APEX ENGINEERING, PC

Pre-Design Investigation (PDI) Work Plan

BCP Site # C224169
2002-2024 Cropsey Avenue
Brooklyn, New York

PREPARED FOR:

Mr. Peter Neglia
2002 Cropsey Associates, LLC
2611 West 2nd Street
Brooklyn, NY 11223

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Apex Engineering, PC

Table of Contents

Tables:

Figures:

Appendices:

List of Acronyms

AA – Alternatives Analysis

AMSL – Above Mean Sea Level

AOC – Area of Concern

AOPC – Area of Potential or Possible Concern

BCA –Brownfield Cleanup Agreement

BCP – Brownfield Cleanup Program

BGS – Below Grade Surface

BTEX – Benzene, Toluene, Ethylbenzene and Xylenes

CAMP – Community Air Monitoring Plan, Community Air Monitoring Program

COC – Chemical or Contaminant or Concern

CPP – Citizen Participation Plan

CQAP - Construction Quality Assurance Plan

CSM – Conceptual Site Model

CVOCs – Chlorinated Volatile Organic Compounds

DCE - Dichloroethylene

DER - Division of Environmental Remediation

DER-10 - DER Technical Guidance for Site Investigation and Remediation

ECs – Engineering Controls

ERD – Enhanced Reductive Dechlorination

ESA – Environmental Site Assessment

FER – Final Engineering Report

FSP – Field Sampling Plan

GW – Groundwater

GWQS – Groundwater Quality Standard

HASP – Health and Safety Plan

IAQ – Indoor Air Quality

ICs – Institutional Controls

IRM – Interim Remedial Measure

ISCO – In-Situ Chemical Oxidation

ISCR – In-Situ Chemical Reduction

MIP – Membrane Interface Probe

NYCDOF - New York City Department of Finance

NYCRR – New York Code of Rules and Regulations

NYSDEC – New York State Department of Environmental Conservation

NYSDOH – New York State Department of Health

O&M – Operation and Maintenance

OM&M – Operation, Maintenance, and Monitoring

PAHs – Polyaromatic Hydrocarbons

PCBs – Polychlorinated Biphenyl Compounds

PCE -Tetrachloroethylene

PDI – Pre-Design Investigation

QA/QC – Quality Assurance / Quality Control

QAPP – Quality Assurance Project Plan

RAWP – Remedial Action Work Plan

RI – Remedial Investigation

CSM – Conceptual Site Model

SCOs – Soil Cleanup Objectives

SI – Subsurface Investigation

SMP – Site Management Plan

SSDS – Sub-Slab Depressurization System

SV – Soil Vapor

SVI – Soil Vapor Intrusion

SVE – Soil Vapor Extraction

SVOCs – Semi-Volatile Organic Compounds

TAGM – Technical and Administrative Guidance Memorandum

TCE – Trichloroethylene

TCL – Target Compound List

TOGS – Technical and Operational Guidance Series

UIC – Underground Injection Control

USEPA – United States Environmental Protection Agency

USGS – United States Geologic Survey

VOCs – Volatile Organic Compounds

WP – Work Plan

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Brooklyn, New York
NYSDEC BCP# C224169

Engineering Certification:

I, Daniel J. Smith, P.E., certify that I am a New York State registered Professional Engineer and that this Pre-Design Investigation Work Plan (PDI) was prepared in accordance with applicable statutes and regulations and in substantial conformance with the Division of Environmental Remediation (DER) Technical Guidance for Site Investigation and Remediation (DER-10).

Please note that nothing in this certification shall preclude field changes that are determined to be necessary in the event of an emergency to be protective of human health and / or the environment. Any such emergency actions / field changes will be coordinated with DER as soon as practical following resolution of the emergency.

Daniel J. Smith, P.E.
NYS License No. 073173

Pre-Design Investigation Work Plan

2002-2024 Cropsey Avenue Site
Brooklyn, New York
NYSDEC BCP# C224169

Executive Summary

2002 Cropsey Associates, LLC entered into a Brownfield Cleanup Agreement (BCA) with the New York State Department of Environmental Conservation (NYSDEC) in September 2014 to investigate and remediate an approximate 0.49-acre property located at 2002-2024 Cropsey Avenue in Brooklyn, New York ("2002-2024 Cropsey Avenue Property" or "Site"). 2002 Cropsey Associates, LLC is a Participant in the Brownfield Cleanup Program. The 2002-2024 Cropsey Avenue Property is located in a mixed-use, residential and commercial area. Currently, the Site is developed with a strip-retail shopping center. Existing shopping center tenants include a luncheonette and restaurant, a nail salon, convenience / drug store, distributors / traders, and a dry cleaner (not the same as the historic dry cleaner associated with contamination at the site). A former dry cleaner operation had reportedly used chlorinated solvents (tetrachloroethene [PCE]) which have impacted vadose zone soil, soil vapor, and groundwater.

The vadose zone soil impacts are limited to the footprint of the shopping center basement. The impacted soil vapor and groundwater have migrated offsite. Impacted soil vapor has been detected underlying the residential buildings south of the Site at 8831 and 8841 20th Avenue. The impacted groundwater plume extends in a narrow band from the Dry Cleaner Area (i.e., the physical tenant space within the Site that has been used by the current and former tenants for dry-cleaning operations) to the southeast along Bay 25th Street. Interim remedial measures (IRMs) were implemented at the Site and the residential properties to the south of the site to address soil vapor intrusion (SVI). A sub-slab depressurization system (SSDS) was installed on the Site and upgrades were made to the parking garage ventilation systems at the residential properties to the south of the Site.

The "Remedial Action Work Plan" (RAWP) describes the proposed remedial activities for the impacts associated with the historical dry-cleaning operations on the 2002-2024 Cropsey Avenue Property. The planned site remedy will include Enhanced Reductive Dechlorination (ERD) to address impacted groundwater together with Institutional Controls (ICs) and engineering controls (ECs). The ICs and ECs will include maintenance of a surface cover system and sub-slab depressurization system (SSDS) to address soil and soil vapors; a Site Management Plan (SMP) to address future site activities to ensure they are protective of human health and the environment and do not adversely impact the remedy; and, and deed notices / restrictions. This document describes the Pre-Design Investigation (PDI) for activities to be completed to support the final design and implementation of the full site remedy as described in the RAWP.

This PDI Work Plan includes the proposed scope of work for updating the groundwater quality data showing the nature and extent of groundwater impacts; evaluation of existing SVI data related to the operation of SSDS; bench-scale and field microcosm studies to obtain data for designing and optimizing the ERD remedy; and the procedures for finalization of the remedial design before implementation.

1.0 Introduction and Objectives

2002 Cropsey Associates, LLC entered into a Brownfield Cleanup Agreement (BCA) with the New York State Department of Environmental Conservation (NYSDEC) in September 2014 to investigate and remediate an approximate 0.49-acre property located at 2002-2024 Cropsey Avenue in Brooklyn, New York. 2002 Cropsey Associates, LLC is a Participant in the Brownfield Cleanup Program (BCP). The site is currently used for commercial purposes (i.e., retail stores).

This Pre-Design Investigation Work Plan (PDI) outlines the procedures to update the groundwater quality data and conduct bench-and field-scale treatability testing to obtain data to support detailed design (e.g. REDOX data, microorganism information, updated contaminant concentration levels, etc.). Data generated will be presented in a PDI Report that will also include the final remedial design for implementation consistent with the RAWP.

