MOBILE LAUNCH PLATFORM/VEHICLE ASSEMBLY AREA
(SWMU 056)
BIOSPARGE EXPANSION INTERIM MEASURES WORK PLAN
KENNEDY SPACE CENTER, FLORIDA

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CERTIFICATION AND APPROVAL

I hereby certify that in my professional judgment this document entitled: *Mobile Launch Platform/Vehicle Assembly Area (SWMU 056) Biosparge Expansion Interim Measures Work Plan* generally satisfies the requirements set forth in Chapter 471, Florida Statues. I have completed and/or been in responsible charge of work completed by qualified professionals working directly under my supervision.

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ABBREVIATIONS AND ACRONYMS

ABS	acrylonitrile butadiene styrene
ADP	Advanced Data Package
ASTM	ASTM International
CCR	Construction Completion Report
cDCE	cis-1,2-dichloroethene
CMD	Corrective Measures Design
CMI	Corrective Measures Implementation
CVOC	chlorinated volatile organic compound
DPT	direct push technology
EPA	Environmental Protection Agency
FDEP	Florida Department of Environmental Protection
ft BLS	feet below land surface
Geosyntec	Geosyntec Consultants
GCTL	Groundwater Cleanup Target Level
IM	interim measures
IMWP	interim measures work plan
KSC	Kennedy Space Center
KSCRT	KSC Remediation Team
LTM	long term monitoring
µg/L	micrograms per liter
MLPV	Mobile Launch Platform/Vehicle Assembly Building
NADC	Natural Attenuation Default Concentration
NASA	National Aeronautics and Space Administration
NEMA	National Electrical Manufacturer's Association
O&M	operation and maintenance
P&ID	Process and Instrumentation Diagram
psi	pounds per square inch
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
ROI	radius of influence
scfm	standard cubic feet per minute
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
VAB	Vehicle Assembly Building
VC	vinyl chloride

SECTION I

INTRODUCTION

1.1 OVERVIEW

This document presents the design details for an Interim Measure (IM) Work Plan (IMWP) for the Mobile Launch Platform/Vehicle Assembly Building (MLPV) Area, located at the John F. Kennedy Space Center (KSC), Florida. The MLPV Area has been designated Solid Waste Management Unit Number 056 (SWMU 056) under KSC's Resource Conservation and Recovery Act (RCRA) Corrective Action Program. This report was prepared by Geosyntec Consultants (Geosyntec) for the National Aeronautics and Space Administration (NASA) under contract number NNK09CA02B and NNK12CA13B, project control number ENV1642. The Advanced Data Package (ADP) presentation covering the elements of this IMWP report received KSC Remediation Team (KSCRT) approval at the December 2015 Team Meeting; the meeting minutes are included in Appendix A.

1.2 PURPOSE

This IMWP presents an approach and design for the expansion of the existing biosparge barrier system at the MLPV Area to mitigate potential discharge of groundwater impacted with vinyl chloride (VC) to the adjacent wetlands. Details about the construction and installation of the existing biosparge barrier system can be found in the MLPV Area Dissolved Plume Corrective Measures Report [NASA 2006] and details about the current sparge system that supplies air to the biosparge system can be found in the 2015 Corrective Measures Implementation (CMI) and IMs Annual Report [NASA 2015c]. The biosparge barrier expansion is designed to treat the area where VC concentrations are present above their Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentrations (NADC) northwest of the biosparge barrier. The area of the biosparge system expansion will be approximately 140 feet in length and will treat the interval from approximately land surface to 50 feet below land surface (ft BLS).

1.3 INTERIM MEASURES OBJECTIVE

The IMWP's objective for MLPV is to provide treatment of VC groundwater impacts above the FDEP NADC to mitigate the potential discharge of the impacted groundwater to downgradient wetlands. It is anticipated that the IM activities will be performed until collapse of the primary plume swath of chlorinated volatile organic compounds (CVOCs).

1.4 INTERIM MEASURES WORK PLAN ORGANIZATION

The remainder of the MLPV IMWP is organized as follows:

Section II: *Summary of Current Conditions* – This section provides a brief description of the site setting and summarizes previous IM activities performed at the MLPV Area.

Section III: *Interim Measures Design* – This section provides specific details of the MLPV biosparge barrier expansion design.

Section IV: *Performance Monitoring and Operation and Maintenance* – This section provides specifics of groundwater monitoring, expected system performance, and operation and maintenance (O&M) activities that will be performed in conjunction with the MLPV biosparge barrier expansion.

Section V: *Interim Measures Reporting* – This section provides a brief description of the documentation and reporting activities to be completed to support the MLPV biosparge barrier expansion.

Section VI: *Exit Strategy and Costing* – This section provides specific details about the exit strategy for the MLPV site, based upon the existing biosparge barrier expansion. A detailed description of the estimated cost of the biosparge barrier is also included.

Section VII: *References* – This section provides the references for the citations in this report.

SECTION II

SUMMARY OF CURRENT CONDITIONS

2.1 LOCATION

The MLPV Area is located with KSC, on the East coast of Florida in Brevard County (Figure 2-1). The site is located within Section 7, Township 22 South, Range 37 East, as shown on the United States Geological Survey's 7.5-minute Orsino topographic quadrangle map (Figure 2-2).

The MLPV facilities were originally built to support the Apollo/Saturn-V vehicle assembly and were later modified (1975) to support Space Transportation System shuttle missions. The Mobile Launch Platform area was used to repair post launch corrosion and/or blast damage on the launch platforms prior to reuse. The Vehicle Assembly Building (VAB) was used to stack and prepare the space vehicles prior to launch.

2.2 BACKGROUND

During the RCRA Facility Investigation (RFI) [NASA 2000, NASA 2003] and pre-Corrective Measures Study activities, CVOC groundwater impacts encompassing an area of approximately 115 acres were delineated. Beneath the parking lot northeast of the VAB, a trichloroethene (TCE) source area was identified, which is associated with an anecdotal TCE spill (approximately 4,000 gallons) that occurred in 1966. The Corrective Measures Design (CMD) [NASA 2004] incorporated a multi-component remedial strategy including: (i) enhanced bioremediation of the source area; (ii) biosparging with air to promote the *in situ* aerobic bioremediation of VC to prevent discharge of the high concentration VC plume to adjacent wetland areas; and (iii) long term monitoring (LTM) of the low concentration dissolved plume.

Details of the bioremediation implementation are provided in the Biotreatability Study Implementation Annual Reports [NASA 2008, NASA 2009] and details of the most recent LTM sampling are provided in VAB Area 2014 Annual Groundwater Monitoring Results [NASA 2015b].

The existing biosparge system has been operating since April 2005, after completion of construction by Jacobs Engineering. The biosparge system injects air into the subsurface via 25 biosparge wells and is designed to treat the dissolved phase VC flux associated with the portion of the plume with concentrations greater than 100 micrograms per liter (µg/L). Monthly O&M is performed on the system, and regularly scheduled groundwater sampling of performance monitoring wells occurs.

After completion of bioremediation of the source area, supplemental assessment occurred from September 2009 to November 2010, with the goal of refining the understanding of the CVOC mass distribution within the dissolved plume (primary plume swath) that extends from the former source area to the biosparge barrier. The results of the supplemental assessment suggested that the CVOC plume that remains is historic dissolved phase flux from the former source area. The dissolved phase plume extends from approximately 30 to 50 ft BLS. After initiation of the supplemental assessment, activities at the site followed the KSCRT multi-step engineering evaluation process. During this process the following was completed: (i) TCE and cis-1,2-dichloroethene (cDCE) delineation was completed to their FDEP Groundwater Cleanup Target Level (GCTLs) and VC was delineated to its FDEP NADC; (ii) a limited evaluation of technologies (bioremediation and air sparging) was performed and air sparging was chosen as the remedial alternative to address the CVOC groundwater impacts with concentrations greater than 300 µg/L TCE and 7,000 µg/L cDCE (defined as the High Concentration Plume); and (iii) the existing sparge system was modified to accommodate two additional legs associated with the air sparge system, so that both the biosparge and air sparge operations could run off the same compressor. Additional details on the engineering evaluation process and air sparge system implementation are provided in the following documents:

- Step 1 Engineering Evaluation ADP [NASA 2011a];
- Step 2 Engineering Evaluation ADP [NASA 2011b];
- 2011 CMI Report: Summary of Interim LTM, Supplemental Assessment, and Biosparge System Operation and Maintenance [NASA 2011d];
- Step 3 Engineering Evaluation ADP: Air Sparge IM Work Plan [NASA 2011e];
- Air Sparge IM Work Plan [NASA 2011f];
- Step 4A Engineering Evaluation ADP: Air Sparge Construction Completion Report (CCR) [NASA 2012];
- Air Sparge System CCR [NASA 2013a];
- Step 4B Engineering Evaluation ADP: Air Sparge System and Biosparge System Re-Start and Initial Performance Monitoring (Re-Start through Month 6) [NASA 2014a]; and
- 2015 CMI and IM Annual Report: Summary of Biosparge and Air Sparge System Operation and Maintenance and Interim Groundwater Monitoring [NASA 2015c].

2.3 EXISTING SPARGE SYSTEM

As described in Section 2.2, the existing sparge system consists of a biosparge barrier and an air sparge system that are both operated by the same air compressor system (the system) housed in an equipment building. The existing sparge system layout is presented on Figure 2-3 and a process and instrumentation diagram (P&ID) of the system is presented on Figure 2-4. The system which provides air to the sparge system is comprised of the primary components described below:

- one rotary claw compressor (Rietschle C-DLR 300: 60 hertz, 25 horsepower, 190 cubic feet per minute, and 31.9 pounds per square inch [psi]) with a variable frequency drive;
- one heat exchanger (Aftercooler AKG CC-450);
- one silencer (SCLR-200);
- one control panel; and
- one sparge manifold with four legs (each leg has individual ball valves and solenoids) (Leg 1 and Leg 2 provide air to biosparge wells and Leg 3 and Leg 4 provide air to air sparge wells).

For the air sparge system, a 4-inch Schedule 80 polyvinyl chloride (PVC) pipe carries air from the sparge system to a manifold near the air sparge system (except where the piping transitions to and from high density polyethylene pipe underneath the crawler tracks). At the manifolds, the air flow is split and directed to the air sparge wells via individual 1-inch Schedule 80 PVC lines. There are four manifolds which split the flow into 45 individual lines that connect to the 45 air sparge wells (ASW01 through ASW045). The 45 air sparge wells have two foot screens, with top of screens that range from approximately 37 to 44 ft BLS. Details regarding the construction of the air sparge portion of the sparge system are provided in the Air Sparge CCR [NASA 2013a].

For the existing biosparge barrier, two, 2-inch acrylonitrile butadiene styrene (ABS) thermoplastic pipes carry air from the sparge system, under launcher road (through a 4-inch PVC carrier pipe that was installed via directional drilling) to the individual biosparge wells. Each biosparge well is plumbed to the main 2-inch ABS pipe by a 1-inch ABS thermoplastic pipe. Details on the construction of the existing biosparge barrier are provided in the MLPV Area Dissolved Plume Corrective Measures Report [NASA 2006].

2.4 CURRENT SITE CONDITIONS

2.4.1 LITHOLOGY. Site lithology was characterized during the RFI activities [NASA 2000, NASA 2003]. A generalized soil lithologic cross section based upon an evaluation of collected soil cores is presented on Figure 2-5.

2.4.2 GROUNDWATER FLOW. The groundwater flow evaluation at MLPV is performed as part of the LTM of the dissolved plume and is separated into three depth intervals: (i) the shallow interval that is less than 20 ft BLS, (ii) the intermediate interval that is 20 to 40 ft BLS, and (iii) the deep interval that is 40 to 50 ft BLS. Groundwater elevations from November 2014 are presented on Figure 2-6, Figure 2-7, and Figure 2-8 for the shallow depth interval, intermediate depth interval, and deep depth interval, respectively. These figures and the corresponding data are provided in the VAB Area 2014 Annual Groundwater Monitoring Report [NASA 2015b]. The groundwater flow direction for all three intervals is generally consistent with historical data, with groundwater flowing radially away from the VAB. The groundwater flow for all three intervals in the area where the air sparge and biosparge system are located generally flows to the north/northeast, specifically from the retention pond area towards the biosparge wall. However, in the intermediate zone, the effect of the air sparge system installed near the retention pond can be observed, as it causes the groundwater to flow radially away from the air sparge area.

2.4.3 VINYL CHLORIDE DISTRIBUTION. The biosparge barrier is designed to treat the area where VC concentrations are greater than 100 µg/L; therefore, the description of the distribution of CVOCs at the site will only focus on VC in the area of the biosparge barrier. Previous investigations at the site have suggested that the interval impacted with VC concentrations greater than 100 µg/L is present from 31 to 50 ft BLS; therefore, only the data from that interval is discussed in this report. The current distribution of VC from 31 to 50 ft BLS is presented on Figure 2-9, and the data from the sampling locations presented on this figure are provided in Tables 2-1 and 2-2. Figure 2-9 presents a combination of the data presented in the VAB Reassessment Area Environmental Conditions Report [NASA 2015a], the 2011 CMI Report Summary of LTM, Supplemental Assessment, and Biosparge System Operation and Maintenance [NASA 2011d], the 2014 CMI and IM Annual Report: Summary of Biosparge and Air Sparge System Operation and Maintenance [NASA 2014b], and the 2015 CMI and IM Annual Report [NASA 2015c].

The locations that were utilized to evaluate the biosparge barrier expansion are highlighted green in Table 2-1. The data from these locations suggests that the VC impacts above 100 µg/L are present from approximately 30 to 45 ft BLS in the area northwest of the biosparge barrier.

Table 2-1. Mobile Laboratory DPT Groundwater Sampling Results: CVOCs
Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Location	Sample Interval (ft BLS)	Sample Date	Concentration (µg/L) Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
FDEP GCTL			**3**	**70**	**100**	**1**
FDEP NADC			**300**	**700**	**1,000**	**100**
DPT0456	26 to 30	10/06/2009	1.0 U	1.0 U	1.7	1.0 U
	31 to 35		1.0 U	1.0 U	1.5	1.0 U
	36 to 40		1.0 U	1.0 U	2.2	1.0 U
	41 to 45		1.0 U	1.3	1.0 U	**4.3**
	46 to 50		**25 U**	**590**	11 I	**1,600**
	51 to 55		1.0 U	1.0 U	1.0 U	**14.0**
DPT0462	26 to 30	10/07/2009	1.0 U	1.0 U	1.0 U	**2.9**
	31 to 35		1.0 U	1.7	1.0	**14.4**
	36 to 40		1.0 U	17.5	5.2	**120**
	41 to 45		**10 U**	**270**	5.7 I	**510**
	46 to 50		2.0 U	**110**	2.0 U	**300**
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0463	6 to 10	11/19/2010	1.0 U	1.0 U	1.0 U	1.0 U
	16 to 20		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	10/08/2009	1.0 U	1.0 U	1.2	1.1
	31 to 35		1.0 U	1.0 U	1.2	1.0 U
	36 to 40		1.0 U	8.6	1.5	**98.4**
	41 to 45		**10 U**	**450**	10 U	**2,000**
	46 to 50		**20 U**	**250**	20 U	**1,200**
DPT0464	26 to 30	10/08/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	1.0 U
	36 to 40		1.0 U	1.0 U	1.4	1.0 U
	41 to 45		1.0 U	1.0 U	1.9	1.2
	46 to 50		**10 U**	**150**	4.7 I	**770**
	51 to 55		1.0 U	1.0 U	1.0 U	**4.3**
DPT0465	26 to 30	10/08/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	1.0 U
	36 to 40		1.0 U	1.0 U	1.0 U	1.0 U
	41 to 45		1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50		1.0 U	44.7	1.1	**190**
DPT0466	26 to 30	10/08/2009	1.0 U	1.0 U	1.0	1.0 U
	31 to 35		1.0 U	1.0 U	1.0	1.0 U
	36 to 40		1.0 U	1.0 U	1.8	**8.5**
	41 to 45		5.0 U	**110**	3.5 I	**470**
	46 to 50		**20 U**	**240**	20 U	**1,100**
DPT0472	26 to 30	10/12/2009	1.0 U	1.0 U	1.0 U	**4.2**
	31 to 35		1.0 U	1.0 U	1.0 U	**4.2**
	36 to 40		1.0 U	33.2	2.1	**290**
	41 to 45		**20 U**	**450**	20 U	**1,300**
	46 to 50		**20 U**	**500**	20 U	**810**
DPT0473	26 to 30	10/12/2009	1.0 U	1.0 U	1.4	1.0 U
	31 to 35		1.0 U	1.0 U	1.8	1.0 U
	36 to 40		1.0 U	1.0 U	1.7	1.0 U
	41 to 45		1.0 U	1.0 U	2.0	1.0 U
	46 to 50		1.0 U	45.2	2.0	**140**
DPT0474	26 to 30	10/12/2009	1.0 U	1.1	1.0 U	**3.5**
	31 to 35		1.0 U	1.1	1.0 U	**27.7**
	36 to 40		1.0 U	13.1	1.0 U	**200**
	41 to 45		1.0 U	9.0	1.0 U	**90.4**
	46 to 50		1.0 U	1.0	1.0 U	**12.6**
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0477	26 to 30	10/13/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	1.0 U
	36 to 40		1.0 U	1.0 U	1.4	1.0 U
	41 to 45		1.0 U	1.0 U	1.8	**7.8**
	46 to 50		**10 U**	**100**	10 U	**740**
	51 to 55		1.0 U	10.2	1.0 U	**110**
	56 to 60		1.0 U	1.0 U	1.0 U	1.0 U
DPT0478	26 to 30	10/13/2009	1.0 U	1.0 U	1.0 U	**1.6**
	31 to 35		1.0 U	1.0 U	1.0 U	**2.9**
	36 to 40		1.0 U	2.2	1.0 U	**31.2**
	41 to 45		**10 U**	**100**	7.6 I	**490**
	46 to 50		**10 U**	**210**	10 U	**230**
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0479	26 to 30	10/13/2009	1.0 U	1.0 U	1.4	1.0 U
	26 to 30	06/18/2014	0.19 U	0.22 U	0.38 I	0.26 U
	31 to 35	10/13/2009	1.0 U	1.0 U	1.7	1.0 U
	31 to 35	06/18/2014	0.19 U	0.22 U	0.29 U	0.41 I
	36 to 40	10/13/2009	1.0 U	1.0 U	1.6	1.0 U
	36 to 40	06/18/2014	0.19 U	0.33 I	0.29 U	0.40 I
	41 to 45	10/13/2009	1.0 U	1.0 U	1.6	1.0 U
	41 to 45	06/18/2014	0.19 U	0.45 I	0.29 U	**1.5**
	46 to 50	10/13/2009	1.0 U	13.3	1.7	**55.3**
	46 to 50	06/18/2014	0.19 U	39.5	4.9	**76.9**
	51 to 55	10/13/2009	1.0 U	6.3	1.0 U	**47.4**
	51 to 55	06/18/2014	1.9 U	**110**	2.9 U	**280**
	56 to 60	06/18/2014	0.19 U	0.22 U	0.29 U	0.26 U
DPT0480	26 to 30	10/14/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0	1.2
	36 to 40		1.0 U	1.0 U	1.0	**6.6**
	41 to 45		**10 U**	**220**	10.0	**740**
	46 to 50		**10 U**	**250**	10 U	**730**

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Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Location	Sample Interval (ft BLS)	Sample Date	Concentration (µg/L)			
			Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
FDEP GCTL			3	70	100	1
FDEP NADC			300	700	1,000	100
DPT0481	26 to 30	10/14/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	**3.6**
	36 to 40		1.0 U	5.1	2.6	**22.4**
	41 to 45		1.0 U	42.9	6.3	**78.0**
	46 to 50		1.0 U	30.4	1.6	**38.4**
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0482	26 to 30	10/14/2009	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	06/19/2014	0.19 U	0.22 U	0.29 U	0.26 U
	31 to 35	10/14/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35	06/19/2014	0.19 U	0.22 U	0.29 U	0.26 U
	36 to 40	10/14/2009	1.0 U	1.0 U	1.0 U	1.0 U
	36 to 40	06/19/2014	0.19 U	0.22 U	0.52 I	0.26 U
	41 to 45	10/14/2009	1.0 U	1.0 U	2.6	1.0 U
	41 to 45	06/19/2014	0.19 U	0.22 U	1.3	0.26 U
	46 to 50	10/14/2009	1.0 U	63.2	3.5	**400**
	46 to 50	06/19/2014	1.9 U	**610**	16.0	**690**
	51 to 55	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55	06/19/2014	0.19 U	0.47 I	0.29 U	**19.4**
	56 to 60	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	56 to 60	06/19/2014	0.19 U	0.22 U	0.29 U	0.26 U
DPT0483	26 to 30	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	1.0 U
	36 to 40		1.0 U	8.6	1.0 U	1.0 U
	41 to 45		1.0 U	5.2	1.0 U	**1.7**
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
	56 to 60		1.0 U	1.0 U	1.0 U	1.0 U
DPT0484	26 to 30	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	06/18/2014	0.19 U	0.22 U	0.29 U	0.26 U
	31 to 35	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35	06/18/2014	0.19 U	1.5	0.29 U	0.26 U
	36 to 40	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	36 to 40	06/18/2014	0.19 U	**82.6**	1.8	0.26 U
	41 to 45	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	41 to 45	06/18/2014	0.19 U	**91.1**	2.8	**44.3**
	46 to 50	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50	06/18/2014	0.19 U	0.22 U	0.29 U	0.26 U
	51 to 55	10/15/2009	1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55	06/18/2014	0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60	06/18/2014	0.19 U	0.22 U	0.29 U	0.26 U
DPT0485	26 to 30	10/16/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	2.7	1.0 U	**32.8**
	36 to 40		1.0 U	37.9	5.0	**60.0**
	41 to 45		1.0 U	48.3	1.2	**40.3**
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0486	26 to 30	10/16/2009	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	3.3	1.0 U	**17.7**
	36 to 40		1.0 U	3.4	1.0 U	**19.3**
	41 to 45		1.0 U	1.1	1.0 U	**12.9**
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0505	26 to 30	1/15/2010	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	**2.5**
	36 to 40		1.0 U	46.8	3.9	**120**
	41 to 45		5.0 U	**75.0**	5.0 U	**160**
	46 to 50		1.0 U	32.4	1.0 U	**83.1**
DPT0506	26 to 30	1/15/2010	1.0 U	1.6	1.5	**50.6**
	31 to 35		1.0 U	2.5	1.0 U	**110**
	36 to 40		1.0 U	11.6	1.0 U	**130**
	41 to 45		1.0 U	1.0 U	1.0 U	**3.8**
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0507	26 to 30	1/15/2010	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	2.4	1.0 U	**16.8**
	36 to 40		1.0 U	9.5	1.0 U	**86.1**
	41 to 45		1.0 U	2.7	1.0 U	**14.8**
	46 to 50		1.0 U	1.0 U	1.0 U	**3.2**
DPT0508	26 to 30	06/14/2010	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	1.0 U
	36 to 40		1.0 U	1.8	1.0 U	10.6
	41 to 45		1.0 U	4.7	1.0 U	**24.1**
	46 to 50		1.0 U	1.2	1.0 U	**8.7**
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0538	26 to 30	11/19/2010	1.0 U	1.0 U	1.1	1.0 U
	26 to 30	06/18/2014	0.19 U	1.3	1.2	**2.9**
	31 to 35	11/19/2010	1.0 U	1.0 U	1.2	1.0 U
	31 to 35	06/19/2014	0.19 U	0.40 I	0.29 U	1.4
	36 to 40	11/19/2010	1.0 U	1.0 U	1.5	1.0 U
	36 to 40	06/19/2014	0.19 U	0.22 U	0.84 I	0.26 U
	41 to 45	11/19/2010	1.0 U	1.0 U	2.7	1.0 U
	41 to 45	06/19/2014	0.19 U	0.22 U	2.1	0.77 I
	46 to 50	11/19/2010	1.0 U	6.0	4.7	**39.5**
	46 to 50	06/19/2014	0.19 U	10.3	11.4	**350**
	51 to 55	06/19/2014	0.19 U	0.79 I	0.29 U	**20.9**
	56 to 60	06/19/2014	0.19 U	0.22 U	0.29 U	0.26 U

