# LAUNCH COMPLEX 39B, SWMU 009
# AIR SPARGING SYSTEM EXPANSION
# IMPLEMENTATION WORK PLAN
# KENNEDY SPACE CENTER, FLORIDA

**Prepared for:**

**National Aeronautics and Space Administration**
**Kennedy Space Center, Florida**

**October 2023**
**Revision 0**

**Prepared by:**

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**AIR SPARGING SYSTEM EXPANSION**
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Prepared for:
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National Aeronautics and Space Administration
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October 2023

## PROFESSIONAL ENGINEER CERTIFICATION

This Implementation Work Plan for the Air Sparging System Expansion at Launch Complex 39B, Solid Waste Management Unit 009, at Kennedy Space Center, Florida, dated October 2023, has been prepared by or under the responsible supervision, direction, or control of the Florida-licensed professional engineer whose signature and seal appear below. This document and the work described herein complies with standard professional practices and requirements of Chapter 62-780, Florida Administrative Code (F.A.C.) and other rules of the Florida Department of Environmental Protection according to Rule 62-780.400(1), F.A.C.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ADP | Advance Data Package |
| AS | Air Sparging |
| ASTM | American Society of Testing and Materials |
| bls | below land surface |
| BMP | Best Management Practice |
| CAO | Corrective Action Objective |
| CCR | Construction Completion Report |
| cDCE | cis-1,2-Dichloroethene |
| COC | Contaminant of Concern |
| CVOC | Chlorinated Volatile Organic Compound |
| DOT | Department of Transportation |
| DPT | Direct Push Technology |
| F.A.C. | Florida Administrative Code |
| FDEP | Florida Department of Environmental Protection |
| GCTL | Groundwater Cleanup Target Level |
| GPR | Ground Penetrating Radar |
| HAP | Hazardous Air Pollutant |
| HCP | High-Concentration Plume |
| HDPE | High-Density Polyethylene |
| HS1 | Hot Spot 1 |
| HS2 | Hot Spot 2 |
| I.D. | Inside Diameter |
| IDIQ | Indefinite Delivery Indefinite Quantity |
| IDW | Investigation-Derived Waste |
| IM | Interim Measure |
| IWP | Implementation Work Plan |
| JPEG | Joint Photographic Experts Group |
| KSC | Kennedy Space Center |
| KSCRT | Kennedy Space Center Remediation Team |

## ACRONYMS AND ABBREVIATIONS (CONTINUED)

| | |
|---|---|
| LC39A | Launch Complex 39A |
| LC39B | Launch Complex 39B |
| LCP | Low-Concentration Plume |
| LOX | Liquid Oxygen |
| LTM | Long-Term Monitoring |
| mg/kg | milligrams per kilogram |
| MNA | Monitored Natural Attenuation |
| NAD | North American Datum |
| NADC | Natural Attenuation Default Concentration |
| NAVD | North American Vertical Datum |
| NASA | National Aeronautics and Space Administration |
| NPDES | National Pollutant Discharge Elimination System |
| O&M | Operation and Maintenance |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PCB | Polychlorinated Biphenyl |
| PFAS | Per- and Polyfluoroalkyl Substances |
| PID | Photoionization Detector |
| PLC | Programmable Logic Control |
| POL | Paint & Oil Locker (remediation site) |
| PPE | Personal Protective Equipment |
| psig | pound per square inch gauge |
| PVC | Polyvinyl Chloride |
| RCRA | Resource Conservation and Recovery Act |
| REC | Record of Environmental Consideration |
| RIS | Remediation Information System |
| ROI | Radius of Influence |
| RPM | Remediation Project Manager |
| SAP | Sampling and Analysis Plan |
| scfm | standard cubic feet per minute |

## ACRONYMS AND ABBREVIATIONS (CONTINUED)

| | |
|---|---|
| SDR | Standard Diameter Ratio |
| SLS | Space Launch System |
| SOP | Standard Operating Procedure |
| SSHASP | Site-Specific Health and Safety Plan |
| STS | Space Transportation System |
| SWMU | Solid Waste Management Unit |
| SWPPP | Stormwater Pollution Prevention Plan |
| TCE | Trichloroethene |
| tDCE | trans-1,2-Dichloroethene |
| TOC | Total Organic Carbon |
| TRPH | Total Recoverable Petroleum Hydrocarbons |
| µg/L | micrograms per liter |
| USEPA | U.S. Environmental Protection Agency |
| VC | Vinyl Chloride |
| VOC | Volatile Organic Compound |

# EXECUTIVE SUMMARY

This Implementation Work Plan (IWP) for expansion of the Air Sparging (AS) system at Launch Complex 39B (LC39B), presents the design and coordination specifics to expand the existing AS Interim Measure (IM) at LC39B located at Kennedy Space Center (KSC), Florida. The existing AS system at LC39B was installed in 2017 and included 279 AS wells. LC39B has been designated as Solid Waste Management Unit (SWMU) 009 under the KSC Resource Conservation and Recovery Act (RCRA) Corrective Action Program.

Expansion of the AS IM will include installation of an additional five AS wells to depths of approximately 13 and 17 feet below land surface (bls) to remediate contaminated groundwater identified northwest of the launch pad, near the liquid oxygen (LOX) tank. The expansion will target concentrations of cis-1,2-dichloroethene (cDCE) and vinyl chloride (VC) greater than Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentrations (NADCs) that were identified during direct push technology (DPT) sampling events between 2019-2022 in shallow intervals between 8 and 16 feet bls. The objective for this expansion is to remediate contaminated groundwater within the treatment zone to below NADCs to support transition to monitored natural attenuation (MNA) through a long-term monitoring (LTM) program. This expansion will treat approximately 0.07-acres of residual groundwater contamination.

The IWP design for this expansion will utilize the existing AS system trailer that is already on-site and operating. The five new AS expansion wells will be integrated into the existing Zone Z4 distribution manifold to deliver compressed air to the new AS wells. To deliver airflow, three existing lateral lines will be split in the field at a lateral split junction point (using 2-way or 3-way splits). Each split lateral will supply air to AS wells at the same depth interval to minimize preferential pathways. The trenching layout for the new AS wells was developed to minimize ground disturbance due to the amount of utilities in the area. One new monitoring well will also be installed and added to LC39B's performance monitoring program to evaluate the effectiveness of the AS system expansion. This well will be sampled on a semi-annual basis for volatile organic compounds, with results evaluated to determine if system adjustments may be required.

The main components of this IWP were presented to the KSC Remediation Team (KSCRT) at the October 2022 Meeting (Meeting 2210-M05). DPT delineation data from the LOX area were also presented, which included some inferred boundaries due to physical restrictions of the LOX tank and associated concrete pad and infrastructure. Planned monitoring well sampling in this area will help determine if back-diffusion may be occurring from beneath the pad. Additionally, based on potential petroleum odors and staining identified at two DPT locations during the January 2022 DPT event in the 10-16 feet bls range, a KSCRT action item was assigned during the October 2022 meeting to collect soil samples for petroleum compounds if similar odors or staining are identified during IM implementation.

Construction completion and performance monitoring will be incorporated into LC39B's groundwater monitoring reports, which are currently submitted on an annual basis to FDEP to document operation and maintenance activities and results from the AS IM.

# SECTION I
# INTRODUCTION

This Implementation Work Plan (IWP) for expansion of the Air Sparging (AS) system Interim Measure (IM) at Launch Complex 39B (LC39B) was prepared by Tetra Tech, Inc., for the National Aeronautics and Space Administration (NASA) under the Indefinite Delivery Indefinite Quantity (IDIQ) Contract 80KSC019D0011, Task Order 80KSC019F0069. LC39B is located at Kennedy Space Center (KSC), Florida, and has been designated as Solid Waste Management Unit (SWMU) 009 under the KSC Resource Conservation and Recovery Act (RCRA) Corrective Action Program.

This IWP presents the design and coordination specifics to expand the existing AS system at LC39B with installation of an additional five AS wells in an area northwest of the launch pad near AS treatment zone, Z4. Expansion of the AS system is designed to remediate residual contaminated groundwater identified during direct push technology (DPT) sampling events between 2019 and 2022 near the liquid oxygen (LOX) tank. This area is near Hot Spot 2 (HS2) where groundwater concentrations have historically been greater than Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentrations (NADCs). The design presented in this IWP includes a description of the installation of infrastructure required to accommodate the expanded AS system.

Groundwater delineation results and AS system expansion plans were presented during the October 2022 KSC Remediation Team (KSCRT) meeting. The advance data package (ADP) presented at this meeting, titled *Launch Complex 39B (SWMU 009), LOX Area DPT Investigations and Air Sparging Expansion*, is included in Appendix A. Meeting minutes for this presentation can be found in Appendix B.

## 1.1 SITE SETTING AND HISTORY

KSC is located in the northern portion of Merritt Island, between the Indian and Banana River Lagoons, in Brevard County, Florida. LC39B is located in the eastern portion of KSC, approximately 0.5 mile inland from the Atlantic Ocean, oriented parallel to the coastline. The launch complex encompasses approximately 160 acres, is octagonal in shape, and surrounded by a 7-foot-high chain-link fence topped with a 1-foot barbed-wire top guard. LC39B is located in a depositional environment of undulating relic swales and broad longitudinal dunes comprising Merritt Island, part of the Indian River Lagoon barrier island complex.

The topography surrounding LC39B is relatively flat and increases in elevation toward the launch pad. The elevation was raised with fill dredged from the area of Gator Hole (a surface water body between Launch Complex 39A [LC39A] and LC39B) to accommodate construction of the launch complex. LC39B encompasses portions of the Wilson, Wilson OE East, Orsino, and False Cape United States Geological Survey Quadrangles within Section 28 and Section 33 of Township 21S, Range 37E.

The location of LC39B within KSC is presented on Figure C-1, and a site layout map of LC39B is presented as Figure C-2. Figures are provided in Appendix C.

## 1.2 BACKGROUND

LC39B was constructed in the mid-1960s to support the Apollo Space Program and the United States' mission to the Moon. The first launch from LC39B occurred in 1969 (Apollo 10), which was the first manned flight to orbit the moon. Following conclusion of the Apollo Space Program, the permanent service tower at the launch pad was replaced with a "clean pad" design to support the Space Shuttle Program. The 1981 launch of Space Shuttle Columbia, or Space Transportation System (STS)-1, from LC39A, marked the initiation of the Space Shuttle era at LC39A and LC39B, and spanned several decades until the Space Shuttle program's conclusion in 2011. In 2009, the Ares-1X test launch was conducted from LC39B in support of the Constellation Program. After this program was cancelled in 2010, the Flight Service Structure was removed from LC39B, returning it to the more versatile "clean pad" design. Since then, LC39B has been upgraded to be a multi-user launch pad, to include NASA's Space Launch System (SLS) rocket and Orion Spacecraft Artemis missions. The first SLS rocket launch, Artemis I (unmanned), occurred on November 16, 2022.

Historical use of chlorinated solvents during the early years of the space program resulted in groundwater contamination at LC39B. The extent of the LC39B groundwater plume was delineated during the 2014 Baseline Reassessment (see Figure C-2) (NASA, 2014). In 2017, an AS system was installed in the western half of the launch complex, extending northwest towards the LOX tank. Full-scale operation began in July 2017. The LC39B AS system was installed with 279 AS wells to depths ranging from 23 to 60 feet below land surface (bls), and with operations split between four treatment zones (Z1 to Z4). Over the years, Zones Z1, Z2, and Z3 have been turned off as IM objectives have been met. Most recently in December 2022, a total of 22 AS wells (three in Zone Z1 and 19 in Zone Z3) were abandoned to support launch pad crane operations. The layout of the existing AS system is shown on Figure C-3.

A more detailed overview of LC39B's background can be found in the most recent annual monitoring report (NASA, 2023).

## 1.3 REMEDIAL HISTORY AND SITE CHARACTERIZATION SUMMARY

Beginning in the mid-1990s, a number of site investigations and IMs were conducted at LC39B. Soil and groundwater contamination was identified, with soil achieving No Further Action status following a soil IM completed in 2015-2016 (NASA, 2016b). Chlorinated solvents are the primary contaminants of concern (COCs) in groundwater and have been detected above FDEP cleanup criteria. The overall mass of chlorinated solvents previously released at the site is unknown.

The following information provides a summary of the residual chlorinated solvent plume, with focus on the area of remaining NADC exceedances being addressed in this AS expansion IWP. A more comprehensive history of remedial actions, monitoring events, and cleanup progress made to date can be found in the most recent annual monitoring report (NASA, 2023).

Conclusion of the STS Program in 2011 provided easier access for environmental investigation near the launch pad. A Re-Assessment Investigation was therefore completed in 2014 to provide new baseline delineation for contamination of groundwater. Field activities included five soil borings advanced to a maximum depth of approximately 80 feet bls, collection of five soil samples for fractional organic carbon analysis, 1,730 DPT groundwater samples from 296 locations for volatile organic compound (VOC) analysis, and completion of two membrane interface probe/cone penetrometer testing profiles. Baseline reassessment results for groundwater, surface water, sediment, and soil were presented in the Baseline Reassessment Report (NASA, 2014). In 2015, KSCRT consensus was reached on delineation of Hot Spot 1 (HS1), HS2, high-concentration plume (HCP), and low-concentration plume (LCP) for trichloroethene (TCE), cis-1,2-dichloroethene (cDCE), and vinyl chloride (VC). The maximum depths of contamination identified in the HS areas were 55 feet bls (HS1) and 28 feet bls (HS2), with total delineated areas as follows: HS1 (1.08 acres), HS2 (0.16 acres), HCP (8.69 acres), and LCP (26.62 acres).

An AS IM was subsequently selected to treat the HCP, including HS1 and HS2, with AS design details presented in an IM Work Plan (NASA 2016a). Construction of the AS system was implemented in January 2017 and consisted of 279 AS wells, with four operational zones and 13 separate legs. System startup and prove-out activities for the LC39B AS system were completed in early 2017. Details regarding these activities can be found in the AS Construction Completion Report (CCR) for LC39B (NASA, 2017b). Full-scale system operation began in July 2017.

After two years of AS operation, DPT sampling events were completed in August 2019 and September/October 2020 to evaluate overall effectiveness of the AS IM in areas outside of the AS radius of influence (ROI) (NASA, 2021a). cDCE and VC concentrations exceeding their respective NADCs were identified in the HS2 area near the LOX tank during these DPT events. A supplemental DPT event was conducted in January 2022 to complete delineation of NADC exceedances in the LOX area (NASA, 2023). A ground penetrating radar (GPR) survey was also conducted to support this DPT event due to the extent of utilities in the LOX area.

Maximum concentrations from the January 2022 DPT sampling event were: TCE (10 micrograms per liter [μg/L] at DPT2000-A, 12-16 feet bls), cDCE (1,000 μg/L at DPT2019-F, 8-12 feet bls), trans-1,2-dichloroethene (tDCE) (140 μg/L at DPT2022-E, 8-12 feet bls), and VC (1,500 μg/L at DPT2022-E, 8-12 feet bls). The residual NADC (referred to as the HCP) and 10-times NADC (referred to as the HS) exceedances were found in the 8-12 feet bls and 12-16 feet bls intervals, with some locations in close proximity to the concrete pad supporting the LOX tank. Coring through concrete was not permissible in the LOX area and therefore delineation sampling could not be completed under the pad. Delineation boundaries in this area are therefore inferred due to physical restrictions (LOX tank and associated concrete pad and infrastructure). Figure C-4 illustrates the DPT dataset for groundwater samples that have been collected over the years in the LOX area.

In addition to groundwater samples, soil samples were collected from three DPT locations in January 2022 for Total Organic Carbon (TOC) and VOC analysis: DPT2000-A (SB1676), DPT2021-H (SB1678), and DPT2001-D (SB1677). TOC levels ranged from 3,200 to 120,000 milligrams per kilogram (mg/kg), suggesting organic carbon (natural or contaminant) remains present in saturated matrix to support reductive dechlorination; although, additional data (e.g., monitored natural attenuation [MNA] parameters) would be needed to evaluate potential biodegradation rates. VOC detections were all low-level and below residential soil cleanup target levels, or less than method detection limits, indicating no sorbed source material. The soil sample locations are illustrated on Figure C-5.

As part of the January 2022 DPT sampling event, soil cores were also collected to 20 feet bls to evaluate lithology. Boring logs from this event confirmed a transition to fine sands at approximately 10 feet bls, which indicates that lithology may be playing a role in residual HS and HCP concentrations in the 8-12 feet bls and 12-16 feet bls intervals in this area. Intermittent clay layers have also been historically encountered around 8-12 feet bls at LC39B, as well as at nearby site LC39A where it was encountered during the most recent DPT event at that site in 2021 (NASA, 2022). In addition to lithology, the placement of existing AS wells, which are located in the general vicinity of residual NADC exceedances and screened at 22 feet bls or 37 feet bls, may also being playing a role in why AS treatment is not adequately reaching residual NADC exceedances in these shallow intervals.

During soil core evaluation, potential petroleum odors and staining were logged at two DPT locations in the 10-16 feet bls range (DPT2019-F and DPT2020-G), which are both located near the edge of the concrete slab (see Figure C-5). No petroleum exceedances were detected in groundwater from nearby monitoring well, MW0032 (screened 8-18 feet bls). During the KSCRT Meeting in October 2022, an action item was assigned to collect soil samples for petroleum compounds if similar odors and staining are observed during AS expansion activities, with consensus to analyze soil samples for polycyclic aromatic hydrocarbons (PAHs) and total recoverable petroleum hydrocarbons (TRPH) (Meeting Minute 2210-M05, Action Item 2210-A05, Decision 2210-D09). This sampling requirement is referenced in Section IV of this IWP.

Results from the January 2022 DPT investigation were presented to the KSCRT in October 2022 to summarize the data evaluation and determine if delineation of NADC exceedances in the LOX area was achieved. A total of 56 groundwater samples at 18 locations from the August 2019, September 2020, and January 2022 DPT events were used to contour the HCP and HS, with January 2022 results generally taking precedence over previous events. Overall, delineation was complete in areas accessible with a drill rig; however, inferred boundaries for the HCP were made on the southern side of the LOX tank concrete due to physical restrictions (LOX tank and associated concrete pad and infrastructure). The extent of the plume beneath the concrete pad is unknown; however, monitoring well sampling in this area will help determine if back-diffusion may be occurring from beneath the pad. Delineation and inferred contours are shown on Figure C-5. Consensus from the KSCRT was reached to install five new AS wells and one new monitoring well to remediate and monitor the residual NADC exceedances in LOX area (Meeting Minute 2210-M05, Decisions 2210-D08 and -D10).

A full review of the January 2022 DPT sampling event with analytical laboratory data can be found in the most recent annual monitoring report (NASA, 2023). The ADP from the October 2022 KSCRT meeting is included in Appendix A. Meeting minutes for this presentation can be found in Appendix B.

The area of remaining NADC exceedances near the LOX tank is the focus of this IWP and is where the AS system expansion is proposed (see Figure C-6). This expansion will treat groundwater contamination with the goal to reduce COCs to less than NADCs. The area of NADC exceedances (the HCP) based on the 2019-2022 DPT sampling events, and a cross-section isopleth across the proposed expansion area (A-A’) is presented on Figure C-7.

## 1.4 LITHOLOGY

The surficial soils of LC39B generally consist of unconsolidated very fine to fine-grained sands and shell, with interfingering layers of silty and clayey fine-grained sands to a depth of approximately 60 feet bls (NASA, 2019). From approximately 8 to 12 feet bls, a two to four-foot-thick clay layer has been encountered intermittently at LC39B. Around 10 feet bls the transition from dense sand to loose sand with silt and shells occurs, extending to about 42 feet bls. Boring data from the January 2022 DPT sampling event, which included soil cores collected to 20 feet bls, confirmed this transition in the shallow interval at about 12 feet bls. Deeper lithology, evaluated during previous sampling events, shows a sandy clay found alternating with clay and silty clay layers, which were initially encountered at 60 feet bls and prevailed to about 95 feet bls (NASA, 2019). Several AS wells installed in 2017 extend down to 60 feet bls, just above this clay layer.

Based on historical soil boring data collected prior to construction of the launch pads, the confining to semi-confining layer initially encountered at approximately 60 feet bls is found to be continuous to approximately 110 feet bls. At this depth, the Hawthorn Formation is encountered. The Hawthorn Formation is typically 30 to 50 feet thick in this area and represents the overlying confining unit to the Floridan Aquifer system (Clarke, E.E. Engineers-Scientists, 1987).

Groundwater data from within the proposed AS system expansion area shows NADC exceedances remaining mostly within the 8-12 feet bls interval, just above the shallow fine sand layer identified in this area (see Figure C-7). There was also one NADC exceedance location within the 12-16 feet bls interval. Based on soil core observations described above, this indicates that lithology may be playing a role in residual NADC exceedances in these intervals.

## 1.5 DOCUMENT ORGANIZATION

The remainder of this document is organized as follows:

*Section II: Interim Measure Summary* – presents a summary of the IM objectives and technical approach for implementation of the AS system expansion.

*Section III: Permitting Requirements and Site Preparation* – details the permitting and site preparation requirements.

*Section IV: Interim Measure Implementation* – discusses the technology to be implemented, details of the monitoring well and AS system, and installation processes.

*Section V: System Commissioning, Verification, and Operation and Maintenance* – describes the steps taken to commission the expanded AS system and transition to full-scale operation.

*Section VI: Performance Monitoring Program* – describes how process and performance monitoring will be implemented, including baseline and post-startup sampling.

*Section VII: Site Controls* – discusses the measures that will be taken to prevent or mitigate unintended exposure to human health and the environment.

*Section VIII: Waste Management Procedures* – describes the processes by which contaminated groundwater, decontamination liquids, and other items will be disposed of.

*Section IX: Remediation Management* – covers various administrative aspects of the project, including scheduling, reporting, and data quality management.

*Section X: References* – lists the documents referenced in this IWP.

# SECTION II
# INTERIM MEASURE SUMMARY

## 2.1 CONTAMINANTS OF CONCERN

As discussed in Section 1.3, the COCs in the AS expansion area exceeding FDEP NADCs include cDCE and VC down to a depth of 16 feet bls. TCE and tDCE were also detected in the expansion area, but only above State of Florida Groundwater Cleanup Target Levels (GCTLs). Groundwater results from DPT sampling events collected over the years in the AS expansion area are illustrated on Figure C-4.

## 2.2 INTERIM MEASURE OBJECTIVE

The IM objective for the AS expansion is to remediate contaminated groundwater within the treatment zone to support transition of the site to MNA through a Long-Term Monitoring (LTM) program. The objective was developed to provide an approach where certain metrics such as remedial performance, plume dynamics, and natural attenuation characteristics can be evaluated to determine an endpoint to the IM. The current Corrective Action Objective (CAO) for the AS IM at LC39B is to reduce concentrations of COCs to less than NADCs via AS. This objective has been achieved for Zones Z1, Z2, and Z3, and are therefore currently turned off. Zone Z4 continues to operate. The overall CAO for the LC39B groundwater plume, to reach No Further Action status, is to reduce concentrations of all groundwater contaminants to below State of Florida GCTLs.

## 2.3 TECHNICAL APPROACH SUMMARY

Compressed air will be injected into the subsurface via one mechanical process system, a conveyance network, and an AS well network. The compressed air will be injected using diffusers to provide a fine bubble matrix to volatilize COCs into a gaseous form. As a secondary treatment mechanism, the AS application will increase the dissolved oxygen content of groundwater, promoting aerobic COC biodegradation.

A network of five new AS wells, 1-inch in diameter, will be installed in the expansion area. These wells will be configured into the existing Zone Z4 manifold based on its geographical proximity to the expansion area (see Figure C-8). The new AS wells will be supplied with compressed air from the existing AS system trailer at LC39B (which was recently relocated from another remediation site at KSC; Paint & Oil Locker [POL] Southern Treatment Area), and flow to the existing AS wells in Zone Z4 will be re-balanced to account for the five new AS wells coming online in the expansion area. The existing AS trailer has the capacity to incorporate these additional five AS wells into existing operations. Running all 51 AS wells within Zone Z4 (46 existing plus five new expansion) would require 306 standard cubic feet per minute (scfm) (based on design of 6 scfm per AS well), which is less than the 350 scfm that the compressor can deliver.

To deliver airflow to the five new AS expansion wells, three existing lateral lines will be split in the field. The location of the lateral line splits will be at the junction point where AS wells 242, 243, and 245 separate into their own trenches going towards their respective AS wells (see Figure C-8). One line will be converted into a 2-way split using a T-shaped fitting that leads to the two new 17 foot bls AS wells (280 and 281). The other two lines will be converted into 3-way splits using two consecutive T-shaped fittings (with connecting nipple), to each supply air to three AS wells. One of the 3-way split laterals will supply air to the three existing 22 foot bls AS wells (the three that previously had dedicated lateral lines – 242, 243, and 245). The other 3-way split lateral will supply air to the three new 13 foot bls AS wells (282, 283, and 284). Because new AS wells will be direct buried with no finished well pad, airflow will be controlled at the manifold distribution cabinet (e.g., for the 3-way split lateral, the flowmeter will be set at the manifold to deliver a total flowrate for all three AS wells that will then be split at the lateral split junction point). The split laterals were designed to supply air to AS wells at the same depth interval (13, 17, or 22 feet bls) to minimize preferential pathways from being formed via differences in head pressure resistance.

The existing manifold cabinet will be used to balance flow and pressure and to distribute compressed air to the AS wells via 1-inch diameter standard diameter ratio (SDR) 11 high density polyethylene (HDPE) lateral piping. Flowmeters at the distribution manifold currently only gauge up to 14 scfm. Because two laterals leaving the manifold cabinet will have a 3-way split, the manifold will have to deliver 18 scfm to those lines such that each individual

AS well can receive the design flowrate of 6 scfm. Consequently, the flowmeters at the manifold cabinet corresponding to those laterals will be replaced with flowmeters that can measure at least 18 scfm. The flowmeter for the 2-way split will also be replaced to ensure airflow is properly regulated to that lateral. The existing header line, which includes a 2-inch diameter SDR 11 HDPE line and currently supplies compressed air from the AS system to Zone Z4, will also be used for the expansion (no new header line required).

Based on the lithology and shallow depth of AS wells to be installed in the expansion area, a design ROI of 15 feet was assumed for placement of each well. This is less than the existing AS wells at the site, which were installed using a 20-foot ROI design. The new AS wells will be installed immediately above the intermittent, shallow fine sand layer at depths of approximately 13 and 17 feet bls (Figure C-9). The location of the fine sand layer will be confirmed via soil cores during installation. AS wells will be constructed with diffusers to distribute fine air bubbles within the treatment zone. The new AS wells will be tied into Zone Z4 (Leg 1). Zone Z4 (Legs 1 and 2) is currently operating continuously, but may be pulsed when new AS wells are brought online to minimize development of channels that could result in preferential pathways and diminished AS removal efficiency. One new monitoring well will also be installed within the expanded AS well network area to provide performance monitoring data for the treatment area.

Like the existing LC39B AS IM, soil vapor extraction will not be utilized for the expansion treatment area for two reasons: (1) The location of the treatment area is not near occupied surface structures or site personnel; and (2) The total calculated annual emissions is less than the Hazardous Air Pollutants (HAPs) annual emissions limit of 1,000 pounds for a single contaminant and 2,500 pounds for total contaminants. The AS emissions calculation, which is included in Appendix D, is based on the 2019-2022 DPT groundwater dataset used for delineation. The calculation focuses on the area where groundwater concentrations still exceed NADCs within the proposed AS expansion area. The rest of Zone Z4 will continue to operate with the expansion area, but emissions are considered negligible based on groundwater concentrations and extent of time that the AS system has been running.

The following subsections describe the main components of the expanded AS IM. These components were presented to the KSC Remediation Team at the October 2022 meeting (Meeting 2210-M05).

**2.3.1 Air Sparging Wells**. A total of five AS wells will be installed, with three installed to a depth of approximately 13 feet bls, and two installed to a depth of approximately 17 feet bls. Soil cores will be collected and evaluated at the bottom of each AS well for identification of the final screen placement. During this process, each core will be observed for potential petroleum odor and staining, which was identified at two DPT locations during the January 2022 DPT event in the 10-16 feet bls range. If similar odors or staining is identified, the NASA Remediation Project Manager (RPM) will be notified and soil samples will be collected and analyzed for PAHs and TRPH, per KSCRT Action Item (2210-A05).

As discussed in the previous section, the new AS wells will be incorporated into Zone Z4, and will be tied into Leg 1 operations. Design pressure was evaluated using two different scenarios to ensure pressure requirements are suitable to deliver air to all new and existing AS wells in Leg 1. Scenario 1 evaluated pressure requirements using the longest lateral length (for a single dedicated line) from the Zone Z4 manifold (ASW234), which would introduce the highest pressure drop based on distance of airflow travel. Scenario 2 evaluated pressure requirements for the expansion area where higher flowrates from the manifold will be split (between several lateral lines in the field) to supply AS wells in this area. This scenario used the AS well (with longest lateral length and depth) that will receive airflow from a 3-way lateral split (ASW243). The higher pressure requirement of 18 pound per square inch gauge (psig) was used for manifold design. Design calculations are included in Appendix D.

The new AS wells will be constructed with 1-inch inside diameter (I.D.) Schedule 40 polyvinyl chloride (PVC) casings and 20-inch long, 40-micron Schumasoil diffusers. At LC39B, all existing AS wells are constructed as 2-inch I.D. AS wells with 2-foot long, 0.010-inch slotted PVC screens, and 1-foot sump. The five new expansion AS wells will be 1-inch I.D. with Schumasoil diffusers, as these have been installed with successful results at other remediation sites at KSC, including nearby LC39A. To align with the original AS system design, each AS well will be operated at a design flowrate of 6 scfm and at sufficient pressure to displace the water column within the AS well and provide air distribution. Wellhead design pressure for the expansion AS wells is 10.4 psig. Design calculations can be found in Appendix D. Final operational pressures will be established based on startup testing and performance monitoring.

The new AS well locations are presented on Figure C-8, with AS well depth profile presented on Figure C-9. The AS ROI, laid out over the NADC exceedances (the HCP), is shown on Figure C-10.

Installation details for AS wells are provided in Section 4.3.1. Table 2-1 provides a summary of AS well construction information including depths, screened intervals, and well materials. Of note, AS well numbers begin at “280”, since there were 279 AS wells installed for the original system at the site.

**2.3.2 Monitoring Wells**. One new monitoring well, with screened interval from 8 to 18 feet bls, will be installed and added to the existing LC39B monitoring well network. This well will be located in the vicinity of the HS and HCP to evaluate performance of the AS system expansion. This well will also be monitored to help determine if back-diffusion may be occurring from beneath the LOX tank concrete pad where delineation could not be completed. The monitoring well will be constructed with Schedule 40 PVC casing and a Schedule 40 PVC 0.010-inch slotted screen. This well will be installed in an unpaved area, with a flush-mount surface completion, locking well cap, and a minimum of 2-foot by 2-foot concrete pad. The concrete pad will have a depth of 6 inches, and the top of the pad is to be no more than 2 inches above ground level. This monitoring well, including its surface completion, will be completed by a Florida-licensed driller. Following installation, the well will be developed via surging and evacuation. The well will be surveyed for location and elevation by a Florida-registered surveyor.

The new monitoring well will be designated as MW0048. Table 2-2 provides monitoring well construction information, including screened interval and well material. The proposed well location is shown on Figure C-8. Section 4.2 provides additional monitoring well installation details.

## 2.4 DESIGN MODIFICATIONS

The proposed AS expansion is limited to a small area where residual NADC exceedances remain in the shallow interval between 8 and 16 feet bls. Existing AS wells installed in 2017 targeted deeper intervals, ranging from 23 to 60 feet bls. Based on soil cores collected during the January 2022 DPT sampling event, lithology in the expansion area includes fine-grained sands to about 12 feet bls, which generally coincides with residual NADC exceedances in the 8-12 and 12-16 feet bls intervals. This information was taken into account for design of the expansion AS wells, which includes five proposed AS wells that will be installed to a depth of 13 or 17 feet bls.

Expansion AS wells will be 1-inch I.D., which differs from the 2-inch I.D. AS wells designed and installed for the original system in 2017. As mentioned previously, successful implementation and results have been found at other KSC remediation sites using 1-inch I.D. AS wells. The use of 1-inch I.D. AS wells will not require a reducer to connect the lateral line to the AS well. As mentioned in Section 2.3, some flowmeters will also need to be replaced in the existing Zone Z4 manifold cabinet with ones capable of measuring the higher flowrate required for laterals that will split airflow in the field. Construction of the new AS wells will include 20-inch long, 40-micron, 1-inch I.D. Schumasoil diffusers versus the 2-foot long, 0.010-inch slotted, 2-inch ID PVC screens that were designed and used for existing AS wells. The Schumasoil screens have been successfully implemented at other KSC remediation sites with similar lithology, to include nearby LC39A.

Design calculations and assumptions relating to AS expansion are provided in Appendix D. This section of the IWP will be updated if notable design modifications, with the approval of NASA, occur.

**Table 2-1. Air Sparging Well Construction Details**

| Well ID (LC39B-AS-) | Zone | Screen Bottom (feet bls)* | Directional Boring/Angle (degrees) | Coordinates (meters) | |
|---|---|---|---|---|---|
| | | | | Easting | Northing |
| 280 | Z4 | 17 | no | 236652.973 | 475998.8489 |
| 281 | Z4 | 17 | no | 236659.7441 | 475996.6646 |
| 282 | Z4 | 13 | no | 236653.0989 | 475993.7521 |
| 283 | Z4 | 13 | no | 236660.9377 | 475991.326 |
| 284 | Z4 | 13 | no | 236654.8736 | 475988.9813 |

bls - below land surface

All wells will be 1-inch diameter Schedule 40 PVC, with 40-micron Schumasoil screen (20-inch)

Coordinates are given in NAD_1983_StatePlane_Florida_East (meters)

NAD - North American Datum

* depth will be confirmed via soil cores

**Table 2-2. Monitoring Well Construction Details**

| Well ID (LC39B-) | Screen Depth (feet bls) | Well Diameter (inch) | Screen Type | Coordinates | |
|---|---|---|---|---|---|
| | | | | Easting (meters) | Northing (meters) |
| MW0048 | 8 to 18 | 1 | 0.010-inch slot | 236657.3667 | 475990.4113 |

Coordinates are given in NAD_1983_StatePlane_Florida_East (meters)
NAD - North American Datum

# SECTION III

# PERMITTING REQUIREMENTS AND SITE PREPARATION

This section identifies the permitting requirements and necessary site preparations for implementation of this IWP.

The following will be completed prior to mobilization:

- Submittal of applications for access and identification badges;
- Submittal of required permits;
- Coordination of site reconnaissance activities through the NASA RPM; and
- Scheduling of utility location and clearances.

## 3.1 PERMIT REQUIREMENTS

IM activities at LC39B are being conducted under NASA's RCRA permit for KSC. All relevant requirements will be observed. Permits and associated requirements consist of the KSC Record of Environmental Consideration (REC), utility locate/excavation permit, and monitoring well permits.

Copies of all permits related to IM work will be retained on site and added to the field copy of this IWP in Appendix E as they are received. The Tetra Tech Construction Supervisor will be responsible for maintaining all required records for the duration of the project. After demobilization, permitting records will be maintained in Tetra Tech's Pittsburgh, Pennsylvania office. Copies of all permits received will also be included in Construction Completion reporting once expansion is complete.

**3.1.1 KSC Record of Environmental Consideration.** A KSC REC is required for this project. The KSC REC lists environmental requirements associated with the project that must be completed to assure compliance with all applicable environmental regulations. Based on discussions with NASA, the REC obtained for DPT sampling in January 2022 (REC #11626) will be updated to complete AS system expansion activities since work will be completed in the same area. A new KSC Environmental Checklist is therefore not required to obtain a REC.

**3.1.2 Site Planning Authorization.** Based on discussions with the NASA RPM, a Site Plan request is not necessary to complete AS system expansion activities. The NASA RPM discussed requirements with KSC Master Planning personnel, who indicated that a new Site Plan was not necessary since a Site Plan was obtained for the original AS system (Site Plan #SP-16-0087), and this is only a minor expansion within an established area.

**3.1.3 Utility Locate/Dig Permit.** A KSC Utility Locate/Dig Permit is required for excavation/intrusive subsurface activities (e.g., drilling and trenching). Based on the date of the last dig permit received for the January 2022 DPT sampling event, a new dig permit will need to be obtained to cover AS system expansion activities. The excavation inspectors will be contacted in advance of anticipated drilling and trenching activities to schedule utility clearance for the specific activity. Excavation will not occur on “no dig days” or “critical days” in compliance with the category assigned in the permit. The Tetra Tech Site Manager will contact the duty office for “no dig day” forecasts.

In addition to the KSC Utility Locate, a supplemental GPR survey will be conducted to ensure all subsurface utilities are identified. A GPR survey was previously completed in this area in November 2021 to support the January 2022 DPT event. The supplemental GPR survey will focus on areas of well installation and trenching to confirm utility locations. Figure C-11 shows the previous GPR survey results with proposed AS expansion wells and trenchlines overlaid on the figure.

**3.1.4 Threatened and Endangered Species Survey.** Based on KSC REC requirements from the January 2022 DPT sampling event (REC #11626), work within the proposed project area may have the potential to impact protected and/or threatened and endangered species, which may include the gopher tortoise. A biological survey may need to be performed by KSC personnel prior to commencement of AS system expansion field activities, which will be determined once the updated REC is received. Measures required to protect endangered or threatened species or species of special concern will be implemented as appropriate. If any protected wildlife such as the gopher tortoise is spotted within the construction area once field activities commence, or if a burrow is observed within 25 feet of an excavation area, Tetra

Tech will immediately contact the KSC wildlife ecologist for support to safely remove the animal(s) from the site.

**3.1.5 Well Permits.** Permit applications will be submitted by the drilling subcontractor to St. Johns River Water Management District and Brevard County for each well installed.

**3.1.6 NPDES Permit.** A National Pollution Discharge Elimination System (NPDES) permit, specifically a NPDES Construction Activity Permit/Notice of Intent to Use Generic Permit for Stormwater Discharge, is not required for proposed site construction activities based on the minimal areas that will be disturbed by construction. The estimated area of groundwater that will be treated by the AS expansion is approximately 0.07 acres, and the estimated area of land disturbance is only 0.005 acres to complete construction activities, such as trenching (approximately 105 feet of trenching estimated). A Storm Water Pollution Prevention Plan (SWPPP) is not required; however, best management practices (BMPs) will be used to include implementation of appropriate pollution prevention techniques to minimize erosion and sedimentation, as well as properly manage stormwater (see Section 7.2).

**3.1.7 Air Permit.** VOCs and HAPs emitted during treatment operations are covered under the current KSC Title V Air Operation Permit. As discussed in Section 2.3, potential emissions from the AS system at LC39B (existing plus proposed expansion) are not expected to exceed HAP emission limits. Based on these estimates, no additional notification or permitting will be required. Air monitoring will be conducted as part of the system expansion to ensure compliance with HAP emission limits and is discussed in Section 7.3.

**3.1.8 Hot Work.** Hot Work permits may be required if open flame and heat-producing devices are used, if welding or cutting operations are necessary, if flammable materials are stored on site, or if any spark-producing activity occurs. Permitting requirements will be coordinated through NASA, if necessary, via submission of a Hot Work permit request. Previous HDPE socket fusion welding conducted at KSC has not required a Hot Work Permit.

## 3.2 PROJECT SUPPORT AREA

Based on the extent of field activities associated with this project, only a limited project support area will be required as part of mobilization activities. The project support area will consist of a decontamination pad and temporary office/storage trailer. Water used for decontamination of drilling equipment will be supplied by an on-site water source at LC39B and transported by the drilling subcontractor. Tetra Tech will coordinate with NASA for the use of the on-site water source.

The Tetra Tech Cocoa, Florida office will be used as an alternative support area. On-site communications will be provided by cellular telephones and radios.

## 3.3 STAKEOUT SURVEY

Prior to utility clearance by the excavation inspectors, a stake-out survey will be conducted to demarcate areas of proposed penetration and intrusive work. The survey will mark new monitoring and AS well locations with wooden stakes. Trench locations will also be marked in the field.

## 3.4 NASA COORDINATION

LC39B is an active launch complex being used by NASA. The NASA RPM will ensure proper coordination and notification is completed prior to mobilizing to the site to begin AS system expansion activities. Tetra Tech will ensure all personnel that need access to LC39B for this project take the appropriate trainings and abide by active launch facility protocols.

# SECTION IV
# INTERIM MEASURE IMPLEMENTATION

This section covers details regarding AS IM implementation. As discussed under Section 2.3, potential petroleum odors and staining were identified at two DPT locations during the January 2022 DPT event in the 10-16 feet bls range. If similar odors or staining are identified during IM implementation, the NASA RPM will be notified and soil samples will be collected and analyzed for PAHs and TRPH.

## 4.1 TECHNOLOGY DESCRIPTION

The IM will generally consist of diffused air injection within an array of AS wells installed at appropriate locations and depths within the plume containing concentrations of cDCE and VC greater than FDEP NADCs. AS involves injection of air into an aquifer to promote the short-term volatilization of chlorinated VOCs (CVOCs) and long-term aerobic biodegradation of residual CVOCs. AS is most often implemented as a direct treatment technology by positioning air injection wells within the footprint of a contaminant plume. AS volatilizes CVOCs from the groundwater and aerates the groundwater to promote aerobic biodegradation.

## 4.2 MONITORING WELL INSTALLATION

This section discusses the activities to be conducted for installation of the new monitoring well that will be part of the AS performance monitoring network for the expansion area. The monitoring well will be installed with a screened interval from 8 to 18 feet bls. The monitoring well location is shown on Figure C-8, and construction details are presented on Figure C-12. The well will be installed in accordance with Section 4.5 of the KSC Sampling and Analysis Plan (SAP) for the RCRA Corrective Action Program (NASA, 2017a). The Tetra Tech geologist/field engineer will be responsible for direction of the Florida-licensed drilling subcontractor, monitoring of drilling operations, logging, and recording well installation and decontamination procedures. A well completion log, included in Appendix F, will be completed during installation of the monitoring well.

The monitoring well will be installed using sonic drilling technology with 4-inch diameter drive casing. Well casing sections will be flush-joint threaded with neoprene O-rings on the male threaded ends to render the joints watertight. The well screen will be 10-feet in length (see Table 2-2) and consist of 1-inch I.D. Schedule 40 PVC with a screen slot size of 0.010 inch. Wastes generated by monitoring well installation will be handled in accordance with Section 8.1 of this IWP.

**Monitoring Well Annular Space Construction**: The filter pack will be silica sand of American Society of Testing and Materials (ASTM) gradation 20/30. Initially, the well casing and screen will be suspended using a winch line on the drilling rig, and then the sand will be poured into the annulus at a rate to avoid sand bridging. The filter pack will be placed within the annulus such that the sand is evenly distributed throughout the screened interval. From top of the screen to 2-feet above the screen, the same silica sand of ASTM gradation 20/30 will be placed. A fine-sand seal of ASTM gradation 30/65, at least 3-feet thick, will be placed on top of the silica sand. The geologist/field engineer will consult with the driller to confirm the appropriate volume of sand required to fill the borehole annulus. As sand is being placed, the driller will confirm the depth to sand as well as the overall sand volume required to construct the filter pack. The remainder of the annulus above the fine-sand seal shall be grouted to the surface, which will be composed of a cement slurry grout mixed in the following proportions by volume:

- Portland Cement – no more than 6.5 to 7 gallons of water per 94-pound bag; and
- Sodium Bentonite– 6 pounds

The grout will be mixed to a uniform consistency, and the slurry mix will be confirmed using an appropriate mud scale. The grout will be allowed to set for a minimum of 24 hours before surface completion. The monitoring well installation will be completed by a Florida-licensed driller. Following installation of the monitoring well, each well will be developed via surging and evacuation until clear to remove drilling fluids and suspended solids.

**Monitoring Well Surface Completion:** Surface completions will include a flush-mounted well cover, metal locking riser cap, and 2-foot by 2-foot by 6-inch concrete pad. Bollards may be used to protect and more easily locate flush-mounted wells. If determined necessary, the bollards will be at least 3-inches in diameter, 6-feet in total length, recessed 3-feet below ground level, set in concrete, and filled with concrete. The bollards will be corrosion resistant and fireproof for protection during launch activities. Well identification tags will be provided in accordance with FDEP Standard Operating Procedures (SOP).

## 4.3 AIR SPARGING SYSTEM INSTALLATION

This section discusses the AS expansion activities to be performed, including installation of AS wells and piping. The existing Zone Z4 header line will be used to supply air to the five new AS wells from the AS trailer currently operating at the site (no new headers required). The existing Zone Z4 manifold cabinet will also be used. The original AS trailer, equipment, and utilities were installed during original system construction in 2017. In June 2023, the AS trailer that operated at the POL Southern Treatment Area remediation site replaced the original trailer from LC39B. Lateral lines for the new AS wells will receive airflow from existing lines that will be split in the field at a lateral split junction point (see Figure C-8). No new pipe racks are needed.