1.1 Site Location and Description

The Site at 2002-2024 Cropsey Avenue is located in the County of Kings, Brooklyn, New York and includes entire Block 6467 and Lot 1 on the New York City Department of Finance (NYCDOF) Tax Map. ***Figure 1*** shows the Site location. The Site is situated on an approximately 0.49-acre area bounded by Cropsey Avenue to the northeast, 20th Avenue to the northwest, a residential building with subgrade parking to the south and southwest, and Bay 25th Street to the southeast. (see ***Figure 2***). The property is fully described in **Appendix A** - Metes and Bounds Survey. A global positioning system coordinate for the starting point is included.

The Site is currently improved with a single-story, multi-unit retail building (which has a partial basement) with an approximately 15,000 square foot (ft^2) area. Concrete-paved sidewalks surround the Site building to the northwest, northeast and southeast. There is a small parking area / trash enclosure located at the southwest corner of the building and a small rear access way to the dry-cleaning establishment within the shopping center at the southeast corner of the building. Behind the building to the south is a small unimproved landscaped / grassy area that borders the adjacent residential property to the south (see **Figure 2**).

The elevation of the Site is approximately 20 feet above mean sea level (msl). Surface topography on-Site is relatively flat but regionally consists of a gentle downward slope to the southwest towards Gravesend Bay, which is approximately 1,000 feet from the Site. The layout of the Site and surrounding properties is presented in **Figure 2**. Local groundwater flow near the Site is generally to the south with localized southeast and southwest components towards Gravesend Bay. The Site-specific depth to water is variable but generally is approximately 20 feet below grade surface (bgs). Additional information regarding local soil and groundwater properties is provided in **Sections 2.2** and **2.3**.

Currently, the Site is developed with a strip-retail shopping center. The Site, and the adjacent residential properties, are located within an R6, Residential Zone district. Land use at the Site is commercial and land use at the adjacent properties is residential. Existing shopping center tenants include a luncheonette and restaurant, a nail salon, convenience / drug store, distributors / traders, and a dry-cleaner (not the same as the historic dry cleaner associated with contamination at the site). The current dry cleaner operation, GLY Cleaners, consists of a closed loop hydrocarbon cleaning system. GLY Cleaners also offers tailoring services. Historic dry-cleaning operations which utilized PCE were conducted in the existing dry cleaner tenant space and in the partial basement of the Site.

1.2 Description of the Surrounding Property

The surrounding community is predominantly a mix of residential and commercial properties and includes supporting community infrastructure such as schools, hospitals, utilities, and protective services (police, fire, etc.). There are no sites such as schools, wetlands, rivers or streams located within a quarter mile of the Site.

Residential properties are located immediately adjacent to the site in the hydrogeologically downgradient direction to the south (with southwesterly components locally). These residential properties were included in the RI off-site investigation. Work during this PDI will include limited activities along public right of ways adjacent to the residential areas (e.g., accessing monitoring wells for testing). 2002 Cropsey Associates, LLC will coordinate all activities with adjacent property owners as necessary to obtain access and inform occupants of the proposed activities.

1.3 Current Site Environmental Conditions

A summary of historic environmental investigations is provided in the RAWP by reference. The following is a summary of the most recent investigation performed during the Remedial Investigation (RI)

1.3.1 Soil Vapor

The primary COCs in soil vapor are chlorinated organic compounds, notably PCE and its degradation compound, Trichloroethene (TCE). The likely, but unconfirmed, source of soil vapor impacts are the historic dry cleaner operations within the Site. Data indicates that releases of dry-cleaning solvents likely entered the subsurface at the former dry cleaner location and migrated vertically into groundwater underlying the Site. Once COCs were in groundwater, they migrated to the south-southeast (off-site) with groundwater flow resulting in soil vapor impacts in overlying areas. Migration of soil vapor impacts are generally consistent with groundwater impacts; however, there appears to be more lateral vapor spread outward from the centerline of the groundwater plume impacts. COCs are present underlying the shopping center as well as the adjacent, off-site parking garages. The most significant soil vapor impacts emanate from the Site along the west side of Bay 25th Street and extend off-site to the vicinity of MW-5/5S. COC concentrations decrease several orders of magnitude beyond MW-5/5S and to the east and west beyond approximately 100 feet laterally from the areas exhibiting the most significant groundwater impacts. Soil vapor and associated IAQ data are summarized in ***Tables 1a and 1b*** and presented graphically in ***Figure 3.***

1.3.2 Soil

The primary Volatile Organic Compounds (VOCs) that were detected in soil above Standards, Criteria, and Guidance values (SCGs) include acetone, PCE, TCE and cis-1,2 Dichloroethene (c12DCE). These COCs exceeded the NYSDEC Soil Cleanup Objective (SCO) for protection of groundwater. Unsaturated zone impacts are very localized immediately underlying the Dry Cleaner Area where PCE was detected at 14,000 µg/kg immediately underlying the dry-cleaner basement floor. No other significant concerns were noted in unsaturated zone soils. Soil impacts are delineated. Soil VOC data are summarized in ***Tables 2*** and presented graphically in ***Figure 4*** (RI data) and ***Figure 5*** (historic investigations).

PCE and c12DCE were detected above the groundwater protection SCOs in soil samples MW-5 (off-site) at 30

and 35 feet bgs which is below the water table and likely related to groundwater impacts in that area. TCE was detected above the groundwater protection SCO in soil sampled during MW-5 installation at 35 feet bgs and similar to PCE and c12DCE detected at that location and depth and is also likely present due to elevated groundwater concentrations in that area.

1.3.3 Groundwater

Groundwater impacts are present. Analytical results indicate that several VOCs (PCE and its degradation products TCE and c12DCE primarily) were detected in both on-site and off-site groundwater above their respective SCGs. The distribution of chlorinated VOC concentrations in groundwater has been delineated horizontally and vertically. There appears to be a relatively narrow band of impacts in shallow groundwater originating at the Dry Cleaner Area (near MW-1S) and extending along the western side of Bay 25th Street to the MW-5S area before declining rapidly in concentration toward MW-9 and MW-10. Only minimal impacts were noted both east and west of this narrow band of shallow groundwater impacts. Intermediate depth groundwater impacts at MW-1I were non-detectable indicating minimal to no significant vertical migration from MW-1S impacts. Similarly, the PCE concentration at MW-5I is several orders of magnitude lower than the MW-5S concentrations indicating that vertical migration is defined. Groundwater data are summarized in ***Table 3*** and presented graphically in ***Figure 6*** (RI data) and ***Figure 7*** (historic investigations).

Additional information regarding the contaminants of concern and distribution of impacts is available in the RI Report. There were no significant, non-VOC impacts noted during the RI.

2.0 Pre-Design Investigation Activities and Site Preparation

This section of the PDI Work Plan addresses the preparation, planning and pre-design tasks to be completed prior to full-scale remedy implementation. Although RI activities have been completed and the area of impact has been delineated to select an appropriate remedy, there are activities that still must be completed to support engineering design optimization of the recommended remedy to maximize effectiveness and reduce total project costs. Those activities in advance of full-scale remedy implementation are to be initiated upon PDI Work Plan approval.