Table 2-1. Mobile Laboratory DPT Groundwater Sampling Results: CVOCs
Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Location	Sample Interval (ft BLS)	Sample Date	Concentration (µg/L) Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
FDEP GCTL			**3**	**70**	**100**	**1**
FDEP NADC			**300**	**700**	**1,000**	**100**
DPT0539	26 to 30	11/19/2010	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	06/17/2014	0.19 U	21.5	0.29 U	**6.2**
	31 to 35	11/19/2010	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35	06/17/2014	0.21 I	7.7	0.34 I	**2.7**
	36 to 40	11/19/2010	1.0 U	1.0 U	1.0 U	1.0 U
	36 to 40	06/17/2014	0.19 U	0.78 I	0.29 U	0.50 I
	41 to 45	11/19/2010	1.0 U	1.0 U	1.6	**3.3**
	41 to 45	06/17/2014	1.9 U	59.0	4.5 I	**200**
	46 to 50	11/19/2010	1.7 U,I	**390**	22.0	**1,500**
	46 to 50	06/18/2014	0.19 U	**260**	19.1	**890**
	51 to 55	11/19/2010	1.0 U	1.0 U	1.0 U	**23.1**
	51 to 55	06/18/2014	0.19 U	3.2	0.29 U	**50.0**
	56 to 60	06/18/2014	0.19 U	0.22 U	0.29 U	0.57 I
DPT0540	26 to 30	11/22/2010	1.0 U	1.0 U	1.0 U	**2.2**
	31 to 35		1.0 U	1.0 U	1.0 U	**6.8**
	36 to 40		1.0 U	18.7	1.8	**170**
	41 to 45		1.0 U	9.7	1.0 U	**62.4**
	46 to 50		1.0 U	1.8	1.0 U	**13.6**
DPT0541	26 to 30	11/22/2010	1.0 U	2.7	1.0 U	**7.6**
	31 to 35		1.0 U	2.9	1.0 U	**11.4**
	36 to 40		1.0 U	4.8	1.0 U	**25.3**
	41 to 45		1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
DPT0542	16 to 20	6/6/2011	1.0 U	1.0 U	1.0 U	1.0 U
	21 to 25		1.0 U	1.0 U	1.0 U	**28.6**
	26 to 30	11/22/2010	1.0 U	1.3	1.0 U	**120**
	31 to 35		1.0 U	5.2	1.0 U	**180**
	36 to 40		1.0 U	2.8	1.0 U	**25.2**
	41 to 45		1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0543	26 to 30	11/23/2010	1.0 U	1.0 U	2.2	1.0
	31 to 35		1.0 U	1.0 U	2.7	1.0 U
	36 to 40		1.0 U	1.0 U	1.0 U	1.0 U
	41 to 45		1.0 U	20.9	2.2	**8.6**
	46 to 50		1.0 U	16.3	1.0 U	**5.0**
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT0544	26 to 30	06/16/2014	0.19 U	0.29 I	0.29 U	0.26 U
	31 to 35	06/16/2014	0.19 U	0.96 I	0.92 I	0.26 U
	36 to 40	06/16/2014	0.19 U	9.1	1.2	0.26 U
	41 to 45	11/23/2010	1.0 U	1.0 U	1.0 U	1.0 U
	41 to 45	06/16/2014	0.19 U	9.7	1.0	0.26 U
	46 to 50	11/23/2010	1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50	06/16/2014	0.19 U	0.22 U	0.29 U	0.26 U
	51 to 55	11/23/2010	1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55	06/16/2014	0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60	06/16/2014	0.19 U	0.22 U	0.29 U	0.26 U
DPT0547	16 to 20	06/06/2011	1.0 U	1.0 U	1.0 U	1.0 U
	21 to 25		1.0 U	1.0 U	1.0 U	**13.3**
	26 to 30		1.0 U	2.6	1.0	**73.2**
	31 to 35		1.0 U	6.3	1.0 U	**100**
	36 to 40		1.0 U	1.0 U	1.0 U	**6.2**
	41 to 45		1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
DPT0548	16 to 20	06/06/2011	1.0 U	1.0 U	1.0 U	1.0 U
	21 to 25		1.0 U	2.6	1.0 U	**5.8**
	26 to 30		1.0 U	3.0	1.0 U	**8.4**
	31 to 35		1.0 U	3.4	1.0 U	**13.3**
	36 to 40		1.0 U	1.3	1.0 U	**5.0**
	41 to 45		1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
DPT0549	16 to 20	06/06/2011	1.0 U	1.0 U	1.0 U	1.0 U
	21 to 25		1.0 U	1.0 U	1.0 U	1.2
	26 to 30		1.0 U	1.0 U	1.0 U	**2.2**
	31 to 35		1.0 U	5.7	1.4	**14.7**
	36 to 40	06/07/2011	1.0 U	24.6	1.9	**37.5**
	41 to 45		1.0 U	1.5	1.0 U	**2.3**
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
DPT0557	26 to 30	06/16/2014	0.19 U	0.22 U	0.29 U	0.26 U
	31 to 35		0.19 U	0.22 U	0.90 I	0.50 I
	36 to 40		0.19 U	1.2	1.9	**10.6**
	41 to 45		0.19 U	28.1	6.3	**93.2**
	46 to 50		0.19 U	0.48 I	0.29 U	1.2
	51 to 55		0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT0558	26 to 30	06/16/2014	0.19 U	0.22 U	1.4	0.26 U
	31 to 35		0.19 U	0.22 U	0.98 I	0.26 U
	36 to 40		0.19 U	2.4	0.84 I	**2.6**
	41 to 45		0.19 U	25.2	1.3	**9.1**
	46 to 50		0.31 I	0.32 I	0.29 U	0.27 I
	51 to 55		0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U

Table 2-1. Mobile Laboratory DPT Groundwater Sampling Results: CVOCs
Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Location	Sample Interval (ft BLS)	Sample Date	Concentration (µg/L)			
			Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
	FDEP GCTL		**3**	**70**	**100**	**1**
	FDEP NADC		**300**	**700**	**1,000**	**100**
DPT0559	26 to 30	06/17/2014	0.19 U	11.7	0.60 I	0.26 U
	31 to 35		0.19 U	**230**	13.9	**180**
	36 to 40		1.9 U	**450**	15.0	**250**
	41 to 45		1.9 U	**280**	6.9 I	**200**
	46 to 50		0.19 U	0.22 U	0.29 U	0.45 I
	51 to 55		0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT0560	26 to 30	06/17/2014	0.19 U	0.70 I	0.29 U	**3.6**
	31 to 35		0.19 U	0.22 I	1.1	1.1
	36 to 40		0.19 U	0.22 I	2.2	**1.7**
	41 to 45		0.19 U	2.3	3.4	**13.6**
	46 to 50		0.19 U	31.2	3.8	**62.1**
	51 to 55		0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT0561	26 to 30	06/17/2014	0.19 U	0.46 I	0.59 I	0.26 U
	31 to 35		0.19 U	0.29 I	0.56 I	0.26 U
	36 to 40		0.19 U	0.22 U	0.29 U	0.26 U
	41 to 45		0.19 U	24.6	4.6	**46.6**
	46 to 50		0.19 U	19.4	16.4	**48.7**
	51 to 55		1.9 U	**390**	23.0	**690**
	56 to 60		0.19 U	1.2	0.29 U	**1.7**
DPT0562	26 to 30	06/18/2014	0.19 U	1.9	0.29 U	0.26 U
	31 to 35		0.19 U	1.2	0.29 U	0.26 U
	36 to 40		0.19 U	0.26 I	0.29 U	0.26 U
	41 to 45		0.19 U	4.8	0.56 I	**3.2**
	46 to 50		0.19 U	68.6	3.4	**120**
	51 to 55		0.19 U	0.35 I	0.29 U	0.36 I
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT0563	26 to 30	06/19/2014	0.19 U	0.22 U	0.57 I	0.26 U
	31 to 35		0.19 U	0.22 U	1.5	0.26 U
	36 to 40		0.19 U	0.22 U	1.4	0.26 U
	41 to 45		0.19 U	8.9	0.29 U	0.26 U
	46 to 50		0.19 U	29.8	1.0	**9.8**
	51 to 55		0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT0564	26 to 30	06/19/2014	0.19 U	0.22 U	0.29 U	0.26 U
	31 to 35		0.19 U	0.27 I	0.29 U	0.26 U
	36 to 40		0.19 U	3.0	0.66 I	0.26 U
	41 to 45		0.19 U	1.7	0.82 I	0.26 U
	46 to 50		0.19 U	0.22 U	0.29 U	0.26 U
	51 to 55		0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT0565	26 to 30	06/20/2014	0.19 U	0.22 U	0.29 U	0.26 U
	31 to 35		0.19 U	0.22 U	0.29 U	0.26 U
	36 to 40		0.19 U	0.46 I	0.86 I	**2.7**
	41 to 45		0.19 U	1.1	0.52 I	0.26 U
	46 to 50		0.19 U	2.3	0.57 I	0.26 U
	51 to 55		0.19 U	0.22 U	0.29 U	0.45 I
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT0566	26 to 30	06/20/2014	0.19 U	0.22 U	0.29 U	0.26 U
	31 to 35		0.19 U	0.22 U	0.29 U	0.65 I
	36 to 40		0.19 U	0.22 U	0.30 I	0.48 I
	41 to 45		0.19 U	0.22 U	4.7	0.26 U
	46 to 50		0.19 U	13.8	13.6	**63.0**
	51 to 55		0.19 U	3.6	0.29 U	**64.9**
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT0567	26 to 30	06/20/2014	0.19 U	0.66 I	0.29 U	**2.4**
	31 to 35		0.19 U	0.22 U	0.29 U	0.59 I
	36 to 40		0.19 U	0.22 U	0.85 I	0.26 U
	41 to 45		0.19 U	0.22 U	1.2	0.76 I
	46 to 50		0.19 U	26.5	5.3	**65.5**
	51 to 55		0.19 U	0.22 U	0.29 U	0.26 U
	56 to 60		0.19 U	0.22 U	0.29 U	0.26 U
DPT1207	6 to 10	01/07/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16	01/08/2013	1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	**2.7**
	36 to 40		1.0 U	1.5	1.0 U	**10.0**
	41 to 45		1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT1209	6 to 10	01/08/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16		1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35		1.0 U	1.0 U	1.0 U	1.0
	36 to 40		1.0 U	2.2	1.0 U	**15.5**
	41 to 45		1.0 U	1.0 U	1.0 U	**5.7**
	46 to 50		1.0 U	1.0 U	1.0 U	1.1
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U

Table 2-1. Mobile Laboratory DPT Groundwater Sampling Results: CVOCs
Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Location	Sample Interval (ft BLS)	Sample Date	Concentration (µg/L)			
			Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
	FDEP GCTL		**3**	**70**	**100**	**1**
	FDEP NADC		**300**	**700**	**1,000**	**100**
DPT1211	6 to 10	01/08/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16		1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	1.8	1.0 U	**8.6**
	31 to 35		1.0 U	3.4	1.0 U	**28.5**
	36 to 40		1.0 U	2.8	1.0 U	**19.3**
	41 to 45		1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55	01/09/2013	1.0 U	1.0 U	1.0 U	1.0 U
DPT1212	6 to 10	01/08/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16		1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	1.0 U	1.0 U	1.4
	31 to 35		1.0 U	1.0 U	1.0 U	**7.8**
	36 to 40		1.3	45.1	3.2	**160**
	41 to 45		1.0 U	14.0	1.0 U	**44.3**
	46 to 50	01/09/2013	1.0 U	1.5	1.0 U	**6.0**
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT1213	6 to 10	01/09/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16		1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	1.8	1.0 U	**11.7**
	31 to 35		1.0 U	2.1	1.0 U	**23.0**
	36 to 40		1.0 U	4.8	1.0 U	**39.0**
	41 to 45		1.0 U	1.0 U	1.0 U	**4.8**
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT1214	6 to 10	01/09/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16		1.2	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	1.0 U	1.0 U	**19.5**
	31 to 35		1.0 U	1.3	1.0 U	**94.9**
	36 to 40		1.0 U	18.1	1.1	**150**
	41 to 45		1.0 U	3.8	1.0 U	**19.5**
	46 to 50		1.0 U	1.0 U	1.0 U	**4.3**
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT1216	6 to 10	01/09/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16		1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	1.0 U	1.0 U	**7.1**
	31 to 35		1.0 U	20.9	1.6	**150**
	36 to 40		1.0 U	8.5	1.0 U	**46.6**
	41 to 45		2.8	1.7	1.0 U	**9.0**
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT1454	6 to 10	03/11/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16		1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	2.3	1.0 U	**7.0**
	31 to 35		1.0 U	2.8	1.0 U	**12.4**
	36 to 40		1.0 U	1.6	1.0 U	**9.9**
	41 to 45		1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U
DPT1456	6 to 10	03/11/2013	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16		1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22		1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30		1.0 U	1.0 U	1.0 U	**6.1**
	31 to 35		1.0 U	1.5	1.0 U	**9.8**
	36 to 40		1.0 U	1.0 U	1.0 U	**5.0**
	41 to 45		1.0 U	1.0 U	1.0 U	1.2
	46 to 50		1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55		1.0 U	1.0 U	1.0 U	1.0 U

Notes:

1. ft BLS indicates feet below land surface.
2. µg/L indicates micrograms per liter.
3. FDEP indicates Florida Department of Environmental Protection.
4. GCTL indicates Groundwater Cleanup Target Level.
5. NADC indicates Natural Attenuation Default Concentration.
6. U indicates not detected above the method detection limit.
7. I indicates concentration is between the method detection limit and the practical quantification limit.
8. Bold values represent exceedances of GCTL.
9. Bold and highlighted values represent exceedances of NADC.

Table 2-2 . Monitoring Well Sampling Results: CVOCs
Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Location	Sample Date	Screen Interval (ft BLS)	Concentration (µg/L)			
			TCE	cDCE	tDCE	VC
		FDEP GCTL	**3**	**70**	**100**	**1**
		FDEP NADC	**300**	**700**	**1000**	**100**
ASMW0004	01/28/2005	35 to 40	5 U	11	5.0 U	26
	06/14/2005		5 U	23	5.0 U	16
	08/08/2005		5 U	15	5.0 U	4.8 J
	09/14/2005		5 U	7.2	5.0 U	1.3 J
	12/20/2005		5 U	3.1 J	5.0 U	10 U
	03/29/2006		5 U	4.4 J	5.0 U	10 U
	06/20/2006		0.30 U	0.9 I	0.80	0.50 U
	09/27/2006		0.71 U	1.7	0.83 U	0.52 U
	12/13/2006		0.30 U	4.2	0.20 U	1.4
	05/28/2007		0.50 U	12.2	0.50 U	0.50 U
	09/06/2007		0.38 U	2.4	0.20 U	0.34 U
	12/31/2007		0.38 U	7.7	0.20 U	0.39
	03/31/2008		0.38 U	8.0	0.20 U	0.65
	06/27/2008		0.32 U	7.5	0.45 U	0.30 U
	09/22/2008		0.32 U	48.5	1.6	41.8
	12/18/2008		0.32 U	48.4	0.73	8.4
	03/05/2009		0.32 U	37.7	0.57	1.8
	09/22/2009		0.32 U	9.9	0.45 U	0.30 U
	03/24/2010		0.24 U	1.0	0.34 U	0.28 U
	10/01/2010		0.24 U	5.0	0.34 U	0.28 U
	03/15/2011		0.26 U	0.45 I	0.35 U	0.22 U
	09/26/2011		0.26 U	5.9	0.35 U	0.22 U
	03/16/2012		0.26 U	40.8	0.35 U	0.22 U
	08/28/2012		0.26 U	18.8	0.35 U	0.22 U
	03/18/2013		0.31 U	**87.3**	0.79 I	0.44 U
	10/25/2013		0.31 U	**119**	1.8	0.90 I
	01/27/2014		0.30 U	**73.7**	1.5	1.2
	04/17/2014		0.30 U	45.0	0.54 I	**5.1**
	07/22/2014		0.50 U	1.3	0.44 U	0.50 U
	10/27/2014		0.50 U	62.0	0.48 I	0.50 U
	01/19/2015		0.48 U	26.0	0.37 U	0.78 I
	04/06/2015		0.61 U	12.0	0.67 U	0.71 U
	07/14/2015		0.61 U	12.0	0.67 U	0.71 U
ASMW0005	01/28/2005	35 to 40	5 U	33	5.0 U	160
	06/14/2005		5 U	38	5.0 U	83
	08/08/2005		5 U	29	5.0 U	92
	09/14/2005		5 U	6.2	5.0 U	14
	12/20/2005		5 U	5 U	5.0 U	10 U
	03/29/2006		5 U	5 U	5.0 U	10 U
	06/20/2006		0.30 U	1.0	0.80	0.50 U
	09/27/2006		0.71 U	1.0	0.83 U	0.52 U
	12/13/2006		0.30 U	0.7 I	0.20 U	1.2
	05/28/2007		0.50 U	0.50 U	0.50 U	0.50 U
	09/06/2007		0.38 U	0.35 I	0.20 U	0.34 U
	12/31/2007		0.38 U	0.28 U	0.20 U	0.34 U
	03/31/2008		0.38 U	0.28	0.20 U	0.34 U
	06/27/2008		0.32 U	0.32	0.45 U	0.30 U
	09/22/2008		0.32 U	1.6	0.45 U	0.30 U
	12/18/2008		0.32 U	0.69	0.45 U	0.44
	03/05/2009		0.32 U	0.20 U	0.45 U	0.30 U
	09/22/2009		0.32 U	1.4	0.45 U	0.30 U
	03/24/2010		0.24 U	0.48 I	0.34 U	0.28 U
	10/01/2010		0.24 U	5.6	0.34 U	0.28 U
	03/15/2011		0.26 U	0.67 I	0.35 U	0.22 U
	09/23/2011		0.26 U	1.6	0.35 U	0.22 U
	03/16/2012		0.26 U	5.3	0.35 U	0.22 U
	08/28/2012		0.26 U	2.4	0.35 U	0.22 U
	03/18/2013		0.31 U	7.3	0.23 U	0.44 U
	10/25/2013		0.31 U	81.3	2.7	50.4
	01/27/2014		0.30 U	52.1	1.6	27.5
	04/17/2014		0.30 U	62.3	1.5	44.2
	07/22/2014		0.50 U	25.0	0.68 I	21.0
	10/27/2014		0.50 U	14	0.44 U	0.50 U
	01/19/2015		0.48 U	26.0	0.60 I	0.50 U
	04/06/2015		0.61 U	99.0	1.1	0.71 U
	07/14/2015		0.61 U	50.0	0.95 I	0.71 U
ASMW0006	01/28/2005	35 to 40	5 U	33	3.3 J	340
	06/14/2005		5 U	130	4.0 JB	560
	08/08/2005		5 U	150	3.8 J	730
	09/16/2005		5 U	150	4.4 J	700
	12/20/2005		5 U	5.0	5 U	20
	03/29/2006		5 U	5 U	5 U	2.8 J
	06/20/2006		0.30 U	0.30 U	0.80 U	0.50 U
	09/27/2006		0.71 U	1.3	0.83 U	0.52 U
	12/13/2006		0.30 U	0.4 I	0.20 U	2.3
	05/28/2007		0.50 U	0.50 U	0.50 U	0.50 U
	09/06/2007		0.38 U	3.5	0.20 U	1.1
	12/31/2007		0.38 U	1.3	0.20 U	1.0