**4.3.1 Air Sparging Well Installation**. A total of five, 1-inch I.D. AS wells will be installed using sonic drilling methods to depths identified in Table 2-1 and at locations shown on Figure C-8. As discussed in Section 2.3, the spacing for AS wells is based on an ROI of 15 feet with approximately 30-foot center-to-center spacing. The 15-foot ROI assumption is based on the lithology encountered in the expansion area, as well as the shallow depth of AS wells to be installed. The target AS installation depths are 13 and 17 feet bls; however, termination depth for each AS well will be determined via soil coring with a soil core collected from the bottom 5-feet of each borehole (8-13 feet bls and 12-17 feet bls) to confirm lithologic conditions are adequate for AS screen placement. The cores will identify the depth of shallow fine-grained sands and any intermittent clay lenses that may be encountered above which the AS wells will be installed. If a clay layer is penetrated, the boring will be backfilled with grout to the top of this layer. Construction details for the AS wells are presented on Figure C-13.

The Tetra Tech geologist/field engineer will be responsible for direction of the drilling subcontractor, monitoring of drilling operations, logging, and recording the well installation and decontamination procedures. A boring log template, provided in Appendix F, will be used to log the soil cores from well drilling activities. The cores will be photographed and managed as investigation-derived waste (IDW).

**Air Sparging Well Installation:** The 1-inch I.D. AS wells will be installed by sonic drilling technology to depths of approximately 13 feet bls (three locations) or 17 feet bls (two locations), above any shallow confining layers. A 4-inch diameter drive casing will be drilled to complete AS well installation. Each well screen will be constructed of a 1-inch I.D., 40-micron Schumasoil diffuser well screen (20-inches in length), and each well casing will be constructed of 1-inch I.D. Schedule 40 PVC. Casing sections will be flush-joint threaded with neoprene O-rings on the male threaded ends to render the joints airtight.

**Air Sparging Well Annular Space Construction:** The filter pack will be silica sand of ASTM gradation 20/30 and will be placed within the annulus in a way to ensure that it will be evenly distributed. Initially, each joined casing and screen will be suspended using a winch line on the drilling rig, and then the sand will be poured into the annulus at a rate to avoid sand bridging. The geologist/field engineer will consult with the driller to confirm the appropriate volume of sand required to fill the borehole annulus around each well screen. As sand is being placed, the driller will confirm the depth to sand as well as the overall sand volume required to construct the filter pack. The filter pack will be placed approximately 6-inches above the screened interval and sealed using a bentonite plug. The seal will be composed of pelletized bentonite with sufficient pellet volume to form a seal that extends at least 3-feet. The pelletized bentonite will be hydrated to eliminate grout migration during the annular space grouting process. The annular space around the well casing will then be filled with a cement slurry grout mixed in the following proportions by volume:

- Portland cement – 9 gallons of water per 94-pound bag; and
- Bentonite powder – No more than 4 pounds per 94-pound bag of Portland cement.

The grout will be mixed to a uniform consistency, and the slurry mix will be confirmed using an appropriate mud scale. Following placement of the grout, the well annulus will be pressurized to ensure an adequate seal between the grout and native material.

**Air Sparging Well Surface Completion:** Surface completion at each AS well will be conducted following trenching and piping installation activities. All AS wells will be direct-buried, and surveyor-style location hubs (stakes) will be installed above each well. Well completion details are included on Figure C-13.

IDW generated during installation of AS wells will be handled in accordance with the KSC IDW Management Plan (NASA, 2006) and as detailed in Section 8.1 of this IWP.

**4.3.2 Piping Installation and Modifications to Distribution Manifold Cabinets**. A 24-inch-deep trenching network of sufficient width will be excavated for installation of compressed air conveyance piping. The trenching layout and cross-sectional details of the trenches are shown on Figures C-8 and C-14, respectively.

The trenching layout was developed to minimize ground disturbance due to the amount of utilities in the area. As outlined in Section 2.3, a lateral split junction point will be excavated where existing AS wells 242, 243, and 245 separate into their own trenches (see Figure C-8). This location will be found by trenching back from existing AS well, 242 (which has a wellhead surface complete). The existing lateral lines will then be split at this junction point (2-way or 3-way) to deliver air to new AS wells. Figure C-14 provides details showing the lateral split junction point.

AS wells installed in the expansion area will be supplied with compressed air from the existing AS system and will be delivered to the AS wells via the existing distribution manifold cabinets. Compressed air will be conveyed via an existing 2-inch I.D. SDR 11 HDPE header that runs from the AS system trailer to the Zone Z4 distribution manifold cabinet locations. As stated in Section 2.3, Zone Z4 was selected to incorporate these additional AS wells based on geographical proximity to the expansion area, as well as the capacity to incorporate and balance additional air flow requirements within this zone. No new distribution cabinet is needed as airflow for the five new AS wells will be delivered from existing lines that will be split in the field, as described above. Details of the existing distribution manifold in protective cabinet are shown on Figures C-15 and C-16.

Minor modifications will be made to the existing distribution manifold for Zone Z4. This will include replacing select flowmeters with ones that can measure at least 18 scfm for lateral lines being split in the field (existing flowmeters only gauge up to 14 scfm, see Figures C-15 and C-16). This is because airflow for each new AS well will be collectively measured and controlled at the distribution manifold in conjunction with other AS wells being split along that lateral line in the field. In other words, each lateral line with multiple AS wells connected to it will only have one dedicated manual flow control valve, flowmeter, check valve, and pressure gauge at the distribution manifold. The target flowrate for each AS well is 6 scfm, and therefore, the collective flowrate at the manifold flowmeter will be 18 scfm for the 3-way split wells and 12 scfm for the 2-way split wells. The air will be distributed from the distribution manifold, via the existing lateral line constructed of 1-inch I.D. HDPE, before it is split at the lateral junction point. Connections of HDPE piping sections and fittings at the lateral split junction point and to new AS wells will be fused via a heat plate. No barbed or compression fittings will be used for HDPE connections. Wellheads will be modified to accept the AS conveyance piping.

Prior to and following backfilling of each trench section, a pneumatic pressure test at 50 psig will be conducted for each installed run of piping. The pressure monitoring will occur over a period of relatively consistent ambient temperatures because HDPE has minor expansion and shrinkage characteristics under temperature fluctuations, which may affect pressure testing.

Single-conductor #10 insulated wire and magnetic utility marking tape will be installed within all trenches at a depth of 6 inches bls for future utility detection. Trenches will be backfilled with native soil, compacted, and resurfaced to match existing conditions (all earthen).

The trenching layout, along with location of existing distribution cabinet associated with Zone Z4 and new proposed AS wells, is presented on Figure C-8. AS well numbers for the expansion area will begin at “280” since the original system included 279 AS wells.

**4.3.3 Air Sparging Trailer and Equipment Information.** The AS compressor trailer currently in use at LC39B will be used for this expansion. The system is located near the LOX area, and electrical service is provided by Building J7-0231. The original trailer housing the AS equipment had approximate dimensions of 8 feet by 24 feet and was leveled and anchored to the subsurface in accordance with the Trailer/Equipment Tiedown Plan (NASA, 2001 and 2017b). This trailer was moved to another remediation site at KSC that needed a larger capacity compressor on March 13, 2023. Since LC39B was then only running at a quarter of its original design (Zones Z1, Z2, and Z3 were turned off with only Zone Z4 running), it was replaced with a smaller AS trailer that was operating at the POL Southern Treatment Area remediation site on June 12, 2023, as remedial measures at POL had concluded. The trailer from the POL Southern Treatment Area site is capable of supplying 350 scfm flow at its maximum pressure of 90 psig. No modifications to this existing AS trailer are required to bring the new AS wells online.

**4.3.4 As-Built Survey**. Surveying will be conducted to provide as-built details for this project. The survey will include new monitoring and AS wells. Surveying will be performed in accordance with the following requirements:

- Surveys will be conducted by a Florida-licensed land surveyor;
- The monitoring well will be marked with a notch on the riser pipe to indicate the proper survey (and water level measurement) location;
- Horizontal locations will be third order, in meters, and relative to the Florida State Plane Coordinate System, East Zone (North American Datum [NAD] of 1983);
- Vertical locations will be referenced to the North American Vertical Datum (NAVD) of 1988 with the following accuracy:
    - Ground elevation: 0.1 foot; and
    - Top of casing elevation: 0.01 foot.

# SECTION V

# SYSTEM COMMISSIONING, VERIFICATION, AND OPERATION AND MAINTENANCE

This section discusses the activities to be conducted to commission, operate, and maintain the expanded AS system at LC39B. As previously stated in this IWP, the original AS system was installed in the western half of the launch complex in 2017. The AS system is split into four zones (Z1 through Z4), with only zone Z4 currently operating. All startup and prove-out procedures were completed as part of the original installation (NASA, 2017b). Details specific to each phase of system operation are included under Sections 5.1, and general operation and maintenance (O&M) procedures are discussed under Section 5.2. O&M checklists and forms to be used during the tasks described in this section are provided in Appendix F.

## 5.1 AIR SPARGING SYSTEM COMMISSIONING AND OPERATION

**5.1.1 Air Sparging System Commissioning.** The objectives for commissioning the AS expansion area are to confirm that the newly installed AS wells, which will be incorporated into the existing Zone Z4 distribution manifold with airflow split in the field at the lateral split junction point (see Figure C-8), and the existing AS compressor system operate as specified to facilitate any necessary modifications in the AS system trailer, and to gather and evaluate initial operational data. Modification of the programmable logic control (PLC) and system manifold pressure regulator set points will be conducted.

The commissioning process is composed of three primary activities:

- Pre-commissioning check;
- Functional performance tests of individual components; and
- Pre-startup functional performance system testing of the combined components.

The commissioning process will verify that all of the components of the expanded system, below and above ground, have been properly installed and mechanically operate as designed and intended for the IM.

A site-specific commissioning checklist (Appendix F) will be completed to ensure that all equipment and instrumentation have been properly prepared and lubricated and that protective covers on rotating equipment are in place. Inspections of equipment lockouts, safety valves and/or other pressure relief devices, and site security devices will also be completed. Any deficiencies will be corrected to meet operational requirements. The checklist will be initialed by the appropriate team member at the completion and acceptance of each particular item.

Checks and individual component testing will be performed to verify that the manifold legs cycle appropriately (if determined legs need to be pulsed on separate cycles). Any deficiencies in the system must be corrected and performance checks successfully completed before the expanded system can be accepted.

**5.1.2 System Verification.** Upon completion of the commissioning process and baseline performance monitoring (see Section 6.1), the expanded AS system will be operated such that the network reaches the desired pressures and flowrates at a steady state. The strategy for verification is to start up the system, comparing observations and test data to design and performance criteria. The check-out will demonstrate proper functionality of the following:

- Fail-safe instrumentation and logic; and
- All valves and orifices.

All related health, safety, and emergency response procedures will be in place and reviewed before this phase of operation. Before process systems are started, a final check on the alignments and positioning of all motor drives, valves, safety devices, and control set points will be conducted.

The general startup sequence for normal operation of the AS system is as follows:

- Ensure that all valves are in proper position (including valves at the distribution manifolds);

- Ensure that the electrical disconnects are in the energized position;

- Ensure that all alarm conditions on the control panel are cleared;

- Verify that the solenoid valve programming is set for pre-set pulse intervals, if necessary, and set in the AUTO position (entries for spare manifold legs should be set as “OFF”, if applicable);
- Turn the selector switch for the refrigerated air dryer to the AUTO position;
- Turn the selector switch for the rotary screw compressor to the AUTO position; and
- Verify operating pressures, flows, and temperatures throughout the system and at the system discharge manifolds.

The system is now in automatic operation, and ON/OFF and START/STOP functions of the system are controlled by the PLC.

After operation has been verified and deemed acceptable at the system location, conditions will be inspected at the distribution manifold cabinets. Pressures and flowrates will be verified and balanced. The following table shows design wellhead flow and pressure and design manifold pressure for the AS wells (new and existing) that will operate with Zone Z4 - Leg 1.

| Zone Z4 - Leg 1 | New and Existing AS Wells |
|---|---|
| **Wellhead Flow (scfm)** | 6 |
| **Wellhead Pressure (psig)** | 10.4 |
| **Manifold Pressure (psig)** | 18 |

At the distribution manifold for Zone Z4 – Leg 1, all AS wells will be set at a flowrate of 6 scfm, except for the three existing lines that will be split in the field. At those lines, which are currently dedicated to AS wells 242, 243, and 245, flowrates will be set to 12 scfm (2-way split) or 18 scfm (3-way splits) at the manifold. Based on friction loss estimates, the initial pressure regulator settings at the system manifold for the Zone Z4 header line is designed to operate at 18 psig. The distribution manifold will be checked to ensure that the wellhead pressure applied to each well is within the design wellhead pressure. The pressure regulator at the manifold will be adjusted to reach a pressure of 10.4 psig at the lateral wellheads.

The sequence terminates when the design and equipment performance is documented to comply with specifications, and the system is ready for transition into the O&M phase. Data will be collected on the startup and O&M checklists (Appendix F) as well as in a field logbook.

Temperature and pressure readings at the air dryer discharge and AS system manifold legs (Zone Z4, Legs 1 and 2) will be documented. Total flow from the discharge of the air compressor and manifold legs will be verified and documented. Observations, sampling, and other performance testing will be performed during startup to ensure that the expanded system is operating as expected. After startup criteria have been satisfied, the same startup procedure will be conducted remotely to ensure that the system can be fully operated remotely should there be a need for remote shutdown in the future.

Soil heterogeneities across the AS expansion area may present conditions under which specific design points cannot be reached. In these cases, the operational curves for the specified equipment will be consulted to verify that the equipment is operating as designed. Adjustments may be required to ensure proper AS application and/or equipment operation.

**5.1.3 System Operation.** After the system has been commissioned and verified operational, Zone Z4 - Leg 1 will be considered ready to be put online in conjunction with the existing LC39B AS well network with Zone Z4 - Leg 2. To achieve the required flow in the expansion area, flow to the existing AS wells in Zone Z4 will be re-balanced to account for the new AS wells coming online. Once fully operational and balanced, remote monitoring of the system will be relied on, and O&M will be performed as needed for performance monitoring requirements and equipment maintenance schedules.

## 5.2 GENERAL O&M PROCEDURES

**5.2.1 Routine Operation/Process Monitoring.** In general, routine O&M consists of observing and adjusting process conditions and checking the system for abnormal conditions (e.g., noise, leaks, temperature, and vibration). Routine system observations will be recorded on the data sheets and forms included in Appendix F. All site activities will be recorded in a field logbook. During each site visit, the following activities will be performed:

- Inspection of the AS system for leakage and excessive vibration, noise, or temperature;
- Inspection of oil levels and lubrication;
- Inspection of the refrigerated air dryer;
- Assessment of differential pressures across filtration units and process equipment;
- Recording of system operational data and comparing data to design conditions and previous operating data; and
- Performing housekeeping.

**5.2.2 Routine Maintenance.** This section describes the routine maintenance and replacement of expendable materials associated with expansion of the AS system. Maintenance will be executed in a manner that prevents emergencies or unscheduled shutdowns. Drawings showing each unit, piping, valves, and electrical schematics are available on site for reference.

If electrical power maintenance is performed on any energized unit, the electrical disconnect located at the service connection will be de-energized, tagged, and locked out. Without prior coordination with NASA and Tetra Tech Health and Safety personnel (for contact information, see the LC39A and LC39B Site-Specific Health and Safety Plan [SSHASP] for Groundwater Interim Measures and System Operations, Maintenance, and Monitoring, Revision 1) (NASA, 2021b, or most updated version at time of IM implementation), no maintenance or work will be conducted on the primary voltage lines located upstream of the transformer associated with the LC39B AS system. The AS system (including receiver tank, manifolds, etc.) and associated process lines will be fully depressurized prior to conducting maintenance activities.

**Air Sparging Well Maintenance:** The new AS wells may require maintenance when excessive solids accumulate in the wells or when pressure and/or flowrates indicate potential well fouling. If either of these situations occur, well rehabilitation may be necessary. Typical issues may be caused by sediment infiltration, chemical scaling, biomass growth, or physical damage. Well maintenance activities will be dictated by flow and pressure performance monitoring at the distribution manifold. The diagnosis of maintenance required will be on a case-by-case basis, and appropriate actions may include repair, chemical treatment, and/or physical surging.

**Air Compressor, Refrigerated Air Dryer, and Air Filters:** Routine maintenance of the air compressor and refrigerated air dryer will be conducted in accordance with manufacturer recommendations. An inspection of the compressor and refrigerated air dryer will be conducted and recorded at least monthly. At a minimum, the following activities will be performed for the air compressor and refrigerated air dryer during monthly O&M visits:

- Inspection of all safety guards on blowers;
- Inspection of all mechanical components and foundation hardware and fittings for tightness;
- Inspection for excessive vibration;
- Inspection of the inlet for particulate fouling;
- Inspection of belts/drive alignment;
- Inspection of oil level and lubrication; and
- Draining of any accumulated condensate within the refrigerated air dryer and receiver tank.

Inlet filters will be replaced on an as-needed basis. Routine lubrication will be performed per manufacturer recommendations. If excessive vibration or heat is encountered, troubleshooting per manufacturer recommendations will be performed.

All O&M activities, including prove-out, will be documented on the site-specific O&M sheets (Appendix F) and in the field logbook.

# SECTION VI
# PERFORMANCE MONITORING PROGRAM

Performance monitoring will be conducted to evaluate the effectiveness of the LC39B AS IM and will help determine if the entire system is operating properly and if additional actions or adjustments are needed. This section discusses the performance monitoring program to evaluate the progress of the AS expansion area. Performance monitoring for the existing AS IM at LC39B is on-going and is being documented in routine monitoring reports. Performance monitoring for the expansion area will also be incorporated into routine monitoring reports. Additionally, process monitoring, as discussed in Section 6.3, will be performed to evaluate IM operations and aid in maintenance and optimization reviews.

In the AS expansion area, performance monitoring will be conducted during baseline and semi-annual events. A baseline sample will be collected from new monitoring well, MW0048 (see Figure C-8). This well will then be incorporated into the site-wide monitoring program on a semi-annual schedule in the May and November timeframes (as currently scheduled for nearby monitoring well MW0032). Sampling procedures will be in accordance with Section 5.2.1.2 of the KSC SAP for the RCRA Corrective Action Program (NASA, 2017a), and FDEP field and laboratory SOPs which are incorporated into the KSC SAP. Table 6-1 summarizes performance monitoring program locations for the AS expansion area, monitoring functions, frequencies, and analytes.

Low-flow sampling techniques will be employed during groundwater sampling activities. Prior to sampling events, the AS system will be turned off at least 72-hours in advance of the sampling event. Each monitoring well will be purged and sampled using a peristaltic pump and dedicated HDPE tubing. Sample tubing will be placed at the mid-point of the well screen. All purge water generated through sampling will be containerized on-site in new 55-gallon drums. The drums will be placed on a NASA-provided spill pallet, and the bell cover will be secured with a strap. The bell cover and drums will be labeled. Each drum of purge water will be sampled and characterized for disposal (further discussed in Section VIII).

## 6.1 BASELINE MONITORING

Baseline monitoring for the AS expansion area will be conducted at the new performance monitoring well, MW0048, to develop a baseline of groundwater concentrations immediately prior to initiating AS in this area. The new monitoring location was selected based on the HCP footprint, depth, and monitoring functions. Groundwater level measurements will be collected from the new monitoring well to provide an overall summary of groundwater elevations but will not be used for groundwater contouring purposes for this specific area. Groundwater contours are routinely developed for LC39B as a whole, and water level measurements from wells within the expansion area will be factored into site-wide groundwater contours when prepared for the site.

The baseline groundwater sample will be analyzed for the standard list of VOCs via U.S. Environmental Protection Agency (USEPA) Method 8260D. Field parameter data will also be measured, including dissolved oxygen, pH, oxidation/reduction potential, water level, temperature, and conductivity. Following interpretation of the baseline dataset, the cycling times for the total system will be determined.

## 6.2 SEMI-ANNUAL PERFORMANCE MONITORING

Performance monitoring for the expansion area will include groundwater sampling and measuring of field parameter data at the new (MW0048) and existing (MW0032) monitoring well locations during semi-annual sampling events. Field parameter data will include dissolved oxygen, pH, oxidation/reduction potential, water level, temperature, and conductivity. All samples collected will be analyzed for the standard list of VOCs by a fixed-based laboratory via USEPA Method 8260D. Semi-annual performance monitoring events, scheduled for May and November timeframes, will be used to evaluate the performance of the system and to determine whether operational adjustments are needed (e.g., cycling modification, flow/pressure adjustment, etc.).

## 6.3 PROCESS MONITORING

Startup and routine monthly monitoring of the expansion area will be conducted as part of O&M activities at LC39B. Forms for AS data acquisition are provided in Appendix F. The following text summarizes the minimum process monitoring required for the AS expansion area and distribution manifold cabinet where the expansion AS wells will be incorporated.

The following will be monitored for the AS system:

- Voltage and load of each service feeder (to verify adequate electrical supply);
- Voltage and load at the compressor and refrigerated air dryer;
- Compressor discharge flow, temperature, and pressure;
- Receiver tank flow and pressure;
- Refrigerated air dryer flow, temperature, pressure, and dewpoint; and
- System manifold flow and pressure (collected while the manifold is active).

The following will be monitored at the distribution manifold:

- Distribution manifold pressure;
- Manifold leg pressure and flow; and
- Manifold conditions and whether condensate is evident at the manifold.

**Table 6-1. Groundwater Performance Monitoring Plan - AS Expansion (Year 1)**

| Well Location (LC39B-) | Screened Interval (ft bls) | Monitoring Function | Baseline Sampling | Sampling Frequency -Year 1 | Analytes | |
|---|---|---|---|---|---|---|
| | | | | | VOCs | Field Parameters |
| MW0032 | 8 to 18 | Monitor performance within treatment area | no | semi-annual (May/November) | yes | yes |
| MW0048 | 8 to 18 | Monitor performance within treatment area | yes | semi-annual (May/November) | yes | yes |

These wells target the expansion area to assess the progress that the new AS wells make, this is a part of the performance monitoring plan that encompasses the whole site
Field parameters - dissolved oxygen, pH, oxidation/reduction potential, water level, temperature, and conductivity
ft bls - feet below land surface
VOC - volatile organic compound

# SECTION VII
# SITE CONTROLS

Tetra Tech will maintain control over the work areas at the site during IM implementation to manage potential impacts from site activities on the environment, NASA operations, and personnel both on and near the site.

## 7.1 SITE SECURITY

Site security will be maintained to protect the health and safety of personnel and to preserve the integrity of NASA operations. General security requirements, project-specific security requirements, site security measures, and standard security measures are described in the following subsections.

**7.1.1 General Security Requirements.** A long-term or short-term KSC badge will be required to enter KSC and to access LC39B. Entry to KSC property, LC39B, or into controlled areas is a privilege that can be denied, suspended, or revoked. Prior to arriving at LC39B, all personnel will be required to notify the Tetra Tech Construction Supervisor. A list of all personnel arriving and/or working at the site will be maintained and provided to the NASA RPM.

**KSC Badging**: Long-term KSC badges are only for those who work routinely at KSC or LC39B and require access for more than 30 days in a calendar year. Long-term KSC badges will be obtained in coordination with the NASA RPM through formal application to KSC Security. All personnel must be naturalized United States citizens. When applying for a long-term KSC visitor badge, the following information must be provided to the NASA RPM:

- Name (exactly as it appears on the individual’s driver’s license or other identification);
- Date of birth;
- Place of birth (city, state);
- Dates of visit;

- Social Security number;
- Citizenship (if not a United States citizen by birth, provide naturalization or alien registration number);
- Employer's company name and address;
- Email address for the applicant;
- Areas to be visited (e.g., LC39B); and
- Purpose of visit.

Long-term badge request applicants will be instructed to complete a National Crime Information Center check, fingerprinting, enrollment in IdMAX, and enrollment at the KSC Badging Office.

Personnel requiring short-term access to LC39B (less than 29 days within a calendar year) will need to obtain a visitor badge. The same information stated above for the long-term badge (name, date of birth, etc.) must be provided to the NASA RPM.

Personnel reporting to the KSC Badging Office to enroll or pick up a badge should be prepared with two forms of identification, one of which must be a government-issued photo identification. Badges assigned by KSC Security must be clearly displayed on the person above the waist, on the outermost garment, and with the picture and expiration date facing outward at all times while on site. Identification badges are not to be worn off site.

**LC39B Badging**

To obtain access to LC39B, special badging requirements are needed. A LENEL pin needs to be set up, and access must be requested through the Pad B leader. Additional training may also be required by NASA to obtain access to LC39B.

**7.1.2 Project-Specific Security Requirements.** Tetra Tech will seek the NASA RPM's assistance in obtaining identification badges assigned to Tetra Tech personnel and vendors for the duration of IM activities. Personnel will present the KSC-issued identification badges to the security guard at the KSC entrance gate, and again to the security guard at the entrance to LC39B (see Section 7.1.1 for requirements on KSC and LC39B badging). All identification badges will be returned to KSC Security upon expiration of the badge, upon completion of the IM, or when possession of the badge is no longer necessary (i.e., upon removal of temporary personnel from the IM).

**7.1.3 Site Security Measures.** Security equipment including traffic cones, signs, and hazard tape will be used to deter entry of unauthorized personnel to the exclusion areas. All vehicles, trailers, and equipment will be secured when not in use. Keys will be removed from construction equipment and placed in a secure location when not in use.

**7.1.4 Standard Security Measures.** The site is not subject to restrictions during normal security conditions and routine work hours, unless mission-essential operations, or launch rehearsals or activities, are taking place. Operational forecasts provided by NASA will be used to help schedule field work around times where site restrictions may be in place. All employees and subcontractors will receive training on site security before they begin working on the site. Training records will be maintained.

Standard security measures will include the following practices:

- The Visitor Logbook will be completely filled out by any visitors to the site and will be kept on site.
- If a visitor refuses to properly register, acts suspiciously, or has no reason to visit the work areas, the Tetra Tech Construction Supervisor will contact the NASA RPM and KSC Security. If the visitor continues to be uncooperative or acts suspiciously, work will stop until the matter has been resolved.
- When entering and departing the work area, all access controls will be followed.

- No alcohol, illegal drugs, or weapons will be permitted on site. Vehicles may periodically be searched for these items.
- Personnel at the site are allowed to conduct only site-related business.

Details of security incidents will be documented and reported to the NASA RPM. These incidents include trespassers on site, vandalism to property or equipment, and accidents or damage to any on-site vehicles. All site workers will comply with KSC traffic enforcement requirements, as stated in KNR 1600.1, Chapter 16. Specifically, speed limits must be maintained, and use of cell phones while driving is prohibited (hands-free only).

**7.1.5 Use and Maintenance of Site Control Measures.** The Tetra Tech Construction Supervisor is responsible for ensuring that site work zones and support areas are properly delineated. Signs posted as part of site control must be legible and unobstructed. The Tetra Tech Construction Supervisor will direct the replacement of damaged or expended control equipment and materials.

**7.1.6 Procedures to Detect Violations of Security Measures.** During work hours, all site employees will be responsible for detecting violations of security measures. If a violation is detected, the Tetra Tech Construction Supervisor will be notified immediately.

If employees, subcontractor personnel, or visitors are found to be violating any security or site rules during work hours, the Tetra Tech Construction Supervisor will be contacted. The Tetra Tech Construction Supervisor will then discuss the violation with the appropriate personnel. After-hour security violations, as detected by signs such as tampering with gates or site facilities, will be duly recorded. Such indications will be reported by the Tetra Tech Construction Supervisor to the NASA RPM and KSC Security.

## 7.2 EROSION AND SEDIMENTATION CONTROL

This section presents the erosion and sediment control devices proposed for the IM. A limited amount of ground disturbance will occur during drilling and trenching operations (0.005 acres); therefore, a NPDES permit will not be required (see Section 3.1.6). A SWPPP is not required either; however, BMPs will be used to include implementation of appropriate pollution prevention techniques to minimize erosion and sedimentation, as well as properly manage stormwater (see below).

**Erosion and Sediment Control Best Management Practices**. The following describes the types of erosion and sediment control BMPs proposed on an as-needed basis by the Construction Supervisor to prevent sediments (contaminated or uncontaminated) from being transported beyond the limits of disturbance. The references presented along with the erosion and sediment control BMPs refer to the Florida Storm Water and Erosion and Sedimentation Control Inspector's Manual (FDEP, 2018).

<u>Filter Sock (Inspector's Manual BMP 3.4.3)</u>: A filter sock is a temporary sediment barrier and storm water runoff filtration device consisting of a three-dimensional, tubular, sediment control filled with biodegradable material placed on the ground and attached to supporting posts. The purpose of a filter sock is to intercept and detain small amounts of sediment from disturbed areas during construction operations and to decrease the velocity of sheet flows and low- to moderate-level channel flows.

<u>Permanent Seeding (Inspector's Manual BMP 4.5)</u>: Permanent seeding is the establishment of perennial vegetative cover on disturbed areas by planting seed. The purpose of permanent seeding is to reduce erosion and decrease sediment yield from disturbed areas. Additionally, permanent seeding permanently stabilizes disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant material. Permanent seeding will be used within the limits of disturbance in all areas of proposed expansion activities.

Other prevention and response measures will be used to prevent surface water contamination and transportation of contamination. These controls are not identified in the Florida Storm Water and Erosion and Sedimentation Control Inspectors Manual, and are as follows:

- Contaminated equipment will be decontaminated before exiting the exclusion zone.
- Any release of hazardous waste or hazardous material will be contained and cleaned up immediately. A spill kit will be maintained on site.

- In the unlikely event of a release of contaminated groundwater to land surface, the NASA RPM will be notified.

- Soil cuttings generated from drilling activities will be collected in 55-gallon drums, sampled, and disposed of appropriately.

## 7.3 FUGITIVE EMISSIONS AND AIR QUALITY MONITORING

As discussed in Section 3.1.7, the LC39B AS system (existing and proposed expansion) is not expected to exceed HAP emission limits. To ensure that HAP requirements are met, fugitive gas emissions will be estimated from groundwater contaminant results at the monitoring wells. If concentrations are estimated at levels that could indicate individual HAP emissions greater than 1,000 pounds per year or total HAP emissions greater than 2,500 pounds per year, an evaluation of system operations and permit requirements will be performed to determine potential corrective action(s).

Air monitoring will be conducted prior to and during startup and verification of the expanded AS system. Real-time field monitoring of ambient air will be conducted with a photoionization detector (PID) to establish a baseline dataset, and then during startup and operation of the expansion area at a frequency of approximately once per hour to determine if background conditions in breathing zones are affected by AS activities. Baseline sampling may also be conducted via summa canisters from select locations within the treatment area if necessary. If the PID screening indicates emissions from the system, it will be screened with a Draeger CMS Analyzer with colorimetric chips to determine individual contaminants and whether summa canister sampling is necessary for a more detailed loading quantification along the plume footprint. If the Draeger indicates concentrations that could be near or greater than total HAP requirements, air samples will be collected for laboratory analysis of VOCs via USEPA Method TO-15 to determine individual and total HAP concentrations. If air sample concentrations indicate emissions greater than criteria, operation of the AS system will be modified such that emissions remain less than permitted HAP limitations. These modifications may include, but are not limited to, reductions in the number of AS wells being operated or adjustments to duration of operation. Based on PID monitoring at other AS sites at KSC with similar contaminants and concentrations, HAPs are not expected to exceed permit levels.

## 7.4 DECONTAMINATION

A temporary decontamination pad (most likely consisting of a plastic tarp and PVC piping to create a collection basin) will be constructed on site and will be used by the drilling subcontractor during installation of monitoring and AS wells. Decontamination fluids will be collected, sediments removed, and water characterized to determine proper disposal. IDW will be properly handled in accordance with the KSC IDW Management Plan, and the most recent NASA guidance on per- and polyfluoroalkyl substances (PFAS) IDW management and disposal.

Decontamination fluids will be placed into 55-gallon drums or staged in double-walled bulk containers and appropriately labeled. The drums will be transported to a designated IDW staging area and secured on spill pallets with secondary containment. Waste management is further discussed in Section 8.1.

## 7.5 SPILL PREVENTION AND CONTROL

The impact to health and the environment due to any spill will depend on the quantity of material spilled and the physical, chemical, and toxic effects of the material. The following items are considered for spill and discharge control:

- Equipment used for installation and operation of the system, and that may include petroleum, oil, and lubricant products;
- Contaminated groundwater extracted during site sampling activities; and
- Untreated air compressor condensate.

**7.5.1 Control Procedures and Protective Measures.** The potential for release of contaminants to the ground will be controlled by containment, proper equipment service, and maintenance practices. Equipment operators will be required to inspect equipment for leaking seals, fittings, and lines during every site visit and will not use the equipment until any deficiencies are corrected. If a release of contaminants to soil occurs, the soil will be excavated and properly treated or disposed of off-site.

**7.5.2 Spill Response.** Tetra Tech will maintain readily accessible spill control/response equipment. Spill supplies including, but not limited to, organic sorbent material, personal protective equipment (PPE), a portable eye wash, and overpacks will be maintained. An inventory of spill control supplies will be maintained and inspected by the Tetra Tech Construction Supervisor throughout installation of the expanded AS IM.

The Tetra Tech Construction Supervisor will be notified if a spill occurs, and the NASA RPM will be notified verbally within 8 hours of the incident. If the spill leads to personnel injury or fire, the initial notification will be made to the emergency telephone number found in the LC39A and LC39B SSHASP for Groundwater Interim Measures and System Operations, Maintenance, and Monitoring, Revision 1 (NASA, 2021b)(or most recent version at time of IM implementation), and a subsequent notification will be made to the NASA RPM. The Tetra Tech Construction Supervisor will direct emergency activities at the spill and will ensure that all health and safety equipment and supplies needed for a spill are readily available and properly used. The personnel responding to the emergency will be instructed on the characteristics of the spilled material(s) and special cleanup procedures. During a hazardous materials spill cleanup, the Tetra Tech Construction Supervisor will designate a Hazardous Waste Operations and Emergency Response trained person to monitor for exposures to chemical contamination to determine the need for protective equipment and apparel, to identify any restricted work areas and controlled access areas, and to provide cleanup guidance.

# SECTION VIII
# WASTE MANAGEMENT PROCEDURES

Types of waste generated during the performance of IM operations may include soil cuttings, well development and purge water, decontamination fluids, and PPE and clothing. Based on historical site activities and types of contaminants present, none of these IDW materials are expected to present a significant risk to human health or the environment if properly managed. The following describes the waste management procedures to be conducted during IM implementation, which will follow the general guidelines as outlined in the KSC IDW Management Plan (NASA, 2006) and the most recent NASA guidance on PFAS IDW management and disposal.

## 8.1 IDW MANAGEMENT

Grab samples (one from each drum generated, with separate drums for soil and water) will be collected from the IDW generated during well installation and groundwater sampling activities to classify the material for disposal. For solid IDW, the samples will be submitted to the laboratory for VOCs, semi-VOCs, 8 RCRA metals, Toxicity Characteristic Leaching Procedure metals, polychlorinated biphenyls (PCBs), and PFAS. For aqueous IDW, the samples will be submitted for VOCs and PFAS. If any petroleum odors or staining are identified during IM implementation, as previously discussed under Section IV, petroleum compounds will also be included in IDW analysis.

Soil cuttings and excess soil core material resulting from well installation activities will be placed directly into Department of Transportation (DOT)-approved 55-gallon drums. The pH of each drum will be measured to ensure that the pH is between 6 and 8.5. If the pH of any drum is outside of this range, a dilute solution of base (to increase pH) or acid (to decrease pH) will be added to the waste incrementally until the waste pH is between 6 and 8.5, preferably close to a pH of 7. Proper management and staging of these wastes will be performed by Tetra Tech after waste sample analytical results are received from the laboratory and reviewed. Appropriate waste profiles and/or manifests provided by the company providing waste transportation and disposal will be completed prior to off-site removal of wastes.

Well development, purge, and decontamination waters will be pumped into DOT-approved 55-gallon drums. The drums will be labeled and logged, and the pH of the contents will be measured. If the pH of the contents of any drum is less than 6 or greater than 8.5, the pH of the IDW contents will be adjusted using either base (to increase pH) or acid (to decrease pH). Logs containing pH levels, pH adjustment summary information, waste quantities, and drum identification information will be documented on the IDW log provided in Appendix F. IDW analytical results will be forwarded to the NASA RPM for proper characterization and disposal method.

## 8.2 DECONTAMINATION FLUIDS

Fluids generated during the decontamination of equipment will be disposed of in the same manner as described for IDW.

## 8.3 PPE AND MISCELLANEOUS TRASH

PPE and clothing will be wiped clean and disposed of in trash containers. All empty, spent, broken, unusable, or unwanted aerosol cans are considered “waste aerosol cans” and must be properly collected, stored, labeled, and disposed of through the KSC Waste Management Office. Waste aerosol cans cannot be discarded in regular trash or in solid waste dumpsters.

# SECTION IX
# REMEDIATION MANAGEMENT

## 9.1 RESOURCES MANAGEMENT

The activities described in the IWP will be implemented by NASA through Tetra Tech. Tetra Tech is responsible for performance of these activities.

## 9.2 SCHEDULE AND TIME MANAGEMENT

The schedule for implementation of the IM at the site is dependent on the critical path, which consists of obtaining necessary authorizations and permit approvals, performing mobilization activities, installing AS and monitoring wells, trenching and installation activities, baseline sampling, system verification, system O&M, and performance monitoring. Field activities may also be affected by NASA operations, launch delays, and weather conditions including wind and lightning, which are addressed in the LC39A and LC39B SSHASP for Groundwater Interim Measures and System Operations, Maintenance, and Monitoring, Revision 1 (NASA, 2021b)(or most recent version at time of IM implementation).

## 9.3 COMMUNICATIONS

An initial project kick-off meeting will be held with Tetra Tech, KSC Safety and Health personnel, and the NASA RPM to review project information. Prior to the start of field activities, a health and safety meeting will be held with the field crew to discuss the project. In addition, a health and safety meeting will be conducted whenever a new subcontractor is scheduled to be on site. Site personnel will meet daily for morning tailgate meetings during IM installation to discuss operations and safety issues and to coordinate activities such as personnel assignments and action items for that day.

Once a week, a project meeting will be held with the Tetra Tech Construction Supervisor, Tetra Tech Site Safety Supervisor, and Tetra Tech Project Manager. The NASA RPM is invited to all meetings and for general site visits. The topics will be safety, progress since the last meeting, potential concerns or conflicts, ideas and suggestions, and quality. Comments from NASA will be discussed, and a response will be given or an action will be taken, as appropriate.

The following is a list of the project meetings that will be held to enhance communication among other members of the project team:

- Post-Award Kick-Off Meeting – A contract pre-performance meeting will be held following the notice to proceed. The meeting will address planned site activities and project tasks, schedule, deliverables, technical matters, and coordination with KSC entities. A site walk and meeting with NASA and Tetra Tech was held on September 21, 2023, to discuss the AS expansion area.

- Daily Tailgate Meetings – Daily tailgate meetings will be led by the Construction Supervisor and will detail operations for the day and discuss safety components associated with work activities. All site personnel and subcontractors will participate in daily meetings and sign the meeting attendance form included in the SSHASP.

- Site Kick-Off Meeting – A site kick-off meeting and "Nuts and Bolts Meeting" will be held as part of mobilization. The Tetra Tech Project Manager, Tetra Tech Construction Supervisor, and key personnel will attend. The NASA RPM, KSC Safety and Health personnel, and key KSC personnel identified by the NASA RPM (e.g., security, LC39B facility manager, locate/excavate personnel, etc.) will be invited to attend.

- Weekly Progress Briefings – Throughout field work, the Tetra Tech Project Manager or Construction Supervisor will brief the NASA RPM weekly on scheduled work, progress, and upcoming activities. Notification will be provided of changes in personnel or equipment. Issues arising from the daily site meetings will be brought to the Tetra Tech Project Manager's attention, and potential problems will be noted.

- Subcontractor Health and Safety Meeting – Along with attendance at daily tailgate meetings, subcontractors will meet with the Construction Supervisor prior to initiating site work and discuss the work activities, the SSHASP (NASA, 2021b or most recent version at time of IM implementation), and hazard analyses for the tasks being completed. Attendance of the meeting will be documented in the SSHASP.

- Final Inspection Conference – A post-construction final inspection conference will be held to discuss and resolve any outstanding issues prior to final inspection of the work. The schedule and procedures for the final inspection will be finalized during this conference.

## 9.4 DOCUMENTATION, RECORDKEEPING, AND REPORTING

Information to be documented and maintained during IM implementation as required by the KSC SAP (NASA, 2017a), and LC39A and LC39B SSHASP for Groundwater Interim Measures and System Operations, Maintenance, and Monitoring (NASA, 2021b or most recent version at time of IM implementation), consists of the following:

- Utility Locate/Excavation Permit;
- Site Planning Request and Authorization (see Section 3.1.2 on use of existing Site Plan);
- Hot Work Permit (if required);
- Digital imaging documentation of site and field activities obtained as part of mobilization activities, during each major phase of the IM, for each area of the IM, whenever unforeseen site conditions are encountered, after restoration activities are complete, and as directed by the NASA RPM. Digital images will be provided in Joint Photographic Experts Group (JPEG) format. Photographs will not be taken of sensitive NASA operations.
- Waste profile sheets, waste characterization results, waste shipment records, waste manifest documentation, and certificates of disposal;
- Analytical results from performance monitoring;

- Data collected during system operation; and
- Documentation required per the SSHASP.

The following text summarizes the reporting requirements and documents to be submitted to NASA as part of IM implementation.

**Remediation Information System.** All analytical data and supporting information will be compiled and input into the Tetra Tech database management system to update the KSC Remediation Information System (RIS). The Tetra Tech database will be used to prepare tag maps, compare site data to KSC RCRA screening criteria, determine frequencies of detection, generate summary tables, and generate figures.

**Construction Completion Reporting.** Following startup of the AS expansion area, Construction Completion will be reported and will include a summary of installation activities conducted as part of IM implementation. Drawings and survey information for the trenching and well locations will be provided as part of Construction Completion reporting. Project-related documents such as waste manifests, permits, inspections, well construction logs, daily field logs, and photo logs will be provided. Construction Completion for initial AS system start-up activities in 2017 was reported in a Construction Completion Report (NASA, 2017b).

**O&M Manual.** For the AS trailer currently at LC39B, which was relocated from the POL Southern Treatment Area remediation site in June 2023, system specifications and equipment cut-sheets were provided in Appendix G of the POL Southern Treatment Area IWP (NASA, 2020). The O&M manual (vendor's manual) includes system components and detailed equipment operating procedures, as well as instructions recommended by the manufacturer for preventative maintenance. The manual also includes part lists, shop drawings, cut sheets, and recommended lubricants.

**Advance Data Packages.** A combined Construction Completion and Performance Monitoring ADP will be developed and presented to the KSCRT for the AS expansion area. The ADP will include a summary of installation activities, permitting, deviations from the IWP, safety procedures, construction photographs, schedule, baseline monitoring, and lessons learned from the implementation. The ADP will also present performance monitoring data from baseline, startup, and the initial six months of operation. Year 1 Performance Monitoring data for the expansion area will be incorporated into LC39B's Annual Performance Monitoring ADP. The ADP will include tables, maps, and other photographs/figures necessary to present findings. The data packages will be submitted a minimum of 2 weeks prior to the appropriate KSCRT Meeting. The ADP will be presented in PowerPoint format during the Team meeting.

**Performance Monitoring Reports.** The existing LC39B AS system is documented in Annual Performance Monitoring Reports, and submitted to NASA and FDEP on an annual basis. The AS expansion area will be integrated into the Annual Performance Monitoring Report. Results from performance groundwater monitoring and IM activities conducted during each operating year will be included in the reports. The reports will also include detailed descriptions of IM implementation operations completed during the reporting period and provide site contaminant and system datasets used to evaluate remedial performance. The annual reports will be sealed by a Florida-registered professional engineer, presented to the KSCRT, and submitted to FDEP.

## 9.5 DATA QUALITY AND SUBMITTAL REQUIREMENTS

The LC39B AS expansion area IM will be subject to the data quality and submittal requirements established in the KSC SAP (NASA, 2017a).

# SECTION X
# REFERENCES

Clark, E.E. Engineers-Scientists, 1987. KSC Subsurface Hydrology and Groundwater Survey, Volume IV, NASA, Kennedy Space Center, Florida.