A PDI is necessary to confirm that the current IRMs are operating as designed and to refine the design parameters for the ERD remedial alternative. The PDI will consist of an update of the SVI investigation data; a comprehensive groundwater sampling event including all site monitoring wells; additional characterization of the subsurface hydrogeology at the site; and, bench- and limited field-scale treatability testing to confirm ERD's potential effectiveness.

2.1 Utility Markers and Easement Layout

The Participant and its contractors are responsible for the identification of utilities that might be affected by work under the PDI and implementation of all required, appropriate, or necessary health and safety measures during performance of work under this PDI. In addition to public mark-outs through ONE-CALL, DIG-SAFE, NYC 311, etc. a private utility mark-out will also be performed to clear any subsurface activity locations prior to the start of work.

2.2 Supplemental Soil Assessment

Per the request of NYSDEC, a supplemental soil investigation is required and is addressed in this PDI Work Plan. This additional sampling event will serve as confirmatory data to document subsurface soil quality along and within the southernmost property boundary in the grassy area behind the building. The NYSDEC is requiring soil quality data in this location due to the fact that previous soil samples were collected several feet from the property boundary and did not cover the entire rear yard of the Site.

A total of five (5) soil borings will be installed approximately one (1) to two (2) feet north of the property boundary, with the Site limits. Additional soil boring locations are shown in ***Figure 9***.

Two (2) soil samples will be collected from within the unsaturated zone (1-2' bgs and 4-5' bgs) from each of the five (5) soil borings to document soil quality along the property boundary as a result of historic dry-cleaning operations performed on-site. Prior to beginning field work, underground utilities near the drilling areas will be identified. A qualified environmental professional will be onsite during drilling and sampling operations to prepare a boring log for the soil boring location. Additional sample collection specifications are provided in the QAPP.

As stated in Section 1.3.2, the primary VOCs that were detected in soil above SCGs include acetone, PCE, TCE and c12DCE. In addition, the soil data collected during the Phase II ESA and the RI indicate that soil impacts have been delineated and are limited to a small area beneath the basement of the Dry Cleaner. As requested by the NYSDEC, the laboratory analysis for the supplemental soil samples will include VOCs as well as Semi-Volatile Organic Compounds (SVOCs), Target Compound List (TCL) metals, Polychlorinated Biphenyls (PCBs), and pesticides / herbicides.

2.3 Groundwater Monitoring and Hydrogeology Assessment

Due to the phased nature of the RI wherein wells were sequentially added over time, a comprehensive sampling event of all existing monitoring wells is needed to update baseline conditions and confirm the local groundwater flow direction in advance of full-scale, detailed design and remedy implementation. In addition, the NYSDEC guidance document to address Groundwater Sampling for Emerging Contaminants (March 2019) has new requirements for sampling that are also to be addressed during the PDI. This PDI Work Plan and the accompanying QAPP have been updated to address emerging contaminants as required by NYSDEC.

Specifically, the following focused tasks will be completed as part of the PDI for groundwater:

- All existing groundwater monitoring wells will be surveyed and gauged to develop / update the implied groundwater flow direction and the Conceptual Site Model (CSM). The implied groundwater flow direction will be compared to prior (partial) monitoring and gauging events to confirm groundwater flow direction and to serve as the final design basis.
- All 13 monitoring wells (MW-1S, MW-1I, MW-2, MW-3, MW-4S, MW-4I, MW-5S, MW-5I, and MW-6 through MW-10) will be sampled in accordance with the Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells outlined in the QAPP.
- Field monitoring and analytical work to be completed on these samples is as follows:
    - Field parameters including pH, oxidation-reduction potential (ORP), temperature, conductivity, dissolved oxygen, and turbidity will be collected from all locations during groundwater sampling using the procedures outlined in the QAPP.
    - All groundwater samples (thirteen total samples plus QA/QC samples) will be submitted to the laboratory for analysis of VOCs according to EPA Method 8260B. VOC results will be used to confirm the limits of the proposed treatment area and to serve as the basis for the design of ERD pilot test amendment dosages and injection well layout at the site.
    - Groundwater samples will be collected from wells MW-1S, MW-2S, and MW-5S (three total samples) and analyzed for 1,4-dioxane by a modified EPA Method 8270 or by EPA Method 522 and PFAS, by EPA Method 537 (or International Organization for Standardization 25101) as additional requested by the NYSDEC. Since there is no known source of PFAS currently or historically at the property, these three wells will provide sufficient, representative screening level data and will serve to satisfy the NYSDEC requirement for dissolved phase groundwater sample collection and analysis for 1,4-dioxane and PFAS (i.e., "emerging contaminants") for this project. Updated protocols for emerging contaminant sampling are provided in the QAPP addendum included in this PDI Work Plan as ***Appendix B***.
    - Samples collected from MW-1S, MW-2, MW-5S, MW-5I, and MW-10 will be analyzed for select geochemical parameters including nitrate (Method 9056A), sulfate (Method 9056A), manganese and total iron (EPA Method 6010C), ferrous iron (SM3500), dissolved gases including methane, ethane, and ethene (RSK-175), alkalinity (SM 2310B), and total organic carbon (TOC; using Method 9060). These sample locations were selected to be representative of the entire ERD remediation area in the shallow and intermediate zone.
    - In addition to the geochemical parameters described above, samples from MW-1S, MW-2, MW-5S, and MW-5I and MW-10 will be also be analyzed for *dehalococcoides* (DHC) and DHC functional genes using quantitative polymerase chain reaction (qPCR). The qPCR results will be used to determine whether the native microbial populations are capable of degrading chlorinated solvents or whether a bioaugmentation amendment may be beneficial for the site.

Groundwater samples from MW-5S will also be collected for use in microcosm studies as described in ***Section 2.5***.

- Hydraulic conductivity will be measured at the site using *in situ* rising head hydraulic conductivity tests (slug tests). Slug tests will be conducted on monitoring wells MW-1S, MW-5S, and MW-5I. Data generated from the slug tests will be used to calculate hydraulic conductivity values using the Bouwer and Rice method. Slug testing will be conducted in accordance with the In Situ Rising Head Hydraulic Conductivity Test Procedures in the Field Sampling Plan (FSP).
- Results of the PDI investigation for groundwater will be utilized in detailed remedial design and presented in the Remedial Design Report following bench-scale treatability testing.

2.4 Bench-Scale Treatability Tests

Limited bench-scale treatability tests are required to obtain additional data necessary for proper design of an effective ERD system to remediate groundwater. In addition to the groundwater PDI activities identified in the previous section, samples of site soil and groundwater will also be collected for bench-scale treatability testing.

Soil samples will be collected within the saturated zone from one soil boring installed near the MW-1S/MW-1I well pair and one soil boring installed near the MW-5S/M5I well pair. Groundwater sample volume as needed for benchscale testing will be collected from MW-1S and MW-5S. Each soil boring will be advanced to a total depth of approximately 45 feet bgs. Soil samples will be collected in accordance with the QAPP. Prior to beginning field work, underground utilities near the drilling areas will be identified. A qualified environmental professional will be onsite during drilling and sampling operations to prepare a boring log for the soil boring location. Additional sample collection specifications are provided in the QAPP.

One soil sample from each soil boring will be submitted to a materials testing laboratory for grain size/hydrometer analysis. Additionally, one sample from each soil boring will be collected for analysis of maximum oil retention and alkalinity and for use in microcosm studies as described below.

