALLED OFF? ☐

EQUIPMENT				CASING			MATERIALS			
RIG #	A-8	JACK HAMMER		DIAMETER	2"	4"	ITEM	QTY.	ITEM	QTY.
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE) #30 (12) #2 (8)		INSTALL (____") WELL COVER	
FLATBED TRUCK #	T-3	FORKLIFT/ HOPPER	YES	10 FT. SCREEN	1		GRAVEL		REMOVE (____") WELL COVER	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE	49'	5 FT. SCREEN			READY MIX		MONUMENT CASING	
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET		BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK	3		PORTLAND CEMENT	18	SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK			BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT		Fill water tote		SLIP CAP			BENTONITE CHIPS	3	CONES/ DELINEATORS	
				THREADED CAP	1		BENTONITE POWDER	1	CORE BOXES	
REMARKS:	(SUP-1) D/S Cont. Core every 2.5'			LOCKING CAPS	1		COATED PELLETS		DRUMS	
	to 19' Install Probe @ 18'						BENTONITE GRANULAR	1	NEW DRUMS	
	Sand - Seal - Tremie Portland						ASPHALT PATCH		TUBING	23'
	up to 6' Clean up - Load up -						SAMPLER / SHOE		VAPOR PROBE (TYPE) ¼"	1
							BIT / AUGER REPAIR		53	
ENGINE HOURS	Start	Stop	Total				WOOD/ STEEL PLUGS	1		
							PLASTIC SHEETING			

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Jamie Mata	☐	600	615	615	700	700	1215	1245	JM	—	—	JM	515	515	545	—	—
Jason Cotter	☐	600	615	615	700	700	1215	1245	JC	—	—	JC	515	515	545	—	—
Luis Mendoza	☐	600	615	615	700	700	1215	1245	LM	—	—	LM	515	515	545	—	—
	☐																
	☐																
	☐																

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INVOICE NUMBER 89z299

DAILY DRILL REPORT

CLIENT: Arcadis | DAY: Fri | DATE: 11-12-21

JOB LOCATION: Vandenberg AFB | CITY: Vandenberg | CLIENT P.O.#

HOLE #

DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
Loading -	600	615	
Travel	615	700	
H/S - Set-up - Finish	700		
SVP-1 - Install 2nd probe @ 5' Sand-Seal			
Move BHE-4) Set-up -			
Dr. 11 10" Auger to 40' Install			
Heat Exchange @ 40' Sand			
-p - Trem. Pellband -			
Pull out - top off - Install			
Bkfl Pipe - Move Rig			
to SVP-2) Set-Rig			
up -			
Clean-up - Load-up -			
Secure site take Material			
Count -			

SURFACE D/A/C | # OF SOIL SAMPLES | FOOTAGE TODAY | HOLE DIAMETER | WELL DIAMETER | TOTAL FOOTAGE

CEMENT SEAL FROM / TO | BENT SEAL FROM / TO | SAND Type ____ FROM / TO | CASING Type ____ FROM / TO | SCREEN Type ____ Slot ____ FROM / TO | WATER LEVEL

TOTAL CHARGEABLE ONSITE RIG HOURS

RENTALS: | MILES/ HOURS: | INSPECTED? ☐ | DELIVERED FULL? ☐ | RETURNED FULL? ☐ | CALLED OFF? ☐

EQUIPMENT

RIG #	R-8	JACK HAMMER	
FLATBED TRUCK #		AUX AIR COMPRESSOR	
FLATBED TRUCK #	T-3	FORKLIFT/ HOPPER	Yes
TRAILER #	T-8	CONT. SAMPLER FOOTAGE	
# OF SAW CUTS		# OF WATER SAMPLES	
# OF CORE CUTS		A/C HOT PATCHES	
#BULL DOG CNCRT		LEVEL C HOURS	
BOBCAT			

REMARKS:

CASING

DIAMETER	2"	4"
20 FT. SCREEN		
10 FT. SCREEN		
5 FT. SCREEN		
20 FT. BLANK		
10 FT. BLANK		
5 FT. BLANK		
SLIP CAP		
THREADED CAP		
LOCKING CAPS		

MATERIALS

ITEM	QTY.	ITEM	QTY
SAND (TYPE)	2	INSTALL (____") WELL COVER	
GRAVEL	4 3/8	REMOVE (____") WELL COVER	
READY MIX		MONUMENT CASING	
QUICK SET		BOLLARD POST	
PORTLAND CEMENT	12	SAMPLE LINERS SST/BRSS	
BENTONITE GROUT		HOLE COVER PLATES	
BENTONITE CHIPS	1	CONES/ DELINEATORS	
BENTONITE POWDER	1	CORE BOXES	
COATED PELLETS		DRUMS	
BENTONITE GRANULAR	1	NEW DRUMS	
ASPHALT PATCH		TUBING	5'
SAMPLER / SHOE		VAPOR PROBE (TYPE) SS	
BIT / AUGER REPAIR		6"	1
WOOD/ STEEL PLUGS	1	6" Bkfl Pipe	2 5'
PLASTIC SHEETING			

ENGINE HOURS	Start	Stop	Total

NAME (Print First & Last)	Per Diem	A.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	P.M. SHOP OUT
Lonnie Moore	☐	600	615	615	700	700	1200	1230	LM	–	–	LM	145				
Juan Cortez	☐	600	615	615	700	700	1200	1230	JC	–	–	JC	145				
Luis Mendoza	☐	600	615	615	700	700	1200	1230	LM	–	–	LM	145				
	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

ABC LIOVIN Rotary | Sonic | DPT | HSA | Air Knife

1180 E. Burnett Street, Signal Hill, CA 90755 (562) 981-8575 Fax (562) 981-9594 www.abcdrilling.com

INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis DAY: Mon DATE: 11 - 15 - 21

JOB LOCATION: VAFB CITY: Vandenberg CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							Load up -	400	445	
# OF SOIL SAMPLES							Travel to site Check in - Mob to site	445	1030	
FOOTAGE TODAY							H&S - Setup on	1030	1099	
HOLE DIAMETER							SUP-2-DIS Cont. Core			
WELL DIAMETER							to 19' Install Probe -			
TOTAL FOOTAGE							Sand - Seal - Grout			
CEMENT SEAL FROM							up to 6.0'		1215	
CEMENT SEAL TO							Lunch	1215	1245	
BENT SEAL FROM							Install 2nd Probe @ 19'	1245		
BENT SEAL TO							4.5' Sand - Seal -			
SAND Type ____ FROM							Install Monument -			
SAND Type ____ TO							Move Rig, Pick up			
CASING Type ____ FROM							Mudd Mats (TISR-4-5)			
CASING Type ____ TO							Setup - DIS Cont. Core to			
SCREEN Type ____ FROM							27.5' Install 2" Well Sand			
SCREEN Slot ____ TO							Surge - Seal - grout up -			
WATER LEVEL										

Install Monument on (TISR-4-D)

TOTAL CHARGEABLE ONSITE RIG HOURS

RENTALS: MILES/ HOURS: INSPECTED? ☐ DELIVERED FULL? ☐ RETURNED FULL? ☐ CALLED OFF? ☐

EQUIPMENT

RIG #	R-8	JACK HAMMER		CMESS	
FLATBED TRUCK #		AUX AIR COMPRESSOR			
FLATBED TRUCK #	T-3	FORKLIFT/ HOPPER		Yes	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE		36.5	
# OF SAW CUTS		# OF WATER SAMPLES			
# OF CORE CUTS		A/C HOT PATCHES			
#BULL DOG CNCRT		LEVEL C HOURS			
BOBCAT					

CASING

DIAMETER	2"	4"
20 FT. SCREEN		
10 FT. SCREEN	1	
5 FT. SCREEN		
20 FT. BLANK		
10 FT. BLANK	2	
5 FT. BLANK		
SLIP CAP		
THREADED CAP	1	
LOCKING CAPS	1	

MATERIALS

ITEM	QTY.	ITEM	QTY.
SAND (TYPE) 2/12 ③ 3/4	(9)	INSTALL (____") WELL COVER	
GRAVEL		REMOVE (____") WELL COVER	
READY MIX		MONUMENT CASING 6"	2
QUICK SET		BOLLARD POST	
PORTLAND CEMENT	12	SAMPLE LINERS SST/BRSS	
BENTONITE GROUT		HOLE COVER PLATES	
BENTONITE CHIPS	2	CONES/ DELINEATORS	
BENTONITE POWDER	1	CORE BOXES	
COATED PELLETS		DRUMS	
BENTONITE GRANULAR	1	NEW DRUMS	
ASPHALT PATCH		TUBING 3/4"	
SAMPLER / SHOE		VAPOR PROBE (TYPE) 6"	2
BIT / AUGER REPAIR			
WOOD/ STEEL PLUGS			
PLASTIC SHEETING	1		

REMARKS: PM Shop - Bank Hotel - Home Depot -

ENGINE HOURS	Start	Stop	Total

NAME (Print First & Last)	Per Diem	A.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	P.M. SHOP OUT
Jamie Moore	☐	400	445	445	1030	1030	1215	1245	JM	—	—	JM	515	515	600	600	700
Jason Cortez	☐	400	445	445	1030	1030	1215	1245	JC	—	—	JC	515	515	600	—	—
Pedro	☐	400	445	445	1030	1030	1215	1245	P	—	—	P	515	515	600	—	—
Carleon	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

ABC LIOVIN Rotary | Sonic | DPT | HSA | Air Knife

1180 E. Burnett Street, Signal Hill, CA 90755 (562) 981-8575 Fax (562) 981-9594 www.abcdrilling.com

INVOICE NUMBER 89 2299

DAILY DRILL REPORT

CLIENT: Arcadis DAY: Tues DATE: 11-16-21

JOB LOCATION: VAFB CITY: Vandenberg AFB CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							Loading	600	615	
# OF SOIL SAMPLES							Travel	615	700	
FOOTAGE TODAY							H&S - Setup - Move	700		
HOLE DIAMETER							Mudd Mats - to (BH6-3)			
WELL DIAMETER							Setup - Drill to 40' Install			
TOTAL FOOTAGE							Heat Exchanger Well -			
CEMENT SEAL FROM							Sand up to 18'		1215	
CEMENT SEAL TO							Lunch	1215	1245	
BENT SEAL FROM							Tramie Pat Hand - Pull	1245		
BENT SEAL TO							out - to pit - Install			
SAND Type ____ FROM							Black Pipe - Clean up -			
SAND Type ____ TO							Move to TSR-HSA Setup -			
CASING Type ____ FROM							D/S Cont. Core every 2.5'			
CASING Type ____ TO							to 40' Install 2" Well -			
SCREEN Type ____ FROM							Sand - Surf - Seal - Clean			
SCREEN Slot ____ TO							up - Load - Trash up -			
WATER LEVEL							Secure site -	TOTAL CHARGEABLE ONSITE RIG HOURS		

RENTALS: MILES/ HOURS: INSPECTED? ☐ DELIVERED FULL? ☐ RETURNED FULL? ☐ CALLED OFF? ☐

EQUIPMENT				CASING			MATERIALS			
RIG #	R8	JACK HAMMER		DIAMETER	2"	4"	ITEM	QTY	ITEM	QTY
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE) 2/12 (8) 2/30 (20)		INSTALL (____") WELL COVER	
FLATBED TRUCK #	T-3	FORKLIFT/ HOPPER	YES	10 FT. SCREEN	1		GRAVEL		REMOVE (____") WELL COVER	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE	35'	5 FT. SCREEN			READY MIX		MONUMENT CASING 6"	1
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET		BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK	3		PORTLAND CEMENT	6	SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK	1		BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT				SLIP CAP			BENTONITE CHIPS	1	CONES/ DELINEATORS	
				THREADED CAP	1		BENTONITE POWDER	1	CORE BOXES	
REMARKS:	Jamie Tire Issues till 10:00			LOCKING CAPS	1		COATED PELLETS		DRUMS	
							BENTONITE GRANULAR		NEW DRUMS	
							ASPHALT PATCH		TUBING	
Build forms for Well Boxes -							SAMPLER / SHOE		VAPOR PROBE (TYPE)	
5' Blank Risers for Monument -							BIT / AUGER REPAIR		5'-6" Blank Pipe for (1)	
ENGINE HOURS	Start	Stop	Total				WOOD/ STEEL PLUGS 10"	1		
							PLASTIC SHEETING	1		

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break required if work more than 5 hrs IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break required if work more than 10 hrs IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Jamie Moore	☐	600	615	615	700	700	1215	1245	JM	—	—	JM	515	515	600	600	1000
Jason Colvin	☐	600	615	615	700	700	1215	1245	JC	—	—	JC	515	515	600	—	—
Pedro Cuevas	☐	600	615	615	700	700	1215	1245	PC	—	—	PC	515	515	600	—	—
	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

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INVOICE NUMBER 892299

DAILY DRILL REPORT

CLIENT: Arcadis DAY: Wed DATE: 11 - 17 - 21

JOB LOCATION: Vandenberg CITY: Vandenberg AFB CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							work on Truck - figure out tire situation	600		
# OF SOIL SAMPLES									700	
FOOTAGE TODAY							Travel	700	745	
HOLE DIAMETER							H&S - Setup on TISR-10	745		
WELL DIAMETER							tremie Portland - Pullout top off - Move - Setup on (TISR-15) Drill to 27.5' w/ wood Plug - Install 2" Well @ 27.5' W/ 10' of 010 Screen - Sand - Surge - Seal - tremie Portland - Pullout - top off - Move BHE-2) Set up - Drill to 40' Install #8 BHE @ 40' Sand up - to 30' Clean up - Load up Secure site			
TOTAL FOOTAGE										
CEMENT SEAL	FROM									
	TO									
BENT SEAL	FROM									
	TO									
SAND Type ____	FROM									
	TO									
CASING Type ____	FROM									
	TO									
SCREEN Type ____	FROM									
Slot ____	TO									
WATER LEVEL										

TOTAL CHARGEABLE ONSITE RIG HOURS

RENTALS: MILES/ HOURS: INSPECTED? ☐ DELIVERED FULL? ☐ RETURNED FULL? ☐ CALLED OFF? ☐

EQUIPMENT				CASING			MATERIALS			
RIG #	B-8	JACK HAMMER	CMESS	DIAMETER	2"	4"	ITEM	QTY.	ITEM	QTY.
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE) 2/16	65	INSTALL (____") WELL COVER	
FLATBED TRUCK #	T-3	FORKLIFT/ HOPPER	YES	10 FT. SCREEN	1		GRAVEL 3/12		REMOVE (____") WELL COVER	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE		5 FT. SCREEN			READY MIX	10	MONUMENT CASING	
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET	1	BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK	2		PORTLAND CEMENT	17	SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK	1		BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT				SLIP CAP			BENTONITE CHIPS	1	CONES/ DELINEATORS	
				THREADED CAP	1		BENTONITE POWDER	1	CORE BOXES	
REMARKS:	Fill water tote. Installed 8 Concrete forms - Lunch - 12:30-1:00			LOCKING CAPS	1		COATED PELLETS		DRUMS	
							BENTONITE GRANULAR		NEW DRUMS	
							ASPHALT PATCH		TUBING	
							SAMPLER / SHOE		VAPOR PROBE (TYPE)	
							BIT / AUGER REPAIR			
ENGINE HOURS	Start	Stop	Total				WOOD/ STEEL PLUGS 10' (1) 8' (1)			
							PLASTIC SHEETING	1		

NAME (Print First & Last)	Per Diem	A.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP (Signal Hill/ Poway/ Bloomington) IN	P.M. SHOP OUT
Jamie Moore	☐	600	700	700	745	745	1230	100	JM	—	—	JM	430	430	515	—	—
Jaime Cortez	☐	600	700	700	745	745	1230	100	JC	—	—	JC	430	430	515	—	—
Pedro Cortez	☐	600	700	700	745	745	1230	100	PC	—	—	PC	430	430	515	—	—
	☐																
	☐																
	☐																

CLIENT SIGNATURE

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INVOICE NUMBER 89 2299

DAILY DRILL REPORT

CLIENT: Arcadis | DAY: Thur | DATE: 11-18-21

JOB LOCATION: Vandenberg AFB | CITY: Vandenberg | CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							Loading	600	615	
# OF SOIL SAMPLES							Travel	615	700	
FOOTAGE TODAY							H&S - Setup - Finish	700		
HOLE DIAMETER							Sand on (BHL-2)			
WELL DIAMETER							Sand from 30' to 8'			
TOTAL FOOTAGE							Tremie Portland - Pull			
CEMENT SEAL FROM							out - top off - Move			
CEMENT SEAL TO							to (TISR-3D) Setup			
BENT SEAL FROM							DPS Cont Core to 40'			
BENT SEAL TO							Shelby Tube Sample			
SAND Type ____ FROM							@ 35 to 37' Install			
SAND Type ____ TO							2" Well @ 40' w/ 10' of			
CASING Type ____ FROM							010 Screen - Sand - Surf			
CASING Type ____ TO							Seal - Tremie Portland		1230	
SCREEN Type ____ FROM							Pullout - top off - Clean			
SCREEN Type ____ Slot ____ TO							up - Move to (TISR-35)			
WATER LEVEL							Setup - Drill to 23' take			

TOTAL CHARGEABLE ONSITE RIG HOURS

RENTALS. | MILES/ HOURS: | INSPECTED? ☐ | DELIVERED FULL? ☐ | RETURNED FULL? ☐ | CALLED OFF? ☐

EQUIPMENT CME 95

RIG # D-8	JACK HAMMER		
FLATBED TRUCK #	AUX AIR COMPRESSOR		
FLATBED TRUCK # T-3	FORKLIFT/ HOPPER		YES
TRAILER # T-8	CONT. SAMPLER FOOTAGE		35'
# OF SAW CUTS	# OF WATER SAMPLES		
# OF CORE CUTS	A/C HOT PATCHES		
#BULL DOG CNCRT	LEVEL C HOURS		
BOBCAT			

CASING

DIAMETER	2"	4"
20 FT. SCREEN		
10 FT. SCREEN	2	
5 FT. SCREEN		
20 FT. BLANK		
10 FT. BLANK	5	
5 FT. BLANK	1	
SLIP CAP		
THREADED CAP	2	
LOCKING CAPS	2	

MATERIALS

ITEM	QTY	ITEM	QTY
SAND (TYPE) 2/16 (12) 0/30 (6)		INSTALL (____") WELL COVER	
GRAVEL		REMOVE (____") WELL COVER	
READY MIX		MONUMENT CASING 6"	(2)
QUICK SET		BOLLARD POST	
PORTLAND CEMENT	24	SAMPLE LINERS SST/BRSS	
BENTONITE GROUT		HOLE COVER PLATES	
BENTONITE CHIPS	2	CONES/ DELINEATORS	
BENTONITE POWDER	2	CORE BOXES	
COATED PELLETS		DRUMS	
BENTONITE GRANULAR		NEW DRUMS	
ASPHALT PATCH		TUBING	
SAMPLER / SHOE		VAPOR PROBE (TYPE)	
BIT / AUGER REPAIR		Shelby Tube	(2)
WOOD/ STEEL PLUGS			
PLASTIC SHEETING	1		

REMARKS: Shelby Sample, Drill to 27.5' Install 2" Well - w/ 10' of 010 Screen - Sand Surr - Seal - tremie Portland Clean up - PE 30-100 - Lunch -

ENGINE HOURS	Start	Stop	Total

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break required if work more than 5 hrs IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break required if work more than 10 hrs IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Jamie Moore	☐	600	615	615	700	700	1230	100	JM	—	—	—	445	445	530	—	—
Jay Cortez	☐	600	615	615	700	700	1230	100	JC	—	—	JC	445	445	530	—	—
Pedro Calling	☐	600	615	615	700	700	1230	100	PC	—	—	PC	445	445	530	—	—
	☐																
	☐																
	☐																

CLIENT SIGNATURE

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INVOICE NUMBER 89 2299

DAILY DRILL REPORT

CLIENT: Arcadis | DAY: Fri | DATE: 11 - 19 - 21

JOB LOCATION: Vandenberg AFB | CITY: Vandenberg AFB | CLIENT P.O.#

HOLE #							DESCRIPTION OF WORK	START	STOP	HOURS TOTAL
SURFACE D/A/C							Loadup -	600	615	
# OF SOIL SAMPLES							Travel	615	700	
FOOTAGE TODAY							H&S Setup - on 6HL-1	700		
HOLE DIAMETER							Drill w/ wood Plugs to 40' Install Heat Exchange			
WELL DIAMETER							Sand-1 to 18' Hemic			
TOTAL FOOTAGE							Portland Clean-up -			
CEMENT SEAL FROM							Loadup - Mob to Arcadis			
CEMENT SEAL TO							for other Job site on			
BENT SEAL FROM							Monday -			
BENT SEAL TO										
SAND Type ____ FROM										
SAND Type ____ TO										
CASING Type ____ FROM										
CASING Type ____ TO										
SCREEN Type ____ FROM										
SCREEN Slot ____ TO										
WATER LEVEL								TOTAL CHARGEABLE ONSITE RIG HOURS		

RENTALS: | MILES/ HOURS: | INSPECTED? ☐ | DELIVERED FULL? ☐ | RETURNED FULL? ☐ | CALLED OFF? ☐

EQUIPMENT CME 95

				CASING			MATERIALS			
RIG #	Q-8	JACK HAMMER		DIAMETER	2"	4"	ITEM	QTY	ITEM	QTY.
FLATBED TRUCK #		AUX AIR COMPRESSOR		20 FT. SCREEN			SAND (TYPE) 0/30 (12)		INSTALL (____") WELL COVER	
FLATBED TRUCK #	T-3	FORKLIFT/ HOPPER	YES	10 FT. SCREEN			GRAVEL		REMOVE (____") WELL COVER	
TRAILER #	T-8	CONT. SAMPLER FOOTAGE		5 FT. SCREEN			READY MIX	10	MONUMENT CASING	
# OF SAW CUTS		# OF WATER SAMPLES		20 FT. BLANK			QUICK SET	2	BOLLARD POST	
# OF CORE CUTS		A/C HOT PATCHES		10 FT. BLANK			PORTLAND CEMENT	2	SAMPLE LINERS SST/BRSS	
#BULL DOG CNCRT		LEVEL C HOURS		5 FT. BLANK			BENTONITE GROUT		HOLE COVER PLATES	
BOBCAT				SLIP CAP			BENTONITE CHIPS		CONES/ DELINEATORS	
				THREADED CAP			BENTONITE POWDER	1	CORE BOXES	
REMARKS:				LOCKING CAPS			COATED PELLETS		DRUMS	
							BENTONITE GRANULAR		NEW DRUMS	
							ASPHALT PATCH		TUBING	
							SAMPLER / SHOE		VAPOR PROBE (TYPE)	
Lunch - 1200 - 1230							BIT / AUGER REPAIR			
							WOOD/ STEEL PLUGS (12) 10" (12)			
							PLASTIC SHEETING			

ENGINE HOURS	Start	Stop	Total

NAME (Print First & Last)	Per Diem	A.M. SHOP Signal Hill/ Poway/ Bloomington IN	A.M. SHOP OUT	Travel to Site IN	Travel to Site OUT	Site Start Time IN	1st Meal Break (required if work more than 5 hrs) IN	1st Meal Break OUT	1st Meal Break INITIAL	2nd Meal Break (required if work more than 10 hrs) IN	2nd Meal Break OUT	2nd Meal Break INITIAL	Site Stop Time OUT	Travel to Shop IN	Travel to Shop OUT	P.M. SHOP Signal Hill/ Poway/ Bloomington IN	P.M. SHOP OUT
Jamie Moore	☐	600	615	615	700	700	1200	1230	JM	—	—	JM					
Sam Cotter	☐	600	615	615	700	700	1200	1230	SC	—	—	SC					
Pedro Carlos	☐	600	615	615	700	700	1200	1230	PC	—	—	PC					
	☐																
	☐																
	☐																

CLIENT SIGNATURE

OPERATOR SIGNATURE

ARCADIS

Real Time Air Monitoring Data Collection Forms

Document all air monitoring conducted on the Site below based on Section E of the HASP. Keep this form with the project files.

Site Name: SD015 TISR Install Date: 11/8/2021 / 11/9/2021 / 11/10/2021 / 11/11/2021 / 11/12/2021

Instrument: PID Model: MiniRAE Serial #: FA04137

Calibration Method: (material used, settings, etc.)	zero gas @ 150
Calibration Results:	PASS @ 100.0 ppm
Calibrated By:	MB R.R.

	Activity Being Monitored	Compounds Monitored	Time	ppm Reading	Action Required? Y/N
11/8	DPT @ DTS-1	VOCs	1245	0.0	N
	DPT @ DTS-7	VOCs	1545	0.0	N
11/9	DPT @ DTS-3	VOCs	1100	0.0	N
	HSA @ BHE-5	VOCs	1100	0.0	N
	DPT @ DTS-10	VOCs	1215	0.0	N
11/10	DPT @ DTS-5	VOCs	0935	0.0	N
	HSA @ BHE-8	VOCs	0935	0.0	N
11/11	HSA @ TISR-4	VOCs	0955	0.0	N
	HSA @ SVP-1	VOCs	1530	0.0	N
11/12	HSA @ BHE-4	VOCs	0830	0.0	N

Describe Any Actions Taken as a Result of this Air Monitoring and Why:

Signed: _____

Site Safety Officer

Make additional copies of this form as necessary.

ARCADIS

Real Time Air Monitoring Data Collection Forms

Document all air monitoring conducted on the Site below based on Section E of the HASP. Keep this form with the project files.