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# APPENDIX A

# LC 39B LOX AREA DPT INVESTIGATIONS AND AIR SPARGING EXPANSION ADVANCE DATA PACKAGE

# Launch Complex 39B (SWMU 009), LOX Area

# DPT Investigations and Air Sparging Expansion

TETRA TECH

October 2022

complex world | CLEAR SOLUTIONS™

# Objectives

TETRA TECH

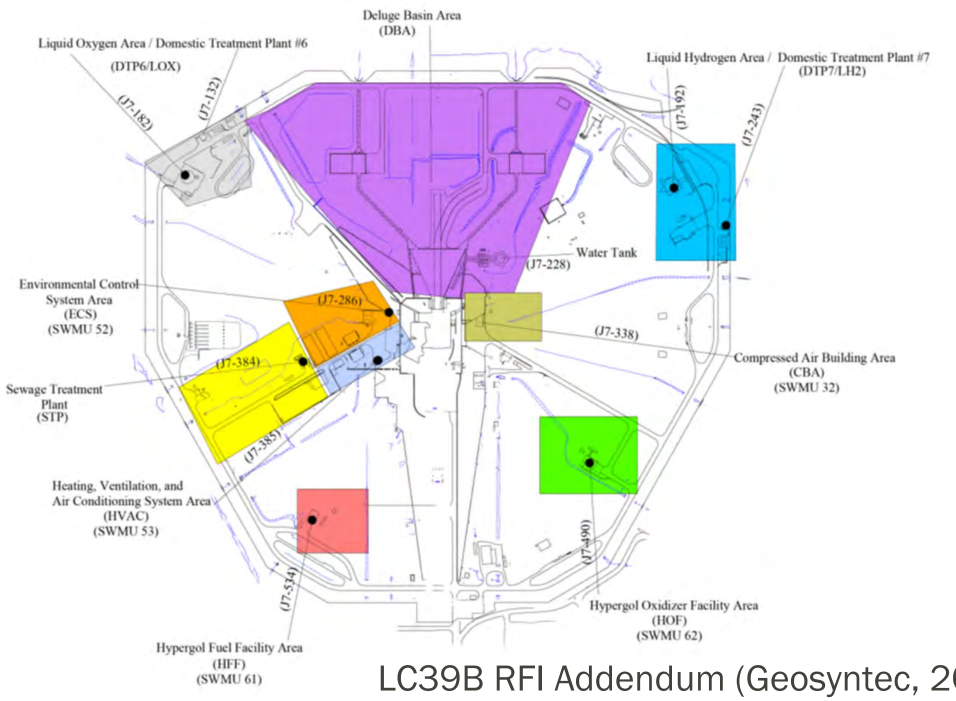
- Introduction and Site Background
- Remediation Milestones
- Groundwater IM Overview
- DPT Groundwater Events and Soil Boring
- System Expansion Design and Implementation

<u>Space Launch System (SLS)</u>

- 39B is an active launch site
- Artemis 1 is the first in a series of increasingly complex missions that will enable human exploration to the Moon and Mars
- Artemis 1 was rolled out to launch pad in April 2022 in preparation for wet dress rehearsal
- Launch date is TBD

# Introduction and Background

- Launch Complex 39B (LC39B) (SWMU 009) is a launch pad which operated from the mid-1960s until 2011 and is scheduled to support future space flights, including NASA's SLS. Complex encompasses 160 acres.
  - Supported the Apollo and Space Shuttle Programs
  - Flight service structure was removed in 2010 to create a “clean pad” to allow multiple types of launch vehicles
- SWMU 009 also includes six other SWMUs. The other SWMUs were consolidated and managed under SWMU 009.
  - SWMU 032 – LC39B Compressed Air Building (J7-0338)
  - SWMU 033 – LC39B Deluge Basin Area
  - SWMU 052 – LC39B ECS Area (J7-0286)
  - SWMU 053 – LC39B HVAC Facility (J7-0385)
  - SWMU 061 – LC39B Hypergol Fuel Facility Area (J7-0534)
  - SWMU 062 – LC39B Hypergol Oxidizer Facility (J7-0490)

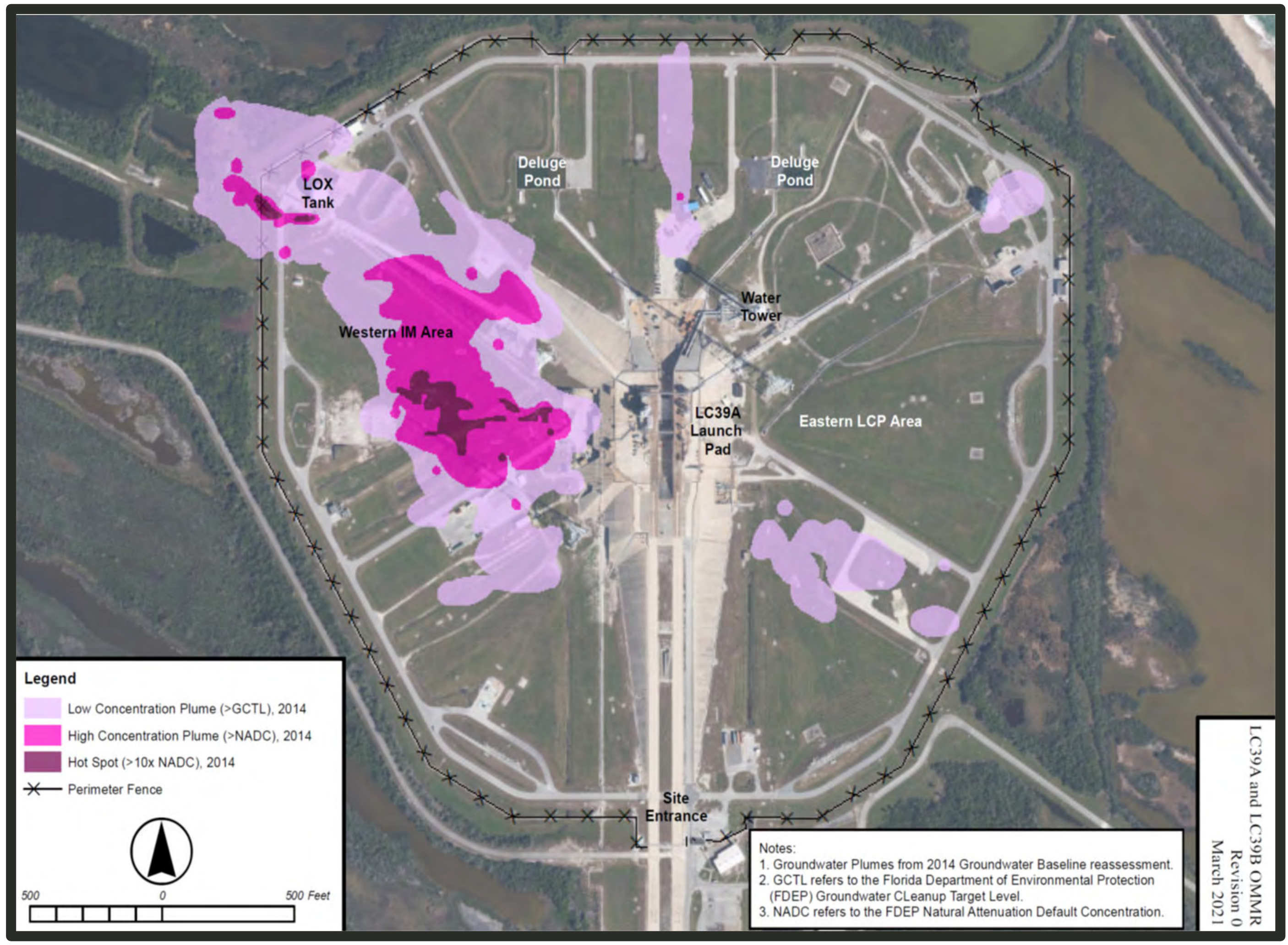


LC39B RFI Addendum (Geosyntec, 2003)

- CS completed in 1997. RFI was conducted from 2000 to 2003 and found groundwater impacts. Soils were also impacted by PCBs.
  - A soil IM was conducted in 2000 to address PCB-impacted soils.
  - Corrective Measures (CM) Study conducted in 2004 to address VOC and metal impacts in groundwater.

# Introduction and Background (continued)

- CM Design completed in 2005, with CM Implementation being completed in 2006.
  - Bioaugmentation to address VOC groundwater impacts in LOX Area (High Concentration Plume [HCP]) with downgradient extraction/recirculation system.
    - KB-1™ and potassium lactate injections coupled with pH adjustments.
  - Monitored natural attenuation (MNA) for LCP areas and metals.
  - Installation of sediment blocks in swales to control offsite discharges/sediment to adjacent wetlands.
- Operations and Maintenance and Performance Monitoring performed from 2007 through 2014.
  - Supplemental biostimulation injections of EOS® and EOS® AquaBupH™ completed in 2008.
  - Due to reduced degradation rates (VC reduction was occurring but was limited due to low pH in treatment zone) and the elimination of the Space Shuttle Program, Supplemental assessment activities inside the launch complex began in late 2011.
  - Recirculation system and performance monitoring discontinued in 2015.
- Baseline reassessment for VOC impacts was completed in 2015.
  - Identified two HS Areas (Hot Spot 1 and Hot Spot 2)
- AS in HCP was selected by KSCRT as remediation technology in 2016.
- AS WP and Step 3 EE was approved by the KSCRT in 2016.




Plumes shown are based on groundwater baseline assessment.

# Introduction and Background (continued)

- Two HS areas at LC39B
  - Hot Spot 1: West of LC39B Launch Pad
  - Hot Spot 2: Near the LOX tank
- AS operation began in July 2017
- Air Sparging system initially operated in 4 zones at LC39B
  - Zone Z1
  - Zone Z2
  - Zone Z3
  - Zone Z4

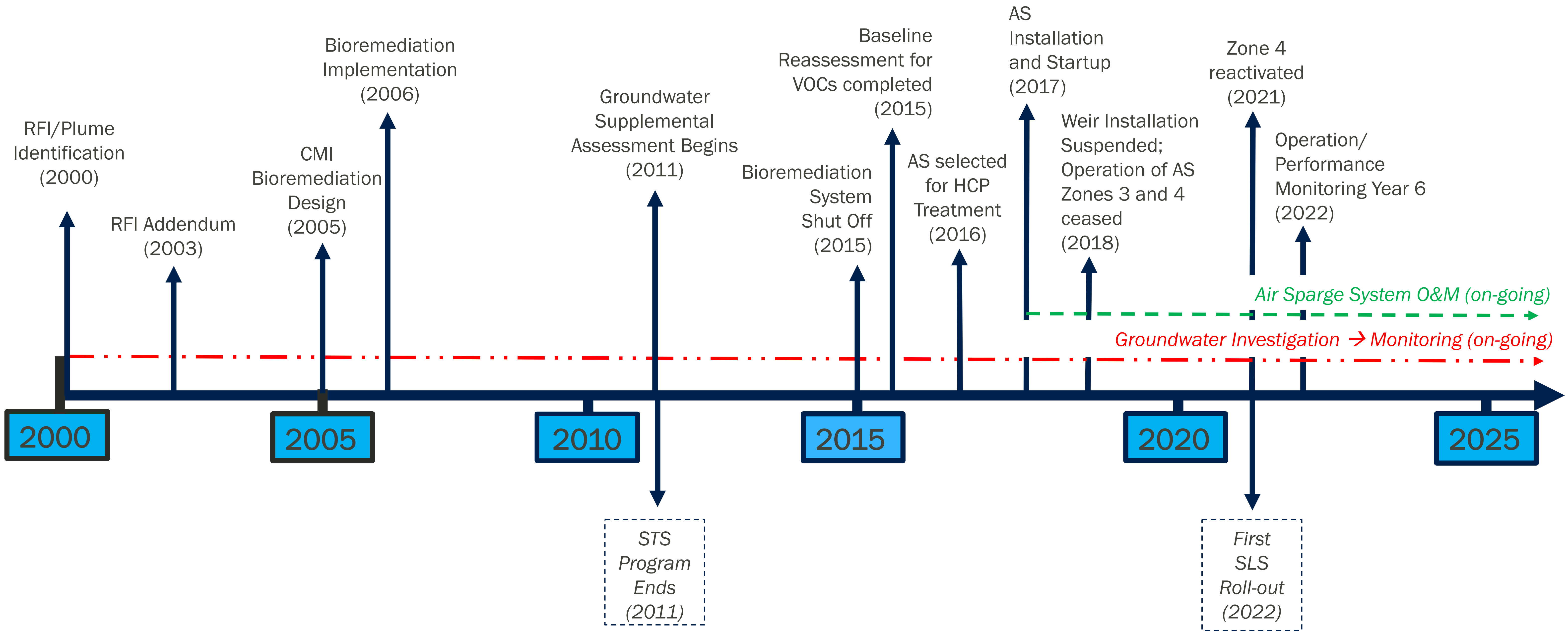
**FDEP Approvals**

| Document | Approval Year |
|---|---|
| Air Sparging WP (Western IM Area) | 2016 |
| Air Sparging Implementation WP | 2017 |
| Construction Completion Report | 2017 |

- Based on performance monitoring results at HS2, weir installation was suspended in October 2018.
- AS operations ceased in Zones Z3 and Z4 in October 2018.
  - Results in July 2018 indicated COCs were below their respective NADCs
- Z4 reactivated in 2021 due to contaminant rebound in 2019/2020

| | HS1 | HS2 |
|---|---|---|
| Groundwater COCs | TCE, cDCE and VC | TCE, cDCE and VC |
| HS Area | 1.08 acres | 0.16 acre |
| HCP Area | 7.96 acres | 0.73 acre |
| LCP Area | 26.62 acres | |
| Max. Depth of Contamination | 55 feet bls | 28 feet bls |

# Timeline of Remediation History

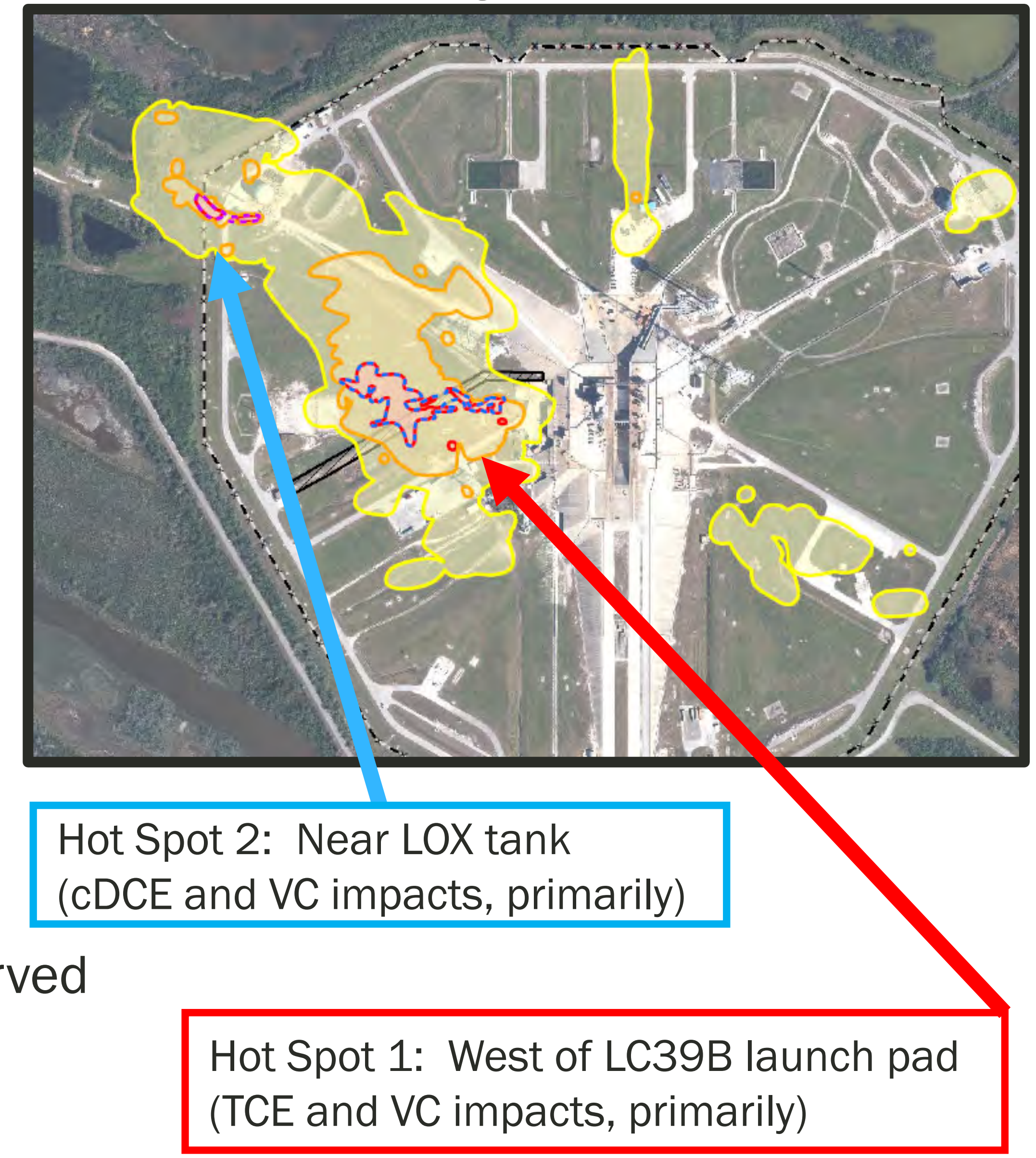


# Groundwater IM Overview

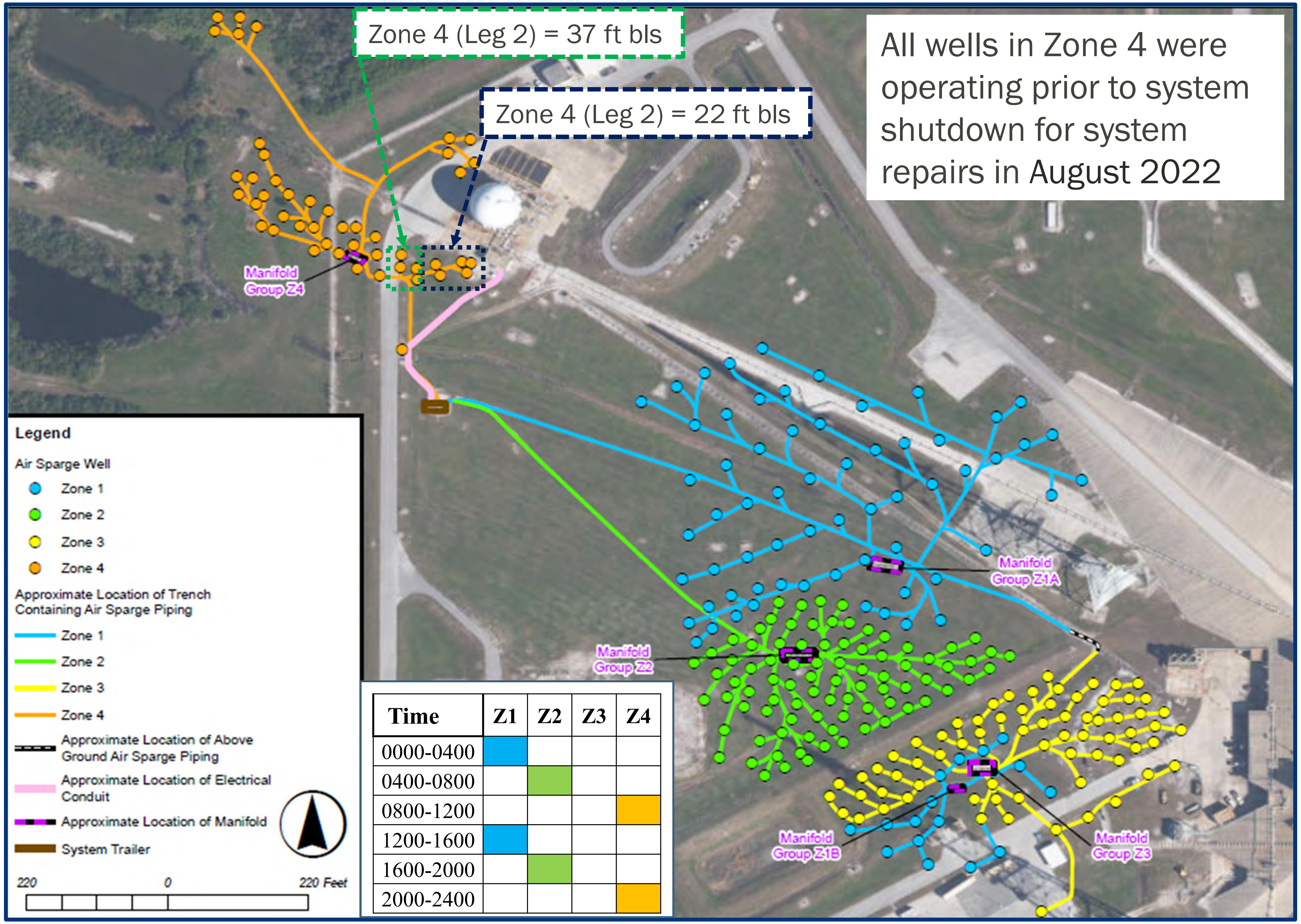
TETRA TECH

- Objective: Reduce COC concentrations in groundwater that exceeded their respective NADCs to concentrations that facilitate transition into Long-term Monitoring
- AS system began operation in June 2017
  - AS Well Details:
    - 279 AS wells, installed to depths ranging from 23 to 60 feet bls (including sump)
    - 2" diameter Schedule 40 PVC with a 2-ft, 0.010-inch slotted screen and a 1-ft Schedule 40 PVC sump
    - Wells operate at ~5 cfm/well with initiation pressures from 11 to 30 psi
  - HDPE compressed air distribution infrastructure:
    - 4" and 2" IPS SDR11 HDPE Headers
    - 1" IPS SDR11 HDPE Laterals
  - 4 AS operational zones
    - 13 total legs; 32 total distribution manifolds
    - Pulse duration and frequency set to compliment each other
    - Zone 3 not operational due to reaching objectives; no rebound observed
  - Electricity supplied from Electrical Equipment Building J7-0231

Plumes shown are based on groundwater baseline assessment.



# Air Sparging System Overview



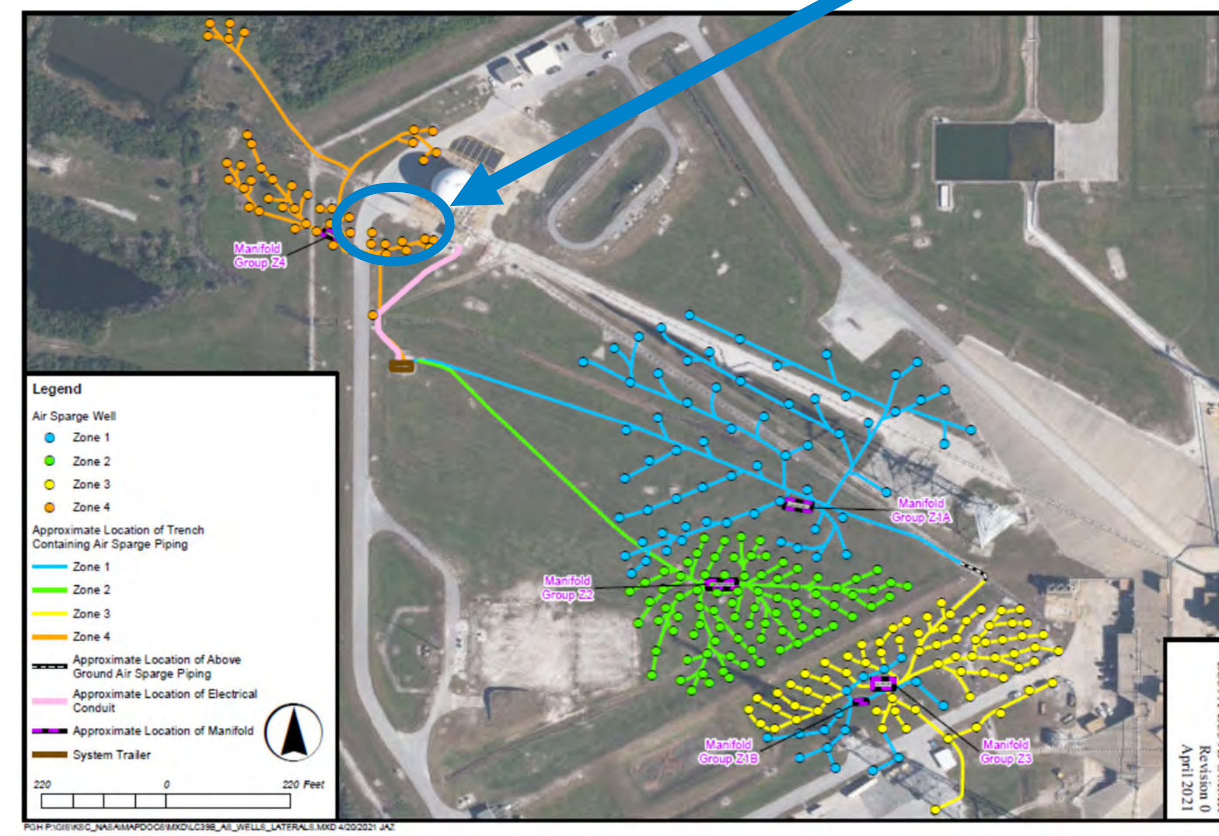

| Time | Z1 | Z2 | Z3 | Z4 |
|---|---|---|---|---|
| 0000-0400 | | | | |
| 0400-0800 | | | | |
| 0800-1200 | | | | |
| 1200-1600 | | | | |
| 1600-2000 | | | | |
| 2000-2400 | | | | |

- 100 HP rotary screw compressor with refrigerated air dryer (530 scfm at 102 psig)
- Three stage air treatment and filtering
  - Two coalescing filters for solids, water, and oil removal
    - 99.3% and 99.9% removal
  - One activated carbon filter for oil vapor and fine oil droplet removal
    - removal to <3 ppb
- Condensate treatment system
  - Includes oil separation, absorbent, and activated carbon
- PLC-based control
  - Includes local and remote HMI

# Overview of LC39B Investigations

- <u>2019-2020 DPT Sampling</u>: Identified residual HS (VC > 10xNADCs) and HCP (cDCE and VC > NADCs) concentrations in LOX area
- <u>February 2021 KSCRT Meeting</u>: Team reached consensus to complete delineation and utility locates as detailed and provide the Team with the final recommendation in future meeting, and complete the design and implementation of a recommended alternative (2102-D16)
- <u>November 2021-January 2022</u>: Conducted GPR and additional DPT to delineate Hot Spot 2 and HCP and identify utilities in the LOX area, in order to support RAE and IMWP development
- <u>March 2022 KSCRT Meeting</u>: Team reached consensus to complete Hot Spot 2 evaluation pending data assessment (2203-D35)

DPT investigation area

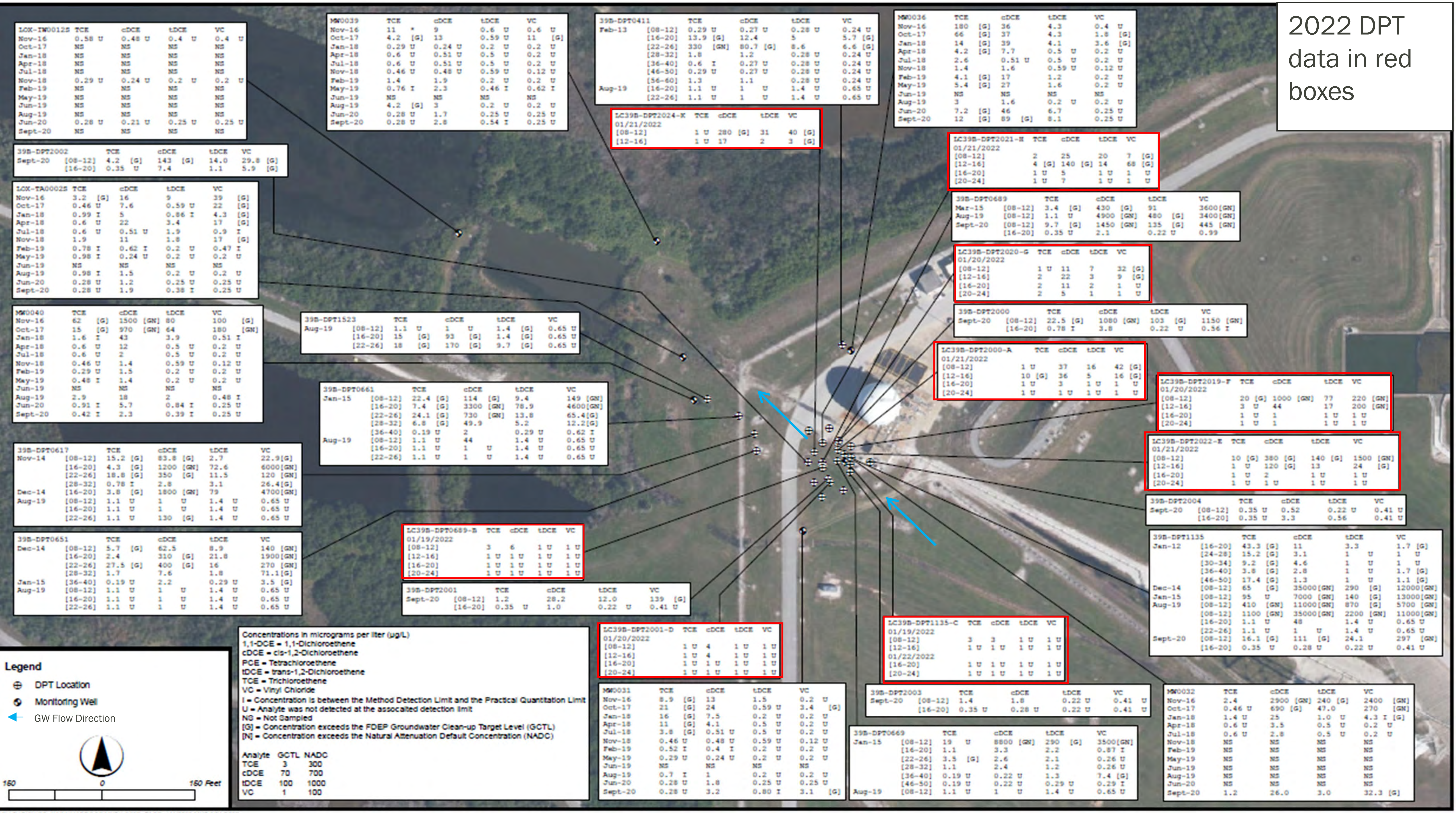


# LC39B DPT Investigation Results

- VC NADC exceedances are located just south of the LOX tank concrete pad at three locations at 8-12' bls and one location at 12-16' bls
- Contouring and data evaluation:
  - 56 Groundwater samples collected at 18 locations
    - Sampling intervals included 0-10', 10'-20', and 20'-30'
  - Results from 2019-2022 DPT groundwater sampling events and performance results within the proposed expansion area were used to generate contaminant interval slides
    - Interval 0-10' includes all data from ground surface to and including 10' bls
    - Interval 10'-20' includes all data greater than 10' bls to and including 20' bls
    - Deeper interval followed same logic
  - Most recent data at location used for contouring
    - DPT0689 replaced by DPT0689-B, DPT2000 replaced by DPT2000-A, and DPT2001 replaced by DPT2001-D
    - One exception: DPT1135 used in addition to DPT1135-C due to non-negligible difference in location
  - Cross-sections provided for vertical evaluation

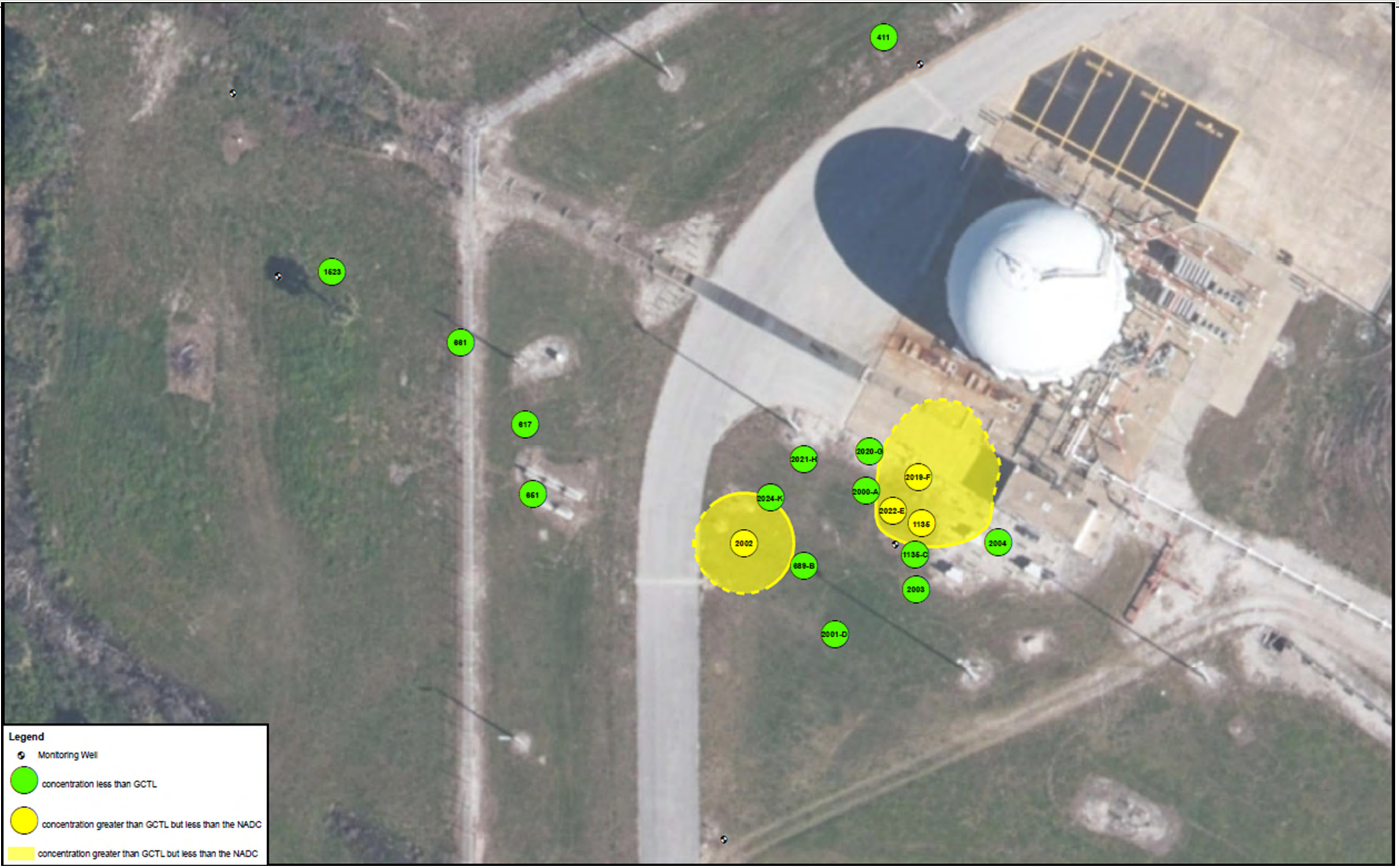
| Interval (ft bls) | 0-10 | 10-20 | 20-30 |
|---|---|---|---|
| | | TCE | |
| Samples | 17 | 26 | 13 |
| Detections | 8 | 5 | 2 |
| >GCTL | 5 | 2 | 1 |
| >NADC | 0 | 0 | 0 |
| >10xNADC | 0 | 0 | 0 |
| Maximum Detection (ppb) | 16.1 | 15 | 18 |
| Average Detection (ppb) | 5.6 | 6.6 | 10 |
| | | cDCE | |
| Samples | 17 | 26 | 13 |
| Detections | 14 | 15 | 5 |
| >GCTL | 4 | 3 | 2 |
| >NADC | 1 | 0 | 0 |
| >10xNADC | 0 | 0 | 0 |
| Maximum Detection (ppb) | 1000 | 140 | 170 |
| Average Detection (ppb) | 135.9 | 35.1 | 62.6 |
| | | tDCE | |
| Samples | 17 | 26 | 13 |
| Detections | 8 | 9 | 2 |
| >GCTL | 1 | 0 | 0 |
| >NADC | 0 | 0 | 0 |
| >10xNADC | 0 | 0 | 0 |
| Maximum Detection (ppb) | 140 | 17 | 9.7 |
| Average Detection (ppb) | 42.6 | 7.0 | 5.4 |
| | | VC | |
| Samples | 17 | 26 | 13 |
| Detections | 8 | | 0 |
| >GCTL | 5 | 6 | 0 |
| >NADC | 2 | 1 | 0 |
| >10xNADC | 1 | 0 | 0 |
| Maximum Detection (ppb) | 1500 | 200 | N/A |
| Average Detection (ppb) | 304 | 53.8 | N/A |