Table 2-2 . Monitoring Well Sampling Results: CVOCs
Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Location	Sample Date	Screen Interval (ft BLS)	Concentration (µg/L)			
			TCE	cDCE	tDCE	VC
		FDEP GCTL	**3**	**70**	**100**	**1**
		FDEP NADC	**300**	**700**	**1000**	**100**
ASMW0006	03/31/2008	35 to 40	0.38 U	1.0	0.20 U	0.82
	06/27/2008		0.32 U	8.8	0.45 U	3.4
	09/22/2008		0.32 U	35.1	0.64	5.2
	12/18/2008		0.32 U	37.6	0.67	8.2
	03/05/2009		0.32 U	18.1	0.56	13.6
	09/22/2009		0.32 U	10.7	0.45 U	3.4
	03/24/2010		0.24 U	33.0	0.50 I	1.5
	10/01/2010		0.24 U	12.3	0.34 U	1.1
	03/15/2011		0.26 U	15.3	0.37 I	2.0
	09/23/2011		0.26 U	2.7	0.35 U	0.22 U
	03/16/2012		0.26 U	24.2	0.52	2.1
	08/24/2012		0.26 U	113	4.4	1.5
	03/18/2013		0.63 U	137	8.6	9.9
	10/25/2013		0.63 U	490	22.3	833
	01/27/2014		3.0 U	493	18.9	902
	04/17/2014		3.0 U	569	25.2	1,350
	06/20/2014		1.9 U	380	18.0	820
	07/22/2014		1.0 U	290	10.0	690
	10/27/2014		0.50 U	1.1	0.44 U	2.1
	01/19/2015		0.48 U	0.85 I	0.37 U	2.2
	04/06/2015		0.61 U	0.67 I	0.67 U	4.7
	07/14/2015		0.61 U	4.3	0.67 U	1.3
IW0031	09/27/2011	25 to 35	0.26 U	1.8	0.70 I	115
	03/16/2012		0.26 U	2.0	0.64	99.2
	08/24/2012		0.26 U	2.2	0.77 I	152
	03/18/2013		0.31 U	1.5	0.51 I	86.5
	10/25/2013		0.31 U	1.4	0.50 I	71.0
	04/17/2014		0.30 U	1.5	0.66 I	79.5
	10/27/2014		0.50 U	1.4	0.59 I	83.0
	01/20/2015		0.48 U	1.4	0.49 I	46.0
	07/14/2015		0.61 U	1.3	0.67 U	51.0
IW0057	12/04/2014	40 to 50	0.61 U	160	16.0	290
	01/19/2015		2.4 U	360	12.0	800
	07/14/2015		1.2 U	300	14.0	1,100
IW0058	12/04/2014	45 to 50	1.2 U	420	25.0	450
	01/19/2015		2.4 U	440	20.0	420
	07/17/2015		6.1 U	880	52.0	940
IW0059	12/04/2014	45 to 50	2.4 U	560	17.0	1,100
	01/19/2015		0.48 U	51.0	5.4	92.0
	07/14/2015		0.61 U	510	35.0	770
IW0060	12/04/2014	40 to 50	0.61 U	40.0	3.1	91.0
	01/19/2015		0.48 U	2.3	0.41 I	0.50 U
	04/06/2015		0.61 U	1.4	0.67 U	0.71 U
	07/14/2015		0.61 U	1.2	0.67 U	0.79 I

<u>Notes</u>:

1. Geosyntec began sampling May 2007.
2. µg/L indicates micrograms per liter.
3. ft BLS indicates feet below land surface.
4. U indicates not detected.
5. I indicates result greater than or equal to method detection limit but less than the reporting limit.
6. J indicates estimated value.
7. B indicates that the analyte was found in the associated blank as well as the sample.
8. FDEP indicates Florida Department of Environmental Protection.
9. GCTL indicates Groundwater Cleanup Target Levels.
10. NADC indicates Natural Attenuation Default Concentration.
11. Bold text indicates analyte detected above GCTL.
12. Bold and highlighted text indicates analyte detected above NADC.
13. CVOCs indicates chlorinated volatile organic compounds.
14. TCE indicates trichloroethene.
15. cDCE indicates *cis*- 1,2-dichloroethene.
16. tDCE indicates *trans*-1,2-dichloroethene.
17. VC indicates vinyl chloride.

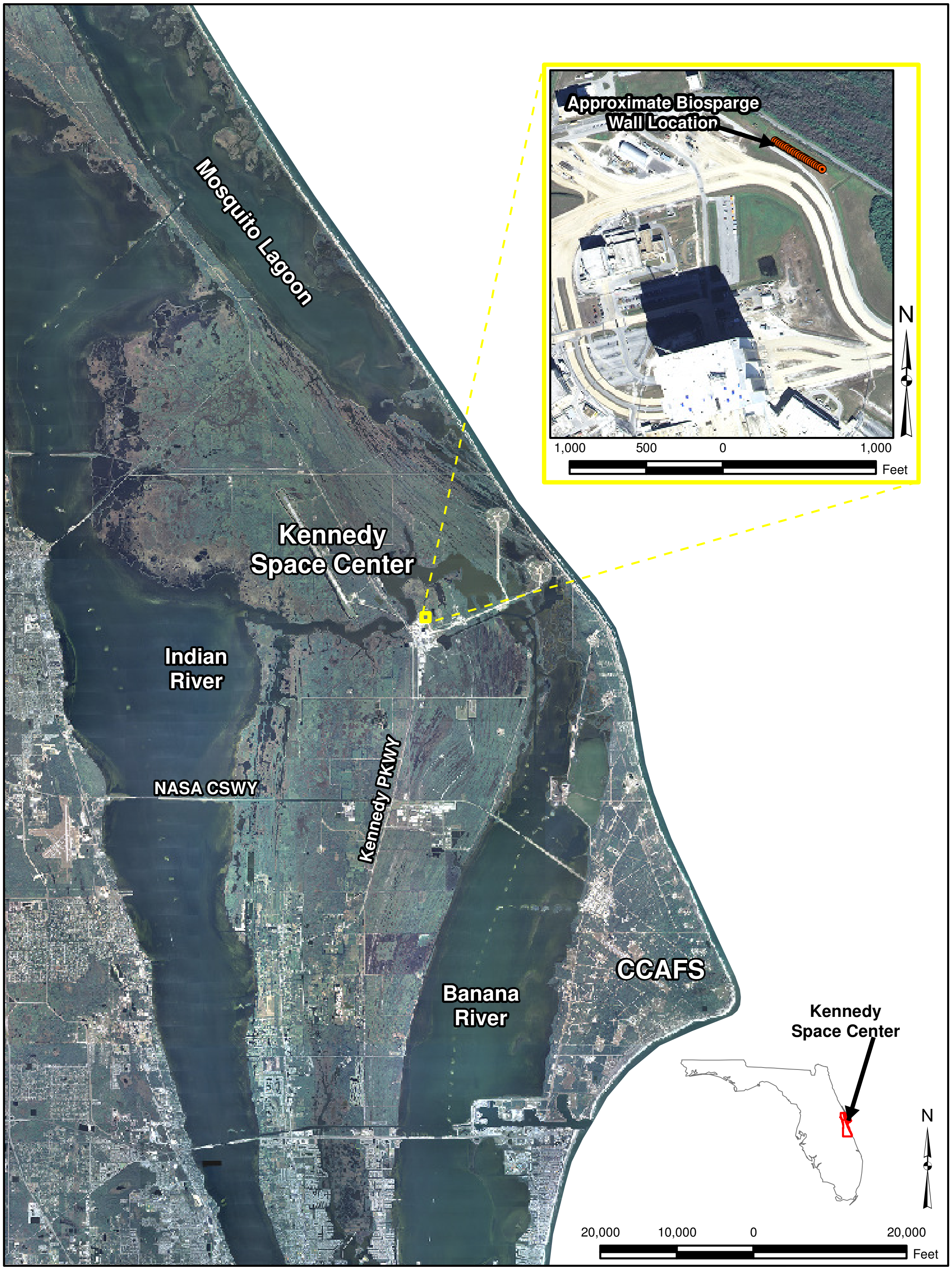
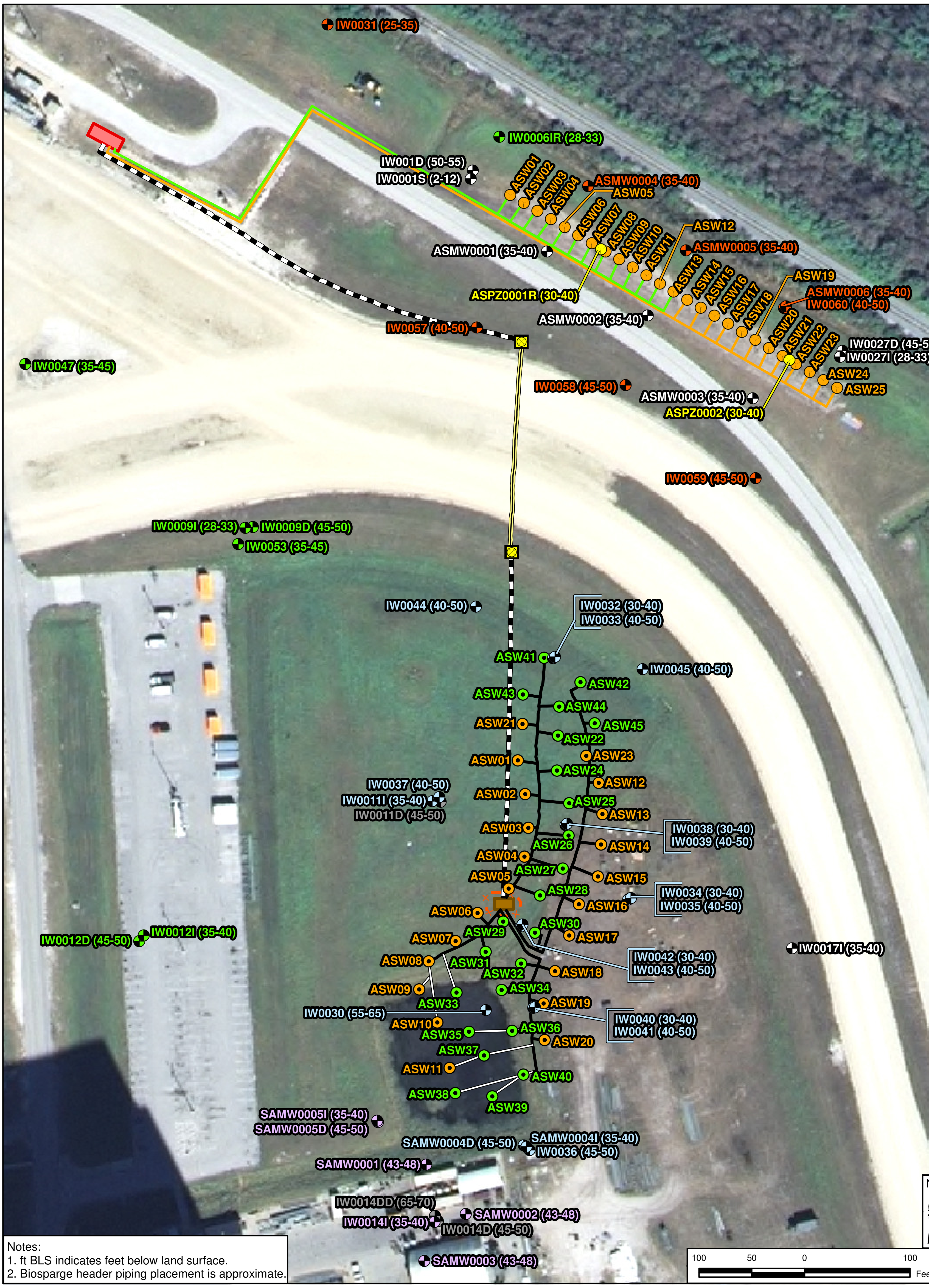


Figure 2-1
Site Location Map

Path: (Titusville-01\DATA) T:\0GIS\FR0579\MXDs\BSE_IMWP_NOV2015\Figure1.mxd 02 November 2015 JRB

USGS 7.5 Minute Orsino Quadrangle [USGS 1976]

Figure 2-2
USGS Topographic Quadrangle Map



Notes:
1. ft BLS indicates feet below land surface.
2. Biosparge header piping placement is approximate.

Figure 2-3
MLPV Site Layout

Legend

- Air Sparge Monitoring Well Location (screen interval (ft BLS))
- Biosparge Monitoring Well Location (screen interval (ft BLS))
- Former Source Area Interim Groundwater Monitoring Location (screen interval (ft BLS))
- Long Term Monitoring Program Monitoring Well Location (screen interval (ft BLS))
- Air Sparge Piezometer Location (screen interval (ft BLS))
- Biosparge Well Location
- Abandoned Montoring Well Location (screen interval (ft BLS))
- Other Monitoring Well Location (screen interval (ft BLS))
- Air Sparge Well Locations, Leg 3
- Air Sparge Well Locations, Leg 4
- Junction Box
- 1" SCH 80 PVC from Manifold to Well
- 1" Flexhose
- 4" High-Density Polyethylene (HDPE) Pipe under Crawler Track
- 4" SCH 80 PVC from Equipment Shed to Manifold
- Biosparge Header Pipe - Leg 1
- Biosparge Header Pipe - Leg 2
- Temporary Construction Fencing
- Manifold
- Equipment Building

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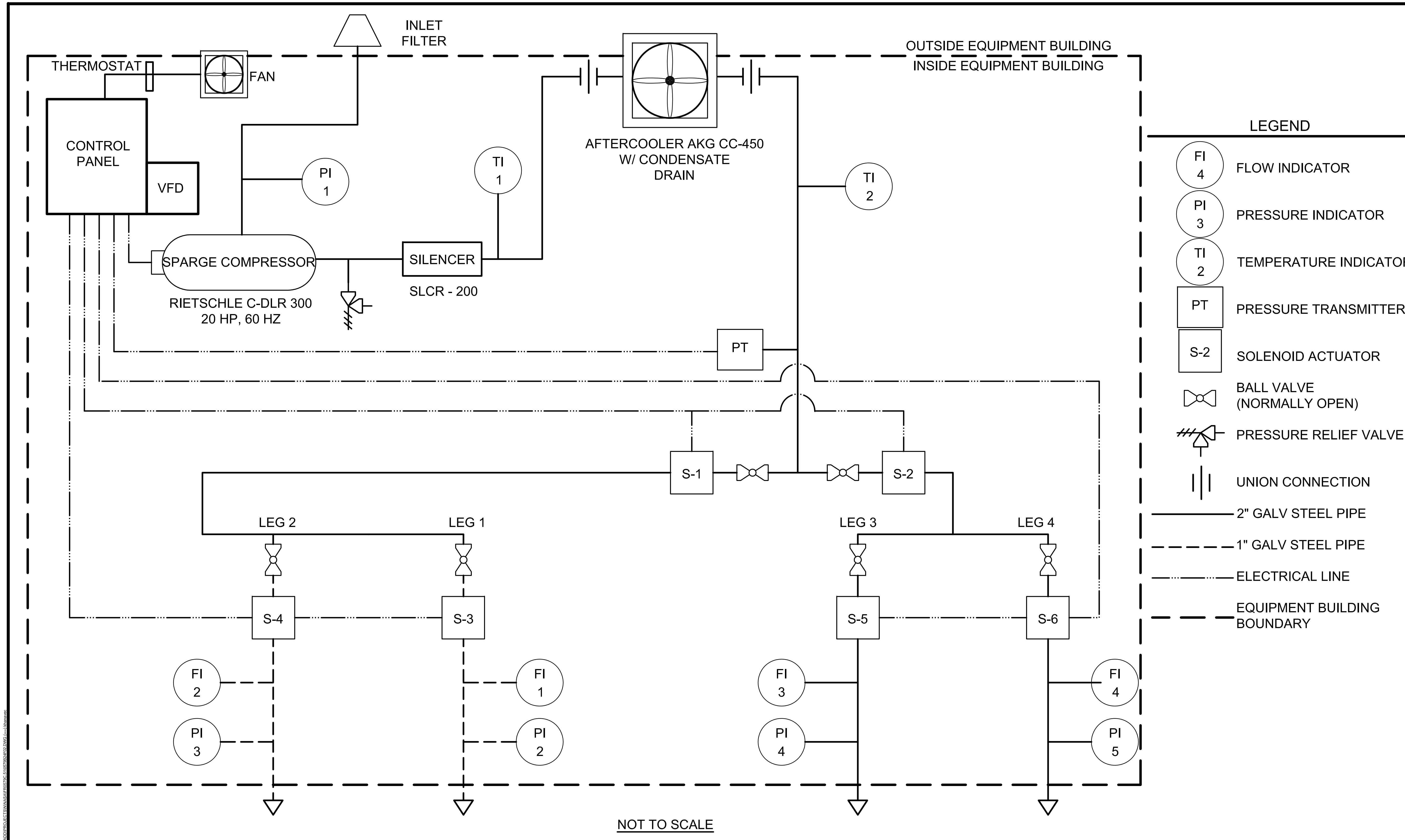
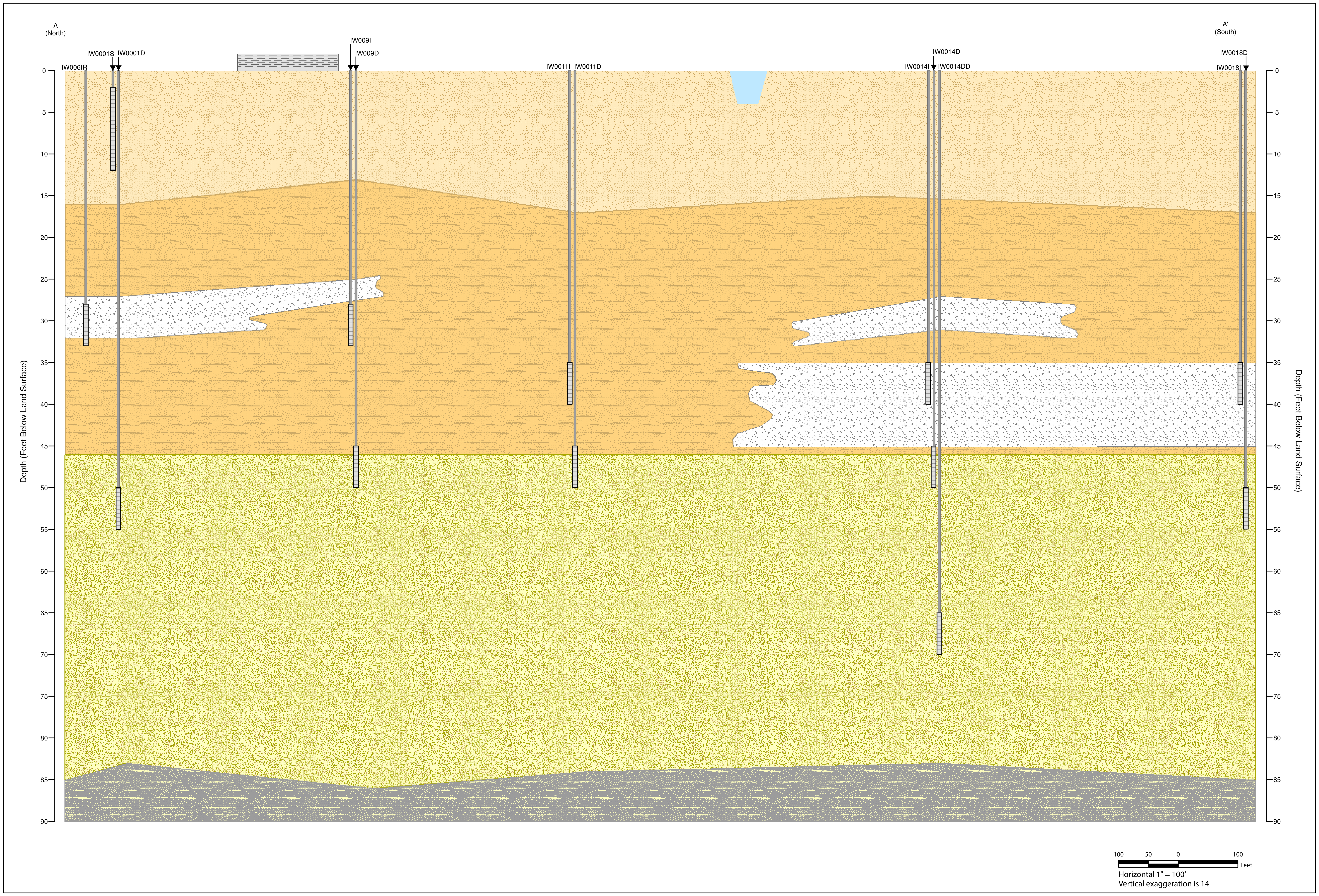


Figure 2-4
Existing Sparge System
Process and Instrumentation
Diagram



Legend

- Fine SAND with silt
- Fragmented SHELLS wtih sand
- Fine SAND with shell fragments
- SAND with varing % of shells, silt, and clay
- CLAY with interbedded thin sand lenses
- Retention Pond (approximate location)
- Crawlerway (approximate location)

Monitoring Well

Screen

Notes:
1. Generalized lithology developed during RFI (rev 1) {NASA 2003}.
2. All locations have prefix the "MLPV-".

