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ENVIRONMENT

Subject:
Revised Interim Groundwater Monitoring Work Plan – 2019
RACER Trust, Plants 2, 3, & 6, Lansing, Michigan

Date:
October 28, 2019

Contact:
Patrick Curry

Phone:
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Our ref:
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Dear Ms. Matlock:

In support of the RCRA Facility Investigation and Corrective Measures Study (CMS) prepared for RACER Trust Plants 2, 3 and 6 located in Lansing, Michigan (Site; **Figure 1**), Arcadis is providing this revised Interim Groundwater Monitoring Work Plan (IGMP) to outline continued interim groundwater monitoring activities at the Site. The overall goal of the interim groundwater monitoring is to evaluate potential changing groundwater conditions and plume stability at the Site, and to verify the results of the Preliminary Geochemical and Plume Stability Assessment Report (Arcadis 2014a) and the updated plume stability evaluations included as part of the Annual Groundwater Monitoring Reports (Arcadis 2015a, 2016, 2017a, 2018a).

The primary revisions included in this work plan are an overall reduction in sampling frequency for compounds that do not drive the potential risk or corrective measures associated with the Site (i.e. metals, volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs]), a continued focus on 1,4-dioxane in groundwater, and the addition of per- and polyfluorinated alkyl substances (PFAS) to the sampling plan.

Site investigations, along with the plume stability and geochemical evaluation completed to date, suggests that concentrations of VOCs, SVOCs and metals are stable to decreasing with some elevated concentrations of metals a result of regional or Site-related geochemistry (Arcadis 2014a). The revised IGMP, as outlined below, is intended to outline groundwater monitoring activities at the Site through 2024 unless circumstances, and resulting discussion with the Michigan Department of Environment, Great Lakes and Energy (EGLE), suggest the need to modify monitoring activities. Performance monitoring associated with corrective measures (e.g. biosparge system) will be covered under a separate workplan.

The overall objectives of the IGMP are to:

- Continue to evaluate the stability of the perched 1,4-dioxane plume, VOC impacts, and areas where metals may be of concern including:
  - Areas with elevated metals concentrations in perched groundwater near the site boundary (RFI Areas 6, 7, 5-8 and 16).
  - Areas with metals known to be site-related (Plant 3, Area 14).
- Evaluate the stability of the deep overburden/weathered bedrock 1,4-dioxane plume (lower 1,4-dioxane plume).
- Evaluate the stability of PFAS impacts at Plants 2, 3, and 6.
- Detect vertical or horizontal migration of constituents of concern (COCs) via a network of sentinel monitoring wells.
- Periodically evaluate perched groundwater in areas identified with semi-volatile organic compounds (SVOCs) in soil to verify SVOCs are not leaching to groundwater above EGLE Part 201 Criteria.
- Monitor light non-aqueous phase liquid (LNAPL) thickness at monitoring wells to verify LNAPL is stable and not migrating.
- Monitor the Lansing Township municipal wells TWP-WELL#3, TWP-WELL#4, TWP-WELL#5, located west of Plants 2 and 3, annually for low-level 1,4-dioxane.

Data collected as part of the IGMP will be evaluated after each event and reported semi-annually. Changes to the IGMP may be proposed as part of the Annual Groundwater Monitoring Report to be provided in the second quarter of each year. A review of the interim groundwater monitoring activities will be completed following implementation of corrective measures to transition the Site into long-term groundwater monitoring.

INTERIM MONITORING PLAN SCOPE OF WORK

As discussed with EGLE, the IGMP has been revised to reduce sampling frequency of some constituents and focus on primary potential risk drivers and impacts that will be, or potentially be, addressed with corrective action. These include monitoring PFAS stability and migration, and continued monitoring of 1,4-dioxane in contact with the bedrock drinking water aquifer. The constituents of concern and gauging/sampling frequency for all monitoring wells are outlined on the revised groundwater sampling matrix included as **Table 1**.

Groundwater Elevation Gauging

Groundwater elevation and LNAPL thickness monitoring is being completed as outlined in **Table 1** and shown on **Figure 2**. A site-wide groundwater elevation gauging event will be completed annually and alternate between the second and fourth quarter events to account for seasonal variability. During the other semi-annual and quarterly monitoring events, groundwater elevation will be measured only at locations sampled as part of that event.

Measurement of LNAPL thickness at Plant 2 and Plant 3 will be completed semi-annually. Monitoring wells are gauged using an electronic water level meter. Gauging methods will be consistent with the approved Field Sampling Plan (Arcadis 2011a).

Groundwater Sampling

Monitoring wells will be sampled as outlined in **Table 1** and shown on **Figures 3 through 7**. **Table 1** indicates the proposed gauging and sampling frequency for each monitoring well and COCs included for each monitoring event.

In general, the more comprehensive site-wide sampling event (including the Lansing Township municipal wells) will be conducted on an annual basis, which includes the bedrock wells. Annual sampling events will be cycled between the second and fourth quarters to capture seasonal variability. Semi-annual sampling will be conducted on wells key to evaluating plume stability and potential migration.

Field sampling and gauging methods as well as quality assurance/quality control procedures will be consistent with the Field Sampling Plan (Arcadis 2011a) and Quality Assurance Project Plan (QAPP) (Arcadis 2011b). Additional PFAS sampling protocols are described in the Poly- and Perfluorinated Alkyl Substance Field Sampling Guidance included as **Attachment 1**. Groundwater samples will be collected utilizing low-flow sampling methods (USEPA, 1996) using a submersible pump and submitted under chain of custody protocol to the analytical laboratory. Field parameters, including dissolved oxygen, oxidation-reduction potential, turbidity and specific conductivity will be monitored for stability during sampling and recorded as a field data summary. Groundwater samples will be submitted to the laboratory (currently Merit Laboratory in Lansing, MI) for one or more of the following analyses:

- 1,4-Dioxane – on-site monitoring wells will be analyzed using USEPA Method 8260B selected-ion method (SIM). The Lansing Township municipal wells will be analyzed using USEPA Method 522. Wells selected for 1,4-dioxane analysis are shown on **Figure 3**.
- Target Compound List (TCL) VOCs – defined in **Table 3** of the QAPP (Arcadis 2011b), by USEPA Method 8260B. Wells selected for VOC analysis are shown on **Figure 4**.
- Select total metals – metals identified with consistent drinking water criteria exceedances (arsenic, nickel, lead, vanadium, chromium, and copper) - by USEPA Method 6020, and hexavalent chromium in Area 14 at Plant 3. Wells selected for metals analysis are shown on **Figure 5**. If turbidity below 10 nephelometric turbidity units (NTU) cannot be achieved during sampling, the sample will be filtered and submitted for dissolved metals analysis, in addition to the total metals analysis, using USEPA Method 6020.
- SVOCs – quadrennial (i.e., once every four years) for select wells in areas of the Site identified with SVOCs in soil. Note that although phthalates have been consistently detected at concentrations slightly above drinking water criteria at the Site, these detections are considered ubiquitous laboratory contaminants. Correspondence with Merit Laboratory has indicated a history of phthalate cross-contamination and review of laboratory QA/QC reporting has indicated phthalate detections in method blanks. As of 2017, non-phthalate SVOC groundwater criteria exceedances have been detected in only 4 out of 761 groundwater samples collected over the sampling record (at 4 separate locations). Additional details regarding interim monitoring of each groundwater bearing unit are provided below. Wells selected for SVOC analysis are shown on **Figure 6**.

- PFAS – evaluated on a quarterly and semi-annual basis. Samples will be analyzed for the 28 PFAS contained in the draft Michigan Department of Environment, Great Lakes, and Energy (EGLE) PFAS Minimum Laboratory Analyte List (EGLE, updated 2019) using modified USEPA Method 537 with isotope dilution, pending an approved USEPA method for groundwater. Samples are currently analyzed by SGS Laboratory in Orlando, Florida. The PFAS analyte list and method will be updated when appropriate as advancements occur. Wells selected for PFAS analysis are shown on **Figure 7**.

LNAPL Monitoring and Recovery

As noted above, LNAPL gauging will be completed semi-annually at LNAPL monitoring wells located on Plants 2 and 3, as shown on **Figure 1**. LNAPL is present in the central portion of Plant 2 (Area 5-2) and in the north-central portion of Plant 3 (Area 17). Trend plots indicate that, in general, LNAPL thickness (when present) gradually increases until it reaches equilibrium within the well and then stabilizes. Based on the monitoring results, there is no indication of LNAPL migration. A natural source zone depletion (NSZD) study at Plant 2 shows that an average of approximately 570 gallons per year naturally degrades at the Site. Based on the results of the NSZD evaluation, RACER proposes to discontinue the manual LNAPL bailing activities. The current removal rates via manual bailing typically vary between 30 and 50 gallons per year. Overall, mass removal due to manual bailing is insignificant relative to NSZD.

Storm Sewer Sampling

Historical storm sewer sampling is summarized in the RCRA Facility Investigation Supplemental Phase 2 Activities Summary Report (Arcadis, 2014b). Storm sewer sampling began at ten sampling locations in 2012 and only the southern outfall of Plant 6 (P6-MH2-SW) indicated sporadic detections of metals and xylenes slightly above groundwater-surface water interface (GSI) criteria. Soils impacted with xylenes were excavated from the southern Plant 6 area (Areas 7 and 9) and subsequent annual sampling results at the southern Plant 6 outfall were non-detect for xylenes, and metals were below GSI criteria.

Arcadis is conducting ongoing field investigations to characterize and define the extent of the PFAS impacts in the storm sewer network. Bulkheading activities have been completed or proposed at Plants 2, 3 and 6. Verification sampling and routine monitoring will be completed as part of these corrective measures with the routine sampling portion added to this IGMP in 2020.

Well Abandonment

Several wells are proposed to be abandoned to streamline the monitoring well network at the Site. These wells primarily include older wells installed as part of the monitoring and evaluation of former underground storage tanks at the Site. These wells are installed close together, are duplicative, and are no longer sampled as part of ongoing monitoring activities. The 14 wells proposed for abandonment are noted on **Table 1** and shown on **Figure 2** through **Figure 7**.

REPORTING

A summary of groundwater monitoring results will be provided to EGLE following each semi-annual sampling event. A semi-annual report will be prepared following the second quarter sampling event and consist of a brief memorandum describing the results of the first and second quarter sampling events. The semi-annual report will include the following:

- A table summarizing analytical data for the quarterly and semi-annual events;
- A table summarizing groundwater elevations;
- A table summarizing measured LNAPL thickness;
- Figures summarizing COC criteria exceedances; and
- A summary of the field parameters recorded at each well during low-flow sampling.

An annual report will be submitted following the fourth quarter sampling event and provide a more detailed narrative documenting any changes observed at the Site. The annual report will also propose changes to the IGMP, as appropriate, based on the results of the sampling. The annual report will include the following:

- A table summarizing analytical data for the quarterly, semi-annual, and annual monitoring events;
- A table summarizing groundwater elevations;
- A table summarizing the measured LNAPL thickness;
- LNAPL thickness trend graphs;
- Groundwater concentration trend graphs with Mann-Kendall analysis completed for new wells, wells at the perimeter of the Site, or wells that have indicated increasing concentrations in the past;
- Figures summarizing COC criteria exceedances for the annual event;
- Figures summarizing groundwater elevation contours for each water bearing unit;
- Groundwater elevation trend graphs;
- A summary of the field parameters recorded at each well during low-flow sampling; and
- Copies of the laboratory analytical reports for the year (including QA/QC results).

Should you need further information, or have any questions, please contact Dave Favero of RACER Trust at 217.741.6235 (dfavero@racertrust.org), or Patrick Curry at 810.225.1926 (patrick.curry@arcadis-us.com).

Sincerely,

Arcadis of Michigan, LLC

Patrick Curry, PG, CPG
Technical Expert-Geology

Copies:
Dave Favero, RACER Trust
Project File

Enclosures:

Tables

1 Revised Interim Groundwater Monitoring Summary

Figures

1 Site Location

2 Groundwater and LNAPL Gauging Plan

3 1,4-Dioxane Monitoring Plan

4 VOCs Monitoring Plan

5 Metals Monitoring Plan

6 SVOCs Monitoring Plan

7 PFAS Monitoring Plan

Attachments

1 PFAS Sampling Guidance

References

Arcadis 2011a. Field Sampling Plan. RACER Trust, Lansing, Michigan Plants 2, 3, and 6 Industrial Land. August 26.

Arcadis 2011b. Quality Assurance Project Plan. RACER Trust, Lansing, Michigan Plants 2, 3, and 6 Industrial Land. August 26.