# 2022 DPT data in red boxes



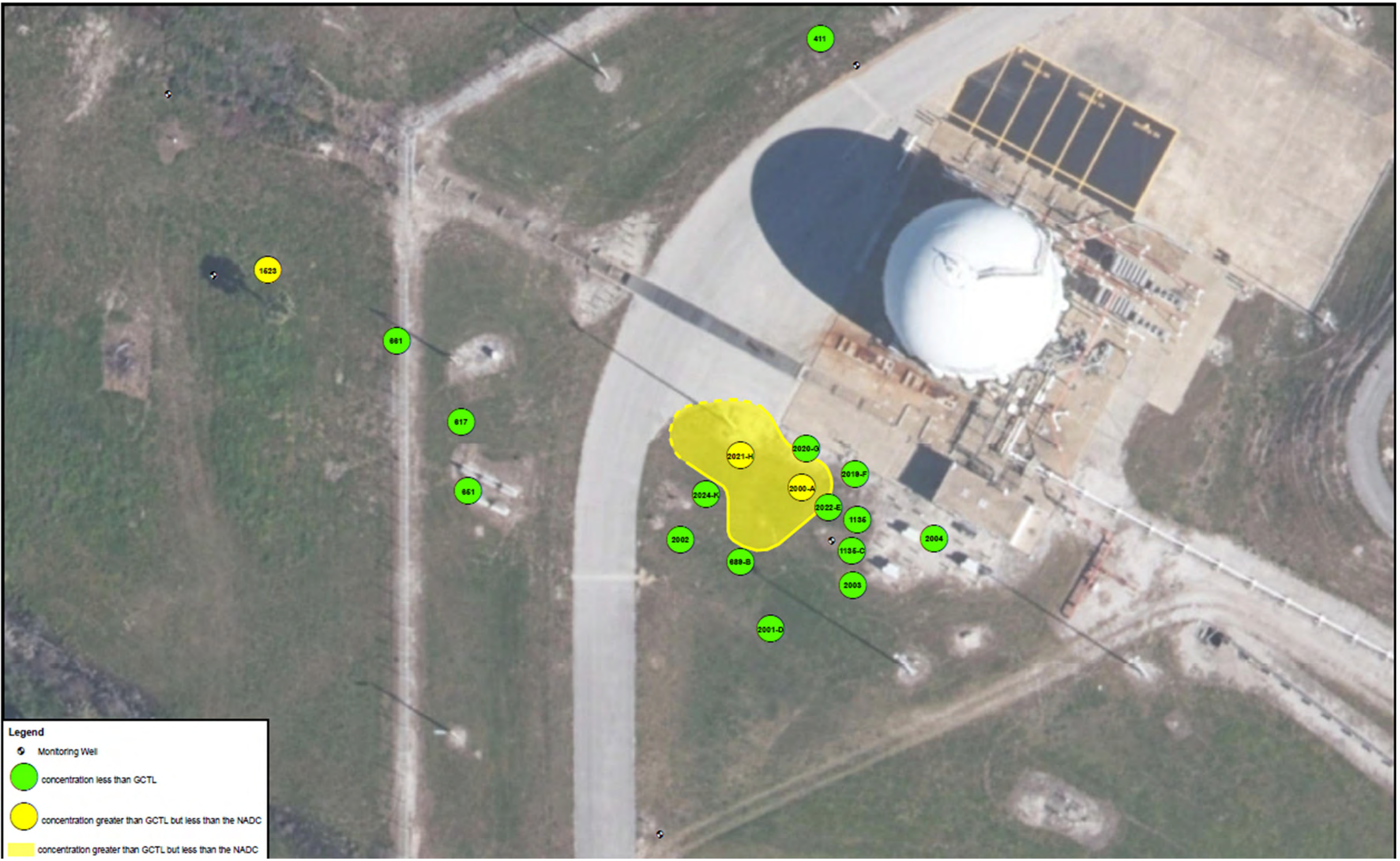
# TCE, Interval: 0 to 10 feet bls

TETRA TECH



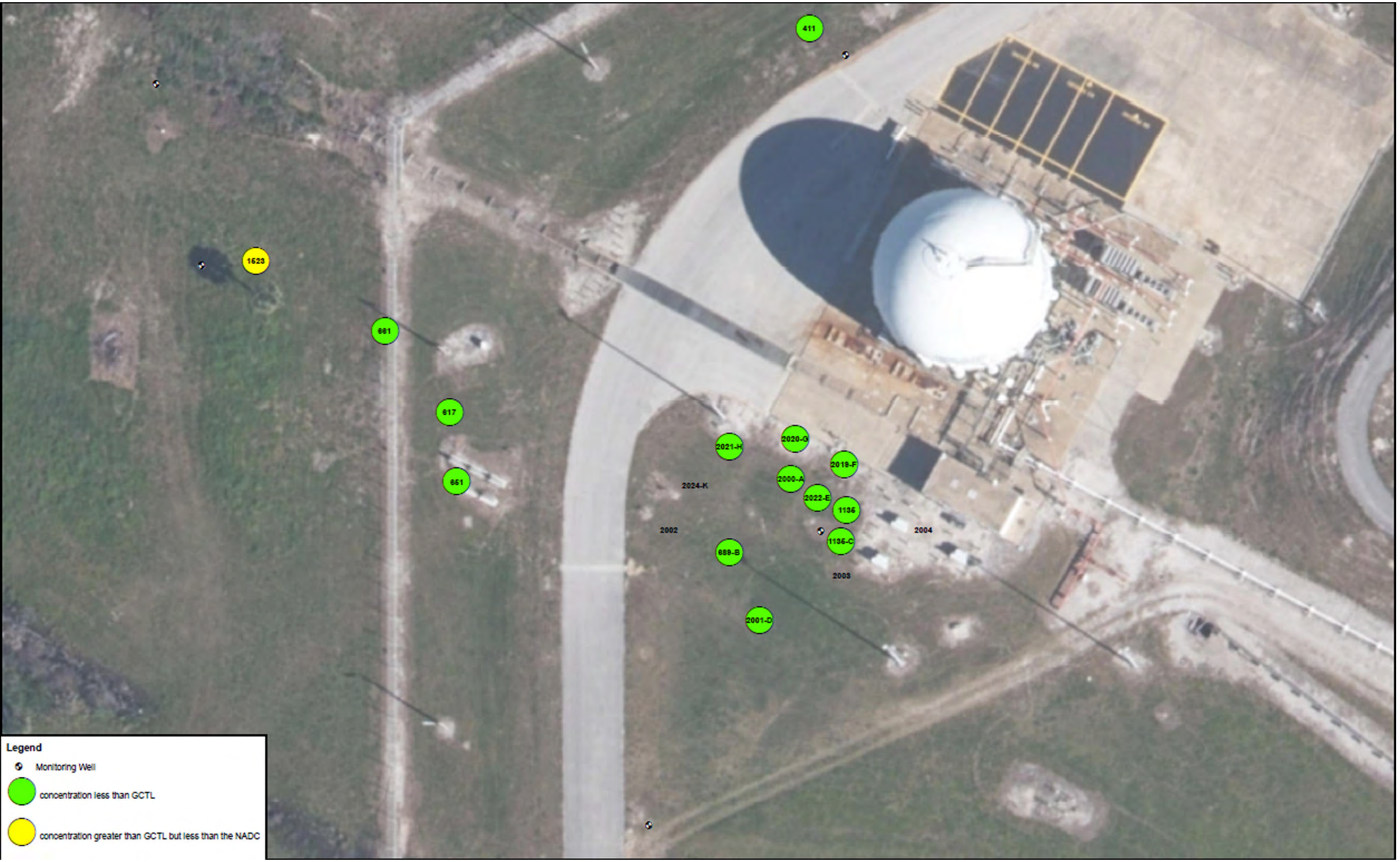

- No results ≥ NADC

# TCE, Interval: 10 to 20 feet bls



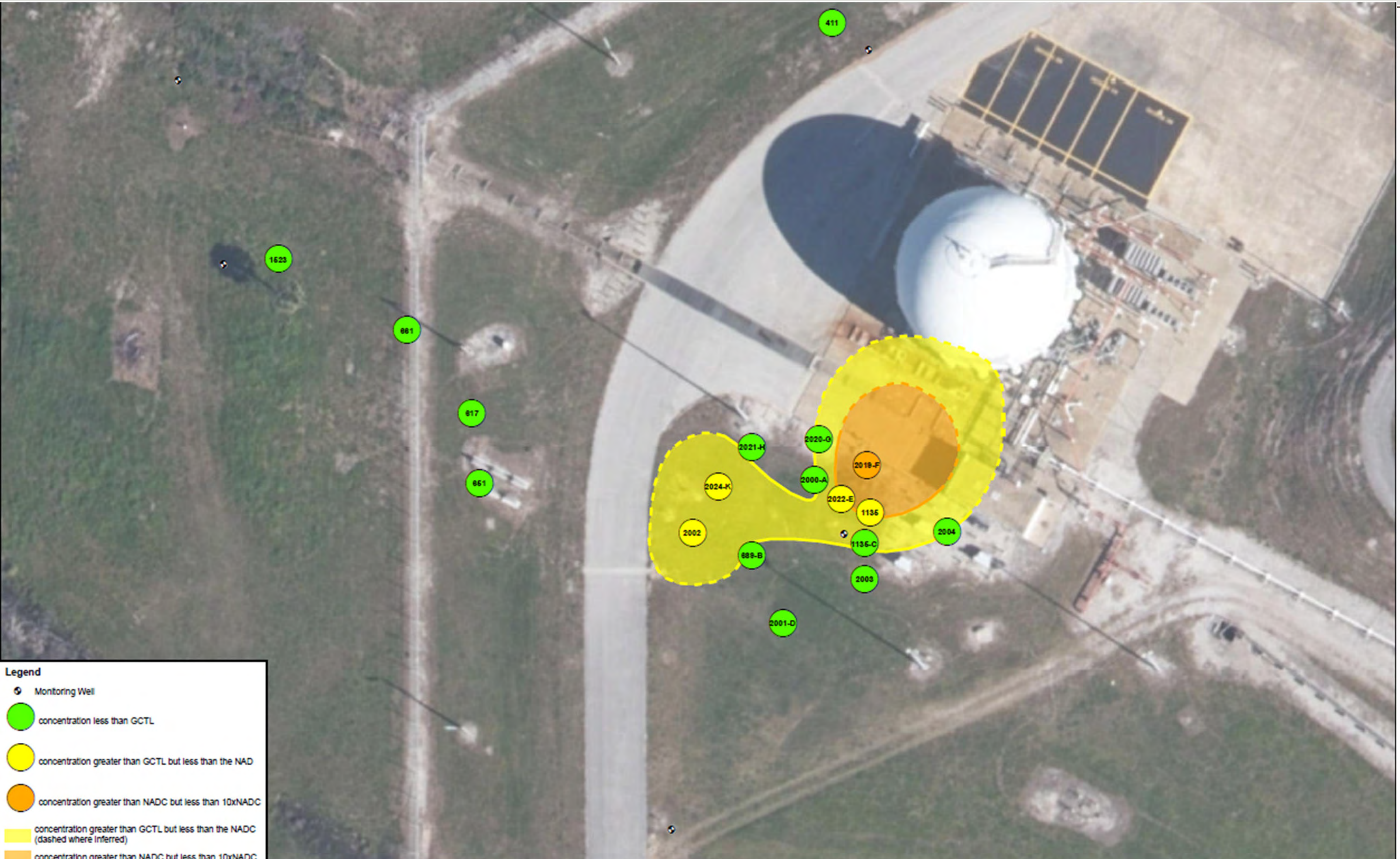

- No results ≥ NADC

# TCE, Interval: 20 to 30 feet bls



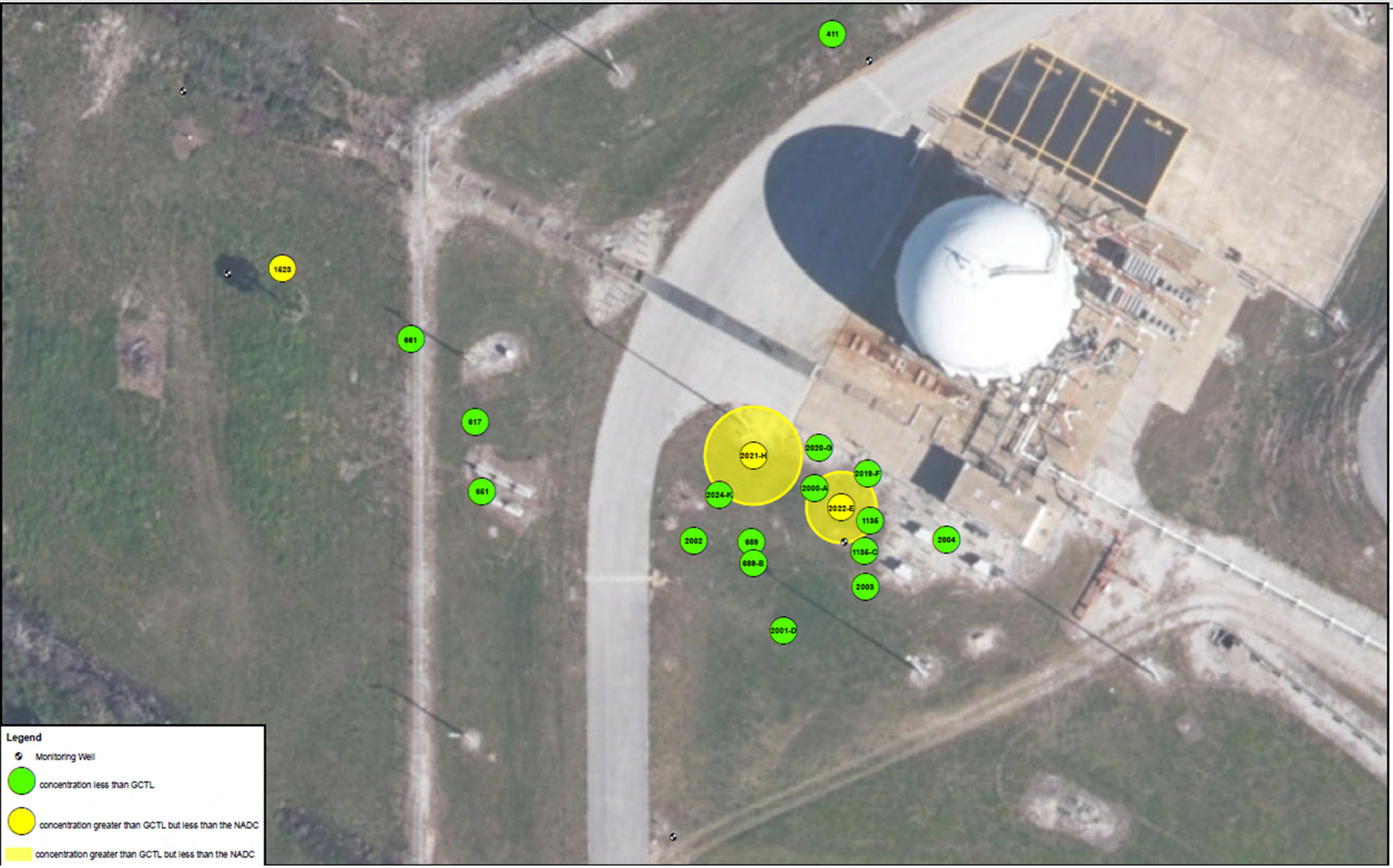

- No results ≥ NADC

# cDCE, Interval: 0 to 10 feet bls




- One result ≥ NADC
  - 1,000 μg/L at DPT2019-F

# cDCE, Interval: 10 to 20 feet bls

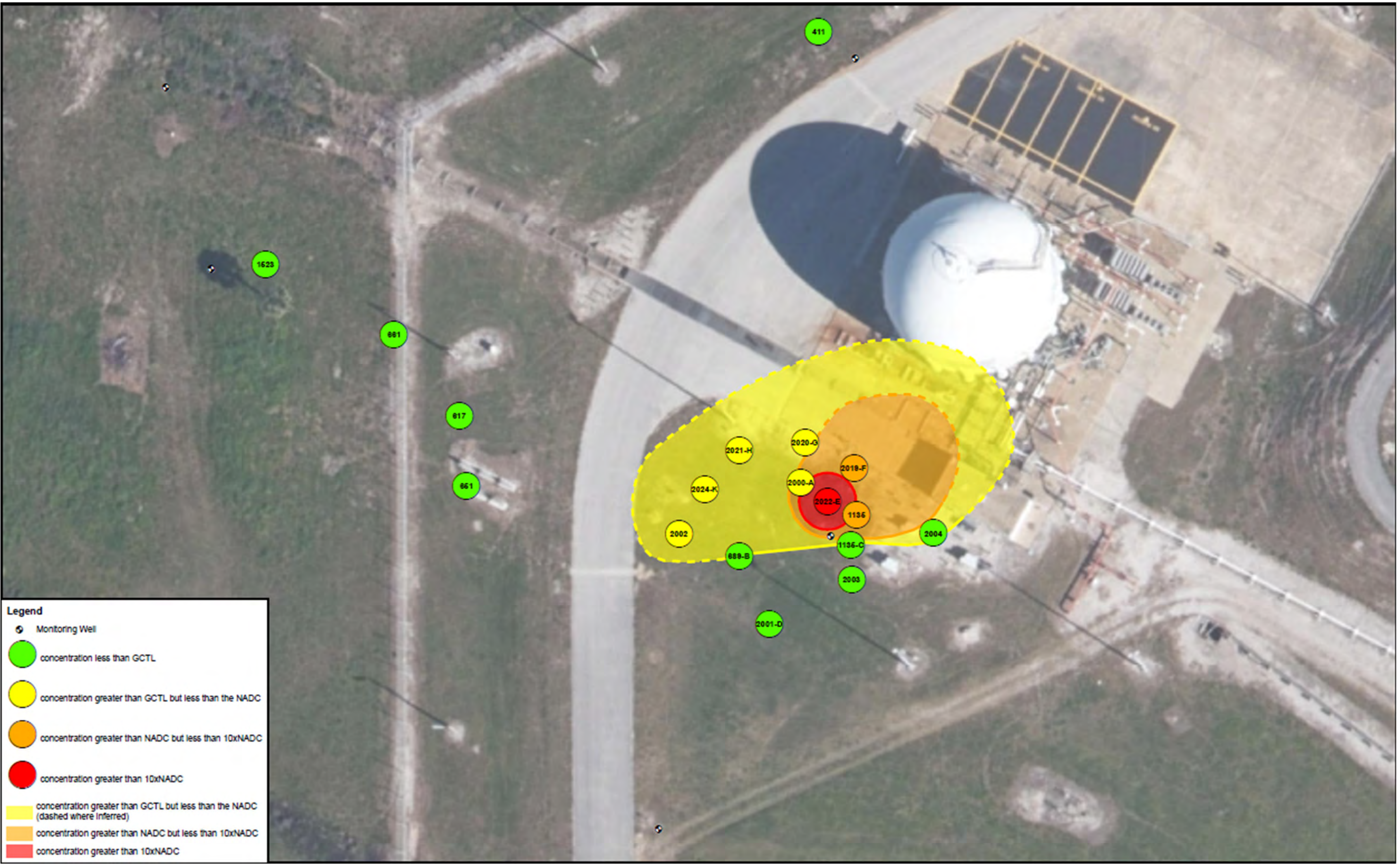



- No results ≥ NADC

# cDCE, Interval: 20 to 30 feet bls

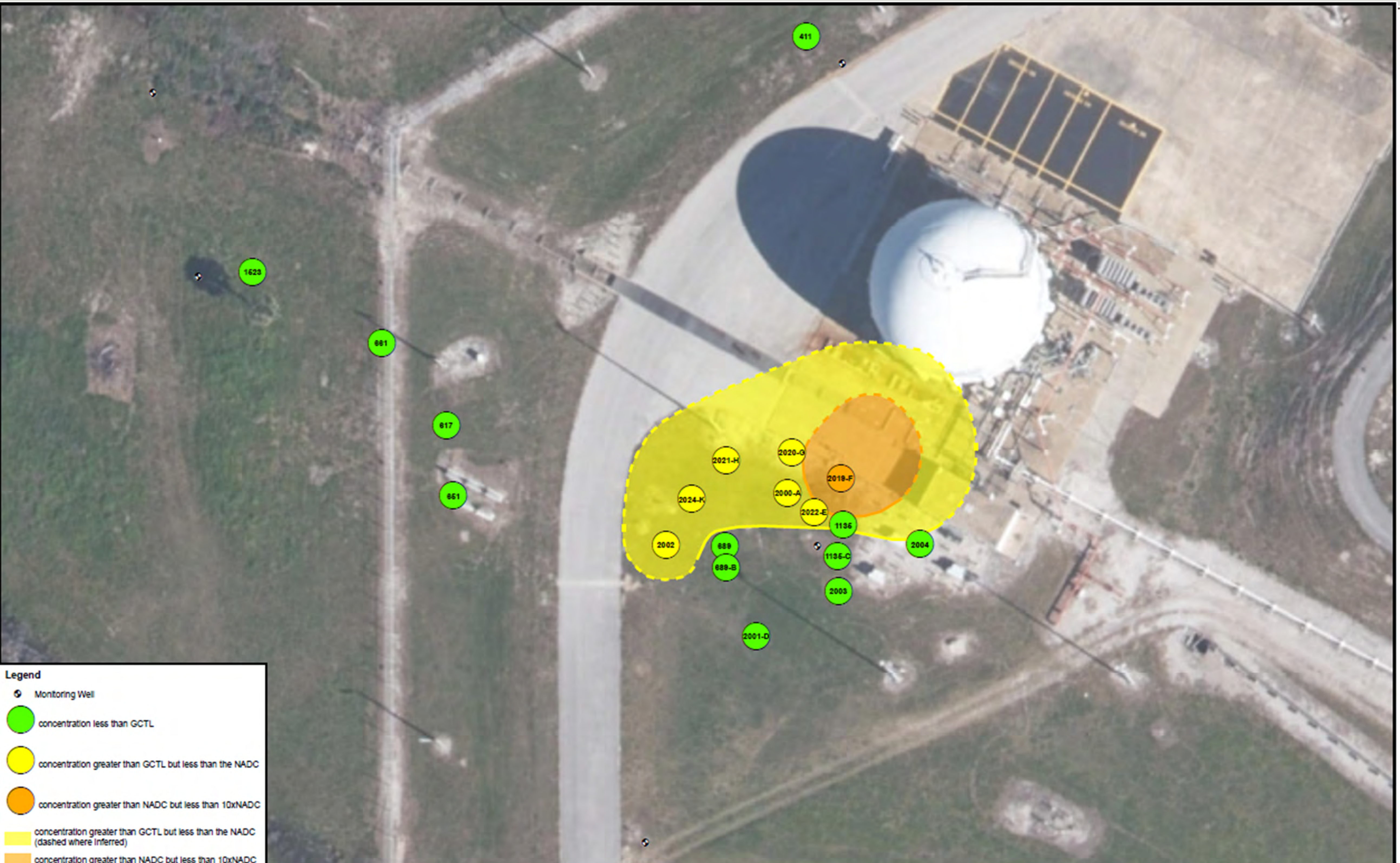

- No results ≥ NADC

# VC, Interval: 0 to 10 feet bls




- Three results ≥ NADC
  - 297 µg/L at DPT1135
  - 220 µg/L at DPT2019-F
  - 1,500 µg/L at DPT2022-E

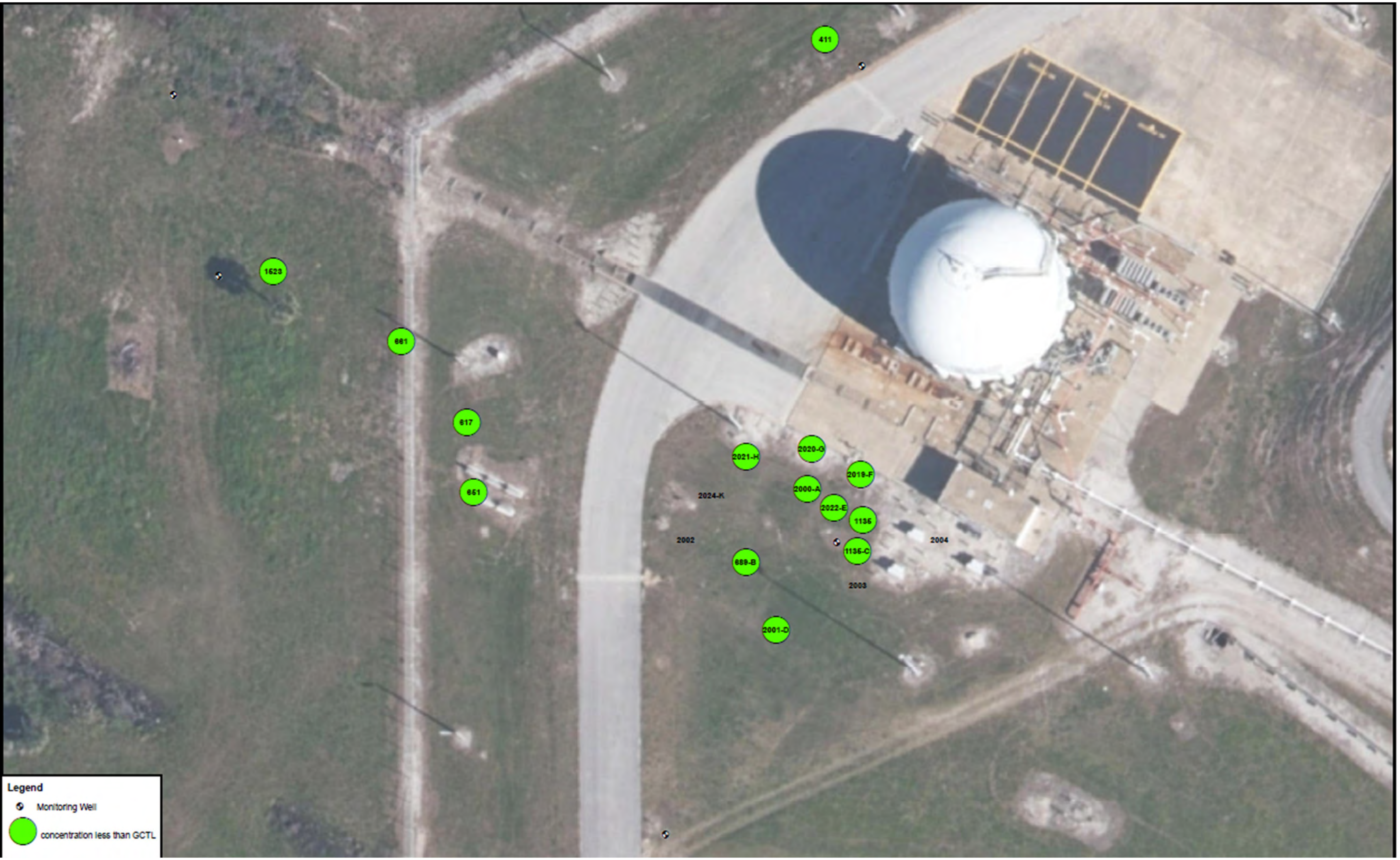
# VC, Interval: 10 to 20 feet bls




- One result ≥ NADC
  - 200 µg/L at DPT2019-F

# VC, Interval: 20 to 30 feet bls

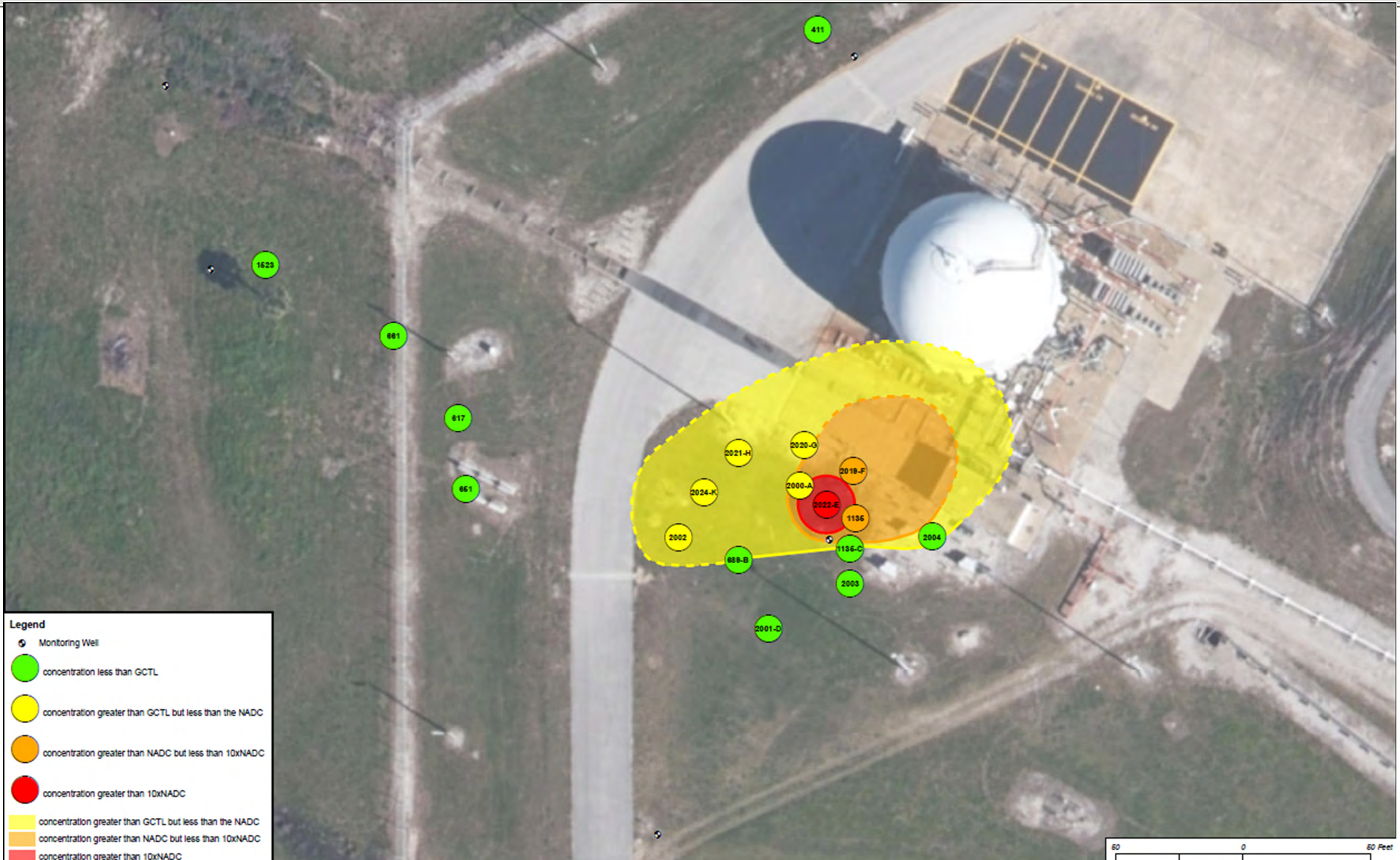
TETRA TECH




- No results ≥ NADC

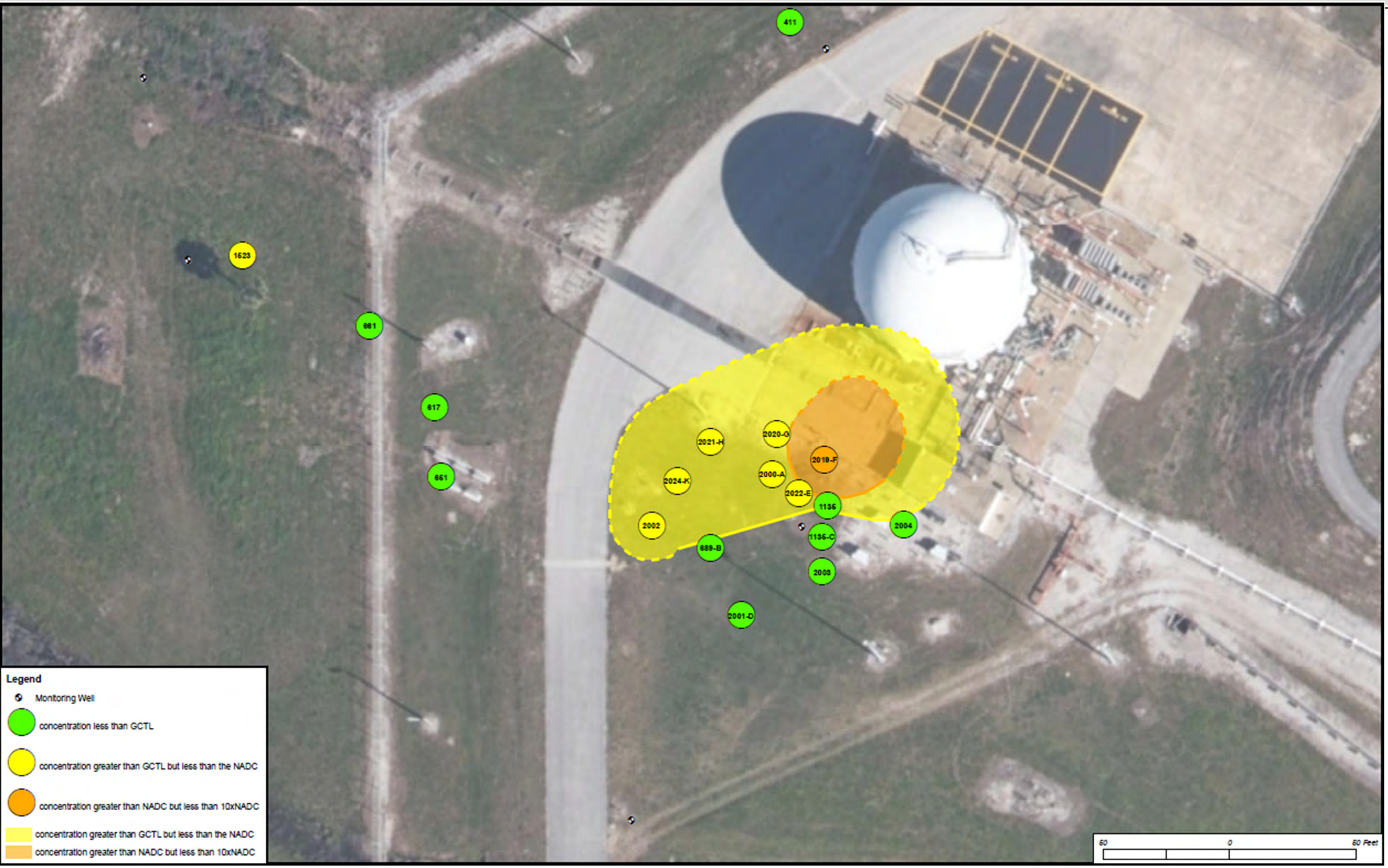
# Plume, Interval: 0 to 10 feet bls

TETRA TECH



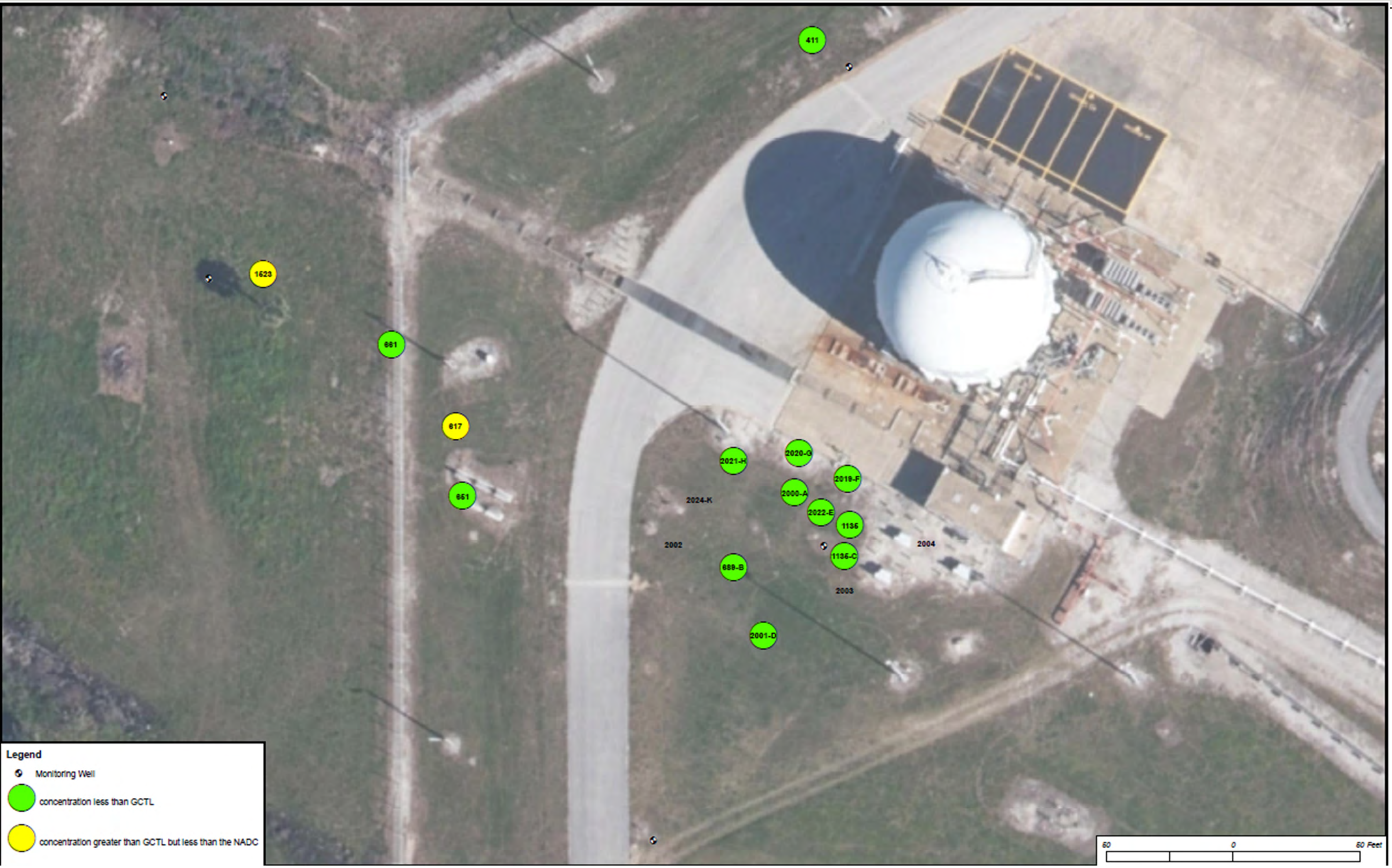

- Maximum cDCE concentration:
    - 1,000 µg/L at DPT2019-F
- Maximum VC concentration:
    - 1,500 µg/L at DPT2022-E

# Plume, Interval: 10 to 20 feet bls



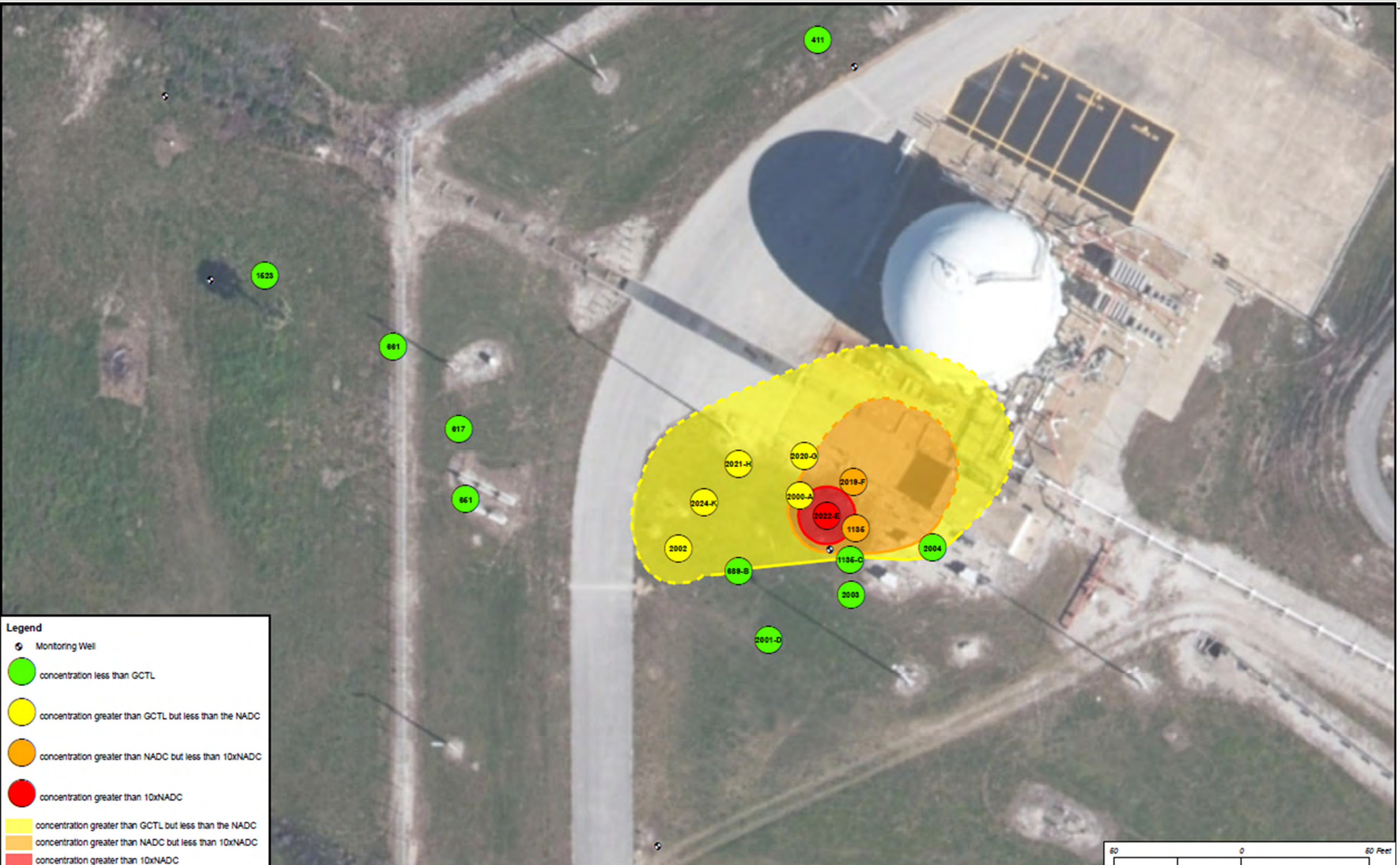

- Maximum cDCE concentration:
  - 140 µg/L at DPT2021-H
- Maximum VC concentration:
  - 200 µg/L at DPT2019-F

# Plume, Interval: 20 to 30 feet bls




- No results ≥ NADC

# Plume, All Intervals



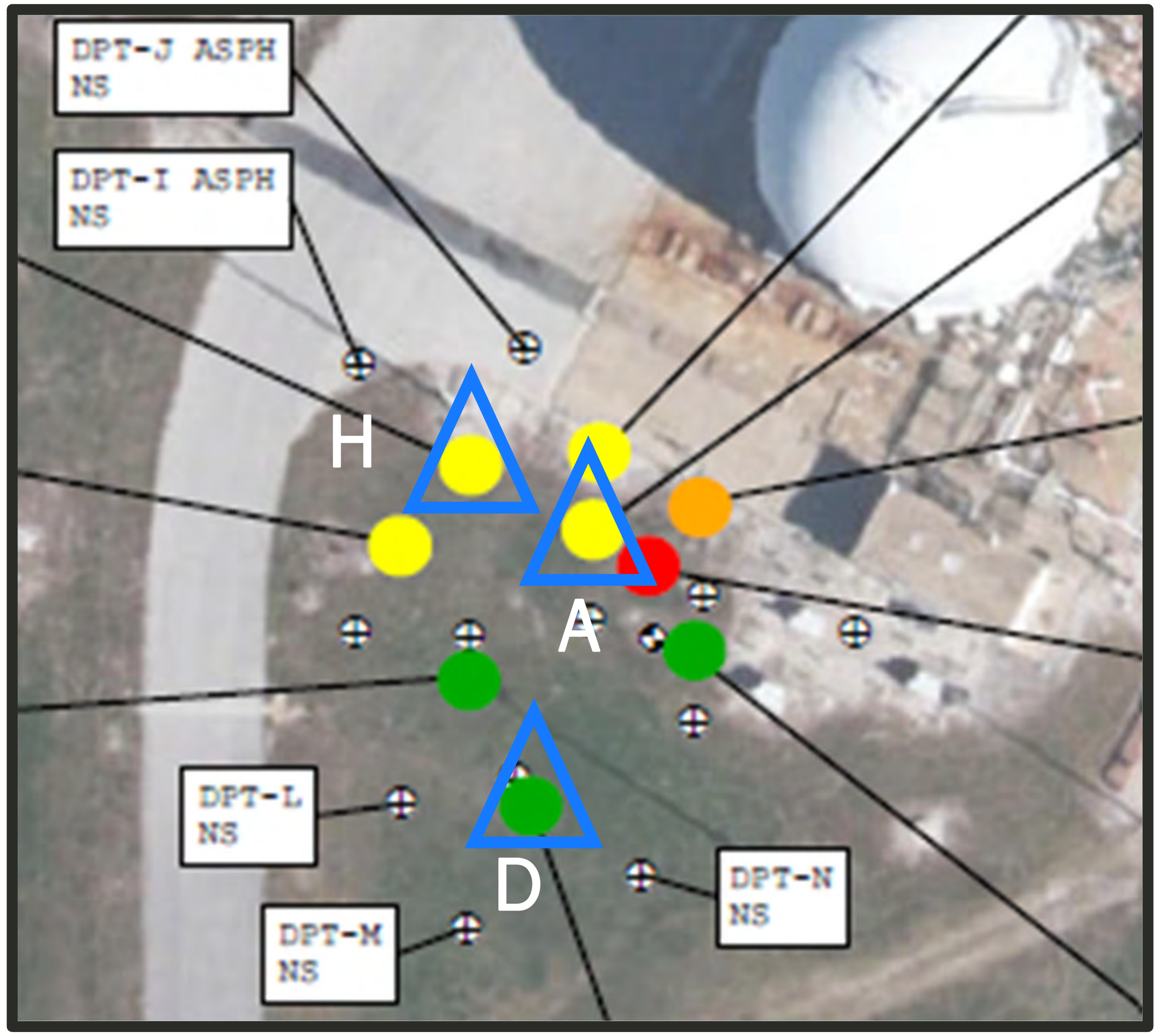

- NADC exceedances in 0-10’ and 10-20’ intervals
  - 0-10’ at DPT1135, DPT2019-F, and DPT2022-E
  - 10-20’ at DPT2019-F
  - All other locations less than NADCs

# Data Review (2022 Investigation), continued

- Soil Analytical Results
  - Samples collected from locations A, D, and H
    - VOC and TOC analysis, multiple intervals – 8, 12, and 18 ft bls
  - No rSCTL exceedances
  - TOC data suggests organic carbon (natural or contaminant) remains present in saturated matrix to support reductive dechlorination
    - Additional MNA parameters (i.e., MEE) may be necessary to evaluate potential biodegradation rates

| Location | Depth | TCE | tDCE | cDCE | VC | TOLUENE | TOC |
|---|---|---|---|---|---|---|---|
| SB1676 (A) | 8 ft | ND | 0.00078 | 0.0014 | ND | 0.00061 IV | 3,200 |
| | 12 ft | ND | 0.0038 | 0.032 | 0.038 | ND | 16,000 |
| | 18 ft | ND | ND | ND | ND | 0.00064 IV | 21,000 |
| SB1678 (H) | 8 ft | ND | 0.0012 | 0.0043 | ND | 0.00068 IV | 2,100 |
| | 12 ft | ND | ND | 0.0028 | ND | ND | 27,000 |
| | 18 ft | 0.00079 I | ND | ND | ND | 0.0013 V | 22,000 |
| SB1677 (D) | 8 ft | 0.0044 | 0.006 | 0.035 | 0.0026 | 0.0013 IV | 120,000 |
| | 12 ft | ND | ND | 0.00063 | ND | 0.00071 IV | 8,200 |
| | 18 ft | ND | ND | ND | ND | 0.00072 IV | 6,800 |

All results in mg/kg
I = Reported value between laboratory MDL and PQL
V = Analyte detected in sample and associated method blank
Residential SCTLs: TCE = 6.4 mg/kg; tDCE = 53 mg/kg; cDCE = 33 mg/kg; VC = 0.2 mg/kg; Toluene = 7,500 mg/kg

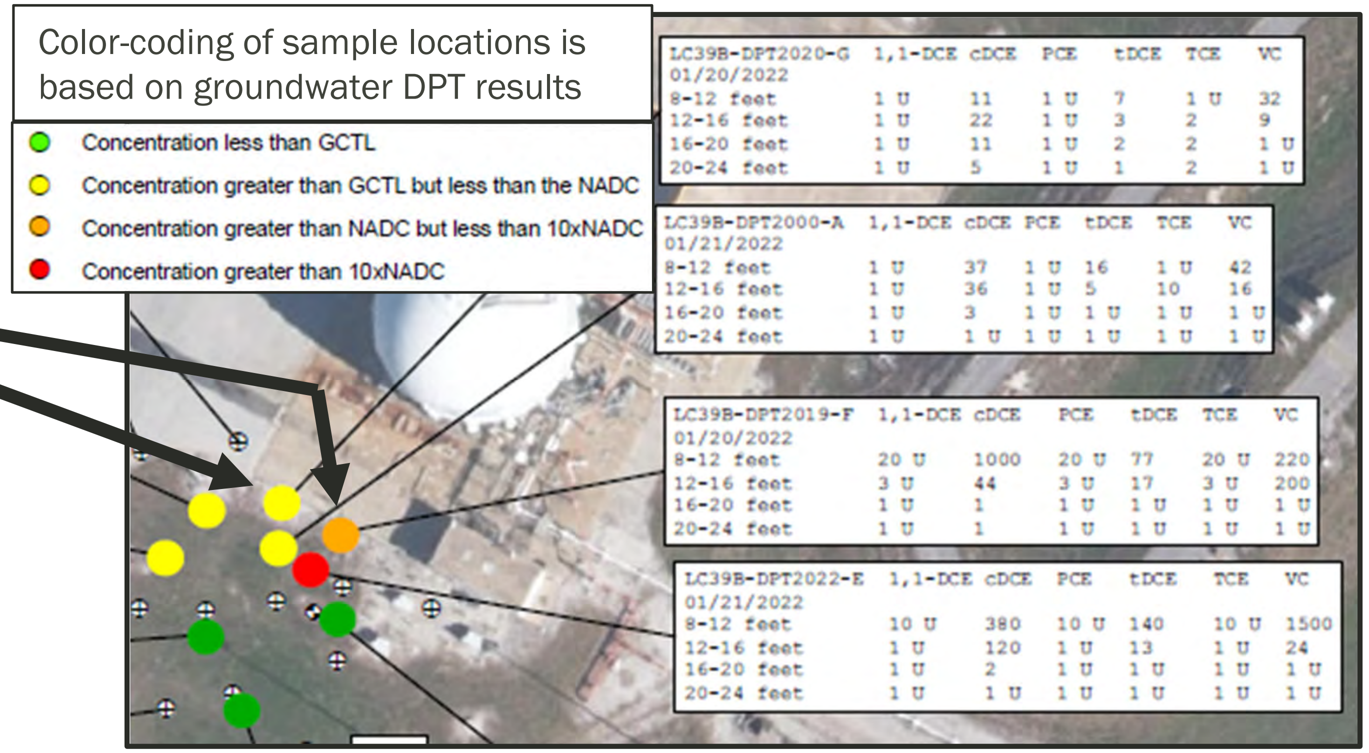


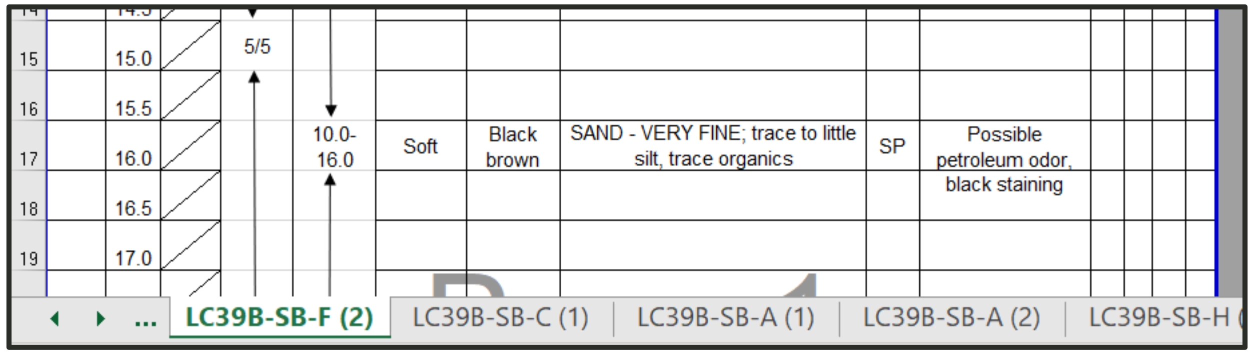

Color-coding of sample locations is based on groundwater DPT results

- Concentration less than GCTL
- Concentration greater than GCTL but less than the NADC
- Concentration greater than NADC but less than 10xNADC
- Concentration greater than 10xNADC

# Data Review (2022 Investigation), continued

- Soil Observations
  - Potential petroleum odors/staining logged at two locations
    - DPT2019-F and DPT2020-G (10-16 ft bls range)
    - Just off concrete slab
    - Mobile lab only analyzed for chlorinated compounds (no BTEX)
    - Uncertain if petroleum identified in this area during previous work (i.e., RFI?)
    - NOTE: Soil data at nearby locations A and H had low-level toluene hits (BEX compounds = ND)
- Groundwater samples collected from MW0032 in May 2022 for analysis of PAHs and TRPH
  - All PAH and TRPH analytes less than laboratory detection limits
- Path forward:
  - During system installation, soil cores pulled from this area will be evaluated for petroleum odor and staining and soil samples will be collected.