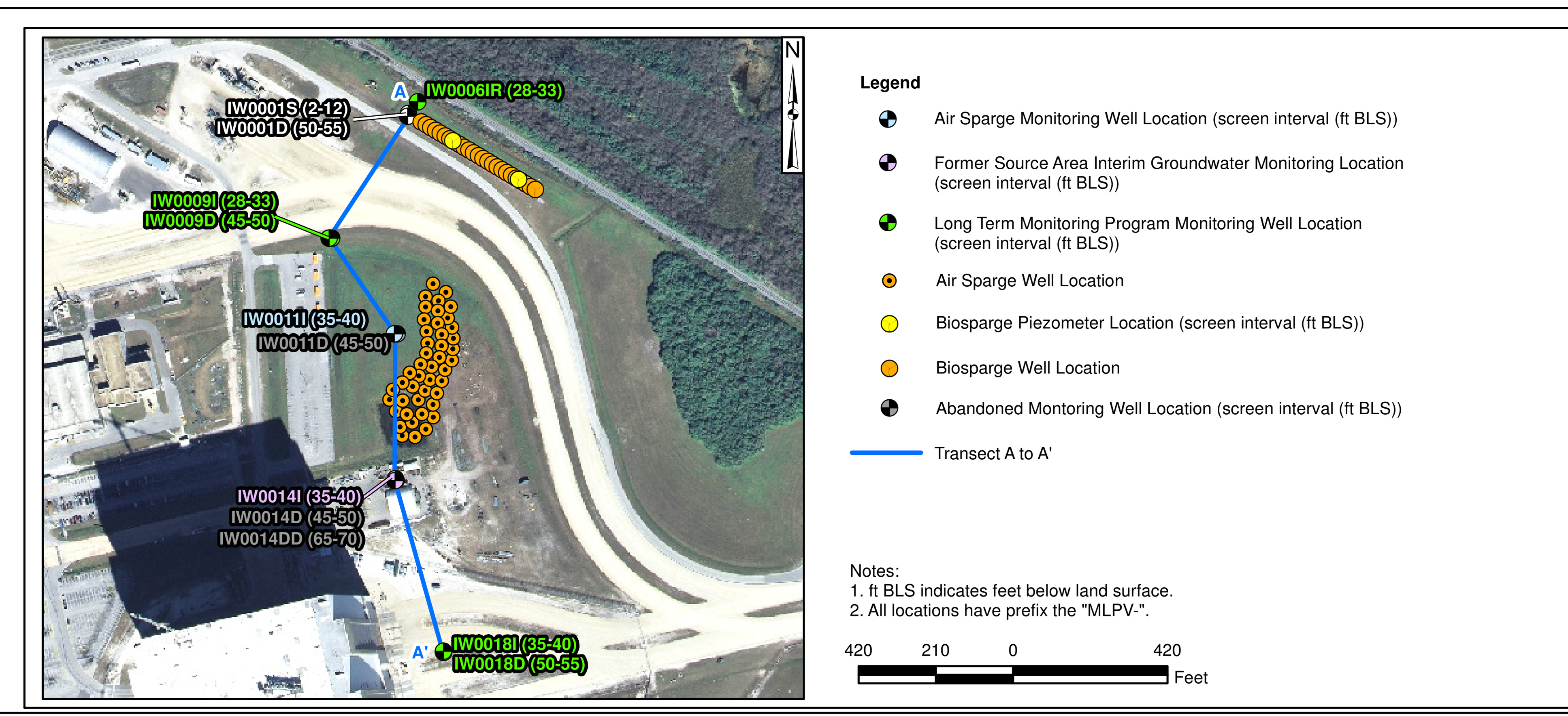


Figure 2-5
Lithologic Cross Section

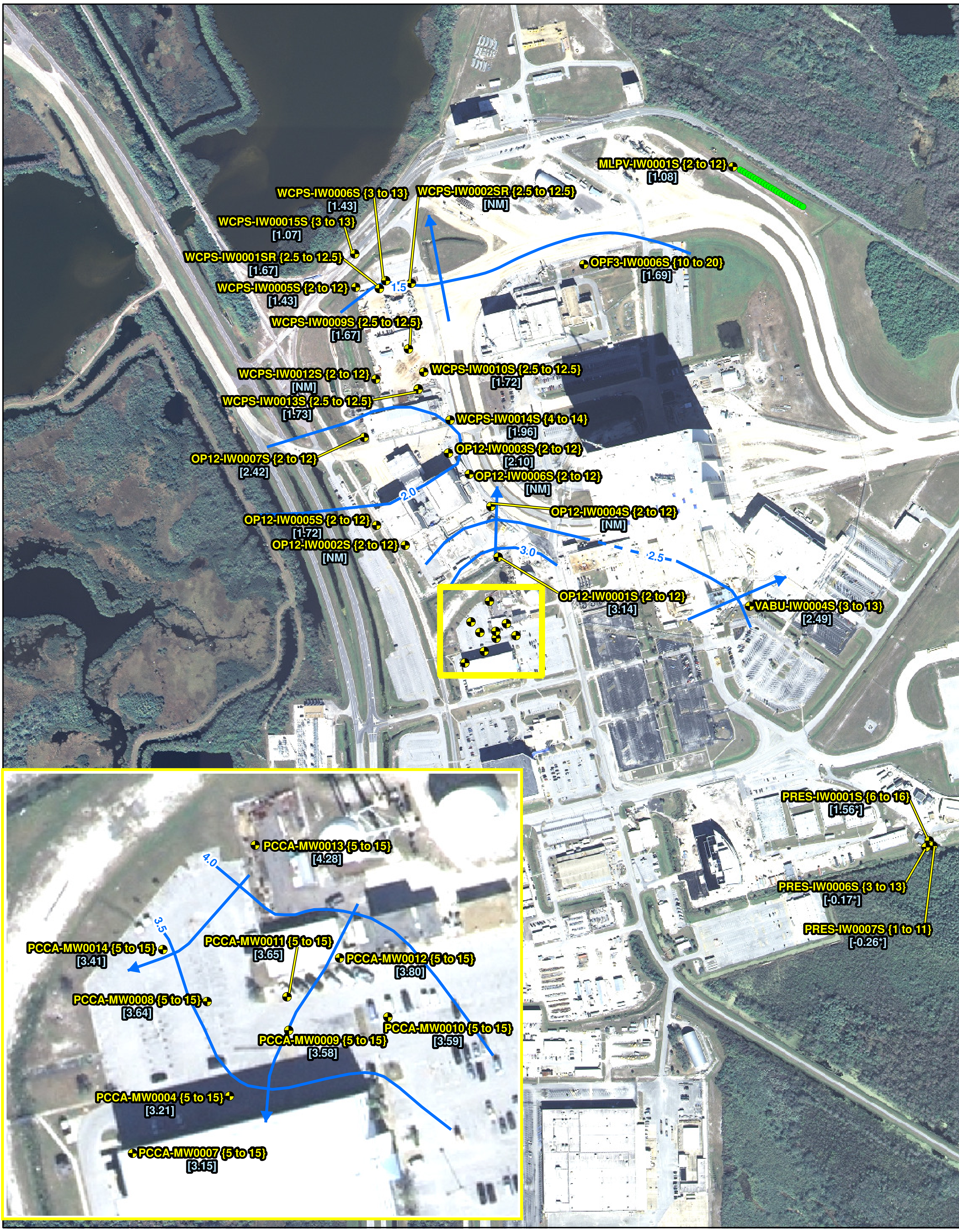


Figure 2-6
VAB Area Shallow Zone Potentiometric Surface Map – November 2014

Legend

- Shallow Monitoring Well Location {screen interval} and [groundwater elevation]
- Biosparge Well Location
- Inferred Equipotential Line
- Equipotential Line
- Generalized Groundwater Flow Direction

Notes:
1. Screen interval is presented in feet, below land surface (ft, BLS).
2. Groundwater elevation is presented in ft, NAVD88.
3. * indicates elevation was not used for contouring.
4. NM indicates not measured.

N

500 250 0 500
Feet

Path: (Titusville-01\Data\)T:\0GIS\FR0579\MXDs\BSE_IMWP_NOV2015\MLPV_gw_elev_shallow_NOV2014.mxd 03 November 2015 JRB

Figure 2-7
VAB Area Intermediate Zone Potentiometric Surface Map - November 2014

Legend

Intermediate Monitoring Well Location {screen interval} and [groundwater elevation]

Biosparge Well Location

Inferred Equipotential Line

Equipotential Line

Generalized Groundwater Flow Direction

N

500 250 0 500
Feet

Notes:
1. Screen interval is presented in feet, below land surface (ft, BLS).
2. Groundwater elevation is presented in ft, NAVD88.
3. NM indicates not measured.

Path: (Titusville-01\Data\)T:\0GIS\FR0579\MXDs\BSE_IMWP_NOV2015\MLPV_gw_elev_int_ NOV2014.mxd 03 November 2015 JRB

Figure 2-8
VAB Area Deep Zone Potentiometric Surface Map - November 2014

Legend

- Deep Monitoring Well Location {screen interval} and [groundwater elevation]
- Biosparge Well Location
- Inferred Equipotential Line
- Equipotential Line
- Generalized Groundwater Flow Direction

N

500 250 0 500 Feet

Notes:
1. Screen interval is presented in feet, below land surface (ft, BLS).
2. Groundwater elevation is presented in ft, NAVD88.

Path: (Titusville-01\Data\)T:\0GIS\FR0579\MXDs\BSE_IMWP_NOV2015\MLPV_gw_elev_deep_NOV2014.mxd 03 November 2015 JRB

80 40 0 80
Feet

N

Legend

- VABRA DPT Sampling Location (Highest VC Concentration)
- DPT Sampling Location (Highest VC Concentration)
- Monitoring Well Location (screen interval (ft BLS)) [Most Recent VC Concentration - July 2015]

Symbology Color Coding

- VC Concentration Less than 1 µg/L
- VC Concentration Greater than 1 µg/L
- VC Concentration Greater than 100 µg/L
- VC Concentration Greater than 1,000 µg/L
- Monitoring Well Location (screen interval (ft BLS)) Not Part of Sampling Program
- Piezometer Location
- Biosparge Well Location
- 100 µg/L VC Isopleth
- 1,000 µg/L VC Isopleth

Screening Criteria			
Parameter	Abbreviation	GCTL	NADC
Vinyl Chloride	VC	1	100

Notes:
1. Results are presented in micrograms per liter (µg/L).
2. ft BLS indicates feet below land surface.
3. I indicates result is between the method detection limit and the practical quantitation limit.
4. U indicates parameter not detected above method detection limit.
5. GCTL indicates Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Level.
6. NADC indicates FDEP Natural Attenuation Default Concentration.
7. * indicates value not used to generate contour.
8. Locations associated with VABRA have the prefix "VABRA-".
9. All other locations have prefix the "MLPV-".

Path: (Titusville-01\DATA) T:\0GIS\FR0579\MXDs\BSE_IMWP_NOV2015\VC_NADC_Plume_Rev1.mxd 04 November 2015 JRB

Figure 2-9
Vinyl Chloride Concentration - 31 to 50 ft BLS

SECTION III

INTERIM MEASURES DESIGN

3.1 OVERVIEW

This section provides information on the design of the biosparge barrier expansion, which includes the biosparge wells and system piping. The biosparge barrier expansion is designed to treat the area where VC concentrations exceed 100 μg/L that is located northwest of the existing biosparge barrier, and relies on the installation of six biosparge wells that will deliver air to the subsurface and provide *in situ* treatment of CVOCs via volatilization and increased aerobic degradation of VC by microorganisms. The number of biosparge wells is based on the width of the 100 μg/L VC plume and a conservative radius of influence (ROI) of 20 feet. The conservative ROI was based upon observations made at the existing biosparge barrier and the air sparge system in the MLPV area.

All calculations for the expansion of the biosparge barrier are based upon the use of the existing MLPV sparge system that provides air to the existing biosparge barrier and air sparge system. A brief description of the equipment is provided in Section 2.3.

The performance of the biosparge barrier expansion will be evaluated using performance monitoring of CVOC concentrations downgradient of the barrier and by documenting system operational parameters. The performance monitoring and O&M requirements are detailed in Section IV.

3.2 BIOSPARGE WELL PLACEMENT

The location of the proposed biosparge wells was based on the design objective of effectively treating the area with VC concentrations greater than 100 μg/L that is northwest of the existing biosparge barrier (Figure 3-1). The layout of the biosparge wells was selected using a 20-foot ROI and a 30-foot spacing. An additional proposed biosparge well is located outside of the 100 μg/L VC plume boundary to increase the treatment area towards the existing biosparge barrier. The location of this biosparge well was to mitigate the potential for VC impacted groundwater to migrate between the biosparge walls (existing biosparge well ROI of greater than 25 feet). The six biosparge wells will have individual piping runs, and the piping from each well will run to a manifold.

3.3 BIOSPARGE WELL DESIGN

3.3.1 WELL LOCATION AND CLEARANCE. Biosparge wells will be installed at the locations presented on Figure 3-1. Each drilling location must be cleared of utilities and approved for drilling prior to initiation of any subsurface activities. All boreholes must be advanced by hand auger from the ground surface to a minimum depth of five feet for the full diameter of the drilling equipment. Due care should be used to avoid utilities and structures with drilling equipment.

3.3.2 BOREHOLE DIAMETER. The borehole diameter for the biosparge wells shall be a minimum of 6 inches and a maximum of 10 inches.

3.3.3 WELL DRILLING AND CONSTRUCTION. Biosparge wells shall be drilled using sonic or hollow-stem auger drilling techniques, with drive casing/augers of an outside diameter and inside diameter sufficient to install the downhole materials. Soil returns (if any) shall be drummed for temporary storage on site. If hollow-stem auger drilling is used, a roll-off should be considered for temporary storage of soil returns due to the increased volume of soil returns as compared to sonic drilling.

Since the vertical extent of the 100 μg/L VC plume in the treatment area is between approximately 30 and 45 ft BLS, the depth of the top of the well screen was positioned to be approximately 3 feet below the vertical extent of the 100 μg/L VC plume (at approximately the same depth of the biosparge wells installed in the existing biosparge barrier) and above the silty/clayey sand identified at approximately 50 ft BLS (Figure 2-5). Proposed biosparge construction details are presented on Figure 3-2. In order to avoid placing the screens within a silty/clayey sand layer that is present at the site around 50 ft BLS, a soil boring will be collected in the installation area prior to the installation of any biosparge wells to evaluate the local lithology.

3.3.4 WELL CASING AND SCREEN. Biosparge well PVC casing and a 24-inch, 40-micron SCHUMASOIL© screen shall be installed through the drive casing or augers. The top of the well screen shall be set at a depth of approximately 48 ft BLS for the biosparge barrier expansion. The depths of the screens may be modified based on results from the soil boring discussed in Section 3.3.3.

The well casing shall be 2-inch diameter Schedule 40 PVC that transitions to 2-inch diameter galvanized at 1 ft BLS. Casing joints shall be flush-joint threaded with a neoprene "O" ring or other means of rendering the joint airtight. If the SCHUMASOIL© screens are not available, 0.020-inch slotted PVC screens will be used in their place. Details of the biosparge well construction are presented on Figure 3-2.

3.3.5 FILTER PACK. During well installation, a filter pack shall be installed in the annular space around the well screen and extend 6 inches above the top of the screen. The filter pack shall be silica sand of ASTM International (ASTM) gradation 20/30.

3.3.6 BENTONITE SEAL. The bentonite seal shall be placed through the annulus between the drive casing/augers and well casing. The drive casing/augers shall be slowly withdrawn as the bentonite seal is installed; the drive casing/auger bit shall not be withdrawn above the top of the bentonite seal during seal placement. The bentonite seal shall be placed over the full borehole diameter to the thickness shown on Figure 3-2. The depth of the top of the bentonite seal shall be confirmed by direct measurement.

The bentonite seal shall be bentonite clay (no additives) in a pressed pellet or chip form. Powdered bentonite shall not be used for the bentonite seal. After placement of the bentonite pellets/chips, a minimum of 15 minutes (or manufacturer's recommended hydration time) shall be provided to allow for bentonite hydration to occur prior to the addition of grout.

3.3.7 GROUT. Grout shall consist of Type I Portland cement as specified in ASTM C-150 and potable water in the approximate proportions of 63 gallons of water to 7, 94-pound bags of cement (the ratio may be varied to yield a workable consistency). The grout shall be placed in the annular space around the well casing, from the top of the bentonite seal to land surface.

3.3.8 CONCRETE. Concrete shall consist of Portland cement, aggregate, and water, and shall have a minimum 28-day compressive strength of 3,000 psi.

3.3.9 SURFACE COMPLETION. The biosparge wells shall be completed with an 18-inch diameter manhole with a 3-ft by 3-ft by 4-ft thick concrete pad. Air sparge well head details are presented on Figure 3-2.

3.3.10 WELL DEVELOPMENT. The biosparge wells shall only be developed to the degree appropriate for their intended purpose. Development shall consist of withdrawing water via a submersible pump. The submersible pump shall be lowered to the total depth of the well, and once at total depth, groundwater extraction will commence until the water is visibly free of particulate matter. A maximum of 20 gallons of water will be removed during the development of each biosparge well.

3.3.11 PERMITS AND WELL COMPLETION FORMS. The biosparge wells shall be installed by a well drilling contractor licensed with the Saint Johns River Water Management District. The licensed well drilling contractor shall obtain permits for the sparge wells from Brevard County prior to installation. The licensed drilling contractor shall complete and submit well completion forms upon completion to Brevard County and provide copies for inclusion with as-built documentation.

3.3.12 BIOSPARGE WELL HEAD PIPING DETAILS. Each biosparge well head will include a sample port to allow for biosparge well clean outs and a check valve to prevent the backflow of groundwater. All above ground components shall be constructed of 1-inch or 2-inch galvanized, or equivalent, and suitable for compressed air situations. PVC piping, valves, and/or ports shall not be used above ground. Air sparge well head details are presented on Figure 3-2.

3.4 BIOSPARGE PIPING DESIGN AND LAYOUT

The proposed biosparge barrier expansion is designed to operate in conjunction with the existing biosparge barrier. Details of the piping design and layout and the operational parameters are discussed below.

3.4.1 PIPE SELECTION AND SIZING. The proposed piping layout is provided on Figure 3-1. The size of the proposed piping shown on Figure 3-1 is based on calculations included in Appendix B. The pipe runs will be constructed from a combination of 1-inch or 2-inch diameter Schedule 80 PVC piping, or equivalent. All above ground piping will be constructed of galvanized piping, or equivalent, and will transition to PVC a minimum of 1 ft BLS.

During construction, each piping section shall be pressurized in 10 psi increments to a final pressure of 60 psi and all joints and fittings shall be tested using a soap solution that will bubble if a leak is detected. Any identified air leaks shall be repaired and the piping section shall be retested to confirm that the leak has been repaired.

3.4.2 PIPING MANIFOLDS. The piping from the sparge system will terminate into a manifold, which will split and direct the air to the biosparge wells (Figure 3-3). The manifold will split the air into six lines (one line per biosparge well). The manifold will contain pressure gauges (Winters, model PEM1405LF, or equivalent) and flow meters (Dwyer, model RMB-50, or equivalent) for each individual biosparge well. The pressure gauge and flow meter will be isolated by three, two way valves ball valves. The valves will allow isolation of the in-line flow meter, so that air only passes through the flow meters when necessary (e.g., collecting a measurement), thus prolonging the life of the equipment. Each manifold will also contain a gate valve which will be used to regulate the flow to each biosparge well. The manifolds will be enclosed in a weather proof National Electrical Manufacturer's Association (NEMA) box (36-inch x 36-inch x 12-inch) and anchored to a 5-ft x 3-ft x 4-inch thick concrete pad.

3.4.3 MULTIPLE ZONE OPERATION. The biosparge barrier expansion piping will be plumbed into the existing sparge system as Leg 5. Currently, the system operates by supplying air in alternating on/off cycles to three zones: (i) Zone 1, consisting of Leg 1 and Leg 2 (existing biosparge barrier legs) operating at the same time; (ii) Zone 2, consisting of Leg 3 (air sparge wells ASW01 through ASW21 and ASW23); and (iii) Zone 3, consisting of Leg 4 (air sparge wells ASW22, and ASW24 through ASW45). After the installation of the biosparge barrier expansion, Leg 5 will be operated at the same time as Leg 1 and Leg 2. It is anticipated that the compressor will provide a flow rate between 3 to 5 standard cubic feet per minute (scfm) against a pressure of approximately 28.7 psi at the most distal location. The head loss calculations are provided in Appendix B and are based upon the proposed maximum flow rates listed above, a pipe degradation factor of 10 percent, and the following conservative assumptions: (i) top of screen depth of 48 ft BLS; (ii) a depth to groundwater of 0 ft BLS; and (iii) that galvanized pipe is used for the sparge system piping.

3.4.4 TRENCHING REQUIREMENTS. The trenching details for the biosparge expansion piping are shown on Figure 3-4. The typical biosparge expansion pipe trenching will be a minimum of 24-inches deep to the top of the biosparge pipe.

3.4.5 DIRECTIONAL DRILLING REQUIREMENTS. A portion of the biosparge pipe will be installed beneath Launcher Road. It will be installed using directional drilling so that it does not impact the roadway. When installed, this portion of the biosparge piping will be installed a minimum of 36-inches deep to the top of the biosparge pipe from the bottom of the basecourse below the asphalt (Figure 3-4). In addition, the 2-inch PVC piping will be installed in a 4-inch carrier pipe underneath the roadway.

3.5 SPARGE SYSTEM

The system utilized to operate the biosparge barrier expansion will be the existing MLPV system. The compressor is capable of producing 190 scfm at a system pressure of 31.9 psi. Details on the existing system are provided in Section 2.3 and additional details are provided in the 2015 CMI and IM Annual Report [NASA 2015c].

3.5.1 SPARGE SYSTEM MODIFICATIONS. System modifications will be necessary in order to operate the biosparge expansion leg in conjunction with the existing biosparge barrier legs. The modifications are presented on the proposed P&ID on Figure 3-5, and include the addition of a new leg (Leg 5; including a new solenoid actuator, flow indicator, and pressure indicator).