Microcosm studies are a cost-effective means to evaluate biodegradation as a treatment mechanism using site soil and groundwater. The microcosm study is designed to evaluate the effectiveness of electron donor amendment and if necessary, bioaugmentation culture, to treat chlorinated solvents. Site soil and groundwater will be collected as described in above. Microcosms will be prepared for the following treatments:

- Unamended control;
- Electron donor amendment only; and
- Electron donor and bioaugmentation culture.

All microcosms will be allowed to react for a time to be determined based upon professional judgement with pH and ORP of each aqueous phase measured periodically along with aqueous VOC and ethane, ethene, and methane gas concentrations. Following completion of the microcosm studies, a final report will be generated which will include a description of the experimental procedures, raw and evaluated data, a discussion of the data, and conclusions drawn from the study, and an estimate of the electron donor demand for the site.

2.5 Community Air Monitoring Program

The Community Air Monitoring Program (CAMP) will be implemented throughout all PDI ground-intrusive field activities. Concerns noted, if any, will be immediately reported to NYSDEC and corrective measures will be

implemented immediately as necessary to meet the intent of the CAMP.

3.0 Reporting

This section of the PDI outlines the formal and informal reporting to be completed during the PDI.

3.1 Daily Reports

Daily reports will be submitted to NYSDEC and NYSDOH Project Managers by the end of each day following the completion of PDI field activities and will include:

- An update of progress made during the reporting day;
- Locations of work and quantities of material imported and exported from the Site;
- A figure indicating wind direction and location of the CAMP monitoring equipment;
- A summary of all complaints, if any, with relevant details (names, phone numbers);
- A summary of CAMP excursions; and,
- An explanation of notable Site conditions.

Daily reports are not intended to be the mode of communication for notification to the NYSDEC of emergencies (accident, spill), requests for changes to the PDI, or other sensitive or time critical information. However, such conditions must also be included in the daily reports. Emergency conditions and changes to the PDI will be addressed directly to NYSDEC Project Manager via personal communication.

Daily Reports will include a description of daily activities keyed to a map for the Site that identifies work areas. These reports will include a summary of air sampling results, odor and dust problems and corrective actions (if any), and complaints (if any) received from the public. The NYSDEC assigned project number will appear on all reports.

3.2 Monthly Reports

Monthly reports will be submitted to NYSDEC and NYSDOH Project Managers within ten (10) days following the end of the month of the reporting period, or at a time to be mutually agreed upon, and will include:

- Activities relative to the Site during the previous reporting period and those anticipated for the next reporting period, including a quantitative presentation of work performed;
- Description of approved activity modifications, or substantial deviations from the PDI, including changes of work scope and/or schedule, the rationale for the change and the impact, if any, on the overall implementation of the remedy.
- Sampling results received following internal data review and validation, as applicable;
- An update of the remedial schedule including the percentage of project completion, unresolved delays encountered or anticipated that may affect the future schedule, and efforts made to mitigate such delays; and
- Photographs illustrating all major remedial program elements

Throughout the project additional records may be generated. Project records will be available for NYSDEC and NYSDOH for review upon request.

3.3 PDI Report

Upon completion of the PDI activities outlined herein, a PDI Report will be submitted to NYSDEC and NYSDOH for review and approval. The PDI Report will also include the final Remedial Design for the initial injection events for the full ERD remedy which is intended to be implemented immediately following RAWP approval and completion of the PDI phase of the overall project. The PDI Report will include the following elements as a minimum:

- A summary of all work performed during the PDI including text, tables and figures. Appendices with raw data will be provided as applicable.
- An update of the groundwater quality data tables and figures to represent baseline conditions prior to remedy implementation.
- Discussion of the treatability and microcosm study results and their applicability to the design and implementation of the full-scale remedy.
- The final remedial design for full-scale implementation, including the details for the planned first injection events.
- A schedule update for remedy implementation, including associated IC/EC documents (e.g., Site Management Plan, Final Engineering Report. etc.

4.0 Schedule for Implementation

The PDI will be implemented immediately upon NYSDEC approval. It is anticipated that 2-3 weeks for initial mobilization and access coordination will be required before the start of field activities. Once mobilized, Apex anticipates approximately 60 days for completion of all field activities and receipt of related analytical data. The final report will be submitted to NYSDEC 30 days following the receipt of final analytical data. Assuming approval to proceed from NYSDEC by July 1, 2019, the PDI is scheduled to be completed in September 2019.