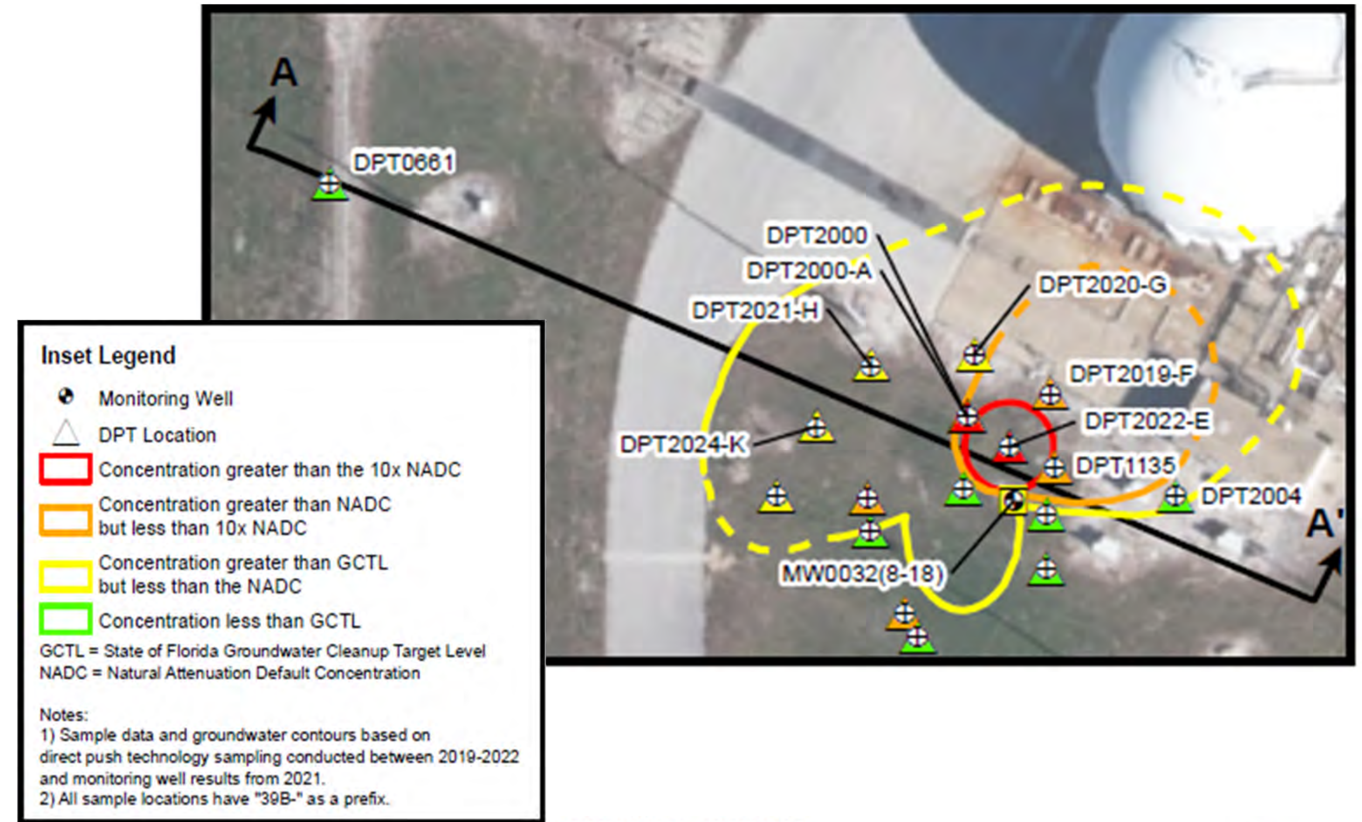


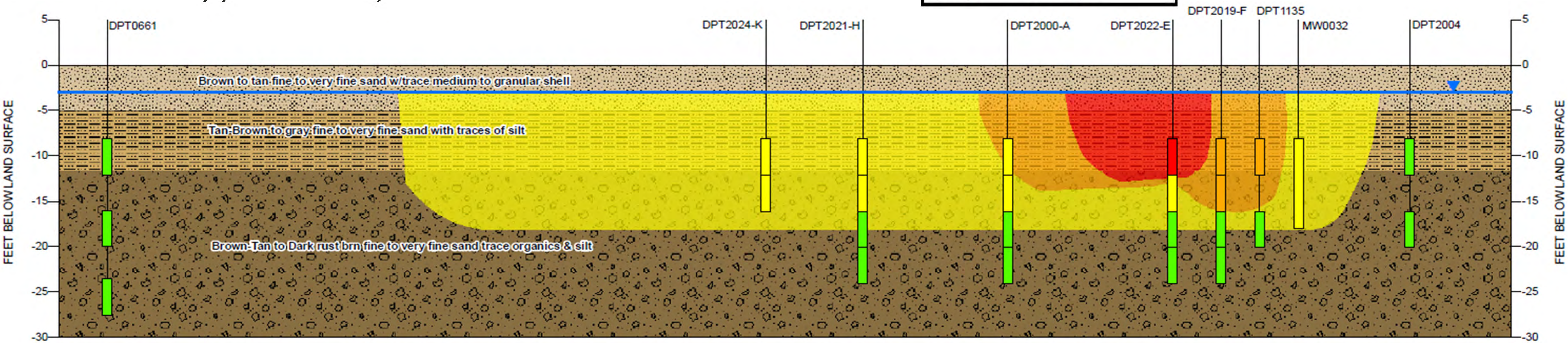




# Lithology Evaluation

TETRA TECH

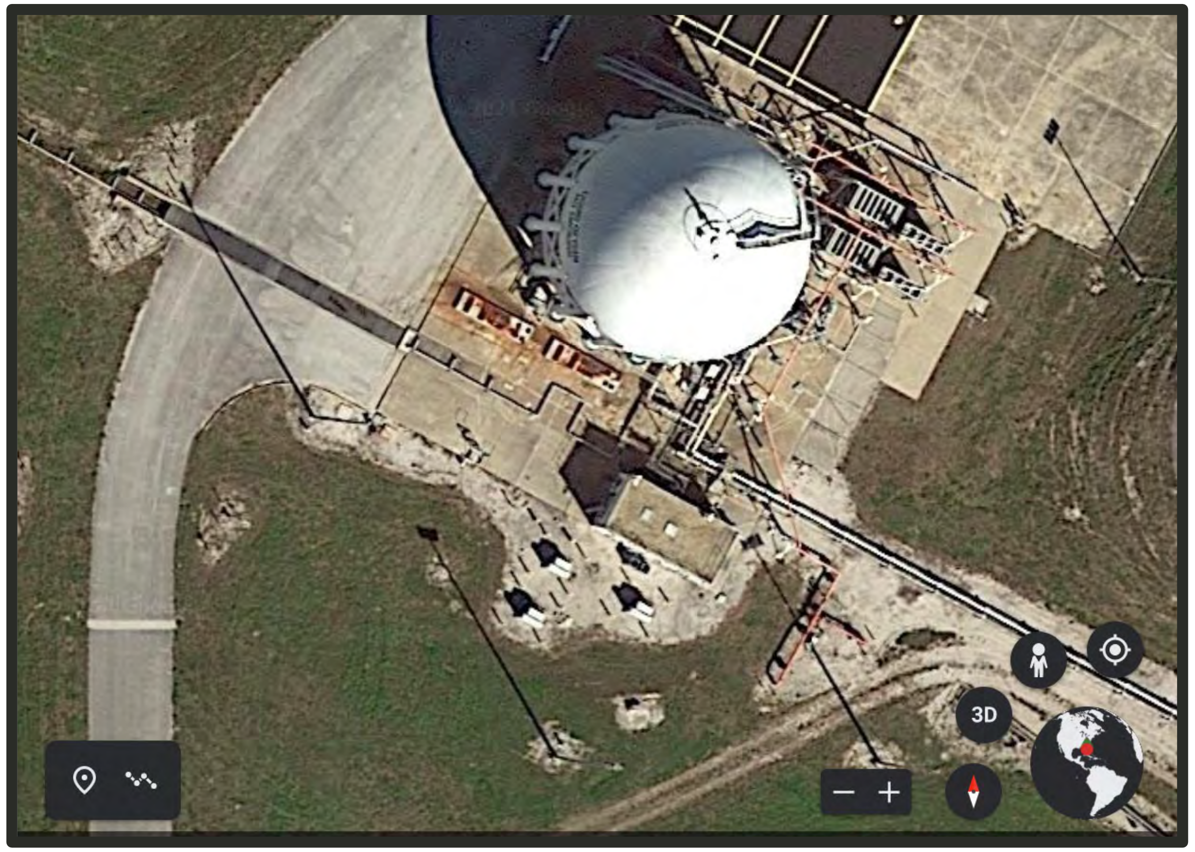
- Residual HS/HCP concentrations within 8-12 ft bls interval, similar to LC39A
- A 2- to 4-foot-thick clay layer has been encountered intermittently from 8-12 ft bls at both LC39A and LC39B
- 10 ft bls is the transition from dense sand (in some areas this could be original fill from construction) to loose sand with silt and shells (10-42 ft bls)
- Boring logs from 2022 confirmed the transition to fine sands at approximately 10 ft bls



# Remediation Challenges

- Potential Challenges: Majority of (current) inferred HS/HCP areas are under concrete, which is associated with LOX storage area and/or associated transformers
  - Highest concentrations are at the edge of electrical transformers, concrete, and significant infrastructure in the LOX Area
  - Aggressive technologies (requiring significant intrusive activities) can not be implemented
    - This eliminates options such as excavation and aggressive oxidation
  - In-situ technologies (chemical/bio injections) may not be feasible due to amount of utilities and material of utilities (i.e., potential corrosion)



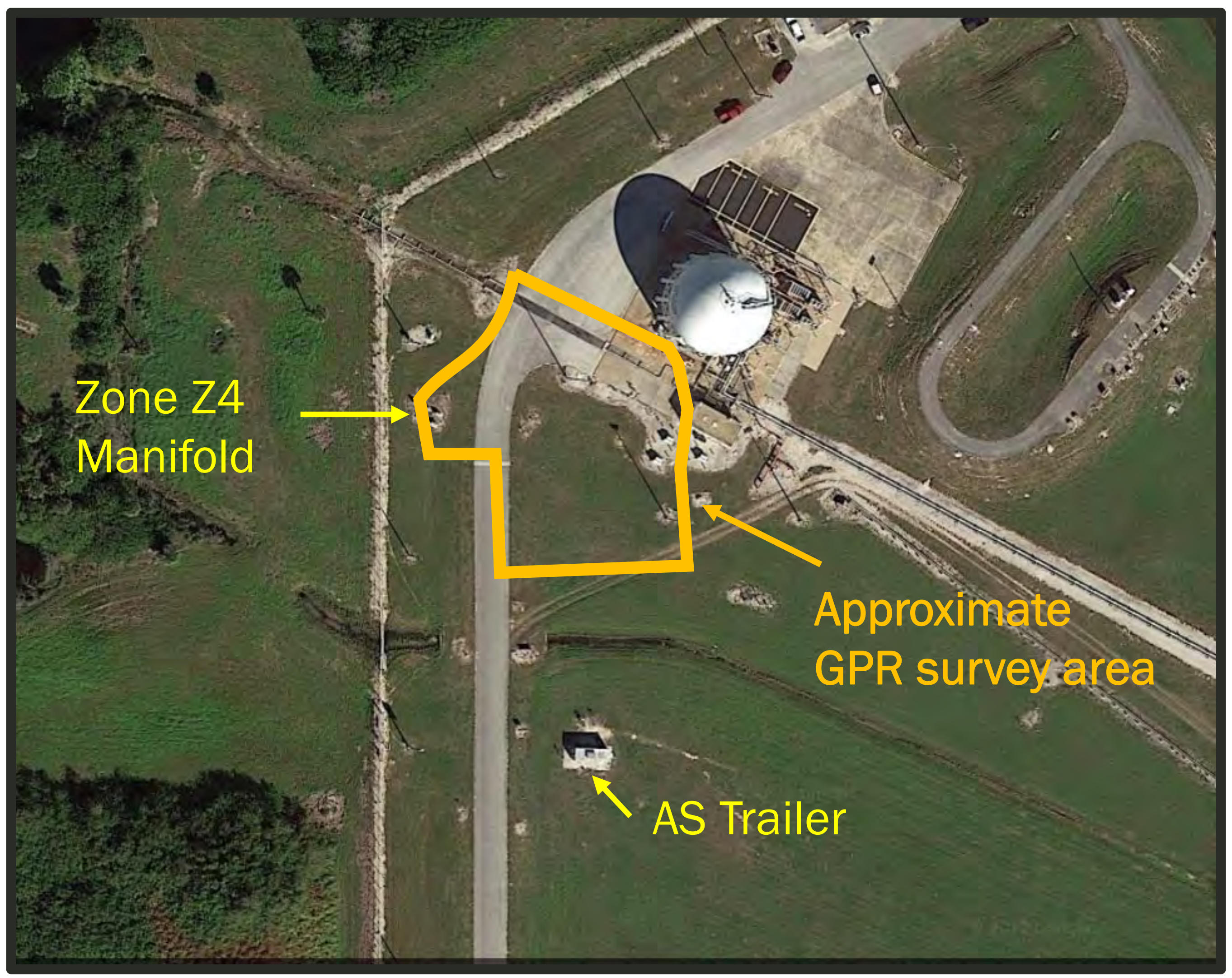

- Expansion of existing air sparge system can effectively target the majority of the HS/HCP while minimizing impacts to utilities/structures in the vicinity

# AS Expansion Summary

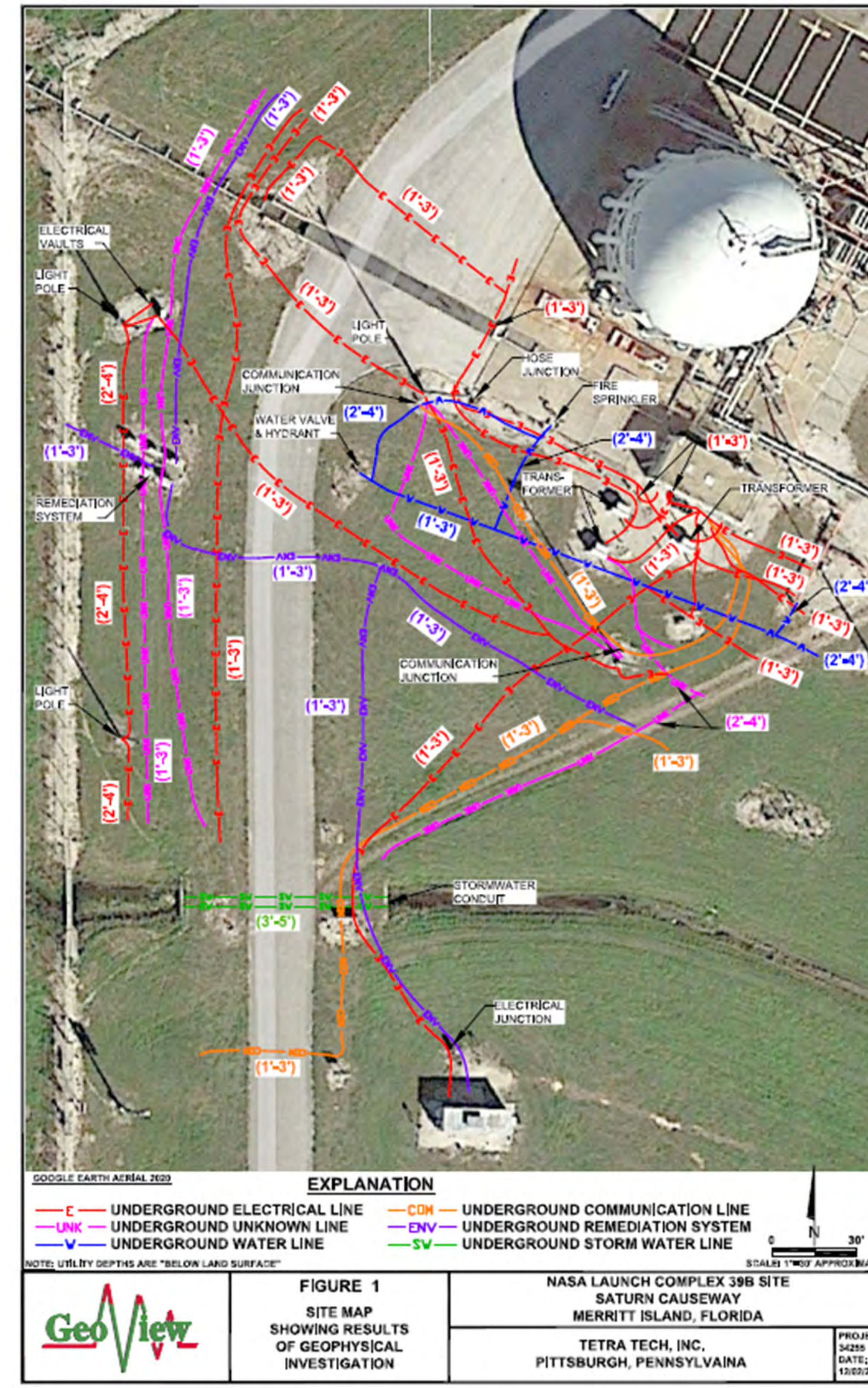
- An AS expansion is recommended due to NADC exceedances remaining in the Hot Spot 2 area during DPT sampling conducted in August 2019, September 2020, and January 2022
- A Ground Penetrating Radar study was completed in the construction area to determine the location and depth of all utilities
- The AS System is proposed to be expanded to address the NADC exceedances identified during the DPT sampling events.
  - 3 AS wells installed at 11 to 13 feet bls; depth will be confirmed via cores from 8 to 13 feet bls
  - 2 AS wells installed at 15 to 17 feet bls; depth will be confirmed via cores from 12 to 17 feet bls
  - AS wells are expected to have a 15-foot radius of influence
- One monitoring well (screened 8 to 18 feet bls) proposed to be installed and added to the Performance Monitoring Program to monitor the effectiveness of the AS System expansion
- Pressurized air piping for this area will be obtained from Zone 4 Manifold

# Geophysical Survey

- Geophysical survey conducted on November 15, 2021
- Both Ground Penetrating Radar (GPR) and Electronic Utility Locate (EUL) equipment used:
  - GPR = identifies both electrical and non-electrical underground utilities
  - EUL = identifies utilities carrying electrical power or could be energized by an induced electrical current



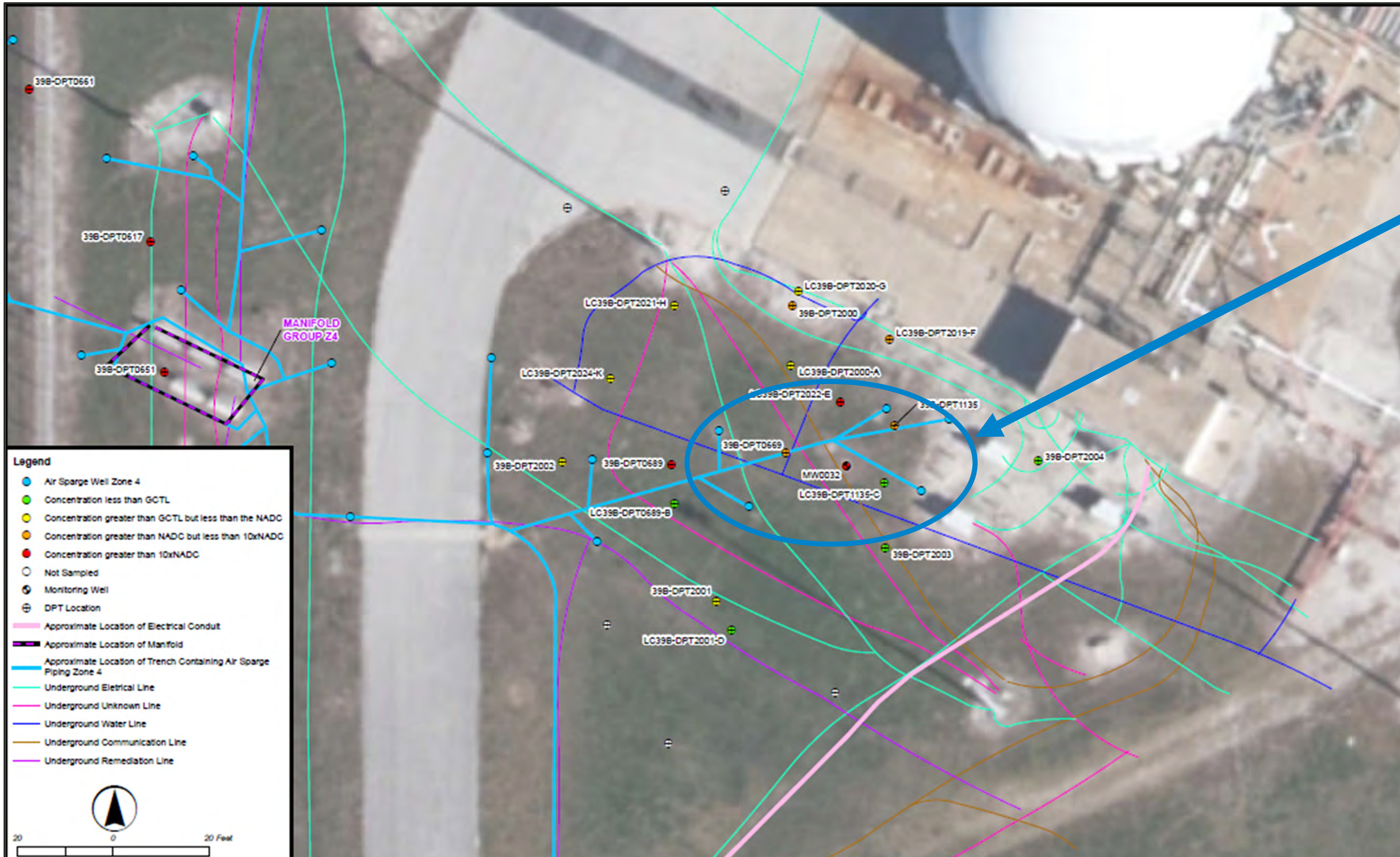

Full size figure at end of presentation



# Geophysical Survey (cont'd)

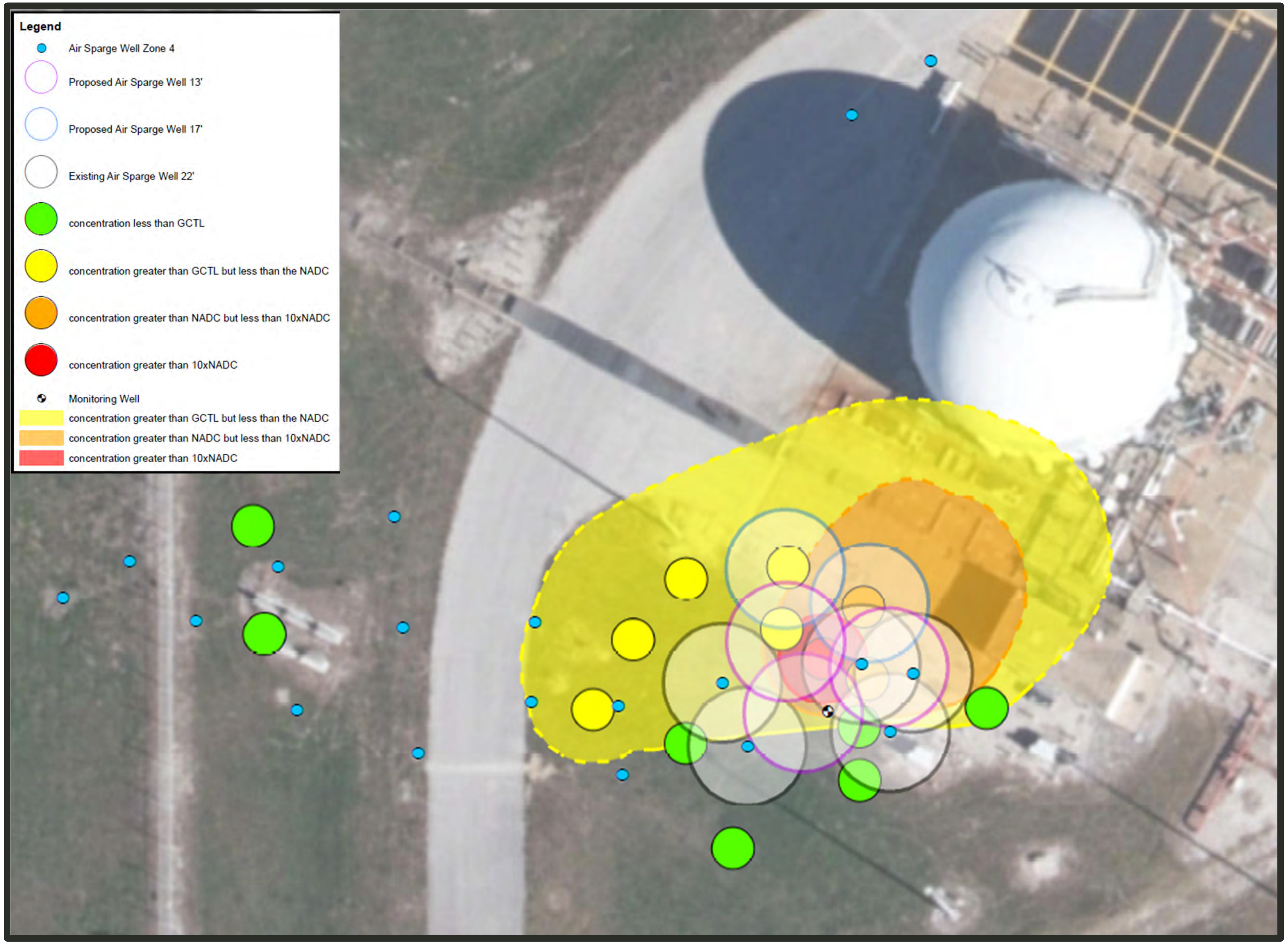
- Results identified several underground utilities in LOX area
  - Estimated depths range between 1 and 4 feet bls
- Some survey limitations include:
  - Thick concrete pads, especially reinforced with rebar, can limit penetration depth of GPR signal
  - EUL path will "jump" to most conductive area (rebar = interference)
  - Small diameter utilities may not be detected/imaged
    - GPR loses 0.5-1" resolution per foot of burial (not be possible to resolve 2" dia. pipe greater than 2-4 ft bls)

# Current AS System Layout with Utility Lines




AS wells in Zone 4 (nearest to residual HS/HCP locations) are installed to 22 feet bls.

# Proposed Air Sparging Well Layout




- 5 new AS wells will be installed to the south of the existing AS system to address contamination in the 8 to 16-foot zone
- Soil Cores will be collected from each AS location from the bottom five feet to confirm target depth and lithology
- Proposed AS Well Details
  - 3 AS wells 11 to 13 feet bls
  - 2 AS wells 15 to 17 feet bls
  - 1-inch diameter SCH 40 PVC riser, 40 micron 20” SchumaSoil diffuser
  - 15-foot Radius of Influence
  - Flow rate of approximately 5 cfm/well
- AS wells will be plumbed to existing lateral lines in the LOX tank area
- Existing AS wells screened from 20 to 22 feet bls cover portion of inferred HCP area to the northeast of proposed wells

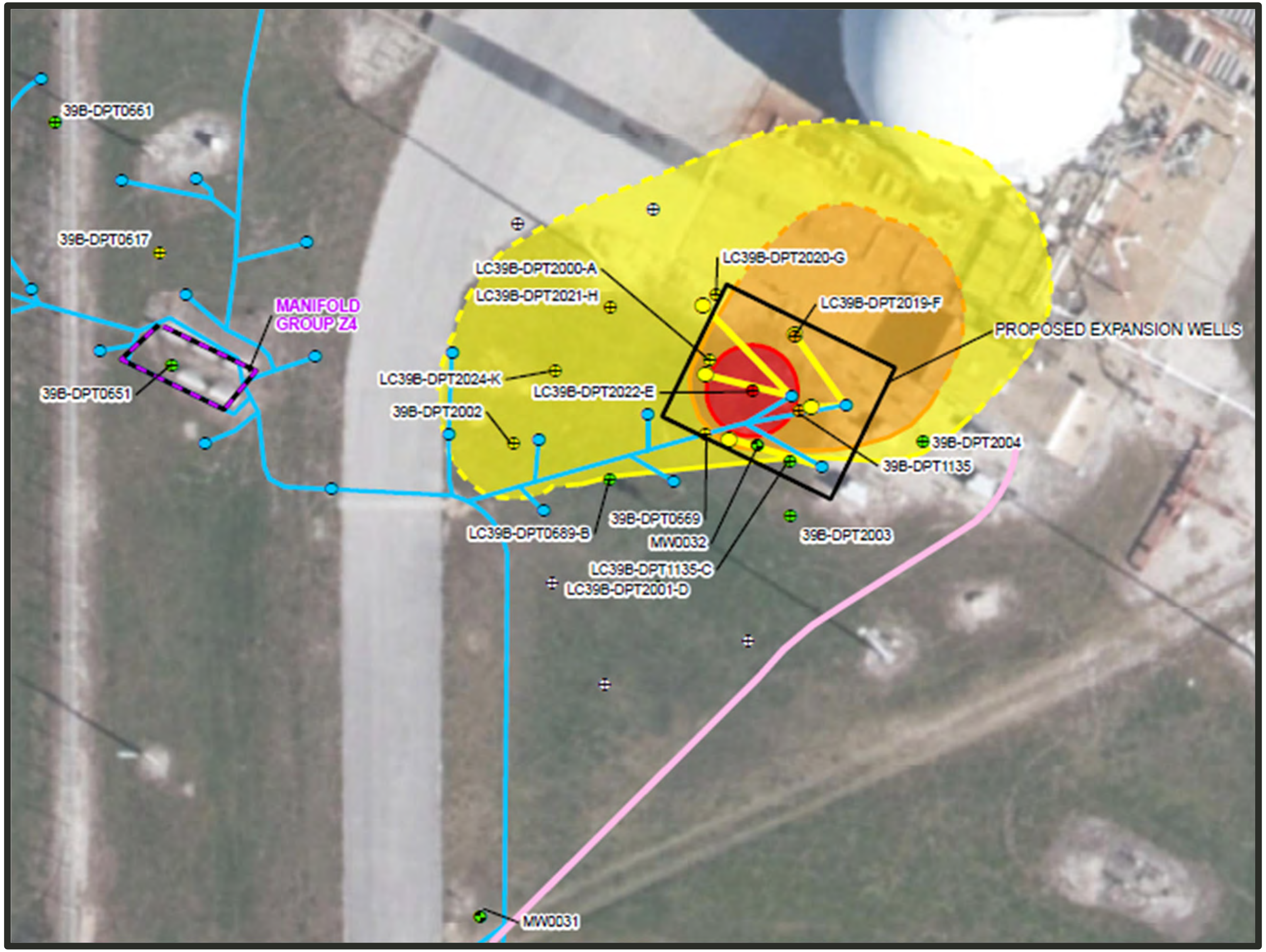
# Proposed AS Construction Area

TETRA TECH

**Legend**

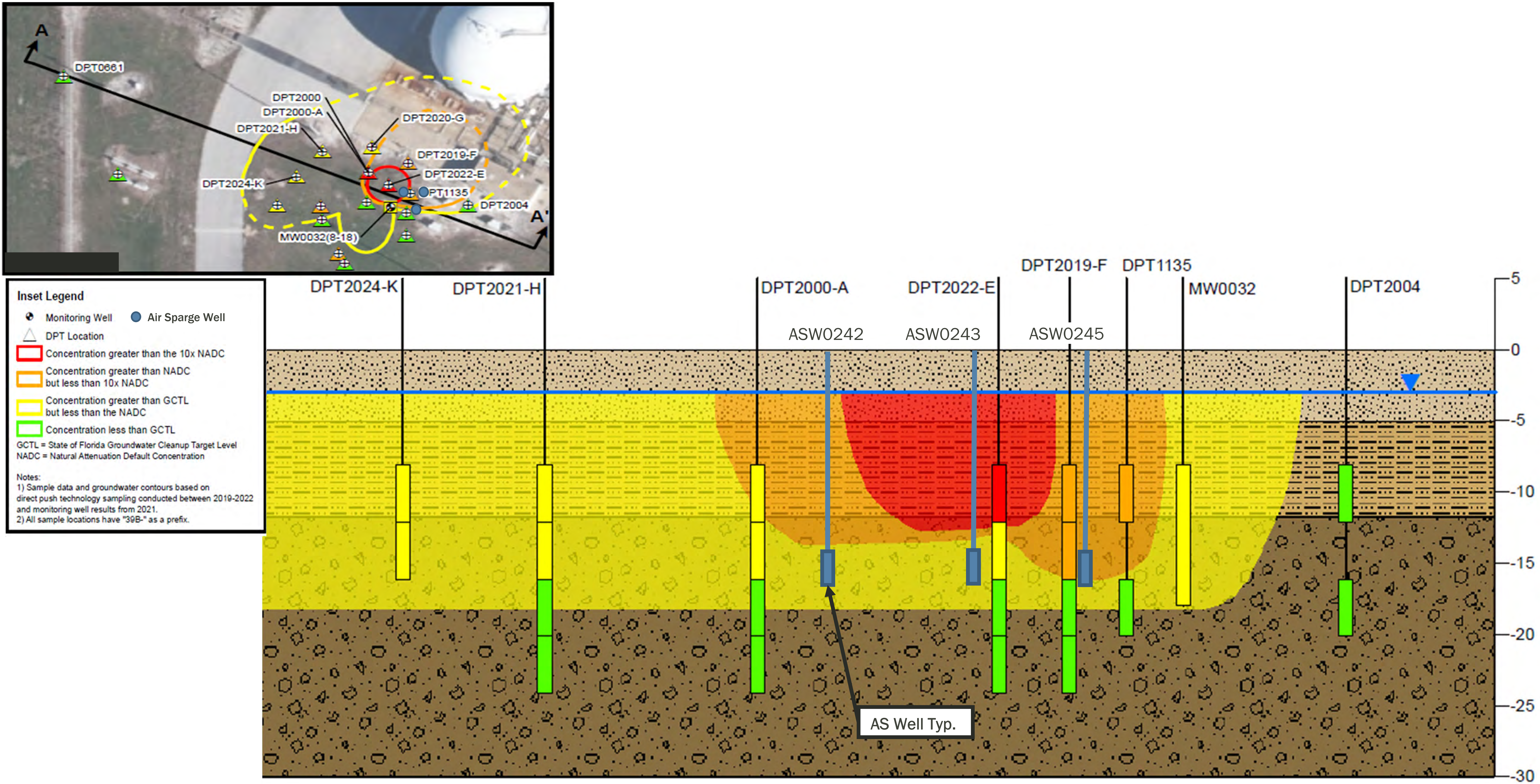
- Proposed Air Sparge Well
- Air Spare Well Zone 4
- Concentration less than GCTL
- Concentration greater than GCTL but less than the NADC
- Concentration greater than NADC but less than 10xNADC
- Concentration greater than 10xNADC
- Not Sampled
- Monitoring Well
- DPT Location
- Lateral Expansion Air Line
- Approximate Location of Electrical Conduit
- Approximate Location of Manifold
- Approximate Location of Trench Containing Air Sparge Piping Zone 4

35 0 35 Feet

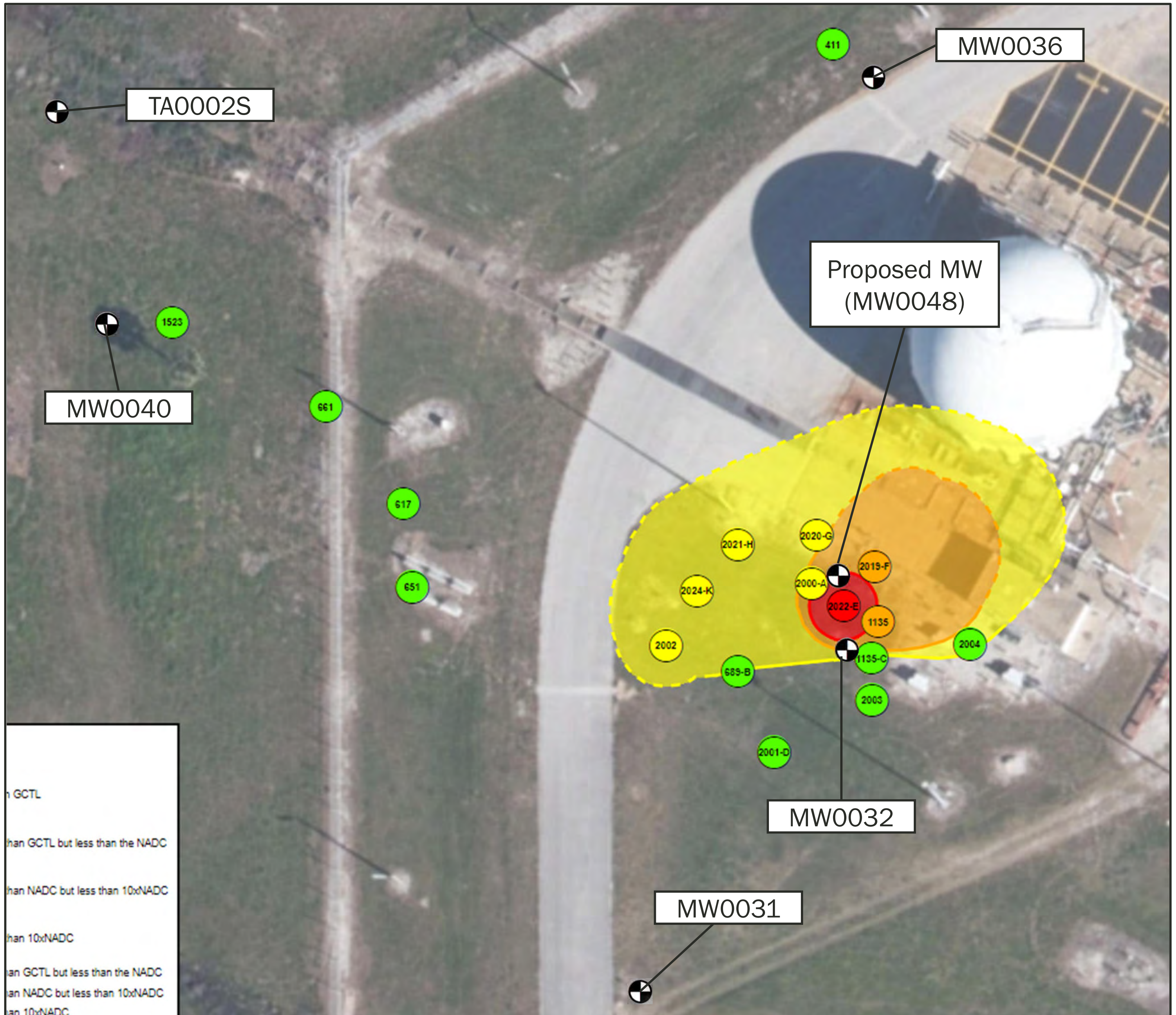


# Cross Section A-A' – Well Placement

TETRA TECH



# Proposed Performance Monitoring




- One existing well (MW0032) screened 8-18 feet in Hot Spot 2
  - MW is adjacent to HS
  - Sampled semi-annually
- Install one new monitoring well slightly downgradient of HS and HCP to evaluate the performance of the AS system expansion
  - Screened 8 to 18 feet bls
- Sample semi-annually for VOCs
  - Field parameters to be collected
  - VOC analysis via EPA Method 8260B
  - Results will be evaluated to determine if system adjustments are required

# Conclusions/Path Forward

- <u>Test Consensus:</u> Expand AS network by installing three wells screened 11-13 feet bls and two wells screened 15-17 feet bls (final depths confirmed by soil cores)
- <u>Test Consensus:</u> Evaluate soil cores pulled during system installation for petroleum odor and staining and collect soil samples for analysis of PAHs and TRPH
- <u>Test Consensus:</u> Install one monitoring well downgradient of HS/HCP and add it to the performance monitoring program on a semi-annual sampling frequency
- Path Forward:
  - Prepare Implementation Work Plan
  - Permitting Authorizations
    - Utility Locate
    - Environmental Checklist
    - Site Planning Authorization
  - Site preparation
  - Sonic AS and Monitoring well installation
  - Trenching, piping, and AS system connection
  - Flow balancing
  - Routine OM&M

# APPENDIX B

# OCTOBER 2022 KSC REMEDIATION TEAM MEETING MINUTES

# Revision 0 Meeting Minutes for October 5th and 6th, 2022

Attendees:

1. Bruce Moore/FDEP
2. Mike Deliz/NASA
3. Ryan O'Meara/NASA
4. Deda Johansen/NASA
5. Anne Chrest/NASA
6. Natasha Darre/NASA
7. Chris Adkison/NASA
8. Tim Appleman/NASA
9. Michelle Moore/NEMCON
10. Mark Jonnet/Tetra Tech
11. Alex Murphy/Tetra Tech
12. Chris Pike/ Tetra Tech
13. Mark Speranza/Tetra Tech
14. Andrew Walters/Tetra Tech
15. Jennifer Gootee/AECOM
16. Linnea King Clark/AECOM
17. Richard Smith/HGL
18. Howard Fowler/HGL
19. James (Jim) Montague/HGL

**2210-M01 Bruce Moore/FDEP**

**Program Update**

Discussion: The #1 issue at the Florida Department of Environmental Protection (FDEP) is the staffing situation. There are fourteen positions in the federal facilities program currently available. Some hires are imminent. Environmental Administrator Laura Barrett resigned. The goal is to fill the Environmental Administrator position by the end of October. Billy Hessman joined in May as a professional geologist (PG) II position. A variety of positions are open and need to be filled. If there is an urgent matter, please call Bruce directly and he can talk in the moment about it. The routine review process may take a while.

NASA inquired if funding was the issue or just not enough people were applying. FDEP stated it has been hard to attract and retain staff. FDEP is still using the three contractors for outside review and will lean heavily on them in the short term.

collected at some prior DPT locations for vertical delineation purposes.

Monitoring wells will be installed adjacent to some surface water sample locations, and staff gauges installed in the surface water. Water levels will be measured and both surface water and groundwater samples collected periodically to determine if there is discharge from groundwater to surface water or vice versa. NASA noted there is a goal for the Remediation program is to perform quarterly sampling across the active PFAS assessment sites.

Rather than take measurements of surface water elevation and groundwater elevation, the suggestion was made to put transducers and water level recorders in wells and surface water to check whether groundwater is receiving stormwater runoff or discharging to surface waters. NASA mentioned this is done at the Hydrocarbon Burn Facility (SWMU #007) site, and HGL stated this was on the wish list to implement at the Fire Station #2 (SWMU #114) site.

First flush samples will be collected after a rain event. Once the monitoring well installation locations are determined, does FDEP want to know where those are? FDEP responded that they would like to know for information purposes. NASA will provide these locations to FDEP prior to installation **(2210-A04).**

**Results: Action Item 2210-A04**

**2210-M05 Chris Pike/Tetra Tech**

**<u>LC39B (SWMU 009) LOX Area DPT Investigations and Air Sparging</u>**

**Objective:**

The purpose of the briefing is to present the results of direct push technology (DPT) investigations conducted in the Liquid Oxygen (LOX) Area at Launch Complex 39B (LC39B) and to propose a system optimization.