3.6 TEMPORARY FENCING REQUIREMENTS

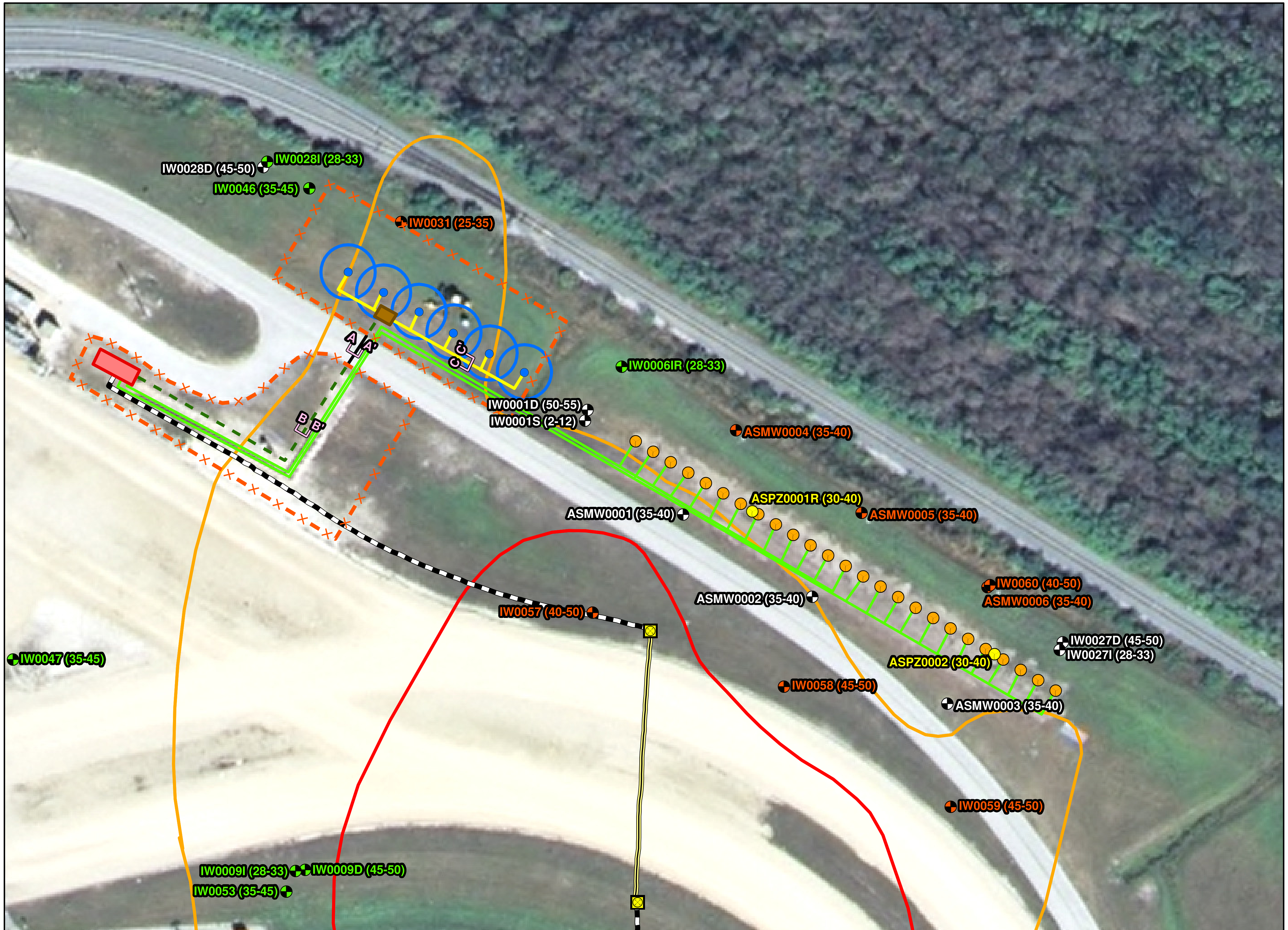
During the implementation of the biosparge barrier expansion, temporary security fencing will be installed around the IM area, maintaining a minimum distance of 50 feet from the IM area where possible. The installed fencing shall have a minimum height of 48-inches. Plastic mesh construction fence may be used as long as it is maintained in good condition, in good appearance, rigid, plumb, and safe throughout the construction period. At each post, the fence must be secured with plastic ties at the top and middle of the fence.

3.7 IMPLEMENTATION TIMELINE

The approximate timeline for primary construction related tasks associated with the biosparge barrier expansion is:

- 15 working days for site preparation, dig permit submittal and approval, and utility locate (site plan is completed for this project);
- 2 working days for monitoring well installation and soil core collection (described in Section IV);
- 25 working days for baseline groundwater sampling, obtaining data from the lab, and analyzing the data;
- 13 working days for biosparge well installation, biosparge piping installation, and system modification; and
- 1 working day for system startup.

After construction is complete, the O&M and performance monitoring will begin as detailed in Section IV.



N

80 40 0 80
Feet

Legend

- Proposed Biosparge Well Location with 20 ft Radius of Influence
- Air Sparge Monitoring Well Location (screen interval (ft BLS))
- Biosparge Monitoring Well Location (screen interval (ft BLS))
- Long Term Monitoring Program Monitoring Well Location (screen interval (ft BLS))
- Other Monitoring Well Location (screen interval (ft BLS))
- Air Sparge Piezometer Location (screen interval (ft BLS))
- Biosparge Well Location
- Junction Box
- 100 µg/L VC Isopleth
- 1,000 µg/L VC Isopleth
- Proposed Biosparge Expansion Piping - 2" Sch. 80 PVC
- Proposed Biosparge Expansion Piping - 2" Sch. 80 PVC under road
- Proposed Biosparge Expansion Piping - 1" Sch. 80 PVC
- Existing Biosparge Header Piping
- 4" High-Density Polyethylene (HDPE) Pipe under Crawler Track
- 4" SCH 80 PVC from Equipment Shed to Air Sparge System Manifold
- Construction Fencing
- Proposed Biosparge Manifold Location (not to scale)
- Equipment Building

Notes:
1. µg/L indicates micrograms per liter.
2. ft BLS indicates feet below land surface.
3. VC indicates vinyl chloride.
4. PVC indicates polyvinyl chloride.
5. A-A' through C-C' details are provided on Figure 3-4.
6. All locations have prefix the "MLPV-".

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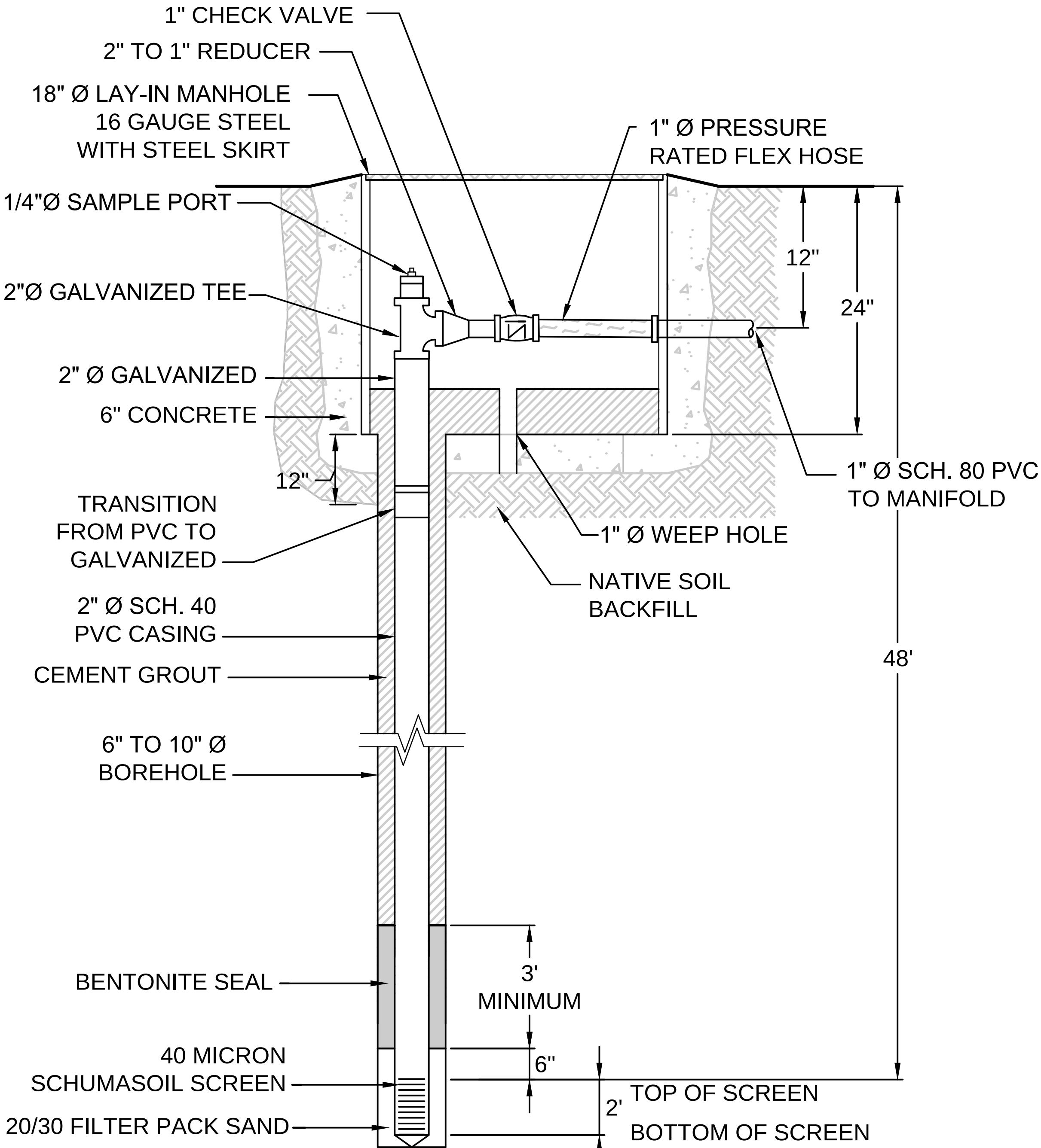
Figure 3-1
Proposed Biosparge Expansion Layout



BIOSPARGE WELLS ASW26 THROUGH ASW31
NOT TO SCALE

NOTES:

1. DEPTH OF SPARGE WELL SCREEN FOR WELLS COMPLETED BELOW GRADE ARE PRESENTED IN FEET BELOW LAND SURFACE (FT BLS).
2. FINAL INSTALLATION DEPTH MAY VARY BASED UPON RESULTS OF A SOIL CORE COLLECTION PRIOR TO INSTALLATION.

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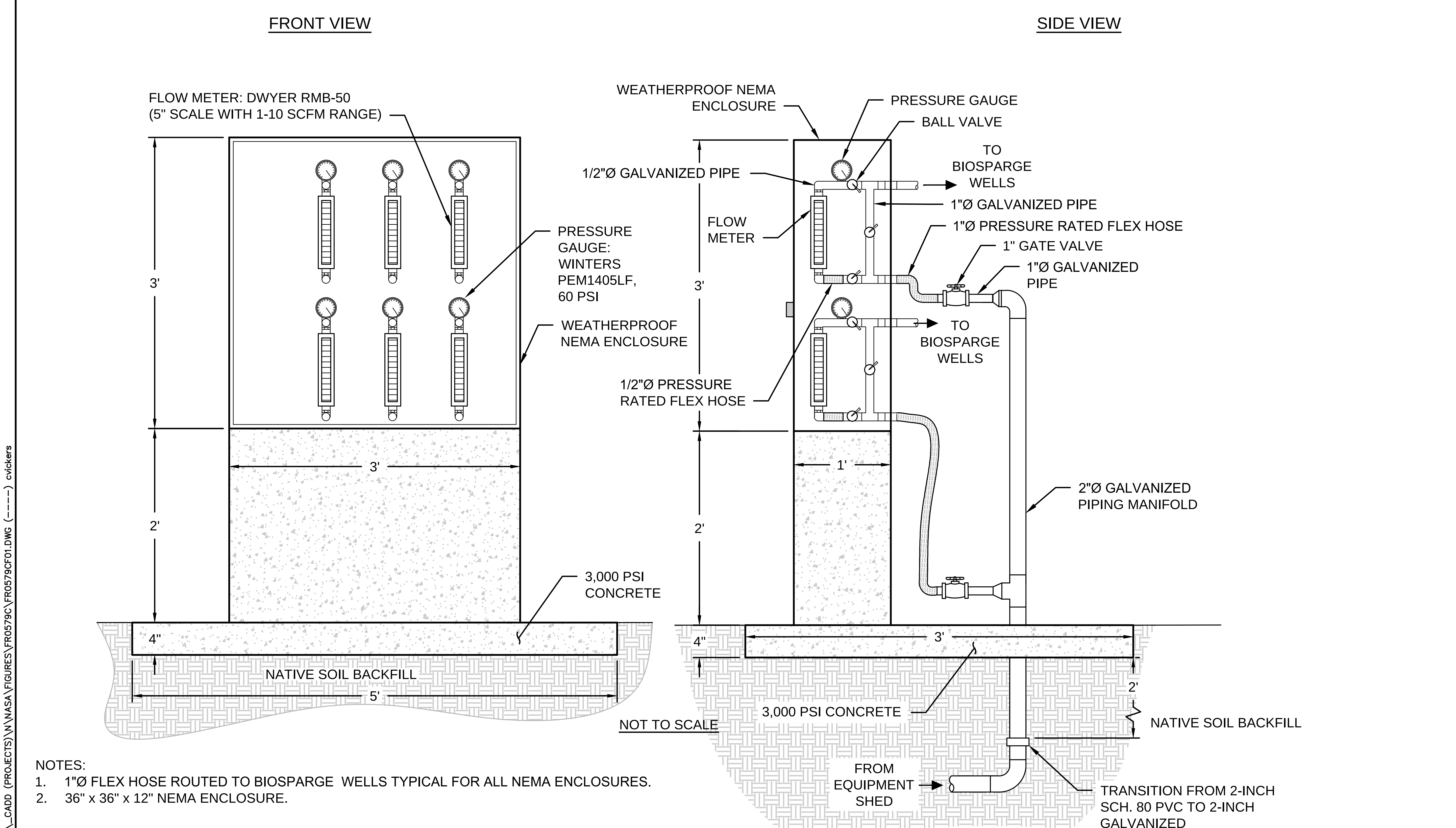
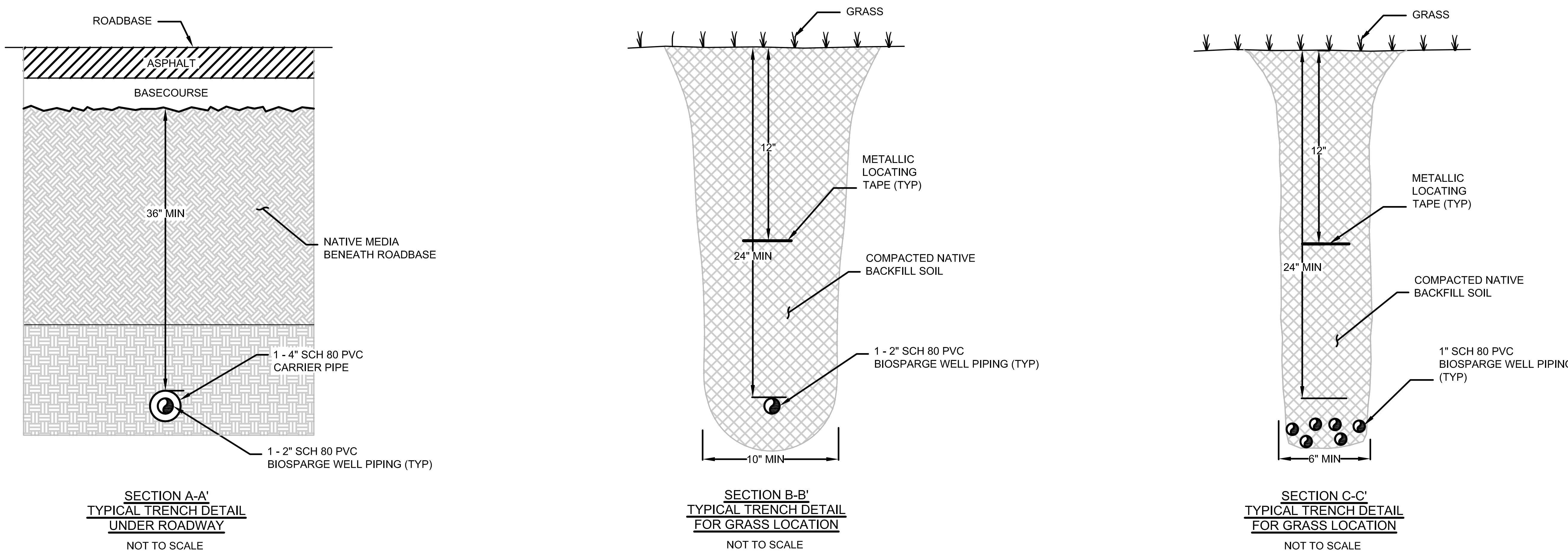
Figure 3-2
Biosparge Well Construction Detail



NOTES:
1. 1"Ø FLEX HOSE ROUTED TO BIOSPARGE WELLS TYPICAL FOR ALL NEMA ENCLOSURES.
2. 36" x 36" x 12" NEMA ENCLOSURE.

Figure 3-3
Front and Side View of
Manifold System



NOTES:

1. ANY DISTURBED GRASS SHALL BE RE-SODDED.
2. NUMBER OF BIOSPARGE PIPES VARY WITH LOCATION FOR TRENCHES INSTALLED IN GRASS AREAS.
3. PIPES SHALL NOT TOUCH WITHIN TRENCH AND SHALL HAVE ¾" (MIN) SAND BUFFER AROUND EACH PIPE TO MINIMIZE ABRASION FOR PIPES INSTALLED IN TRENCHES IN GRASS AREA.
4. CROSS SECTIONS ARE SHOWN ON FIGURE 3-1.

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Figure 3-4
Trenching and Directional Drilling
Cross Section Details

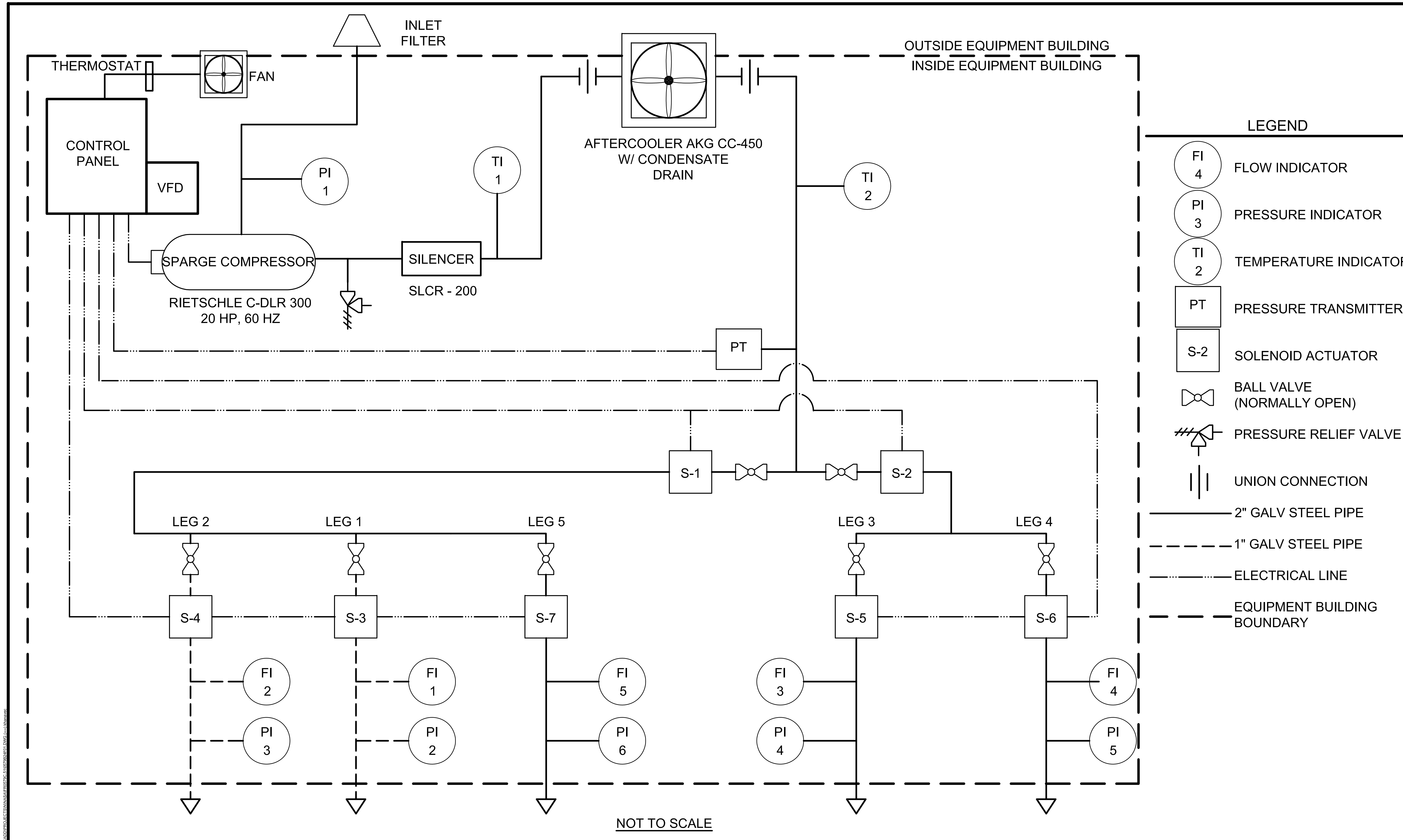


Figure 3-5
Proposed Sparge System
Process and Instrumentation Diagram

SECTION IV

PERFORMANCE MONITORING AND OPERATION AND MAINTENANCE

4.1 OVERVIEW

This section details the proposed groundwater monitoring strategy, system start up activities, and O&M activities associated with the biosparge barrier expansions.

4.2 GROUNDWATER MONITORING

All groundwater samples will be collected in general accordance with the FDEPs standard operating procedures [FDEP 2014] and the KSC Sampling and Analysis Plan [NASA 2011c].