Tables

Table 1a
Historic Soil Vapor and Indoor Air Sampling Results Summary

Analyte Method TO-15 (ug/m³)	Historical NYSDOH Regulations		2013 and 2015 NYSDOH Revised Standards		Initial screening sampling (sub-slab only)			March 2016 sampling event including sub-slab and IAQ samples									
	Matrix 1 & 2 SubSlab Vapor	Matrix 1 & 2 Indoor Air	Air	Immediate Action Level	SV-6 10/30/15	SV-7 10/30/15	SV-8 10/30/15	SV-9* 3/4/16	IAQ-9* 3/4/16	SV-10 3/9/16	IAQ-10 3/9/16	SV-11 3/4/16	IAQ-11 3/4/16	Ambient 3/9/16	SV-12 3/17/16	SV-13 3/17/16	SV-14 3/17/16	Ambient 3/17/16
Acetone	NA	NA			634	1220	632	363	41.1	527	16	2.2 U	9.7	13	10 U	447	1310	2
1,3-Butadiene	NA	NA			0.27 U	0.27 U	0.27 U	0.062 U	1.7 J	0.24 U	0.062 U	1.6 U	0.55	0.062 U	7.3 U	0.24 U	0.24 U	0.062 U
Benzene	NA	NA			4.8	5.4	6.1	0.64	6.4	3.5	2.6	89.1	8	1.1	33.9 J	15	16	0.099 U
Bromodichloromethane	NA	NA			0.87 U	0.87 U	0.87 U	0.26 U	1 U	1 U	0.26 U	6.6 U	0.26 U	0.26 U	31 U	1 U	1 U	0.26 U
Bromoform	NA	NA			0.85 U	0.85 U	0.85 U	0.17 U	0.65 U	0.65 U	0.17 U	4.1 U	0.17 U	0.17 U	20 U	0.65 U	0.65 U	0.17 U
Bromomethane	NA	NA			0.34 U	0.34 U	0.34 U	0.07 U	0.29 U	0.29 U	0.07 U	1.8 U	0.07 U	0.07 U	8.5 U	0.29 U	0.29 U	0.07 U
Bromoethene	NA	NA			0.35 U	0.35 U	0.35 U	0.079 U	0.32 U	0.32 U	0.079 U	2.1 U	0.079 U	0.079 U	9.6 U	0.32 U	0.32 U	0.079 U
Benzyl Chloride	NA	NA			0.52 U	0.52 U	0.52 U	0.14 U	0.57 U	0.57 U	0.14 U	3.6 U	0.14 U	0.14 U	16 U	0.57 U	0.57 U	0.14 U
Carbon disulfide	NA	NA			0.34 U	0.34 U	0.34 U	2.2	0.4 U	0.4 U	0.097 U	7.8 J	0.097 U	0.097 U	12 U	6.2	5.9	0.097 U
Chlorobenzene	NA	NA			0.6 U	0.6 U	0.6 U	0.26 U	1 U	1 U	0.26 U	6.4 U	0.26 U	0.26 U	30 U	1 U	1 U	0.26 U
Chloroethane	NA	NA			0.23 U	0.23 U	0.23 U	0.095 U	0.37 U	0.37 U	0.095 U	14	0.095 U	0.095 U	11 U	0.37 U	0.37 U	0.095 U
Chloroform	NA	NA			40	0.59 U	12	1.1	0.32 U	0.32 U	0.083 U	2.1 U	0.083 U	0.083 U	9.8 U	57.6	17	0.083 U
Chloromethane	NA	NA			0.25 U	0.25 U	0.25 U	0.11 U	1.4 J	0.43 U	1.8	2.7 U	1.3	1.8	13 U	0.43 U	0.43 U	0.39 J
3-Chloropropene	NA	NA			0.34 U	0.34 U	0.34 U	0.085 U	0.34 U	0.34 U	0.085 U	2.1 U	0.085 U	0.085 U	9.7 U	0.34 U	0.34 U	0.085 U
2-Chlorotoluene	NA	NA			0.67 U	0.67 U	0.67 U	0.088 U	0.35 U	0.35 U	0.088 U	2.2 U	0.088 U	0.088 U	10 U	0.35 U	0.35 U	0.088 U
Carbon tetrachloride	>250 Mitigate	>5 Mitigate			0.62 U	0.62 U	0.62 U	0.2 U	0.75 U	0.75 U	0.2 U	5 U	0.2 U	0.6 J	23 U	0.75 U	0.75 U	0.2 U
Cyclohexane	NA	NA			2.1 J	2.6 J	2.4 J	0.96	0.22 U	0.22 U	0.055 U	2170	1	0.055 U	396	10	7.9	0.055 U
1,1-Dichloroethane	NA	NA			0.49 U	0.49 U	0.49 U	0.061 U	0.25 U	0.25 U	0.061 U	1.6 U	0.061 U	0.061 U	7.3 U	0.25 U	0.25 U	0.061 U
1,1-Dichloroethylene	NA	NA			0.44 U	0.44 U	0.44 U	0.083 U	0.33 U	0.33 U	0.083 U	2.1 U	0.083 U	0.083 U	9.9 U	0.33 U	0.33 U	0.083 U
1,2-Dibromoethane	NA	NA			1.1 U	1.1 U	1.1 U	0.32 U	1.3 U	1.3 U	0.32 U	8.5 U	0.32 U	0.32 U	38 U	1.3 U	1.3 U	0.32 U
1,2-Dichloroethane	NA	NA			0.4 U	0.4 U	0.4 U	0.073 U	0.28 U	0.28 U	0.073 U	1.8 U	0.073 U	0.073 U	8.5 U	0.28 U	0.28 U	0.073 U
1,2-Dichloropropane	NA	NA			0.92 U	0.92 U	0.92 U	0.1 U	0.41 U	0.41 U	0.1 U	2.6 U	0.1 U	0.1 U	12 U	0.41 U	0.41 U	0.1 U
1,4-Dioxane	NA	NA			0.9 U	0.9 U	0.9 U	0.16 U	0.65 U	0.65 U	0.16 U	4.3 U	0.16 U	0.16 U	19 U	0.65 U	0.65 U	0.16 U
Dichlorodifluoromethane	NA	NA			2.8 J	2.6 J	3 J	2.7	2.4 J	2.8 J	3.2	2.4 U	2.8	3.4	11 U	2.9 J	2.9 J	0.69 J
Dibromochloromethane	NA	NA			1.4 U	1.4 U	1.4 U	0.45 U	1.8 U	1.8 U	0.45 U	11 U	0.45 U	0.45 U	53 U	1.8 U	1.8 U	0.45 U
trans-1,2-Dichloroethylene	NA	NA			0.32 U	0.32 U	6.3	0.11 U	0.44 U	0.44 U	0.11 U	18 J	0.11 U	0.11 U	13 U	0.44 U	0.44 U	0.11 U
cis-1,2-Dichloroethylene	>1000 Mitigate	>100 Mitigate			0.39 U	0.39 U	6.3	0.083 U	0.33 U	0.33 U	0.083 U	2.1 U	0.083 U	0.083 U	120	0.33 U	0.33 U	0.083 U
cis-1,3-Dichloropropene	NA	NA			0.64 U	0.64 U	0.64 U	0.068 U	0.28 U	0.28 U	0.068 U	1.8 U	0.068 U	0.068 U	8.2 U	0.28 U	0.28 U	0.068 U
m-Dichlorobenzene	NA	NA			0.66 U	0.66 U	0.66 U	0.12 U	0.47 U	0.47 U	0.12 U	3 U	0.12 U	0.12 U	14 U	0.47 U	0.47 U	0.12 U
o-Dichlorobenzene	NA	NA			0.72 U	0.72 U	0.72 U	0.096 U	0.38 U	0.38 U	0.096 U	2.5 U	0.096 U	0.096 U	11 U	0.38 U	0.38 U	0.096 U
p-Dichlorobenzene	NA	NA			0.46 U	0.46 U	0.46 U	0.16 U	0.66 U	0.66 U	0.16 U	4.1 U	0.16 U	0.16 U	19 U	0.66 U	0.66 U	0.16 U
trans-1,3-Dichloropropene	NA	NA			0.37 U	0.37 U	0.37 U	0.082 U	0.33 U	0.33 U	0.082 U	2.1 U	0.082 U	0.082 U	10 U	0.33 U	0.33 U	0.082 U
Ethanol	NA	NA			15	16	16	29.2	23.9	88.4	35	41.8	30	21.7	17 U	33.7	37.1	4.7
Ethylbenzene	NA	NA			20	19	15	0.48 J	0.74 U	0.74 U	0.56 J	4.8 U	1.4	0.18 U	50.4 J	79.5	73.4	0.18 U
Ethyl Acetate	NA	NA			0.9 U	10	0.9 U	7.2	5.4	12	6.8	6.8 U	4.3	9.4	32 U	1.1 U	1.1 U	0.76
4-Ethyltoluene	NA	NA			9.3	6.9	5.9	0.084 U	0.33 U	0.33 U	0.084 U	2.1 U	0.084 U	0.084 U	9.8 U	23	19	0.084 U
Freon 113	NA	NA			0.84 U	0.84 U	0.84 U	0.16 U	0.66 U	0.66 U	0.16 U	4.2 U	0.16 U	0.76 J	19 U	0.66 U	0.66 U	0.16 U
Freon 114	NA	NA			0.7 U	0.7 U	0.7 U	0.22 U	0.91 U	0.91 U	0.22 U	5.6 U	0.22 U	0.22 U	26 U	0.91 U	0.91 U	0.22 U
Heptane	NA	NA			19	19	15	0.49 J	0.33 U	0.33 U	0.78 J	1480	1.4	0.41 J	101	63.9	61.9	0.082 U
Hexachlorobutadiene	NA	NA			1.4 U	1.4 U	1.4 U	0.21 U	0.86 U	0.86 U	0.21 U	5.5 U	0.21 U	0.21 U	26 U	0.86 U	0.86 U	0.21 U
Hexane	NA	NA			5.6	7.4	6.7	0.92	3	2 J	2.4	5780	2.9	1.1	1720	20	22	0.67 J
2-Hexanone	NA	NA			27	20	14	2.5	0.74 U	0.74 U	0.18 U	4.5 U	0.18 U	0.18 U	22 U	2.5 J	9	0.18 U
Isopropyl Alcohol	NA	NA			1.2 U	1.2 U	3.9	20	34.2	62.2	4.4	9.8 U	18	4.9	44 U	5.2	9.3	0.81
Methylene chloride	NA	NA			1.9 U	1.9 U	1.9 U	0.63 J	0.35 U	1.5 J	5.6	2.2 U	0.76	1.7	10 U	0.35 U	0.35 U	1.4
Methyl ethyl ketone	NA	NA			56.9	64	36.9	392	0.56 U	776	2.2	1010	0.77	1.3	17 U	23	36.3	0.14 U
Methyl Isobutyl Ketone	NA	NA			0.45 U	0.45 U	0.45 U	4.9	0.9 U	4.9	0.23 U	5.7 U	0.23 U	0.23 U	27 U	8.6	4.9	0.23 U
Methyl Tert Butyl Ether	NA	NA			0.36 U	0.36 U	0.36 U	0.072 U	0.28 U	0.28 U	0.072 U	1.8 U	0.072 U	0.072 U	8.3 U	0.28 U	0.28 U	0.072 U
Methylmethacrylate	NA	NA			0.49 U	0.49 U	0.49 U	0.16 U	0.66 U	0.66 U	0.16 U	4.1 U	0.16 U	0.16 U	19 U	0.66 U	0.66 U	0.16 U
Propylene	NA	NA			0.55 U	4	22.2	2.6	7.9	4.5	5.5	1.4 U	0.055 U	0.055 U	6.5 U	5.5	12	0.055 U
Styrene	NA	NA			0.43 U	0.43 U	0.43 U	0.064 U	0.26 U	0.26 U	0.064 U	1.7 U	0.064 U	0.064 U	7.7 U	0.26 U	0.26 U	0.064 U