Site Name: SP015 Date: 11/15/21 → 11/19/21

Instrument: PID Model: MiniRAE300 Serial #: FA04137 & ppbRAE3000 FA03297

Calibration Method: (material used, settings, etc.)	ISOBUTYLENE 100ppm / Fresh Air
Calibration Results:	Pass : 100.1 ppm / PASS → 11/15/21
Calibrated By:	NB

Iso / Fresh Air
Pass : 100.0ppm → 11/18/21
NB
11/18/2021

	Activity Being Monitored	Compounds Monitored	Time	(ppm) Reading	Action Required? Y/N
11/15	HSA @ SVP-2	VOCs	1145	0.0	N
	HSA @ TISR-11-S	VOCs	1500	0.0	N
11/16	HSA @ BHE-3	VOCs	0930	0.0	N
	HSA @ TISR-1	VOCs	1600	0.0	N
11/17	HSA @ BHE-2	VOCs	1140	0.0	N
	Backfill @ BHE-2	VOCs	1500	0.0	N
11/18	HSA @ TISR-3-D	VOCs	1100	0.0	N
	HSA @ TISR-3-S	VOCs	1400	0.0	N
11/19	HSA @ BHE-1	VOCs	0800	0.0	N

Describe Any Actions Taken as a Result of this Air Monitoring and Why:

Signed: _____

Site Safety Officer

Make additional copies of this form as necessary.

TYPE OF CLASS: VAFB 30th EOD UXO Safety Awareness Briefing

Shop# 805-605-1375

INSTRUCTOR(S): SrA Logan

DATE: 09 Nov 21

Annual Requirement

	PRINTED NAME	SIGNATURE	RANK	SQ	PHONE	Company
1	Juan Cortez				425 577 8574	ABC
2	Luis Mendoza				951 497 6579	ABC
3	Jamie Moore				562 706 2259	ABC
4	Matthew Becker				562-607-2238	ARCADIS
5	Francine Cason				562-756-0570	ARCADIS
6	Megan Ward-Barangay				7146066018	ARCADIS
7	Marshall Bruza				9169956297	ARCADIS
8	Tracy Curry		CIV	CES	605-0392	DoD SF
9	Tiffany Whitsitt-Odell		CIV	CES	6006-2044	DoD SF
10	Jonah Monhollanc				6195380983	Arcadis
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

TOTAL MAN-HOURS: Officer: Enlisted:

Site Visit Report

ARCADIS Project Number:	Dates of Site Visit:
30024237	11/29/21
ARCADIS Project Name:	**Location of Project:**
SD015 TISR Install	USFB
ARCADIS Personnel Present:	**Other Persons Present:**
Hans Mealer	ABC Layne crew

Purpose of Site Visit: Well drilling and installation

Date & Time:	Activities:
11/29/21 8:00	Arrived @ Meeks Trailer
9:09	ABC crew arrived @ Meeks yard
9:43	Arrived @ site SD015. Started setting mud mats and setting drill rig ready to ~~start~~ drill
9.53	Drill rig set to drill TISR-2D
11:44	Sampled from 37.5' to 40'. Double vacuum bagged
11:55	Started well installation
12:43	Lunch break after they finished pouring the bentonite
13:40	Started Grouting TISR-2D
14:25	Finish grouting. Installed monument
14:32	Tower down to move to TISR-2S
14:44	Started drilling TISR-2S
15:07	Finished drilling TISR-2S to 27.5' and started pouring sand pack (2/16)
15:54	Started Grouting
16:04	Tower down and housekeeping
16:19	Left SD015, head to Meeks trailer
16:40	Left Meeks trailer

Weather: Sunny, High 60's

Signature & Date: 11/29/21

Hans Mealer

ARCADIS

Site Visit Report

ARCADIS Project Number:	Dates of Site Visit:
30024237	11/29/21
ARCADIS Project Name:	**Location of Project:**
SD015 TISR Install	USFB
ARCADIS Personnel Present:	**Other Persons Present:**
Hans Mealer	ABC Layne crew

Purpose of Site Visit: Well drilling and installation

Date & Time:	Activities:
11/29/21 8:00	Arrived @ Meeks Trailer
9:09	ABC crew arrived @ Meeks yard
9:43	Arrived @ site SD015. Started setting mud mats and setting drill rig ready to ~~start~~ drill
9.53	Drill rig set to drill TISR-2D
11:44	Sampled from 37.5' to 40'. Double vacuum bagged
11:55	Started well installation
12:43	Lunch break after they finished pouring the bentonite
13:40	Started Grouting TISR-2D
14:25	Finish grouting. Installed monument
14:32	Tower down to move to TISR-2S
14:44	Started drilling TISR-2S
15:07	Finished drilling TISR-2S to 27.5' and started pouring sand pack (2/16)
15:54	Started Grouting
16:04	Tower down and housekeeping
16:19	Left SD015, head to Meeks trailer
16:40	Left Meeks trailer

Weather: Sunny, High 60's

Signature & Date: 11/29/21

Hans Mealer

ARCADIS

Site Visit Report

ARCADIS Project Number:	Dates of Site Visit:
30024237	11/30/21
ARCADIS Project Name:	**Location of Project:**
SD015 TISA Install	SD015 USFB
ARCADIS Personnel Present:	**Other Persons Present:**
Mario Alcalde	ABC Liquin

Purpose of Site Visit:

Date & Time:	Activities:
7:00	Arrived @ location
7:15	Conducted tailgate with ABC Liquin crew
7:30	Housekeeping and positioning rig to drill BHE-6
8:02	Started drilling BHE-6
8:51	Pressure test heat exchanger for BHE-6 with DTS-8
9:17	TD BHE-6 @ 40.5' deep. They hit bedrock and it was lifting the rig
9:31	Started pouring 0/30 sand to install the well. BHE-6 with DTS-8 is in the hole.
11:15	While getting ready to install the monument for SVP-1 they notice that the tube was bent in two locations. To ensure that the tube didn't have any leaks, we proceeded to dig aprox 2ft 5gs to find tube that was in perfect condition and splice it ~~to~~ MA with aprox 8' of tube to reach the opening of the monument. They currently don't have a connector and this will have to wait until tomorrow
11:33	Started building skirts for the mounts @ TISA-~~XXXXX~~ MD 2D, DTS-7 and BHE-1
12:28	Finish pouring 22 bags of 0/30 sand. Lunch break
13:12	Grout well with 3% hydrogel cement (70 gallons)
13:27	Tower down to move the rig to DST-11 location
14:07	Rig situated to drill DST-11
14:21	Started drilling DST-11

Weather: Sunny / high 60's

Signature & Date: 11/30/21

Site Visit Report Site: SD015 Date: 11/30/21 Pg 2 of 2

Date & Time:	Activities: Well drilling and installation
14:45	TD ~~DST-11~~ DTS-11 @ 40' bgs
15:11	PID sample @ 37' 58.0 ppm VOC's (While pulling augers out of the hole)
15:13	Back-fill the hole with native soil
15:20	Tower down
15:25	Drill rig situated to drill DTS-12, Housekeeping
15:29	Started drilling DTS-12
15:45	Stopped drilling @ 25' deep (augers in hole) Housekeeping and concrete work

ARCADIS

Site Visit Report

ARCADIS Project Number:	Dates of Site Visit:
30024237	12/1/21
ARCADIS Project Name:	**Location of Project:**
SD015 TESR Installation	SD015 USFB
ARCADIS Personnel Present:	**Other Persons Present:**
Hans Alcalde Erik Jorgensen Rob Nesbitt	ABC Liquid Matt Bartlett Francis Carson Megan } CSULB

Purpose of Site Visit:

Date & Time:	Activities:
7:00	Arrived at SD015 and conducted tailgate
7:21	Started drilling DTS-12 from 25' to TD
7:37	TD DTS-12 at 40' deep
7:41	Install temperature sensor DTS-12 in hole
7:47	When driller attempted to pull the augers out of the hole, the temp sensor started to come out. Re-drill to 40' and try to install the temp sensor again.
8:02	Erik Jorgensen and Rob Nesbitt from Arcadis are on site
8:27	After speaking with Jacob Mulholland and Matt Bartlett we decided to attach a piece of metal to the bottom of the sensor to weigh it to the bottom of the hole. CSULB is on site
8:33	Pulling out the augers
8:56	Tower down
9:01	Started concrete (5 yards) work and housekeeping
10:28	Soil drum from BME-1 is on its way to the Arcadis Drum yard
12:04	ABC Liquid is off site

Weather:	Signature & Date: 12/1/21

ARCADIS

ARCADIS

Real Time Air Monitoring Data Collection Forms

Document all air monitoring conducted on the Site below based on Section E of the HASP. Keep this form with the project files.

Site Name: SD015 Date: 11/29/21

Instrument: PID Model: Mini RAE 3000 Serial #: FA 04137

Calibration Method: (material used, settings, etc.)	Isobutylene 100 ppm / Fresh air
Calibration Results:	Pass / 100 ppm / Pass : 0.0 ppm
Calibrated By:	

Activity Being Monitored	Compounds Monitored	Time	Reading	Action Required? Y/N
HSA TISA-2D (drilling)	VOCs	10:46	0.0 ppm	N
HSA TISA-2D (drilling)	VOCs	11:14	0.0	N
HSA TISA-2S (drilling)	VOCs	14:53	0.0	N
HSA TISA-2S (install)	VOCs	15:33	0.0	N

Describe Any Actions Taken as a Result of this Air Monitoring and Why:

Signed: _____
Site Safety Officer

Make additional copies of this form as necessary.

ARCADIS

Real Time Air Monitoring Data Collection Forms

Document all air monitoring conducted on the Site below based on Section E of the HASP. Keep this form with the project files.

Site Name: SD015 Date: 11/30/21

Instrument: PID Model: MiniRAE 3000 Serial #: TA04132

Calibration Method: (material used, settings, etc.)	Isobutylene 100 ppm / Fresh air
Calibration Results:	Pass 100.5 ppm / Pass 0.0 ppm
Calibrated By:	

Activity Being Monitored	Compounds Monitored	Time	Reading	Action Required? Y/N
Drilling BHE-6	VOCs	8:32	0.0	N
Drilling BHE-6	VOCs	9:07	0.0	N
Drilling ~~AST-11~~ DTS-11	VOCs	14:34	0.0	N
Pulling the auger out of DST-11	VOCs	15:01	0.0	N
Drilling DTS-12	VOCs	15:38	0.0	N

Describe Any Actions Taken as a Result of this Air Monitoring and Why:

Signed: _____
Site Safety Officer

Make additional copies of this form as necessary.

ARCADIS

Real Time Air Monitoring Data Collection Forms

Document all air monitoring conducted on the Site below based on Section E of the HASP. Keep this form with the project files.

Site Name: SD015 Date: 12/1/21

Instrument: PID Model: MiniRAE 3000 Serial #: 594132

Calibration Method: (material used, settings, etc.)	Fresh air
Calibration Results:	0.0 (Pass)
Calibrated By:	Marc Nicolia

Activity Being Monitored	Compounds Monitored	Time	Reading	Action Required? Y/N
Drilling DTS-12	VOC's	7:27	0.0	N
Pulling augers out of DTS-12	VOC's	8:47	0.0	N

Describe Any Actions Taken as a Result of this Air Monitoring and Why:

Signed: _____

Site Safety Officer

Make additional copies of this form as necessary.

CITY: SAN RAFAEL, CA DIV/GROUP: ENVCAD DB: J. HARRIS
C:\BIM\OneDrive - ARCADIS\BIM360 - OneDrive Sync Location\AUS-AFCEC-VANDENBERG AFB-LOMPOC California\Project Files\2022\01-In Progress\01-DWG\SD015-COVER-TISR.dwg LAYOUT: COVER SAVED: 2/10/2022 2:12 PM ACADVER: 24.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE:
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XREFS: IMAGES: PROJECTNAME: ----

CONSTRUCTION DRAWINGS FOR

THERMAL IN-SITU SUSTAINABLE REMEDIATION (TISR^{SM}) SYSTEM



IMAGE: BING MAPS, © 2017 MICROSOFT CORPORATION

LOCATION MAP

0 2 4
MILES



VANDENBERG U.S. AIR FORCE BASE
SITE SD015
LOMPOC, CALIFORNIA

DATE ISSUED / DATE REVISED

JANUARY 2022

ARCADIS Design & Consultancy for natural and built assets

ARCADIS U.S., INC.

KEY CONTACTS:

PROJECT SITE:
VANDENBERG AIR FORCE BASE
EL RANCHO ROAD AND ASTRAL ROAD/ASTRO ROAD
LOMPOC, CALIFORNIA 93436

ENGINEER:
ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401
TELEPHONE: 805.242.0168
CONTACT: WILLIAM SEMEL, P.E.

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G-3A	SD015 TISR^{SM} DISTRIBUTED TEMPERATURE SENSING LOCATIONS
G-4	EQUIPMENT LAYOUT
G-5	MANIFOLD DETAILS
G-6	BOREHOLE HEAT EXCHANGER SCHEMATIC AND DTS POINT CONSTRUCTION DETAILS
G-6A	MONITORING POINT CONSTRUCTION DETAILS
G-7	TRENCH CROSS SECTION AND MANIFOLD DETAILS
P-1	TISR^{SM} PROCESS AND INSTRUMENTATION DIAGRAM
	ELECTRICAL - E DRAWINGS
E-1	ELECTRICAL SPECIFICATIONS (1 OF 2)
E-2	ELECTRICAL SPECIFICATIONS (2 OF 2) & SYMBOL LEGEND
E-3	ELECTRICAL ONE LINE DIAGRAM
E-4	SD015 TISR^{SM} ELECTRICAL SITE PLAN

DIV/GROUP: ENV/CAD LD: JMEYER PIC: PM: TM: LYR:ON=*;OFF=*REF*
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SD015 AB-TITLEBLOCK-X00
SD015-GIS DATA-BASEMAP

15MW9

15MW8

15-SVP-2

2 G-1/G-1A P-1 PUMP STATION DETAIL

BHE MANIFOLD

1 G-1 G-5

15-EW/IW-05

UE UE

A G-1/G-1A G-5

UE UE UE UE UE UE

1 G-1/G-1A G-3 SOLAR COLLECTOR ARRAY(SC-101/SC-102)

BRANCH CONNECTION TO HEADER

15-TISR-1S
15-TISR-1D
15-BHE-3
BHE RADIUS OF INFLUENCE (8 FEET)
15-BHE-2
15-BHE-1
15-TISR-3D
15-TISR-3S
15-MW-41
15-SVP-1
15-BHE-5
15-BHE-4
15-IW-17
15-TISR-4D
15-TISR-4S
15-TISR-2D
15-TISR-2S
15-BHE-6
15-BHE-8
15-BHE-7
B G-1 G-5

EXISTING DGR ELECTRICAL TRANSFORMER AND CONTROL PANELS

15-EW-10

UE

UE

1 G-1/G-1A P-1 ABOVE -GRADE PIPING AND PROCESS SYSTEM DETAILS

BOREHOLE HEAT EXCHANGER DETAIL A G-1/G-1A G-4

15-IW-06a

15-EW/IW-06

EXISTING DGR TREATMENT COMPOUND

TETHYS ROAD

LEGEND:

- EXISTING MONITORING WELL
- PROPOSED TEMPORARY GROUNDWATER MONITORING WELL (INSTALLED BY OTHERS)
- PROPOSED NESTED SOIL VAPOR PROBE (INSTALLED BY OTHERS)
- PROPOSED BOREHOLE HEAT EXCHANGER (BHE) (20'-40' BGS) (INSTALLED BY OTHERS)
- EXISTING EXTRACTION WELL
- EXISTING INJECTION WELL
- ABOVEGRADE STAINLESS STEEL INSULATED FLEX PIPE (COLD CIRCULATION LINE)
- ABOVEGRADE STAINLESS STEEL INSULATED FLEX PIPE (HOT CIRCULATION LINE)
- EXISITING EXTRACTION PIPING
- UE TRENCHED ELECTRICAL AND CONTROL WIRING CONDUIT

NOTE:

1. BOREHOLE HEAT EXCHANGERS, DTS POINTS, GROUNDWATER MONITORING WELLS AND SOIL VAPOR PROBES TO BE INSTALLED BY OTHERS. CONTRACTOR IS RESPONSIBLE FOR CONNECTION OF CONVEYANCE PIPING TO BHEs STICKUPS.
2. CONVEYANCE PIPING FOR HEATING FLUID WILL BE INSTALLED ABOVE–GRADE.
3. ALL PROPOSED REMEDIATION WELL AND MONITORING POINT LOCATIONS AND TRENCH LINES SHOWN ARE APPROXIMATE, AND WILL BE ADJUSTED IN THE FIELD TO AVOID UTILITIES.
4. BOREHOLE HEAT EXCHANGER, DTS POINTS, AND TRENCH LOCATIONS ARE APPROXIMATE AND WILL BE RELOCATED BASED ON FIELD CONDITIONS AS NEEDED.
5. ONE PUMP STATION WILL BE INSTALLED.
6. BHE = BOREHOLE HEAT EXCHANGER

0 10' 20'
GRAPHIC SCALE

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Professional Engineer's Name

Professional Engineer's No.

State	Date Signed	Project Mgr.
CA		XX
Designed by	Drawn by	Checked by
XX	JAM	XX

ARCADIS

ARCADIS U.S., INC.

VANDENBERG AIR FORCE BASE ● CALIFORNIA
CONSTRUCTION DRAWINGS ● SD015

SD015 TISR^{SM} SITE PLAN

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ARCADIS Project No.
30027243

Date
JANUARY 2022

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

G-3

DIV/GROUP: ENVCAD LD: JMEYER PIC: PM: TM: LYR:ON=*;OFF=*REF*
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SD015-GIS DATA-BASEMAP

15MW9
15MW8
15-SVP-2
15-EW/IW-05
15-DTS-1
15-TISR-1S
15-TISR-1D
15-DTS-2
15-BHE-1
15-BHE-2
15-BHE-3
15-DTS-3
15-TISR-3D
15-TISR-3S
15-MW-41
15-DTS-12
15-SVP-1
15-DTS-6
15-BHE-5
15-DTS-4
15-DTS-7
15-DTS-5
15-BHE-4
15-TISR-4D
15-TISR-4S
15-IW-17
15-TISR-2D
15-TISR-2S
15-BHE-6
15-DTS-8
15-BHE-7
15-DTS-9
15-BHE-8
15-DTS-11
15-IW-06a
DTS BOREHOLE DETAIL
B
G-1A G-4
15-DTS-10
15-EW/IW-06
15-EW-10
EXISTING DGR
ELECTRICAL TRANSFORMER
AND CONTROL PANELS
EXISTING DGR
TREATMENT COMPOUND
TETHYS ROAD

LEGEND:

- EXISTING MONITORING WELL
- PROPOSED TEMPORARY GROUNDWATER MONITORING WELL (INSTALLED BY OTHERS)
- PROPOSED NESTED SOIL VAPOR PROBE (INSTALLED BY OTHERS)
- PROPOSED BOREHOLE HEAT EXCHANGER (BHE)(20'-40' BGS) (INSTALLED BY OTHERS)
- EXISTING EXTRACTION WELL
- EXISTING INJECTION WELL
- SOLAR COLLECTOR
- EXISTING EXTRACTION PIPING
- UE — TRENCHED ELECTRICAL AND CONTROL WIRING CONDUIT
- DTS FIBER TRANSMISSION LINE (INSTALLED BY OTHERS)
- DTS BOREHOLE (INSTALLED BY OTHERS)
- DTS INSTALLED WITH BHE (INSTALLED BY OTHERS)

NOTE:

1. ALL PROPOSED REMEDIATION WELL AND MONITORING POINT LOCATIONS AND TRENCH LINES SHOWN ARE APPROXIMATE, AND WILL BE ADJUSTED IN THE FIELD TO AVOID UTILITIES.
2. BOREHOLE HEAT EXCHANGER, DTS POINTS, AND TRENCH LOCATIONS ARE APPROXIMATE AND WILL BE RELOCATED BASED ON FIELD CONDITIONS AS NEEDED.
3. DTS = DISTRIBUTED TEMPERATURE SENSING.
4. ALL DTS LOCATIONS AND ASSOCIATED ABOVEGROUND INFRASTRUCTURE (CONDUIT) INSTALLED BY OTHERS.

0 10' 20'
GRAPHIC SCALE

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Professional Engineer's Name		
Professional Engineer's No.		
State: CA	Date Signed	Project Mgr.: XX
Designed by: XX	Drawn by: JAM	Checked by: XX

ARCADIS U.S., INC.

VANDENBERG AIR FORCE BASE ● CALIFORNIA
CONSTRUCTION DRAWINGS ● SD015

SD015 TISR^{SM} DISTRIBUTED TEMPERATURE SENSING LOCATIONS

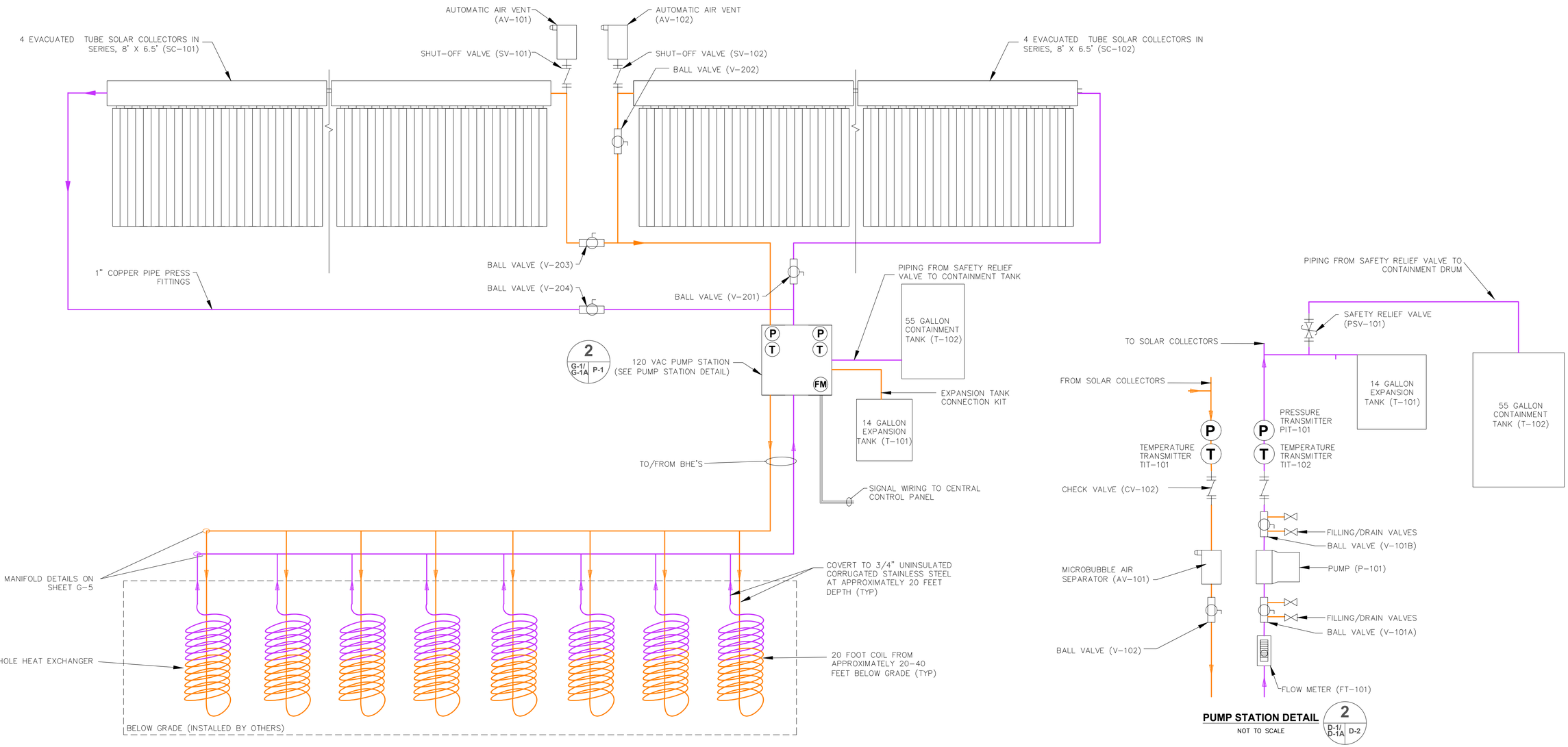
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ARCADIS Project No.: 30027243
Date: JANUARY 2022

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

G-3A

DIV/GROUP: ENVCAD LD: JMEYER PIC: PM: TM: LYR:ON=*;OFF=*REF*
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XREFS:
SD015 AB-TITLEBLOCK-X00



ABOVE-GRADE PIPING AND PROCESS SYSTEM DETAILS 1 (D-1/ D-1A | D-2)

NOT TO SCALE

PUMP STATION DETAIL 2 (D-1/ D-1A | D-2)

NOT TO SCALE

NOTE:

1. THE EXPANSION TANK AND CONTAINMENT DRUM WILL CONTAIN THE HEATING FLUID ONLY (50% FOOD-GRADE PROPYLENE GLYCOL AND 50% DEIONIZED WATER).