4.2.1 MONITORING WELL INSTALLATION. To aid in the evaluation of the biosparge barrier expansion four proposed monitoring wells (MWA through MWD [proposed monitoring well IDs to be modified to numerical values at time of installation]) will be installed. As presented on Figure 4-1, the proposed monitoring wells will be installed as two well clusters, with one well screened from 35 to 40 ft BLS and the other well screened from 40 to 45 ft BLS. One monitoring well cluster will be installed upgradient of the biosparge barrier to monitor the CVOC concentrations upgradient of the biosparge barrier, and the other cluster will be installed downgradient of the biosparge barrier to evaluate the biosparge barrier's effectiveness at reducing CVOC concentrations. The screen intervals for the monitoring wells were selected based on the direct push technology (DPT) sampling results presented on Figure 2-9 and in Table 2-1 and described as follows: (i) impacts upgradient of the barrier were identified in the intervals of 36 to 40 and 41 to 45 ft BLS at DPT0505; and (ii) impacts within the area of the biosparge barrier expansion and downgradient of the proposed biosparge barrier expansion were identified in the intervals of 31 to 35 and 36 to 40 ft BLS (DPT0540, DPT0506, DPT1212 and DPT1214). The downgradient well cluster screen intervals were selected to assure that the upgradient impacts identified in the 41 to 45 ft BLS interval were treated by the biosparge barrier. The impacts identified from 31 to 35 ft BLS will be monitored using the existing monitoring well IW0031. Monitoring wells MWA through MWD will be constructed of ¾-inch PVC and construction details are provided on Figure 4-2.

4.2.2 BASELINE GROUNDWATER SAMPLING. The baseline groundwater sampling event will occur after installation of the proposed monitoring wells, and will include the monitoring wells listed in Table 4-1. The collected samples will be laboratory analyzed for CVOCs using Environmental Protection Agency (EPA) Method 8260B. Baseline sampling results will be used to confirm pre-sparging groundwater conditions.

4.2.3 PERFORMANCE MONITORING. Performance monitoring of the biosparge barrier expansion will occur in accordance with the schedule presented in Table 4-1. The performance monitoring will occur simultaneously with the performance monitoring for the existing biosparge barrier (when possible). The collected samples will be laboratory analyzed for CVOCs using EPA Method 8260B.

4.3 BIOSPARGE O&M

4.3.1 MODIFIED SYSTEM STARTUP. Upon startup, the sparge system will operate in its current configuration, where Zone 1, Zone 2, and Zone 3 operate in 2-hour cycles for 8 hours a day (per Zone). Zone 1 will be modified, however, to include Leg 5, so that the existing biosparge barrier and the biosparge barrier expansion operate at the same time. Total flow rates and other operational parameters will be monitored for each zone during start up, along with individual biosparge well pressures and flow rates. The system operational cycles will be adjusted, as necessary, to optimize system performance.

4.3.2 SYSTEM O&M. Upon implementation of the biosparge expansion, the equipment will be monitored for the first day three days of operation, weekly the first month, and monthly thereafter (occurring at the same time as the regularly scheduled O&M event for the existing sparge system). System monitoring will include the collection of the following:

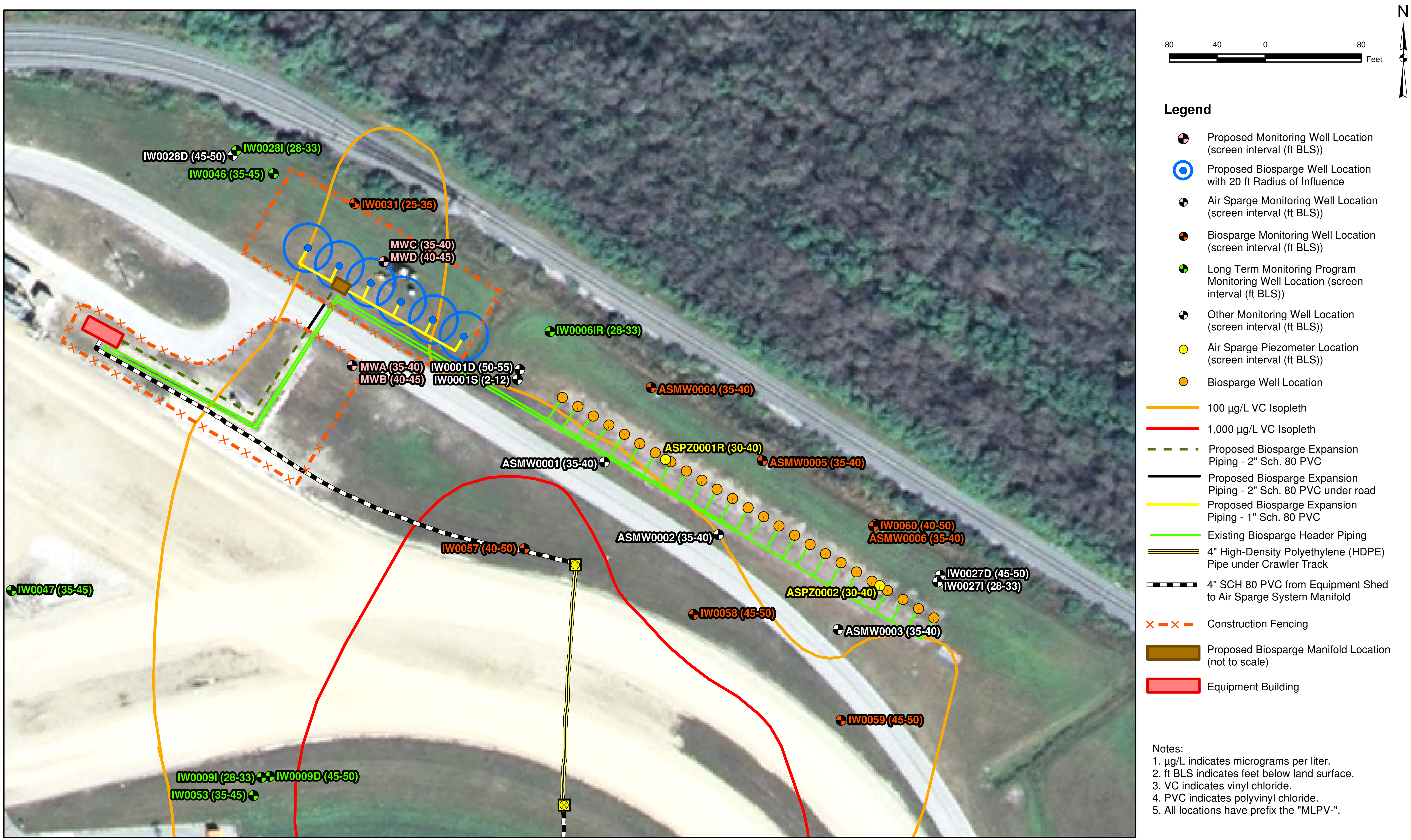
- individual sparge well air flow rates and pressures;
- system operating temperatures and pressures;
- hour meter readings;
- electric meter readings; and
- individual leg and over systems air flow measurements.

In addition, the system will be monitored remotely using telemetry on a weekly basis. Any periodic equipment maintenance activities recommended by equipment manufacturers will also be performed as part of the O&M activities. The results of O&M activities will be documented in O&M logs.

Table 4-1. Proposed Biosparge Barrier Expansion Performance Monitoring Plan
Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

System Monitored	Location	Screened Interval (ft BLS)	Baseline	Frequency	Analytical Parameters
Biosparge Barrier	IW0031	25 to 35	Baseline	Quarterly	CVOCs (EPA 8260B)
	MWA	35 to 40	Baseline	1st Month, Quarterly	
	MWB	40 to 45	Baseline	1st Month, Quarterly	
	MWC	35 to 40	Baseline	1st Month, Quarterly	
	MWD	45 to 50	Baseline	1st Month, Quarterly	

<u>Notes</u>:
1. ft BLS indicates feet below land surface.
2. CVOC indicates chlorinated volatile organic compounds.
3. Year 2 sample frequency may be modified based upon year 1 performance monitoring results.



Notes:
1. µg/L indicates micrograms per liter.
2. ft BLS indicates feet below land surface.
3. VC indicates vinyl chloride.
4. PVC indicates polyvinyl chloride.
5. All locations have prefix the "MLPV-".

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Figure 4-1
Proposed Monitoring Well Locations

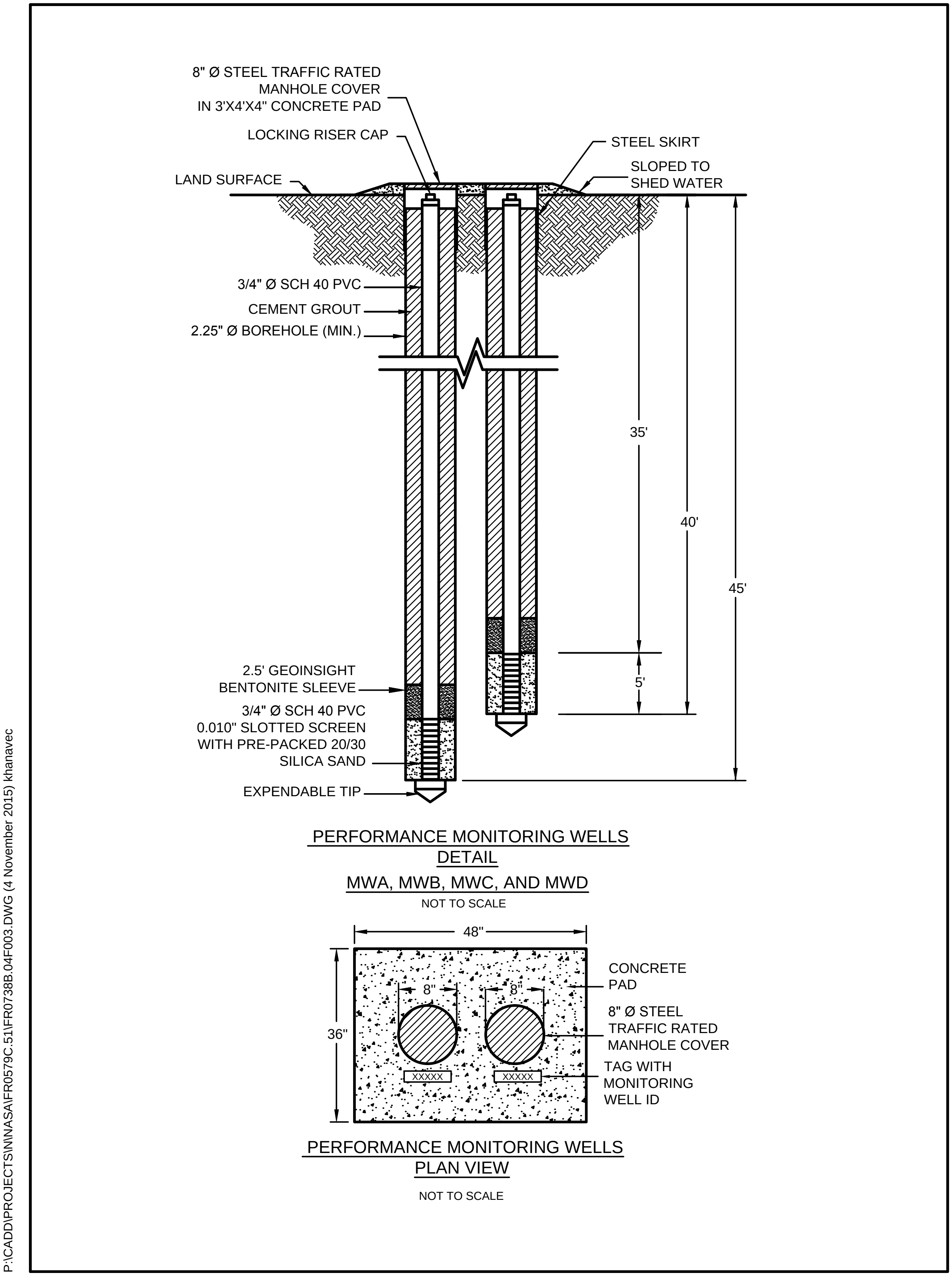

Figure 4-2
Proposed Monitoring Well Construction Details

SECTION V

INTERIM MEASURES REPORTING

5.1 INTERIM MEASURES CONSTRUCTION COMPLETION DOCUMENTATION

The MLPV Biosparge Barrier Expansion IM CCR will document installation and startup activities associated with the expanded biosparge barrier, groundwater monitoring, and system startup. The CCR will include as-built drawings, baseline sampling results, and recommendations for continued operation and/or proposed modifications, as well as any other items required by the KSCRT Engineering Evaluation Process, Revision 4. The MLPV IM CCR will be signed/sealed by the Florida licensed professional engineer in charge of the project.

The details of the CCR will be presented to the KSCRT during the MLPV Annual CMI and Interim Measure Annual Report presentation.

5.2 INTERIM MEASURES PERFORMANCE MONITORING DOCUMENTATION

The biosparge barrier expansion operation information will be included in the MLPV Annual CMI and Interim Measure Annual Report (Step 4 Engineering Evaluation). At a minimum, the annual report will include:

- results of laboratory analyses of groundwater samples;
- O&M activities performed during the reporting period;
- information regarding any repairs and/or modifications made to the sparge system; and
- recommendations and conclusions pertaining to the combined operation and/or optimization of the sparge system.

Annual reports will be signed/sealed by the Florida licensed professional engineer in charge of the project. All reports are subject to potential modification of structure, format, and content to be consistent with the evolving Engineering Evaluation Step process.

SECTION VI

EXIT STRATEGY AND COSTING

6.1 INTERIM MEASURES EXIT STRATEGY

The biosparge barrier expansion (and existing barrier) will be operated until collapse of the primary plume swath is observed. Following the confirmation of plume swath collapse, the biosparge barrier system will be shut down and post-active remediation monitoring would begin.

6.2 INTERIM MEASURES COSTING

The capital cost and extra annual operational cost for the biosparge barrier expansion are provided in Table 6-1. The estimated capital cost for installation of the expansion is approximately $108,000 and the estimated increase in annual costs for the MLPV site for the operation, maintenance of the biosparge expansion for the first year of operation is $18,000.

Table 6-1. Biosparge Barrier Expansion Costing
Biosparge Expansion Interim Measures Work Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

TECHNOLOGY: Biosparging of Vinyl Chloride (VC) Plume with Concentrations Greater than 100 micrograms per liter (µg/L; northwest of existing biosparge barrier)

DESCRIPTION: Installation of six biosparge barrier wells to a maximum depth of 50 feet below land surface (ft BLS). Installation of two monitoring wells screened from 35 to 40 ft BLS, and two monitoring wells screened 40 to 45 ft BLS. Operation of the system and performance monitoring of the expanded biosparge barrier for one year.

Item	Description	Unit	No. of Units	Unit Cost	Total	Cost Reference
CAPITAL COSTS						
BIOSPARGE WELL INSTALLATION - 6 WELLS						
Site Preparation	Miscellaneous site preparation, surveying, utility clearance	LS	1	$ 5,000	$ 5,000	Eng. Estimate
Hollow Stem Auger Mobilization	Mobilization of ATV rig	EA	1	$ 330	$ 330	EDS Quote 11/2015
Hollow Stem Auger Per Diem	Assumes 2 wells can be installed per day	DAY	3	$ 220	$ 660	EDS Quote 11/2015
Hollow Stem Soil Core Collection	Collection of soil core to 55 ft BLS and grouting (if necessary)	FT	55	$ 11	$ 605	EDS Quote 11/2015
Hollow Stem Well Install	2" biosparge well installed to 50 ft BLS	FT	300	$ 25	$ 7,590	EDS Quote 11/2015
Decon Pit Construction		EA	1	$ 275	$ 275	EDS Quote 11/2015
Wellheads	Galvanized piping, valves, and transition from PVC to galvanized piping	EA	6	$ 495	$ 2,970	EDS Quote 11/2015
Well Completions	18" bolt down manhole in a 36" x 36" x 4" concrete pad	EA	6	$ 440	$ 2,640	EDS Quote 11/2015
Schumasoil well screens (40 micron)	24 inch screens	EA	6	$ 86	$ 516	ECT Quote 10/2015
Well Development	Development of biosparge wells (30 minutes per well)	HR	3	$ 110	$ 330	EDS Quote 11/2015
Skid Steer Rental for IDW Management	Rental for managing drill cuttings	DAY	4	$ 220	$ 880	FECC Quote 5/2015
IDW Handling/Disposal	Includes characterization and disposal of soil cuttings from drilling (up to 15 tons)	EA	1	$ 2,511	$ 2,511	FECC 11/2015 and Test America 6/2015
MONITORING WELL INSTALLATION - 4 MONITORING WELLS						
Mobilization/Demobilization		EA	1	$ 330	$ 330	EDS Quote 11/2015
DPT Rig Daily Rate	Includes install and development of two monitoring well clusters (max depths of 35 and 40 ft BLS)	DAY	1	$ 1,485	$ 1,485	EDS Quote 11/2015
1" x 10 ft PVC Riser		FT	14	$ 15	$ 216	EDS Quote 11/2015
1" x 5 ft PVC Riser		FT	2	$ 11	$ 22	EDS Quote 11/2015
1" x 5 ft PVC prepacked screen		EA	4	$ 80	$ 321	EDS Quote 11/2015
Bentonite Sleeve		EA	4	$ 65	$ 260	EDS Quote 11/2015
8-inch Manhole with concrete Pad	Set two wells into one concrete pad - 36" x 48" x 4"	EA	2	$ 264	$ 528	EDS Quote 11/2015
Survey	Survey of monitoring wells	EA	4	$ 130	$ 520	Kugelmann Quote 6/2015
OVERLAPPING COST						
55-gallon Drum	For liquid IDW from well development	EA	3	$ 61	$ 182	EDS Quote 11/2015
Drilling Oversight	Includes biosparge well installation (4 days) and monitoring well installation (1 day)	DAY	5	$ 1,500	$ 7,500	Eng. Estimate
Permits	Permits only required for monitoring wells (10 wells per permit)	EA	1	$ 110	$ 110	EDS Quote 11/2015
Subtotal					**$ 36,000**	
BIOSPARGE SYSTEM EXPANSION						
Mobilization and demobilization	Mobilization for manifold construction and piping installation	LS	1	$ 3,080.00	$ 3,080	FECC Quote 11/2015
Biosparge piping installation	1" and 2" PVC Schedule 80 pipe installation (including trenching and directional drilling; estimate 4 days for completion)	LS	1	$ 16,041	$ 16,041	FECC Quote 11/2015
Biosparge manifold	Construction of manifold for biosparge expansion (estimate 3 days for completion)	LS	1	$ 9,900	$ 9,900	FECC Quote 11/2015
Sparge system modification	Modification of existing sparge system (estimate 2 days for system modification and one day system start up)	LS	1	$ 6,845	$ 6,845	PRM Quote 6/2015
Construction Oversight	Oversight for installation of system piping and manifold (4 days for piping, 3 days for manifold, and 3 days for system mod and start up)	DAY	10	$ 1,500	$ 15,000	Eng. Estimate
Subtotal					**$ 51,000**	
BASELINE GROUNDWATER SAMPLING AND REPORTING						
Sampling 5 monitoring wells	Collection and analysis of groundwater samples from 4 newly monitoring wells and 1 existing monitoring well during baseline monitoring event; all samples analyzed for CVOCs; includes data evaluation	EA	5	$ 765.00	$ 3,825	Eng. Estimate
Project management/support	during construction activities (2 hrs per day)	HR	32	$ 175.00	$ 5,600	Eng. Estimate
Reporting/Data Evaluation	Construction Completion Report (no ADP)	EA	1	$ 12,000.00	$ 12,000	Eng. Estimate
				Subtotal	**$ 21,000**	
				Total Capital Cost	**$ 108,000**	
ANNUAL OPERATION, MAINTENANCE AND MONITORING						
SPARGE SYSTEM MAINTENANCE AND MW SAMPLING/REPORTING						
Operation and Monthly Maintenance	1 man crew monthly O&M, weekly telemetric monitoring	DAY	0	$ 2,200	$ -	Eng. Estimate
Electricity	25 hp total for two sparge systems (24 hours per day operation for 1 year)	kWh	0	$ 0.09	$ -	Eng. Estimate
Annual parts and Labor allowance		LS	0	$ 1,500	$ -	Eng. Estimate
Performance Monitoring - Year 1	Collection of samples from 4 new monitoring wells after first month of operation and then collection of samples from the 4 new monitoring wells and 1 existing monitoring well, quarterly; all samples analyzed for CVOCs, includes data evaluation	EA	24	$ 765	$ 18,360	Eng. Estimate
Project management		LS	0	$ 5,000	$ -	Eng. Estimate
Reporting/Data Evaluation (Annual ADP and Report)		EA	0	$ 35,000	$ -	Eng. Estimate
	Operation and Maintenance Cost for Biosparge System Expansion				**$ 18,000**	
				Total Cost:	**$ 126,000**	

Note: The cost for operation and maintenance, electricity, annual parts, reporting and project management are already included in the operation of the existing biosparge system; therefore, no cost are included here.

SECTION VII

REFERENCES

Florida Department of Environmental Protection, March 2014. *Department of Environmental Protection Standard Operating Procedures for Field Activities, DEP-SOP-001/01*.

National Aeronautics and Space Administration, August 2000. *Mobile Launch Platform Rehabilitation Sites, SWMU No. 056, RCRA Facility Investigation Report, John F. Kennedy Space Center, Florida, Revision 2*, prepared by Geosyntec Consultants, Boca Raton, Florida, NASA Document Number KSC-JJ-4642.

National Aeronautics and Space Administration, September 2003. *MLP/VAB Area, SWMU No. 056, VAB SWMU Assessment, Confirmation Sampling and MLP/VAB Area RFI Addendum Report, John F. Kennedy Space Center, Florida, Revision 1*, prepared by Geosyntec Consultants, Boca Raton, Florida, NASA Document Number KSC-TA-6170.

National Aeronautics and Space Administration, June 2004. *MLP/VAB Area, SWMU No. 056, Corrective Measures Design Report, Revision 0, John F. Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida, NASA Document Number KSC-TA-6778.

National Aeronautics and Space Administration, June 2006. *MLP/VAB Area, SWMU No. 056*, *Dissolved Plume Corrective Measures Report, Revision 0, John F. Kennedy Space Center, Florida*, prepared by Jacobs Engineering, Cape Canaveral, Florida, NASA Document Number KSC-TA-8072.

National Aeronautics and Space Administration, February 2008. *MLP/VAB Area, SWMU No. 056*, *Biotreatability Study Implementation Annual Report, Revision 0, John F. Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida, NASA Document Number KSC-TA-9203.