Table 1
Historic Soil Vapor and Indoor Air Sampling Results Summary

Analyte Method TO-15 (ug/m³)	Historical NYSDOH Regulations		2013 and 2015 NYSDOH Revised Standards		Initial screening sampling (sub-slab only)			March 2016 sampling event including sub-slab and IAQ samples									
	Matrix 1 & 2 SubSlab Vapor	Matrix 1 & 2 Indoor Air	Air	Immediate Action Level	SV-6 10/30/15	SV-7 10/30/15	SV-8 10/30/15	SV-9* 3/4/16	IAQ-9* 3/4/16	SV-10 3/9/16	IAQ-10 3/9/16	SV-11 3/4/16	IAQ-11 3/4/16	Ambient 3/9/16	SV-12 3/17/16	SV-13 3/17/16	SV-14 3/17/16	Ambient 3/17/16
1,1,1-Trichloroethane	NA	NA			0.71 U	0.71 U	0.71 U	0.13 U	0.51 U	0.51 U	0.13 U	3.3 U	0.13 U	0.13 U	15 U	0.51 U	0.51 U	0.13 U
1,1,2,2-Tetrachloroethane	NA	NA			0.82 U	0.82 U	0.82 U	0.11 U	0.44 U	0.44 U	0.11 U	2.8 U	0.11 U	0.11 U	13 U	0.44 U	0.44 U	0.11 U
1,1,2-Trichloroethane	NA	NA			0.76 U	0.76 U	0.76 U	0.21 U	0.87 U	0.87 U	0.21 U	5.4 U	0.21 U	0.21 U	25 U	0.87 U	0.87 U	0.21 U
1,2,4-Trichlorobenzene	NA	NA			1.3 U	1.3 U	1.3 U	0.42 U	1.6 U	1.6 U	0.42 U	10 U	0.42 U	0.42 U	49 U	1.6 U	1.6 U	0.42 U
1,2,4-Trimethylbenzene	NA	NA			29	21	17	1.6	0.3 U	0.3 U	0.074 U	1.9 U	1.6	0.074 U	8.8 U	80.1	62.9	0.074 U
1,3,5-Trimethylbenzene	NA	NA			9.3	6.9	5.9	0.48 J	0.88 U	0.88 U	0.22 U	5.4 U	0.54 J	0.22 U	26 U	24	19	0.22 U
2,2,4-Trimethylpentane	NA	NA			2.7 J	2.6 J	3.1 J	0.11 U	2.2 J	0.43 U	2.3	2.7 U	5.1	0.84 J	13 U	13	11	0.11 U
Tertiary Butyl Alcohol	NA	NA			22	29	25	20	0.64 U	21	0.16 U	56.4	0.16 U	0.16 U	19 U	3.6	7.6	0.16 U
Tetrachloroethylene	>1000 Mitigate	>100 Mitigate	30	300	753	16	2620	1460	1.1	1500	0.75	7.5	0.49	0.95	18 U	14	258	0.16 U
Tetrahydrofuran	NA	NA			0.5 U	0.5 U	0.5 U	1170	0.53 U	1050	1.5	2450	0.13 U	0.13 U	16 U	0.53 U	0.53 U	0.13 U
Toluene	NA	NA			69.3	67.5	58.4	3.4	7.9	6	4.9	1.2 U	12	2.8	199	357	344	0.49 J
Trichloroethylene	>250 Mitigate	>5 Mitigate	2	20	1.3	0.54 U	157	1	0.4 U	4.3	0.1 U	10	0.1 U	0.1 U	12 U	0.4 U	7.5	0.1 U
Trichlorofluoromethane	NA	NA			1.8 J	0.46 U	0.46 U	1.5	0.49 U	0.49 U	1.9	3.1 U	1.4	2.1	15 U	0.49 U	0.49 U	0.12 U
Vinyl chloride	>250 Mitigate	>5 Mitigate			0.33 U	0.33 U	0.33 U	0.054 U	0.21 U	0.21 U	0.054 U	23	0.054 U	0.054 U	854	0.21 U	0.21 U	0.054 U
Vinyl Acetate	NA	NA			0.77 U	0.77 U	0.77 U	0.19 U	0.77 U	0.77 U	0.19 U	4.9 U	0.19 U	0.19 U	23 U	0.77 U	0.77 U	0.19 U
m,p-Xylene	NA	NA			80.8	69.1	57.8	2	3.5	1.9 J	1.7	7.4 U	6.1	0.96	182	297	264	0.3 U
o-Xylene	NA	NA			27	24	20	1.3	0.87 U	0.87 U	0.65 J	5.6 U	2.1	0.22 U	54.3 J	87.3	76.4	0.22 U
Xylenes (total)	NA	NA			108	93.4	77.7	3.2	3.5	1.9 J	2.3	5.6 U	8.3	0.96	236	384	340	0.22 U

Notes

* - Sub-slab and IAQ results transposed in lab; values tabulated correspond to what is believed to be the correct values
All results recorded in ug/m^3