LEGEND:

- HOT CIRCULATION LINE FOR THE PROPOSED TRENCH
- COLD CIRCULATION LINE FOR THE PROPOSED TRENCH
- (FM) FLOW METER
- (T) TEMPERATURE GAUGE
- (P) PRESSURE GAUGE

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Professional Engineer's Name		
Professional Engineer's No.		
State: CA	Date Signed:	Project Mgr.: XX
Designed by: XX	Drawn by: JAM	Checked by: XX

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CONSTRUCTION DRAWINGS • SD015

TISR[SM] PROCESS AND INSTRUMENTATION DIAGRAM

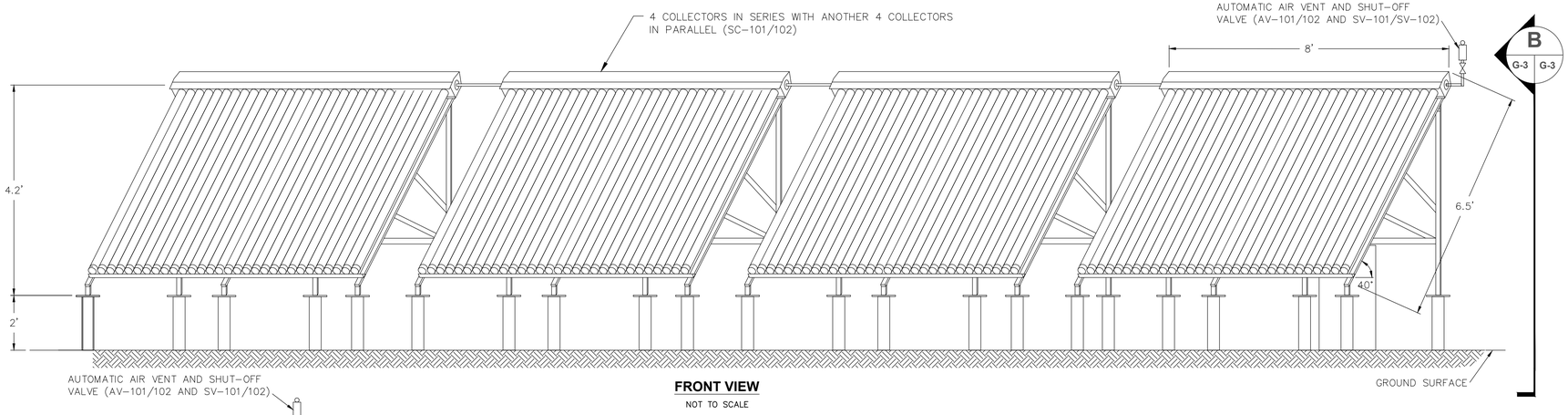
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ARCADIS Project No. 30027243

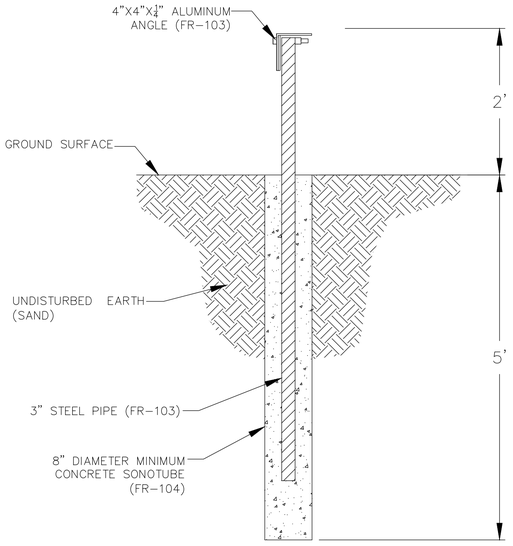
Date JANUARY 2022

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

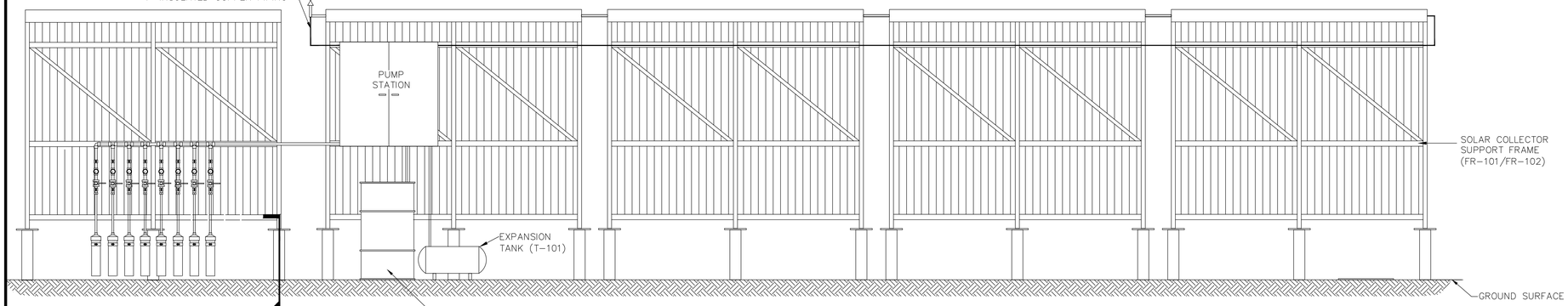
P-1



FRONT VIEW
NOT TO SCALE



SUPPORT BASE ANCHORAGE DETAIL (TYP) A (G-3 | G-3)
NOT TO SCALE

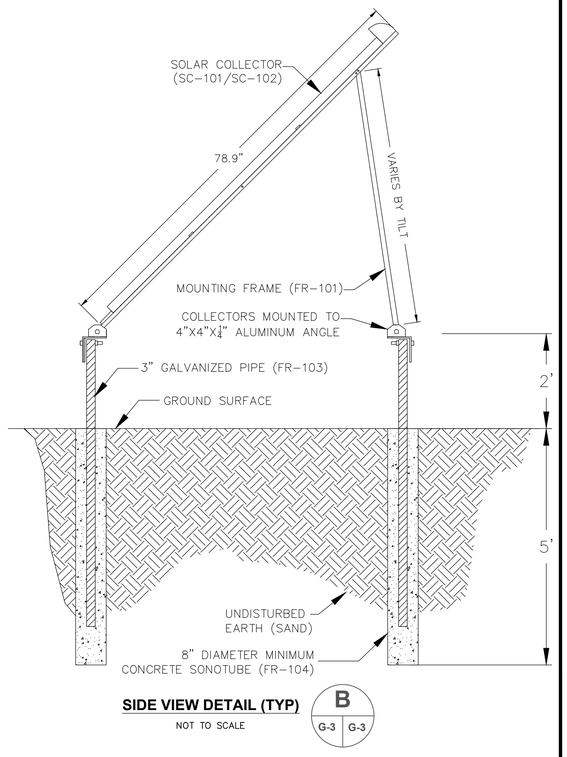


BACK VIEW
NOT TO SCALE

SOLAR TRANSECT DETAIL 1 (G-1/G-1A | G-3)
NOT TO SCALE

NOTES:

1. PUMP CONTROL, CIRCULATION PUMP, DATALOGGER, TELEMETRY MODEM ARE HOUSED IN THE CONTROL PANEL.
2. THE EXPANSION TANK AND CONTAINMENT DRUM WILL CONTAIN THE HEATING FLUID ONLY (50% FOOD-GRADE PROPYLENE GLYCOL AND 50% DEIONIZED WATER).



SIDE VIEW DETAIL (TYP) B (G-3 | G-3)
NOT TO SCALE

DIV/GROUP: ENVCAD LD: JMEYER PIC: PM: TM: LYR:ON=*;OFF=*REF*
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XREFS:
SD015 AB-TITLEBLOCK-X00

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Professional Engineer's Name		
Professional Engineer's No.		
State: CA	Date Signed:	Project Mgr.: XX
Designed by: XX	Drawn by: JAM	Checked by: XX

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VANDENBERG AIR FORCE BASE • CALIFORNIA
CONSTRUCTION DRAWINGS • SD015

EQUIPMENT LAYOUT

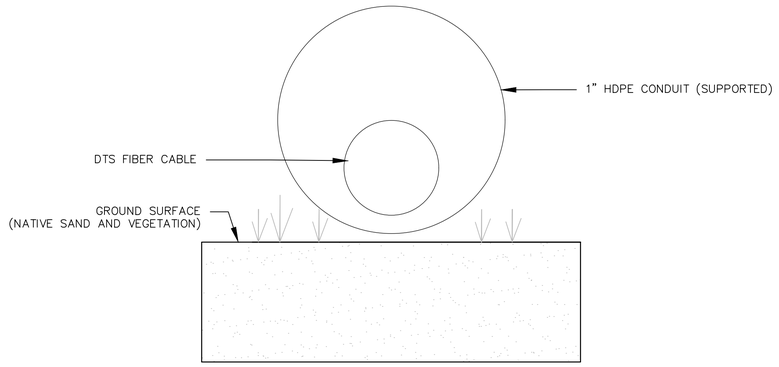
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ARCADIS Project No.
30027243

Date
JANUARY 2022

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

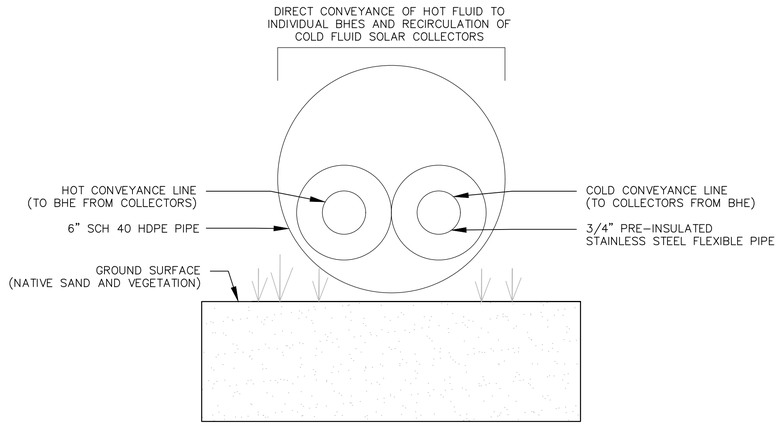
G-4



CROSS SECTION - ABOVEGROUND DTS CONVEYANCE LINE (INSTALLED BY OTHERS)

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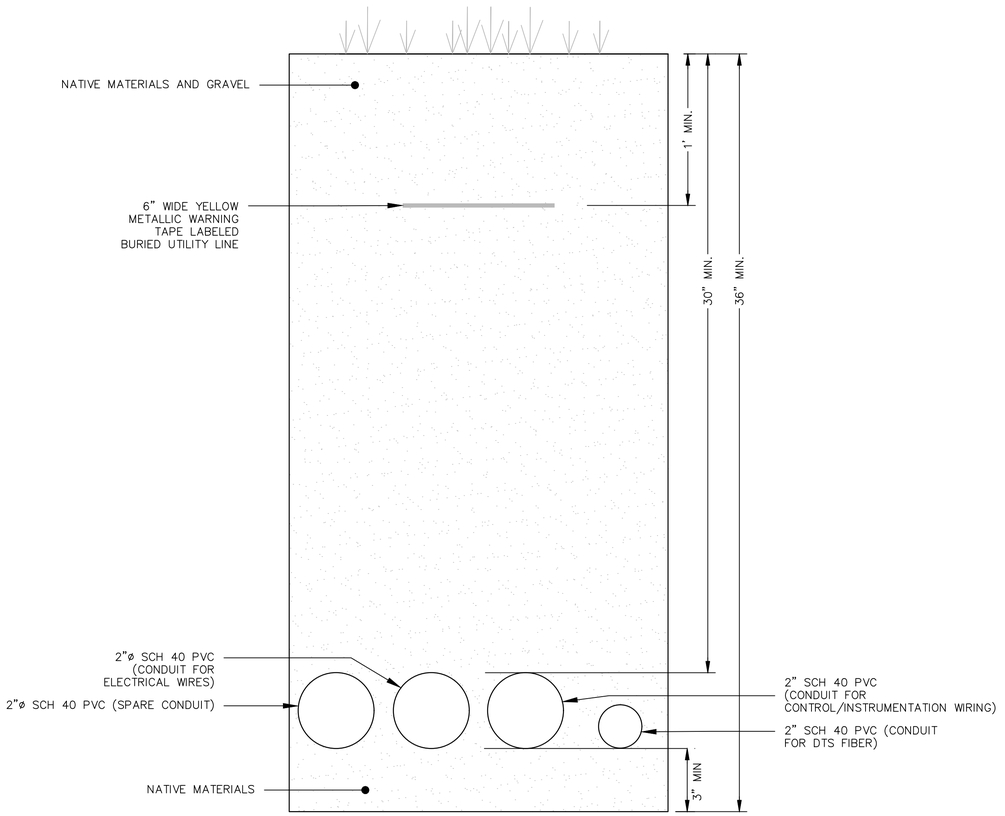
1 | G-1 | G-5



CROSS SECTION - ABOVE GROUND BHE CONVEYANCE LINE 1 OF 8

NOT TO SCALE

B | G-1 | G-5



CROSS SECTION - ELECTRICAL TRENCH

NOT TO SCALE

A | G-1/ G-1A | G-5

NOTES:

1. CONTRACTOR SHALL PERFORM BACKFILL AND COMPACTION IN ACCORDANCE WITH THE SPECIFICATIONS IN THE BID SPECIFICATIONS PACKAGE.
2. ELECTRICAL CONDUITS WILL HAVE A DIAMETER SUITABLE FOR THE REQUIRED CONDUCTOR SIZE FOR THE ELECTRICAL POWER SERVICE TYPE (TO BE DETERMINED).

DIV/GROUP: ENVCAD LD: JMEYER PIC: PM: TM: LYR:ON=*;OFF=*REF*
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Professional Engineer's Name

Professional Engineer's No.

State	Date Signed	Project Mgr.
CA		XX
Designed by	Drawn by	Checked by
XX	JAM	XX

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CONDUIT CROSS SECTION DETAILS

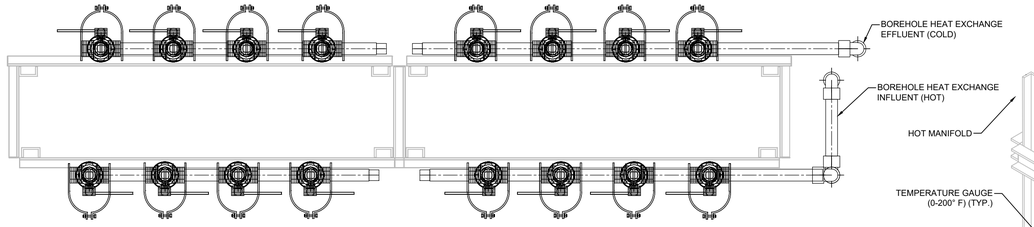
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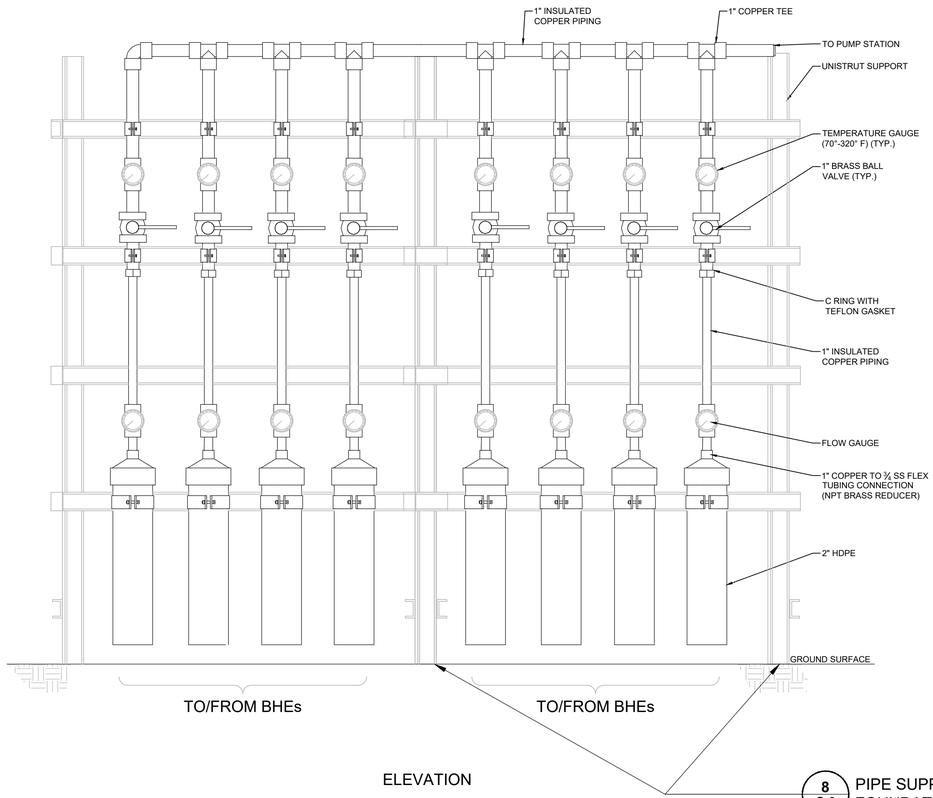
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G-7



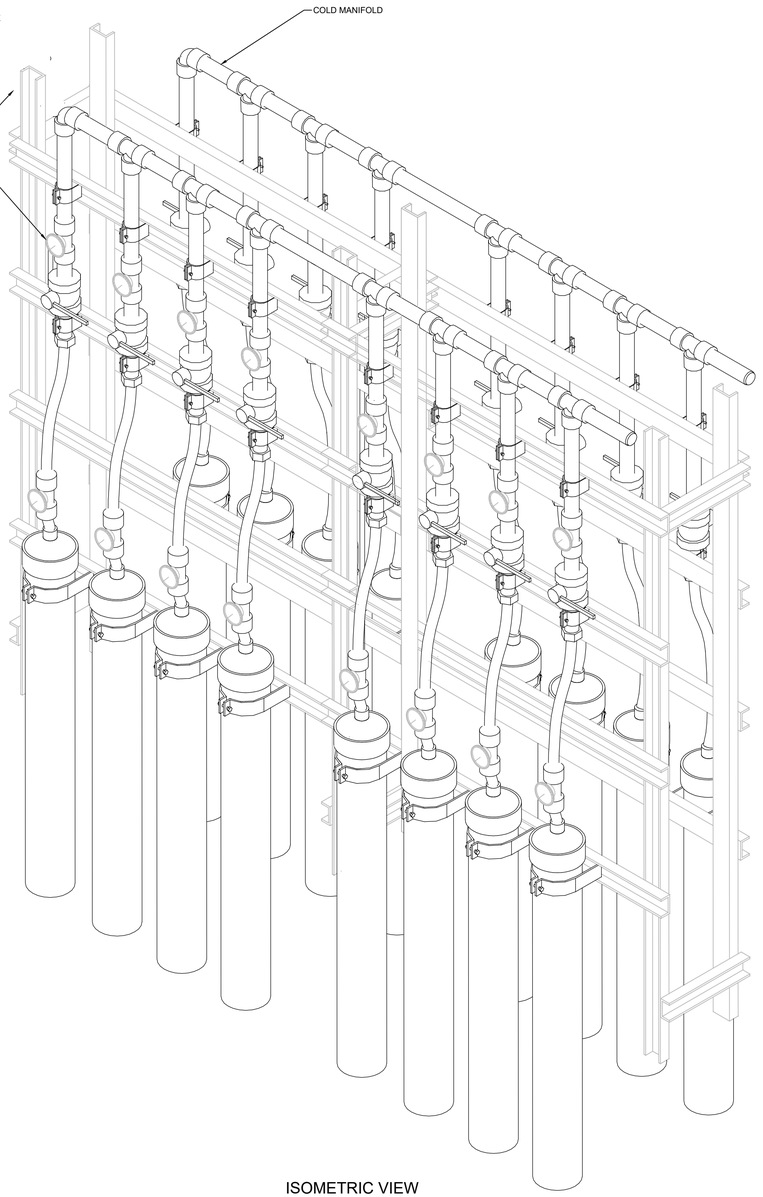
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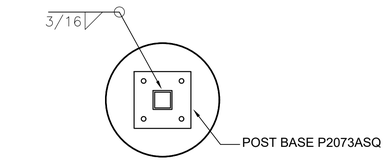


ELEVATION

8 G-9 PIPE SUPPORT FOUNDATION DETAIL

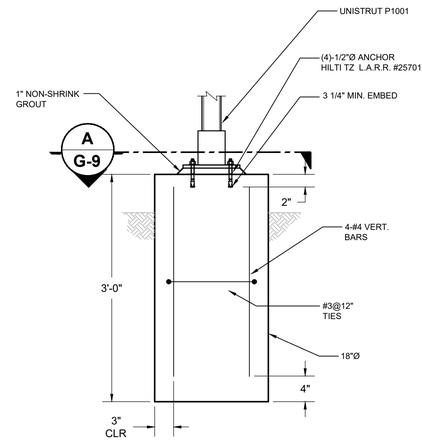


ISOMETRIC VIEW



A G-9 BASE PLATE SECTION

NOT TO SCALE



NOTES:

ANCHOR: HILTI TZ
ANCHOR SIZE: 1/2"
SPECIAL INSPECTION: YES
RATING BASIS: ESR-1817
SUBSTRATE: NORMAL WEIGHT CONCRETE
SUBSTRATE RATING: 4000 PSI

7 G-4 MANIFOLD DETAILS (TYPICAL OF 8)

8 G-9 PIPE SUPPORT FOUNDATION DETAIL

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Professional Engineer's Name

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State	Date Signed	Project Mgr.
CA		XX
Designed by	Drawn by	Checked by
XX	JAM	XX

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TRENCH CROSS SECTION AND MANIFOLD DETAILS

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G-5

SCOPE OF WORK

1. THE CONTRACTOR SHALL MOBILIZE TO THE SITE AND PREPARE EQUIPMENT STORAGE AREAS AND MATERIALS LAYDOWN YARD. THE CONTRACTOR IS RESPONSIBLE FOR THE SECURITY OF THEIR EQUIPMENT AND ANY MATERIALS PURCHASED FOR THE PROJECT.
2. THE CONTRACTOR SHALL INSTALL NEW UNDERGROUND PIPING AND ELECTRICAL CONDUIT/CONDUCTORS FROM THE POWER DROP METER TO THE PUMPING STATION. ALSO, UNDERGROUND CONDUITS AND WIRING SHALL BE COMPLETED FOR ALL POWER AND CONTROL WIRING TO FOR THE PUMPING STATION. ADDITIONAL DETAILS AND SPECIFICATIONS FOR THE ELECTRICAL WORK ARE PRESENTED IN THE ELECTRICAL DRAWINGS.
3. EIGHT BOREHOLE HEAT EXCHANGERS (BHEs), TWELVE DISTRIBUTED TEMPERATURE SENSING POINTS (DTS), AND TWO SOIL VAPOR MONITORING POINTS (SVP) WILL BE INSTALLED BY OTHERS.
4. THE CONTRACTOR SHALL COMPLETE THE REMEDIATION SYSTEM SO THAT IT IS FULLY FUNCTIONAL. THIS INCLUDES ALL PIPING AND WIRING AND ANY NECESSARY CONNECTIONS. THE CONTRACTOR SHALL PARTICIPATE IN THE COMMISSIONING AND TESTING OF THE UNIT TO ASSURE THAT THE SYSTEM IS FUNCTIONING PER THE DESIGN AND THERE ARE NO LEAKS OR OPERATIONAL ISSUES.
5. THE CONTRACTOR SHALL KEEP THE WORK SITE CLEAN ON A DAILY BASIS AND ALL DEBRIS SHALL BE REMOVED AND THE SITE LEFT IN CLEAN CONDITION AFTER THE COMPLETION OF WORK.
6. ARCADIS WILL PROVIDE OVERSIGHT OF CONSTRUCTION ACTIVITIES. A FIELD ENGINEER/SUPERVISOR WILL BE DEFINED AT A LATER TIME. THE CONTRACTOR WILL ABIDE BY ARCADIS DIRECTION AND THE CONTRACTOR IS REQUIRED TO COMPLETE THE PROJECT TO THE SATISFACTION OF ARCADIS.

SITE HEALTH AND SAFETY

1. CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE LOCAL, STATE, AND FEDERAL HEALTH AND SAFETY CODES ALWAYS.
2. THE CONTRACTOR AND SUB-CONTRACTOR PERSONNEL ARE REQUIRED TO HAVE 40-HOUR OSHA HAZWOPER TRAINING AND 8-HOUR REFRESHER TRAINING, AND ALL EMPLOYEES MUST BE CURRENT IN THEIR CERTIFICATIONS. SOME SUBCONTRACTORS THAT DO NOT CONTACT IMPACTED SOILS OR GROUNDWATER MAY BE EXEMPT FROM THIS REQUIREMENT
3. THE CONTRACTOR SHALL PROVIDE A SITE-SPECIFIC HEALTH AND SAFETY PLAN (HASP) AND COMPLY WITH ALL ARCADIS AND/OR ARCADIS CLIENT HEALTH AND SAFETY GUIDELINES.
4. THE CONTAMINANTS OF CONCERN ARE CHLORINATED VOLATILE ORGANIC COMPOUNDS. ADDITIONAL DATA ON THESE COMPOUNDS CAN BE PROVIDED BY ARCADIS.
5. IT IS THE CONTRACTOR'S RESPONSIBILITY FOR EDUCATING ITS SUPERVISORS, EMPLOYEES, AND SUB-CONTRACTORS OF ALL HEALTH AND SAFETY REQUIREMENTS. CONTRACTOR IS RESPONSIBLE FOR WORKER SAFETY.
6. AT A MINIMUM, ALL ONSITE CONTRACTOR PERSONNEL SHALL BE IN LEVEL D PPE WHICH IS DEFINED AS HARD HAT, STEEL TOE BOOTS, AND SAFETY GLASSES.
7. ARCADIS OVERSIGHT PERSONNEL WILL ALSO BE ONSITE TO ASSURE THAT THE WORK IS BEING COMPLETED IN A SAFE MANNER.