National Aeronautics and Space Administration, May 2009. *MLP/VAB Area, SWMU No. 056*, *Biotreatability Study Implementation Annual Report, Revision 0, John F. Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida, NASA Document Number KSC-TA-10296.

National Aeronautics and Space Administration, February 2011a. *MLP/VAB Area, SWMU No. 056*, *Step 1 Engineering Evaluation Advanced Data Package, Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida.

National Aeronautics and Space Administration, May 2011b. *MLP/VAB Area, SWMU No. 056*, *Step 2 Engineering Evaluation Advanced Data Package, Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida.

National Aeronautics and Space Administration, June 2011c. *Sampling and Analysis Plan for the RCRA Corrective Action Program at the John F. Kennedy Space Center, Florida* (*Revision 4*), prepared by Geosyntec Consultants, NASA Document Number KSC-TA-6169.

National Aeronautics and Space Administration, August 2011d. *MLP/VAB Area, SWMU No. 056*, *2011 Corrective Measures Implementation Report: Summary of Interim Long Term Monitoring, Supplemental Assessment, and Biosparge System Operation and Maintenance, Revision 0, Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, NASA Document Number KSC-TA-11518.

National Aeronautics and Space Administration, October 2011e. *MLP/VAB Area, SWMU No. 056*, *Step 3 Engineering Evaluation Air Sparge Interim Measures Work Plan, Advanced Data Package, Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida.

National Aeronautics and Space Administration, November 2011f. *MLP/VAB Area, SWMU No. 056, Air Sparge Interim Measures Work Plan, Revision 0, John F. Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida, NASA Document Number KSC-TA-11880.

National Aeronautics and Space Administration, October 2012. *MLP/VAB Area, SWMU No. 056*, *Step 4a Engineering Evaluation: Air Sparge Construction Completion, Advanced Data Package, Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida.

National Aeronautics and Space Administration, January 2013a. *Mobile Launch Platform/Vehicle Assembly Area Air Sparge System Construction Completion Report, Revision 0, John F. Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida, NASA Document Number KSC-TA-12341.

National Aeronautics and Space Administration, March 2014a. *MLP/VAB Area, SWMU No. 056*, *2014 Step 4B Engineering Evaluation: Air Sparge System and Biosparge System Restart and Initial Performance Monitoring (Re-Strat through Month 6), Advanced Data Package, John F. Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida.

National Aeronautics and Space Administration, August 2014b. *MLP/VAB Area, SWMU No. 056*, *2014 Corrective Measures Implementation and Interim Measures Annual Report: Summary* *of Biosparge System Operation and Air Sparge System Operation (Step 4C), Advanced Data Package, John F. Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida.

National Aeronautics and Space Administration, August 2014c. *MLP/VAB Area, SWMU No. 056, 2014 Corrective Measures Implementation and Interim Measures Report: Biosparge and Air Sparge System Operation and Maintenance, Revision 0, Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida.

National Aeronautics and Space Administration, June 2015a. *Vehicle Assembly Building Re-Assessment Area 2015 Environmental Conditions Assessment Report, Revision 1, Kennedy Space Center, Florida,* prepared by Geosyntec Consultants, Clearwater, Florida.

National Aeronautics and Space Administration, August 2015b. *Vehicle Assembly Building Area 2014 Annual Groundwater Monitoring Results, Revision 0, Kennedy Space Center, Florida,* prepared by Geosyntec Consultants, Pensacola, Florida.

National Aeronautics and Space Administration, November 2015c. *MLP/VAB Area, SWMU No. 056, 2015 Corrective Measures Implementation and Interim Measures Report: Summary of Biosparge and Air Sparge System Operation and Maintenance and Interim Groundwater Monitoring, John F. Kennedy Space Center, Florida*, prepared by Geosyntec Consultants, Titusville, Florida.

APPENDIX A

MEETING MINUTES

Revision 0 Meeting Minutes for December 3rd, 2015

Attendees:

John Armstrong/FDEP	Matt Shelton/Tetra Tech
Rosaly Santos-Ebaugh/NASA	Chris Hook/ Tetra Tech
Anne Chrest/NASA	Debbie Wilson/Tetra Tech
Dihn Vo/NASA	Rob Simcik/Tetra Tech
Guy Fazzio/Jacobs	Rob Murphy/Tetra Tech
Rebecca Daprato/Geosyntec	Joe Applegate/Arcadis
Eric Sager/Geosyntec	Scott Star/Arcadis
Joe Bartlett/Geosyntec	
Mark Speranza/Tetra Tech	

1512-M01 Team

General Information and Minutes

Discussion: IT training stresses password protection of personal identification (social security, date of birth, etc). Please password protect your badge requests and call the project manager with the password. Do not email passwords.

Team no longer needs to send advanced data packages (ADP) to Tim. Team revised amount of ADP copies to 5 for the NASA RPMs and only need to bring one copy of extra ADP to Team meeting.

Team consensus reached that October 2015 revision 0 meeting minutes are final.

Results: Decision item 1512-D01

1512-M02 Matt Shelton/ Tetra Tech

Supply Warehouse #3 (SW3) (SWMU 088)

Goal: Present Step 4C Engineering Evaluation which summarizes background and site information, performance metrics, system operation and maintenance (O&M), performance monitoring, recommendations for groundwater monitoring, and team consensus.

Discussion: The system initially operated from May 2009 to March 2010, resulting in trichloroethene (TCE) reduction to less than Natural Attenuation Default Concentration (NADC) in the Aggressive Remediation Zone (ARZ) and vinyl chloride (VC) reduced to less than NADC in the ARZ. Monitoring well MW0008 which was outside of the ARZ increased from 212 micrograms per liter (µg/L) in 2008 to 1,130 µg/L in 2010. DPT Sampling was conducted to delineate extent of VC in the area of MW0008

		Team consensus reached to conduct monitoring well sampling semi-annually and annually as outlined in ADP and conduct surface water monitoring at three locations semi-annually. Team discussed data gap around monitoring well with TCE outside of air sparge system influence. Florida Department of Environmental Protection (FDEP) requested team look at the DPT data collected previously in that area. Team will also look at the data for the concentrations from CM&S to the north of the site. **Results**: Decision items 1512-D02 to D03
1512-M03	Debbie Wilson/ Tetra Tech	LC39A Operations Support Building (PRL 175) **Goal**: Discuss a path forward for modification to confirmation sampling work plan as site conditions have changed since submittal of the work plan. **Discussion**: Space X has constructed a hanger in the area of Location of Concern 5 Crawler Laydown Area, which was a former parking and laydown area used during Pad A construction. Based on current site layout all sampling locations are still accessible. Recommended to collect the DPT groundwater samples and not the soil samples, since the ground has been disturbed during construction of the Space X hanger. The locations were previously selected based on the area that was used the most based on historical aerial photos. When Space X leaves the property they will have to sample the site and prove that the site is not impacted. Team consensus reached for no soil sample collection and only DPT groundwater sample collection at Location of Concern 5. **Results**: Decision items 1512-D04
1512-M04	Rebecca Daprato/ Geosyntec	Mobile Launch Platform/Vehicle Assembly Building Area (SWMU 056) **Goal**: Present biosparge barrier expansion design details. **Discussion**: MLPV site background: A dissolved chlorinated volatile organic compound (CVOC) plume following groundwater flow to northeast, towards wetlands, is present. The existing biosparge barrier treats the area with VC concentrations greater than NADC. Based on historic DPT groundwater sampling and recent

monitoring well sampling results, the VC NADC plume (31 to 45 ft BLS) expands to the northwest past the existing biosparge barrier. The corrective action objective (CAO) is to mitigate potential discharge of groundwater impacted with VC greater than NADC. The interim measure (IM) objective is to expand the biosparge barrier to treat area where VC is present above NADC to northwest of the existing biosparge barrier.

Propose installation of 6 additional biosparge wells (20 ft ROI, approximately 30 ft apart) and use existing system to operate concurrently with existing biosparge barrier. Propose installation of two upgradient and two downgradient monitoring wells (screened 35 to 40 and 40 to 45 ft BLS).

Proposed biosparge wells be constructed of 2" polyvinyl chloride (PVC) with 24" Schumasoil screens, 20/30 filter packs, and 3-foot bentonite seals. A manifold is to be constructed to house the biosparge wells' flow and pressure gauges. Portions of the piping installed between the equipment shed and manifold proposed to be installed via direction drilling below road.

The additional biosparge wells (Leg 5) will be added to the operational zone for the existing biosparge system. System will operate in zones: 2 hours each; Zone 1 (Biosparge Legs 1, 2, and 5), Zone 2 (as Air sparge Leg 3), and Zone 3 (as Air sparge Leg 4). Operation and Maintenance (O&M) will be performed one day following construction completion and then transition to monthly.

Sampling of newly installed monitoring wells will consist of baseline, 1st month, and quarterly sampling, thereafter. Monitoring wells proposed to be constructed of ¾" PVC, 10-slot screen with 2.5-ft Geoinsight bentonite sleeve.

Capital cost: $108,000 and annual operation: $18,000. Total implementation cost with one year of monitoring: $126,000.

Test consensus on biosparge well expansion, sampling plan, and O&M.

Results: Decision items 1512-D05

1512-M05 Joseph Bartlett/ Vertical Processing Facility (SWMU077)

APPENDIX B

PIPING SIZING AND HEAD LOSS CALCULATIONS

(FURNISHED ON CD)

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: NASA **Project:** MLPV BS IM Work Plan **Project/Proposal #:** FR0579C **Task #:** 51

TITLE OF COMPUTATIONS **PIPE SIZING AND FRICTION LOSS CALCULATIONS**

COMPUTATIONS BY:

Signature

11/19/15
DATE

Printed Name and Title: Mike Burcham, EIT, Senior Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:
(Peer Reviewer)

Signature

11/19/15
DATE

Printed Name and Title: Rebecca C. Daprato, Ph.D., P.E., Senior Engineer

COMPUTATIONS CHECKED BY:

Signature

11/19/15
DATE

Printed Name and Title: Jim Langenbach, P.E., BSCE, Principal Engineer

COMPUTATIONS BACKCHECKED BY:
(Originator)

Signature

11/19/15
DATE

Printed Name and Title: Mike Burcham, EIT, Senior Staff Engineer

APPROVED BY:
(PM or Designate)

Signature

11/19/15
DATE

Printed Name and Title: Rebecca C. Daprato, Ph.D., P.E., Senior Engineer

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

Written By: Mike Burcham Date: 11/19/2015 Reviewed by: Rebecca Daprato Date: 11/19/2015

Client: NASA Project: MLPV BS IM Work Plan Project/Proposal No.: FR0579C Task No.: 51

Pipe Sizing and Friction Loss Calculations
Mobile Launch Platform/Vehicle Assembly Building Biosparge Barrier Expansion Interim Measure Work Plan

The biosparge system expansion is designed with 6 biosparge wells that will be operated in combination with 25 existing biosparge wells for a total of 31 biosparge wells operating as part of a single zone (Zone 1). Zone 1 will be composed of Leg 5 (new biosparge barrier) and Leg 1 and Leg 2 (separate Legs of existing biosparge barrier). The calculations to operate the expanded Zone 1 are provided below.

Zone 1 Operation

Summary: The biosparge barrier will be expanded to include 6 new biosparge wells with 24-inch, 40-micron SCHUMASOIL© screens with a maximum depth of approximately 50 feet below land surface (ft BLS). There are 25 existing biosparge wells with 2.5-foot, 0.010 slot screens installed to a maximum depth between approximately 49.9 and 50.9 ft BLS that will be operate simultaneously with the newly installed biosparge wells. Each of the newly installed biosparge wells will be have individual lines that connect to a manifold.

Design Radius of Influence: The design radius of influence is 20 ft for all the newly installed biosparge wells.

Design Air Flow Rate: It is anticipated the system will operate with a design flow rate of 3 to 5 cubic feet per minute (cfm) per biosparge well with a total flow rate range of 93 to 155 cfm for the entirety of the expanded zone (39 to 65 cfm for Leg 1, 36 to 60 cfm for Leg 2, and 18 to 30 cfm for Leg 5).

Water Column Pressure Requirement – Leg 1 and Leg 2:

Depth to groundwater conservatively estimated	=	0 ft
Max depth to top of well screen in Leg 1 or Leg 2	=	48.4 ft
Thickness of water column in Leg 1 or Leg 2	=	48.4 ft

Head pressure

Leg 1 or 2 $= 48.4\,ft * 12\frac{in}{ft} * 0.036127\frac{psi}{in.\,H_2O} =$ 21 psi

Water Column Pressure Requirement – Leg 5:

Depth to groundwater conservatively estimated	=	0 ft

Max depth to top of well screen in Leg 5	=	48 ft
Thickness of water column in Leg 5	=	48 ft

Head pressure

Leg 5 $= 48\,ft * 12\frac{in}{ft} * 0.036127\frac{psi}{in.\,H_2O} =$ <u>20.8 psi</u>

<u>Maximum Air Friction Loss in Piping Run</u>:

Attachment A presents the calculations for the maximum air friction loss for the expanded Zone 1 that includes calculations for Leg 1, Leg 2, and Leg 5. For the existing biosparge system, Leg 1 for contains biosparge wells ASW01 to ASW13 and Leg 2 contains biosparge wells ASW14 to ASW25. Leg 5 will contain six biosparge wells (ASW26 to ASW31).

Pressure loss coefficients for air in PVC pipe were not readily available, so to be conservative, the pressure loss coefficients for galvanized pipes from the Gast Manufacturing Air Pipe Friction Loss Table (Appendix B; Table 1) were used for all straight pipe lengths. Since equivalent pipe lengths were readily available for PVC pipe fittings (Gast Manufacturing Appendix B, Table 3), those values were used for the PVC fittings present in the system.

The existing portions of the sparge system (Leg 1 and Leg 2) were constructed using ABS thermoplastic pipe; therefore, the use of readily available pressure loss values for comparable pipe (Chem-Aire pipe) were investigated (Table V and Table VI of Engineering and Design Document from Chem-Aire). To be conservative and consistent, it was decided that for straight line piping, the loss coefficients for galvanized piping would be used. For fittings, the equivalent pipe lengths for Chem-Air pipe fittings were used when available, and for PVC when not (e.g. reducers).

Each newly installed biosparge well will be piped individually from the manifold. Friction losses from the equipment shed to the manifold will be calculated as the same for each well. The maximum friction loss will come from the most distal well head from the manifold location.

Friction loss for each piping section was calculated based on the air flow rate, piping material, piping diameter, and additional hardware losses within the section.

<u>Leg 5 Friction Loss Calculations</u>

For the expansion piping (Leg 5), friction losses were calculated for: (i) the main header piping (2-inch) which extends from the equipment shed to the manifold; (ii) the manifold; (iii) the

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Client: NASA Project: MLPV BS IM Work Plan Project/Proposal No.: FR0579C Task No.: 51

piping to the individual biosparge wells ASW26 through ASW31; and iv) and the biosparge well head and well.

<u>Maximum friction loss through piping from equipment shed through manifold:</u>

Conservative estimated friction loss within equipment shed: <u>3.0 psi</u>

From shed to manifold:

2″ Sch. 80 PVC run from shed to manifold =	290 ft
90° elbow: $4\ ea * 6\ equivalent\ ft =$	24 ft
Total:	314 ft

Pressure drop / 10 ft of 2-inch pipe (in H_2O) = 0.21 @ 30 cfm
(0.21 value from Lookup Values for Friction Loss in Galvanized Steel Pipe)

$\frac{314\ ft}{10\ ft} * 0.21\ in\ H_2O * \frac{0.036127\ psi}{1\ in\ H_2O} =$ <u>0.24 psi</u>

Galvanized manifold piping prior to splitting flow in half within manifold:

2″ Galvanized pipe =	5 ft
Tee (through): $1\ ea * 3.5\ equivalent\ ft =$	3.5 ft
Total:	8.5 ft

Pressure drop / 10 ft of 2-inch pipe (in H_2O) = 0.21 @ 30 cfm
(0.21 value from Lookup Values for Friction Loss in Galvanized Steel Pipe)

$\frac{8.5\ ft}{10\ ft} * 0.21\ in.H_2O * \frac{0.036127\ psi}{1\ in\ H_2O} =$ <u>0.01 psi</u>

Galvanized manifold piping after splitting flow in half within the manifold:

2″ Galvanized pipe =	5 ft
90° elbow: $1\ ea * 5\ equivalent\ ft =$	5 ft
Tee (through): $1\ ea * 3.5\ equivalent\ ft =$	3.5 ft
Tee (branch): $1\ ea * 10.5\ equivalent\ ft =$	10.5 ft
Reducer: $1\ ea * 8\ equivalent\ ft =$	8 ft
Total:	32.0 ft

Pressure drop / 10 ft of 2-inch pipe (in H_2O) = 0.10 @ 15 cfm
(0.10 value from Lookup Values for Friction Loss in Galvanized Steel Pipe)

$\frac{32.0\ ft}{10\ ft} * 0.10\ in. H_2O * \frac{0.036127\ psi}{1\ in\ H_2O} =$ <u>0.01 psi</u>

Galvanized manifold for each biosparge well:

1″ Galvanized pipe =	2 ft
Tee (branch): $2\ ea * 5\ equivalent\ ft =$	10 ft
Gate Valve: $1\ ea * 0.70\ equivalent\ ft =$	0.70 ft
Ball Valve: $1\ ea * 0.27\ equivalent\ ft =$	0.27 ft
Total:	13.0 ft

Pressure drop / 10 ft of 1-inch pipe (in H_2O) = 0.21 @ 5 cfm
(0.21 value from Lookup Values for Friction Loss in Galvanized Steel Pipe)

$\frac{13.0\ ft}{10\ ft} * 0.21\ in. H_2O * \frac{0.036127\ psi}{1\ in\ w.g.} =$ <u>0.01 psi</u>

Total friction loss from equipment shed through manifold (psi):
3.0 + 0.24 + 0.01 + 0.01 + 0.01 = <u>**3.3 psi**</u>

<u>Maximum friction loss through piping from manifold to most distal well in Leg 5 (ASW31):</u>

From manifold to most distal well in Zone 1 (ASW31):

1″ Sch. 80 PVC run from manifold to well =	90 ft
90° elbow: $2\ ea * 2.25\ equivalent\ ft\ (PVC\ pipe) =$	4.50 ft
Total:	94.5 ft

Pressure drop / 10 ft of 1-inch pipe (psi) = 0.21 @ 5 cfm
(0.21 value from Lookup Values for Friction Loss in Galvanized Steel Pipe)

$\frac{94.5\ ft}{10\ ft} * 0.21\ in. H_2O * \frac{0.036127\ psi}{1\ in\ H_2O} =$ <u>**0.07 psi**</u>

<u>Maximum friction loss through biosparge well head and well for Leg 5 (ASW31):</u>

Through 1-inch well head components to bottom of 2-inch well:

2″ Sch. 40 PVC well=		48 ft
Tee (branch - 2″):	$1\ ea * 10.5\ equivalent\ ft =$	10.5 ft
Check valves (1″):	$1\ ea * 9\ equivalent\ ft =$	9 ft
Reducer (1″):	$1\ ea * 2.5\ equivalent\ ft =$	2.5 ft

Total 1-inch:	11.5 ft
Total 2-inch:	58.5

Pressure drop / 10 ft of 1-inch pipe (psi) = 0.21 @ 5 cfm
Pressure drop / 10 ft of 2-inch pipe (psi) = 0.10 @ 5 cfm
(0.21 and 0.10 values from Lookup Values for Friction Loss in Galvanized Steel Pipe)

$$\left(\frac{11.5\ ft}{10\ ft} * 0.21\ in. H_2O + \frac{58.5\ ft}{10 ft} * 0.10\ in. H_2O\right) * \frac{0.036127\ psi}{1\ in\ H_2O} = \qquad \textbf{0.03 psi}$$

Leg 1 Friction Loss Calculations

For the existing biosparge Legs (Leg 1 and Leg 2) friction losses were calculated for: (i) the main header piping (2″ ABS thermoplastic piping) that extends from the equipment shed to the 1″ ABS thermoplastic piping that connects to the biosparge wells; (ii) the 1″ piping that extends from the main header piping (2″) to the biosparge wells; and (iii) the biosparge well head and well.

When calculating the pressure loss through the piping header from the equipment shed to the most distal biosparge well (ASW13), it was assumed that each biosparge well would receive 5 cfm of air; therefore, a total of 65 cfm of total air flow is assumed to be provided by the compressor to Leg 1. A reduction in flow of 5 cfm occurs as the air flow passes by each biosparge well. As such, the value for the pressure drop per 10-feet of 2″ header pipe between the equipment shed and the most distal biosparge well is adjusted to match the estimated flow at each biosparge well location. The total pressure loss from the equipment shed to the start of the 1″ transition piping between the piping header and biosparge well ASW13, was calculated by summing the pressure loss for each individual portion of the piping header between the shed and ASW13 (shed to ASW01, ASW01 to ASW02, etc.).

Maximum friction loss from shed to 1″ transition for the most distal well in Leg 1 (ASW13):

Conservative estimated friction loss within equipment shed: 3.0 psi

From shed to most distal existing biosparge well transition:
2″ header pipe from shed to ASW13 transition = 680 ft total

Tee (through):	$12\ ea * 4.3\ equivalent\ ft =$	51.6 ft total
45° elbow:	$2\ ea * 2.8\ equivalent\ ft =$	5.60 ft total
90° elbow:	$4\ ea * 5.5\ equivalent\ ft =$	22.0 ft total
Total:		759.2 ft total

Pressure drop range / 10 ft of 2-inch pipe (psi) = 0.76 to 0.10 from 65 to 5 cfm
(pressure drop values from Lookup Values for Friction Loss in Galvanized Steel Pipe)

The calculation for friction loss was calculated using the following equation:

$$\frac{Equiv.Length\ in\ ft}{10\ ft} * Pressure\ Drop\ in. H_2O * \frac{0.036127\ psi}{1\ in\ H_2O} = \quad \underline{\text{Pressure Drop in psi}}$$

The friction loss was calculated for each portion of the 2″ header pipe between the equipment shed and each biosparge well for Leg 1.