TABLE 1B

Indoor Air Sampling Results

VOCs (ug/m^3)	Matrix A, B, & C Sub-Slab Soil Vapor	Matrix A, B, & C Indoor Air	IAQ-1 (Dry Cleaner) 2/5/19		IAQ-2 (Hallway) 2/5/19		IAQ-3 (Upwind) 2/5/19	
1,1,1-Trichloroethane	>100 Mitigate	>10 Mitigate	0.109	U	0.109	U	0.109	U
1,1,2,2-Tetrachloroethane	NA	NA	1.37	U	1.37	U	1.37	U
1,1,2-Trichloroethane	NA	NA	1.09	U	1.09	U	1.09	U
1,1-Dichloroethane	NA	NA	0.809	U	0.809	U	0.809	U
1,1-Dichloroethene	>6 Mitigate	>1 Mitigate	0.079	U	0.079	U	0.079	U
1,2,4-Trichlorobenzene	NA	NA	1.48	U	1.48	U	1.48	U
1,2,4-Trimethylbenzene	NA	NA	1.55		1.05		0.983	U
1,2-Dibromoethane	NA	NA	1.54	U	1.54	U	1.54	U
1,2-Dichlorobenzene	NA	NA	1.20	U	1.20	U	1.20	U
1,2-Dichloroethane	NA	NA	0.809	U	0.809	U	0.809	U
1,2-Dichloroethane (total)	NA	NA	0.079	U	0.079	U	0.079	U
1,2-Dichloropropane	NA	NA	0.924	U	0.924	U	0.924	U
1,3,5-Trimethylbenzene	NA	NA	0.983	U	0.983	U	0.983	U
1,3-Butadiene	NA	NA	0.655		0.442	U	0.442	U
1,3-Dichlorobenzene	NA	NA	1.20	U	1.20	U	1.20	U
1,4-Dichlorobenzene	NA	NA	1.20	U	1.20	U	1.20	U
1,4-Dioxane	NA	NA	0.721	U	0.721	U	0.721	U
2,2,4-Trimethylpentane	NA	NA	0.934	U	0.934	U	0.934	U
2-Butanone	NA	NA	2.12		6.55		1.52	
2-Hexanone	NA	NA	0.820	U	0.820	U	0.820	U
3-Chloropropene	NA	NA	0.626	U	0.626	U	0.626	U
4-Ethyltoluene	NA	NA	0.983	U	0.983	U	0.983	U
4-Methyl-2-pentanone	NA	NA	2.05	U	2.05	U	2.05	U
Acetone	NA	NA	69.4		285		9.98	
Benzene	NA	NA	2.98		1.80		1.20	
Benzyl chloride	NA	NA	1.04	U	1.04	U	1.04	U
Bromodichloromethane	NA	NA	1.34	U	1.34	U	1.34	U
Bromoform	NA	NA	2.07	U	2.07	U	2.07	U
Bromomethane	NA	NA	0.777	U	0.777	U	0.777	U
Carbon disulfide	NA	NA	0.623	U	0.623	U	0.623	U
Carbon tetrachloride	>6 Mitigate	>1 Mitigate	0.465		0.453		0.428	
Chlorobenzene	NA	NA	0.921	U	0.921	U	0.921	U
Chloroethane	NA	NA	0.528	U	0.528	U	0.528	U
Chloroform	NA	NA	7.47		0.977	U	0.977	U
Chloromethane	NA	NA	1.41		1.34		1.20	
cis-1,2-Dichloroethene	>6 Mitigate	>1 Mitigate	0.079	U	0.079	U	0.079	U
cis-1,3-Dichloropropene	NA	NA	0.908	U	0.908	U	0.908	U
Cyclohexane	NA	NA	0.688	U	0.688	U	0.688	U
Dibromochloromethane	NA	NA	1.70	U	1.70	U	1.70	U
Dichlorodifluoromethane	NA	NA	2.52		2.33		2.40	
Ethanol	NA	NA	186		184		9.42	U
Ethyl Acetate	NA	NA	2.26	U	13.7		1.80	U

TABLE 1B

Indoor Air Sampling Results

VOCs (ug/m^3)	Matrix A, B, & C Sub-Slab Soil Vapor	Matrix A, B, & C Indoor Air	IAQ-1 (Dry Cleaner) 2/5/19		IAQ-2 (Hallway) 2/5/19		IAQ-3 (Upwind) 2/5/19	
Ethylbenzene	NA	NA	0.869	U	0.869	U	0.869	U
Freon-113	NA	NA	1.53	U	1.53	U	1.53	U
Freon-114	NA	NA	1.40	U	1.40	U	1.40	U
Heptane	NA	NA	1.25		1.14		0.820	U
Hexachlorobutadiene	NA	NA	2.13	U	2.13	U	2.13	U
Isopropanol	NA	NA	32.0		24.3		1.76	
Methyl tert butyl ether	NA	NA	0.721	U	0.721	U	0.721	U
Methylene chloride	>100 Mitigate	>10 Mitigate	1.74	U	1.74	U	1.74	U
n-Hexane	NA	NA	0.895		1.33		0.871	
o-Xylene	NA	NA	0.869	U	0.869	U	0.869	U
p/m-Xylene	NA	NA	1.86		1.74	U	1.74	U
Styrene	NA	NA	0.852	U	0.852	U	0.852	U
Tertiary butyl Alcohol	NA	NA	1.52	U	1.52	U	1.52	U
Tetrachloroethene	>100 Mitigate	>10 Mitigate	**81.4**		4.67		0.651	
Tetrahydrofuran	NA	NA	1.47	U	4.16		1.47	U
Toluene	NA	NA	4.26		6.14		2.85	
trans-1,2-Dichloroethene	NA	NA	0.793	U	0.884		0.793	U
trans-1,3-Dichloropropene	NA	NA	0.908	U	0.908	U	0.908	U
Trichloroethene	>6 Mitigate	>1 Mitigate	0.371		0.107	U	0.107	U
Trichlorofluoromethane	NA	NA	1.15		1.36		1.13	
Vinyl bromide	NA	NA	0.874	U	0.874	U	0.874	U
Vinyl chloride	>6 Mitigate	>0.2 Mitigate	0.051	U	0.051	U	0.051	U

Notes:

1. The foregoing criterions were taken from the *NYSDOH Final Guidance For Evaluating Soil Vapor Intrusion* in New York State of New York, dated October 2006, Matrices revised May 2017
2. VOCs - Volatile Organic Compounds, Method TO-15
3. ug/m^3 - micrograms per cubic meter
4. "--" - Analyte Not Detected at Concentrations Exceeding Method Detection Limit
5. Bolded values indicates the presence of a compund in sample
6. Highlighted Value indicates that the VOC was detected at a concentration exceeding its NYSDOH guidance threshold
7. U = Analyte not detected above laboratory reporting limits