PIPING AND PIPING APPURTENANCE MATERIALS

1. PIPING MATERIALS AND PIPING APPURTENANCES ARE IDENTIFIED ON THE CONSTRUCTION DRAWINGS. ADDITIONAL SPECIFICATIONS ARE PROVIDED IN THIS SECTION. IF THERE ARE ANY DISCREPANCIES BETWEEN THESE SPECIFICATIONS AND THE CONSTRUCTION DRAWINGS, THE ENGINEER SHALL BE CONSULTED TO RESOLVE THE DISCREPANCY.
2. NEW PIPING MATERIAL SHALL BE SCHEDULE 40 HDPE, STAINLESS STEEL AND COPPER AS SHOWN ON THE CONSTRUCTION DRAWINGS.
3. ALL HDPE GLUED CONNECTIONS SHALL USE WELD-ON P-70 PRIMER AND 711 PVC CEMENT PER THE MANUFACTURER'S SPECIFICATIONS.
4. ALL STAINLESS STEEL FLEXIBLE TUBING CONNECTIONS MUST BE MADE PER MANUFACTURES RECOMMENDATIONS TO PREVENT LEAKAGE.
5. ALL VALVES SHALL HAVE A MINIMUM RATING OF 150 PSI AND SHALL HAVE TEFLON SEALS UNLESS OTHERWISE SPECIFIED.
6. ALL OTHER MATERIALS NOT SPECIFICALLY DESCRIBED BUT REQUIRED FOR A COMPLETE AND PROPER INSTALLATION OF THE WORK OF THIS SECTION, SHALL BE NEW, FIRST QUALITY OF THEIR RESPECTIVE KIND, AND AS SELECTED BY CONTRACTOR SUBJECT TO THE APPROVAL OF ARCADIS.
7. PIPE AND PIPING APPURTENANCES THAT ARE ONSITE SHALL BE PROPERLY STORED TO PREVENT DAMAGE OR THEFT. ANY DAMAGED OR STOLEN MATERIALS WILL BE REPLACED BY THE CONTRACTOR.

PIPING INSTALLATION

1. THE PIPING INSTALLERS PROVIDED BY THE CONTRACTOR SHALL BE THOROUGHLY TRAINED AND
2. EXPERIENCED IN THE NECESSARY CRAFTS AND FAMILIAR WITH THE SPECIFICATIONS PROVIDED HERE.
3. CONSTRUCTION DRAWINGS SHOW GENERAL ARRANGEMENT, DIRECTION, AND SIZE OF PIPES AND ARE NOT INTENDED TO SHOW EVERY OFFSET, VALVE, AND FITTING, OR EVERY STRUCTURAL DIFFICULTY THAT MAY BE ENCOUNTERED. INSTALL THE PIPING AND APPURTENANCES TO SUIT. VERIFY ALL MEASUREMENTS AT THE SITE. INSTALL ALL PIPING IN STRICT ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND IN ACCORDANCE WITH ALL APPLICABLE STATE AND LOCAL CODES.
4. THE CONTRACTOR SHALL PROVIDE ADEQUATE PIPE SUPPORTS FOR ALL NECESSARY PIPES.
5. PRESSURE GAUGES, SAMPLE PORTS, AND OTHER INSTRUMENTATION SHALL BE INSTALLED IN LOCATIONS THAT ARE EASILY READABLE AND ACCESSIBLE FOR MAINTENANCE.
6. THE EXACT LOCATIONS OF PIPING APPURTENANCES AND TRENCHING SHALL BE DETERMINED IN THE FIELD DURING CONSTRUCTION AND DISCUSSED WITH THE ENGINEER'S REPRESENTATIVE.
7. ALL ABOVE-GROUND PIPING SHALL BE PERMANENTLY LABELED WITH DIRECTIONAL FLOW ARROWS AND LINE CONTENTS SHALL BE IDENTIFIED.
8. ALL 90-DEGREE BENDS INSTALLED UNDERGROUND OR WHERE OTHERWISE INDICATED ON THE CONSTRUCTION DRAWINGS SHALL BE CONSTRUCTED USING LONG-SWEEP ELBOWS TO ALLOW FOR CLEANING THE LINES IN THE FUTURE.
9. CONTRACTOR SHALL COMPLY WITH LOCAL PLUMBING PERMITS REQUIRED FOR THIS WORK AND WORK SHALL BE COMPLETED IN ACCORDANCE WITH THE CALIFORNIA PLUMBING CODE.

PRESSURE TESTING

1. THE CONTRACTOR SHALL COMPLETE PRESSURE TESTS FOR ALL PIPING. ARCADIS SHALL BE PRESENT DURING THE TESTS TO OBSERVE THE TESTS PROCEDURES AND VERIFY THE RESULTS OF THE TESTS. THE CONTRACTOR SHALL PROVIDE THE TEST FORMS TO DOCUMENT THE TEST CONDITIONS AND THE FORMS MUST BE SIGNED BY THE ENGINEER'S REPRESENTATIVE AT THE TIME OF THE TEST.
2. HYDROSTATIC TESTS (WITH WATER) FOR ALL WATER PIPING SHALL BE CONDUCTED USING CLEAN POTABLE WATER. PIPE SHALL BE CAPPED BEFORE TESTING AND EQUIPMENT SUCH AS FLOW METERS SHOULD BE ISOLATED TO PREVENT DAMAGE. THE PIPING SYSTEM MAY BE TESTED IN SECTIONS WITH APPROVAL FROM ARCADIS. HYDROSTATIC TESTS WILL BE COMPLETED AT A PRESSURE OF 50 PSI. ONCE THE TEST PRESSURE HAS BEEN ACHIEVED, THE TEST WILL LAST FOR A MINIMUM OF 1 HOUR OR AS MUCH TIME AS MAY BE REQUIRED TO PROPERLY INSPECT ALL JOINTS AND CONNECTIONS. HYDROSTATIC TEST ACCEPTANCE SHALL BE +/- 5% OF THE PRESSURE RATING. DEVIATIONS REGARDING TEST PRESSURE AND TIMES SHALL REQUIRE APPROVALS BY ARCADIS.
3. DURING THE PIPE TESTS, THE PIPING SYSTEM SHALL BE INSPECTED FOR LEAKS AND SHALL BE DRIP TIGHT WITH NO SIGNS OF LEAKAGE.
4. IF THE TEST RESULTS ARE NOT CONSIDERED TO BE ACCEPTABLE BY ARCADIS, THEN THE CONTRACTOR SHALL IDENTIFY AND REPAIR THE LEAKS. THE PIPE MUST BE RE-TESTED AFTER THE REPAIRS UNTIL ACCEPTABLE TEST RESULTS ARE ACHIEVED.
5. WRITTEN RECORDS OF THE PIPE TEST SHALL BE MADE BY THE CONTRACTOR OF EACH PIPE SEGMENT AND SUBMITTED TO ARCADIS. THE TEST RECORDS SHALL INCLUDE THE FOLLOWING:
   a. DATE OF TEST
   b. PIPE SEGMENT TESTED
   c. TEST PRESSURE, AIR TEMPERATURE AND TIME BEFORE AND AFTER TEST
   d. REMARKS (INCLUDING DESCRIPTION OF TEST RESULTS, LEAKS, AND REPAIRS)
   e. SIGNATURE OF THE CONTRACTOR AND ARCADIS.

EXCAVATION/TRENCHING

1. PRIOR TO BEGINNING ANY EXCAVATION WORK, CONTRACTOR SHALL FORMALLY CONTACT THE REGIONAL UNDERGROUND UTILITY NOTIFICATION SERVICE SUCH AS UNDERGROUND SERVICE ALERT, AND OBTAIN ALL NECESSARY CLEARANCES BEFORE BREAKING GROUND. CONTRACTOR SHALL REVIEW AVAILABLE UTILITY MAPS AND VERIFY THE LOCATIONS OF ALL UTILITIES. ARCADIS WILL HIRE A THIRD-PARTY SERVICE PROVIDER TO CONDUCT A UTILITY SURVEY USING GROUND PENETRATING RADAR (GPR) AND METAL DETECTION AT A MINIMUM. ANY IDENTIFIED ANOMALIES WILL BE DETECTED WITH MARKED WITH ORANGE PAINT ON THE SIDE OF TRENCH.
2. THE CONTRACTOR SHALL HAND EXCAVATE OR SOFT DIG ALL TRENCHES PROPOSED IN AREAS 30" ADJACENT TO UNDERGROUND UTILITIES. ALL UNCOVERED UTILITIES ARE TO BE FULLY EXPOSED AND SHALL BE SUPPORTED, BEDDED, AND BACKFILLED IN ACCORDANCE WITH THE UTILITY OWNER'S REQUIREMENTS AND SPECIFICATIONS. DAMAGE TO UNDERGROUND UTILITIES OR PIPELINES CAUSED BY THE CONTRACTOR SHALL BE REPAIRED AT THE EXPENSE OF THE CONTRACTOR.
3. IT IS EXPECTED THAT ALL TRENCHES WILL BE INSTALLED USING A BACKHOE OR BY SOFT DIG METHODS. IF OTHER TRENCHING METHOD IS USED, THE CONTRACTOR SHALL OBTAIN APPROVAL FROM ARCADIS.
4. EXCAVATED SOILS SHALL BE STOCKPILED WITHIN A BERMED-AREA INSIDE THE WORK ZONE. SOIL STOCKPILES SHALL BE PLACED ON 10-MIL PLASTIC VISQUEEN AND COVERED WITH A MINIMUM OF 6-MIL PLASTIC VISQUEEEN TO PREVENT CONTACT WITH RAINWATER AND/OR PREVENT DUST GENERATION. EARTHEN MATERIALS SHALL NOT BE USED TO SECURE THE VISQUEEN TOP COVER.
5. PIPING SHALL BE LAID IN THE TRENCHES IN AN ORDERLY MANNER. SAND BEDDING WILL BE PLACED BELOW, AROUND, AND ABOVE ALL PIPING FOR COMPACTION AND TO PREVENT DAMAGE WHEN BACKFILLING. SAND BEDDING WILL BE REQUIRED AS ILLUSTRATED ON THE CONSTRUCTION DRAWINGS.
6. ALL PIPING SHALL BE BURIED AT LEAST 24 INCHES DEEP. MAGNETIC LOCATION TAPE SHALL BE INSTALLED ABOVE THE PIPING AND CONDUIT WHEN BACKFILLING.
7. FOR TRENCHES GREATER THAN 18" WIDE, TWO LINES OF TAPE SHALL BE PLACED WITH EACH LINE 4" FROM THE SIDES OF THE TRENCH.
8. EXCAVATED MATERIAL CAN BE USED FOR TRENCH BACKFILL IF SOILS ARE GRANULATED AND LOOSE MATERIAL (NO ROCKS). WHEN BACKFILLING, THE CONTRACTOR SHALL PROPERLY COMPACT THE SOILS IN 6-INCH LIFTS USING A VIBRATORY COMPACTOR.
9. TRENCHES SHALL BE BACKFILLED IN 8" LOOSE LIFTS TO A MINIMUM 90% OF A MAXIMUM DRY-DENSITY AND WITHIN 95% OF AN OPTIMAL MOISTURE CONTENT FORM A MOISTURE-DENSITY RELATION REPRESENTATIVE OF LAB COMPACTION TEST. OBTAIN A NEW MOISTURE-DENSITY CURVE UPON EACH VARIATION IN SOIL INDEX PROPERTIES.

WELL MONUMNET INSTALLATION

1. WELL MONUMENTS FOR THE BHEs, DTS LOCATIONS, MONITORING WELLS AND SVPs ARE DETAILED WITH THE CONSTRUCTION DRAWINGS.
2. ALL WELL MONUMENTS WILL BE INSTALLED TO SPECIFICATIONS BY OTHERS AND ARE NOT INCLUDED IN THE CONTRACTOR'S SCOPE OF WORK.

ELECTRICAL INSTALLATION

1. MORE COMPLETE AND DETAILED ELECTRICAL SCOPE AND SPECIFICATIONS (DRAWING E-1) ARE INCLUDED WITH THE ELECTRICAL DRAWINGS.
2. THE CONTRACTOR SHALL COMPLETE THE INSTALLATION OF THE ELECTRIC POWER FROM THE EXISTING FEED TO THE PUMPING STATION CONTROL PANEL.
3. THE CONTRACTOR SHALL COMPLETE POWER AND CONTROL WIRING TO THE PUMPING STATION.
4. THE CONTRACTOR'S ELECTRICAL INSTALLATION SHALL MEET THE NATIONAL ELECTRIC CODE (NEC) AND ANY OTHER APPLICABLE FEDERAL, STATE, AND LOCAL CODE.
5. A LOCAL ELECTRICAL PERMIT IS REQUIRED TO COMPLETE THE WORK FOR THIS PROJECT AND A LICENSED ELECTRICIAN.

EROSION AND SEDIMENTATION CONTROLS

1. CONTRACTOR SHALL INSTALL MEASURES TO DIVERT STORMWATER FLOW AROUND THE WORK AREA AND AWAY FROM OPEN EXCAVATIONS (E.G., TEMPORARY BERMS, CURBING, HAY BALES, OR SIMILAR METHODS) IN PAVED AREAS AS NECESSARY DURING CONSTRUCTION.
2. CONTRACTOR SHALL INSTALL SEDIMENT FILTERS IN STORM DRAINS LOCATED WITHIN OR ADJACENT TO TRENCHING WORK AREAS THAT RECEIVE SURFACE WATER RUNOFF FLOWS FROM THE WORK AREA.
3. CONTRACTOR SHALL CONTROL FUGITIVE DUST GENERATED DURING CONSTRUCTION AS NECESSARY BY APPLYING A LIGHT SPRAY OF WATER OR OTHER APPROVED DUST CONTROL MEASURES.
4. CONTRACTOR SHALL EMPLOY CONTROLS TO PREVENT CONSTRUCTION VEHICLES FROM TRACKING EXCAVATED SOIL OUT OF THE WORK AREA AND SHALL DESIGN THE WORK AREA LAYOUT TO LIMIT THE POTENTIAL FOR TRACKING OF SOIL OFF-SITE. THE CONTRACTOR SHALL ALSO EMPLOY GOOD HOUSEKEEPING PRACTICES DURING CONSTRUCTION. RESIDUAL EXCAVATED SOIL SHALL BE CLEANED FROM PAVED SURFACES TO THE EXTENT PRACTICAL, TO PREVENT THIS MATERIAL FROM BECOMING ENTRAINED IN SURFACE WATER RUNOFF.

CLEANING

1. A CLEAN WORK AREA SHALL BE MAINTAINED THROUGHOUT AND AT THE END OF EACH WORKING DAY AND AT THE COMPLETION OF THE PROJECT.
2. ALL CONSTRUCTION DEBRIS SHALL BE DISPOSED OF AFTER THE COMPLETION OF WORK, INCLUDING BUT NOT LIMITED TO RUBBLE, CONCRETE AND PIPE. THE DISPOSAL OF ALL CONSTRUCTION DEBRIS SHALL BE AT A LICENSED WASTE DISPOSAL/TREATMENT FACILITY.
3. THE CONTRACTOR IS RESPONSIBLE FOR THE DISPOSAL OF ALL EXCAVATED SOIL THAT IS NOT RE-USED FOR TRENCH BACKFILL. SOILS SHALL BE CHARACTERIZED AND TAKEN OFF-SITE FOR DISPOSAL AT A LICENSED WASTE DISPOSAL FACILITY.

FINAL INSPECTION

1. A FINAL INSPECTION WILL BE COMPLETED BY ARCADIS. THE CONTRACTOR SHALL RESOLVE AND/OR CORRECT ANY DEFICIENCIES THAT ARE NOTED BY ARCADIS.

SUBMITTALS

1. THE FOLLOWING SUBMITTALS NEED TO BE PROVIDED BY THE CONTRACTOR TO THE ENGINEER AT THE SCHEDULE INDICATED BELOW:
   a. SCHEDULE - THE CONTRACTOR SHALL PROVIDE A DETAILED CONSTRUCTION SCHEDULE TO THE ENGINEER WITHIN 10 DAYS OF A NOTICE TO PROCEED. THE SCHEDULE SHALL INCLUDE A DAILY BREAKDOWN OF WORK TASKS FOR EACH PROPOSED WORKWEEK.
   b. CONTRACTOR HEALTH AND SAFETY PLAN (HASP) - THE CONTRACTOR SHALL PROVIDE THEIR HASP TO THE ENGINEER 15 DAYS AFTER AWARD OF THE CONTRACT. THE ENGINEER SHALL PROVIDE ACCEPTANCE OF THE HASP PRIOR TO THE START OF ON-SITE WORK ACTIVITIES.
   c. EQUIPMENT - CONTRACTOR SHALL PROVIDE SUBMITTALS TO THE ENGINEER FOR REVIEW FOR ANY MATERIALS OR EQUIPMENT SELECTED THAT ARE NOT SPECIFIED IN THE DESIGN DRAWINGS, OR FOR ANY ALTERNATE MATERIALS OR EQUIPMENT PROPOSED. EQUIPMENT AND MATERIAL SUBMITTALS SHALL BE PROVIDED TO THE ENGINEER AND APPROVED PRIOR TO CONTRACTOR ORDERING.
   d. RECORD DRAWINGS - THE CONTRACTOR SHALL PROVIDE COMPLETE RECORD DRAWINGS OF THE PROJECT WORK. RECORD DRAWINGS SHALL INCLUDE HAND-WRITTEN MARKUPS OF THE CONSTRUCTION DRAWINGS AS PREPARED BY THE ENGINEER. THE RECORD DRAWINGS MUST BE SUBMITTED TO THE ENGINEER WITHIN 5 DAYS AFTER CONSTRUCTION COMPLETION.
   e. PIPE TEST RECORDS - THE CONTRACTOR SHALL PROVIDE TEST RECORDS FOR ALL PIPE TESTING AS SPECIFIED ABOVE. THE PASSING PIPE TEST FORMS MUST BE SIGNED BY THE ENGINEER. THE TEST RECORDS MUST BE SUBMITTED TO THE ENGINEER WITHIN 24 HOURS OF CONSTRUCTION COMPLETION.
   f. THE CONTRACTOR SHALL PROVIDE TO THE CLIENT COPIES OF ALL WASTE MANIFESTS AND/OR CERTIFICATIONS OF RECLAMATION FOR ALL MEDIA (SOIL, CONSTRUCTION DEBRIS, ETC.) REQUIRING DISPOSAL. THESE MANIFESTS AND/OR CERTIFICATES SHALL BE SUBMITTED TO THE CLIENT PRIOR TO INVOICING.

DIV/GROUP: ENV/CAD LD: JMEYER PIC: PM: TM: LYR:ON=*;OFF=*REF*
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CA		XX
Designed by	Drawn by	Checked by
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SPECIFICATIONS

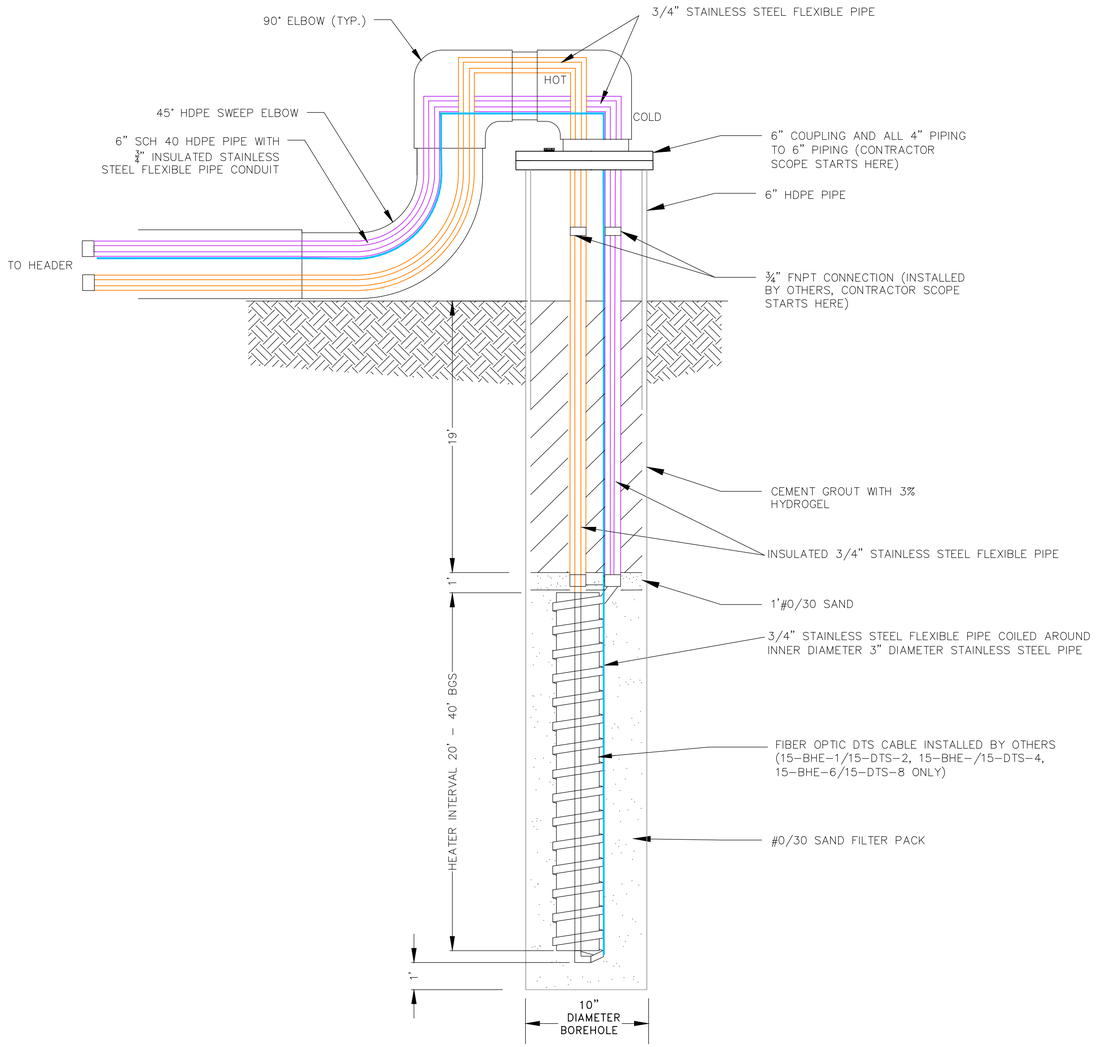
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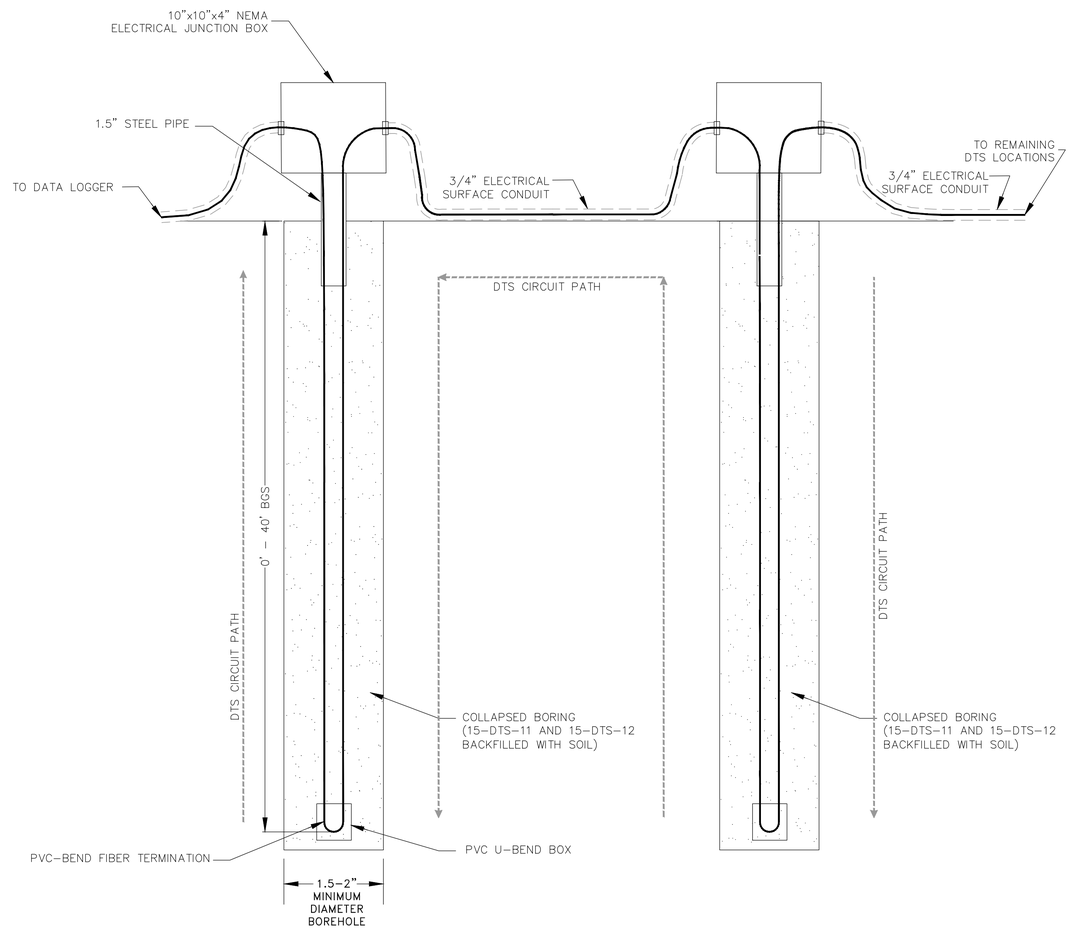
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SUITE 150
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G-2



BOREHOLE HEAT EXCHANGER DETAIL (TYP) A (D-1/D-1A | D-4)

NOT TO SCALE



DISTRIBUTED TEMPERATURE SENSING (DTS) (INSTALLED BY OTHERS) INSTALLATION NEW AND EXISTING MONITORING WELL DETAIL (TYP) B (D-1A | D-4)

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Professional Engineer's Name		
Professional Engineer's No.		
State: CA	Date Signed:	Project Mgr.: XX
Designed by: XX	Drawn by: JAM	Checked by: XX

ARCADIS U.S., INC.