**Discussion:**

Chlorinated volatile organic compounds (VOCs) are being treated by air sparging at LC39B. The presentation documented investigations conducted between November 2021 and January 2022, with some 2019 results also used in groundwater contouring. The investigations focused on an area of persistent VOCs on the southwest side of the LOX sphere. Recent groundwater data document a small plume where trichloroethene (TCE) exceeds its groundwater cleanup target level and cis-1,2-dichloroethene (cDCE) and vinyl chloride (VC) above their natural attenuation default concentrations (NADC). A large part of the plume, including the more highly contaminated portion, is under or partially under concrete. Soil samples were also collected and analyzed for VOCs and total organic carbon. No results indicative of sorbed source material were observed.

Based on data assessment, it was recommended to optimize the existing air sparging system with the addition of five new air sparging wells in the Hot Spot 2 area, located adjacent to the LOX sphere. The air sparging wells were proposed to be installed to address contamination in the 8- to 16-foot zone. The installation of one monitoring well was also recommended.

FDEP noted the report of potential petroleum odors/staining in soil, referring to Slide 26, and that the soil samples were analyzed only for chlorinated compounds. The suggested path forward is to send soil cores collected during sparge system installation to be analyzed for petroleum compounds if staining or odor are observed. Tetra Tech stated that would be an easy addition to sample for. FDEP requested that a sample be collected from the suspect intervals and sent the samples to the lab, versus performing a visual inspection only (**2210-A05).**

The Team reached consensus to expand air sparging network by installing three wells screened 11 to 13 feet below land surface and two wells screened 15 to 17 feet below land surface. Final depths will be confirmed by soil cores **(2210-D08).**

The Team reached consensus to collect soil samples for analysis of polynuclear aromatic hydrocarbons (PAHs) and total recoverable petroleum hydrocarbons (TRPH) (**2210-D09).**

The Team reached consensus to install one monitoring well downgradient of the treatment area and add it to the air sparge system performance monitoring program on a semi-annual sampling frequency (**2210-D10).**

FDEP referred to the limitations created by the concrete pad and stated we do not know how much of the plume extends under the path. At some point this may need to be revisited. Tetra Tech responded that the new monitoring well is close to the pad and theoretically would show whether diffusion comes back from underneath. FDEP suggested there could be a statement in the work plan that sampling is constrained by the pad. If a residual plume remains under the pad despite the additional air sparge well, it will be reevaluated at a later time.

**Results: Decision Items 2210-D08 through D10**
**Action Item 2210-A05**

**2210-M06 Chris Pike/Tetra Tech**

**Launch Complex 39B (SWMU #009) Weir Evaluation**

**Objective:**

The purpose of the advance data package (ADP) is to present the results of Outstanding Florida Waters (OFW) monitoring and weir evaluation at Launch Complex 39B and to propose a path forward.

**Discussion:**

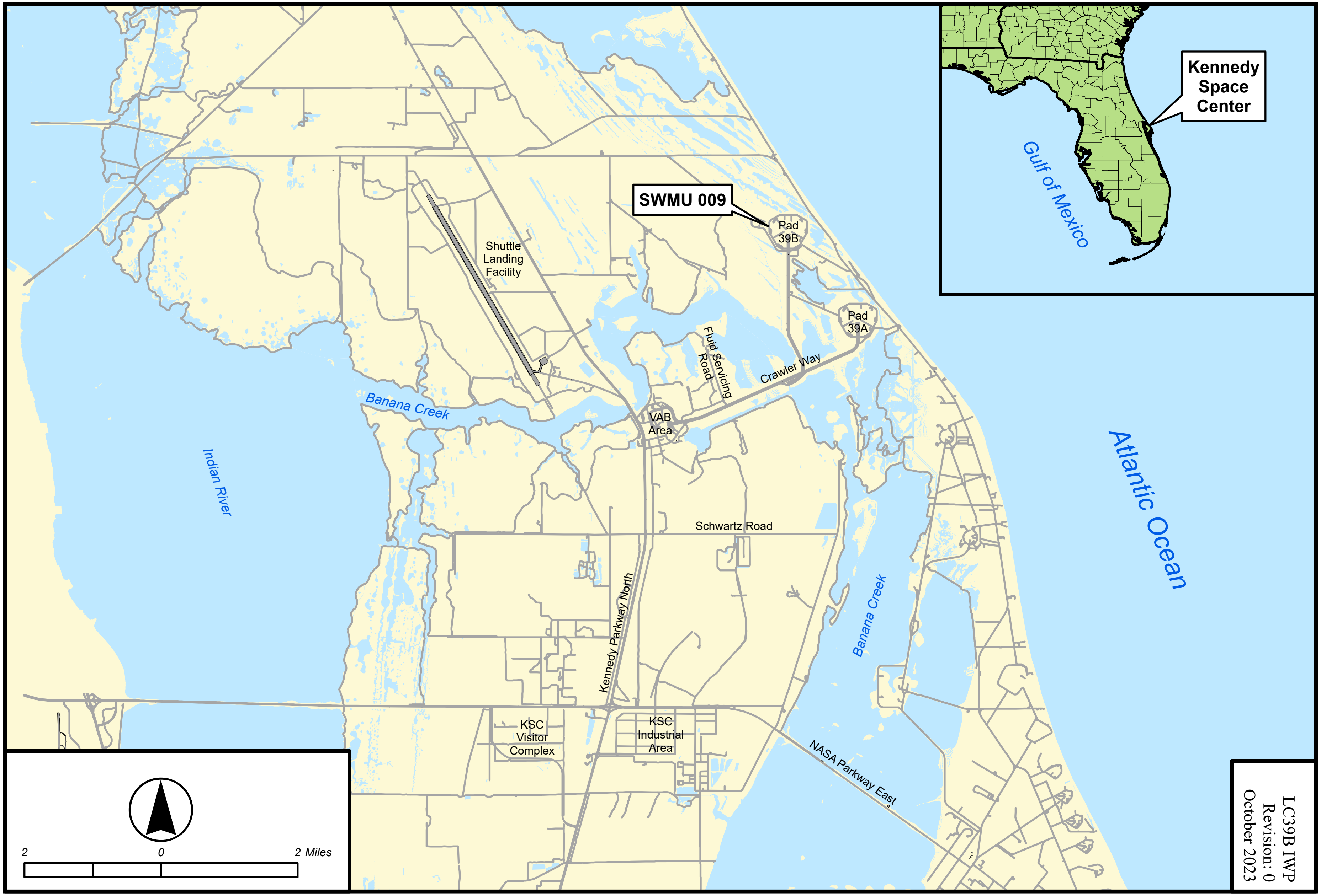
This ADP documents a sampling event conducted in August 2022, that included collection of monitoring well and surface water samples in the vicinity of the proposed weir. A weir was originally recommended in 2016 to mitigate potential discharge of groundwater impacted with volatile organic compounds (VOCs) from Hot Spot 2 to a pond that connects to the OFW. Hot Spot 2 encompasses the area near the LOX sphere. The weir installation was suspended in 2018 due to performance monitoring results from Hot Spot 2 indicating chlorinated VOC concentrations adjacent to the pond were below groundwater cleanup target levels (GCTLs). An action item was established in 2018 to revisit the weir installation prior to the St. Johns River Water Management District (SJRWMD) and United States Army Corps of Engineers (USACE) permit expirations in July 2023. No detections of VOCs were observed in the August 2022 sampling results.

# APPENDIX C

# FIGURES

FIGURE C-1 LOCATION OF LC39B

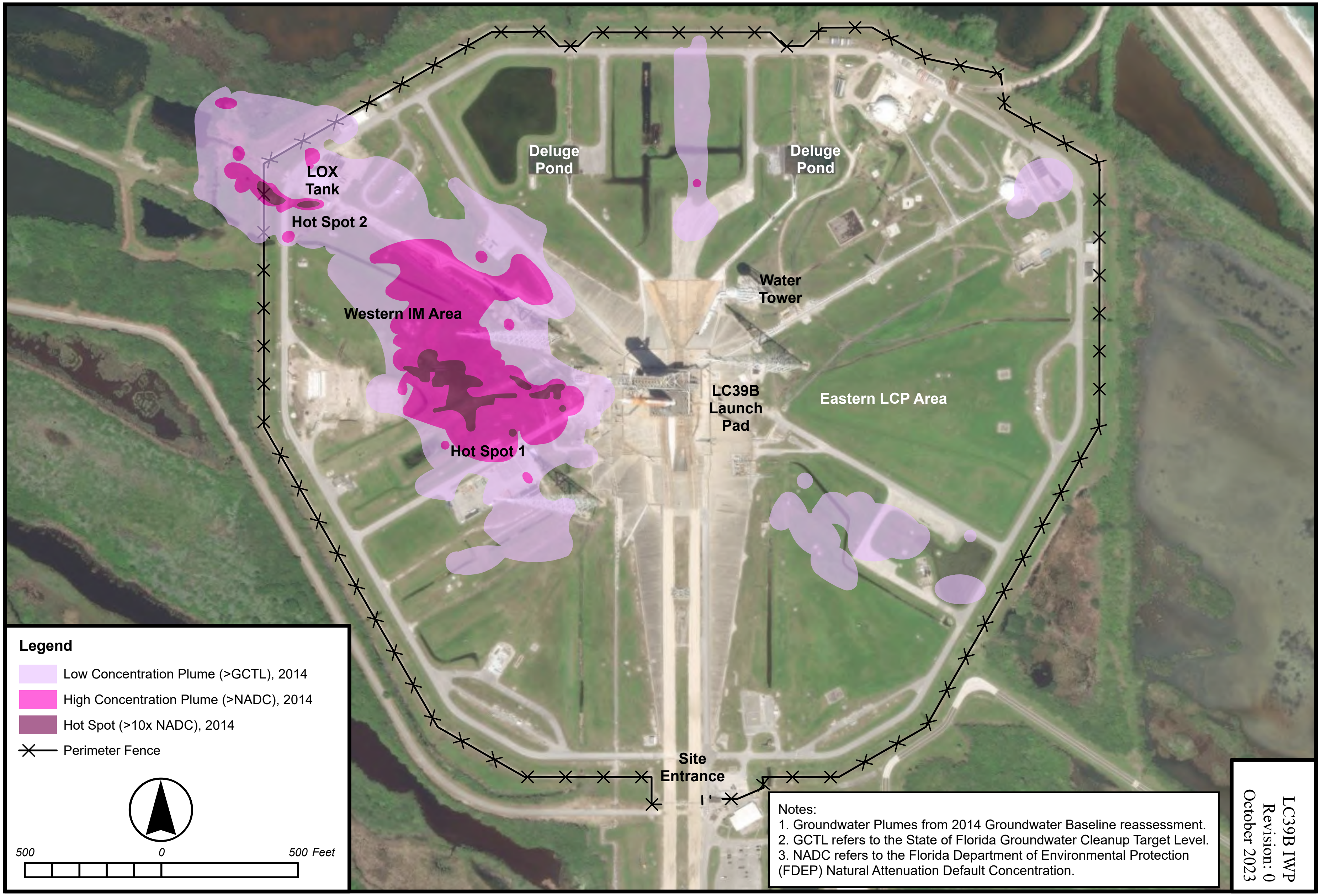
SWMU 009, KENNEDY SPACE CENTER, FLORIDA




LC39B IWP
Revision: 0
October 2023

\\EGSS706GISFS1\EGS\PITTSBURGH\GIS\GIS\KSC_NASA\MAPDOCS\APRX\LC39B_SITE_LOCATION.APRX LC39B_SITE_LOCATION 09/20/23 KM

FIGURE C-2 LAUNCH COMPLEX 39B SITE LAYOUT
SWMU 009, KENNEDY SPACE CENTER, FLORIDA




Notes:
1. Groundwater Plumes from 2014 Groundwater Baseline reassessment.
2. GCTL refers to the State of Florida Groundwater Cleanup Target Level.
3. NADC refers to the Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration.



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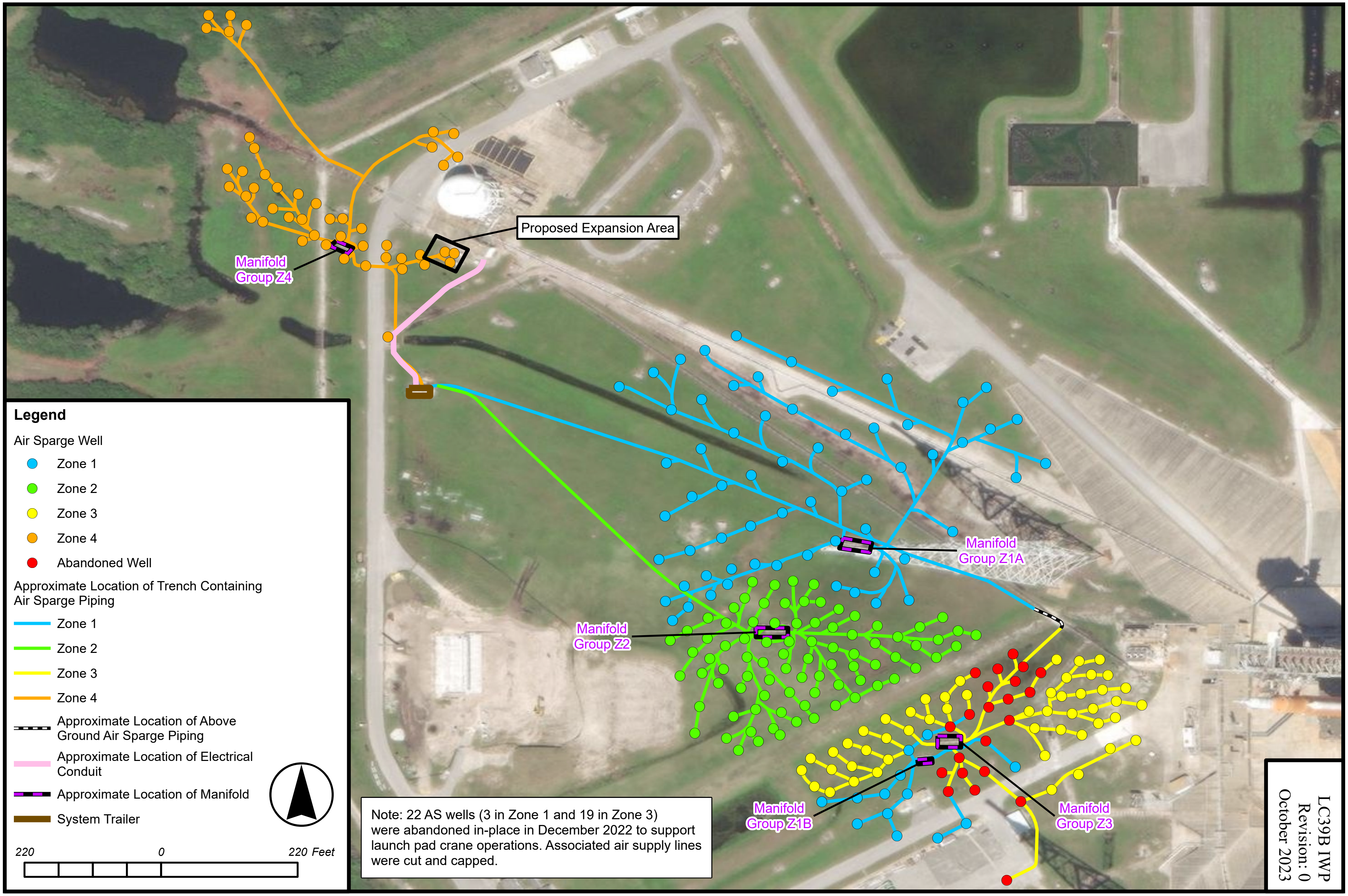
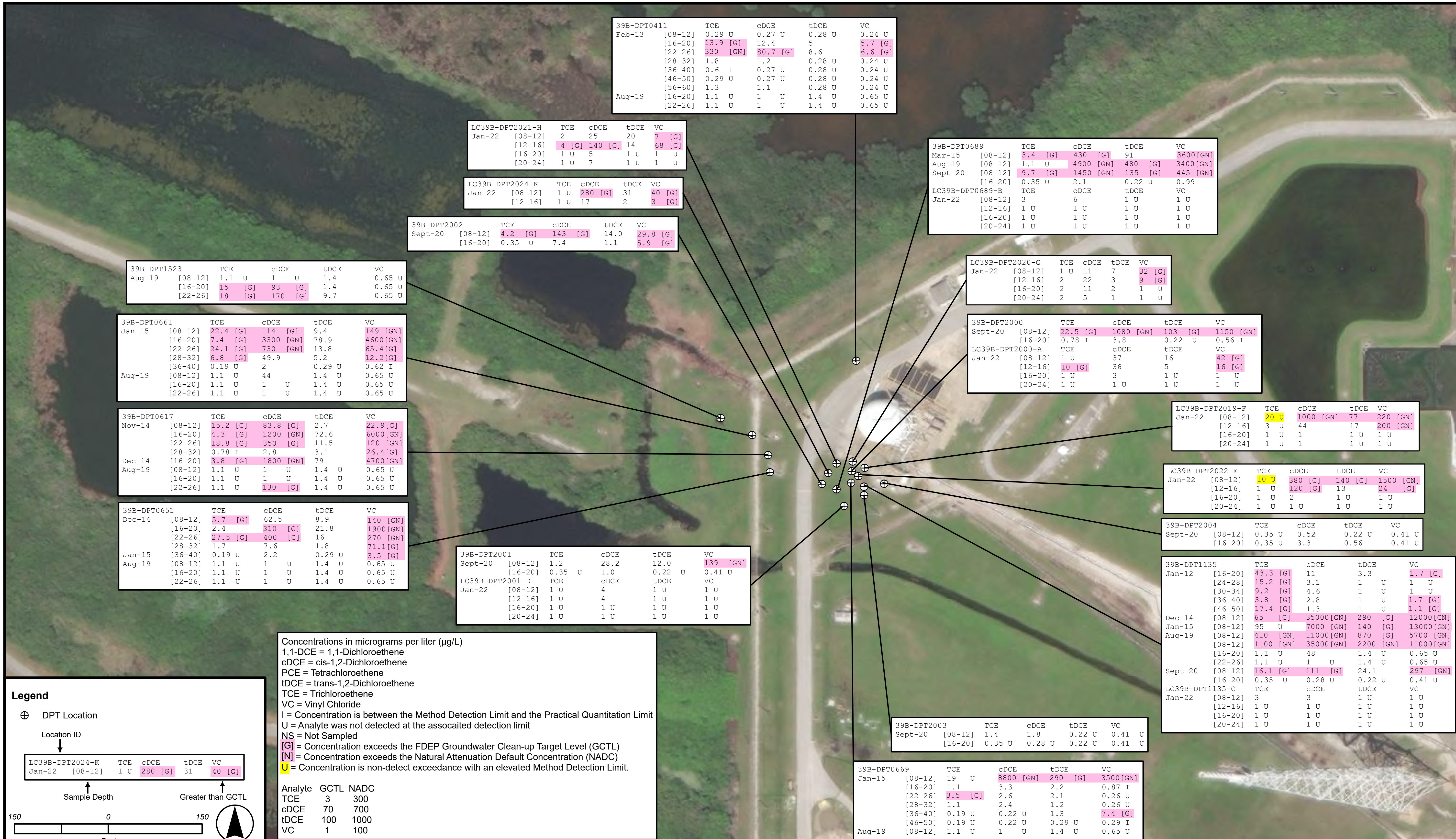
FIGURE C-3 EXISTING AIR SPARGE SYSTEM LAYOUT
SWMU 009, KENNEDY SPACE CENTER, FLORIDA




\\EGSS706GISFS1\EGS\PITTSBURGH\GIS\GIS\KSC_NASA\MAPDOCS\APRX\LC39B_AS_WELLS_LATERALS.APRX LC39B_AS_WELLS_LATERALS 09/26/23 KM

# FIGURE C-4 DPT GROUNDWATER LOCATIONS AND RESULTS

SWMU 009, KENNEDY SPACE CENTER, FLORIDA



| 39B-DPT0411 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Feb-13 | [08-12] | 0.29 U | 0.27 U | 0.28 U | 0.24 U |
| | [16-20] | 13.9 [G] | 12.4 | 5 | 5.7 [G] |
| | [22-26] | 330 [GN] | 80.7 [G] | 8.6 | 6.6 [G] |
| | [28-32] | 1.8 | 1.2 | 0.28 U | 0.24 U |
| | [36-40] | 0.6 I | 0.27 U | 0.28 U | 0.24 U |
| | [46-50] | 0.29 U | 0.27 U | 0.28 U | 0.24 U |
| | [56-60] | 1.3 | 1.1 | 0.28 U | 0.24 U |
| Aug-19 | [16-20] | 1.1 U | 1 U | 1.4 U | 0.65 U |
| | [22-26] | 1.1 U | 1 U | 1.4 U | 0.65 U |

| LC39B-DPT2021-H | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-22 | [08-12] | 2 | 25 | 20 | 7 [G] |
| | [12-16] | 4 [G] | 140 [G] | 14 | 68 [G] |
| | [16-20] | 1 U | 5 | 1 U | 1 U |
| | [20-24] | 1 U | 7 | 1 U | 1 U |

| LC39B-DPT2024-K | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-22 | [08-12] | 1 U | 280 [G] | 31 | 40 [G] |
| | [12-16] | 1 U | 17 | 2 | 3 [G] |

| 39B-DPT2002 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Sept-20 | [08-12] | 4.2 [G] | 143 [G] | 14.0 | 29.8 [G] |
| | [16-20] | 0.35 U | 7.4 | 1.1 | 5.9 [G] |

| 39B-DPT1523 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Aug-19 | [08-12] | 1.1 U | 1 U | 1.4 | 0.65 U |
| | [16-20] | 15 [G] | 93 [G] | 1.4 | 0.65 U |
| | [22-26] | 18 [G] | 170 [G] | 9.7 | 0.65 U |

| 39B-DPT0661 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-15 | [08-12] | 22.4 [G] | 114 [G] | 9.4 | 149 [GN] |
| | [16-20] | 7.4 [G] | 3300 [GN] | 78.9 | 4600 [GN] |
| | [22-26] | 24.1 [G] | 730 [GN] | 13.8 | 65.4 [G] |
| | [28-32] | 6.8 [G] | 49.9 | 5.2 | 12.2 [G] |
| | [36-40] | 0.19 U | 2 | 0.29 U | 0.62 I |
| Aug-19 | [08-12] | 1.1 U | 44 | 1.4 U | 0.65 U |
| | [16-20] | 1.1 U | 1 U | 1.4 U | 0.65 U |
| | [22-26] | 1.1 U | 1 U | 1.4 U | 0.65 U |

| 39B-DPT0617 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Nov-14 | [08-12] | 15.2 [G] | 83.8 [G] | 2.7 | 22.9 [G] |
| | [16-20] | 4.3 [G] | 1200 [GN] | 72.6 | 6000 [GN] |
| | [22-26] | 18.8 [G] | 350 [G] | 11.5 | 120 [GN] |
| | [28-32] | 0.78 I | 2.8 | 3.1 | 26.4 [G] |
| Dec-14 | [16-20] | 3.8 [G] | 1800 [GN] | 79 | 4700 [GN] |
| Aug-19 | [08-12] | 1.1 U | 1 U | 1.4 U | 0.65 U |
| | [16-20] | 1.1 U | 1 U | 1.4 U | 0.65 U |
| | [22-26] | 1.1 U | 130 [G] | 1.4 U | 0.65 U |

| 39B-DPT0651 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Dec-14 | [08-12] | 5.7 [G] | 62.5 | 8.9 | 140 [GN] |
| | [16-20] | 2.4 | 310 [G] | 21.8 | 1900 [GN] |
| | [22-26] | 27.5 [G] | 400 [G] | 16 | 270 [GN] |
| | [28-32] | 1.7 | 7.6 | 1.8 | 71.1 [G] |
| Jan-15 | [36-40] | 0.19 U | 2.2 | 0.29 U | 3.5 [G] |
| Aug-19 | [08-12] | 1.1 U | 1 U | 1.4 U | 0.65 U |
| | [16-20] | 1.1 U | 1 U | 1.4 U | 0.65 U |
| | [22-26] | 1.1 U | 1 U | 1.4 U | 0.65 U |

| 39B-DPT2001 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Sept-20 | [08-12] | 1.2 | 28.2 | 12.0 | 139 [GN] |
| | [16-20] | 0.35 U | 1.0 | 0.22 U | 0.41 U |
| LC39B-DPT2001-D | | TCE | cDCE | tDCE | VC |
| Jan-22 | [08-12] | 1 U | 4 | 1 U | 1 U |
| | [12-16] | 1 U | 4 | 1 U | 1 U |
| | [16-20] | 1 U | 1 U | 1 U | 1 U |
| | [20-24] | 1 U | 1 U | 1 U | 1 U |

| 39B-DPT0689 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Mar-15 | [08-12] | 3.4 [G] | 430 [G] | 91 | 3600 [GN] |
| Aug-19 | [08-12] | 1.1 U | 4900 [GN] | 480 [G] | 3400 [GN] |
| Sept-20 | [08-12] | 9.7 [G] | 1450 [GN] | 135 [G] | 445 [GN] |
| | [16-20] | 0.35 U | 2.1 | 0.22 U | 0.99 |
| LC39B-DPT0689-B | | TCE | cDCE | tDCE | VC |
| Jan-22 | [08-12] | 3 | 6 | 1 U | 1 U |
| | [12-16] | 1 U | 1 U | 1 U | 1 U |
| | [16-20] | 1 U | 1 U | 1 U | 1 U |
| | [20-24] | 1 U | 1 U | 1 U | 1 U |

| LC39B-DPT2020-G | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-22 | [08-12] | 1 U | 11 | 7 | 32 [G] |
| | [12-16] | 2 | 22 | 3 | 9 [G] |
| | [16-20] | 2 | 11 | 2 | 1 U |
| | [20-24] | 2 | 5 | 1 | 1 U |

| 39B-DPT2000 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Sept-20 | [08-12] | 22.5 [G] | 1080 [GN] | 103 [G] | 1150 [GN] |
| | [16-20] | 0.78 I | 3.8 | 0.22 U | 0.56 I |
| LC39B-DPT2000-A | | TCE | cDCE | tDCE | VC |
| Jan-22 | [08-12] | 1 U | 37 | 16 | 42 [G] |
| | [12-16] | 10 [G] | 36 | 5 | 16 [G] |
| | [16-20] | 1 U | 3 | 1 U | 1 U |
| | [20-24] | 1 U | 1 U | 1 U | 1 U |

| LC39B-DPT2019-F | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-22 | [08-12] | 20 U | 1000 [GN] | 77 | 220 [GN] |
| | [12-16] | 3 U | 44 | 17 | 200 [GN] |
| | [16-20] | 1 U | 1 | 1 U | 1 U |
| | [20-24] | 1 U | 1 | 1 U | 1 U |

| LC39B-DPT2022-E | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-22 | [08-12] | 10 U | 380 [G] | 140 [G] | 1500 [GN] |
| | [12-16] | 1 U | 120 [G] | 13 | 24 [G] |
| | [16-20] | 1 U | 2 | 1 U | 1 U |
| | [20-24] | 1 U | 1 U | 1 U | 1 U |

| 39B-DPT2004 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Sept-20 | [08-12] | 0.35 U | 0.52 | 0.22 U | 0.41 U |
| | [16-20] | 0.35 U | 3.3 | 0.56 | 0.41 U |

| 39B-DPT1135 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-12 | [16-20] | 43.3 [G] | 11 | 3.3 | 1.7 [G] |
| | [24-28] | 15.2 [G] | 3.1 | 1 U | 1 U |
| | [30-34] | 9.2 [G] | 4.6 | 1 U | 1 U |
| | [36-40] | 3.8 [G] | 2.8 | 1 U | 1.7 [G] |
| | [46-50] | 17.4 [G] | 1.3 | 1 U | 1.1 [G] |
| Dec-14 | [08-12] | 65 [G] | 35000 [GN] | 290 [G] | 12000 [GN] |
| Jan-15 | [08-12] | 95 U | 7000 [GN] | 140 [G] | 13000 [GN] |
| Aug-19 | [08-12] | 410 [GN] | 11000 [GN] | 870 [G] | 5700 [GN] |
| | [08-12] | 1100 [GN] | 35000 [GN] | 2200 [GN] | 11000 [GN] |
| | [16-20] | 1.1 U | 48 | 1.4 U | 0.65 U |
| | [22-26] | 1.1 U | 1 U | 1.4 U | 0.65 U |
| Sept-20 | [08-12] | 16.1 [G] | 111 [G] | 24.1 | 297 [GN] |
| | [16-20] | 0.35 U | 0.28 U | 0.22 U | 0.41 U |
| LC39B-DPT1135-C | | TCE | cDCE | tDCE | VC |
| Jan-22 | [08-12] | 3 | 3 | 1 U | 1 U |
| | [12-16] | 1 U | 1 U | 1 U | 1 U |
| | [16-20] | 1 U | 1 U | 1 U | 1 U |
| | [20-24] | 1 U | 1 U | 1 U | 1 U |

| 39B-DPT2003 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Sept-20 | [08-12] | 1.4 | 1.8 | 0.22 U | 0.41 U |
| | [16-20] | 0.35 U | 0.28 U | 0.22 U | 0.41 U |

| 39B-DPT0669 | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-15 | [08-12] | 19 U | 8800 [GN] | 290 [G] | 3500 [GN] |
| | [16-20] | 1.1 | 3.3 | 2.2 | 0.87 I |
| | [22-26] | 3.5 [G] | 2.6 | 2.1 | 0.26 U |
| | [28-32] | 1.1 | 2.4 | 1.2 | 0.26 U |
| | [36-40] | 0.19 U | 0.22 U | 1.3 | 7.4 [G] |
| | [46-50] | 0.19 U | 0.22 U | 0.29 U | 0.29 I |
| Aug-19 | [08-12] | 1.1 U | 1 U | 1.4 U | 0.65 U |

Concentrations in micrograms per liter (µg/L)
1,1-DCE = 1,1-Dichloroethene
cDCE = cis-1,2-Dichloroethene
PCE = Tetrachloroethene
tDCE = trans-1,2-Dichloroethene
TCE = Trichloroethene
VC = Vinyl Chloride
I = Concentration is between the Method Detection Limit and the Practical Quantitation Limit
U = Analyte was not detected at the assocaited detection limit
NS = Not Sampled
[G] = Concentration exceeds the FDEP Groundwater Clean-up Target Level (GCTL)
[N] = Concentration exceeds the Natural Attenuation Default Concentration (NADC)
U = Concentration is non-detect exceedance with an elevated Method Detection Limit.

| Analyte | GCTL | NADC |
|---|---|---|
| TCE | 3 | 300 |
| cDCE | 70 | 700 |
| tDCE | 100 | 1000 |
| VC | 1 | 100 |

**Legend**

⊕ DPT Location

Location ID

| LC39B-DPT2024-K | | TCE | cDCE | tDCE | VC |
|---|---|---|---|---|---|
| Jan-22 | [08-12] | 1 U | 280 [G] | 31 | 40 [G] |

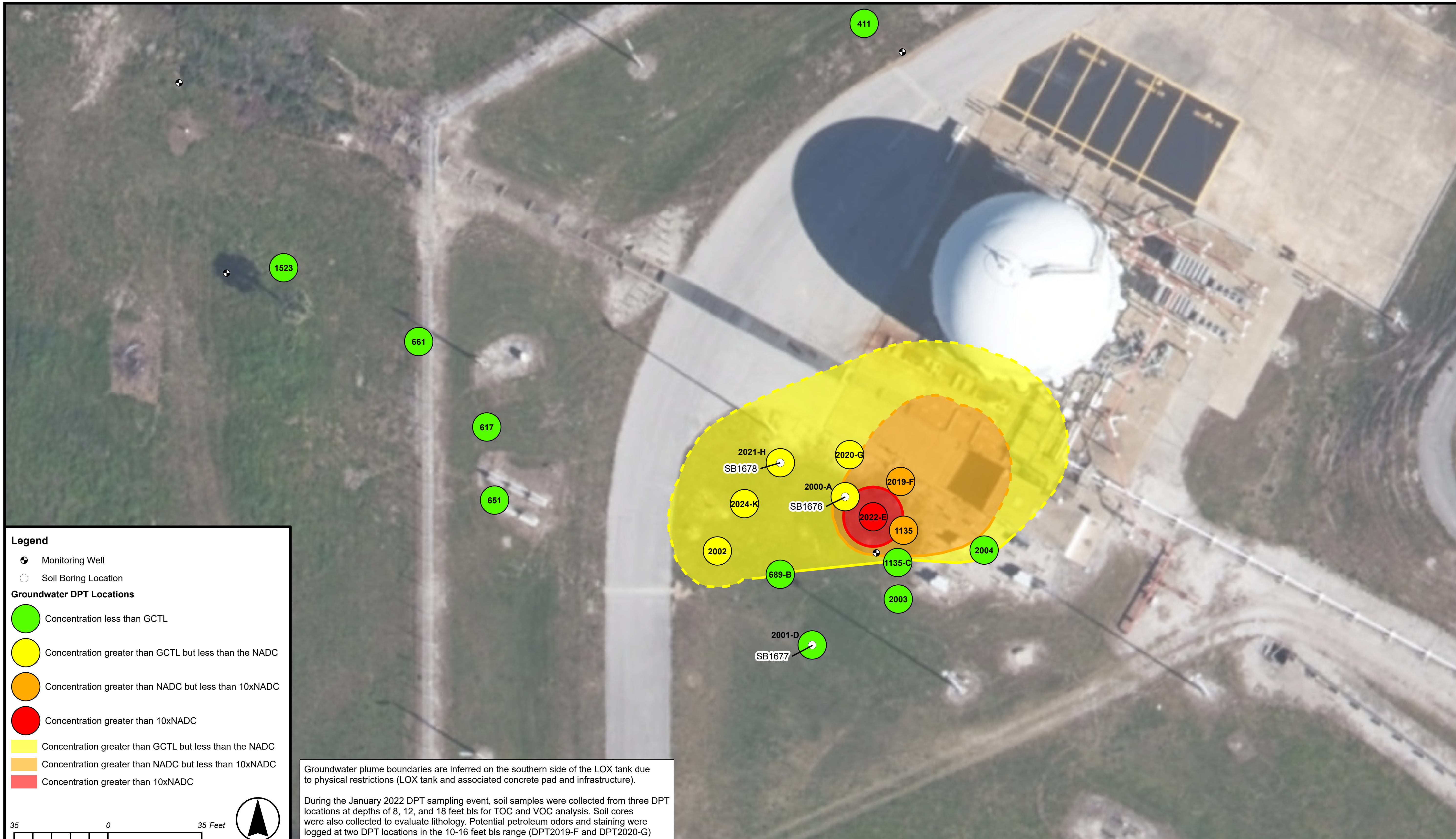
Sample Depth

Greater than GCTL

150 0 150

Feet

FIGURE C-5 2022 DPT SOIL BORING LOCATIONS
SWMU 009, KENNEDY SPACE CENTER, FLORIDA



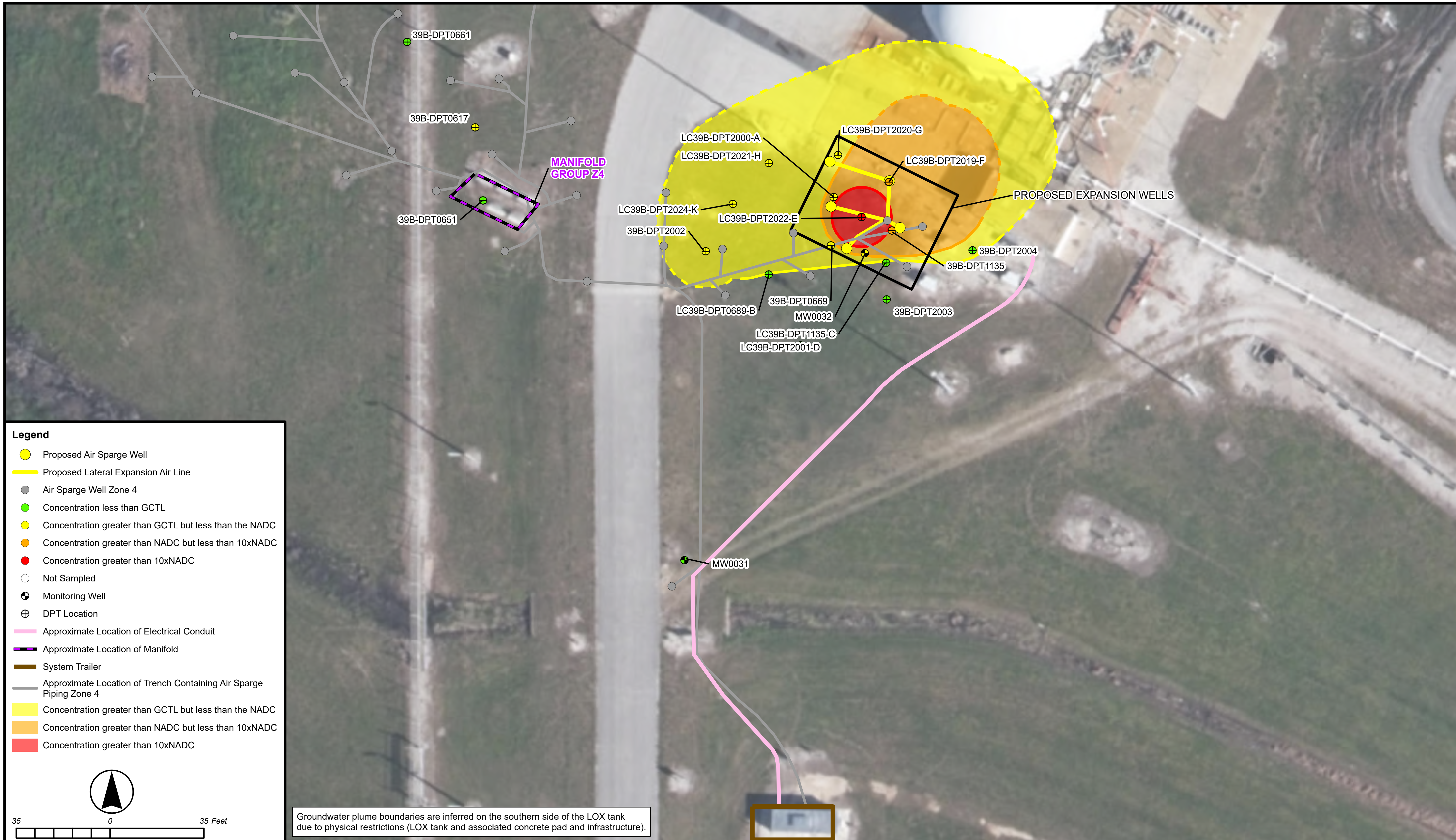

Groundwater plume boundaries are inferred on the southern side of the LOX tank due to physical restrictions (LOX tank and associated concrete pad and infrastructure).

During the January 2022 DPT sampling event, soil samples were collected from three DPT locations at depths of 8, 12, and 18 feet bls for TOC and VOC analysis. Soil cores were also collected to evaluate lithology. Potential petroleum odors and staining were logged at two DPT locations in the 10-16 feet bls range (DPT2019-F and DPT2020-G)

FIGURE C-6 PROPOSED AIR SPARGE EXPANSION AREA

SWMU 009, KENNEDY SPACE CENTER, FLORIDA

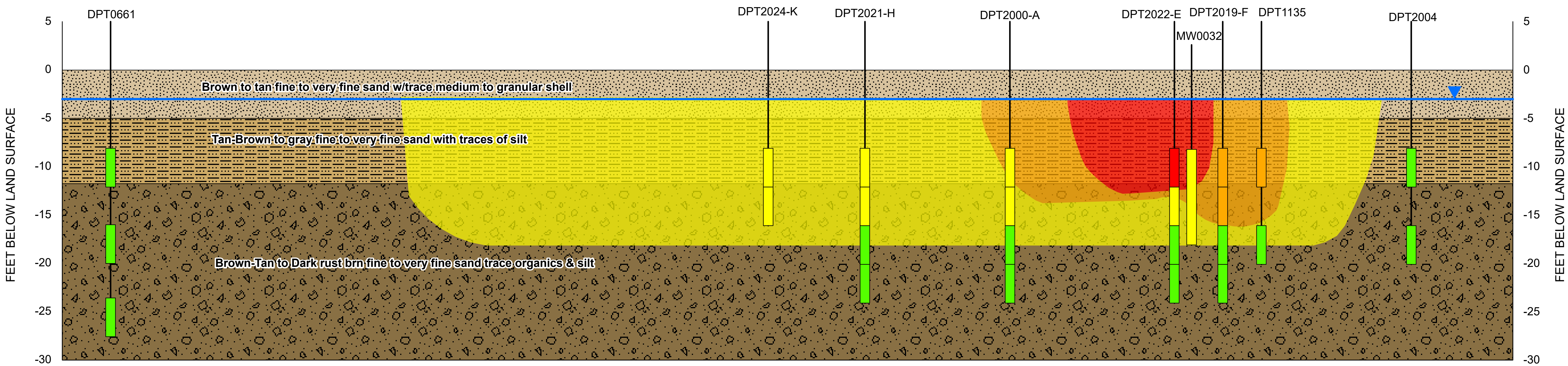





\\EGSS706GISFS1\EGS\PITTSBURGH\GIS\GIS\KSC_NASA\MAPDOCS\APRX\LC39B_PROP_AS_WELLS_PLUME.APRX LC39B_PROP_AS_WELLS_PLUME 09/25/23 KM

# FIGURE C-7 CROSS-SECTION A-A'

SWMU 009, KENNEDY SPACE CENTER, FLORIDA




**Legend**

**Groundwater Plume Boundaries**

- Concentration greater than GCTL but less than the NADC
- Concentration greater than NADC but less than 10xNADC
- Concentration greater than 10xNADC
- Water Level

35 0 35 Feet

Groundwater plume boundaries are inferred on the southern side of the LOX tank due to physical restrictions (LOX tank and associated concrete pad and infrastructure).

**Inset Legend**

- Monitoring Well
- DPT Location
- Concentration greater than the 10x NADC
- Concentration greater than NADC but less than 10x NADC
- Concentration greater than GCTL but less than the NADC
- Concentration less than GCTL

GCTL = State of Florida Groundwater Cleanup Target Level
NADC = Natural Attenuation Default Concentration

Notes:
1) Sample data and groundwater contours based on direct push technology sampling conducted between 2019-2022 and monitoring well results from 2022.
2) All sample locations have "39B-" as a prefix.