Total pressure loss from the equipment shed to the 1″ transition for the most distal well in Leg 1 (ASW13): <u>1.70 psi</u>

Total friction loss from equipment shed to 1″ transition for Leg 1 (psi):
3.0 + 1.70 = **<u>4.7 psi</u>**

<u>Maximum friction loss from the 1″ transition through most distal well in Leg 1 (ASW13):</u>

From Leg 1 transition to biosparge ASW13 well head:

1″ pipe from header pipe to ASW13 =		12 ft total
90° elbow (1″):	$1\ ea * 5.5\ equivalent\ ft =$	5.5 ft total
Reducer (1″):	$1\ ea * 8\ equivalent\ ft =$	8 ft
Total:		25.5 ft

Pressure drop / 10 ft of 1-inch pipe (in H_2O) = 0.21 @ 5 cfm
(0.21 value from Lookup Values for Friction Loss in Galvanized Steel Pipe)

$$\frac{25.5\ ft}{10\ ft} * 0.21\ in. H_2O * \frac{0.036127\ psi}{1\ in\ H_2O} = \quad \mathbf{\underline{0.02\ psi}}$$

Written By: Mike Burcham Date: 11/19/2015 Reviewed by: Rebecca Daprato Date: 11/19/2015

Client: NASA Project: MLPV BS IM Work Plan Project/Proposal No.: FR0579C Task No.: 51

Friction loss through biosparge well head and well (ASW13):

Through 1-inch well head components to bottom of 2-inch well:

1″ Sch. 40 PVC well=		48.4 ft
Tee (branch):	$1\ ea * 6.0\ equivalent\ ft =$	6.00 ft
Gate valves:	$1\ ea * 1.0\ equivalent\ ft =$	1.00 ft
Total 1-inch:		7.0 ft

Pressure drop / 10 ft of 1-inch pipe (psi) = 0.21 @ 5 cfm
(0.21 value from Lookup Values for Friction Loss in Galvanized Steel Pipe)

$$\frac{55.4\ ft}{10\ ft} * 0.21\ in. H_2O * \frac{0.036127\ psi}{1\ in\ H_2O} =$$ **0.04 psi**

Leg 2 Friction Loss Calculations

For the existing biosparge Legs (Leg 1 and Leg 2) friction losses were calculated for: (i) the main header piping (2″ ABS thermoplastic piping) that extends from the equipment shed to the 1″ ABS thermoplastic piping that connects to the biosparge wells; (ii) the 1″ piping that extends from the main header piping (2″) to the biosparge wells; and (iii) the biosparge well head and well. Friction losses for Leg 2 were calculated the same as was done for Leg 1, and the calculations for friction loss within both the 1″ transition from the header pipe to the most distal biosparge well and the biosparge well heads and wells are the same for both Leg 2 and Leg 1; therefore, the calculations are not repeated in this section.

Maximum friction loss from shed to 1″ transition for the most distal well in Leg 2 (ASW25):

Conservative estimated friction loss within equipment shed: 3.0 psi

From shed to furthest existing biosparge well transition:

2″ pipe from shed to ASW25 =		863 ft total
Tee (through):	$11\ ea * 4.3\ equivalent\ ft =$	47.3 ft total
45° elbow:	$2\ ea * 2.8\ equivalent\ ft =$	5.60 ft total
90° elbow:	$4\ ea * 5.5\ equivalent\ ft =$	22.0 ft total
Total:		938 ft

Pressure drop / 10 ft of 2-inch pipe (psi) = 0.67 to 0.10 from 60 to 5 cfm
(pressure drop values from Lookup Values for Friction Loss in Galvanized Steel Pipe)

See Leg 1 for details on how the pressure loss was calculated.

Total pressure loss from the equipment shed to the 1″ transition for the most distal well in Leg 2 (ASW25): 1.95 psi

Total friction loss from equipment shed to 1″ transition for Leg 2 (psi):
3.0 + 1.70 = **4.95 psi**

Maximum friction loss from the 1″ transition through most distal well in Leg 2 (ASW25):

Same value as Leg 1: **0.02 psi**

Friction loss through biosparge well head and well (ASW25):

Same value as Leg 1: **0.04 psi**

Total Pressure Losses

The total pressure loss for each zone is the summation of the: (i) water column pressure; (ii) pressure loss in equipment shed; (iii) pressure loss through manifold (as applicable); (iv) pressure loss through all piping; (v) pressure loss in most distal biosparge well head and well; and (vi) pressure loss due to the well screen (assumed to be 0.10 psi).

Total Pressure Requirement:

	Leg 5 Pressure Loss (psi)	**Leg 1 Pressure Loss (psi)**	**Leg 2 Pressure Loss (psi)**
Water column	20.8	21.0	21.0
Equipment Shed	3.0	3.0	3.0
Piping Frictional Loss to Transitions	0.24	1.70	1.95
Manifold Loss	0.03	NA	NA
Piping Frictional Loss to Wellheads	0.07	0.02	0.02
Biosparge wellhead and well	0.03	0.04	0.04
Well screen exit	0.10	0.10	0.10
Total	**24.3**	**25.8**	**26.1**
Total with a 10% degradation factor	**26.7**	**28.4**	**28.7**

Based upon the total design flow of 155 cfm and maximum design pressure of 28.7 psi, the existing air compressor, a Rietschle C-DLR 300 (25 hp, 60 Hz; capable of operating at 190 cfm against a pressure of 31.9 psi), is capable of operating Leg 1, 2, and 5 simultaneously (25 existing biosparge wells and the 6 additional wells).

ATTACHMENT A

Appendix B - Pipe Size and Head Loss Calculations

	Leg 1	Leg 2	Leg 5	Zone 1
Number of Wells	13	12	6	31
Total Design Flow (cfm)	65.0	60.0	30.0	155
Well Design Flow Rate (cfm)	5.0	5.0	5.0	5.0
Design Compressor Pressure (psi)	**31.9**	**31.9**	**31.9**	**31.9**

	Leg 1	Leg 2	Leg 5
Water Column (psi)	21.0	21.0	20.8
Shed Loss (psi)	3.00	3.00	3.00
Piping Frictional Loss to Transtions (psi)	1.70	1.95	0.24
Manifold Loss (psi)	---	---	0.03
Piping Frictional Loss to Wellheads(psi)	0.02	0.02	0.07
Biosparge Well Head (psi)	0.04	0.04	0.03
Well screen exit loss (psi)	0.1	0.1	0.1
Total Pressure (psi)	**25.8**	**26.1**	**24.3**
Total Pressure with 10% degradation factor (psi)	**28.4**	**28.7**	**26.7**

Orange indicates that the value is entered manually

Shed to Manifold (Leg 5)	Shed	Comp. to Manifold (PVC)	Manifold Pre-Split (Galvanized)	Manifold Split (Galvanized)	Manifold for ASW31 (Galvanized)
Air Flow Rate (cfm)	0.0	30.0	30.0	15.0	5.0
Pipe Diameter (in)	2	2	2	2	1
Pressure drop/10 ft pipe (in H_2O)	-	0.21	0.21	0.10	0.21
Approximate Pipe Length (ft)	0	290	5	5	2
# of 45 Degree Elbows	0	0	0	0	0
Equivalent Pipe Length per 45 Elbow (ft)	-	2.50	-	-	-
Equivalent Pipe Length (ft)	-	0	-	-	-
# of 90 Degree Elbows	0	4	0	1	0
Equivalent Pipe Length per 90 Elbow (ft)	-	6.00	5	5	3
Equivalent Pipe Length (ft)	-	24	0	5	0
# of Tees (through)	0	0	1	1	0
Equivalent Pipe Length per Tee (ft)	-	4.30	3.5	3.5	2
Equivalent Pipe Length (ft)	-	0	3.5	3.5	0
# of Tees (branch)	0	0	0	1	2
Equivalent Pipe Length per Tee (ft)	-	1.00	10.5	10.5	5
Equivalent Pipe Length (ft)	-	0	0	10.5	10
# of Ball Valves (fully opened)	0	0	0	0	0
Equivalent Pipe Length per Ball Valve (ft)	-	-	-	-	0.3
Equivalent Pipe Length (ft)	-	-	-	-	0
# of Gate Valves (fully opened)	0	0	0	0	1
Equivalent Pipe Length per Gate Valve (ft)	-	1.00	1.5	1.5	0.7
Equivalent Pipe Length (ft)	-	0	0	0	0.7
# of Ball Valves	0	0	0	0	1
Equivalent Pipe Length per Ball Valve (ft)	-	-	0.60	0.60	0.27
Equivalent Pipe Length (ft)	-	-	0	0	0.27
# of Reducers	0	0	0	1	0
Equivalent Pipe Length per Reducer (ft)	-	8	8	8	2.5
Equivalent Pipe Length (ft)	-	0	0	8	0
Total Equivalent Length (ft)	-	314.0	8.5	32.0	13.0
Friction Loss (in H_2O)	-	6.53	0.18	0.32	0.27
Friction loss (psi)	3.00	0.24	0.01	0.01	0.01

Note: Number of 2" and 1" components estimated assuming that most distal point will be connected to a flow meter on the top row of NEMA enclosure

Leg 5 (Manifold [M] to ASWs) - PVC Lines	M to ASW26	M to ASW27	M to ASW28	M to ASW29	M to ASW30	M to ASW31
Air Flow Rate (cfm)	5.0	5.0	5.0	5.0	5.0	5.0
Pipe Diameter (in)	1	1	1	1	1	1
Pressure drop/10 ft pipe (in H_2O)	0.21	0.21	0.21	0.21	0.21	0.21
Conservative Pipe Length (ft)	40	20	20	40	65	90
No of through tees	0	0	0	0	0	0
Equivalent pipe length per tee (ft)	1.70	1.70	1.70	1.70	1.70	1.70
Length (ft)	0	0	0	0	0	0
No of branch tees	0	0	0	0	0	0
Equivalent pipe length per tee (ft)	1.00	1.00	1.00	1.00	1.00	1.00
Length (ft)	0	0	0	0	0	0
Number of Gate Valves (fully open)	0	0	0	0	0	0
Equivalent pipe length per valve (ft)	1.00	1.00	1.00	1.00	1.00	1.00
Length (ft)	0	0	0	0	0	0
Number of 45 degree elbows	0	0	0	0	0	0
Equivalent pipe length per elbow (ft)	1.40	1.40	1.40	1.40	1.40	1.40
Length (ft)	0	0	0	0	0	0
Number of 90 degree elbows	2	2	2	2	2	2
Equivalent pipe length per elbow	2.25	2.25	2.25	2.25	2.25	2.25
Length (ft)	4.5	4.5	4.5	4.5	4.5	4.5
Total Equivalent Length (ft)	45	25	25	45	70	94.5
Friction loss (in H_2O)	0.9	0.5	0.5	0.9	1.5	2.0
Friction loss (psi)	0.03	0.02	0.02	0.03	0.05	0.07

Note: Assume that each ASW is 20 ft from the other, and that the nearest ASWs are 20 ft from the manifold. Also, that the trench is 20 ft from the ASWs

Expansion Biosparge Well	ASW31
Air Flow Rate (cfm)	5.0
Pipe Diameter (in)	1.0
Friction loss/10 ft pipe (in H_2O)	0.21
Number of reducers (1-inch)	1
Equivalent pipe length per ball valve (ft)	2.5
Length (ft)	2.50
Number of check valves (1-inch)	1
Equivalent pipe length per check valve (ft)	9.0
Length (ft)	9
Total Equivalent Length (ft) for 1"	11.5
Friction loss (in H_2O)	0.2
Length of well (assumed Galvanized)	48
Pipe Diameter (in)	2
Pressure drop/10 ft pipe (in H_2O)	0.10
No of branch tees (2-inch)	1
Equivalent pipe length per tee (ft)	10.5
Length (ft)	10.5
Total Equivalent Length (ft) for 2"	58.5
Friction loss (in H_2O)	0.59
TOTAL Friction loss (psi)	0.03

Leg 1 (Shed [S] to ASWs) - Chemair Lines

		S to ASW01	ASW01 to ASW02	ASW02 to ASW03	ASW03 to ASW04	ASW04 to ASW05	ASW05 to ASW06	ASW06 to ASW07	ASW07 to ASW08	ASW08 to ASW09	ASW09 to ASW10	ASW10 to ASW11	ASW11 to ASW12	ASW12 to ASW13	To Most Distal
Shed to 1" Tranistion (2" piping)	Air Flow Rate (cfm)	65.0	60.0	55.0	50.0	45.0	40.0	35.0	30.0	25.0	20.0	15.0	10.0	5.0	
	Pipe Diameter (in)	2	2	2	2	2	2	2	2	2	2	2	2	2	
	Pressure drop/10 ft pipe (in H_2O)	0.76	0.67	0.57	0.48	0.41	0.34	0.28	0.21	0.14	0.10	0.10	0.10	0.10	
	Conservative Pipe Length (ft)	500	15	15	15	15	15	15	15	15	15	15	15	15	680.0
	No of through tees	0	1	1	1	1	1	1	1	1	1	1	1	1	12.0
	Equivalent pipe length per tee (ft)	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	
	Length (ft)	0	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	51.6
	No of branch tees	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Equivalent pipe length per tee (ft)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Number of Gate Valves (fully open)*	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Equivalent pipe length per valve (ft)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Number of 45 degree elbows	2	0	0	0	0	0	0	0	0	0	0	0	0	2.0
	Equivalent pipe length per elbow (ft)	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	
	Length (ft)	5.6	0	0	0	0	0	0	0	0	0	0	0	0	5.6
	Number of 90 degree elbows	4	0	0	0	0	0	0	0	0	0	0	0	0	4.0
	Equivalent pipe length per elbow	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	
	Length (ft)	22	0	0	0	0	0	0	0	0	0	0	0	0	22.0
	Number of reducers	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Equivalent pipe length per elbow	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Total - 2"	**Total Equivalent Length (ft)**	528	19	19	19	19	19	19	19	19	19	19	19	19	759.2
	Friction loss (in H_2O)	40.2	1.3	1.1	0.9	0.8	0.7	0.5	0.4	0.3	0.2	0.2	0.2	0.2	47.0
	Friction loss (psi)	1.45	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	1.70
Transition to Well Head (1" piping)	Air Flow Rate (cfm)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
	Pipe Diameter (in)	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Pressure drop/10 ft pipe (in H_2O)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	
	Conservative Pipe Length (ft)	12	12	12	12	12	12	12	12	12	12	12	12	12	
	No of through tees	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Equivalent pipe length per tee (ft)	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	
	No of branch tees (1")	1	1	1	1	1	1	1	1	1	1	1	1	0	
	Equivalent pipe length per tee (ft)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
	Length (ft)	12	12	12	12	12	12	12	12	12	12	12	12	0	
	Number of Gate Valves (fully open)*	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Equivalent pipe length per valve (ft)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Number of 45 degree elbows	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Equivalent pipe length per elbow (ft)	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Number of 90 degree elbows (1")	0	0	0	0	0	0	0	0	0	0	0	0	1	
	Equivalent pipe length per elbow	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	5.5	
	Number of reducers (1")	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Equivalent pipe length per elbow	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	
	Length (ft)	8	8	8	8	8	8	8	8	8	8	8	8	8	
Total - 1"	**Total Equivalent Length (ft)**	32	32	32	32	32	32	32	32	32	32	32	32	25.5	
	Friction loss (in H_2O)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5	
	Friction loss (psi)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Total - Leg 1		**S to ASW01**	**S to ASW02**	**S to ASW03**	**S to ASW04**	**S to ASW05**	**S to ASW06**	**S to ASW07**	**S to ASW08**	**S to ASW09**	**S to ASW10**	**S to ASW11**	**S to ASW12**	**S to ASW13**	
	Friction loss (in H_2O)	40.9	42.2	43.3	44.2	45.0	45.7	46.2	46.6	46.9	47.1	47.2	47.4	47.5	
	Friction loss (psi)	1.48	1.52	1.56	1.60	1.63	1.65	1.67	1.68	1.69	1.70	1.71	1.71	1.72	

Existing Biosparge Well	**ASW13**
Air Flow Rate (cfm)	5.0
Pipe Diameter (in)	1.0
Friction loss/10 ft pipe (in H_2O)	0.21
Number of gate valves	1
Equivalent pipe length per ball valve (ft)	1.0
Length (ft)	1.00
No of branch tees	1
Equivalent pipe length per tee (ft)	6.0
Length (ft)	6
Number of check valves	0
Equivalent pipe length per check valve (ft)	9.0
Length (ft)	0
Length of well (assumed Galvanized)	48.4
Pipe Diameter (in)	1
Pressure drop/10 ft pipe (in H_2O)	0.21
Friction loss (in H_2O)	1.02
Total Equivalent Length (ft)	7.0
Friction loss (in H_2O)	1.2
Friction loss (psi)	0.04

Leg 2 (Shed [S] to ASWs) - Chemair Lines

		S to ASW14	ASW14 to ASW15	ASW15 to ASW16	ASW16 to ASW17	ASW17 to ASW18	ASW18 to ASW19	ASW19 to ASW20	ASW20 to ASW21	ASW21 to ASW22	ASW22 to ASW23	ASW23 to ASW24	ASW24 to ASW25	To Most Distal
Shed to 1" Transition (2" piping)	Air Flow Rate (cfm)	60.0	55.0	50.0	45.0	40.0	35.0	30.0	25.0	20.0	15.0	10.0	5.0	
	Pipe Diameter (in)	2	2	2	2	2	2	2	2	2	2	2	2	
	Pressure drop/10 ft pipe (in H_2O)	0.67	0.57	0.48	0.41	0.34	0.28	0.21	0.14	0.10	0.10	0.10	0.10	
	Conservative Pipe Length (ft)	698	15	15	15	15	15	15	15	15	15	15	15	863.0
	No of through tees	0	1	1	1	1	1	1	1	1	1	1	1	11.0
	Equivalent pipe length per tee (ft)	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	
	Length (ft)	0	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	47.3
	No of branch tees	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Equivalent pipe length per tee (ft)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Number of Gate Valves (fully open)*	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Equivalent pipe length per valve (ft)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Number of 45 degree elbows	2	0	0	0	0	0	0	0	0	0	0	0	2.0
	Equivalent pipe length per elbow (ft)	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	
	Length (ft)	5.6	0	0	0	0	0	0	0	0	0	0	0	5.6
	Number of 90 degree elbows	4	0	0	0	0	0	0	0	0	0	0	0	4.0
	Equivalent pipe length per elbow	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	
	Length (ft)	22	0	0	0	0	0	0	0	0	0	0	0	22.0
	Number of reducers	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Equivalent pipe length per elbow	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Total - 2"	**Total Equivalent Length (ft)**	726	19	19	19	19	19	19	19	19	19	19	19	938
	Friction loss (in H_2O)	48.5	1.1	0.9	0.8	0.7	0.5	0.4	0.3	0.2	0.2	0.2	0.2	53.9
	Friction loss (psi)	1.75	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	1.95
Transition to Well Head (1" piping)	Air Flow Rate (cfm)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
	Pipe Diameter (in)	1	1	1	1	1	1	1	1	1	1	1	1	
	Pressure drop/10 ft pipe (in H_2O)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	
	Conservative Pipe Length (ft)	12	12	12	12	12	12	12	12	12	12	12	12	
	No of through tees	0	0	0	0	0	0	0	0	0	0	0	0	
	Equivalent pipe length per tee (ft)	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	
	No of branch tees (1")	1	1	1	1	1	1	1	1	1	1	1	0	
	Equivalent pipe length per tee (ft)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	
	Length (ft)	12	12	12	12	12	12	12	12	12	12	12	0	
	Number of Gate Valves (fully open)*	0	0	0	0	0	0	0	0	0	0	0	0	
	Equivalent pipe length per valve (ft)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	
	Number of 45 degree elbows	0	0	0	0	0	0	0	0	0	0	0	0	
	Equivalent pipe length per elbow (ft)	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	0	
	Number of 90 degree elbows (1")	0	0	0	0	0	0	0	0	0	0	0	1	
	Equivalent pipe length per elbow	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	
	Length (ft)	0	0	0	0	0	0	0	0	0	0	0	5.5	
	Number of reducers (1")	1	1	1	1	1	1	1	1	1	1	1	1	
	Equivalent pipe length per elbow	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	
	Length (ft)	8	8	8	8	8	8	8	8	8	8	8	8	
Total - 1"	**Total Equivalent Length (ft)**	32	32	32	32	32	32	32	32	32	32	32	25.5	
	Friction loss (in H_2O)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5	
	Friction loss (psi)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Total - Leg 2		**S to ASW14**	**S to ASW15**	**S to ASW16**	**S to ASW17**	**S to ASW18**	**S to ASW19**	**S to ASW20**	**S to ASW21**	**S to ASW22**	**S to ASW23**	**S to ASW24**	**S to ASW25**	
	Friction loss (in H_2O)	49.1	50.2	51.2	52.0	52.6	53.2	53.6	53.8	54.0	54.2	54.4	54.5	
	Friction loss (psi)	1.78	1.82	1.85	1.88	1.90	1.92	1.94	1.95	1.95	1.96	1.97	1.97	

Existing Biosparge Well	ASW25
Air Flow Rate (cfm)	5.0
Pipe Diameter (in)	1.0
Friction loss/10 ft pipe (in H_2O)	0.21
Number of gate valves	1
Equivalent pipe length per ball valve (ft)	1.0
Length (ft)	1.00
No of branch tees	1
Equivalent pipe length per tee (ft)	6.0
Length (ft)	6
Number of check valves	0
Equivalent pipe length per check valve (ft)	9.0
Length (ft)	0
Length of well (assumed Galvanized)	48.4
Pipe Diameter (in)	1
Pressure drop/10 ft pipe (in H_2O)	0.21
Friction loss (in H_2O)	1.02
Total Equivalent Length (ft)	7.0
Friction loss (in H_2O)	1.2
Friction loss (psi)	0.04