VANDENBERG AIR FORCE BASE ● CALIFORNIA
CONSTRUCTION DRAWINGS ● SD015

BOREHOLE HEAT EXCHANGER SCHEMATIC AND DTS POINT CONSTRUCTION DETAILS

DRAFT - FOR BIDDING PURPOSES ONLY

ARCADIS Project No.
30027243

Date
JANUARY 2022

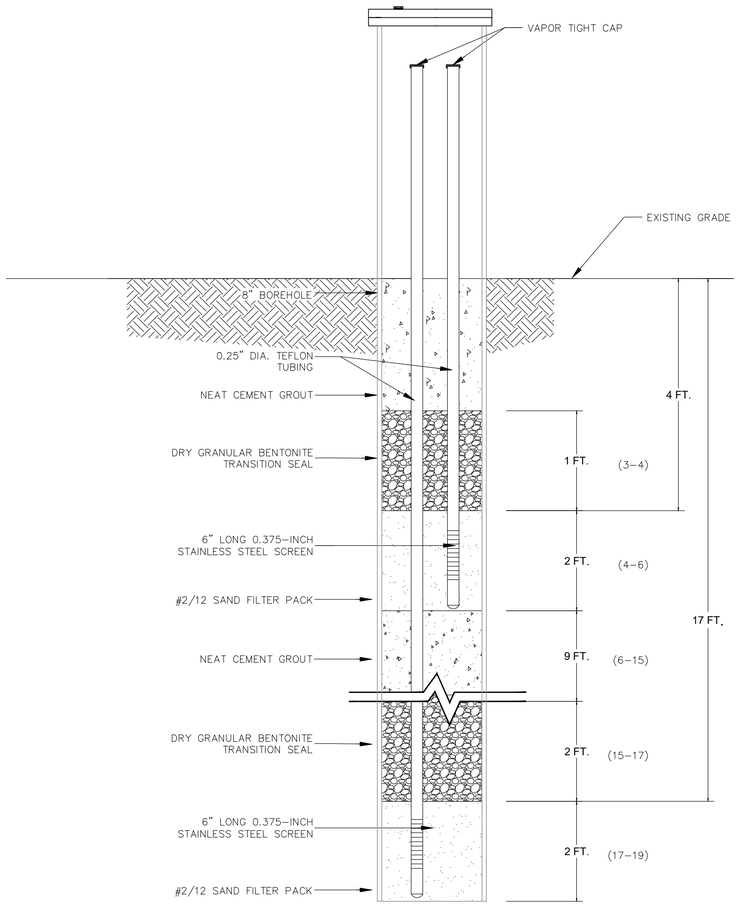
ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

G-6

DIV/GROUP: ENVCAD LD: JMEYER PIC: PM: TM: LYR:ON=*;OFF=*REF*
C:\BIM\OneDrive - ARCADIS\BIM360 - OneDrive Sync Location\AUS-AFCEC-VANDENBERG AFB-LOMPOC California\Project Files\2022\01-In Progress\01-DWG\SD015 AB-D2-PID-CONSTRUCTION DETAIL.dwg LAYOUT: G-6A SAVED: 2/11/2022 11:02 AM ACADVER: 24.0S (LMS TECH) PAGESETUP: ----
PLOTSTYLETABLE: ---- PLOTTED: 2/11/2022 11:03 AM BY: MEYER, JULIE
XREFS:
SD015 AB-TITLEBLOCK-X00

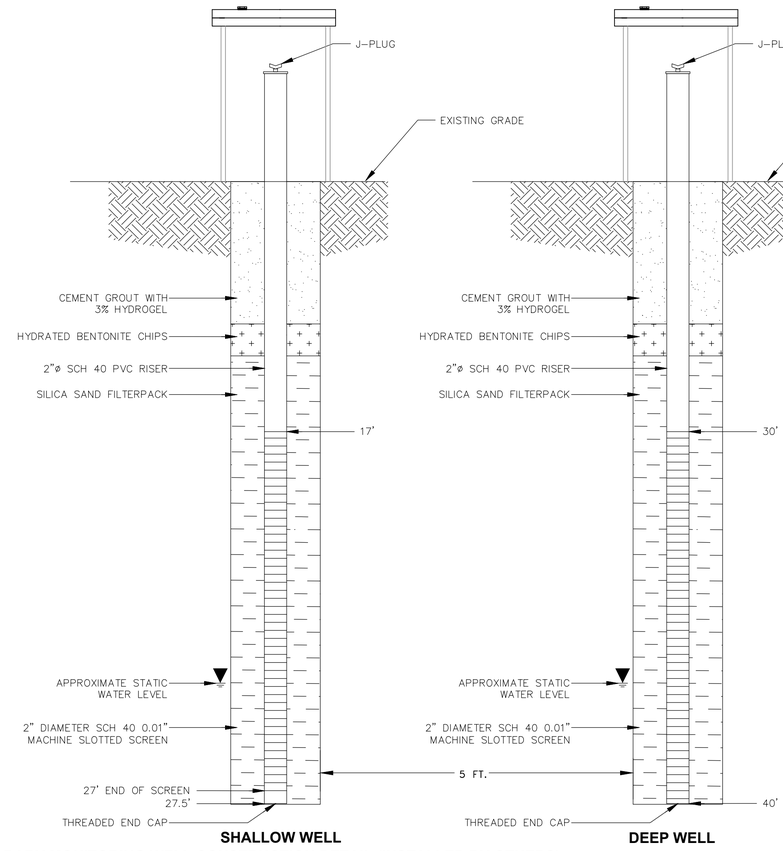
SOIL VAPOR AND GROUNDWATER MONITORING WELL CONSTRUCTION SCHEDULE

ID	Date Installed	Drillling method	Well Diameter (in)	Screening Interval (ft bgs)	Screen material	Screen slot	Sump	Total Depth (ft bgs)	Filter pack depth (ft bgs)	TOC elevation (ft msl)	Casing Material	Northing	Easting
TISR-1S	11/17/2021	8" HAS	2	17.5 to 27.5	2" SCH 40 SLOTTED PVC	0.01	NO	27.5	2/16 SAND 15.5 TO 27.5	88.88	SCH 40 PVC	2121784.75	5781522.80
TISR-1D	11/17/2021	8" HSA	2	30 to 40	2" SCH 40 SLOTTED PVC	0.01	NO	40	2/16 SAND 28 TO 40	88.95	SCH 40 PVC	2121785.31	5781525.54
TISR-2S	11/29/2021	8" HSA	2	17 to 27	2" SCH 40 SLOTTED PVC	0.01	NO	27.5	2/16 SAND 15.5 TO 27.5	88.88	SCH 40 PVC	2121753.96	5781487.24
TISR-2D	11/29/2021	8" HSA	2	30 to 40	2" SCH 40 SLOTTED PVC	0.01	NO	40	2/16 SAND 28 TO 40	88.67	SCH 40 PVC	2121755.65	5781490.34
TISR-3S	11/18/2021	8" HSA	2	17.5 to 27.5	2" SCH 40 SLOTTED PVC	0.01	NO	27.5	2/16 SAND 15.5 TO 27.5	89.01	SCH 40 PVC	2121773.06	5781497.30
TISR-3D	11/18/2021	8" HSA	2	30 to 40	2" SCH 40 SLOTTED PVC	0.01	NO	40	2/16 SAND 28 TO 40	88.72	SCH 40 PVC	2121774.38	5781499.78
TISR-4S	11/15/2021	8" HSA	2	17.5 to 27.5	2" SCH 40 SLOTTED PVC	0.01	NO	27.5	2/16 SAND 15.5 TO 27.5	88.72	SCH 40 PVC	2121759.31	5781520.87
TISR-4D	11/11/2021	8" HSA	2	30 to 40	2" SCH 40 SLOTTED PVC	0.01	NO	40	2/16 SAND 28 TO 40	88.75	SCH 40 PVC	2121759.62	5781523.90
SVP-1	11/11/2021	8" HSA	.25 in	PROBES AT 4.5 and 17.5	0.375" STAINLESS STEEL	-	NO	17.5	2/12 SAND 4 TO 6 AND 17 to 19	86.50	0.25 in TEFLON TUBING	2121767.07	5781514.16
SVP-2	11/15/2021	8" HSA	.25 in	PROBES AT 4.5 and 17.6	0.375" STAINLESS STEEL	-	NO	17.5	2/12 SAND 4 TO 6 AND 17 to 19	85.84	0.25 in TEFLON TUBING	2121833.69	5781430.17



SOIL VAPOR PROBE CONSTRUCTION DETAIL (INSTALLED BY OTHERS)

NOT TO SCALE



TEMPORARY MONITORING WELL CONSTRUCTION DETAIL (INSTALLED BY OTHERS)

NOT TO SCALE

NOTES:

1. ALL DEPTH INTERVALS ARE IN FEET BELOW GROUND SURFACE.

FT = FEET
FT BGS = FEET BELOW GROUND SURFACE
FT MSL = FEET MEAN SEA LEVEL
GPM = GALLONS PER MINUTE
HSA = HOLLOW STEM AUGER
IN = INCHES
PVC = POLYVINYL CHLORIDE
PVC SCH. 40 = SCHEDULE 40 PVC
S.S. = STAINLESS STEEL
TOC = TOP OF CASING

THIS BAR REPRESENTS ONE INCH ON THE ORIGINAL DRAWING:

USE TO VERIFY FIGURE REPRODUCTION SCALE

No.	Date	Revisions	By	Ckd

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Professional Engineer's Name

Professional Engineer's No.

State	Date Signed	Project Mgr.
CA		XX

Designed by	Drawn by	Checked by
XX	JAM	XX

ARCADIS U.S., INC.

VANDENBERG AIR FORCE BASE ● CALIFORNIA
CONSTRUCTION DRAWINGS ● SD015

MONITORING POINT CONSTRUCTION DETAILS

DRAFT - FOR BIDDING PURPOSES ONLY

ARCADIS Project No. 30027243

Date JANUARY 2022

ARCADIS
735 TANK FARM ROAD
SUITE 150
SAN LUIS OBISPO, CA 93401

G-6A

Well Development Log

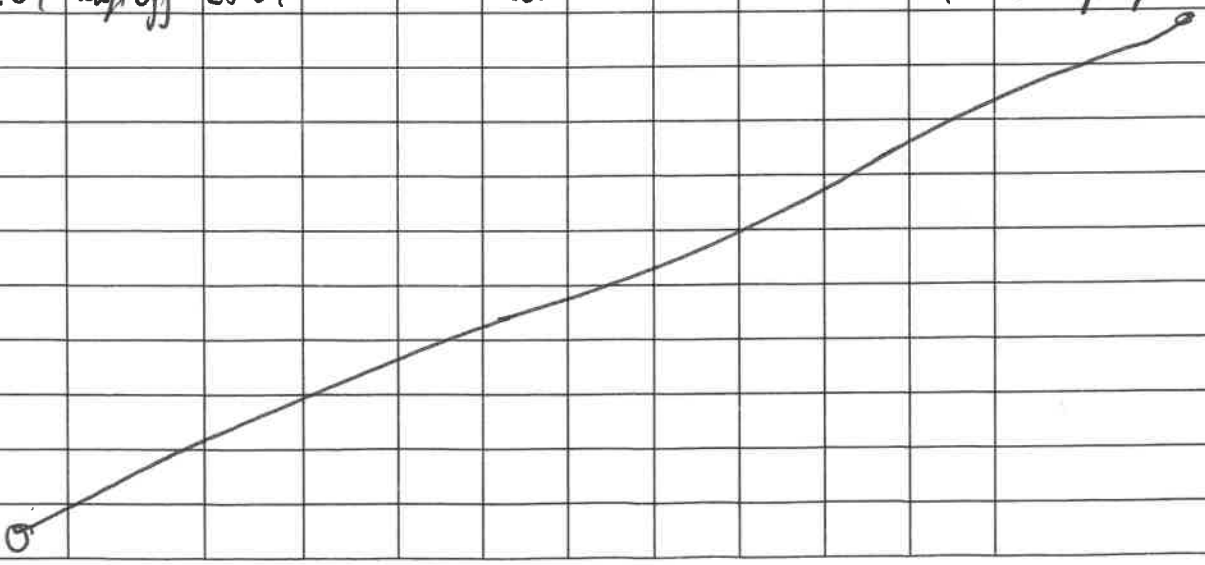
Page 1

Date 12/09/21 Project # SD015 TISR Operator

Well ID TISR-1S Water level TOC 23.62 Measured Bottom (BTOC) 30' 1.5"

Arcadis Staff Mark Mcclea Screen Interval 17-27 Stickup 2' 4"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
908	TAG	23.62	30' 1.5"								
9:10	Start Bail I										
9:12	End Bail I	25.78									Very turbid. Medium to VF light brown sand (3 bails (1.5 gallons) to dark
9:16	Start Surge I										
9:26	End Surge I	23.25									
9:43	Start Bail II										
9:47	End Bail II	23.52									The bail still had a lot of sediments. 3 bails (1.5 gallons)
9:48	Start Surge II										Very turbid. Medium to VF sand light to dark brown
9:58	End Surge II	23.18									
10:02	Start Bail III										4 bails (2 gallons)
10:09	End bail III	23.04									
12:05	Pump	23.15								1	Water quality meter is broken
12:15		26.32			≈6.2					1	PH strips don't measure below 6.2
12:16		25.87			<6.2					<1	Adjusted GPM to aroune 0.75
12:25		25.61			<6.2					<1	
12:33		25.43			<6.2					<1	
12:43		25.~~40~~ 25			<6.2					<1	
13:07		26.04			<6.2					<1	
13:09	Pump off	26.04			<6.2					<1	Total pumped ≈ 50 gallons



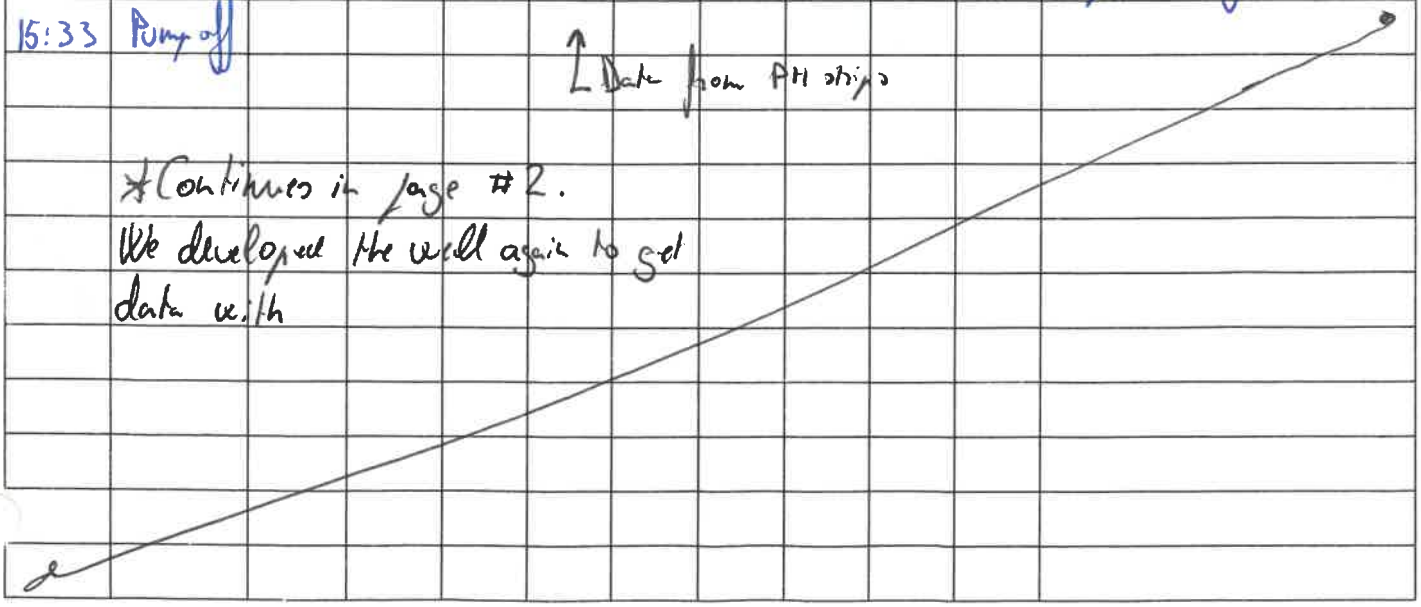
Well Development Log

Date 12/09/21 Project # SD015 TISR Operator

Well ID TISR - 1D Water level TOC 22.87 Measured Bottom (BTOC) 42' 8"

Arcadis Staff Mario Alcalá Screen Interval 30' - 40' Stickup 2' 4"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
10:26	TAG										
10:28	Start Bail I										
10:31	End Bail II	23.05		Very turbid. Medium to VF sand grey and brown							
10:35	Start Surge I										
10:48	End Surge I	23.05		Turbid. Medium to VF sand Grey to brown							
10:52	Start Bail II										
10:55	End Bail II	23.45									
10:56	Start Surge II										
11:06	End Surge II	23.16									
11:11	Start Bail III			turbid some medium to VF sand Grey to brown							
11:14	End Bail III	23.46									
13:30	Start Bail IV										8 bails (4 gallon)
13:45	End Bail IV	23.09		some VF grey to brown sand							the well recovered fast after sailing. By the 8th sail the water looked less turbid
14:29	Pump On			* Horiba water quality meter wasn't working							
14:30		24.05			≈6.2					≈0.5	Adjusted GPM to ≈0.5
14:45		24.30			26.2					0.5	
15:15		24.65			≈6.2					0.5	
15:30		24.76			<6.2					0.5	Pumped ≈ 35 gallon
15:33	Pump off										
					Data from PH strips						
	*Continues in page #2.										
	We developed the well again to get										
	data with										



Well Development Log

Date 12/10/21 Project # SD015 TISA Operator

Well ID TISA 1D Water level TOC 22.85 Measured Bottom (BTOC) 42' 8"

Arcadis Staff Mario Alcalde Screen Interval 30'-40' Stickup 2' 4"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
7:46	Tag	22.85									
7:55	Pump										
~~7:55~~ 8:10 Min		25.37		19.60	6.14	-111	0.970	4.69	64.2	0.75	Started pumping @ ≈ 0.75 GPM
8:20		26.47		19.60	6.13	-112	0.968	4.78	25.2	0.76	
8:30		25.60		19.65	6.27	-111	0.963	4.69	1.1	0.75	
8:35		25.66		19.65	6.12	110	0.946	3.96	0.7	0.75	Pumped approx 30 gallons
8:37	Pump off										

Well Development Log

Page 1 / _

Date 12/07/21 Project # SA 300 27243 Operator _____

Well ID IESN-2S Water level TOC 23.17 Measured Bottom (BTOC) 29.89

Arcadis Staff MAR / MS Screen Interval 17' to 27' Stickup ~~2.45'HA~~ 2.35'

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
10:59	Tag	23.17	29.89								
11:27	Initial bail	"	"	Very turbid, VF to F sand, brown							
11:36		23.94									
11:37	Surge I	Surge for 10 min									
11:48	Surge I end										
11:48	Bail I starts	Very turbid, some VF sand, brown					5 bails (1.5 gallons)				
11:51	Surge II										
11:57	Surge II end	23.40	"		Prepare for bail						
11:59	Bail II	"	"	Very turbid, some VF sand, brown							6 bails, 3 gallons, little sand at the end
12:04	End bail II	23.90	"	Set up for pump							
		DTW	TD	TEMP	pH	ORP	COND	DO	TURB	GPM	
		23.20									
12:17	PUMP	26.01	29.89	16.25	5.8	153	0.480	0.00	>1000	~~0.25~~ 0.4 HA	Pumping 4½ gallons per min HA
12:29	"	24.43	"	17.13	5.73	-71	0.402	"	>1000	0.4	Started pumping @ 2 GPM and flow slowed to ~0.4
12:37	"	25.10	"	17.20	5.78	-103	0.405	"	980	"	
12:50	"	25.06	"	17.15	5.88	-124	0.405	"	462	"	
13:00	"	25.10	"	17.15	5.84	-132	0.406	"	267	"	
13:11	"	24.52	"	17.44	5.85	-123	0.411	"	>1000	"	Pulled pump up to clear water ~20 gallons produced
13:23	"	24.36	"	17.7	5.92	-145	0.407	"	489	"	
13:33	"	25.40	"	17.00	581	-117	0.398	"	590	"	* Moved pump up and down
13:42	"	25.69	"	16.87	5.83	-139	0.409	"	247	"	
13:52	"	25.75	"	16.87	6.01	-144	0.407	"	212	"	
14:02	"	25.80	"	16.87	5.84	-146	0.407	"	208	"	
14:12	"	25.85	"	16.83	5.84	-146	0.405	"	139	"	
14:22	"	25.90	"	16.79	6.06	-145	0.405	"	97	"	Lowered the flow to ~0.25 *They injected molasses
14:32	"	24.60	"	17.33	5.84	-152	0.420	"	48	"	
14:33	Pump off										Pumped ~48 gallons

HA Flow ~0.25 GPM

Well Development Log

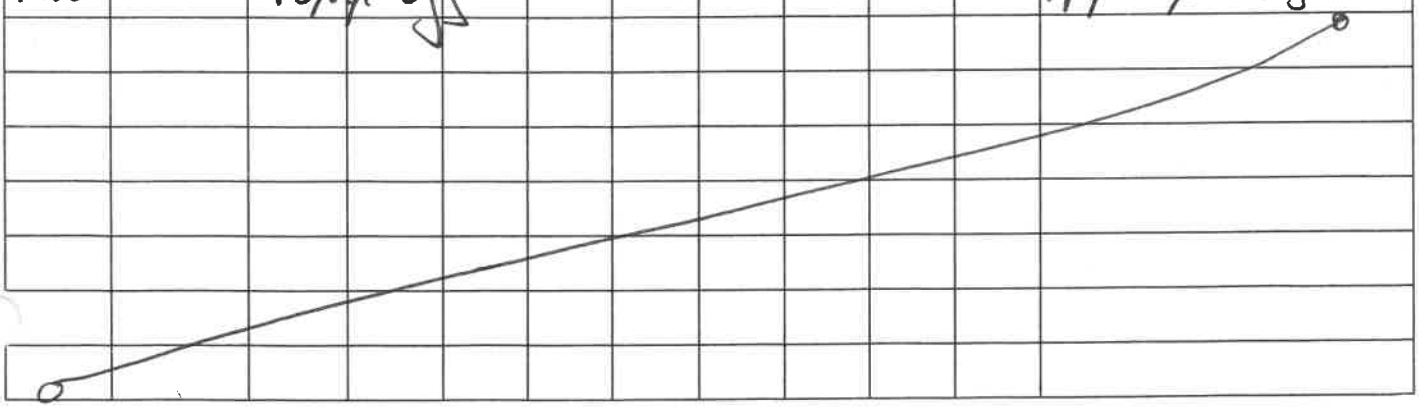
Page 1

Date 12/08/21 Project # 30027243 Operator

Well ID TISA - MW 20 Water level TOC 24.40 Measured Bottom (BTOC) 42.90

Arcadis Staff Hawa Abdalla Screen Interval 30' to 40' Stickup 2'1"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
7:00	Tas	24.40	42.90								
7:08	Bail I	26.14	"		Some	MF VF	sand,	brown			3 bails (1.5 gallons)
7:60	Surge I										
7:22	End Surge I										
7:22	Bail II	27.43	"		Little	VF	sand,	brown			3 bails (1.5 gallons)
7:40	Surge II										Surged for 10 minutes
7:58	End Surge II	24.38									
09:04	Start Pumping	24.04		Temp	pH	ORP	Cond	D.O	TURB	GPM	Drop with the pump in
		30.20								0.75	
		30.20								0.5	Holding @ 30.20 with 0.5GPM
09:14		30.03		9.04	5.39	12	0.534	–	>1000	"	* Temperature not working well
09:24		31.11		10.57	5.46	4	0.557	–	955	"	
09:34		29.00		11.12	6.07	-2	0.551	–	470	0.25	* Slowed down GPM
09:44		28.60		13.80	5.63	-2	0.519	–	303	0.25	
09:54		28.37		16.03	5.56	-3	0.494	–	164	"	Temperature ~~rising~~ readings are getting better
10:04		28:35		16.80	5.54	-2	0.488	–	100	"	
10:14		28.10		16.55	5.78	-4	0.492	–	61	"	
10:29		27.90		17.06	5.56	-5	0.489	–	49	"	
10:39		27.76		17.51	5.56	-5	0.487	–	89	"	
10:49		27.90		17.14	6.16	-14	0.487	–	160	"	
10:59		27.80		17.64	5.62	-13	0.483	–	159	"	
11:02		Pump off									Pumped approx ~30 gallons