Arcadis 2014a. Preliminary Groundwater Geochemical and Plume Stability Assessment. Plants 2, 3, and 6, Industrial Land, Lansing, Michigan. April 24 (as amended).

Arcadis 2014b. RCRA Facility Investigation Supplemental Phase 2 Activities Summary Report, RACER Trust, Plants 2, 3 & 6, Lansing, Michigan, February 26.

Arcadis 2014c. Revised Interim Groundwater Monitoring Work Plan. RACER Trust, Plants 2, 3, & 6, Lansing, Michigan. November 11.

Arcadis 2015a. 2014-2015 Annual Groundwater Monitoring Report. RACER Trust Plants 2, 3, and 6, Lansing, Michigan. June 26.

Arcadis 2015b. 2015 LNAPL Removal Work Plan. RACER Trust, Plant 2, Lansing, Michigan. March 4.

Arcadis 2016a. 2015-2016 Annual Groundwater Monitoring Report, RACER Trust, Plants 2, 3, & 6 Industrial Land, Lansing, Michigan. June 27.

Arcadis 2016b. Lower 1,4-Dioxane Plume Toe Investigation Report. RACER Trust, Plant 2, Lansing, Michigan. March 11.

Arcadis 2016c. Supplemental Lower 1,4-Dioxane Plume Toe Investigation Report. RACER Trust, Plant 2, Lansing, Michigan. September 21.

Arcadis 2017a. Revised Interim Groundwater Monitoring Workplan. RACER Trust, Plants 2, 3, & 6, Lansing, Michigan. January 30.

Arcadis 2017b. Annual Groundwater Monitoring Report. RACER Trust, Plants 2, 3, & 6, Lansing, Michigan. May 5.

Arcadis 2017. Interim Measure Workplan: Lower 1,4-Dioxane Biosparge. Lansing Industrial Land, Lansing, Michigan. October 19.

Arcadis 2018a. 2017 Annual Groundwater Monitoring Report. RACER Trust, Plants 2, 3, & 6, Lansing, Michigan. May 7.

Arcadis. 2018b. PFAS Investigation Work Plan (Rev. 2). RACER Trust, Lansing, Michigan, Plant 6. October 10.

Arcadis. 2018c. Monitoring Well PFAS Summary – Plants 2 and 6, RACER Trust Site, Lansing, Michigan. September 14.

Arcadis, 2019a. PFAS Investigation Phase 1 Summary – Plant 6 RACER Trust Site, Lansing, Michigan. January 29.

Arcadis, 2019b. Site Specific Health and Safety Plan. RACER Trust, Lansing Plants 2, 3, and 6. June.

Arcadis 2019c. 2018 Annual Groundwater Monitoring Report. RACER Trust, Plants 2, 3, & 6, Lansing, Michigan. May 15.

Cummings, T.R. 1989. Natural Groundwater Quality in Michigan, 1974-1987. USGS Open File Report 89-259.

EGLE. 2014. RRD Op Memo 2, Attachment 5 – Michigan Department of Environmental Quality. Remediation and Redevelopment Division. Operational Memorandum No. 2. Sampling and Analysis – Attachment 5. October 22, 2004.

EGLE. 2018. Part 201 Generic Cleanup Criteria and Screening Levels. GSI Criteria Updated June 25, 2018.

Puls, R.W. and M.J. Barcelona. 1996.Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures. EPA/540/S-95/504. April

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. EPA 530/R-09-007. March.

TABLES

Well	Gauging*	Analyte					Primary Function	Reason(s) for Change
		VOCs	1,4-Dioxane	Select Metals**	SVOCs	PFAS		
Plant 2								
Perched								
MW-01(2)	A	B					VOC monitoring	VOC Change from A to B. MTBE is detected consistently below criteria. No other VOCs detected
MW-02(2)	Abandon							consistent non-detects / do not need 4 wells in Area 1
MW-03(2)	Abandon							consistent non-detects / do not need 4 wells in Area 1
MW-12-09	A	B	A			SA	VOC monitoring, perched 1,4-dioxane monitoring, PFAS monitoring	
MW-12-18	SA	B				SA	VOC monitoring, PFAS monitoring	VOC change from SA to B /1,1-DCE at 1 to 2 ug/L is the only VOC detected / Removed Metals Analysis / Consistent Non-Detects
P2-MW-04	A		A		Qd		perched 1,4-dioxane monitoring, SVOC evaluation	
P2-SB-20	A						groundwater elevation monitoring	Removed VOC, 1,4-d Analysis / Consistently non-detect for at least the past 6 years
LMW-12-01	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / No LNAPL Observed for 4 Quarters
LMW-12-02	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Max LNAPL Thickness Observed in 4 Quarters was 0.04 feet.
LMW-12-03D	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Elliminate LNAPL Removal
LMW-12-03S	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Max LNAPL Thickness Observed in 4 Quarters was 0.01 feet.
LMW-12-04	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Max LNAPL Thickness Observed in 4 Quarters was 0.02 feet.
LMW-12-05	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Max LNAPL Thickness Observed in 4 Quarters was 0.18 feet.
LMW-12-06	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / No LNAPL Observed for 4 Quarters
LMW-12-07	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Max LNAPL Thickness Observed in 4 Quarters was 0.02 feet.
LMW-12-08	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA
LMW-14-12D	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Elliminate LNAPL Removal
LMW-14-13D	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / No LNAPL Observed for One Year
LMW-14-14D	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / No LNAPL Observed Monthly for One Year
LMW-14-15D	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Elliminate LNAPL Removal
LMW-15-16D	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Elliminate LNAPL Removal
LMW-15-17D	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / Max LNAPL Thickness Observed During Monthly Checks for One Year was 0.01 feet.
PMW-01	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA
PMW-02	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA
PMW-03	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA / No LNAPL Observed for 4 Quarters
P2-SB-37	SA						LNAPL Monitoring	Reduce LNAPL gauging to SA
MW-12-07	A						groundwater elevation monitoring	Removed VOC Analysis / Has always been non-detect for VOCs
MW-12-08	A						groundwater elevation monitoring	Reduce LNAPL gauging to SA
MW-12-17	Abandon							Consistent non-detects / do not need 4 wells in Area 1
P2-MW-02	A						groundwater elevation monitoring	Removed VOC Analysis / Consistently non-detect for VOCs
P2-MW-03	A						groundwater elevation monitoring	
P2-SB-03	A						groundwater elevation monitoring	Removed VOC and 1,4-D Analysis / Consistently non-detect for VOCs and 1,4-D
P2-SB-06	A						groundwater elevation monitoring	Removed VOC and SVOC Analysis / Consistently non-detect for VOCs and SVOCs
MW-14-54	A	B					VOC monitoring, SVOC evaluation	VOC change from A to B / Stable Trends. Removed SVOC Analysis / Consistent Non-Detects
MW-14-55	A	B					VOC monitoring	VOC change from A to B / Intermittent VOC detections are consistently below criteria
MW-14-57	A		A				perched 1,4-dioxane monitoring	Remove VOCs/ Intermittent VOC detections are consistently below criteria
MW-14-58	SA	B	A			SA	perched 1,4-dioxane monitoring, PFAS Monitoring	VOC Analysis changed to biennial / VOCs never detected 1,4-D Change from SA to A / Stable trend
MW-14-59	SA	B	A		Qd	SA	perched 1,4-dioxane monitoring, SVOC monitoring, PFAS monitoring	VOC change from A to B / 1,1-DCE exceeds DW but has been stable for 5 years
MW-14-60	SA	B	A		Qd	SA	perched 1,4-dioxane monitoring, SVOC monitoring, PFAS monitoring	VOC change from A to B / VC exceeds DW but has been stable for 3 years
MW-14-62	SA	B	A		Qd	SA	perched 1,4-dioxane monitoring, SVOC monitoring, PFAS Monitoring	VOC change from A to B / Intermittent VOC detections are consistently below criteria
Deep Overburden and Weathered Bedrock								
MW-13-43	SA		SA				lower 1,4-dioxane monitoring	
MW-13-45	SA		SA				lower 1,4-dioxane monitoring	
MW-13-51	A		A				lower 1,4-dioxane monitoring	1,4-D change from B to A / Increased Monitoring of Plume
MW-14-56	A		A			SA	lower 1,4-dioxane monitoring / PFAS monitoring	Removed VOC Analysis / Consistent Non-Detects Removed Metals Analysis / No exceedances 1,4-D Change from SA to A / APC plume / Added PFAS
MW-14-61	SA	A	SA		Qd	SA	lower 1,4-dioxane monitoring, VOC, SVOC & PFAS monitoring	VOC change from SA to A / Single detections of 1,1,1-TCA and Chloroethane below criteria / Added SVOCs/PFAS
MW-14-63	A		A				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No detections
MW-15-72	SA	A	SA		Qd	SA	lower 1,4-dioxane monitoring/VOC, SVOC, PFAS monitoring	Added SVOC / PFAS Analysis
MW-15-73	A		A				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections Removed Metals Analysis / No metal exceedences 1,4-D Change from SA to A / APC plume
MW-16-74	SA		SA				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections
MW-16-75	SA		SA				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections
MW-16-76	A		A				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No 1,4-D exceedances
MW-16-77	SA		SA				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No 1,4-D exceedances
MW-16-78	SA		SA				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections
MW-16-79	SA		SA				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections
MW-16-80	SA		SA				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections
MW-16-81	SA	A	SA			SA	lower 1,4-dioxane monitoring / PFAS monitoring	VOCs change from SA to A / No VOC detections 1,4-D Change from Q to SA/ >4 samples collected
MW-16-82	SA		SA				lower 1,4-dioxane monitoring	VOCs removed / No VOC detections 1,4-D Change from Q to SA / >4 samples collected
MW-16-83	A		A				lower 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No 1,4-D detections
MW-16-84	SA	A	SA				lower 1,4-dioxane monitoring	VOCs change from SA to A / No VOC detections 1,4-D Change from Q to SA/ >4 samples collected
MW-16-85	SA	A	SA				lower 1,4-dioxane monitoring	VOC change from SA to A / No VOC detections
MW-17-86	SA	A	SA				lower 1,4-dioxane monitoring	Well added / VOC to A
MW-19-115	SA		SA				lower 1,4-dioxane monitoring	Well added
MW-19-116	SA		SA				lower 1,4-dioxane monitoring	Well added
MW-19-117	SA		SA				lower 1,4-dioxane monitoring	Well added
PW-14-01	SA		SA				lower 1,4-dioxane monitoring	
PW-14-02	SA	B	SA				lower 1,4-dioxane monitoring	VOC change from SA to B / No VOC detections
TW-14-02	SA	B	SA				lower 1,4-dioxane monitoring	VOC change from SA to B / No VOC detections
Bedrock								
MW-12-01	A		A(1)				bedrock 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No 1,4-D detections > DW
MW-12-02	A		A(1)				bedrock 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No 1,4-D detections >DW
MW-12-05R	A		A(1)				bedrock 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No 1,4-D detections >DW
MW-13-44	A		A(1)				bedrock 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No 1,4-D detections >DW
MW-12-06	A		A(1)				bedrock 1,4-dioxane monitoring	Removed VOC Analysis / No VOC detections 1,4-D Change from SA to A / No 1,4-D detections
MW-17-87	A		A(1)				bedrock 1,4-dioxane monitoring	Well added
MW-19-118S	A		A(1)				bedrock 1,4-dioxane monitoring	New nested deep bedrock well / 1,4-Dioxane only
MW-19-118D	A		A(1)				bedrock 1,4-dioxane monitoring	New nested deep bedrock well / 1,4-Dioxane only
MW-19-125	A		A(1)				bedrock 1,4-dioxane monitoring	Proposed deep bedrock well / 1,4-Dioxane only
Lansing Township Wells								
TWP-03	-		A(1)				Municipal Well 1,4-dioxane monitoring	
TWP-04	-		A(1)				Municipal Well 1,4-dioxane monitoring	
TWP-05	-		A(1)				Municipal Well 1,4-dioxane monitoring	

Notes:

* Site wide gauging to alternate between semi-annual events to account for seasonal variability. Semi-annual gauging includes all wells sampled semi-annually.

** Select metals includes arsenic, nickel, lead, vanadium, chromium, and copper.

(1) = Analyzed for 1,4-dioxane via low-level USEPA Method 522

New wells will be added to the figures and incorporated into the annual monitoring once 4 samples are collected and a COC list is determined.