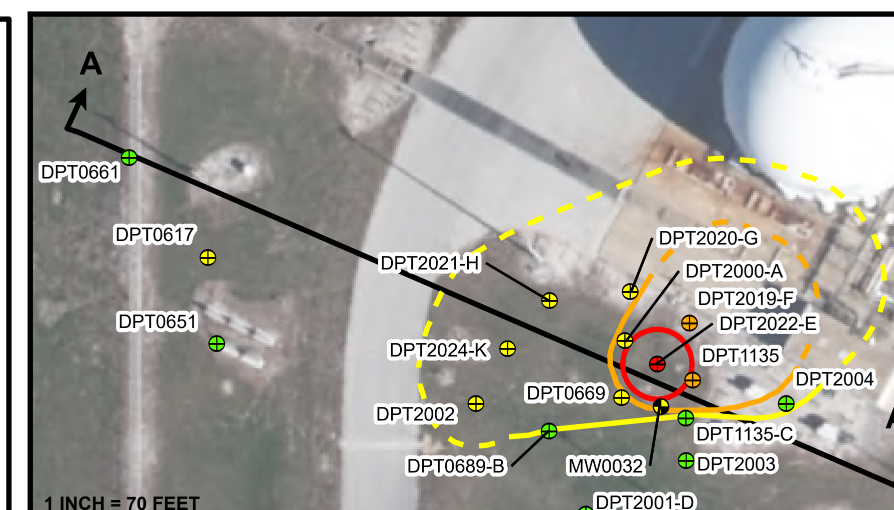
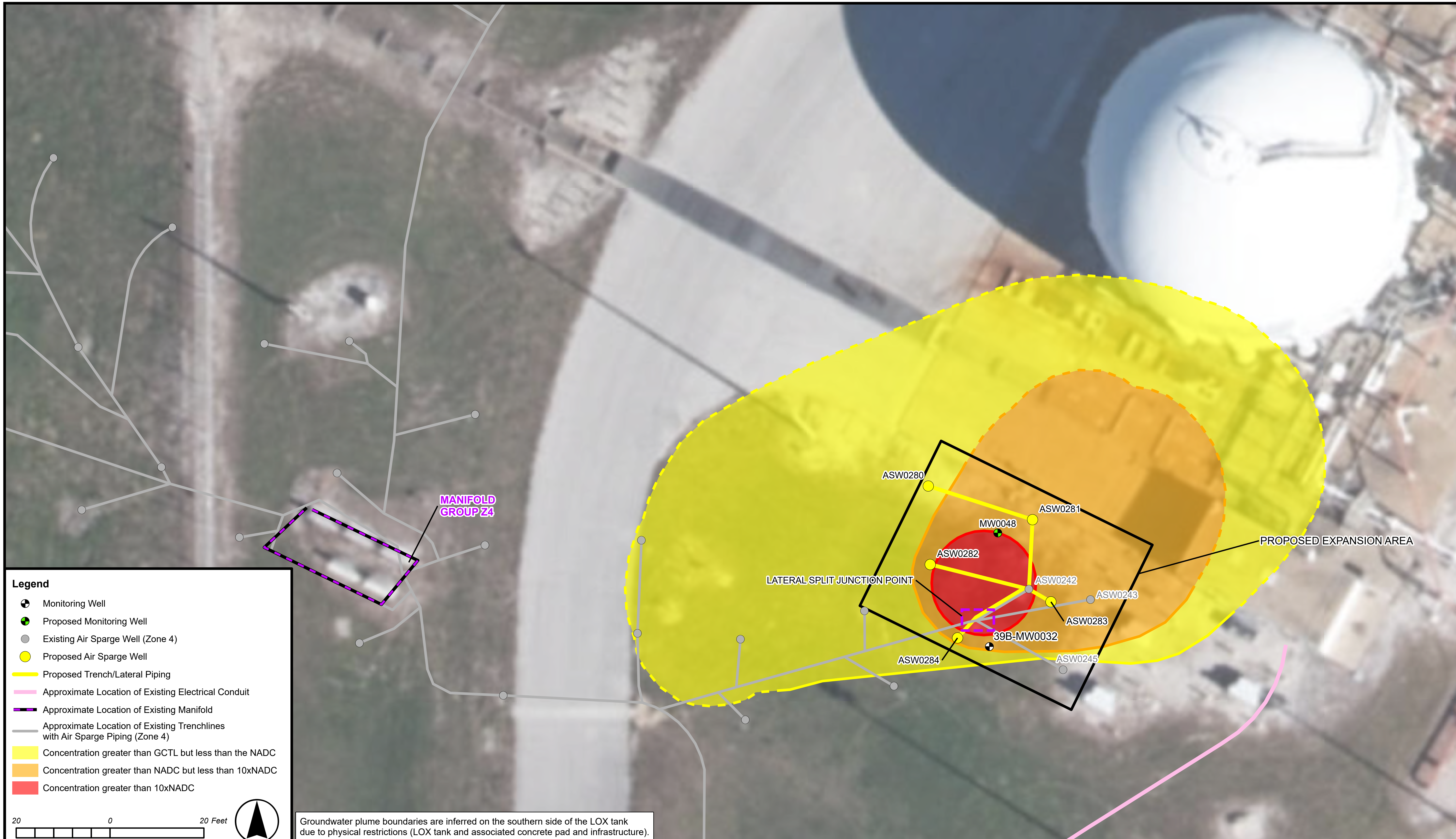


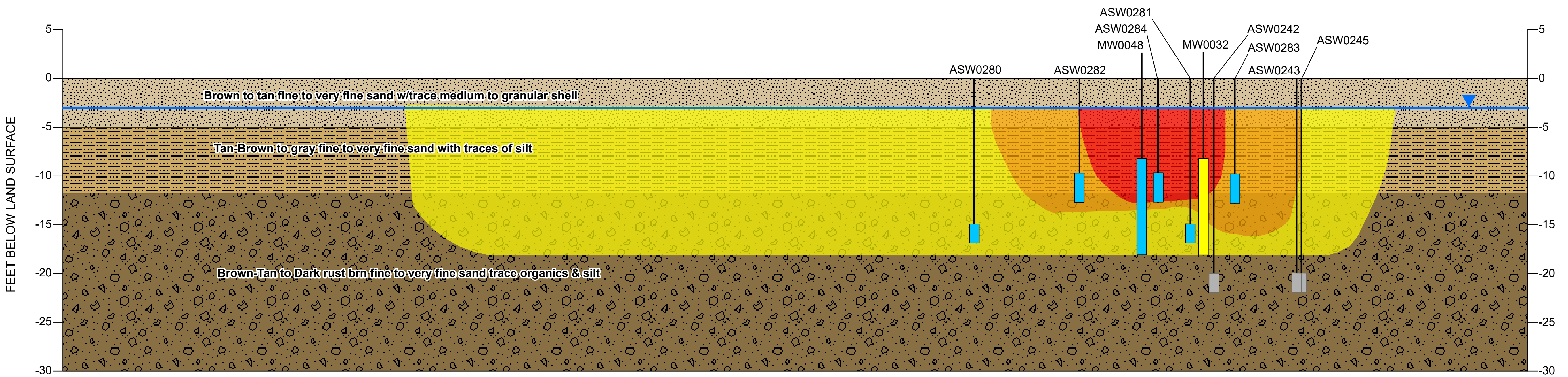
FIGURE C-8 EXPANSION AREA - AIR SPARGE WELL LOCATIONS AND TRENCHING LAYOUT
SWMU 009, KENNEDY SPACE CENTER, FLORIDA




\\EGSS706GISFS1\EGS\PITTSBURGH\GIS\GIS\KSC_NASA\MAPDOCS\APRX\LC39B_AS_EXPANSION.APRX LC39B_AS_EXPANSION_AREA 09/25/23 KM

# FIGURE C-9 EXPANSION AREA - AIR SPARGE AND MONITORING WELL DEPTH PROFILE

SWMU 009, KENNEDY SPACE CENTER, FLORIDA




**Legend**

- Proposed Monitoring Well or ASW Location
- Existing ASW Location

Groundwater Plume Boundaries

- Concentration greater than GCTL but less than the NADC
- Concentration greater than NADC but less than 10xNADC
- Concentration greater than 10xNADC
- Water Level

35 0 35 Feet

Groundwater plume boundaries are inferred on the southern side of the LOX tank due to physical restrictions (LOX tank and associated concrete pad and infrastructure).

**Inset Legend**

- Proposed Air Sparge Well
- Existing Monitoring Well
- Proposed Monitoring Well
- Concentration greater than the 10x NADC
- Concentration greater than NADC but less than 10x NADC
- Concentration greater than GCTL but less than the NADC
- Concentration less than GCTL

GCTL = State of Florida Groundwater Cleanup Target Level
NADC = Natural Attenuation Default Concentration

Notes:
1) Sample data and groundwater contours based on direct push technology sampling conducted between 2019-2022 and monitoring well results from 2022.
2) All sample locations have "39B-" as a prefix.

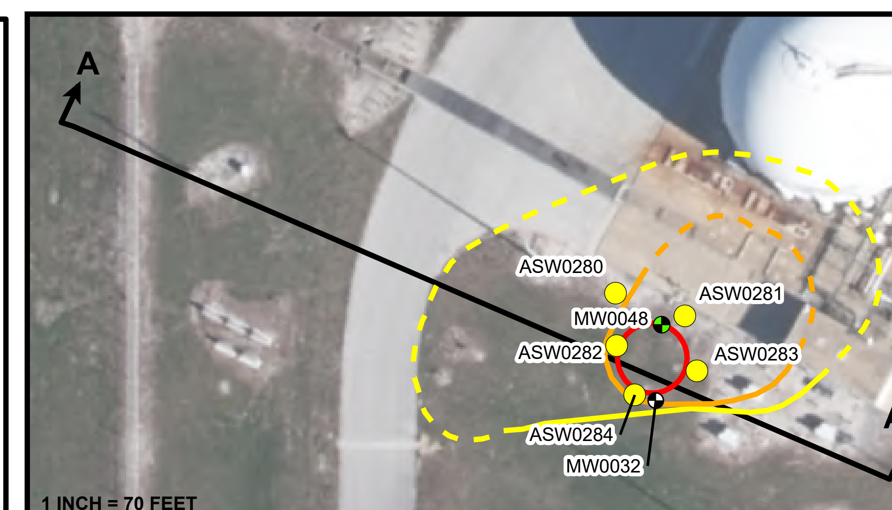
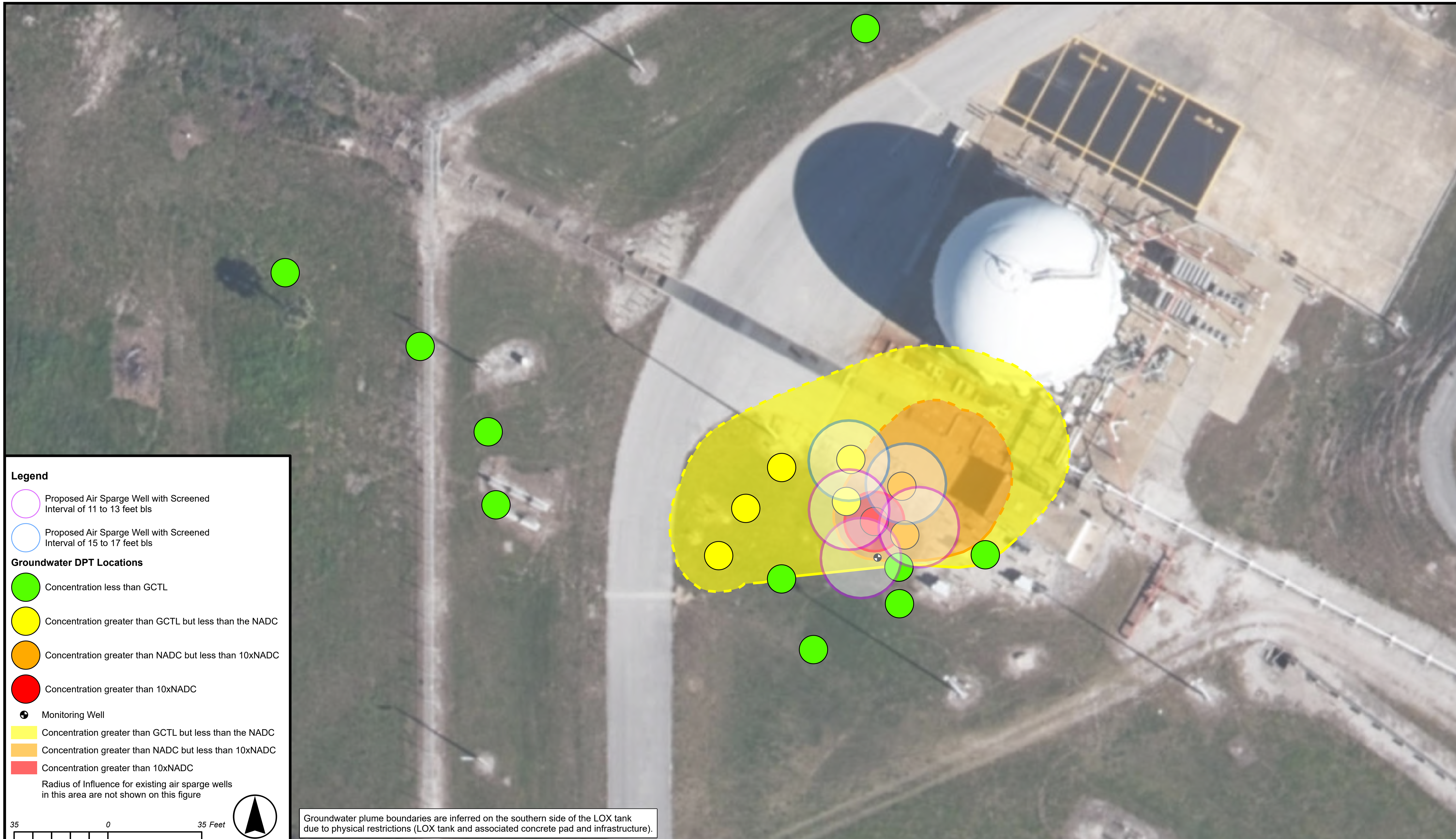


FIGURE C-10 EXPANSION AREA - AIR SPARGE RADIUS OF INFLUENCE

SWMU 009, KENNEDY SPACE CENTER, FLORIDA

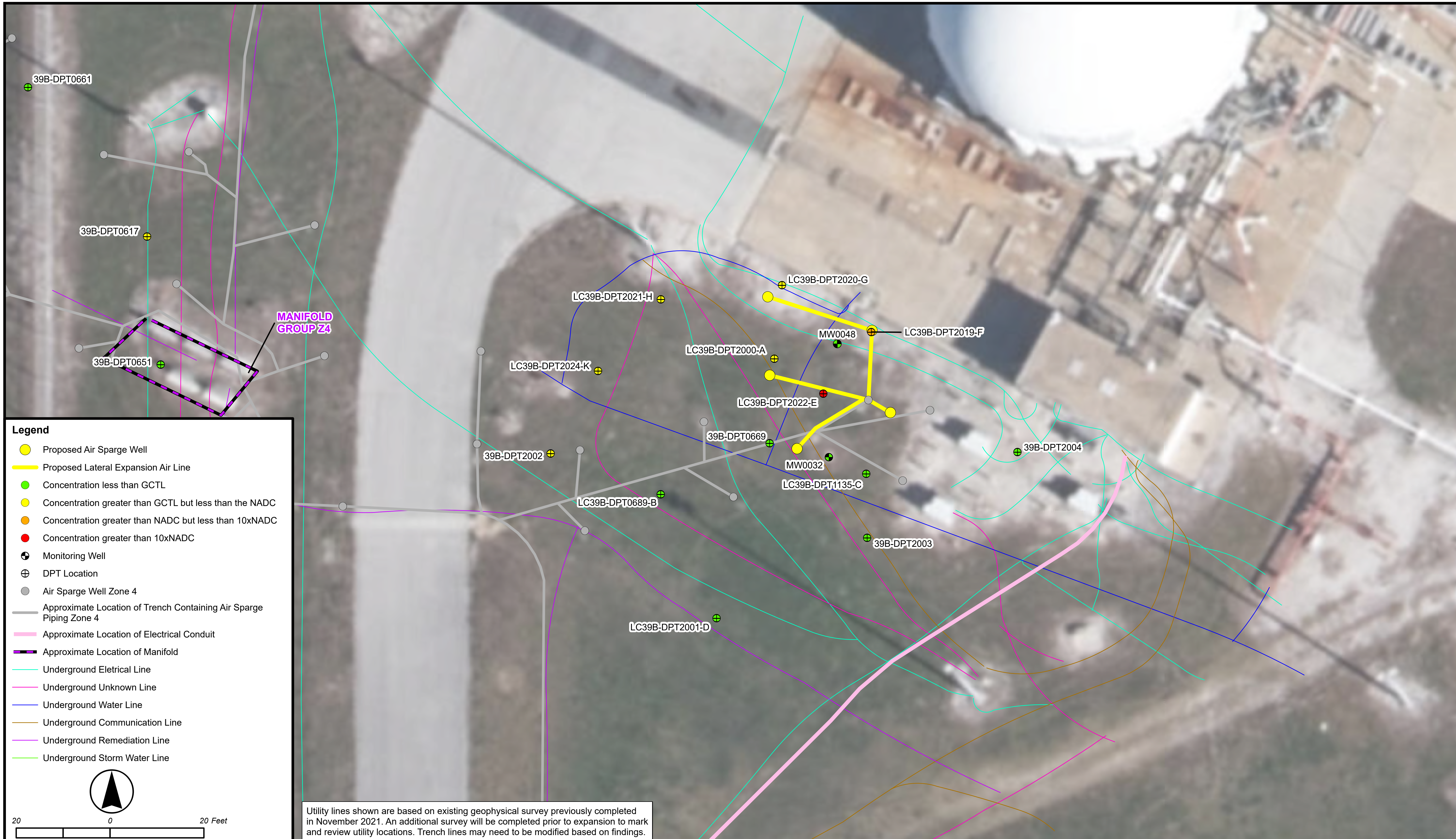





\\EGSS706GISFS1\EGS\PITTSBURGH\GIS\GIS\KSC_NASA\MAPDOCS\APRX\LC39B_EXP_AREA_AS_ROI.APRX LC39B_EXP_AREA_AS_ROI 09/22/23 KM

# FIGURE C-11 EXISTING UTILITIES IN AREA OF AIR SPARGE EXPANSION

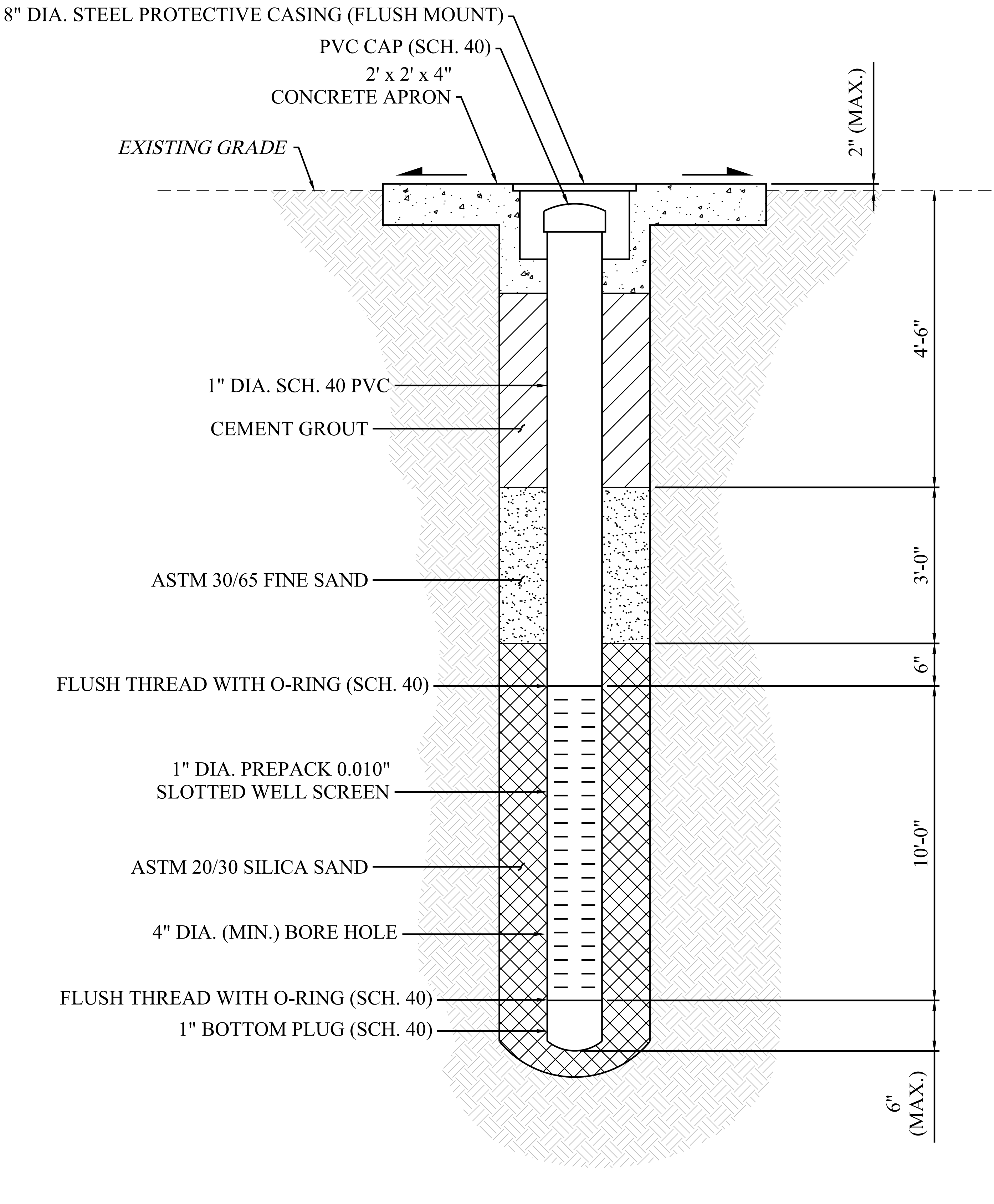
SWMU 009, KENNEDY SPACE CENTER, FLORIDA



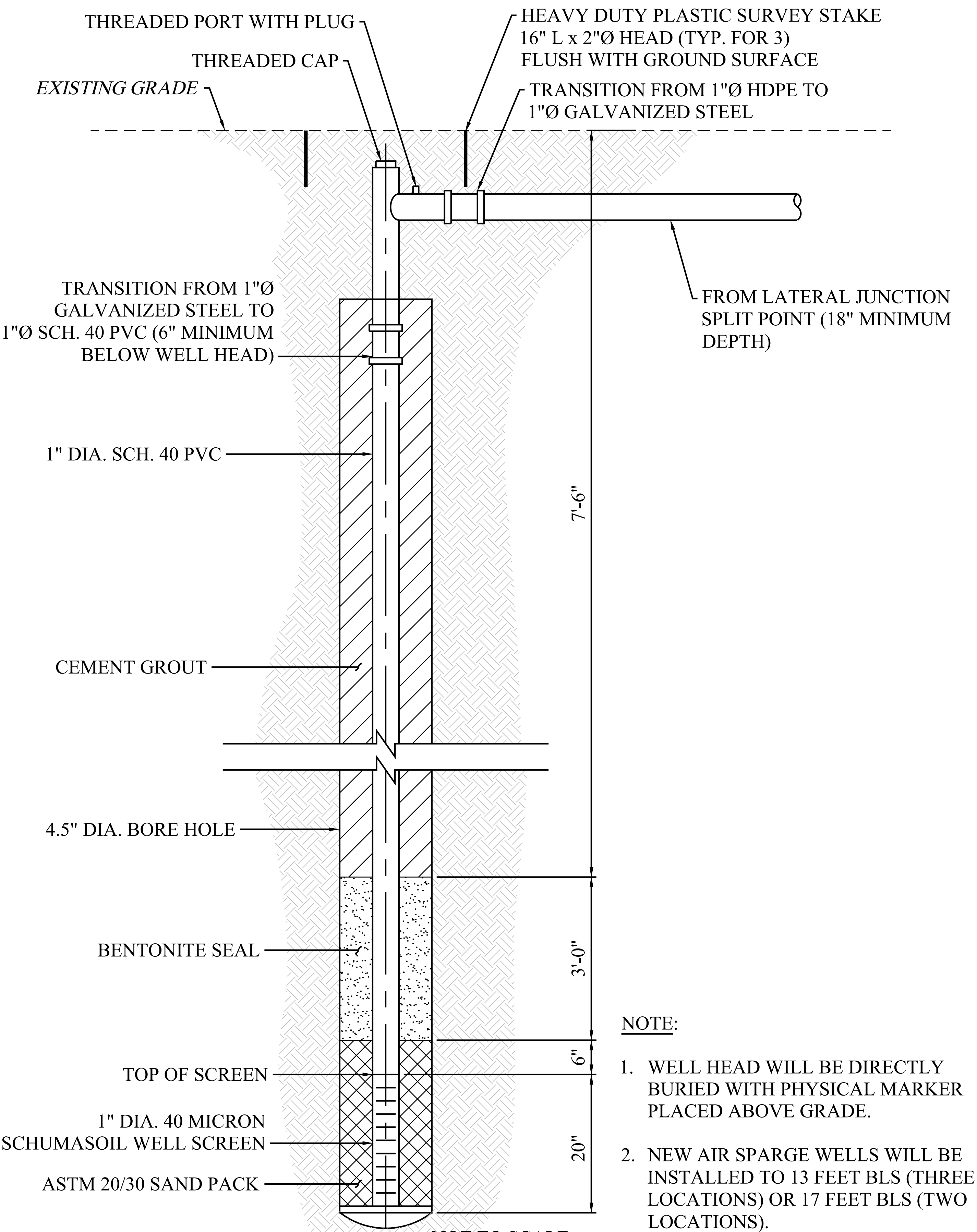

\\EGSS706GISFS1\EGS\PITTSBURGH\GIS\GIS\KSC_NASA\MAPDOCS\APRX\LC39B_GPR_W_AS_EXPANSION.APRX LC39B_GPR_W_AS_EXPANSION 09/22/23 KM

FIGURE C-12 MONITORING WELL CONSTRUCTION DETAIL
SWMU 009, KENNEDY SPACE CENTER, FLORIDA





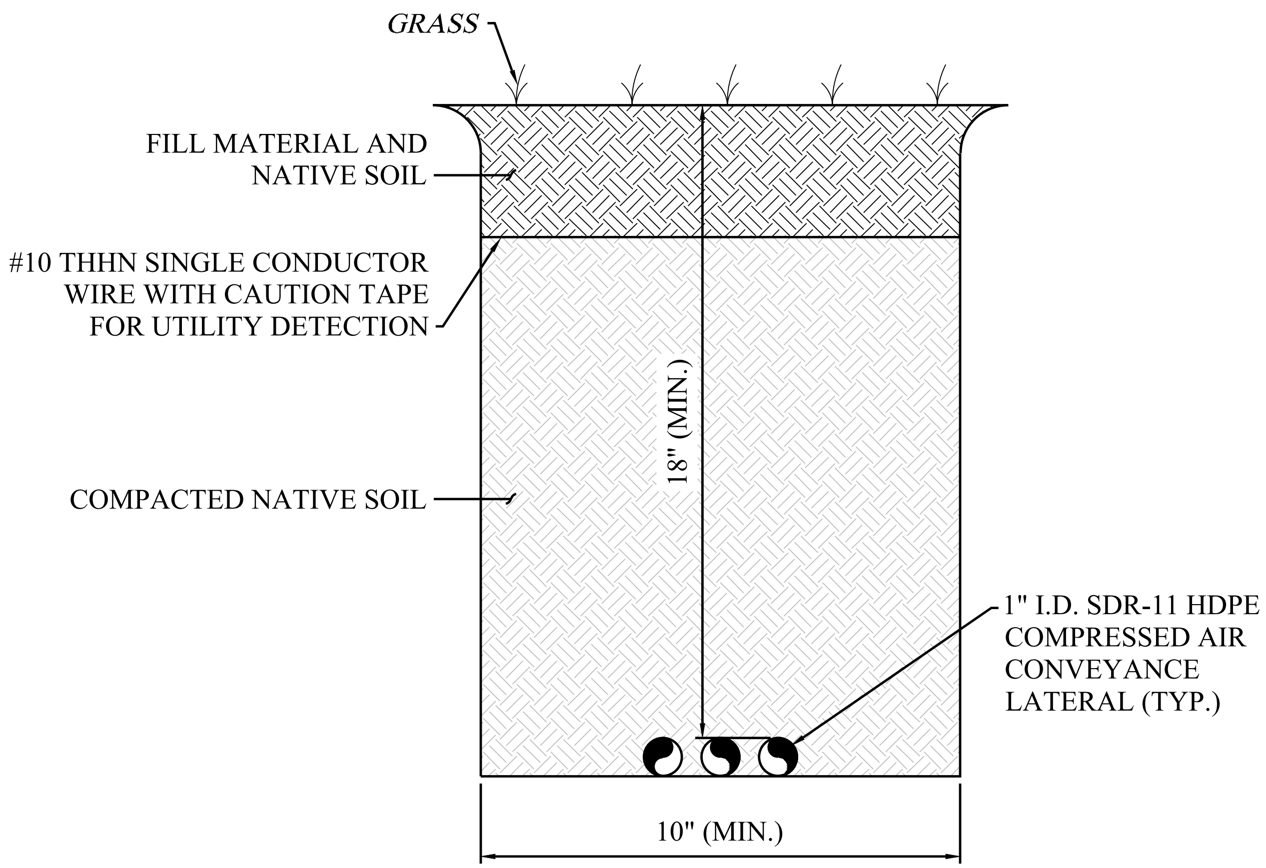

NOT TO SCALE



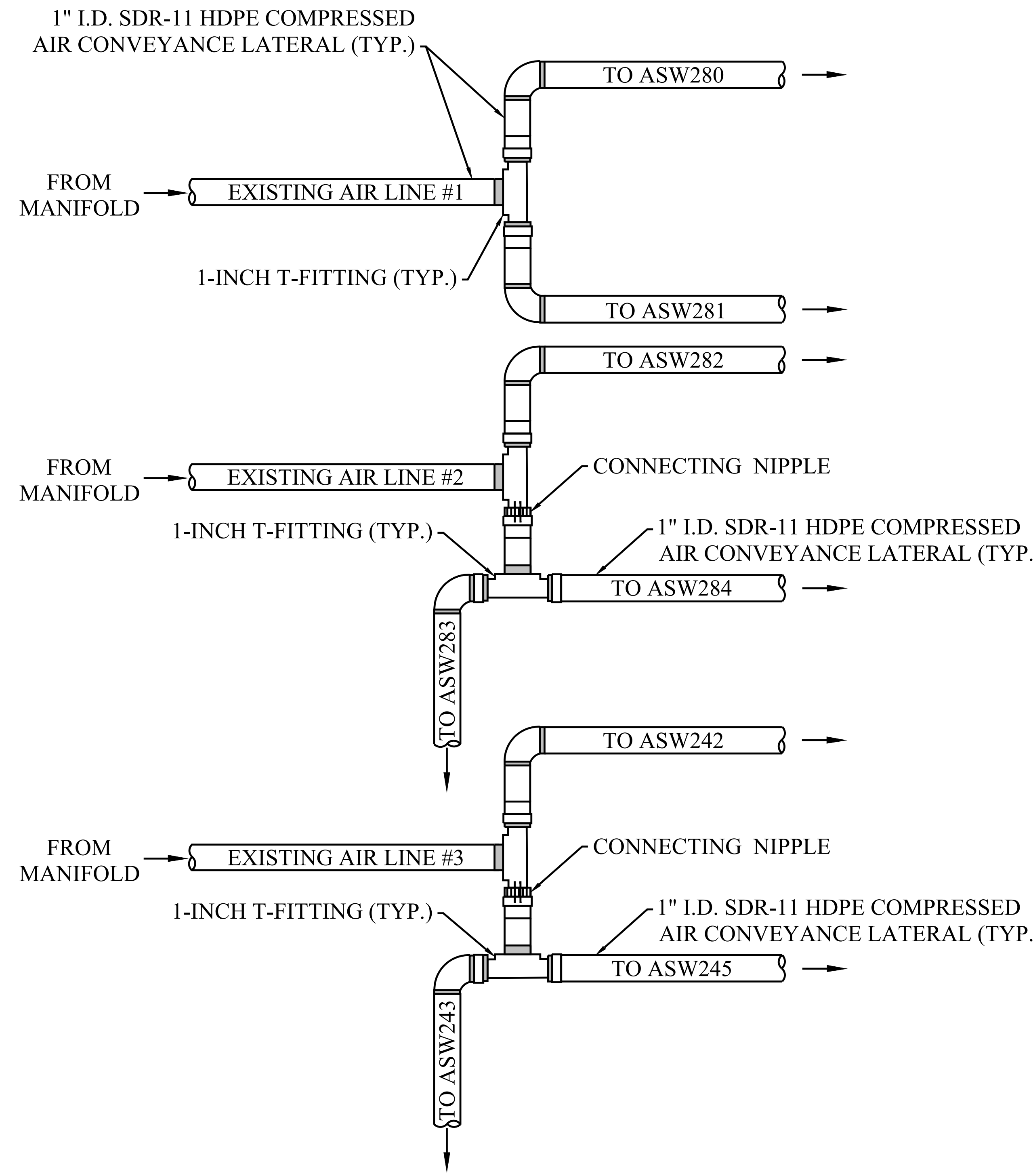

NOTE:

1. WELL HEAD WILL BE DIRECTLY BURIED WITH PHYSICAL MARKER PLACED ABOVE GRADE.
2. NEW AIR SPARGE WELLS WILL BE INSTALLED TO 13 FEET BLS (THREE LOCATIONS) OR 17 FEET BLS (TWO LOCATIONS).

NOT TO SCALE



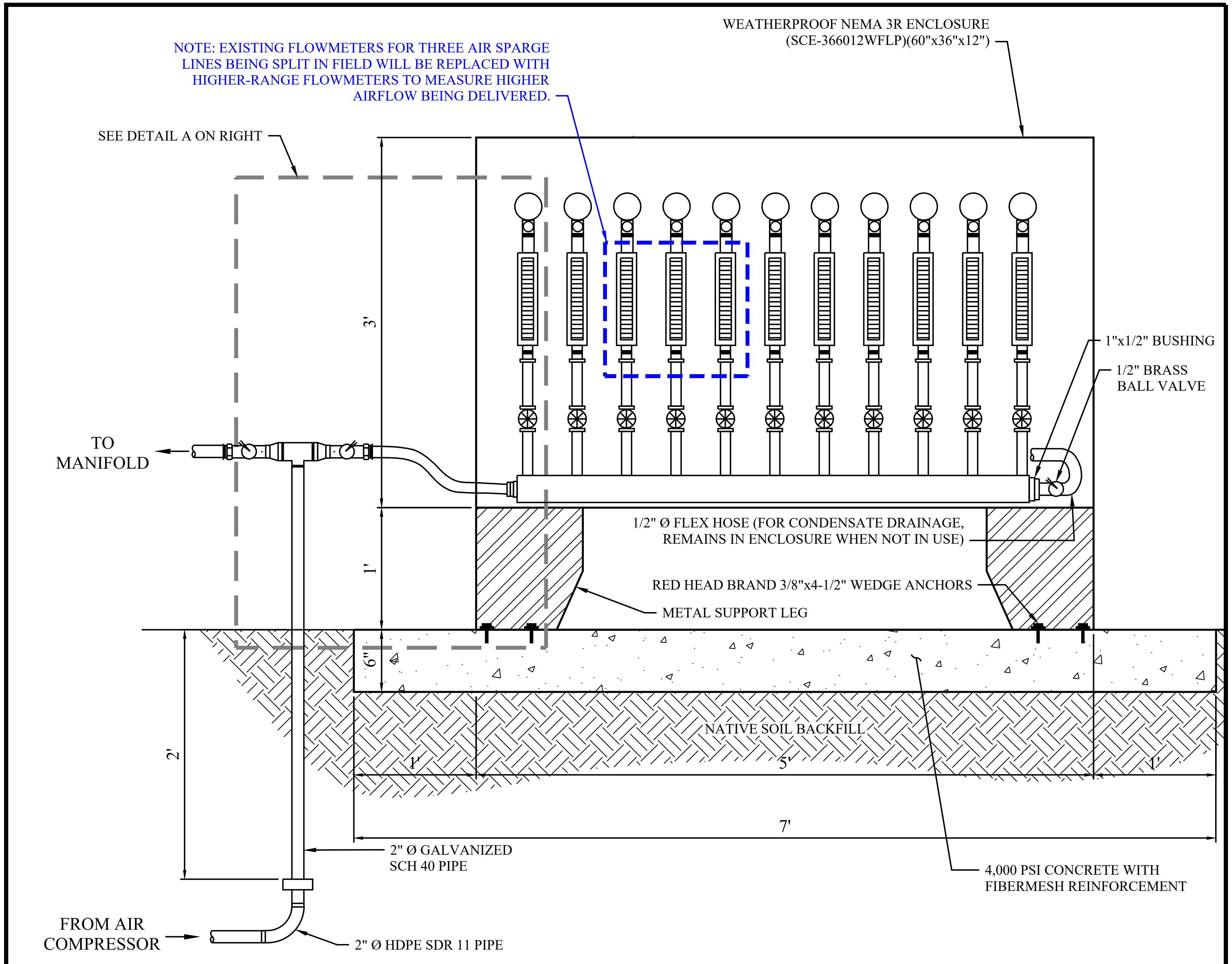

LATERAL TRENCHING CROSS-SECTION



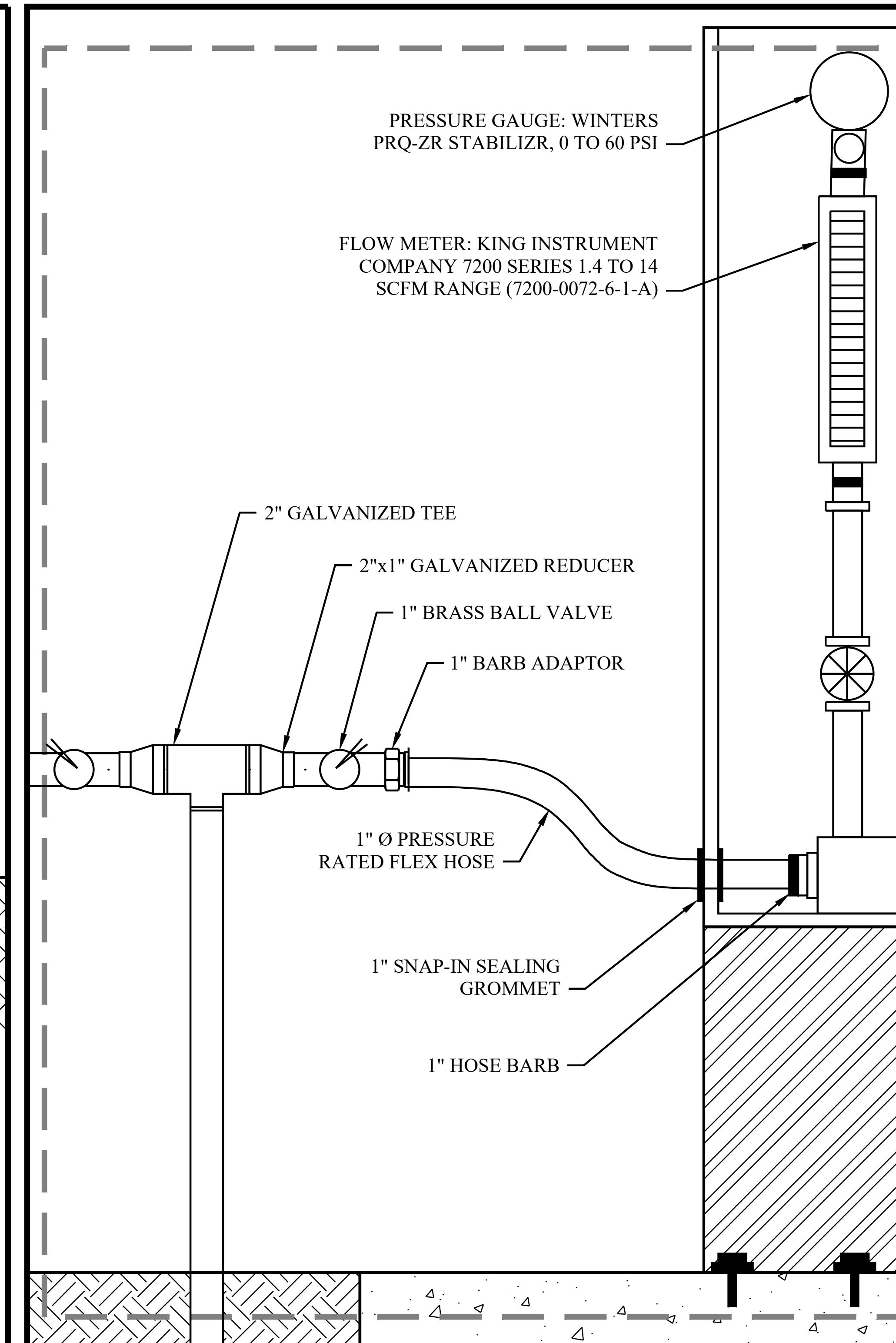

LATERAL SPLIT JUNCTION POINT

NOT TO SCALE

NOTE: ALL EXISTING ZONE 4 DISTRIBUTION MANIFOLD EQUIPMENT WILL BE USED FOR EXPANSION, EXCEPT FOR THREE FLOWMETERS THAT WILL BE REPLACED (AS SHOWN BELOW) WHERE AIRFLOW WILL BE SPLIT BETWEEN MULTIPLE AIR SPARGE WELLS.



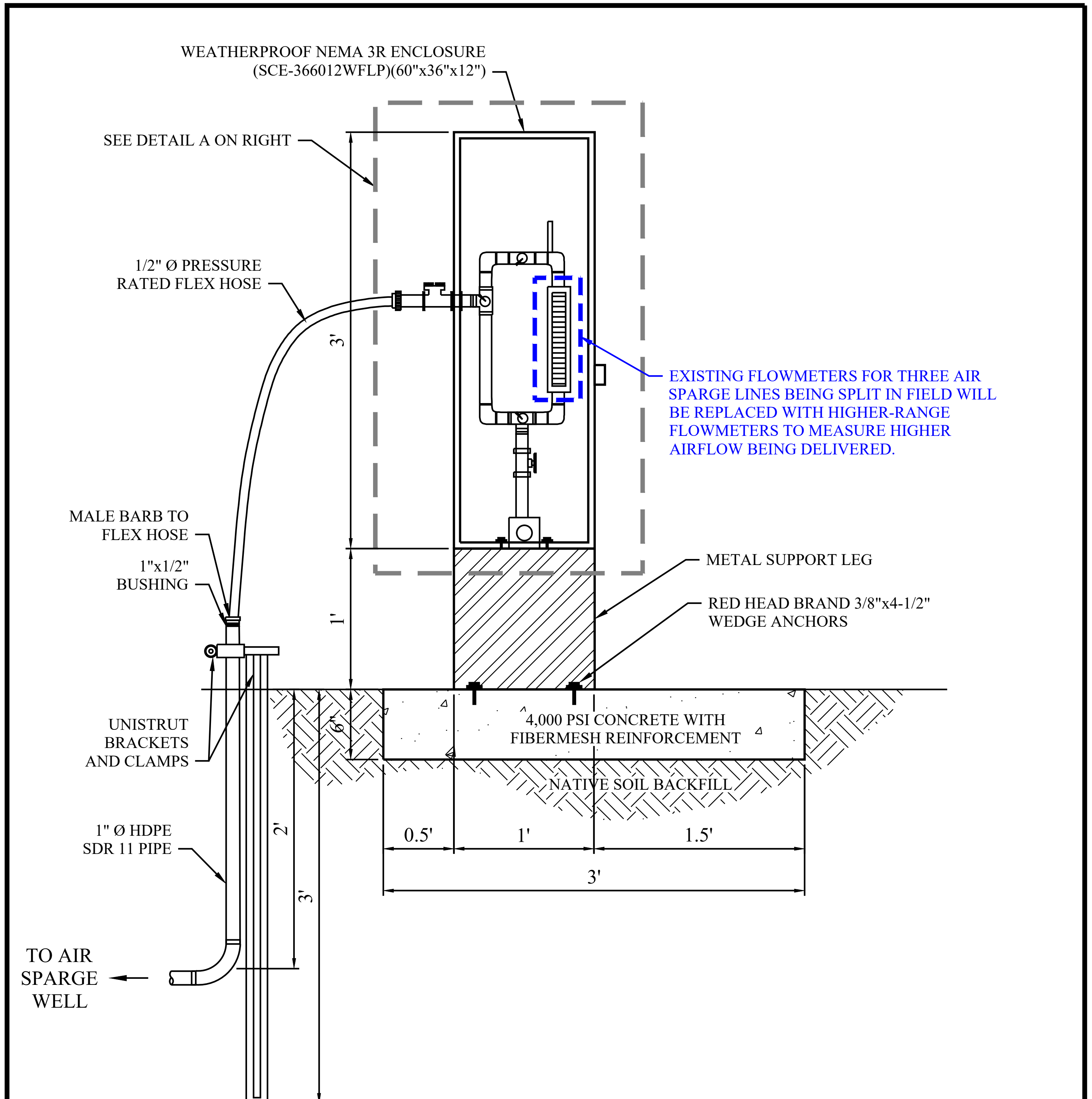

FRONT VIEW



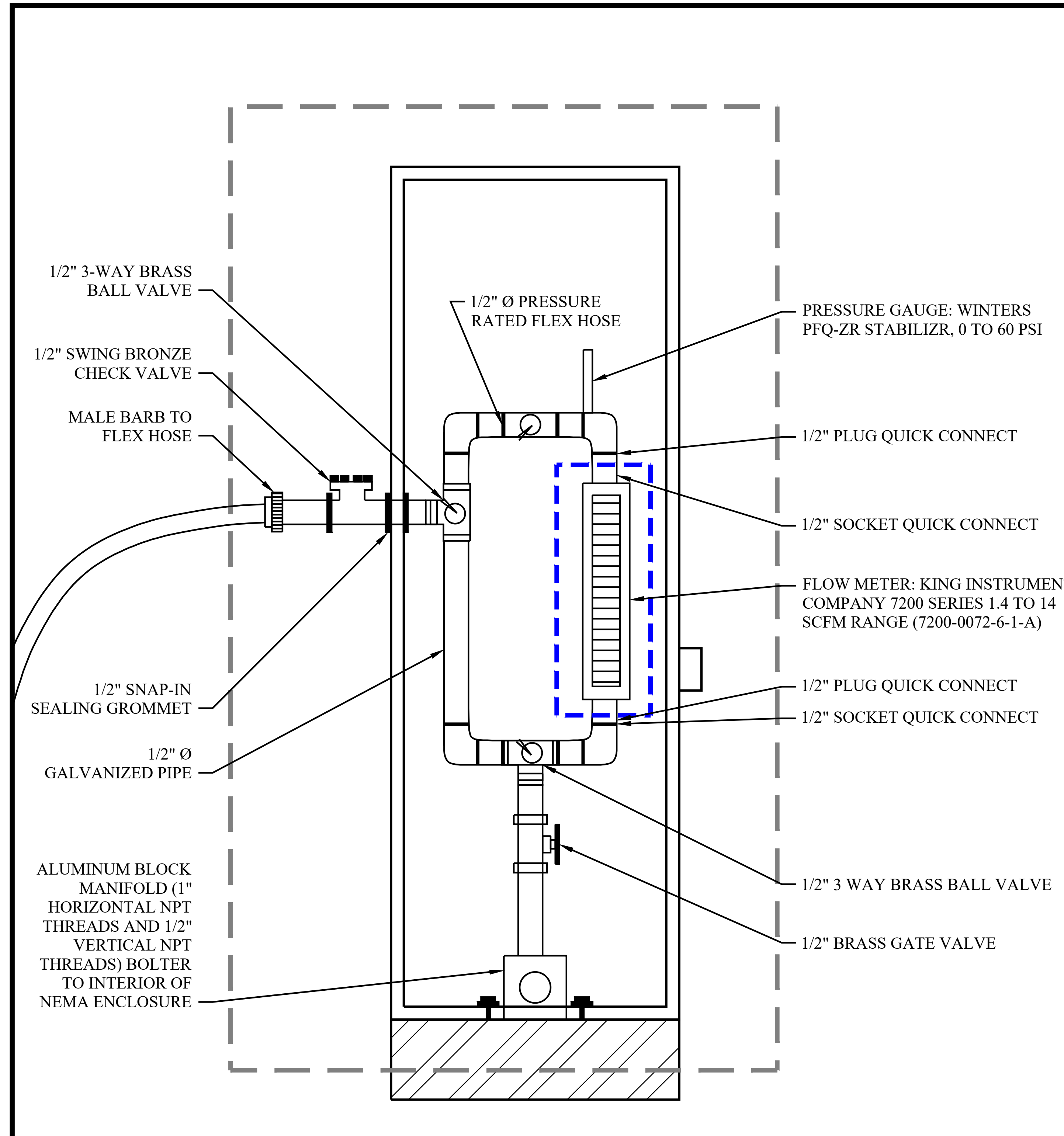

DETAIL A - FRONT VIEW

NOT TO SCALE

NOTE: ALL EXISTING ZONE 4 DISTRIBUTION MANIFOLD EQUIPMENT WILL BE USED FOR EXPANSION, EXCEPT FOR THREE FLOWMETERS THAT WILL BE REPLACED (AS SHOWN BELOW) WHERE AIRFLOW WILL BE SPLIT BETWEEN MULTIPLE AIR SPARGE WELLS.