* 7:29 to 7:32 → Bail a third time. Very little sand VF sand

Well Development Log

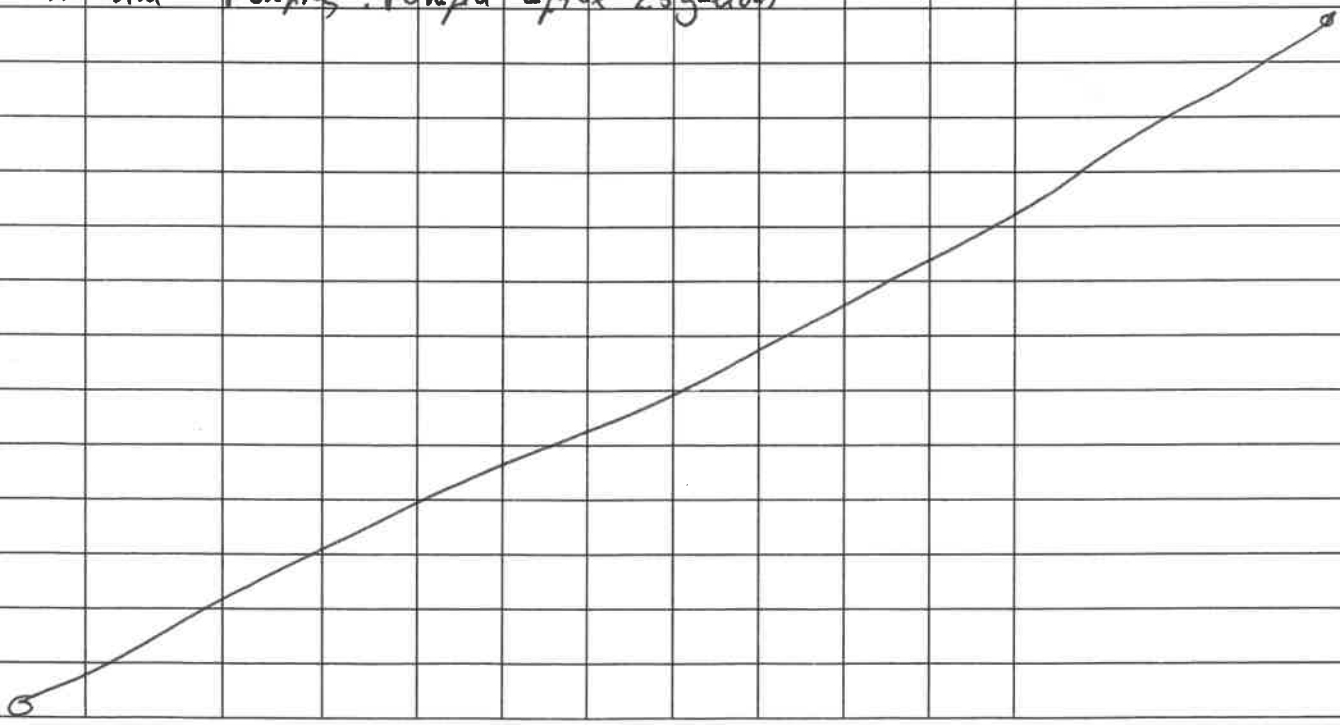
Page __ / __

Date 12/07/21 Project # 300 27243 Operator

Well ID TISR 3S Water level TOC 23.35 Measured Bottom (BTOC) 30.2

Arcadis Staff MAR / AS Screen Interval 17' to 27 Stickup 2.6'

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
12:41	Tag	23.35	30.2	-	-	-	-			-	Very turbid. Med to VF Brown sand
12:53	Bail I	23.70	30.19								3 bails (1.5 gallons)
12:56	Surge I starts										Surged for 10 min
13:06	End Surge I	23.35	"								
13:10	Bail II	23.65									Some sand. Very turbid VF brown sand, 3 bails 1.5 gallons)
13:16	Bail II ended	↓									
13:22	Surge II starts										
13:28	Surge II ends	23.40									Surged 6 min
13:35	Bail III	23.50									3 bails (1.5 gallons)
	Pump on	12/8/21		Temp	pH	ORP	COND	DO	TURB	GPM	
8:02	Pump starts	23.35	~~23.35~~								Pumping at ~~0.25~~ 0.75 GPM
8:12		24.40		7.91	5.76	-106	0.561	~~000~~ OO	>1000	0.75	* Horiba's temp not working ok
8:27		24.40		6.23	5.76	-125	0.592	—	387	"	"
8:37		24.6		7.83	5.78	+32	0.553	-	125	"	"
8:47		24.65		7.63	5.86	-135	0.553	-	59	"	
Finished		Pumping. Pumped a total of 25 gallons									



Well Development Log

Date 12/08/21 Project # 30027243 Operator

Well ID IISR-3D Water level TOC 22.90 Measured Bottom (BTOC) 42'0.5"

Arcadis Staff Hans Mcolea Screen Interval 30 to 40' Stickup 3ft 2'3"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
9:24	Tag	22.90	42'65"								
9:31	Start Bail I				Medium to UF sand, grey brownish						
9:34	End Bail I	26.55	"								3 bails (1.5 gallons)
9:30	Started Surge I										
10:00	End Surge I	24.92	"								Surged 10 min
10:04	Bail II										
10:08	End Bail II	25.50	"	Some	Fine to UF sand, grey brownish						3 bails (1.5 gallons)
10:28	Started Surging II										
10:32	End Surge II	24.22	"								
10:41	Start bail III										3 bails (1.5 gallons)
10:43	End bail III	28.45	"	Little	fine to UF	sand,	brown				
11:42	PUMP	22.99	"	TEMP	pH	ORP	COND	DO	TURB	GPM	
		32.73 ~~30.2~~	"							~0.4	Adjusting GPM
11:57	"	32.47	"	17.10	6.17	40	0.508	—	>1000	"	
12:07	"	32.99	"	16.75	5.37	27	0.502	—	>1000	"	
12:17	"	33.30	"	16.84	5.32	25	0.505	—	>1000	"	
12:27	"	33.75		16:88	5.31	21	0.498	—	>1000	"	
12:30	"										Pump the well dry to clean it
12:37	"	35.50									Stopped pumping
12:40	"	~~36.50~~ 34.50									Well recovered 1 foot in 3 min
12:42	"	~~32.50~~ 33.50									Well recovered 1 foot in 2 min
											Let the well recover to ~~28~~ 22.9 DTW
13:17	TAG	25.63'									35 is @ 23.35'
				(12/10/21)							(Total pumped = 18 gallons)
7:31	Bail										Bail the well to get rid of sediments (1.5 gallons)
		26.95 (after bail)									
7:38	Pump										Pump the well dry (approx ~~3.5~~ 2 gallons)

35
23.35

Total pumped and bailed ≈ 26 gallons

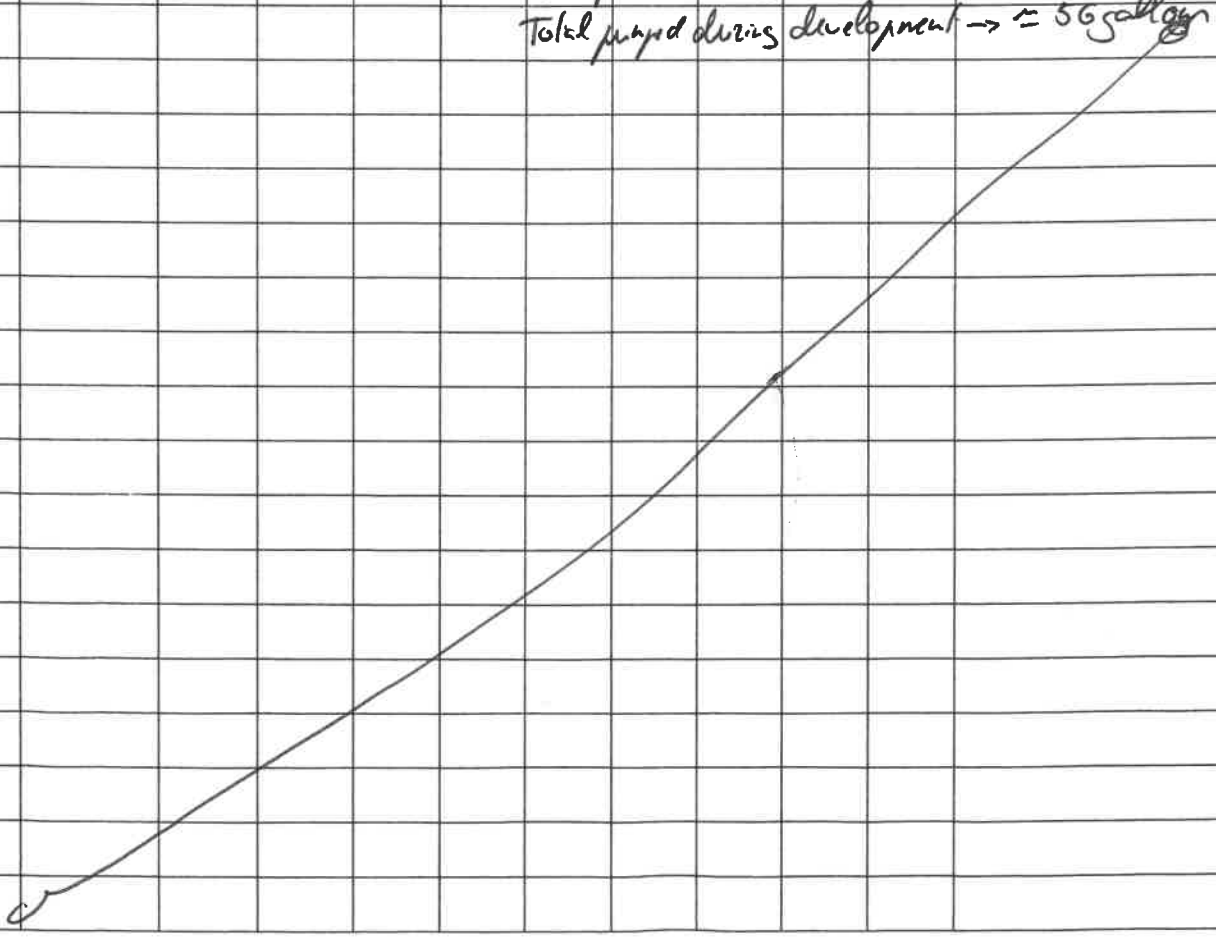
Well Development Log

Date 12/10/21 Project # 3002243 Operator

Well ID TISA 3D Water level TOC 22.90 Measured Bottom (BTOC) 42' 0.5"

Arcadis Staff Maria Medina Screen Interval 30' to 40' Stickup 2' 3"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
10:37	Tag	22.60									
10:38	Pump on	29.65		19.92	5.90	65	0.718	1.47	>1000	0.4	Adjust pump to ~~0.25~~ 0.4 GPM
10:54		32.55		20.57	5.93	43	0.722	1.26	>1000	0.4	
11:10		33.70		20.62	5.90	50	0.719	1.22	>1000	0.25	Flow lowered to 0.25
11:26		35.15		20.69	5.99	37	0.693	0.78	>1000	0.25	
11:42		36.47		20.66	5.96	2	0.691	0.61	>1000	0.25	
12:02		38.15		20.77	5.78	26	0.719	1.12	>1000	0.25	
12:13		39.17		20.80	5.86	26	0.714	0.98	>1000	0.25	Lowered pump to the bottom
12:23		39.65		20.83	5.65	56	0.710	1.45	>1000	0.25	
12:32		*		20.82	5.53	79	0.720	1.27	>1000	0.25	Water level below pump
12:34	Pump off										
						Pumped ≃ 30 gallon					
						Total pumped during development → ≃ 55 gallon					



41'5" HA
22.68 HA

Well Development Log

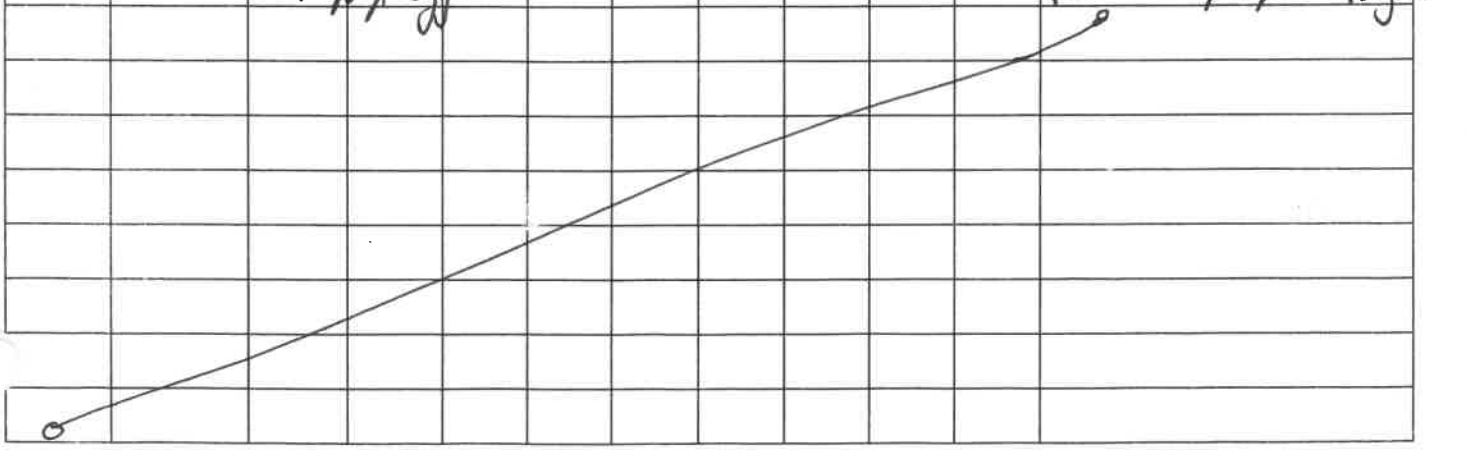
Page _1_

Date 12108/21 Project # 300027243 Operator

Well ID TISR 45 Water level TOC 22.75 Measured Bottom (BTOC) 30' 1"

Arcadis Staff Mario Alcalde Screen Interval 17'-27' Stickup 2' 3"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
12:14	Tag	22.75	30'1"								
12:25	Start Bail I										
12:30	End Bail I	22.68		Very turbid zone	turbid medium	to VF	sand,	brownish			3 bails (1.5 gallons)
12:39	Start Surge I										
12:50	End Surge I	22.72									
12:52	Start Bail II										
12:57	End bail II	22.80		Very turbid zone	turbid medium to	VF	sand,	brownish			3 bails (1.5 gallons)
12:58	Start Surge II										
13:10	End Surge II	22.79									
13:11	Start bail III										
13:14	end bail III	22.82									3 bails (1.5 gallons)
13:43	PUMP			Temp	pH	ORP	COND	DO	TURB	GPM	
13:53	RM	23.30		15.31	5.64	-21	0.313	-	>1000	1	Pump on
14:02		23.20		16.61	5.42	-35	0.314	-	690	1	
14:17		23.30		16.02	5.44	-45	0.311	-	290	1	
14:32		23.37		16.07	5.48	-52	0.307	-	221	1	
14:47		23.29		16.10	5.50	-54	0.305	-	872	1	Raised the pump to try to clean the well
14:57		23.31		16.12	5.51	-56	0.306	-	285	1	
15:02		23.31		16.08	5.53	-60	0.305	-	166	1	
15:17		23.31		16.08	5.53	-61	0.306	-	121	1	
15:20		Pump off									Total volume pumped: 95 gallons



Well Development Log

Date 12/08/21 Project # 30027243 Operator

Well ID TISA 4D Water level TOC 22.87 Measured Bottom (BTOC) 42'5"

Arcadis Staff Hana Abdalla Screen Interval 30-40 Stickup 2'3.5"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
14:19	Tag	22.87	42'5"								
14:20	Bail I Start										
14:24	Bail I End	28.01		Very turbid. some sand		Mostly	VF-F sands.	Brownish			3 bails (1.5 gallons)
14:28	Start Surge I										
14:30	End Surge I	28.10		Very turbid. some sand		Mostly fine	sands.	Brownish			
14:40	Start Bail II	27.36									
14:53	Start Surge II										
14:57	End Surge II										ABC didn't complete surge II
			Next day (12/09/21)								
7:42	Start Surge III										
7:52	End Surge III	27.40									
8:00	Start Bail III										
8:04	End Bail III	26.54									
8:08	Pump on									0.25	Flow adjusted to a 250PM
8:23	Pump off			12.67	⊘						Horiba is not giving good data. Reset cell and computer and clean the sensors
9:12	Pump on									0.25	
9:14											Horiba still not working. Taking PH measurements with strips
9:40	Pump off										Stopped pump, the Well is still too dirty. Bail again
13:53	Start Bail IV	22.99									*8 bails (4 gallons)
14:00	End Bail IV	33.60									
14:06		31.00									test to check the speed of recovery
14:10		29.00									
14:12		28.00									
14:14		27.00									
14:18		26.00									
				Next day (12/10/21)							
7:29		22.20 (Pumping)									Pump the well dry (approx 3.5 gallons)
838		23.85									
				Continues page #2							

Pumped approx 11 gallons

Total pumped and bailed ≈ 20 gallons

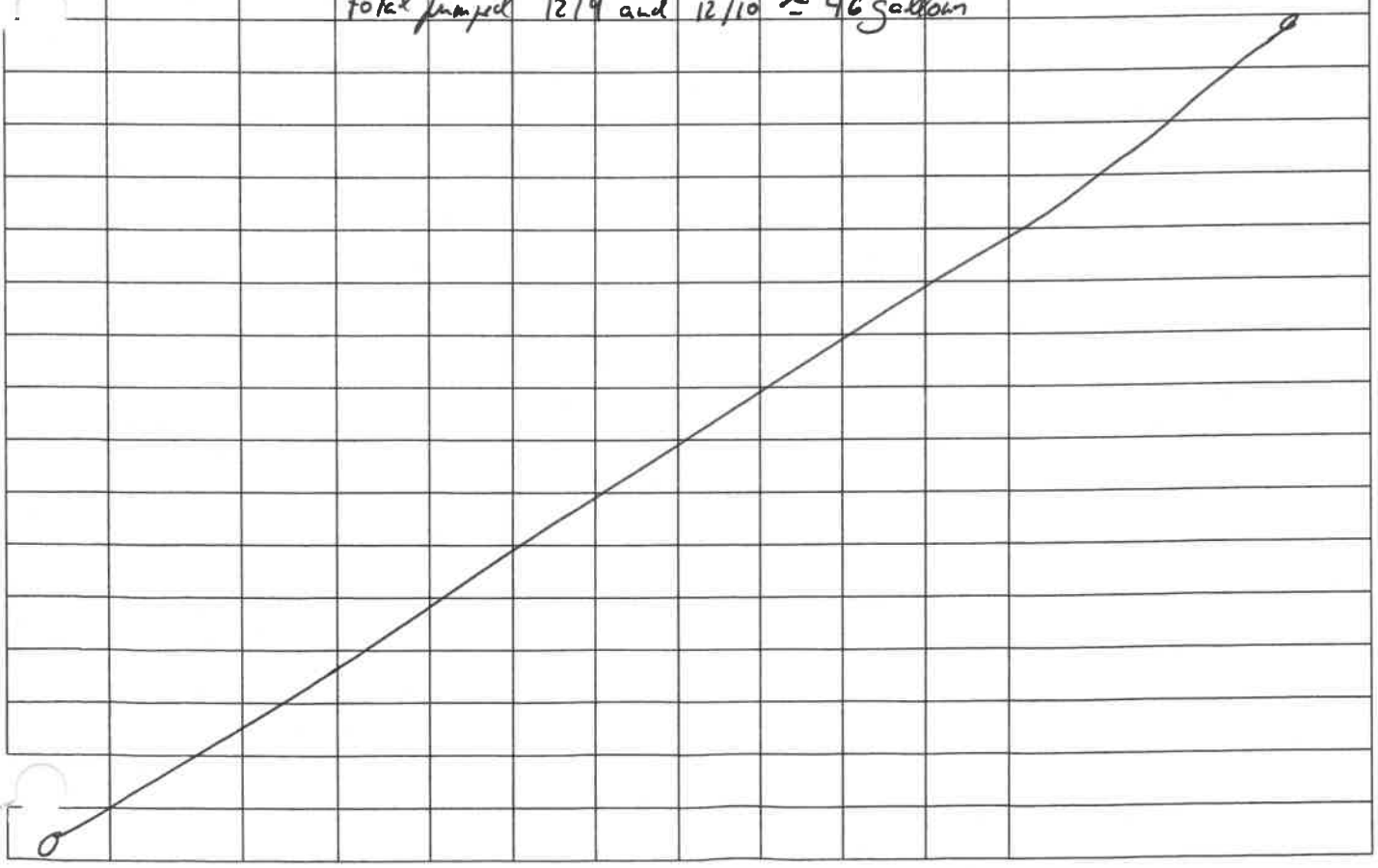
Well Development Log

Date 12/10/21 Project # SO15 TISA 300027243 Operator

Well ID TISA-4D Water level TOC 27.87 Measured Bottom (BTOC) 42' 6"

Arcadis Staff Mario Alcalá Screen Interval 30'-40' Stickup 2' 3.5"

TIME	TASK	DTW	TD	TEMP.	pH	ORP	COND.	D.O.	TURB.	GPM	NOTES
8:48	Purge										Adjusted flow to 0.25 GPM
8:56		30.05		18.15	5.82	0	1.65	0.55	>1000	0.25	
9:11		27.65		18.04	5.82	-6	1.75	0.67	>1000	0.25	
9:25		32.20		19.55	5.59	3	1.46	0.51	269	0.50	Tried to adjust the flow
9:35		38.78		18.86	5.91	-38	1.73	0.26	>1000	0.25	Back to 0.25
9:46		39.55		19.08	5.81	-12	1.70	0.48	916	0.25	
9:55		36.95		18.36	5.81	-8	1.69	0.36	>1000	0.25	Lowered pump
10:05		33.15		18.69	5.81	4	1.8	0.22	426	0.25	
10:20		28.95		19.15	5.69	23	1.62	0.82	216	0.25	
10:30		29.30		19.51	5.66	23	1.66	0.74	166	0.25	
10:32											Pump the well dry (2 gallons)
			Total pumped today ≈ 2 gallons								
			total pumped 12/9 and 12/10 ≈ 46 gallons								



ARCADIS Design & Consultancy for natural and built assets

Boring/Well ID TISR-1-D

Page 1 of 2

Project/ Client:	VSFB ~~VAFB~~	Site Address/ Location:	SD015	Job No.	30024237
Start Date:	11/16/21	End Date:	11/16/21	Total Depth:	40`
Hole Diameter:	8"	Depth to 1st Water:			
Sampling Device:	Core barrel	Length:	5`	Diameter:	3.5"
Sampling Interval:	continuous				
Hammer Weight:	NA	Hammer Drop:	NA	Drilling Contractor:	ABC Liain
Drilling Rig:	CME95	Drilling Method:	HSA	Drilling Fluid Used:	water
Driller:	Jamie Moore	Helper(s):	Juan Carter, Pedro Carreon		
Logged By:	Marshall Brusca / Mario Alcalea	Reviewed By:		Date Reviewed:	

Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description Depth: Principal Components, (angularity, plasticity, dilatency): Minor Components, (angularity, plasticity, dilatency); Sorting, Moisture Content, Consistency/Density, Color (Munsel Chart), Additional Comments.	PID Reading
1	Hand Auger		60			0.0-23.5`: Sand (SW): f-m grain, subround.; well sorted dry to moist, v. loose, dark yellowish brown (10YR 4/6)	
2							
3							
4							
5							0.0
7			27			* @ 8` becomes yellowish brown (10YR 5/6)	
			28				
10							0.0
12			26			* @ 12.5` becomes vf-m grain	
			24				
15							0.0
			22				
17							
			24				
20			5			* @20` becomes v. moist; <5% silt; v. dark grayish brown (10YR 3/2)	0.0

Remarks/Notes:

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infrastructure, environment, buildings

Boring/Well ID TISR-1-D

Project/ Client: USFB ~~VAFB~~

Site Address/ Location: SOOS

Job No.: 30024237

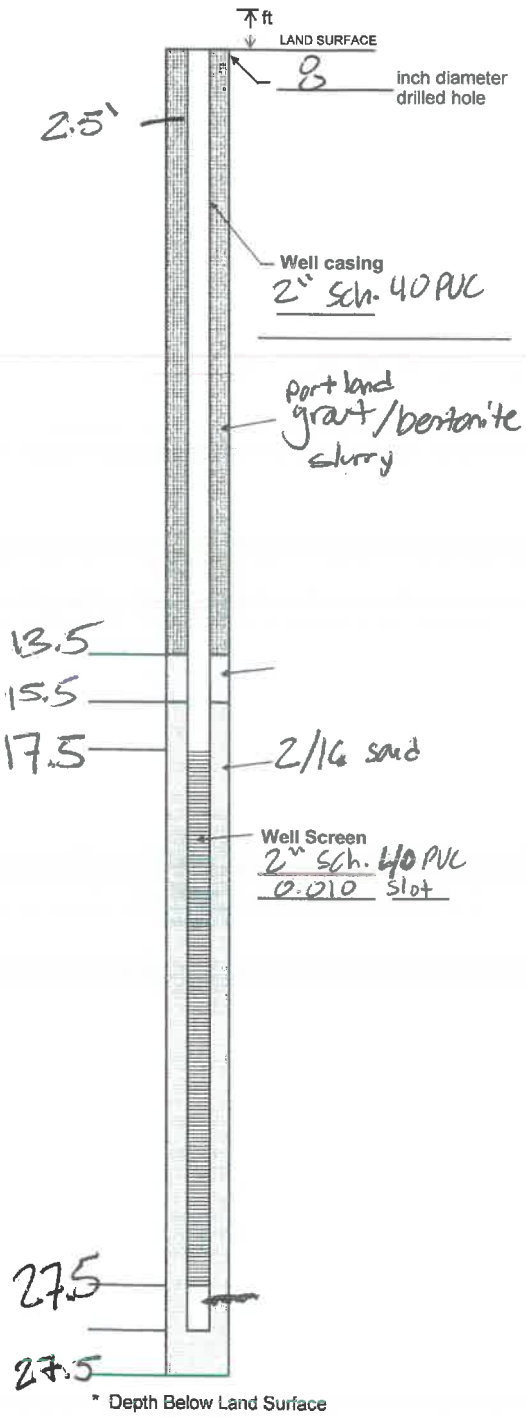
Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description Depth: Principal Components, (angularity, plasticity, dilatency); Minor Components, (angularity, plasticity, dilatency); Sorting, Moisture Content, Consistency:Density, Color (Munsel Chart), Additional Comments.	PID Reading
22			5			same as above	
			30			23.5-24.0': silty sand (sm): vf-m grain, subrand.; 10-15% silt; 35-40% weathered shale and chert; poorly sorted, m. dense, wet, v. dark grayish brown (10YR 3/2); some iron staining	
25						24.0-25.5': silty sand (sm): vf-coarse grain, subrand; 20-25% silt; poorly sorted, m. dose, wet, v. dark grayish brown (10YR 3/2)	0.6
			30			25.5-27.0': gravelly sand (SP): vf-m grain, subrand; 10-15% gravel (2-15 mm), subrund; 5-10% silt; loose, wet, poorly sorted, v. dark grayish brown (10YR 3/2)	
27						27-28.5': silty sand (sm): vf-m grain, subrand; 20-25% silt; poorly sorted, dense, wet, brownish yellow (10YR 6/8); at 28' becomes mixture of shale, gravel, and chert in sand	
			30				8.8
30						28.5-39.0': silty sand (sm): vf-f grain, subrand; 35-40% silt; well sorted, wet, m dense, gray (2.5Y 5/1)	
			30				
32							
			30				
35					TISR-1-D		7.6
			30	*15:40	35-37.5'		
37							
			30				
40						39.0-40': gravelly sand (SP): vf-f grain, subrand; 15-20% gravel (2-12 mm), subang. to subrand; 30-35% silt; poorly sorted, wet, m. dense, gray (2.5Y 5/1)	3.6