M = Monthly

Q = Quarterly

SA = Semi-annual

A = Annual

B = Biennial (starting 2nd quarter of 2020)

Qd = Quadrennial

Well	Gauging*	Analyte						Primary Function	Reason(s) for Change
		VOCs	1,4-Dioxane	Select Metals**	Hexavalent Chromium	SVOCs	PFAS		
Plant 3									
Perched									
CH-14-RO	SA			A	A		SA	metals monitoring, PFAS montiroing	Removed VOC Analysis / No VOC detections
MW-05(3)	A	A						VOC monitoring	
MW-06(3)	Abandon								Removed VOC & SVOC Analysis / ND or Decreasing Trend / Abandon - Redundant
UNK-09	Abandon								Remove Guaging/Abandon - Redundant
UNK-10	A	A						VOC monitoring	
UNK-11	A	A				Qd		VOC monitoring, SVOC monitoring	Removed Metals Analysis / Stable to Decreasing Trend / Added SVOC Analysis
MW-13-31	A							groundwater elevation monitoring	Removed Metals & SVOCs/ Stable to Decreasing Trend /attributed to offsite
MW-13-32	A			B		Qd		groundwater elevation monitoring/ SVOC & Metals monitoring	Perimeter monitoring for metals and SVOCs
MW-13-33	Abandon								Removed Metals Analysis / Stable to Decreasing Trend / Abandon
LMW-12-09	SA							Reduce LNAPL gauging to SA	LNAPL Gauging will Occur SA/ Max LNAPL Thickness Observed in 4 Quarters was 0.04 feet.
LMW-12-10	SA							Reduce LNAPL gauging to SA	LNAPL Gauging will Occur SA
LMW-12-11	SA							Reduce LNAPL gauging to SA	LNAPL Gauging will Occur SA / No LNAPL Observed for 4 Quarters
UNK-13	SA							Reduce LNAPL gauging to SA	Change LNAPL Gauging to SA
UNK-14	SA							Reduce LNAPL gauging to SA	Change LNAPL Gauging to SA
MW-04(3)	A							groundwater elevation monitoring	
MW-12-19	A							groundwater elevation monitoring	
P3-SB-07	SA							groundwater elevation monitoring	Guaging used to evaluate bulkheading and PFAS area
P3-SB-28	A					Qd		groundwater elevation monitoring, SVOC monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend
MW-14-65	A							groundwater elevation monitoring	Removed VOC and SVOC Analysis / ND
UNK-15	Q						Q	PFAS monitoring	
MW-18-88	Q	A		A	A		Q	PFAS monitoring/ monitoring VOC & Metals	Well Added
MW-18-89	Q						Q	PFAS monitoring	Well Added
MW-18-90	Q						Q	PFAS monitoring	Well Added
MW-18-91	Q						Q	PFAS monitoring	Well Added
MW-18-92	SA						SA	PFAS monitoring	Well Added
MW-18-95	Q						Q	PFAS monitoring	Well Added
MW-18-96	SA						SA	PFAS monitoring	Well Added
MW-18-98	Q						Q	PFAS monitoring	Well Added
MW-18-99	Q						Q	PFAS monitoring	Well Added
MW-18-100	SA						SA	PFAS monitoring	Well Added
MW-18-102	SA						SA	PFAS monitoring	Well Added
MW-18-103	Q						Q	PFAS monitoring	Well Added
MW-18-104	SA						SA	PFAS monitoring	Well Added
MW-18-105	Q						Q	PFAS monitoring	Well Added
MW-18-106	SA						SA	PFAS monitoring	Well Added
MW-19-107	SA						SA	PFAS monitoring	Well Added
MW-19-108	SA						SA	PFAS monitoring	Well Added
MW-19-110	SA						SA	PFAS monitoring	New perched monitoring well installed August 2019
MW-19-111	SA						SA	PFAS monitoring	New perched monitoring well installed August 2019
MW-19-112	SA						SA	PFAS monitoring	New perched monitoring well installed August 2019
MW-19-113	SA						SA	PFAS monitoring	New perched monitoring well installed August 2019
MW-19-114	SA						SA	PFAS monitoring	New perched monitoring well installed August 2019
Deep Overburden and Weathered Bedrock									
MW-12-20	A		B					lower 1,4-dioxane monitoring	Removed VOC Analysis / Stable to Decreasing Trend
MW-12-21	SA	B	SA					lower 1,4-dioxane monitoring, VOC monitoring	VOC Changed from A to B / Stable to Decreasing Trend Removed Metals Analysis / Stable to Decreasing Trend
MW-13-22	A	B	A					lower 1,4-dioxane monitoring, VOC monitoring	VOC Changed from A to B / Stable to Decreasing Trend Removed Metals Analysis / Stable to Decreasing Trend
MW-13-23	A		A					lower 1,4-dioxane monitoring	
MW-13-24	A		A					lower 1,4-dioxane monitoring	
MW-13-25	SA		SA					lower 1,4-dioxane monitoring	Removed VOC Analysis / Stable to Decreasing Trend
MW-13-26	A							groundwater elevation monitoring	Remove B 1,4-d / 6 yrs ND
MW-13-29	A		A					lower 1,4-dioxane monitoring	
MW-13-30	A							groundwater elevation monitoring	Remove B 1,4-d / 6 yrs ND
MW-13-34	SA	B	SA					lower 1,4-dioxane monitoring, VOC monitoring,	VOC Changed from A to B / Stable to Decreasing Trend
MW-13-40	A							groundwater elevation monitoring	Removed 1,4-dioxane, added MW-18-97
MW-13-41	A	B						VOC monitoring	Added VOC Analysis Removed Metals Analysis / Stable to Decreasing Trend
MW-13-46	SA		SA					lower 1,4-dioxane monitoring	'Removed VOC Analysis / ND or Stable to Decreasing Trend
MW-13-48	SA	B	SA					lower 1,4-dioxane monitoring. VOC monitoring	VOC Changed from A to B / Stable to Decreasing Trend
MW-13-49	A		A					lower 1,4-dioxane	'Removed VOC Analysis / ND or Stable to Decreasing Trend
MW-19	A	B	A					lower 1,4-dioxane monitoring	
MW-22	A							metals monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend / Removed 1,4-D Analysis / Stable to Decreasing Trend
MW-23	SA						SA	PFAS monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend / Removed 1,4-D Analysis / Stable to Decreasing Trend / Add PFAS
MW-91-2 (abandoned) / MW-91-2R	SA		A	A	A		SA	lower 1,4-dioxane, PFAS and metals monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend MW-91-2 abandoned and replaced in August 2019
MW-02-02(3)	A		A					lower 1,4-dioxane monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend / Removed Metals Analysis / Stable to Decreasing Trend
MW-02-04(3)	SA		A	A			SA	lower 1,4-dioxane, PFAS and metals monitoring	Add PFAS
MW-02-01(3)	A							groundwater elevation monitoring	
MW-02-03(3)	A							groundwater elevation monitoring	
MW-04-03(3)	A							groundwater elevation monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend/VC attributed to offsite
MW-04-04(3)	A							groundwater elevation monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend/VC attributed to offsite
MW-13-27	A							groundwater elevation monitoring	
MW-14-64	A		A					lower 1,4-dioxane monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend
MW-15-71	A		B					lower 1,4-dioxane monitoring	1,4-D Changed from A to B / Stable to Decreasing Trend
PW-14-03	SA		SA					lower 1,4-dioxane monitoring	Remove VOCs / Stable to Decreasing Trend
MW-18-93	SA						SA	Lower PFAS monitoring	Well Added
MW-18-94	SA		A				SA	Lower PFAS, 1,4-Dioxane monitoring	Well Added
MW-18-97	SA		A				SA	Lower PFAS monitoring	Well Added
MW-18-101	SA						SA	Lower PFAS monitoring	Well Added
MW-93-1	A							groundwater elevation monitoring	
Bedrock									
MW-91-5	SA		A(1)					bedrock monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend / 1,4-D Changed from SA to A / ND or Stable to Decreasing Trend
MW-91-6	SA		A(1)					bedrock monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend / 1,4-D Changed from SA to A / ND or Stable to Decreasing Trend
MW-13-28	SA		A(1)					bedrock monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend / 1,4-D Changed from SA to A / ND or Stable to Decreasing Trend
MW-13-38	A		A(1)					bedrock monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend / 1,4-D Changed from SA to A / ND or Stable to Decreasing Trend
MW-13-39B	A							groundwater elevation monitoring	
MW-13-47	SA		A(1)					bedrock monitoring	Removed VOC Analysis / Stable to Decreasing Trend 1,4-D Changed from SA to A / Stable to Decreasing Trend
MW-04-01(3)	Abandon								Anomalous elevation in bedrock / no used for contouring or sampling
MW-04-02(3)	A							groundwater elevation monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend/VC attributed to offsite
MW-12-04	A							groundwater elevation monitoring	
MW-13-37	A		A(1)					1,4-D monitoring	Added Annual 1,4-Dioxane
MW-88-1	A							groundwater elevation monitoring	
MW-91-3	A							bedrock monitoring	Removed VOC Analysis / ND or Stable to Decreasing Trend/VC attributed to offsite
MW-91-4	A							groundwater elevation monitoring	Removed VOC Analysis / Stable to Decreasing Trend
MW-19-119S	A		A(1)					bedrock monitoring	New nested deep bedrock well / 1,4-Dioxane only
MW-19-119D	A		A(1)					bedrock monitoring	New nested deep bedrock well / 1,4-Dioxane only

Notes:

* Site wide gauging to alternate between semi-annual events to account for seasonal variability. Semi-annual gauging includes all wells sampled semi-annually.

** Select metals includes arsenic, nickel, lead, vanadium, chromium, and copper.

(1) - Analyzed for 1,4-dioxane via low-level USEPA Method 522

Q = quarterly

SA = semi-annual

A = annual

B = biennial (starting 2nd quarter of 2020)

Qd = Quadrennial

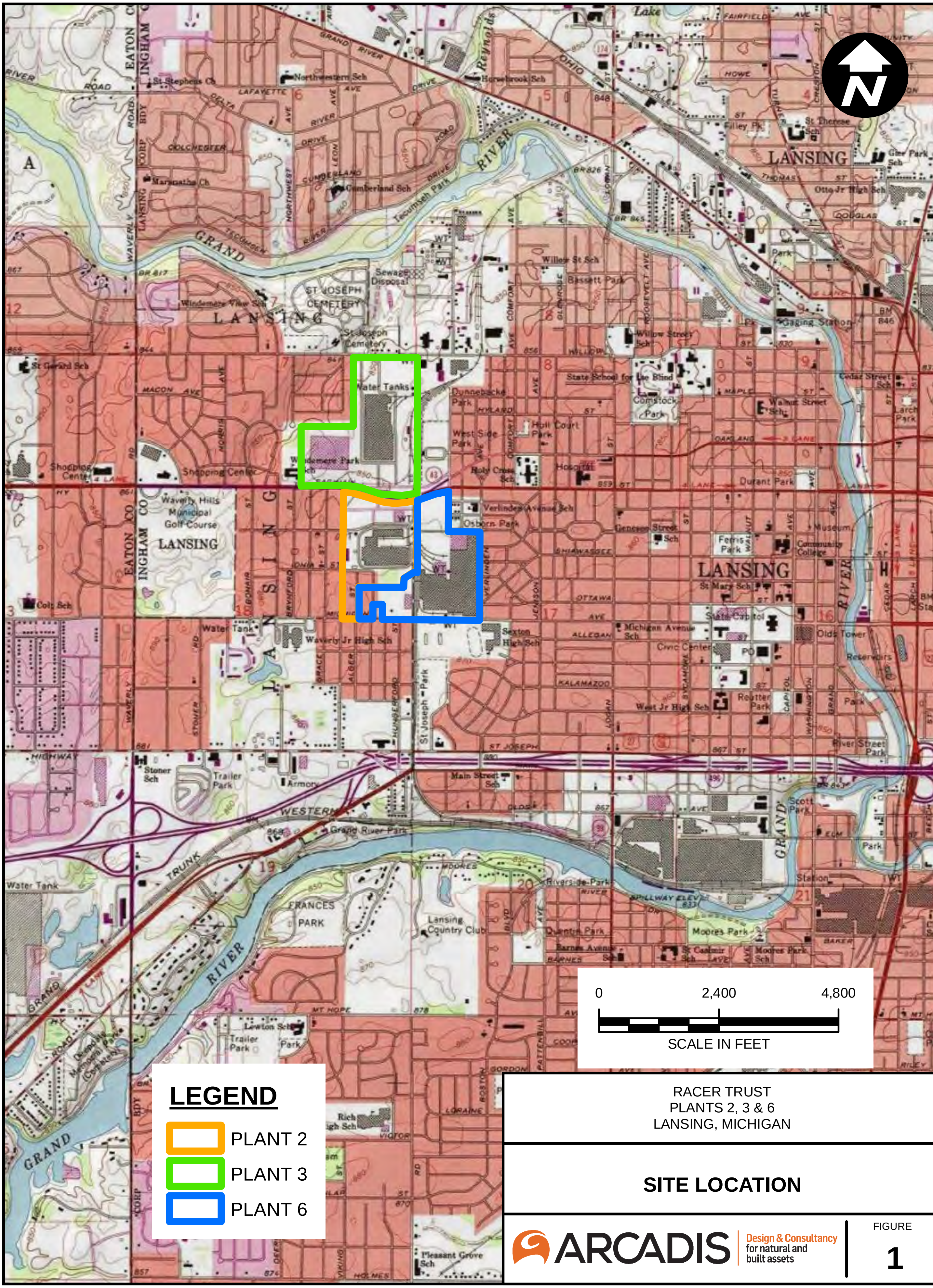
Table 1
Revised Interim Groundwater Monitoring Summary - Plant 6