SIDE VIEW




DETAIL A - SIDE VIEW

NOT TO SCALE

# APPENDIX D

# DESIGN AND AIR EMISSION CALCULATIONS

| **Tetra Tech** | | | **Air Sparge Pressure Calculation** |
|---|---|---|---|
| SITE: LC39B Air Sparge Expansion | CHECKED BY: LM | BY: AMW | PAGE: 1 OF 1 |
| SUBJECT: Wellhead Pressure and Line Loss Calc. | FILE No: 112G08962 | DATE: 07/24/2023 | |

**Design Wellhead Pressure Calculation:**

| | **Z4, Leg 1 - Longest Dedicated Lateral (ASW 234)** | **Z4, Leg 1 - Longest Split Lateral (Expansion)** |
|---|---|---|
| Well Screen Depth | **22.0** | **22.0** |
| DTW (average) | 4.0 | 4.0 |
| Water Column | 18.0 | 18.0 |
| $S.G._{water}$ | 1.0 | 1.0 |
| $S.G._{soil}$ | 2.3 | 2.3 |
| Porosity | 0.30 | 0.30 |
| $P_{soil\ column}$ | 12.6 | 12.6 |
| $P_{watercolumn}$ | 2.3 | 2.3 |
| $P_{total\ overburden\ pressure}$ | 14.9 | 14.9 |
| %Maximum Overburden Pressure | 70% | 70% |
| $\mathbf{P_{design\ wellhead\ (gauge)}}$ | **10.4** | **10.4** |

| **Air Conveyance Line Loss Calculation:** | Z4L1 - Longest Dedicated Lateral | | Z4L1 - Longest Split Lateral (Expansion) | |
|---|---|---|---|---|
| | Z4- Leg 1 Header | Max Lateral ASW 234 | Z4- Leg 1 Header | Max Lateral ASW 243 |
| D, Nominal Pipe Diam (in) | 2 | 1 | 2 | 1 |
| L, Pipe Length (ft) * 1.25 | 250 | 565 | 250 | 300 |
| Q, Air Flow Rate (cfm) | 108 | 6 | 108 | 18 |
| f, Friction Factor (in. w.c./ft)[2] | 0.112 | 0.018 | 0.108 | 0.127 |
| Quantity of 45 deg. Elbows | 0 | 1 | 0 | 0 |
| Quantity of 90 deg. Elbows | 4 | 5 | 4 | 2 |
| Quantity of Gate Valves (Fully Open) | 0 | 0 | 0 | 0 |
| Quantity of Branch Tees | 1 | 1 | 1 | 3 |
| Quantity of Reducers | 1 | 0 | 1 | 0 |
| Total Equivalent Length | 291 | 586 | 291 | 323 |
| Line Friction Loss (in. w.c.) | 32.5 | 10.7 | 31.3 | 41.0 |
| Line Friction Loss (psi) | 1.2 | 0.4 | 1.1 | 1.5 |

**Pressure Summary:**

| | | |
|---|---|---|
| **Header Line Loss** | **1.2 psi** | **1.1 psi** |
| **Lateral Line Loss** | **0.4 psi** | **1.5 psi** |
| **Assumed Dist. Manifold Pressure Loss** | **5.0 psi** | **5.0 psi** |
| **Wellhead Pressure** | **10.4 psi** | **10.4 psi** |
| **Totals** | **17.0 psi** | **18.0 psi** |

[2] Refer to subsequent friction factor calculations (turbulant flow assumed)

**Pressure at System Manifold Discharge:**
**System Manifold Pressure: Zone 4, Leg 1 - Max** **18.0 psig**

**Fitting Equivalent Pipe Lengths (ft)**

| | 1" ID | 2" ID |
|---|---|---|
| Elbows (45 deg) | 1.3 | 2.5 |
| Elbows (90 deg) | 2.7 | 5.5 |
| Gate Valve (Fully Open) | 0.6 | 1.2 |
| Branch Tee | 5.8 | 11.0 |
| Reducer | -- | 8.0 |

Note: Calculations were performed to evaluate pressure requirements (at wellhead and manifold discharge) to operate Zone 4, Leg 1 with the five new expansion ASWs. Two different scenarios were assessed, each assuming expansion-in-place (total of 18 ASWs on Leg 1, each 6 scfm design). Scenario 1 evaluates pressure requirements using the longest lateral length (for a single dedicated line) from the Zone 4 manifold (ASW 234), which would introduce the highest pressure drop based on distance of airflow travel. Scenario 2 evaluates pressure requirements for the expansion area where higher flowrates from the manifold will be split (between several lateral lines in the field) to supply ASWs in this area. This scenario uses the ASW (with longest lateral length and depth) that will receive airflow from a 3-way lateral split (ASW 243). Results from these two scenarios were compared to determine if the expansion area required additional pressure at the manifold to supply higher flowrates to lateral lines being split. The higher manifold pressure from Scenario 1 vs. Scenario 2 was used for design requirements. Both scenarios showed similar manifold pressures to accommodate design flowrate and wellhead pressure, but Scenario 2 was slightly higher and therefore used for design requirements.

## Friction factor calculation (Zone Z4 - Longest Dedicated Lateral)

For turbulent flow:

$f=1.35/[\ln(e/(3.7*D) + 5.74/Re^{0.9})]^2$

| | | | | | | |
|---|---|---|---|---|---|---|
| Q | volumetric flow at standard conditions | 108 | SCFM | or | 0.050970324 | $m^3$/sec |
| P1 | pipe inlet absolute pressure (assumed as average) | 26.51 | psi | or | 182783.2474 | Pa |
| T | pipe air temperature | 85 | deg. F | or | 302 | deg. K |
| Pst | standard atmospheric pressure | 14.70 | psi | | 101325 | Pa |
| Tst | standard temperature (NIST) | 68 | deg. F | or | 293 | deg. K |
| D | pipe ID | 2 | inches | or | 0.0508 | meters |
| A | pipe cross section area | 3.1415927 | sq. in. | or | 0.00202683 | square meters |
| V | actual fluid velocity (V = Q/A*(Pst/P1)*(T/Tst) | 2832.66 | feet/min | or | 14.39 | m/sec |
| mu | dynamic viscosity at reference temperature | 1.64E-04 | $f^2$/sec | or | 1.83E-05 | kg/(m*sec) |
| Tref | reference temperature | | | | 291.15 | deg. K |
| mu | dynamic viscosity at actual temperature | | | | 1.88E-05 | kg/(m*sec) |
| ro | air density at inlet conditions (ro=P1/(R*T) | | | | 2.11 | $kg/m^3$ |
| Re | Re = V * D * ro/ mu | | | | 8.18E+04 | turbulent |
| e | pipe roughness (PVC, plastic) | | | | 0.00002 | m |
| **f** | **pipe friction coefficient** | | | | **0.021** | |

## Pressure loss calculation

| | | | | | | |
|---|---|---|---|---|---|---|
| P1 | pipe inlet absolute pressure | 26.51047 | psi | or | 182783.2474 | Pa |
| L | pipe length | 250 | feet | or | 76 | meters |
| R | gas constant | | | | 286.9 | J/(kg*K) |
| T | pipe air temperature | 85 | deg. F | or | 302 | deg. K |
| r | air density at standard conditions | 0.075 | $lb/f^3$ | or | 1.20 | $kg/m^3$ |
| w | mass flow rate W = Q * r | 8.10 | lb/min | | 0.0614 | kg/sec |
| **P2** | **pressure at the end of pipe (absolute)** | **25.5** | **psi** | **or** | **175827** | **Pa** |
| **DP** | **pipe pressure loss** | **1.01** | **psi** | **or** | **6956** | **Pa** |
| **P2** | **pressure at end of pipe (gauge)** | **10.8** | **psi** | | | |

## Friction factor calculation (Zone Z4 - Longest Dedicated Lateral)

For turbulent flow:

$f=1.35/[\ln(e/(3.7*D) + 5.74/Re^{0.9})]^2$

| | | | | | | |
|---|---|---|---|---|---|---|
| Q | volumetric flow at standard conditions | 6 | SCFM | or | 0.002831685 | $m^3$/sec |
| P1 | pipe inlet absolute pressure (assumed as average) | 25.50 | psi | or | 175826.7751 | Pa |
| T | pipe air temperature | 85 | deg. F | or | 302 | deg. K |
| Pst | standard atmospheric pressure | 14.70 | | | 101325 | Pa |
| Tst | standard temperature (NIST) | 68 | deg. F | or | 293 | deg. K |
| D | pipe ID | 1 | inches | or | 0.0254 | meters |
| A | pipe cross section area | 0.7853982 | sq. in. | or | 0.000506707 | square meters |
| V | actual fluid velocity (V = Q/A*(Pst/P1)*(T/Tst) | 654.39 | feet/min | | 3.32 | m/sec |
| mu | dynamic viscosity at reference temperature | 1.64E-04 | $f^2$/sec | | 1.83E-05 | kg/(m*sec) |
| Tref | reference temperature | | | | 291.15 | deg. K |
| mu | dynamic viscosity at actual temperature | | | | 1.88E-05 | kg/(m*sec) |
| ro | air density at inlet conditions (ro=P1/(R*T) | | | | 2.03 | kg/$m^3$ |
| Re | Re = V * D * ro/ mu | | | | 9.09E+03 | turbulent |
| e | pipe roughness (PVC, plastic) | | | | 0.00002 | m |
| **f** | **pipe friction coefficient** | | | | **0.034** | |

## Pressure loss calculation

| | | | | | | |
|---|---|---|---|---|---|---|
| P1 | pipe inlet absolute pressure | 25.50 | psi | or | 175826.7751 | Pa |
| L | pipe length | 565 | feet | or | 172 | meters |
| R | gas constant | | | | 286.9 | J/(kg*K) |
| T | pipe air temperature | 85 | deg. F | or | 302 | deg. K |
| r | air density at standard conditions | 0.075 | lb/$f^3$ | or | 1.20 | kg/$m^3$ |
| w | mass flow rate W = Q * r | 0.45 | lb/min | | 0.0034 | kg/sec |
| **P2** | **pressure at the end of pipe (absolute)** | **25.1** | **psi** | **or** | **173256** | **Pa** |
| **DP** | **pipe pressure loss** | **0.37** | **psi** | **or** | **2571** | **Pa** |
| **P2** | **pressure at end of pipe (gauge)** | **10.4** | **psi** | | | |

## Friction factor calculation (Zone Z4 - Longest Split Lateral [Expansion])

For turbulent flow:

$f=1.35/[\ln(e/(3.7*D) + 5.74/Re^{0.9})]^2$

| | | | | | | |
|---|---|---|---|---|---|---|
| Q | volumetric flow at standard conditions | 108 | SCFM | or | 0.050970324 | $m^3$/sec |
| P1 | pipe inlet absolute pressure (assumed as average) | 27.48 | psi | or | 189440.3685 | Pa |
| T | pipe air temperature | 85 | deg. F | or | 302 | deg. K |
| Pst | standard atmospheric pressure | 14.70 | psi | | 101325 | Pa |
| Tst | standard temperature (NIST) | 68 | deg. F | or | 293 | deg. K |
| D | pipe ID | 2 | inches | or | 0.0508 | meters |
| A | pipe cross section area | 3.1415927 | sq. in. | or | 0.00202683 | square meters |
| V | actual fluid velocity (V = Q/A*(Pst/P1)*(T/Tst) | 2733.12 | feet/min | or | 13.88 | m/sec |
| mu | dynamic viscosity at reference temperature | 1.64E-04 | $f^2$/sec | or | 1.83E-05 | kg/(m*sec) |
| Tref | reference temperature | | | | 291.15 | deg. K |
| mu | dynamic viscosity at actual temperature | | | | 1.88E-05 | kg/(m*sec) |
| ro | air density at inlet conditions (ro=P1/(R*T) | | | | 2.18 | kg/$m^3$ |
| Re | Re = V * D * ro/ mu | | | | 8.18E+04 | turbulent |
| e | pipe roughness (PVC, plastic) | | | | 0.00002 | m |
| **f** | **pipe friction coefficient** | | | | **0.021** | |

## Pressure loss calculation

| | | | | | | |
|---|---|---|---|---|---|---|
| P1 | pipe inlet absolute pressure | 27.476004 | psi | or | 189440.3685 | Pa |
| L | pipe length | 250 | feet | or | 76 | meters |
| R | gas constant | | | | 286.9 | J/(kg*K) |
| T | pipe air temperature | 85 | deg. F | or | 302 | deg. K |
| r | air density at standard conditions | 0.075 | lb/$f^3$ | or | 1.20 | kg/$m^3$ |
| w | mass flow rate W = Q * r | 8.10 | lb/min | | 0.0614 | kg/sec |
| **P2** | **pressure at the end of pipe (absolute)** | **26.5** | **psi** | **or** | **182737** | **Pa** |
| **DP** | **pipe pressure loss** | **0.97** | **psi** | **or** | **6703** | **Pa** |
| **P2** | **pressure at end of pipe (gauge)** | **11.8** | **psi** | | | |

## Friction factor calculation (Zone Z4 - Longest Split Lateral [Expansion])

For turbulent flow:

$f=1.35/[\ln(e/(3.7*D) + 5.74/Re^{0.9})]^2$

| | | | | | | |
|---|---|---|---|---|---|---|
| Q | volumetric flow at standard conditions | 18 | SCFM | or | 0.008495054 | $m^3$/sec |
| P1 | pipe inlet absolute pressure (assumed as average) | 26.50 | psi | or | 182737.4963 | Pa |
| T | pipe air temperature | 85 | deg. F | or | 302 | deg. K |
| Pst | standard atmospheric pressure | 14.70 | | | 101325 | Pa |
| Tst | standard temperature (NIST) | 68 | deg. F | or | 293 | deg. K |
| D | pipe ID | 1 | inches | or | 0.0254 | meters |
| A | pipe cross section area | 0.7853982 | sq. in. | or | 0.000506707 | square meters |
| V | actual fluid velocity (V = Q/A*(Pst/P1)*(T/Tst) | 1888.91 | feet/min | | 9.60 | m/sec |
| mu | dynamic viscosity at reference temperature | 1.64E-04 | $f^2$/sec | | 1.83E-05 | kg/(m*sec) |
| Tref | reference temperature | | | | 291.15 | deg. K |
| mu | dynamic viscosity at actual temperature | | | | 1.88E-05 | kg/(m*sec) |
| ro | air density at inlet conditions (ro=P1/(R*T) | | | | 2.11 | $kg/m^3$ |
| Re | Re = V * D * ro/ mu | | | | 2.73E+04 | turbulent |
| e | pipe roughness (PVC, plastic) | | | | 0.00002 | m |
| **f** | **pipe friction coefficient** | | | | **0.027** | |

## Pressure loss calculation

| | | | | | | |
|---|---|---|---|---|---|---|
| P1 | pipe inlet absolute pressure | 26.503834 | psi | or | 182737.4963 | Pa |
| L | pipe length | 300 | feet | or | 91 | meters |
| R | gas constant | | | | 286.9 | J/(kg*K) |
| T | pipe air temperature | 85 | deg. F | or | 302 | deg. K |
| r | air density at standard conditions | 0.075 | lb/$f^3$ | or | 1.20 | $kg/m^3$ |
| w | mass flow rate W = Q * r | 1.35 | lb/min | | 0.0102 | kg/sec |
| **P2** | **pressure at the end of pipe (absolute)** | **25.1** | **psi** | **or** | **173256** | **Pa** |
| **DP** | **pipe pressure loss** | **1.38** | **psi** | **or** | **9482** | **Pa** |
| **P2** | **pressure at end of pipe (gauge)** | **10.4** | **psi** | | | |

# AIR SPARGING CLEANUP DURATION ESTIMATION

| | | | |
|---|---|---|---|
| CLIENT SITE NO.: | LC39B Proposed Expansion Treatment Area | | |
| TTNUS PROJECT NO.: | 80KSC019F0069 | By: | AMW |
| DATE CALCULATED: | 9/29/2023 | Checked By: | LM |
| (Source: "Air Sparging Model for Predicting Groundwater Cleanup Rate" K.L. Sellers and R.P Schreiber, CDM Inc. 1992) | | | |

The following first order decay/rate equation may be used to estimate a conservative time for the contaminants of concern concentrations to be reduced below the remedial action ojectives. This model calculates both the average and maximum clean-up times as dictated by the initial concemtrations.

$$C_{(t)} = C_{(o)} \times e^{-Bt}$$

Variables:

$C_{(t)}$ = Concentration at end of duration or RAO's (ug/L)

$C_{(o)}$max = Initial Maximum Concentration (ug/L)

$C_{(o)}$ave = Initial Weighted Average Concentration (ug/L)

e = base of the natural log (approx. 2.71828)

B = first order differential rate constant

t = duration (solving for)

Solving for t reduces to:

$$\mathbf{t = \ln(C_{(t)/}C_{(o)}) / -B}$$

| CONTAMINANT TYPE | $C_o$ Max (ug/l)* | $C_o$ Ave (ug/L)* | $C_t$ (ug/L)* | t Max (years) | t Ave (years) |
|---|---|---|---|---|---|
| TCE | 18 | 6.5 | 300 | N/A | N/A |
| cDCE | 1000 | 83 | 700 | 0.05 | N/A |
| tDCE | 140 | 21 | 1000 | N/A | N/A |
| VC | 1500 | 189 | 100 | 0.38 | 0.09 |
| Total VOCs | 2658 | 299 | 2100 | 0.03 | N/A |

Note: Maximum and average concentrations are from 2022 Hot Spot 2 DPT investigation.

# AIR SPARGING CLEANUP DURATION ESTIMATION

| | | | |
|---|---|---|---|
| CLIENT SITE NO.: | LC39B Proposed Expansion Treatment Area | | |
| TTNUS PROJECT NO.: | 80KSC019F0069 | By: | AMW |
| DATE CALCULATED: | 9/29/2023 | Checked By: | |
| (Source:"Air Sparging Model for Predicting Groundwater Cleanup Rate" K.L. Sellers and R.P Schreiber,CDM Inc. 1992) | | | |

The first order rate coefficient B can be calculated by the following equation.

$$B = f \times d \times D/L \times S/V \times H/\upsilon \times Q/V_s$$

Variables:

| | | | |
|---|---|---|---|
| f = Fraction of plume sparged (unitless) | f = | 1.0 | assumed |
| d = Fraction of 24-hour day unit operates (unitless) | d = | 1.0 | assumed |
| D = Contaminant diffusion coefficent ($m^2/s$) | D = | see below | |
| L = Diffusive distance around bubble (m) [Recalculated using Site-16] | L = | **2.43E-03** | |
| S/V = effective surface area to volume ratio of a bubble ($m^{-1}$) | S/V = | 1236.5 | |
| H = Depth of screen below water table (m) | H = | 4.1 | |
| $\upsilon$ = Bubble terminal Rise velocity (m/s) | $\upsilon$ = | 2.38E-01 | |
| Q = Total air flow ($m^3/s$) | Q = | 1.63E-02 | |
| $V_s$ = Volume of water in plume that contact bubbles ($m^3$) | $V_s$ = | 623.8 | |

| CONTAMINANT TYPE | D ($m^2/s$) | B ($sec^{-1}$) | B ($yr^{-1}$) |
|---|---|---|---|
| Total VOCs | 1.00E-09 | 2.27E-07 | 7.16E+00 |

# AIR SPARGING CLEANUP DURATION ESTIMATION

| | | | |
|---|---|---|---|
| CLIENT SITE NO.: | LC39B Proposed Expansion Treatment Area | | |
| TTNUS PROJECT NO.: | 80KSC019F0069 | By: | AMW |
| DATE CALCULATED: | 9/29/2023 | Checked By: | |

(Source:"Air Sparging Model for Predicting Groundwater Cleanup Rate" K.L. Sellers and R.P Schreiber,CDM Inc. 1992)

Estimation of Contaminant Diffusion Coefficient

| | | |
|---|---|---|
| **Volatiles =** | **1.00E-09** | **$m^2/s$** |
| **Semi-Volatiles =** | **8.00E-10** | **$m^2/s$** |

Calculate the diffusive distance around bubble (L)

This model assumes L = r

Where r is equal to the effective radius of the bubble

$$r = 2 \times R \times \{6\sigma/[R^2 \times (P_w - P_a) \times g]\}^{1/3}$$

Given

| | | | |
|---|---|---|---|
| **R =** | **4.00E-05** | **m** | (orifice diameter of the sparger or well screen slot) |
| **σ =** | **0.0728** | **N/m** | (air water surface tension) |
| **Pw =** | **1000** | **$kg/m^3$** | (density of water) |
| **Pa =** | **1.29** | **$kg/m^3$** | (density of air at 50F) |
| **g =** | **9.8** | **$m/s^2$** | (acceleration due to gravity) |
| **well slot =** | **1.57E-03** | **in** | (40-micron diffusers) |

**L = r = 2.43E-03 m**

S/V is the effective surface area to volume ratio of a bubble

S/V = 3/r

r is calculated above, therefore

**S/V = 1236.5 $m^{-1}$**

υ is the terminal rise velocity of a bubble

$$\upsilon = \{1.04 \times g \times r + (1.07 \times \sigma)/(r \times P_w)\}^{1/2}$$

Where:

| | | | |
|---|---|---|---|
| **g =** | **9.8** | **$m/s^2$** | (acceleration due to gravity) |
| **r =** | **2.43E-03** | **m** | (calculated above) |
| **σ =** | **0.0728** | **N/m** | (air water surface tension) |
| **$P_w$ =** | **1000** | **$kg/m^3$** | (density of water) |

υ = **0.238 m/s**

The height H is equal to the average total depth of the sparge well to the water table

| | | | |
|---|---|---|---|
| **TD =** | 17 | **ft** | Weighted average of well #'s and depths |
| **DTW =** | 4 | **ft** | |
| **H =** | **13.4** | **ft** | |
| **H =** | **4.1** | **m** | |

The air flow rate is determined by the number of sparge wells and a correction for pressure caused by well depth

Q = # wells x flow rate per well x adjustment for pressure

| | | | |
|---|---|---|---|
| **# wells =** | **8** | **unitless** | |
| **flow/well =** | **6** | **SCFM** | |
| **TD =** | **17** | **ft** | Weighted average of well #'s and depths |
| **DTW =** | **4** | **ft** | |
| **ADJF =** | **0.72** | **unitless** | |
| **Q =** | **34.43** | **CFM** | |
| **Q =** | **1.63E-02** | **$m^3/s$** | |

Note: treatment area is limited to the 8 AS wells within the Hot Spot 2 high concentration plume since concentrations in the majority of Zone 4 outside of the Hot Spot 2 are less than GCTL

Volume of plume in sparged area is determined by following calculation

$V_s = A \times h \times \eta$

Where:

| | | |
|---|---|---|
| **ROI =** | 15.0 | **ft (Radius of Influence) - Weighted Average** |
| **A =** | 5,652 | **ft (Radius of Influence Area * Number of Wells)** |
| **h =** | **13.00** | **ft (groundwater plume average thickness)** |
| **$\eta$ =** | 0.3 | **unitless (assumed porosity)** |
| **$V_s$ =** | **22042.8** | **$ft^3$** |
| **$V_s$ =** | **623.8** | **$m^3$** |

# AIR SPARGING CLEANUP DURATION ESTIMATION

| | | | |
|---|---|---|---|
| CLIENT SITE NO.: | LC39B Proposed Expansion Treatment Area | | |
| TTNUS PROJECT NO.: | 80KSC019F0 By: | AMW | |
| DATE CALCULATED: | 9/29/2023 | Checked By: | |
| (Source:"Air Sparging Model for Predicting Groundwater Cleanup Rate" K.L. Sellers and R.P Schreiber,CDM Inc. 1992) | | | |

**Estimate the VOC emission rate from the AS system:**

Emission from air sparging:

**Vs x -dC(t)/dt**

**where:Vs= plume volume=** **624** **$m^3$**

**dC(t)/dt= rate of decrease of gw concentration**

**= $C_{(o)}$ x (-B) x $e^{-Bt}$**

**Daily Emissions Loading (LC39B) (based on recent dataset):**

| Time (day) | TCE (lb/day) | cDCE (lb/day) | tDCE (lb/day) | VC (lb/day) | Total (lb/day) |
|---|---|---|---|---|---|
| 0 | 0.000 | 0.002 | 0.001 | 0.005 | 0.008 |
| 30 | 0.000 | 0.001 | 0.000 | 0.003 | 0.004 |
| 180 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 365 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Annual Emissions Loading (LC39B) (based on recent dataset):**

| Time (day) | TCE (lb) | cDCE (lb) | tDCE (lb) | VC (lb) | Total (lb) |
|---|---|---|---|---|---|
| 0-30 | 0.004 | 0.052 | 0.013 | 0.118 | 0.188 |
| 30-180 | 0.008 | 0.098 | 0.025 | 0.222 | 0.353 |
| 180-365 | 0.000 | 0.006 | 0.002 | 0.014 | 0.022 |
| **Total** | **0.012** | **0.156** | **0.040** | **0.355** | **0.564** |

Conclusion:

LC39B: Emissions for any single contaminant is less than 2.7 lbs per day and total is less than 6.8 lbs per day. Annual emissions for each individual HAP is less than 1,000 lbs per year and total HAPs are less than 2,500 lbs per year. Therefore, no vapor extraction will be required to attain the KSC Title V Operational Permit requirement for remediation activities at LC39B.

## APPENDIX E

## PERMITS

**(As necessary, completed permits will be added to the field copy of this IWP as received, and included in future Construction Completion reporting)**

# APPENDIX F

# FIELD LOG SHEETS

# Tetra Tech, Inc.

**PROJECT: Air Sparge IM Expansion** **JOB #: ____________________**
**LOCATION: LC39B** **DATE: ____________________**
**PROJECT MANAGER: Debbie Wilson** **FOL: ____________________**

## DAILY ACTIVITIES CHECKLIST

### Startup Checklist

| Activity | Yes | No | N/A |
|---|---|---|---|
| Pertinent site activities/information entered into site logbook | | | |
| All onsite personnel listed in logbook | | | |
| Required medical information onsite for all workers (Tetra Tech and Subcontractors) | | | |
| Required MSDS's onsite | | | |
| Proper equipment calibrations performed (list equipment) | | | |
| 1 ____________________ | | | |
| 2 ____________________ | | | |
| 3 ____________________ | | | |
| 4 ____________________ | | | |
| Calibration logs filled out | | | |
| Tailgate H&S meeting held prior to beginning field activities | | | |
| Required work permits filled out/signed | | | |
| Required utility clearances obtained | | | |
| Required PPE onsite and in use | | | |
| Information required to be posted is in place | | | |
| (OSHA poster, hospital route, key phone numbers, etc.) | | | |

### Exit Checklist

| Activity | Yes | No | N/A |
|---|---|---|---|
| Logbooks completely and comprehensively filled out | | | |
| Field forms complete and accounted for/properly filed | | | |
| Samples properly packaged/shipped | | | |
| COCs faxed to appropriate in-house personnel | | | |
| All equipment accounted for, on charge if needed, and properly secured | | | |
| All personnel accounted for | | | |
| Arrangements made for upcoming work (permits, clearances, equipment, etc.) | | | |
| Site properly secured | | | |

Note - not all items listed apply to every job, and some additional requirements may apply on a job-specific basis.

Tetra Tech, Inc.

# DAILY ACTIVITIES RECORD

**PROJECT NAME:** LC39B Air Sparging IM Expansion **PROJECT NUMBER:** ____________

**CLIENT:** NASA, Kennedy Space Center **LOCATION:** ____________

**DATE:** ____________ **ARRIVAL TIME:** ____________

**TETRA TECH PERSONNEL:** ____________ **DEPARTURE TIME:** ____________

**CONTRACTOR:** ____________ **DRILLER:** ____________

| ITEM | QUANTITY ESTIMATE | QUANTITY TODAY | PREVIOUS TOTAL QUANTITY | CUMULATIVE QUANTITY TO DATE |
|---|---|---|---|---|
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COMMENTS: ____________

APPROVED BY:

TETRA TECH REPRESENTATIVE ____________ DRILLER ____________

DATE: ____________

# Tetra Tech, Inc.

**PROJECT:** **LC39B Air Sparging IM Expansion**
**JOB & CTO #:** ___________________________
**PROJECT MANAGER: Debbie Wilson**___________

**LOCATION:** **LC39B**
**MOBILIZATION DATE:** ________________________
**RETURN DATE:**_______________________________

## FIELD PROJECT PRE-MOBILIZATION CHECKLIST

### TRAVEL

___ Airline reservations
___ Hotel reservations/BOQs
___ Vehicle rental
___ Itinerary
___ Phone/pager number

### DRILLING/DPT/SURVEY

**Subcontractor**

___ POC phone #/address
___ Drill Specification RFP
___ Contact (time & place to meet)
___ Confirm subcontract w/ TtNUS Procurement
___ Health and Safety documentation for all personnel on site
___ Copy of Drillers license
___ Well / boring permits

**Utilities (2 weeks lead time)**

___ Contact Site POC (Date:_____________)
___ Contact Local "Call Before You Dig"
___ Utility Clearance Form

**Forms**

___ Boring logs / Test Pit logs
___ Well construction / development forms
___ Daily activity forms
___ IDW inventory
___ IDW drum labels
___ Chemical Inventory
___ MSDS's

### EQUIPMENT MOBILIZATION

___ Equipment Requisition form completed / equipment ordered
___ 3rd Party rental / misc. equipment ordered
___ Equipment calibration forms
___ Span / calibration gas and regulator

### SAMPLING

**Forms**

___ Sample log sheets
___ Low-flow purge data sheets
___ COC records
___ COC seals
___ Sample labels (from database group)

**Laboratory**

___ POC address/phone#
___ Order bottles / preservatives
___ Shipping address, also check Sat. address
___ Bottle & preservation req'ts from lab
___ ______________________________

### MISCELLANEOUS

**Schedule**

___ Plan field operations w/ Project manager

**Documents for Field Program**

___ Logbook(s)
___ Field Sampling plan
___ Health & Safety plan
___ Maps
___ H & S Guidance Manual

**Authorization**

___ Kick-off meeting held
___ Gov't rate letter
___ H&S/OSHA 40-hour certifcate
___ 8-Hour Refresher Training Certificate
___ Medical Clearance Letter
___ Supervisory Training Certificate
___ Health & Safety Clearance Letter
___ Full-size OSHA Poster

### HYDROGEOLOGY EQUIPMENT

___ Slug test/pumping test forms
___ Groundwater elevation data sheets
___ Graph paper
___ Data Logger/transducer/data cable
___ Existing well construction & water level data
___ M-Scope, slug

### SHIPPING

**Forms**

___ FedEx Airbills, local dropoff location & hours
___ FedEx Gov. Acct# (1771-8058-0)
___ Lab Shipping Labels
___ Warehouse Shipping Labels
___ Blank Labels

**Supplies**

___ Tape
___ Packing materials
___ Baggies, Large garbage bags

### OTHER

___ Site POC name/phone #
___ Personnel information to POC
___ Mobilization schedule to POC
___ Site access authorizations
___ Field office / trailer arrangements made
___ Electric, phone hookups arranged
___ Steel-toed boots, safety glasses, & hard hat
___ First aid equipment
___ Insect repellent
___ ______________________________
___ ______________________________

Note - not all items listed apply to every job, and some additional requirements may apply on a job-specific basis.

# BORING LOG

Tetra Tech, Inc.

Page ___ of ___

PROJECT NAME: LC39B Air Sparging IM Expansion
PROJECT NUMBER:
DRILLING COMPANY: x
DRILLING RIG:

BORING No.:
DATE:
GEOLOGIST:
DRILLER:

| Sample No. and Type or RQD | Depth (Ft.) or Run No. | Blows / 6" or RQD (%) | Sample Recovery / Sample Length | Lithology Change (Depth/Ft.) or Screened Interval | MATERIAL DESCRIPTION | | | U S C S * | Remarks | PID/FID Reading (ppm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Soil Density/ Consistency or Rock Hardness | Color | Material Classification | | | Sample | Sampler BZ | Borehole** | Driller BZ** |
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* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm):

Converted to Well: Yes ______ No ______ Well I.D. #:

Tetra Tech, Inc.

# GROUNDWATER LEVEL MEASUREMENT SHEET

**Project Name:** LC39B Air Sparging IM Expansion **Project No.:** ____________________

**Location:** ____________________ **Personnel:** ____________________

**Weather Conditions:** ____________________ **Measuring Device:** ____________________

**Tidally Influenced:** Yes ____ No ____ **Remarks:** ____________________

| Well or Piezometer Number | Date | Time | Elevation of Reference Point (feet)* | Total Well Depth (feet)* | Water Level Indicator Reading (feet)* | Thickness of Free Product (feet)* | Groundwater Elevation (feet)* | Comments |
|---|---|---|---|---|---|---|---|---|
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* All measurements to the nearest 0.01 foot

Tetra Tech, Inc.

# GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: LC39B Air Sparging IM Expansion
Project No.: ____________

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: ____________
[] QA Sample Type: ____________

Sample ID No.: ____________
Sample Location: ____________
Sampled By: ____________
C.O.C. No.: ____________
Type of Sample:
[] Low Concentration
[] High Concentration

**SAMPLING DATA:**

| | Color | pH | S.C. | Temp. | Turbidity | DO | Salinity | Other |
|---|---|---|---|---|---|---|---|---|
| Date: | | | | | | | | |
| Time: | (Visual) | (S.U.) | (mS/cm) | ($^0$C) | (NTU) | (mg/l) | (%) | |
| Method: | | | | | | | | |

**PURGE DATA:**

| Date: | Volume | pH | S.C. | Temp. | Turbidity | DO | Salinity | Other |
|---|---|---|---|---|---|---|---|---|
| Method: | | | | | | | | |
| Monitor Reading (ppm): | | | | | | | | |
| Well Casing Diameter & Material | | | | | | | | |
| Type: | | | | | | | | |
| Total Well Depth (TD): | | | | | | | | |
| Static Water Level (WL): | | | | | | | | |
| One Casing Volume(gal/L): | | | | | | | | |
| Start Purge (hrs): | | | | | | | | |
| End Purge (hrs): | | | | | | | | |
| Total Purge Time (min): | | | | | | | | |
| Total Vol. Purged (gal/L): | | | | | | | | |

**SAMPLE COLLECTION INFORMATION:**

| Analysis | Preservative | Container Requirements | Collected |
|---|---|---|---|
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**OBSERVATIONS / NOTES:**

**Circle if Applicable:**

| MS/MSD | Duplicate ID No.: |
|---|---|

**Signature(s):**

Tetra Tec, Inc.

# MONITORING WELL DEVELOPMENT RECORD

Page ___ of _____

Well: ______________________________ Depth to Bottom (ft.): ________________ Responsible Personnel: _____________________________________
Site: LC39B AS IM Expansion __________ Static Water Level Before (ft.): _________ Drilling Co.: _____________________________________________
Date Installed: ______________________ Static Water Level After (ft.): __________ Project Name: ____________________________________________
Date Developed: _____________________ Screen Length (ft.): _________________ Project Number: __________________________________________
Dev. Method: _______________________ Specific Capacity: __________________
Pump Type: _________________________ Casing ID (in.): ______________________

| Time | Estimated Sediment Thickness (Ft.) | Cumulative Water Volume (Gal.) | Water Level Readings (Ft. below TOC) | Temperature (Degrees C) | pH | Specific Conductance (Units _____) | Turbidity (NTU) | Remarks (odor, color, etc.) |
|---|---|---|---|---|---|---|---|---|
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Precommissioning/Shakedown Inspection Checklist
LC39B AS IM Expansion, SWMU 009
Kennedy Space Center, Florida
Page 1 of 1

| | | |
|---|---|---|
| **Site: LC39B, SWMU 009** | **Date:** | |
| **Name:** | | |
| **Purpose:** | | |
| **Weather:** | | |
| | **Verification** | **Comments** |
| **Subsurface** | | |
| Wells installed and developed | Y / N | |
| Well heads assembled and installed correctly | Y / N | |
| Distribution manifold assembled and installed correctly | Y / N | |
| Trenches, seals, piping installed as specified | Y / N | |
| **Piping Installation** | | |
| Piping complete (aboveground and subsurface) | Y / N | |
| Control and check valves installed and operation verified | Y / N | |
| Valves accessible and operational | Y / N | |
| Piping clearly labeled and valves tagged | Y / N | |
| Final approval from utility inspector (if applicable) | Y / N | |
| **Equipment Building** | | |
| Treatment system built to specifications | Y / N | |
| Vibration dampers installed on heavy equipment, bolted in place | Y / N | |
| Motor and blower coupling alignments level and true | Y / N | |
| Blower and pump rotation verified | Y / N | |
| Pipe supports installed/tested | Y / N | |
| Pumps and seals intact (no leaks) | Y / N | |
| Belts properly tensioned, guards in place | Y / N | |
| Lubricating oil filled, motors greased | Y / N | |
| **Electrical/Controls/Instrumentation** | | |
| Grounding installed/inspected | Y / N | |
| Lighting/Exhaust Fans/HVAC/Thermostats functional | Y / N | |
| Lockouts/covers/panels in place | Y / N | |
| Pressure/vacuum/flow/temp. transducers functioning/calibrated | Y / N | |
| Temperature, pressure, and vacuum gauges installed | Y / N | |
| High and low fluid level, pressure, and temp. sensors operating | Y / N | |
| Disconnects in sight of unit being controlled | Y / N | |
| Controls/Alarms/Interlocks functional and calibrated | Y / N | |
| Power connected to on-line monitoring instruments | Y / N | |
| Final approval from electrical inspector, if applicable | Y / N | |
| **General** | | |
| Operators have been properly trained | Y / N | |
| Air sparge system functional | Y / N | |
| Control panel purge system functional | Y / N | |
| **Other (Enter additional commisioning inspections)** | | |
| | Y / N | |
| | Y / N | |
| | Y / N | |
| | Y / N | |
| | Y / N | |
| | | |
| Signature: | Date: | |

| STARTUP SEQUENCE CHECKLIST | | |
|---|---|---|
| **Site: LC39B, SWMU 009** | | **Date:** |
| **Name:** | | |
| **Purpose:** | | |
| **Weather:** | | |
| **Verification** | **Verification** | **Comments** |
| Review HASP and system O&M manual | Y / N | |
| Verify that ALL commissioing activities have been completed | Y / N | |
| Verify liquid/air-tight seals at AS wells are tight | Y / N | |
| Verify that filter elements are installed | Y / N | |
| Verify that condensate lines and treatment system is prepared for operation | Y / N | |
| Ensure that ALL baseline samples and measurements have been collected | Y / N | |
| Energize system control panel | Y / N | |
| Verify rotating equipment operation/rotation through manual bump overide | Y / N | |
| Calibrate all dedicated and portable instruments & file calibration sheets | Y / N | |
| **Treatment System Startup** | | |
| Place manual distribution valves into their appropriate positions | Y / N | |
| Place manual system valves into their appropriate positions | Y / N | |
| Verify electrical disconnect is in energized poistion | Y / N | |
| Ensure all alarms conditions are cleared | Y / N | |
| Turn solenoid valves selector switch to AUTO, verify sequencing | Y / N | |
| Turn air compressor selector switch to AUTO | Y / N | |
| Verify operating flows, pressures, and temperatures | Y / N | |
| Verify system of sequence of operation and operating parameters | Y / N | |
| Inspect lines for leaks at operating conditions | Y / N | |
| **Other** | | |
| Collect Samples as indicated in IWP | Y / N | |
| Complete O&M checklist upon completion of shakedown/start-up | Y / N | |
| | | |

**Signature:** **Date:**

**LC39B - Discharge Manifold Data Recording Sheet (Monthly)**

| | | | Manifold Data | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Zone Z1 | | Zone Z2 | | Zone Z3 | | Zone Z4 | |
| Date | Time | Initials | psig | cfm | psig | cfm | psig | cfm | psig | cfm |
| | | | (currently off) | | (currently off) | | (currently off) | | | |
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Routine System Inspection Checklist
LC39B AS IM Expansion, SWMU 009
Kennedy Space Center, Florida


| | Each Visit | Every 3 Months or 2000 hours | Every 6 Months | As needed |
|---|---|---|---|---|
| **ROTARY SCREW COMPRESSOR** | | | | |
| Check Unit for loose bolts and parts | X | | | |
| Clean/Replace Air Filter | X | | | |
| Replace Oil | | X | | |
| Lubricate Bearings | | X | | |
| **RECEIVER TANK** | | | | |
| Purge Tank | X | | | |
| Check Regulator | X | | | |
| **REFRIGERATED AIR DRYER** | | | | |
| Check Unit for loose bolts and parts | X | | | |
| Cleaning Coil cooling fins of oil and dust | X | | | |
| Internal Coil Flush | | | | X |
| Electric Motor Lubrication | | X | | |
| Cleaning of Fan Blades | X | | | |
| **CONDENSATE MANAGEMENT SYSTEM** | | | | |
| Inspect autodrains and check valves | X | | | |
| Properly dispose of separated oil | | | | X |
| Replace carbon media | | | X | |
| Flush carbon with dilute acid | | | | X |

IDW Management Form
LC39B AS IM Expansion, SWMU 009
Kennedy Space Center, Florida


| **Site** | **Generation Date** | **Media** | **Source** | **Number of Drums Present** | **Pallet ID** | **Drum ID Number (Bar Code)** | **Contact** | **Location of Drums** | **IDW Origination** | pH | pH adjusted? | Adjusted pH | **Concentrations (ug/L)** | **Strap** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LC34 (Example) | 09/10/12 | Water | DPT Sampling DPT's 0161-0170 (80%) | 1 | 00765 | 185505 | [NASA RPM] (###) ###-#### | Top of Hill North end of HBF | Purge water DPT's 0161-0170 | 7.50 | No | NA | Maximums: TCE = 210, cDCE = 8100, tDCE = 140, VC = 5900 | Yes |
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