Remarks/Notes:

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Well Construction Log

(Unconsolidated)



Project ~~VSFB~~ ~~VAFB~~ Well TISR-1-S

Town/City Lompoc, CA

County San Bernardino State CA

Permit No. 332 /103

Installation Date(s) 11/17/21

Drilling Method HSA

Drilling Contractor ABC Liquin

Drilling Fluid water

Well Purpose monitoring / remediation

Remarks

Prepared by MB

Gallons of grout calc (length x 0.25 x 7.48): 20.5

Gallons installed: 28

Filter pack sand bags calc (length x 0.25 x 2): 6

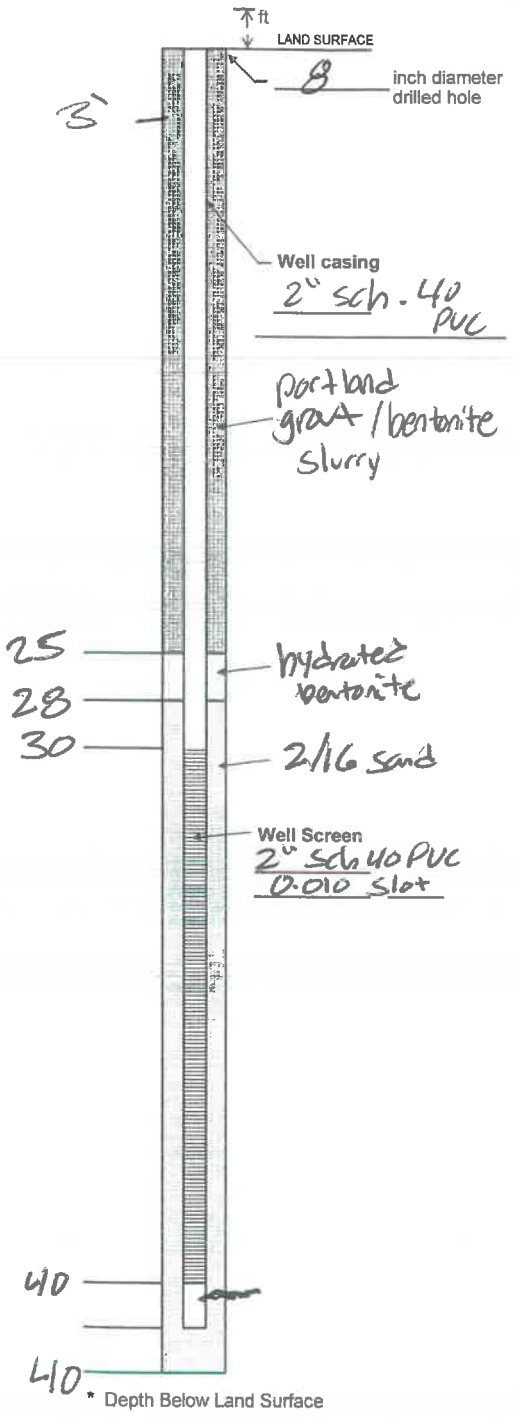
Filter pack sand bags installed: 7.5

Bentonite : 1 bag

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Well Construction Log

(Unconsolidated)



Project VSFB VAFB Well TISR-1-D

Town/City Lompoc, CA

County San Bernardino State CA

Permit No. 332/103

Installation Date(s) 11/16/2021

Drilling Method HSA

Drilling Contractor ABC

Drilling Fluid water

Well Purpose Monitoring/remediation

Remarks

Prepared by Marshall Bruza

Gallons of grout calc (length x 0.25 x 7.48): 41.1

Gallons installed: 80

Filter pack sand bags calc (length x 0.25 x 2): 6

Filter pack sand bags installed: 8

Bentonite bags: 1

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Boring/Well ID TISA - 2D

Page 1 of 2

Project/ Client:	VAFB	Site Address/ Location:	SD 15 VSFB			Job No.	
Start Date:	11/29/21	End Date:	11/29/21	Total Depth:	40	Hole Diameter:	8"
Depth to 1st Water:							
Sampling Device:	Core barrell	Length:	5'	Diameter:	3"	Sampling Interval:	2.5'
Hammer Weight:	-	Hammer Drop:	-	Drilling Contractor:	ABC Louis		
Drilling Rig:	CME 95	Drilling Method:	HSA	Drilling Fluid Used:	Water		
Driller:	Jamie Moore	Helper(s):	Luis Hendon / Juan Cabs				
Logged By:	Hans Reeder	Reviewed By:		Date Reviewed:			

Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description	PID Reading
1	Hand Auger					0-20.5 Sand (SW) Medium to very fine, poorly to subrounded, well sorted, dry yellowish brown 10YR 5/6 * Iron staining @ 17.5'	
2			60				
3							
4							
5							0.8
			28				
			28				
10							1.1
			30				
			26				
15							1.9
			25				
			MH 25 26				
20							1.2
						20.5 - 24.25	

Remarks/Notes: Dry to moist @ 18.5' and moist to wet @ 15.4'
* 27.5 to 30 had more recovery than the drive interval due to the expansion and stretching of the clay

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Boring/Well ID TISA-2D

Project/ Client: VAFB

Site Address/ Location: SD015

Job No.:

Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description Depth, Principal Components (angularity, plasticity, dilatency), Minor Components (angularity, plasticity, dilatency), Sorting, Moisture Content, Consistency/Density, Color (Munsel Chart), Additional Comments	PID Reading
			30			Poorly graded sand with silt and clay (SP-SM) medium to UF sand, round to subrounded, poorly sorted wet, trace of silt and clay, non plastic fast dilatency. Dark brown (10YR 3/3) * Clay increases at the bottom	
			27				
25						24.25 - 25 Poorly graded sand with silt and gravel (SP-SC) Very coarse to medium sand, round to subround, poorly sorted wet. Little gravel (20%), round, large pebbles to granules. little silt (15%). (10YR (2/1) Very dark brown	1.0
			28			25-28 (SP-SM) Granules to fine sand, very coarse to subround, poorly sorted wet, trace of silt, non plastic, fast dilatency, Dark brown (10YR 3/3) * Clay pebbles at the bottom	
			37			28 - 31.75 Silty sand (SM) Very fine to medium sand, round to subrounded, poorly sorted, wet, some silt (30%), non plastic, fast dilatency	
30						* 5" thick gravel layer @ 30'	7.6
			30			31.75 - 33 Poorly graded sand (SP) medium to UF, round to subround, poorly sorted, wet, traces of silt non plastic, fast dilatency, light grey (10YR 7/2) * traces iron staining at the bottom	
			30			33 - 38.5 Silt (ML) medium to high plasticity, slow dilatency. (40%) Clay, with traces of UF sand. occasionally medium to fine gravel grayish brown (10YR 5/2)	12.8
35			20				
			30	11:44		38.5' - 40.5' Very weathered shale	
40							84.7

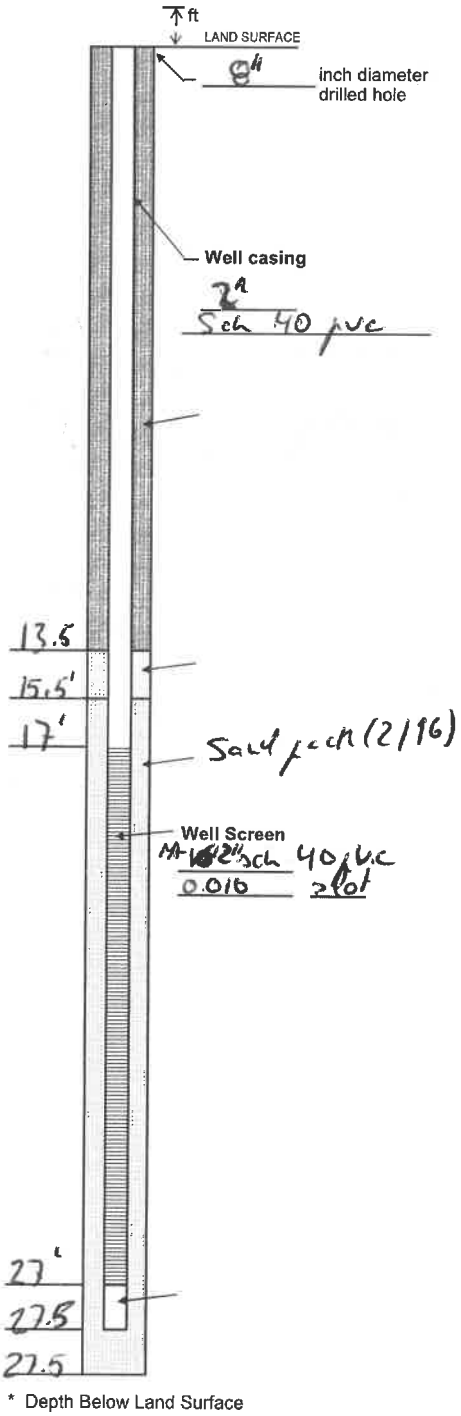
Remarks/Notes:

* Weathered shale @ 38.5'

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Well Construction Log

(Unconsolidated)



* Depth Below Land Surface

Project VAFB **Well** IISA-25

Town/City Lompoc, CA

County San Bernardino **State** CA

Permit No. 332 / 103

Installation Date(s) 11/29/21

Drilling Method HSA

Drilling Contractor ABC Liquid

Drilling Fluid Water

Well Purpose Monitoring / remediation

Remarks

Prepared by Mario Alcala

Gallons of grout calc (length x 0.25 x 7.48):

Gallons installed: 50 gallon

Filter pack sand bags calc (length x 0.25 x 2):

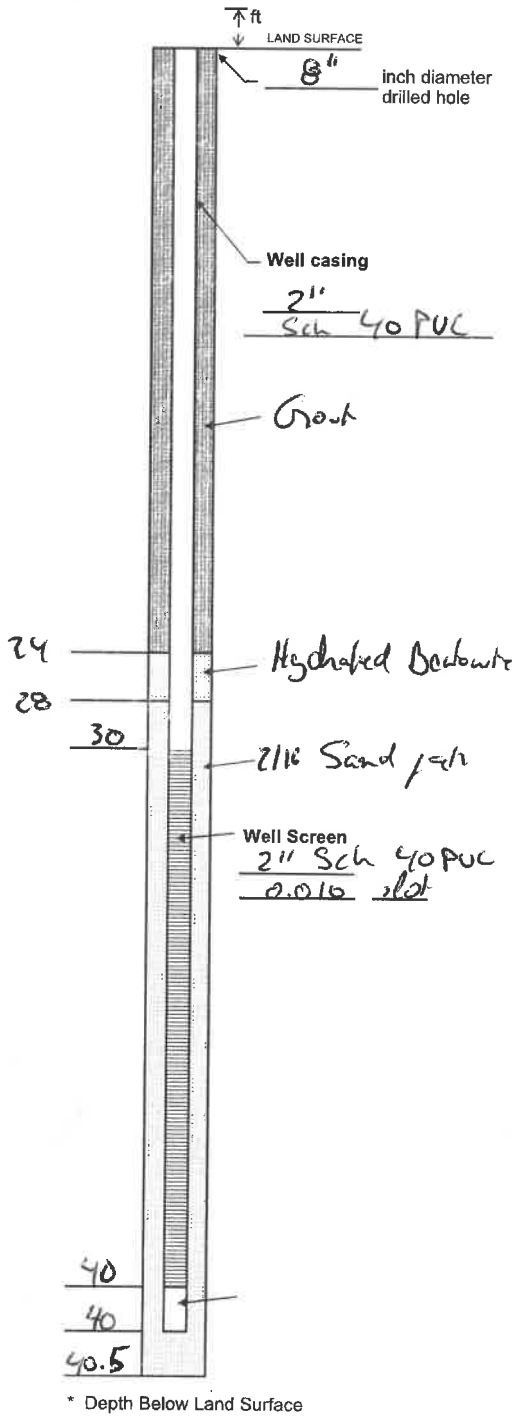
Filter pack sand bags installed: 7.5 2/16

1.5 bentonite chips

ARCADIS

Well Construction Log

(Unconsolidated)



* Depth Below Land Surface

Project VAFB **Well** TISA-2D

Town/City Lompoc, CA

County San Bernardino **State** CA

Permit No. 332/103

Installation Date(s) 11/29/21

Drilling Method HSA

Drilling Contractor ABC Liquid

Drilling Fluid water

Well Purpose Monitoring/Remediation

Remarks

Prepared by Kara Hadla

Gallons of grout calc (length x 0.25 x 7.48):

Gallons installed: 75 gallons

Filter pack sand bags calc (length x 0.25 x 2):

Filter pack sand bags installed: 9 2/1c sand pack
1.5 bentonite chips

ARCADIS Design & Consultancy for natural and built assets

Boring/Well ID TISR-3-D

Page 1 of 2

Project/ Client:	USFB ~~VAPE~~	Site Address/ Location:	SDOLS		Job No. 30024237
Start Date: 11/18/21	End Date: 11/18/21	Total Depth: 40' bgs	Hole Diameter: 8"		Depth to 1st Water:
Sampling Device: core barrel		Length: 5'	Diameter: 3.5"	Sampling Interval: Continuous	
Hammer Weight: NA		Hammer Drop: NA		Drilling Contractor: ABC Livin	
Drilling Rig: CME95		Drilling Method: HSA		Drilling Fluid Used: water	
Driller: Jamie Moore		Helper(s): Juan Cortez, Pedro Carreon			
Logged By: Mario Alcolea / Marshall Brusca		Reviewed By:		Date Reviewed:	

Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description Depth: Principal Components, (angularity, plasticity, dilatency); Minor Components, (angularity, plasticity, dilatency); Sorting, Moisture Content, Consistency/Density, Color (Munsel Chart), Additional Comments.	PID Reading
1	HAND AUGER		60"			0.0-16.0': sand (SW): vf to m grain, subrand, well sorted, dry, loose, yellowish brown (10YR 5/6)	
2							
3							
4							
5							0.6
7			30				
10			30				0.7
12			30				
15			30				0.2
17			30			16.0-20.5': same as above; dry to moist; at 18.5' iron staining; at 19.5' iron staining and becomes v. moist	
20			28			20.5-24': silty sand (SM): vf to coarse, subrand; 10-15% silt; poorly sorted, m. dense, wet, v. dark grayish brown (10YR 3/2); <5% pebbles (2-12mm); <5% clay	0.2
			29				

Remarks/Notes:

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infrastructure, environment, buildings

Boring/Well ID TISR-3-D

Project/ Client: USTF VAFB

Site Address/ Location: SCDF5

Job No.: 30024237

Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description Depth; Principal Components, (angularity, plasticity, dilatency); Minor Components, (angularity, plasticity, dilatency); Sorting, Moisture Content, Consistency/Density, Color (Munsel Chart), Additional Comments.	PID Reading
22			29				
			30			24.0 - 25.0': silty sand (SM): f-m grain, subround; 15-20% silt; loose, well sorted, wet, black (10YR 2/1)	
25							1.1
			30			25.0 - 28.0': sand and silt (SM): vf-coarse grain, subround; 50% silt, fast dilatency, low plasticity; poorly sorted, m. dense, wet, v. dark grayish brown (10YR 3/2)	
27							
			30			28.0 - 29.5': clayey sand (SC): vf-f grain, subround; 40-45% clay, high plasticity, no dilatency; 45% silt; poorly sorted, wet, m. dense, gray (10YR 6/1); 29.0-29.5' layer of weathered shale and chert w/ iron staining	
30						29.5 - 30.0': sand and silt (SM): vf-m grain, subround; 50% silt, m. plasticity, slow dilatency; well sorted, m. dense, wet, light brownish gray (10YR 6/2)	66.0
			30			30.0 - 31.0': silty sand (SM): vf-f grain, subround; 35-40% silt; well sorted, m. dense, wet, grayish brown (10YR 5/2); at 31' 6" layer of weathered shale	
32						31.0 - 32.5': clayey sand (SC): vf-m grain, subround; 35-40% clay; 5-10% silt; high plasticity, no dilatency; poorly sorted, m. dense, wet, gray (10YR 6/1)	
			30			32.5 - 33.5': clayey sand (SC): vf-f grain, subround; 20-25% clay; 15-20% silt, poorly sorted, m. dense, wet, pale brown (10YR 6/3); some iron staining	
35						33.5 - 34.5': silty sand (SM): vf-m grain, subround; ~~35-40% silt~~ 15-20% silt; well sorted, loose, wet, dark gray (10YR 4/1)	22.0
			30	#11:00	TISR-3-D 35-37.5'	34.5 - 38.5': silty sand (SM): vf-f grain, subround; 35-40% silt; well sorted, loose, wet, gray (10YR 5/1); iron staining @ 38'	
37							
			30			38.5 - 40': weathered shale, laminated (1-2mm), dark gray (10YR 4/1); iron staining present	
40							56.0

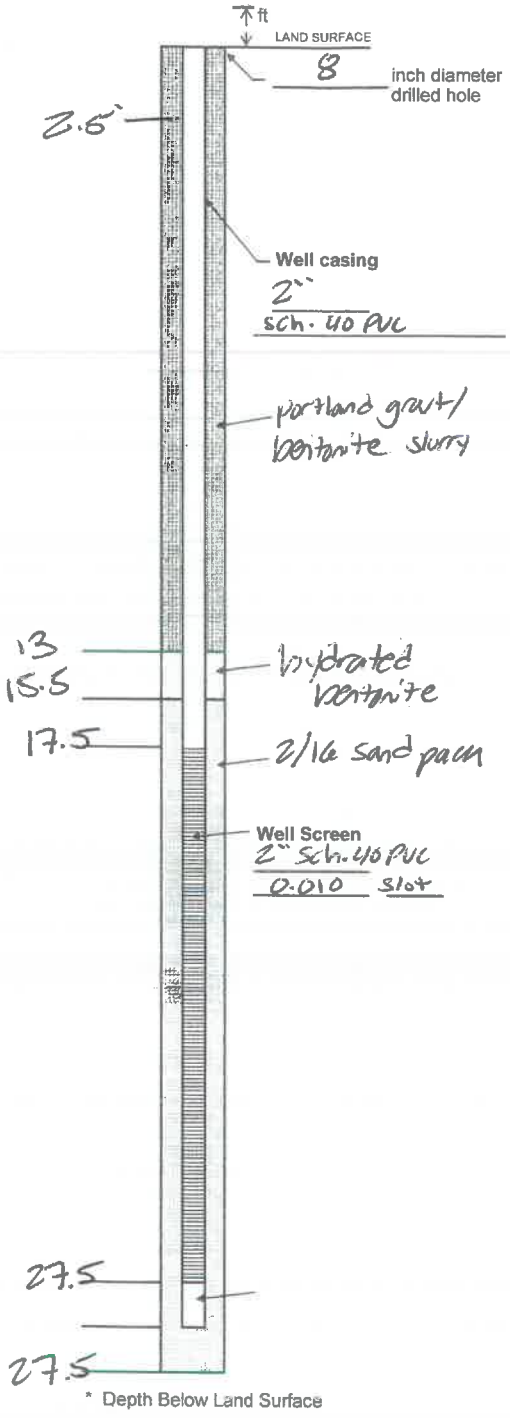
TD = 40' bgs

Remarks/Notes:

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Well Construction Log

(Unconsolidated)



Project VSFB ~~VAFB~~ Well TISR-3-S

Town/City Lompoc, CA

County San Bernardino State CA

Permit No. 332/103

Installation Date(s) 11/18/21

Drilling Method HSA

Drilling Contractor ABC Liquin

Drilling Fluid water

Well Purpose Monitoring / Remediation

Remarks

Prepared by Marshall Brusca

Gallons of grout calc (length x 0.25 x 7.48): 19.6

Gallons installed: 45

Filter pack sand bags calc (length x 0.25 x 2): 6

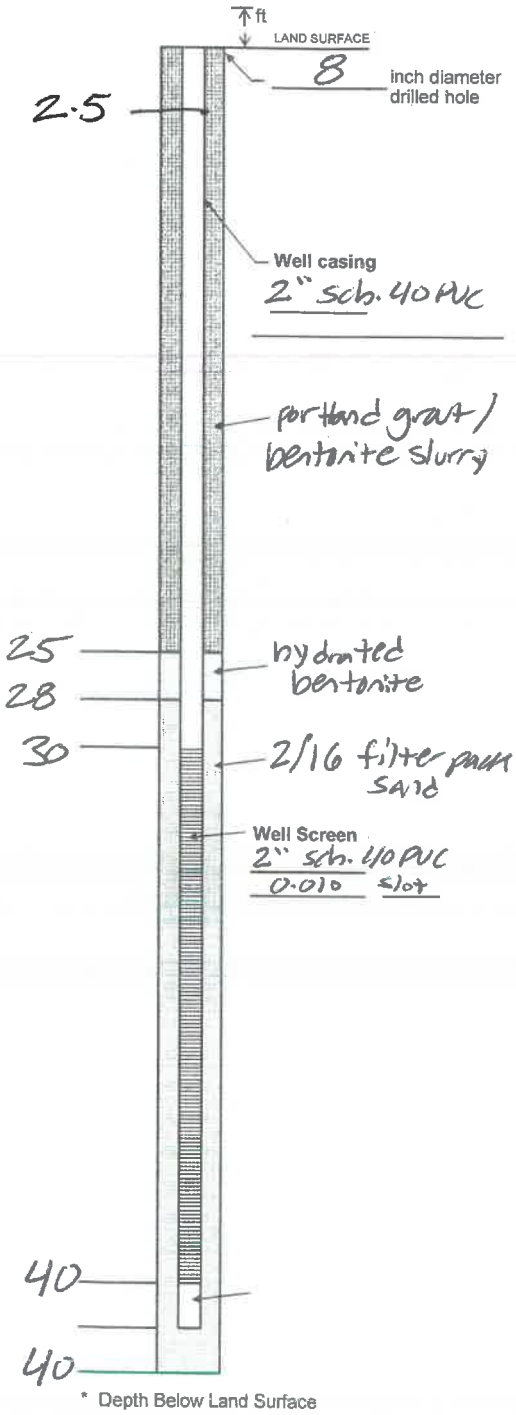
Filter pack sand bags installed: 8

Bentonite bags: 1

ARCADIS

Well Construction Log

(Unconsolidated)



Project USFB ~~VAFB~~ Well TISR-3-D

Town/City Lompoc, CA

County San Bernardino State CA

Permit No. 332103

Installation Date(s) 11/18/2021

Drilling Method HSA

Drilling Contractor ABC Liain

Drilling Fluid water

Well Purpose Monitoring / remediation

Remarks

Prepared by Marshall Brusca

Gallons of grout calc (length x 0.25 x 7.48): 42

Gallons installed: 70

Filter pack sand bags calc (length x 0.25 x 2): 6

Filter pack sand bags installed: 7.5

Bentonite bags: 1

ARCADIS Design & Consultancy for natural and built assets

Boring/Well ID TISR-4-D

Project/ Client:	USFB ~~VAFB~~ (VAFB)	Site Address/ Location:	SD015			Job No.	30024237
Start Date:	11/11/21	End Date:	11/11/21	Total Depth:	40' bgs	Hole Diameter:	8"
Depth to 1st Water:	18.85' bgs @ 1610						
Sampling Device:	Core barrel	Length:	5'	Diameter:	3.5"	Sampling Interval:	Continuous
Hammer Weight:	NA	Hammer Drop:	NA	Drilling Contractor:	ABC Liain		
Drilling Rig:	CME 95	Drilling Method:	HSA	Drilling Fluid Used:	water		
Driller:	Jamie Moore	Helper(s):	Luis Mendoza, Juan Cortez				
Logged By:	Marshall Brusca	Reviewed By:		Date Reviewed:			

Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description Depth: Principal Components, (angularity, plasticity, dilatency); Minor Components, (angularity, plasticity, dilatency); Sorting, Moisture Content, Consistency/Density, Color (Munsel Chart), Additional Comments.	PID Reading
1	Hand Auger	NA	60			0.0 - 20.0' : Sand (SW) : f-m grain, subang. to subrnd, <5% silt ; well sorted, dry to moist, loose, yellowish brown (10YR 5/6)	
2							
3							
4							
5							0.2
7			28				
10			29				0.4
12			25				
15			26				1.8
17			24			* moisture content increases to moist @ 17' * becomes v. dark grayish brown (10YR 3/2) @ 19'	
20			33			20.0 - 26.0' : silty sand (SM) : vf - m grain, subang. to subrnd. ; 5-10% silt ; 5-10% clay ; poorly sorted, wet, loose, black (10YR 2/1)	1.1
			19				

Remarks/Notes:

ARCADIS
infrastructure, environment, buildings

Boring/Well ID TISR-4-0

Project/ Client: VSFB ~~VAFB~~

Site Address/ Location: SODS

Job No.: 30024237

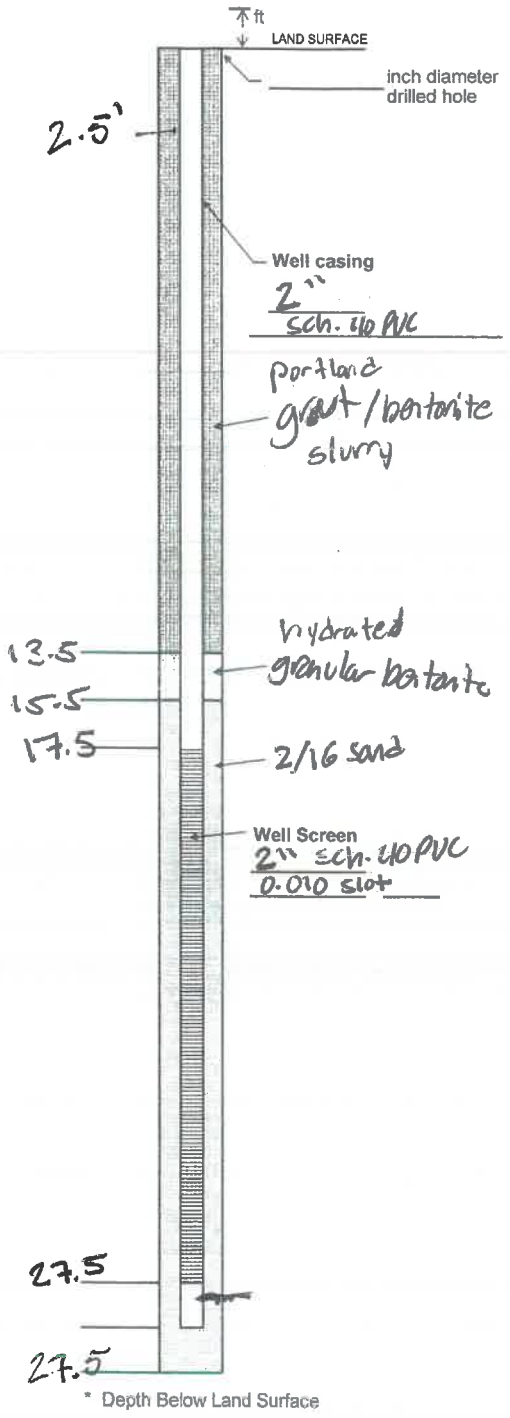
Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description Depth; Principal Components, (angularity, plasticity, dilatency); Minor Components, (angularity, plasticity, dilatency); Sorting, Moisture Content, Consistency/Density, Color (Munsel Chart), Additional Comments.	PID Reading
22			19			* gravel content increases to 10-15% @ 21' (2-8mm), subang. to subround	
			22				
25						~~Silty~~ 26.0 - 27.0': silty sand (SM): f-coarse grain, subang. to subround; 20-25% silt; 10-15% clay; 10-15% gravel and chert (4-8mm), subang. to subround.; poorly sorted, wet,	0.8
			30				
27						dense, dark yellowish brown (10YR 4/6)	
			30			27.0 - 34.0': Shale/ Chert and sand: f-m grain, 25-30% sand; Shale/ chert (2-45mm); 10-15% gravel (2-15mm); poorly sorted, wet, dense, dark yellowish brown (10YR 4/6)	102.0
30						* Shale/ Chert content decreases from 55-60% to 25-30% and	
			30			color changes to dark grayish brown (10YR 3/2) @ 31.5'	
32							
			30				
35						34.0 - 38.5': silty sand (SM): vf-m grain, subang. to subround.; 35-40% silt; 5-10% gravel (2-8mm), subang. to subround.; poorly sorted, wet, loose, v. dark greenish gray (GLEY 1 3/1)	1.1
			30	1200	TISR-4 35-37.5 (4Kg)		
37							
			30			38.5 - 40.0': weathered shale: dry, v. dark bluish gray	
40							16.1
						TD = 40' bgs	

Remarks/Notes:

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Well Construction Log

(Unconsolidated)



Project VSFB ~~VAFB~~ Well TISR-4-S

Town/City Lompoc, CA

County San Bernardino State CA

Permit No. 332/03

Installation Date(s) 11/15/2021

Drilling Method HSA

Drilling Contractor ABC Liquin

Drilling Fluid water

Well Purpose Monitoring / Remediation

Remarks

Prepared by MB

Gallons of grout calc (length x 0.25 x 7.48): 20.5

Gallons installed: 38 gal.

Filter pack sand bags calc (length x 0.25 x 2): 6

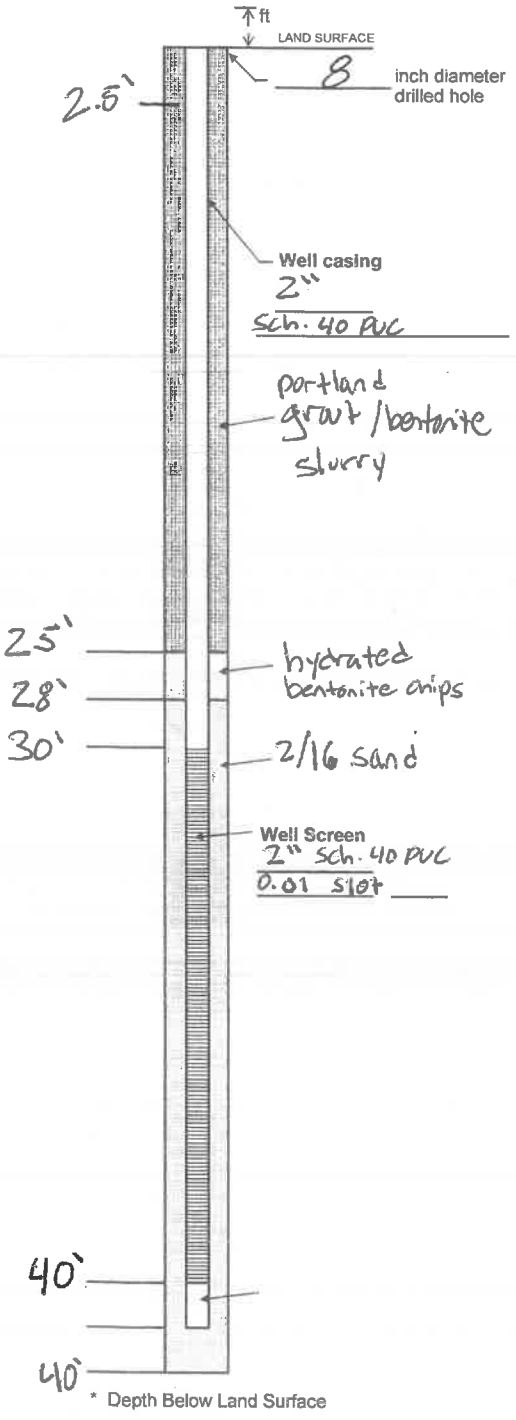
Filter pack sand bags installed: 8

Bentonite bags used: 1.5

ARCADIS

Well Construction Log

(Unconsolidated)



Project ~~VAFB~~ VSFB Well TISR-4-DEEP

Town/City Lompoc, CA

County San Bernardino State CA

Permit No. 332/103

Installation Date(s) 11/11/2021

Drilling Method HSA

Drilling Contractor ABC

Drilling Fluid water

Well Purpose remediation / monitoring

Remarks

Prepared by Marshall Brusca

Gallons of grout calc (length x 0.25 x 7.48): 25 x 0.25 x 7.48 = 46.8

Gallons installed: 55 gal

Filter pack sand bags calc (length x 0.25 x 2): 12 x 0.25 x 2 = 6

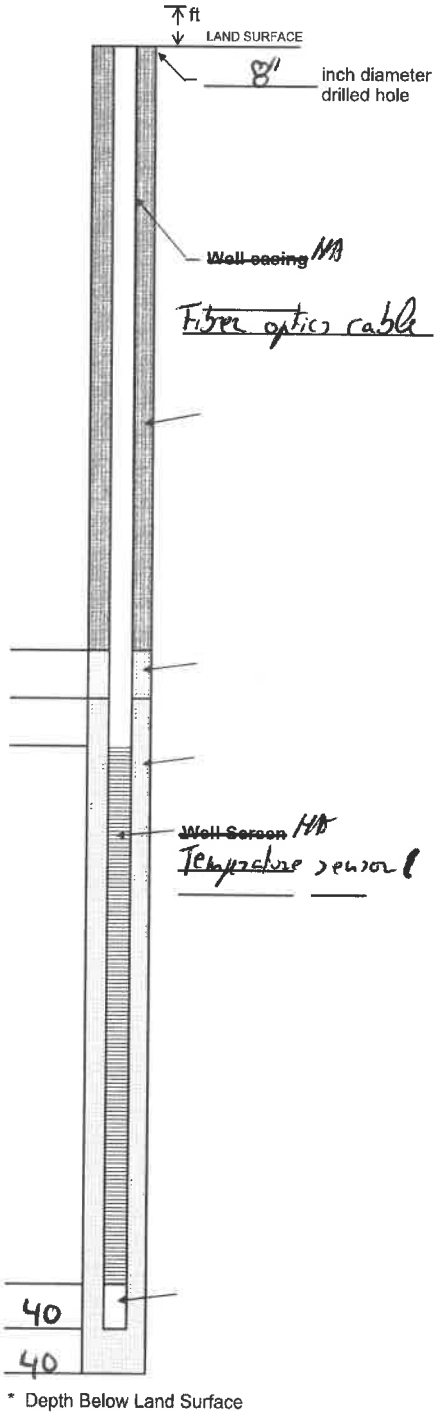
Filter pack sand bags installed: 6 bags

Bentonite bags installed: 1 bag

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Well Construction Log

(Unconsolidated)



* Depth Below Land Surface

DTS

Project VAFB **Well** ~~DST-~~ 11

Town/City Lompoc, CA

County San Bernardino **State** CA

Permit No. 332/103

Installation Date(s) 11/30/21

Drilling Method HSA

Drilling Contractor ABC Liquid

Drilling Fluid Water

Well Purpose Temperature sensor installation

Remarks

Prepared by Hans Alcalla

Gallons of grout calc (length x 0.25 x 7.48):

Gallons installed: N/A

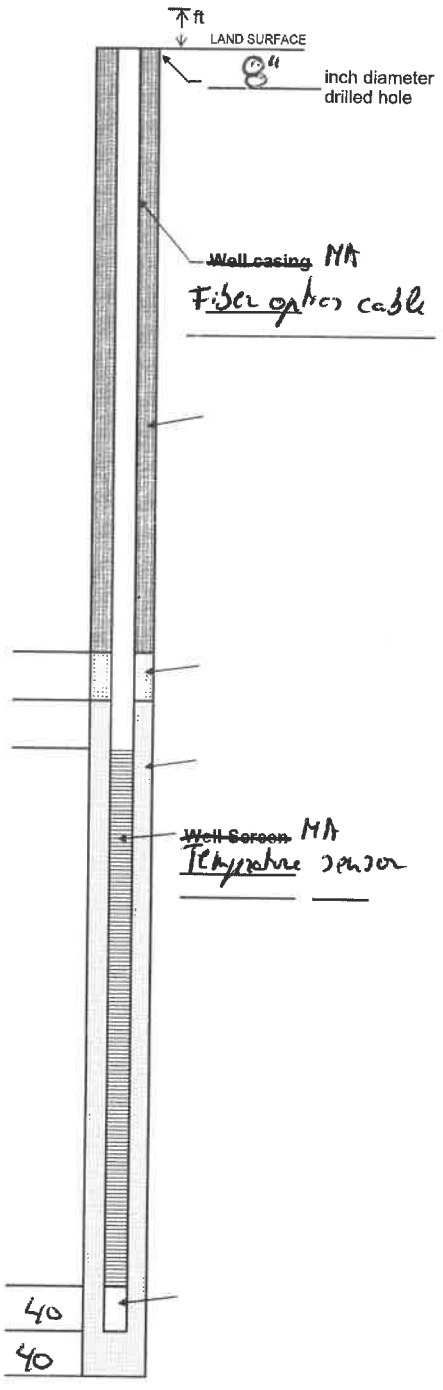
Filter pack sand bags calc (length x 0.25 x 2):

Filter pack sand bags installed: Native soil

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Well Construction Log

(Unconsolidated)



* Depth Below Land Surface

Project VAFB Well DTS-12

Town/City Lompoc, CA

County San Bernardino State CA

Permit No. 3321103

Installation Date(s) 11/30/21 - 12/1/21

Drilling Method HSA

Drilling Contractor ABC Liquid

Drilling Fluid Water

Well Purpose Temperature monitoring

Remarks

Prepared by Mario Alcalde

Gallons of grout calc (length x 0.25 x 7.48):

Gallons installed: N/A

Filter pack sand bags calc (length x 0.25 x 2):

Filter pack sand bags installed: Native soil

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Boring/Well ID SUP-1

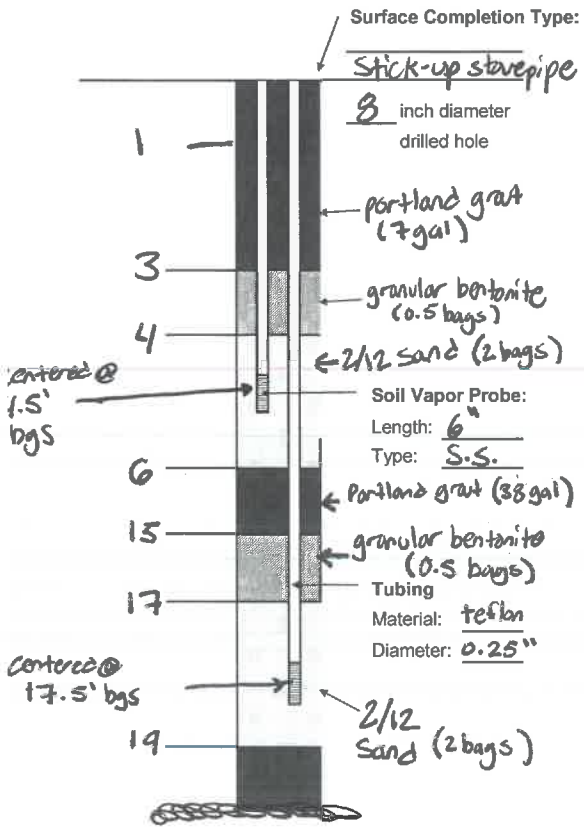
Page 1 of 1

Project/ Client:	VSFB ~~VAFB~~	Site Address/ Location:	SD015			Job No.	30024237
Start Date:	11/11/21	End Date:	11/11/21	Total Depth:	19' bgs	Hole Diameter:	8"
Depth to 1st Water:	NA						
Sampling Device:	core barrel	Length:	5'	Diameter:	3.5"	Sampling Interval:	continuous
Hammer Weight:	NA	Hammer Drop:	NA	Drilling Contractor:	ABC Livin		
Drilling Rig:	CME 95	Drilling Method:	HSA	Drilling Fluid Used:	water		
Driller:	Jamie Moore	Helper(s):	Luis Mendoza, Juan Cortez				
Logged By:	Marshall Brusca	Reviewed By:		Date Reviewed:			

Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description Depth: Principal Components, (angularity, plasticity, dilatency); Minor Components, (angularity, plasticity, dilatency); Sorting, Moisture Content, Consistency/Density, Color (Munsel Chart), Additional Comments.	PID Reading
1	Hand Auger	NA		NA	NA	0.0 - 19.0' : sand (SW) : vf - m grain, subang. to subround.; well sorted, dry to moist, loose, yellowish brown (10yr 5/8)	
2							
3			60				
4							
5							0.4
7			28				
			30				
10							0.7
12			29				
			27				
15							0.8
17			26			* 18.0 - 19.0 : silty sand (SM) : vf - m grain, subang. to subround; 15-20% silt; <5% clay; poorly sorted, v. moist, loose, dark grayish brown (10yr 4/2)	
19			18				0.9
20						TD : 19' bgs	

Remarks/Notes:

Soil Vapor Construction Log



Project SD015 Well SVP-1

Town/City Lompoc, CA

County Santa Barbara State CA

Permit No. 332/103

Installation Date(s) 11/11/2021

Drilling Method HSA

Drilling Contractor ABC Civin

Drilling Fluid water

Well Purpose monitoring

Remarks

Prepared by Marshall Brusca

*Depths are feet below ground surface
**Backfill material repeated with depth

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Boring/Well ID SVP-2

Page 1 of 1

Project/Client: VSFB ~~VAFB~~

Site Address/Location: SD15

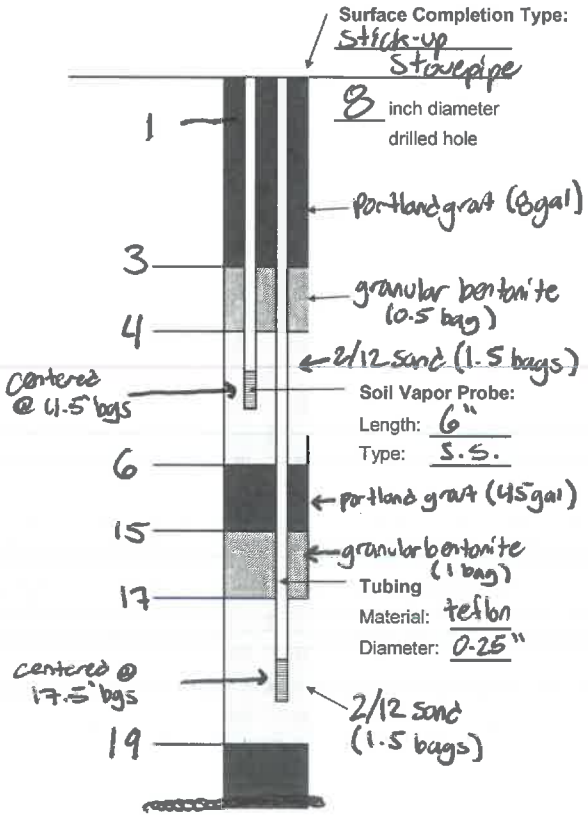
Job No. 30024237

Start Date:	11/15/21	End Date:	11/15/21	Total Depth:		Hole Diameter:	8"
Depth to 1st Water:	NA						
Sampling Device:	Core barrel	Length:	5'	Diameter:	3.5"	Sampling Interval:	Continuous
Hammer Weight:	~~140 lbs~~ NA	Hammer Drop:	~~30 in~~ NA	Drilling Contractor:	ABC		
Drilling Rig:	CME 95	Drilling Method:	HSA	Drilling Fluid Used:	water		
Driller:	Jamie Moore	Helper(s):	Juan Cortez Pedro Carreon				
Logged By:	Marshall Brisca / Mario Alcala	Reviewed By:		Date Reviewed:			

Depth (ft)	Drive Interval	Blows per 6"	Recovery (in.)	Time	Sample ID	Description	PID Reading
1	HAND AUGER		60"			0.0 – 19.0': SAND (SW): f-m grain, ~~subang.~~ to subrnd; well sorted, moist, v. loose, dark yellowish brown (10YR 4/6); at 7.5' brownish yellow (10YR 6/6)	
2							
3							
4							
5							0.3
7			30"				
10			27"				0.9
12			28"				
15			28"				0.8
17			28"				
20			18"			TD = 19' bgs	0.9

Remarks/Notes:

Soil Vapor Construction Log



Project SD015 Well SVP-2

Town/City Lompoc, CA

County Santa Barbara State CA

Permit No. 332/103

Installation Date(s) 11/15/2021

Drilling Method HSA

Drilling Contractor ABC Liquin

Drilling Fluid water

Well Purpose Monitoring

Remarks

Prepared by Marshall Bruscia

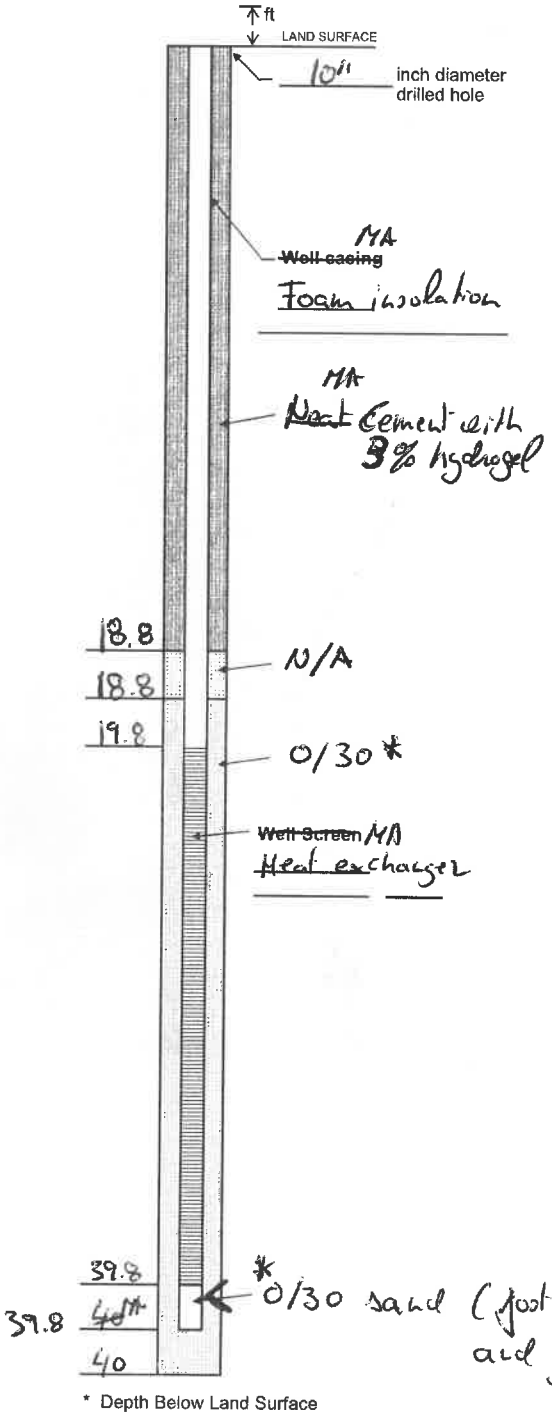
*Depths are feet below ground surface
**Backfill material repeated with depth

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Well Construction Log

(Unconsolidated)



Project VAFB **Well** BHE-G

Town/City Lompoc, CA

County San Bernardino **State** CA

Permit No. 332103

Installation Date(s) 11/30/21

Drilling Method HSA

Drilling Contractor ABC Liquid

Drilling Fluid Water

Well Purpose Monitoring / Remediation

Remarks

Prepared by Hans Hoole

Gallons of grout calc (length x 0.25 x 7.48):

Gallons installed: 70 gallons

Filter pack sand bags calc (length x 0.25 x 2):

Filter pack sand bags installed: 22 0/30 sand

APPENDIX D HEAT TRANSPORT MODEL ASSUMPTIONS AND PARAMETERS

Assumptions, Parameters, Equations, Methodology, and Results

E.1 Assumptions

The analytical modeling of the solar thermal remediation system relies on several key assumptions:

1. **Subsurface Homogeneity**: The hydrogeologic setting is assumed to be isotropic with uniform thermal and hydraulic properties.
2. **Steady-State Conditions**: Heat transfer and decay rate calculations assume steady-state conditions over long-term simulations.
3. **Negligible Heat Loss**: Minimal energy loss from borehole heat exchangers (BHEs) due to insulation and deep installation.
4. **Constant Groundwater Flow**: Darcy velocity remains constant across the modeling domain.
5. **Temperature-Dependent Decay**: Decay factors for volatile organic compounds (VOCs) increase with temperature following empirical relationships.
6. **No Chemical Transport**: The model assumes contaminants remain stationary, with no advective transport due to groundwater movement.

E.2 Parameters

Key parameters used in the simulations include:

Table E1. Thermal and Hydraulic Properties

Parameter	Value	Units
Darcy Velocity	11	m/yr
Porosity	0.4	-
Rock Heat Capacity	790	J/kg·°C
Rock Grain Density	2200	kg/m3
Bulk Heat Capacity	2.7 x 10^6	J/m3·°C
Thermal Conductivity	1.9	W/m·°C
Heater Length	6.1	m
Depth to Heater Top	6.1	m

Table E2. Power Input per Borehole

Month	Watts Per Borehole
June	355
July	164
August	313
September	225
October	247
November	322
December	232
January	252
February	312
March	309
April	361
May	342

E.3 Equations

The analytical model is based on finite line source heat propagation and first-order decay kinetics.

Heat Transfer Equation

The temperature change at any point (x, y, z) and time (t) is given by:

$$T(x,y,z,t)$$

where:

- Q_n= Heat flow rate per borehole (W)
- G(x,y,z,t) = Green's function solution for heat conduction and convection
- N = Number of borehole heat exchangers

Thermal Enhanced Decay

The decay concentration after heating is calculated as:

$$C_{th}=C_o e^{-k_{th}t}$$

where:

- C_o = Initial contaminant concentration
- k_{th} = Temperature-dependent decay coefficient
- t = Time (years)

E.4 Methodology

1. **Model Calibration**: A range of groundwater velocities (3-15 m/yr) was tested to match field data.
2. **Temperature Simulation**: Conducted over 3, 6, and 10 years for different remediation configurations.
3. **Decay Factor Interpolation**: Decay factors were assigned in 5-degree increments between 0°C and 60°C.
4. **Solar Power Optimization**: Different BHE and solar panel configurations were analyzed for cost-effectiveness.

E.5 Results

Temperature Change Over Time

- Simulated temperature changes aligned well with field data for groundwater velocities below 8 m/yr.
- Higher velocities caused excessive heat dispersion, reducing model accuracy.

Table E3. Thermal Enhanced Decay Projections

Years Heated	20% Enhancement	30% Enhancement	55% Enhancement	80% Enhancement
3	Yes	Yes	No	No
6	Yes	Yes	Yes	No
10	Yes	Yes	Yes	Yes

- The optimized system (16 BHEs, 16 panels) significantly increased the thermally enhanced decay area compared to the initial system (8 BHEs, 8 panels).

Conclusion

This appendix provides a detailed reference for the assumptions, parameters, equations, and methodology used in modeling the solar thermal remediation system at Vandenberg Space Force Base. The results indicate that increasing the number of BHEs and solar panels enhances contaminant degradation efficiency over time.