Revised May 2019
RACER Trust Plants 2, 3, and 6 - Lansing, Michigan

Well	Gauging*	Analyte: VOCs	Analyte: 1,4-Dioxane	Analyte: Select Metals**	Analyte: SVOCs	Analyte: PFAS	Primary Function	Reason(s) for Change
Plant 6								
Perched								
MW-02-03(6)	A	B	A		Qd		perched 1,4-dioxane monitoring, SVOC monitoring	VOC Changed from A to B / Stable to Decreasing Trend
MW-03-04	A						groundwater elevation monitoring	Removed VOC, 1,4-d Analysis / Stable to Decreasing Trend
MW-03-06	A	B	A				perched 1,4-dioxane monitoring	VOC Changed from A to B / Stable to Decreasing Trend Removed Metals and SVOC Analysis / Stable to Decreasing Trend
MW-03-08	A	B					perched VOC monitoring	VOC Changed from A to B / removed 1,4-d /Stable to Decreasing Trend
MW-04-05(6)	A					A	perched PFAS monitoring	Removed VOC, 1,4-d and Metals Analysis / Stable to Decreasing Trend
MW-12-11	A					A	PFAS monitoring	Removed Metals Analysis / Stable to Decreasing Trend /PFAS Stability
MW-12-12	Q					Q	PFAS monitoring	Removed Metals Analysis / Stable to Decreasing Trend /PFAS Stability
MW-12-13	Q			A		Q	PFAS monitoring	Metals Changed from SA to A / Stable to Decreasing Trend / PFAS Stability
MW-12-16	A						groundwater elevation monitoring	Removed VOC Analysis / Stable to Decreasing Trend Removed Metals / Stable to Decreasing Trend attributed to offsite
MW-13-35	A						groundwater elevation monitoring	Removed VOC Analysis / Stable to Decreasing Trend Removed Metals / Stable to Decreasing Trend attributed to offsite/ Retain well for potential PFAS monitoring
MW-13-36R	Q			A		Q	Metals and PFAS monitoring	Metals Changed from SA to A / Stable to Decreasing Trend / PFAS Stability
MWBP-10-UST1-4	Abandon							Only used for groundwater elevation monitoring. High well density in Area 7
MWBP-10A-UST1-4	Abandon							Only used for groundwater elevation monitoring. High well density in Area 8
MWBP-10-UST5-6	A	B		B			VOCs/metal monitoring	VOC Changed from A to B / Stable to Decreasing Trends Metals Changed from SA to B / Stable to Decreasing Trends
MWBP-11-UST1-4	A	B		B			VOCs/metal monitoring	VOC Changed from A to B / Stable to Decreasing Trends
MWBP-12A-UST1-4	Abandon							Consistently non detect for VOCs/stable metals. High well density in area 7.
MWBP-12-UST1-4	A	B		B	Qd		VOCs/metal monitoring, SVOC monitoring	VOC Changed from A to B / Stable to Decreasing Trends
P6-SB-18	A						groundwater elevation monitoring	
P6-SB-37	A						groundwater elevation monitoring	
MW-02-02(6)	Abandon							Only used for groundwater elevation monitoring.
MW-03-02	A						groundwater elevation monitoring	Removed Metals Analysis / Stable to Decreasing Trend
MW-03-05	A	B	A				perched 1,4-dioxane monitoring, VOCs monitoring	VOC Changed from A to B / Stable to Decreasing Trend
MW-12-10R	A						groundwater elevation monitoring	
MW-12-14	A						groundwater elevation monitoring	
MW-12-15								Removed VOC Analysis / Stable to Decreasing Trend Removed Metals / Stable to Decreasing Trend attributed to offsite/ Retain well for potential PFAS monitoring
MWBP-12-UST5-6	Abandon							Consistently non detect for VOCs/stable metals. High well density in area 7.
MWBP-13A-UST1-4	Abandon							Consistently non detect for VOCs/stable metals. High well density in area 7.
P6-MW-01	A						groundwater elevation monitoring	
P6-SB-07	Q				Qd	Q	PFAS monitoring, SVOCs monitoring	PFAS Stability
P6-SB-21	A						groundwater elevation monitoring	
P6-SB-35	A						groundwater elevation monitoring	
SME-MW-02	Abandon							Only used for groundwater elevation monitoring.
MW-14-66	A			B			metals monitoring	Removed VOC Analysis / Stable to Decreasing Trend / Added PFAS
MW-14-67	Q			B		Q	metals monitoring, PFAS Monitoring	Removed VOC Analysis / Stable to Decreasing Trend
MW-14-70	Q					Q	PFAS monitoring	PFAS Stability
MW-14-68	A						PFAS monitoring	Dry Since Installation in 2014 / Continue to check Annually
MW-14-69	A						PFAS monitoring	Dry Since Installation in 2014 / Continue to check Annually
Deep Overburden and Weathered Bedrock								
MW-13-52	A		A				lower 1,4-dioxane monitoring	Removed VOC Analysis / Stable to Decreasing Trend 1,4-D Changed from B to A
MW-13-53	A		A				lower 1,4-dioxane monitoring	Removed VOC Analysis / Stable to Decreasing Trend 1,4-D Changed from B to A
Bedrock								
MW-04-01(6)	A		B				bedrock 1,4-dioxane monitoring	Removed VOC Analysis / Stable to Decreasing Trend
MW-04-04R	A		B			A	bedrock 1,4-dioxane monitoring, PFAS Monitioring	Removed VOC Analysis / Stable to Decreasing Trend
MW-04-06R	A		B			A	bedrock 1,4-dioxane monitoring, PFAS Monitioring	Removed VOC Analysis / Stable to Decreasing Trend
MW-12-03	A						groundwater elevation monitoring	
MW-13-50	A		B				bedrock 1,4-dioxane monitoring	Removed VOC Analysis / Stable to Decreasing Trend

* Site wide gauging to alternate between semi-annual events to account for seasonal variability. Semi-annual gauging includes all wells sampled semi-annually.
** Select metals includes arsenic, nickel, lead, vanadium, chromium, and copper.
Q = quarterly
SA = semi-annual
A = annual
B = biennial (starting 2nd quarter of 2020)
Qd = Quadrennial

FIGURES



RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

SITE LOCATION

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
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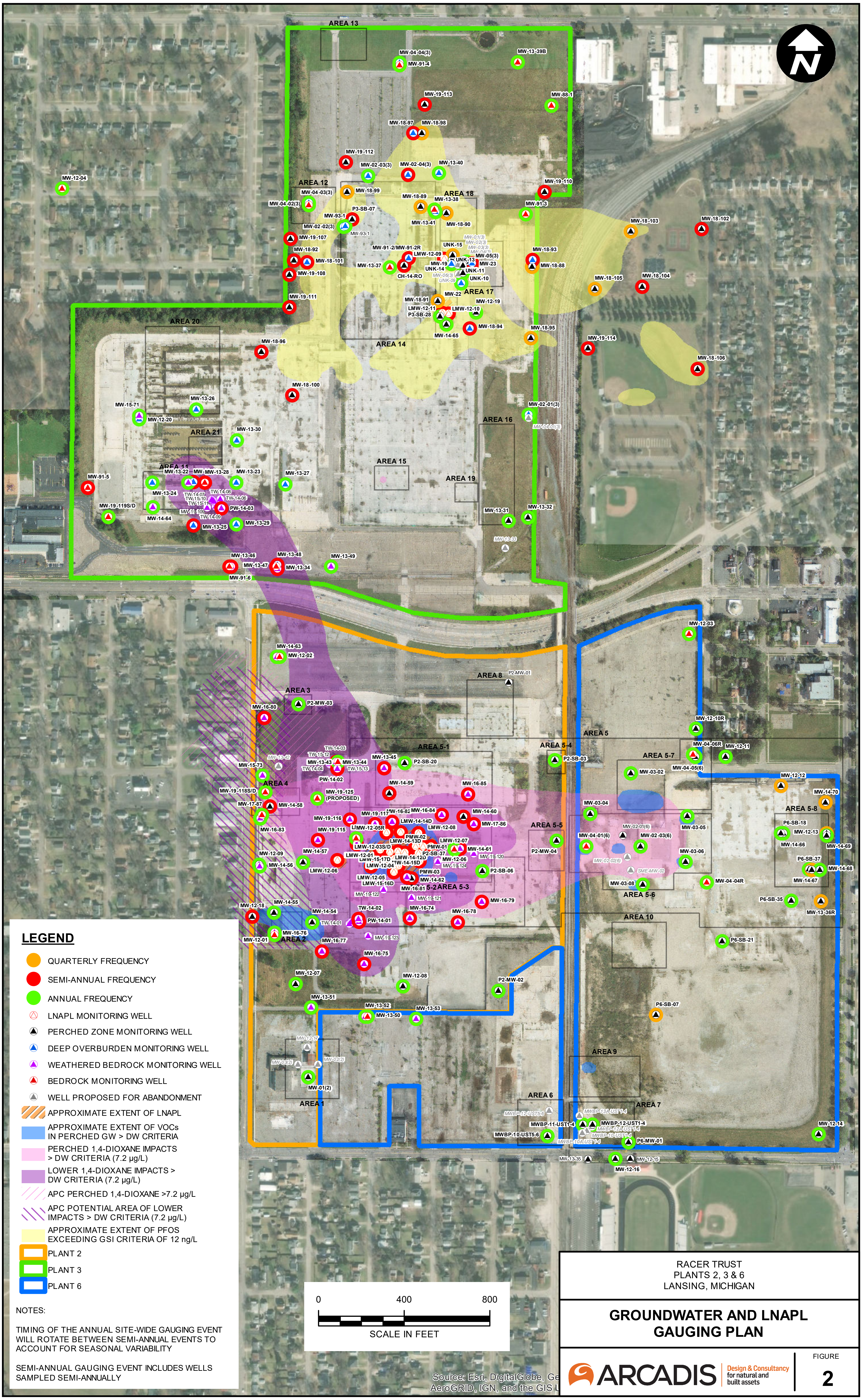

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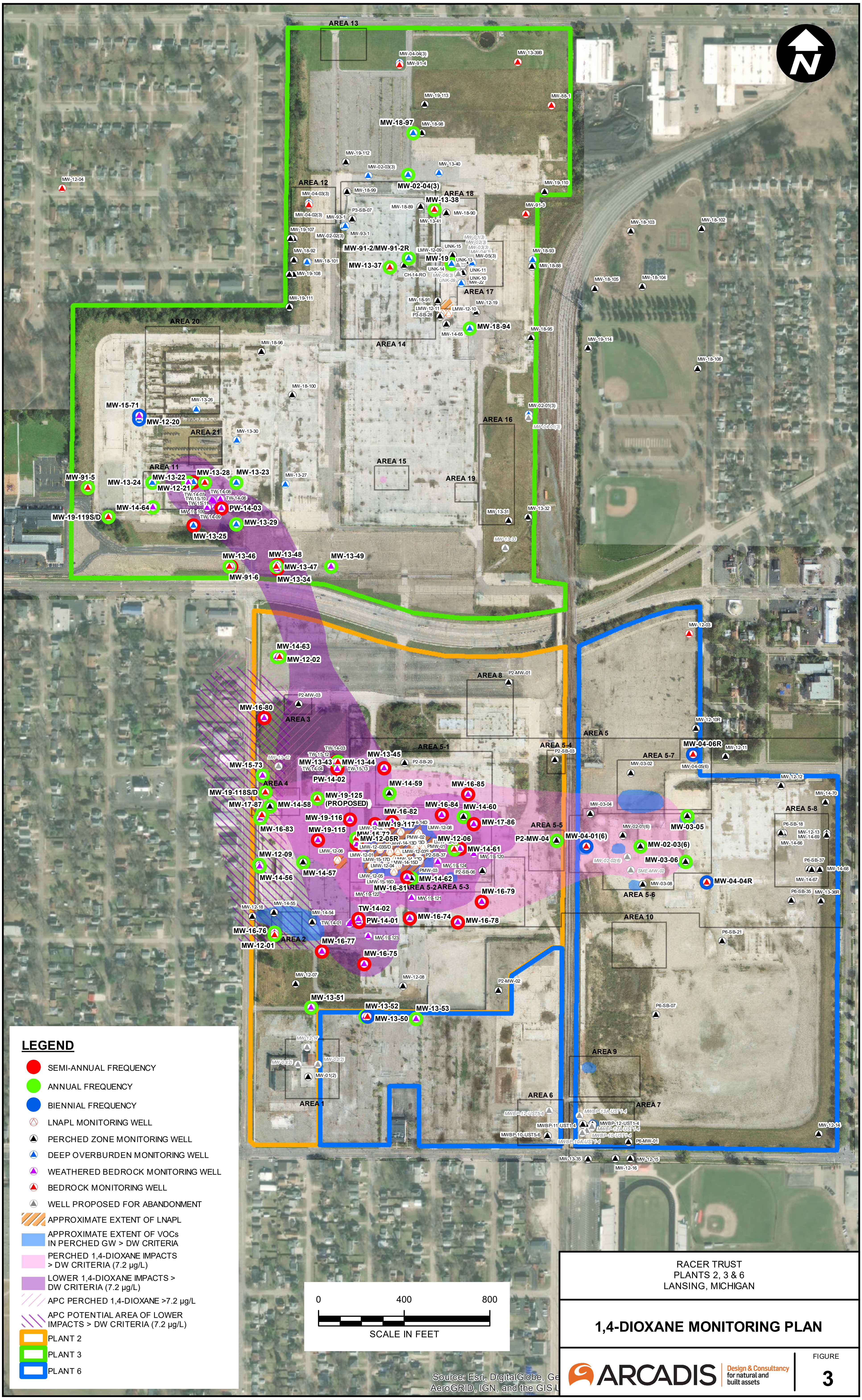

LEGEND

- SEMI-ANNUAL FREQUENCY
- ANNUAL FREQUENCY
- BIENNIAL FREQUENCY
- LNAPL MONITORING WELL
- PERCHED ZONE MONITORING WELL
- DEEP OVERBURDEN MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL
- BEDROCK MONITORING WELL
- WELL PROPOSED FOR ABANDONMENT
- APPROXIMATE EXTENT OF LNAPL
- APPROXIMATE EXTENT OF VOCs IN PERCHED GW > DW CRITERIA
- PERCHED 1,4-DIOXANE IMPACTS > DW CRITERIA (7.2 µg/L)
- LOWER 1,4-DIOXANE IMPACTS > DW CRITERIA (7.2 µg/L)
- APC PERCHED 1,4-DIOXANE >7.2 µg/L
- APC POTENTIAL AREA OF LOWER IMPACTS > DW CRITERIA (7.2 µg/L)
- PLANT 2
- PLANT 3
- PLANT 6

0 400 800
SCALE IN FEET

RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

1,4-DIOXANE MONITORING PLAN

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FIGURE
3

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
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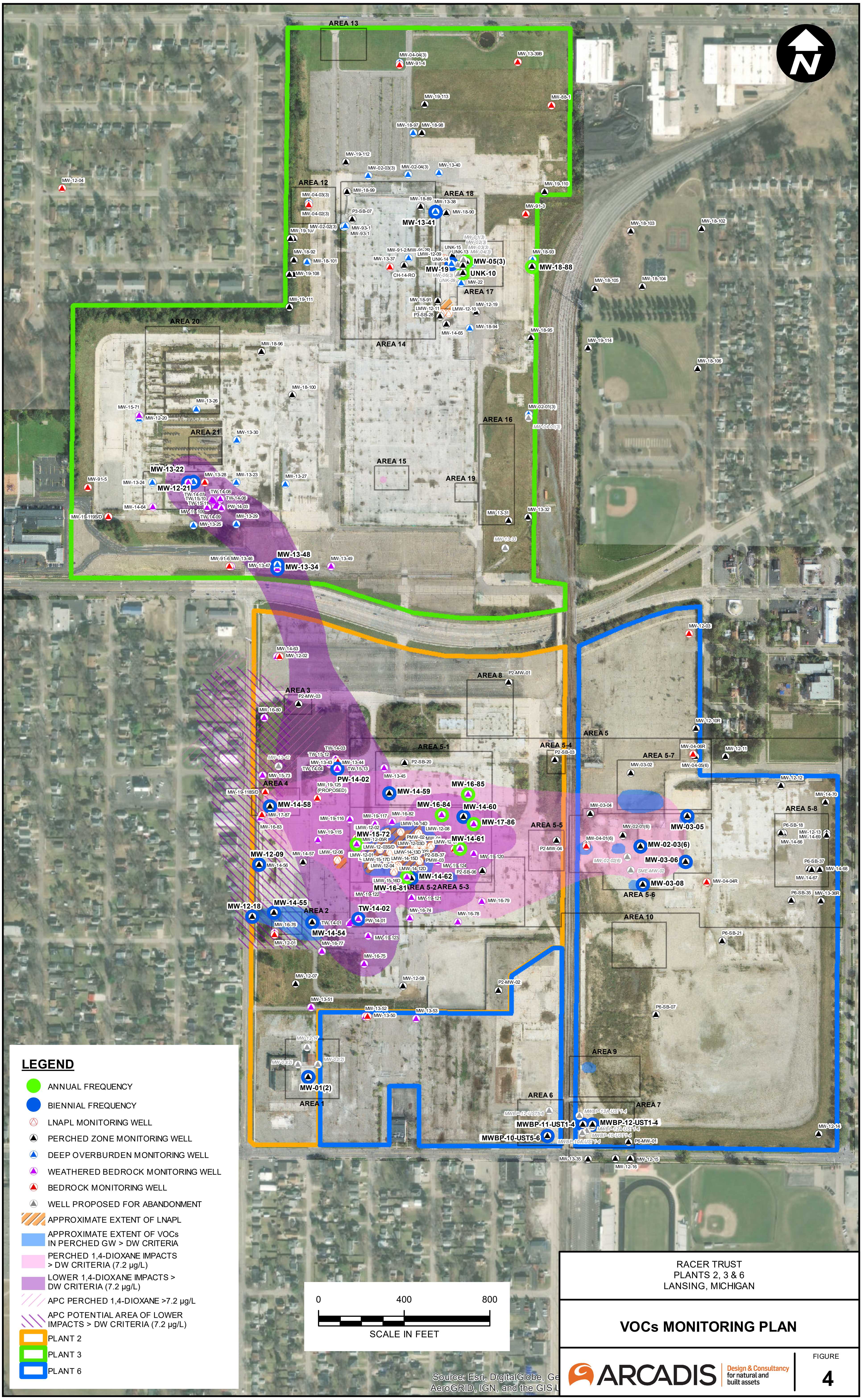

LEGEND

- ANNUAL FREQUENCY
- BIENNIAL FREQUENCY
- LNAPL MONITORING WELL
- PERCHED ZONE MONITORING WELL
- DEEP OVERBURDEN MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL
- BEDROCK MONITORING WELL
- WELL PROPOSED FOR ABANDONMENT
- APPROXIMATE EXTENT OF LNAPL
- APPROXIMATE EXTENT OF VOCs IN PERCHED GW > DW CRITERIA
- PERCHED 1,4-DIOXANE IMPACTS > DW CRITERIA (7.2 µg/L)
- LOWER 1,4-DIOXANE IMPACTS > DW CRITERIA (7.2 µg/L)
- APC PERCHED 1,4-DIOXANE >7.2 µg/L
- APC POTENTIAL AREA OF LOWER IMPACTS > DW CRITERIA (7.2 µg/L)
- PLANT 2
- PLANT 3
- PLANT 6

0 400 800

SCALE IN FEET

Source: Esri, DigitalGlobe, Ge... AeroGRID, IGN, and the GIS U...

RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

VOCs MONITORING PLAN

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FIGURE 4

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
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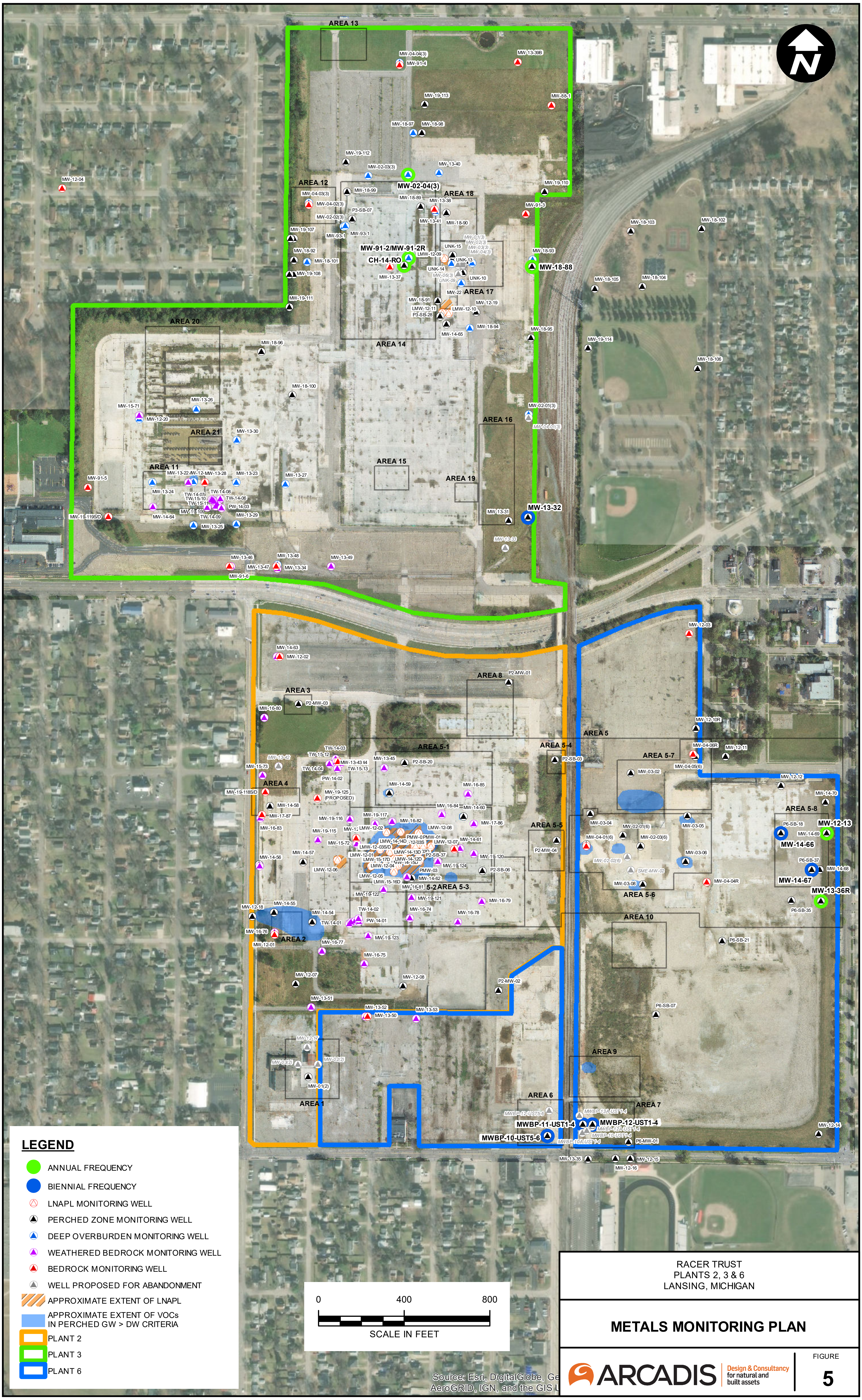

RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

METALS MONITORING PLAN

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FIGURE 5

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
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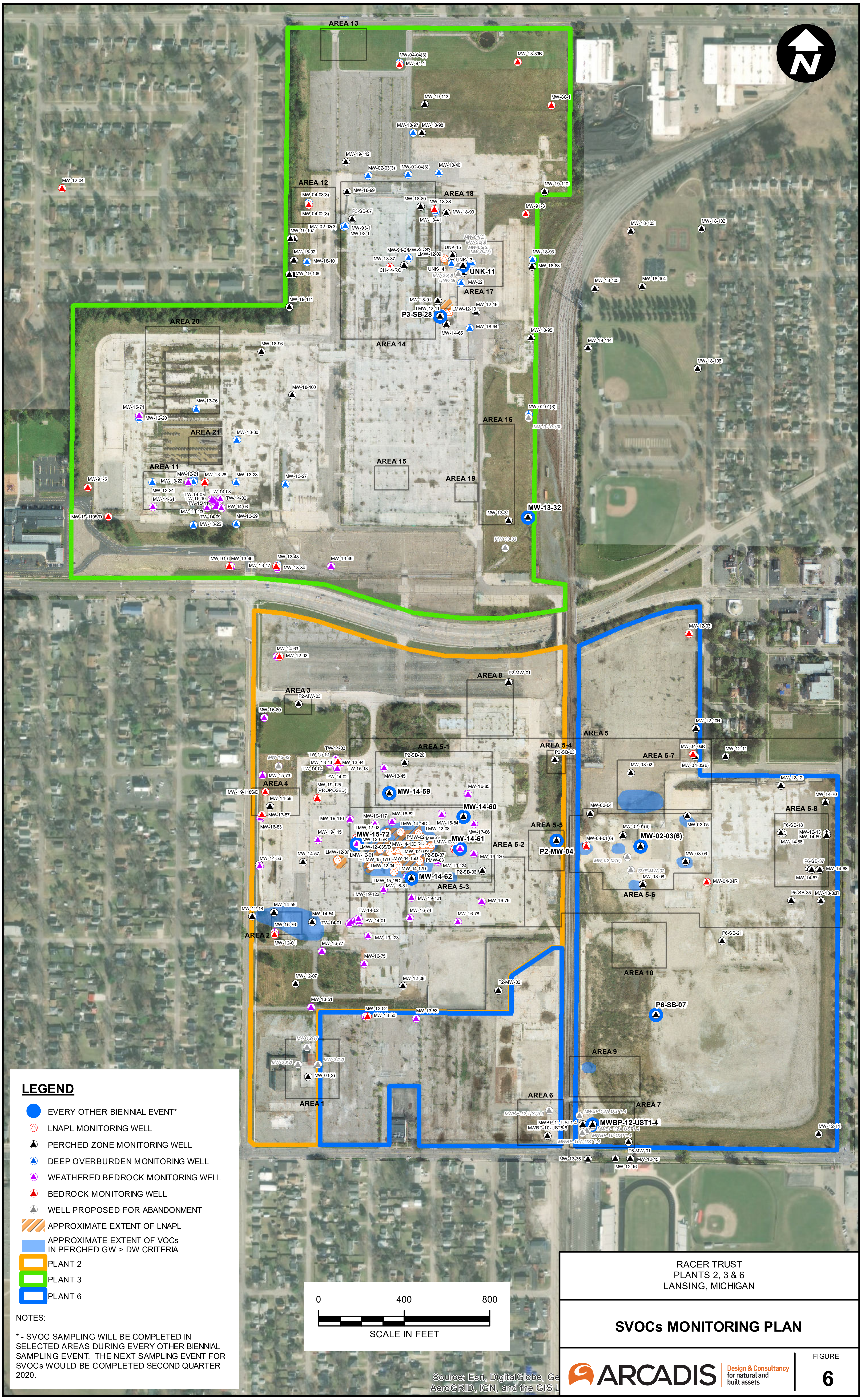

LEGEND

- EVERY OTHER BIENNIAL EVENT*
- LNAPL MONITORING WELL
- PERCHED ZONE MONITORING WELL
- DEEP OVERBURDEN MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL
- BEDROCK MONITORING WELL
- WELL PROPOSED FOR ABANDONMENT
- APPROXIMATE EXTENT OF LNAPL
- APPROXIMATE EXTENT OF VOCs IN PERCHED GW > DW CRITERIA
- PLANT 2
- PLANT 3
- PLANT 6

NOTES:

* - SVOC SAMPLING WILL BE COMPLETED IN SELECTED AREAS DURING EVERY OTHER BIENNIAL SAMPLING EVENT. THE NEXT SAMPLING EVENT FOR SVOCs WOULD BE COMPLETED SECOND QUARTER 2020.

RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

SVOCs MONITORING PLAN

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FIGURE
6

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
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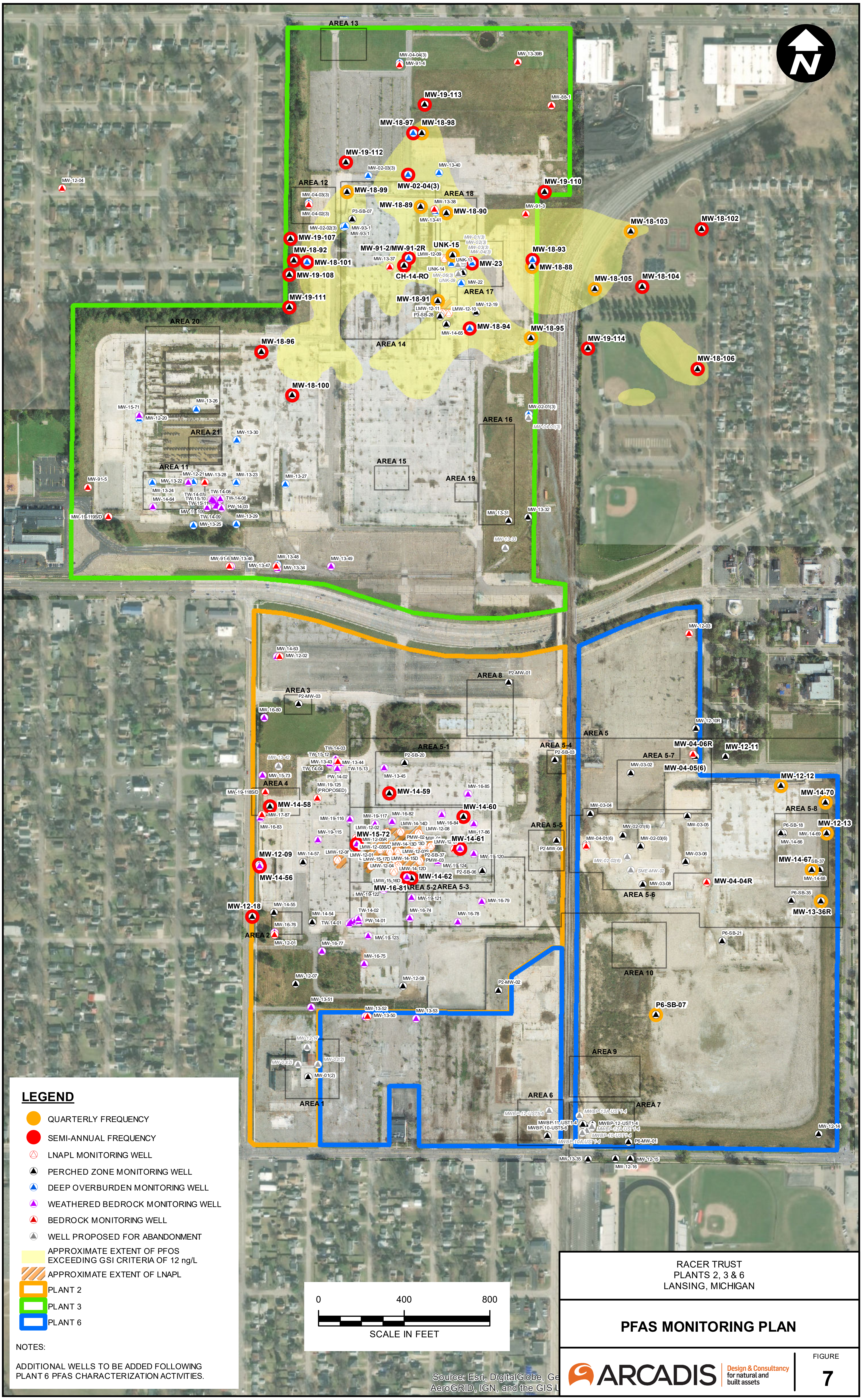

LEGEND

- QUARTERLY FREQUENCY
- SEMI-ANNUAL FREQUENCY
- LNAPL MONITORING WELL
- PERCHED ZONE MONITORING WELL
- DEEP OVERBURDEN MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL
- BEDROCK MONITORING WELL
- WELL PROPOSED FOR ABANDONMENT
- APPROXIMATE EXTENT OF PFOS EXCEEDING GSI CRITERIA OF 12 ng/L
- APPROXIMATE EXTENT OF LNAPL
- PLANT 2
- PLANT 3
- PLANT 6

NOTES:

ADDITIONAL WELLS TO BE ADDED FOLLOWING PLANT 6 PFAS CHARACTERIZATION ACTIVITIES.

0 400 800

SCALE IN FEET

Source: Esri, DigitalGlobe, Ge... AeroGRID, IGN, and the GIS U...

RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

PFAS MONITORING PLAN

ARCADIS Design & Consultancy for natural and built assets

FIGURE
7

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
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ATTACHMENT 1

PFAS Sampling Guidance

POLY- AND PERFLUORINATED ALKYL SUBSTANCES (PFAS) FIELD SAMPLING GUIDANCE

Rev: 4

Rev Date: March 26, 2019

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	April 27, 2017	All	Initial Release	Erica Kalve Erika Houtz Sue Tauro
1	June 19, 2018	1 through 4 and 17	Updated Information on Sampling Materials	Erica Kalve Erika Houtz
2	October 15, 2018	6 to 16	Minor updates on laboratory elements, updates to decontamination procedures, and clarification on equipment and reagent blank collection	Erika Houtz Erica Kalve
3	December 17, 2018	4, 6, 17	Removed Sharpies from acceptable field writing implements; Changed language in Section 3.2 and Section 10.5 to provide stricter guidance for DoD projects.	Erika Houtz, Erica Kalve
4	March 26, 2019	4,5	Removed Citranox from acceptable Decon solutions in Table 1a, added all fluoropolymer containing materials to prohibited items in Table 1b. Made a correction that Liquinox contains trace levels of 1,4 Dioxane, not Alconox.	Erika Houtz

APPROVAL SIGNATURES

Prepared by:

	Erika F. Houtz	3/26/2019
	Erika F. Houtz, PhD, PE Environmental Engineer and PFAS Analytical Lead	Date:
Reviewed by:	Erica Kalve	12/17/2018
	Erica Kalve, PG-CA Emerging Contaminants Focus Group Leader	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The purpose of this Technical Guidance Instructions (TGI) is to provide guidance on field sampling to be used for poly-and perfluorinated alkyl substances (PFASs). This protocol was adapted from various sources including Arcadis Australia, Transport Canada, and the U.S Army Corp of Engineers (USACE) Omaha. In general, sampling techniques used for PFAS site characterization are consistent with conventional sampling techniques used in the environmental industry, but special consideration is made regarding PFAS-containing materials and cross-contamination potential. **Table 1a** provides a summary of materials that have been approved for site investigation; this list is expected to grow longer as industry experience increases. **Table 1b** provides a summary of field equipment and materials that have available testing information and/or industry knowledge regarding PFAS cross-contamination potential and it is recommended that these materials be prohibited for sample collection; for materials that are suspected of containing PFASs and/or to retain PFASs, these recommendations are considered preliminary and subject to change.

Table 1a: Summary of Acceptable Sampling Equipment and Materials for PFAS Site Investigations

Sampling Materials	Additional Considerations	References
Water Sampling Materials		
High density polyethylene (HDPE) or silicone tubing materials	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
HDPE HydraSleeves™	Low density polyethylene (LDPE) HydraSleeves™ are not recommended	USACE 2016; MassDEP 2017
Drilling and Soil Sampling Materials		
PFAS-free drilling fluids	--	DER 2016
PFAS-free makeup water	Confirm PFAS-free water source via laboratory analysis prior to investigation	--
Acetate liners	For use in soil sampling	USACE 2016
Sample Containers and Storage		
HDPE sample containers with HDPE lined lids for soil and water samples	Laboratory should provide; whole bottle analysis of aqueous samples combined with a solvent rinse of bottle is recommended	DER 2016, MassDEP 2017
Ice contained in plastic (polyethylene) bags (double bagged)	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation		
Ball point pens	--	MassDEP 2017
Standard paper and paper labels	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Decontamination		
Water-only decontamination	Confirm PFAS-free water source via laboratory analysis prior to investigation	DER 2016
Alconox® or Liquinox® followed by deionized water or PFAS-free water rinse	Liquinox® known to contain trace levels of 1,4-dioxane	NHDES 2016; USACE 2016; MassDEP 2017
Methanol, isopropanol, or acetone	Special health and safety precautions are necessary	UNEP 2015; USACE 2016

Note: This list is considered preliminary and additional materials may be added as additional information becomes available. Project teams are expected to follow a methodical evaluation process of materials to be used and confirm acceptance prior to implementation of field activities.

Table 1b: Summary of Sampling Equipment and Materials Not Recommended for PFAS Site Investigations.

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFASs	References
Water Sampling Materials				
Teflon®, PTFE-containing or other fluoropolymer coated or containing field equipment (e.g., tubing, bailers, liners, tape, plumbing paste, pump parts)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Passive diffusion bags			x	MassDEP 2017
LDPE HydraSleeves ™			x	USACE 2016; MassDEP 2017
Water particle filters			x	MassDEP 2017
Drilling and Soil Sampling Materials				
Aluminum foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFASs	x	x		DER 2016
Sample Containers and Storage				
Glass sample containers with lined lids			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
LDPE containers and lined lids			x	USACE 2016
Teflon® or PTFE- lined lids on containers (e.g., sample containers, rinsate water storage containers)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Reusable chemical or gel ice packs (e.g., BlueIce®)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation				
Self-sticking notes and similar office products (e.g., 3M Post-it-notes)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Waterproof paper, notebooks, and labels	x			DER 2016, MassDEP 2017
Non-Sharpie® markers		x		NHDES 2016
Decontamination				
[Some] detergents and decontamination solutions (e.g., Decon 90® Decontamination Solution)	x	x		DER 2016; NHDES 2016; MassDEP 2017

Note: For materials that are suspected of containing PFASs, or have the potential to retain PFASs, project specific considerations may provide adequate justification for use during the field event. For example, further evaluation may be conducted in the form of pre-field equipment blank sample analysis.

Given the extremely low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFASs, field personnel are advised to err on the side of caution by strictly following these protocols, frequently replacing nitrile gloves, and rinsing field equipment to help mitigate the potential for false detections of PFASs. A summary of other specific items related to field sampling for PFASs are discussed in the sections below.

This TGI applies to all Arcadis and subcontractor personnel involved in field sampling for PFAS.

3 PERSONNEL QUALIFICATIONS

3.1 Sampling Personnel

Field personnel must have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, and site-specific training, as needed. In addition, field personnel will be versed in the other relevant SOPs (e.g., low flow sampling) and will possess the skills and experience necessary to successfully complete the desired field work. The site Health and Safety Plan (HASP) and other documents will identify any other training requirements such as site-specific safety training or access control requirements.

3.2 Laboratories

These laboratories are example laboratories that could be used to analyze environmental media for PFASs, pending project approval:

- United States: TestAmerica, SGS, Vista, ALS, and Eurofins
- Canada: Axys-SGS and Maxxam Laboratories

Other laboratories may be used if they are appropriately accredited for PFAS analysis according to any project requirements. It is recommended that a laboratory is Environmental Laboratory Accreditation Program (ELAP)-accredited for PFAS analysis in accordance with the Department of Defense (DoD) Quality Systems Manual (QSM) 5.1 Table B-15 or any subsequent updates. **For all data collection efforts at DoD sites, PFAS data must be obtained using a method that is DoD ELAP-accredited under QSM 5.1 or later.**

4 EQUIPMENT LIST

The following equipment and materials must be available for sampling:

- Site plan of sampling locations, relevant work plan (or equivalent), and this TGI;
- Appropriate health and safety equipment, as specified in the site HASP;
- Dedicated plastic sheeting (preferably high-density polyethylene [HDPE]) or other clean surface to prevent sample contact with the ground;
- Conductivity/temperature/pH meter;
- Dissolved oxygen meter, oxidation reduction potential meter, and turbidity meter;
- Depth to water meter;

- If using low-flow groundwater sampling techniques, peristaltic pump (groundwater sampling)/bladder pump (with PFAS free bladder/ HDPE bladder), flow through cell, and accompanying HDPE and silicone tubing;
- Hydrasleeves, if using Hydrasleeves for groundwater sampling;
- Metal trowel for soil samples; specialized soil/sediment sampling equipment as required;
- Brushes for scrubbing sampling equipment;
- Pens, pencils, and/or Sharpies for writing;
- Clipboards, field binders, and field note pages that are not waterproof;
- Labeled sample bottles:
    - Water: HDPE bottles fitted with polypropylene screw cap only; some types of PFAS samples (primarily drinking water) may require preservative, which will be indicated by the laboratory conducting the analysis. The laboratory will specify the sample bottle volume.
    - Soil and sediment: HDPE bottles fitted with polypropylene screw cap only; no preservatives. The laboratory will specify the sample bottle volume.
- If high concentrations of PFASs related to class B firefighting foams are expected, bring additional small vials to conduct field-based shaker tests for foaming;
- Ziploc® bags to hold ice and samples;
- Bottles containing “PFAS-free” water used for reagent blanks;
- Labeled coolers for samples with ice; Blue ice is not permitted;
- Deionized or distilled water for initial decontamination rinsing;
- “PFAS-free” water provided by the laboratory for final decontamination rinsing;
- Methanol, isopropanol, or acetone if able to be brought safely to field site; especially important for decontamination during soil sampling;
- Alconox or Liquinox®;
- Packing and shipping materials;
- Groundwater Sampling Log; and
- Chain-of-Custody (COC) Forms.

5 CAUTIONS

5.1 Food Packaging

Some food packaging may be treated with PFAS-containing chemicals to prevent permeation of oil and water in the food outside of the packaging. To avoid potential food packaging-related PFAS contact:

- Do not bring any food outside of the field vehicles onsite and eat snacks and meals offsite.
- Wash hands after eating.
- Remove any field garments or outer layers prior to eating. Do not put them back on until done eating and hands are washed.

5.2 Field Gear

5.2.1 Clothing

Many types of clothing are treated with PFASs for stain and water resistance, in particular outdoor performance wear under brand names such as Gore-Tex®. To avoid potential clothing-related PFAS contact:

- Do not wear any outdoor performance wear that is water or stain resistant, or appears to be. Err on the side of caution.
- Wear pre-laundered (multiple washings, i.e. 6+) clothing that is not stain resistant or water proof.
- Natural fabrics such as cotton are preferred. Synthetic fabrics may also be acceptable if there is no indication on the label that the fabric is water and stain resistant.
- Most importantly, avoid contacting your clothing with sampling equipment, bottles, and samples.

5.2.2 Personal Protective Equipment

Safety Footwear

Some safety footwear has been treated to provide a degree of waterproofing and increased durability and may represent a source of trace PFASs. For the health and safety of field personnel, footwear must be protected at all times to avoid potential PFAS contamination. To do this:

- Do not contact your footwear with equipment, bottles, or samples in any way.
- Do not allow gloves used for sampling to come in contact with safety footwear.

Nitrile Gloves

Wear disposable nitrile gloves at all times. Don a new pair of nitrile gloves **before** the following activities at each sample location:

- Decontamination of re-usable sampling equipment;
- Contact with sample bottles or "PFAS-free" water bottles;
- Insertion of anything into the sample ports (e.g., HDPE tubing); and
- Handling of any quality assurance/quality control (QA/QC) samples including field blanks and equipment blanks.

Don a new pair of nitrile gloves **after** the following activities:

- Handling of any non-dedicated sampling equipment;
- Contact with contaminated surfaces; or
- When judged necessary by field personnel.

5.3 Personal Hygiene

- Shower at night.
- Do not use personal care products after showering such as lotions, makeup, and perfumes, UNLESS medically necessary.
- Use sunscreen and insect repellent ONLY if necessary for health and safety. If they are necessary, apply sunscreen and repellant prior to initiating field sampling. If sunscreen and/or repellant need to

be reapplied, ensure a safe distance away from the sampling locations and equipment (i.e., more than 10 meters (m) away). Wash hands after application.

5.4 Visitors

Visitors to the site are asked to remain at least 10 m from sampling areas.

5.5 Rain Events

Special care should be taken when rain is falling at the project site:

- Do not perform field sampling when rain fall is persistent at a consistent rate that saturates the ground (i.e., formation of puddles) because rain gear is not permitted while sampling. Intermittent showers or fog are acceptable conditions to proceed. If rain showers occur; field gear must be removed from the monitoring well location until the rain subsides.
- If project timelines are tight, consider the use of a gazebo tent that can be erected over the top of the monitoring well to provide shelter from the rain. The canopy material is possibly a PFAS-treated surface and should be managed as such; therefore, wear gloves when moving the tent, change them immediately after moving the tent, and avoid further contact with the tent until all sampling activities have been finished and the team is ready to move on to the next site.

6 HEALTH AND SAFETY CONSIDERATIONS

- The ability to safely access the surface water sampling locations must be verified before sampling.
- Field activities must be performed in accordance with the site HASP, a copy of which will be present onsite during such activities.
- Safety hazards associated with sampling surface water include fast-moving water, deep water, and steep slopes close to sampling sites. Use extreme caution when approaching sampling sites.
- If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.
- Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

7 PROCEDURE

7.1 Field Equipment Cleaning

Reusable field sampling equipment will require cleaning between uses. For groundwater sampling, between uses, decontaminate the flow-through cell and any non-dedicated equipment (i.e., interface probe of depth to water meter) that comes into contact with well water. Trowels and other materials used to sample soil samples will also require decontamination, although dedicated, single use equipment such as liners should be used where possible.

After donning a new pair of nitrile gloves:

- Rinse sampling equipment with Alconox or Liquinox® cleaning solution; Scrub equipment with a plastic brush if needed;
- Rinse two times with distilled water or deionized water;

- Rinse one time with “PFAS-free” water or once with methanol/isopropanol/acetone, if it is available, and once with “PFAS-free” water; organic solvents are especially useful for decontaminating soil sampling equipment. If organic cleaning solvents cannot be brought to site, scrub equipment a second time after a single distilled or deionized water rinse, then rinse two times with distilled or deionized water and once with “PFAS-free” water (i.e., two scrubbings and four water rinsings total).
- Collect all rinsate in a sealed pail for disposal. Do not reuse decontamination solutions between sampling locations.

7.2 Borehole/Monitoring Well Development

If a drill rig is being used to drill for soil cores or to install monitoring wells, wear clean nitrile gloves before collecting each continuous soil sample. Additional requirements include the following:

- Verify in writing with the manufacturer that single-use liners used to collect each sample are made of a material that does not contain PFASs;
- Collect soil samples in laboratory-supplied HDPE bottles.
- Store the sample bottles in coolers and keep at a temperature of 0 to 6ºC until transported to the laboratory.

7.2.1 Well Condition Survey/ Water Level Monitoring

Using equipment that has been thoroughly decontaminated according to the procedures in Section 7.1, conduct the well condition surveys and water level monitoring:

- Conduct monitoring well inspections and record water levels.
- Use an interface probe to evaluate presence/absence of non-aqueous phase liquid (NAPL).
- Measure the depth to water from the top of the polyvinyl chloride (PVC) riser and the total depth of the well.
- Record information in the field notes.

7.2.2 Monitoring Well Development and Purging

Follow these requirements for monitoring well development and purging:

- Do not use Teflon™ tubing for purging or sample collection. HDPE tubing is acceptable.
- Do not re-use materials between wells. Upon completion of use, remove all disposable materials (such as HDPE and/or silicone tubing) and place in heavy duty garbage bags for disposal.
- During development of the well, create sufficient energy to agitate the water column and create flow reversals in the well screen, filter pack and formation to loosen fine-grained materials and draw them into the well. The pumping or bailing action should then draw all drilling fluids and fine-grained material out of the borehole and adjacent formation and then out of the well. Review the Arcadis Monitoring Well Development guidance (Arcadis 2010) for more detailed information.
- Follow the low-flow purge and sampling techniques per the U.S. Protection Agency’s (EPA’s) guidance document titled *Low Stress (Low Flow) purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells* (2010) and ASTM’s standard titled *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations* (2002). Also available for review is the Arcadis Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells (Arcadis 2011).

- To purge the well, if using HDPE tubing and a peristaltic pump, insert the end of the tubing to the approximate depth of the midpoint of the screened section of the monitoring wells. Measure the length of HDPE tubing to be inserted into each monitoring well and pre-cut it to approximate lengths (such as the previously measured arm span of a field technician) to avoid contact with any materials other than the monitoring well and peristaltic pump. Flow rates should be as low as can be reasonably achieved. Collect and appropriately dispose of purge water.
- Silicone tubing should direct the purge water through a flow-through cell for field parameter measurements of pH, conductivity, temperature, dissolved oxygen, and turbidity. Calibrate the instrument in the field prior to use. Decontaminate the instrument and flow-through cell at each monitoring well location before purging.
- Record field parameters in intervals (generally of 3-minute duration) to ensure purge water has cycled through the flow-through cell. Sample the wells after field parameter measurements indicate stabilization, which allows collection of representative formation water (generally acceptable standards are three consecutive pH readings to within ±0.1 units, and three consecutive conductivity, temperature and dissolved oxygen measurements to within 3%). Turbidity must be monitored, but does not need to be used as a stabilization indicator of purge completion. Record field parameter measurements at each well. Drawdown should be monitored throughout the purge.
- If wells are suspected to be dewatering throughout the purge (i.e., reduced flow rate/difficulty pumping water or bubbles begin to come through the flow through cell), turn off the pump and allow the water level to recover for ½ hour, followed by sample collection. Document these activities in the field notes.

7.3 Sample Collection

Different laboratories may supply sample collection bottles of varying sizes depending on the type of media to be sampled.

7.3.1 Sample Containers

- Collect samples in HDPE bottles fitted with an unlined (no Teflon™), polypropylene screw cap.
- Complete bottle labels after the caps have been placed back on each bottle.
- Do not use glass bottles due to potential loss of analyte through adsorption. This is particularly important for aqueous samples.
- Review with analytical lab the sample size, sample container, etc. depending upon the type of PFAS analysis that is being requested.

7.3.2 Soil Sampling

Before Sample Collection

- Place plastic sheeting adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Trowels or drilling equipment that will come into contact with a sample should be decontaminated prior to sample collection, preferably with methanol/isopropanol/acetone;
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Collect soil samples using a clean stainless steel trowel or with single-use PFAS-free liners;
- Place soil samples in labeled HDPE bottles supplied by the laboratory.
- Note the time on the sample label.
- Collect any necessary duplicates/co-located samples and matrix spikes – verify with laboratory whether they need to be collected in separate sample bottles.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place soil sample bottles in a sealed Ziploc© bag (optional).
- Record the label information and time of sampling in the field notes.
- Place soil sample bottles in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. Do not use blue ice.

7.3.3 Groundwater Sampling

Before Sample Collection

- Place plastic sheeting adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the labeled HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.
- Measure depth to water and field parameters. Turbidity and the physical appearance of the purged water should be noted on the Groundwater Sampling Log.

During Sample Collection

- Start groundwater sample collection upon stabilization of field parameters.
- If low-flow groundwater sampling techniques are being used, disconnect the silicone tubing from the flow-through cell, enabling collection of groundwater samples prior to passing through the cell.
- Hydrasleeves are also considered acceptable for sampling of PFAS in groundwater – consult the project manager to determine which technique should be used. In general, low flow sampling is preferable.
- Collect groundwater samples (to the neck of the bottle, some headspace is acceptable) from the dedicated sampling ports at the center of the well screen. While collecting the sample, make sure the bottle cap remains in the other hand of the sampler, until replaced on the bottle.
- To mitigate cross contamination, collect groundwater samples in a pre-determined order from least impacted to greater impacted based on previous analytical data or knowledge about past activities at the site. If no analytical data are available, samples are to be collected in the following order:
    1. First sample the upgradient well(s).

   2. Next, sample the well located furthest downgradient of the interpreted or known source.
   3. The remaining wells should be progressively sampled in order from downgradient to upgradient, such that the wells closest to the interpreted or known source are sampled last.
- NOTE: If high concentrations of PFASs related to class B firefighting foams are expected in a groundwater sample, conduct a Shaker test by collecting and shaking a small portion of the sample (~10 to 25 mL) on site in a small disposable vial. If foaming is noted within the sample, document the foaming when samples are submitted for analysis; the 'shaker test' vial can then be disposed. This shaker test provides information about how each of the samples should be handled analytically.
- After collecting the sample, tightly screw on the polypropylene cap (snug, but not too tight). This will minimize leaking or cross contamination of the sample. Most PFASs, including all analytes measured by USEPA Method 537, are not volatile at environmental pH.
- Note the time on the sample label.
- Collect any necessary duplicates and matrix spikes. As the laboratory should be analyzing the entire aqueous sample rather than sub-sampling, separate bottles will be required for these samples.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.
- Do not rinse PFAS sample bottles during sampling. Do not filter samples.

After Sample Collection

- Place groundwater sample bottles in a sealed Ziploc© bag (optional).
- Record the label information and time of sampling in the field notes and COC. Note ‘shake test’ results if appropriate.
- Place groundwater samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Treat all disposable sampling materials as single use and dispose of them appropriately after sampling at each monitoring well.

7.3.4 Sediment Sampling

Before Sample Collection

- Place plastic sheeting (preferably HDPE) adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Where surface water samples and sediment samples are collected at the same location, collect surface water samples first to minimize siltation.

- Collect sediment samples either manually using a stainless steel trowel or using a petite ponar grab sampler, depending on field conditions at each sampling location during sampling program.
- Collect sediment samples from the upper 10 cm of sediment.
- For a sample to be acceptable overlying, low turbidity water must be present.
- Decant the overlying water and use a stainless steel trowel to collect only the upper 5 centimeters (cm) of sediment.
- Collect sediment samples directly into laboratory-supplied bottles that are suitable in both material and size.
- Do not overfill the sample bottle.
- Make sure that the sample does not contain vegetation, that the sediment is undisturbed, and that the sampler shows no signs of winnowing or leaking.
- Make sure bottle caps remain in the gloved hand of the sampler until sampling is complete and caps are replaced on the bottle.
- Note the time on the sample label.
- Collect any necessary duplicates and matrix spikes.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place sample bottles in a sealed Ziploc© bag (optional).
- Record the label information and time of sampling in the field notes.
- Place samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Measure surface water pH, conductivity, temperature, and total dissolved solids (TDS) at each location **after** both surface water and sediment sampling is completed.

7.3.5 Surface Water Sampling

Before Sample Collection

- Place plastic sheeting (preferably HDPE) adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Avoid sampling the surface.
- Where surface water samples and sediment samples are collected at the same location, collect surface water samples first to minimize siltation.

- Collect surface water samples directly into laboratory-supplied bottles; wide-mouth bottles may be preferable to narrow mouth bottles for ease of surface water collection.
- Make sure bottle caps remain in the gloved hand of the sampler until sampling is complete and caps are replaced on the bottle.
- Note the time on the sample bottle.
- Collect any necessary duplicates and matrix spikes. As the laboratory should be analyzing the entire aqueous sample rather than sub-sampling, separate bottles will be required for these samples.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place sample bottles in a sealed Ziploc© bag (optional).
- Record the label information and time of sampling in the field notes.
- Place samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Measure surface water pH, conductivity, temperature, and TDS at each location **after** both surface water and sediment sampling.

7.4 Shipping

- If samples cannot be shipped the same day as collected, arrange an appropriate means of keeping the samples cool overnight and maintain the temperature between 0 and 10°C for the first 48 hours after collection, and then between 0 and 6°C thereafter.
- Store samples in appropriate transport bottles (coolers) with ice (Ziploc© bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Complete the appropriate procedures for COC, handling, packing, and shipping.
- Fill out and check COC Forms against the labels on the sample bottles progressively after each sample is collected.
- Place all disposable sampling materials (such as plastic sheeting, and health and safety equipment) in appropriate containers.
- Ship samples via courier service with priority overnight delivery. Tracking numbers for all shipments should be provided and recorded after they have been sent out to ensure their timely delivery.
- Do not ship samples via Fed Ex for Saturday delivery.

8 WASTE MANAGEMENT

All rinsate should be collected in a sealed pail for disposal. Drill cuttings and purge water will be managed as specified in the Field Sampling Plan (FSP) or Work Plan, and according to state and/or federal requirements. PPE and decontaminated fluids will be contained separately and staged at the sampling location. Containers must be labeled at the time of collection. Labels will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, groundwater, PPE). General guidelines for investigation derived waste (IDW) handling and storage are set forth in a separate IDW guidance document (Arcadis 2009).

Typical waste characterization procedures include collection of a composite sample of the drill cutting material and a composite sample of the purge water for laboratory analysis. Samples are typically analyzed for disposal toxicity characteristic leaching procedure (TCLP) analysis for metals and VOCs. For PFASs, a simple leach test with neutral pH water may be more indicative of actual risk. Additionally, generators of waste are required to include analysis of other constituents that are reasonably believed to be present including (in this case) PFASs.

Emerging contaminants pose a unique challenge for disposal because acceptance of such waste will be based on the local facility and their permit restrictions. Project teams will be required to identify appropriate facilities based on the facility's legal ability to accept the waste and the team should confirm that the facility is meeting the regulatory requirements for accepting waste containing PFASs. In general, facilities that provide solidification and/or incineration will be likely to meet the necessary requirements to accept PFAS-containing waste. The facility will then provide the definitive laboratory analysis requirements needed to meet their permit requirements for waste classification.

9 DATA RECORDING AND MANAGEMENT

9.1 Field Notes

Waterproof field books must not be used for field notes. Instead, field notes should be on loose paper on Masonite, plastic, or aluminum clip boards. Other requirements for field notes include:

- Pens, pencils, and Sharpies may be used.
- Keep field notes and writing implements away from samples and sampling materials.
- One person should conduct sampling while another records field notes.
- Do not write on sampling bottles unless they are closed.

9.2 Other Project Documentation

- Complete Groundwater Sampling Logs.
- Make sure COC Forms are properly completed. Verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the 537 list, etc.) are required for analysis and note on the COC.

10 QUALITY CONTROL

Refer to quality control requirements for the project to ensure that appropriate quality assurance and quality control (QA/QC) samples are collected. When collecting QA/QC samples, the same guidelines apply as when collecting regular samples – specifically that:

- Samples should be collected in laboratory-supplied HDPE bottles;
- Bottle caps must remain in the hand of the sampler until replaced on the bottle;
- Labels must be completed after the caps have been placed back on each bottle; and

- Samples must be stored in appropriate transport bottles (coolers) with ice (Ziploc© bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

10.1 Equipment Blanks (if relevant)

QA/QC sampling typically includes daily collection of equipment blanks using the laboratory-supplied “PFAS-free” water. For peristaltic pump tubing, laboratory supplied “PFAS-free” water should be poured into a clean HDPE sample bottle and then pumped through new HDPE tubing using the peristaltic pump (with new silicone tubing). The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

10.2 Field Duplicates

QA/QC sampling typically includes the collection of one field duplicate for every 10 or 20 samples collected. Each duplicate sample will be collected immediately after the initial sample of which it is a duplicate into a separate laboratory-provided sample bottle. Do not indicate to the laboratory which sample the duplicate replicates, i.e. it should be given a blind reference on the COC and sample name such as “duplicate”.

10.3 Field Reagent Blanks

QA/QC sampling for PFASs typically includes the submission of one laboratory supplied field reagent blank per day. The field reagent blank sample is brought to the site in a laboratory-supplied sample bottle. Field staff transfer the laboratory-supplied reagent blank to an empty sample bottle. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel and should be placed in the same cooler as the other PFAS samples.

10.4 Matrix Spikes (optional in some cases)

QA/QC sampling includes submitting a sample to be used as a matrix spike if the project requires it. If a separate sample bottle is required, an additional sample will be collected immediately after the initial sample of which it is a duplicate into a separate laboratory-supplied sample bottle.

10.5 Laboratory Analytical QA/QC

- Arcadis recommends that any request for PFAS analysis in groundwater or soil should be conducted by an ELAP-accredited method compliant with QSM 5.1 Table B-15. Requirements laid out in Table B-15 strictly govern acceptable laboratory data quality for PFAS analysis in environmental samples. **For all data collection efforts at DoD sites, PFAS data must be obtained using a method that is DoD ELAP-accredited under QSM 5.1 or later.**
- Laboratory QA/QC should consist of one laboratory blank and one laboratory control sample (or blank spike) per batch of samples, and additional QA/QCs as indicated by the laboratory QA/QC procedures.
- Isotope dilution should be used for quantification with isotope-labeled surrogate standards, as available, according to the guidelines of QSM 5.1 Table B-15. USEPA Method 537 does not allow for isotope dilution in their PFAS drinking water method.

- For drinking water, groundwater, and surface water samples, laboratories must extract the entire sample and include a solvent rinse of the bottle for analysis. Aqueous samples should generally not be sub-sampled prior to analysis, unless they are high concentration and require serial dilution (US DoD 2017).
- Soil samples should be analyzed in their entirety or thoroughly homogenized before extraction and analysis.
- As part of the internal QA/QC of laboratory results, relative percent difference (RPD) should be calculated between samples and corresponding field or laboratory duplicates. The laboratory quality assurance portion of the laboratory certificates should be reviewed to verify that all calculations/recoveries were within acceptable limits as established by the laboratory method and guidelines in Table B-15 of QSM 5.1 or later (USDoD 2017).

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