Table 2
Historic Soil Analytical Results Summary

Analyte	NY SCO - Residential w/CP-51 (10/10)	NY SCO - Commercial w/CP-51 (10/10)	NY SCO - Protection of Groundwater	Initial Site Screening Data (October 2015)						January 2016 Investigation					
VOCs	(6 NYCRR 375-6 12/06)	(6 NYCRR 375-6 12/06)	w/CP-51 (10/10) (6 NYCRR 375-6 12/06)	SB-1 1 ft 10/29/2015	SB-1 5 ft 10/29/2015	SB-2 1 ft 10/29/2015	SB-2 5 ft 10/29/2015	SB-3 1 ft 10/29/2015	SB-3 5 ft 10/29/2015	MW-1I 20 ft 1/18/2016	MW-1I 45 ft 1/18/2016	MW-1I 50 ft 1/18/2016	MW-4S 23.5 ft 1/19/2016	MW-4S 30 ft 1/19/2016	MW-4S 40 ft 1/19/2016
Acetone	100	500	0.05	0.0362	0.0025 U	**0.0751**	0.0196	0.014	0.0116	0.003 U	0.0027 U	0.0057 J	0.023	**0.0581**	0.0057 J
Benzene	2.9	44	0.06	0.00014 U	0.00015 U	0.00014 U	0.00014 U	0.00014 U	0.00014 U	0.00018 U	0.00016 U	0.00021 U	0.00018 U	0.00022 U	0.00013 U
Bromochloromethane	-	-	-	0.00032 U	0.00035 U	0.00033 U	0.00033 U	0.00033 U	0.00032 U	0.00042 U	0.00037 U	0.00049 U	0.00042 U	0.0005 U	0.00029 U
Bromodichloromethane	-	-	-	0.00016 U	0.00018 U	0.00016 U	0.00016 U	0.00017 U	0.00016 U	0.00021 U	0.00019 U	0.00025 U	0.00021 U	0.00025 U	0.00015 U
Bromoform	-	-	-	0.00025 U	0.00027 U	0.00025 U	0.00025 U	0.00025 U	0.00024 U	0.00032 U	0.00028 U	0.00038 U	0.00032 U	0.00038 U	0.00022 U
Bromomethane	-	-	-	0.00038 U	0.00041 U	0.00038 U	0.00038 U	0.00039 U	0.00037 U	0.00049 U	0.00043 U	0.00058 U	0.00049 U	0.00059 U	0.00035 U
2-Butanone (MEK)	100	500	0.3	0.002 U	0.0022 U	0.002 U	0.002 U	0.0021 U	0.002 U	0.0026 U	0.0023 U	0.003 U	0.0026 U	0.0031 U	0.0018 U
Carbon disulfide	100		2.7	0.00024 U	0.00026 U	0.00024 U	0.00024 U	0.00024 U	0.00023 U	0.00031 U	0.00027 U	0.00036 U	0.00031 U	0.00037 U	0.00022 U
Carbon tetrachloride	1.4	22	0.76	0.00024 U	0.00026 U	0.00024 U	0.00024 U	0.00025 U	0.00024 U	0.00031 U	0.00027 U	0.00037 U	0.00031 U	0.00037 U	0.00022 U
Chlorobenzene	100	500	1.1	0.00016 U	0.00018 U	0.00016 U	0.00016 U	0.00017 U	0.00016 U	0.00021 U	0.00018 U	0.00025 U	0.00021 U	0.00025 U	0.00015 U
Chloroethane			1.9	0.0005 U	0.00054 U	0.00051 U	0.00051 U	0.00052 U	0.00049 U	0.00065 U	0.00057 U	0.00077 U	0.00065 U	0.00078 U	0.00046 U
Chloroform	10	350	0.37	0.00016 U	0.00017 U	0.00016 U	0.00016 U	0.00016 U	0.00015 U	0.0002 U	0.00018 U	0.00024 U	0.0002 U	0.00024 U	0.00014 U
Chloromethane	-	-	-	0.00027 U	0.0003 U	0.00028 U	0.00028 U	0.00028 U	0.00027 U	0.00035 U	0.00031 U	0.00042 U	0.00035 U	0.00043 U	0.00025 U
Cyclohexane	-	-	-	0.00033 U	0.00036 U	0.00033 U	0.00033 U	0.00034 U	0.00032 U	0.00043 U	0.00038 U	0.0005 U	0.00043 U	0.00051 U	0.0003 U
1,2-Dibromo-3-chloropropane	-	-	-	0.00057 U	0.00062 U	0.00058 U	0.00057 U	0.00058 U	0.00056 U	0.00073 U	0.00065 U	0.00087 U	0.00074 U	0.00089 U	0.00052 U
Dibromochloromethane				0.00021 U	0.00023 U	0.00022 U	0.00022 U	0.00022 U	0.00021 U	0.00028 U	0.00024 U	0.00033 U	0.00028 U	0.00033 U	0.00019 U
1,2-Dibromoethane	-	-	-	0.00014 U	0.00015 U	0.00014 U	0.00014 U	0.00014 U	0.00013 U	0.00018 U	0.00016 U	0.00021 U	0.00018 U	0.00021 U	0.00012 U
1,2-Dichlorobenzene	100	500	1.1	0.00013 U	0.00014 U	0.00013 U	0.00013 U	0.00013 U	0.00013 U	0.00016 U	0.00015 U	0.00019 U	0.00016 U	0.0002 U	0.00012 U
1,3-Dichlorobenzene	17	280	2.4	0.00016 U	0.00018 U	0.00017 U	0.00017 U	0.00017 U	0.00016 U	0.00021 U	0.00019 U	0.00025 U	0.00021 U	0.00026 U	0.00015 U
1,4-Dichlorobenzene	9.8	130	1.8	0.00024 U	0.00025 U	0.00024 U	0.00024 U	0.00024 U	0.00023 U	0.0003 U	0.00027 U	0.00036 U	0.0003 U	0.00037 U	0.00021 U
Dichlorodifluoromethane	-	-	-	0.00038 U	0.00041 U	0.00038 U	0.00038 U	0.00039 U	0.00037 U	0.00049 U	0.00043 U	0.00058 U	0.00049 U	0.00059 U	0.00034 U
1,1-Dichloroethane	19	240	0.27	0.00015 U	0.00016 U	0.00015 U	0.00015 U	0.00015 U	0.00014 U	0.00019 U	0.00017 U	0.00023 U	0.00019 U	0.00023 U	0.00013 U
1,2-Dichloroethane	2.3	30	0.02	0.00014 U	0.00015 U	0.00014 U	0.00014 U	0.00014 U	0.00014 U	0.00018 U	0.00016 U	0.00021 U	0.00018 U	0.00022 U	0.00013 U
1,1-Dichloroethene	100	500	0.33	0.00062 U	0.00067 U	0.00063 U	0.00063 U	0.00064 U	0.00061 U	0.0008 U	0.0007 U	0.00095 U	0.0008 U	0.00096 U	0.00056 U
cis-1,2-Dichloroethene	59	500	0.25	0.00082 U	0.00088 U	0.00082 U	0.00082 U	0.00084 U	0.0008 U	0.0011 U	0.00093 U	0.0012 U	0.0011 U	0.0013 U	0.00074 U
trans-1,2-Dichloroethene	100	500	0.19	0.00062 U	0.00067 U	0.00063 U	0.00063 U	0.00064 U	0.00061 U	0.0008 U	0.00071 U	0.00095 U	0.0008 U	0.00097 U	0.00056 U
1,2-Dichloropropane				0.00025 U	0.00027 U	0.00025 U	0.00025 U	0.00026 U	0.00024 U	0.00032 U	0.00028 U	0.00038 U	0.00032 U	0.00039 U	0.00023 U
cis-1,3-Dichloropropene	-	-	-	0.00012 U	0.00013 U	0.00012 U	0.00012 U	0.00013 U	0.00012 U	0.00016 U	0.00014 U	0.00019 U	0.00016 U	0.00019 U	0.00011 U
trans-1,3-Dichloropropene	-	-	-	0.00019 U	0.0002 U	0.00019 U	0.00019 U	0.00019 U	0.00018 U	0.00024 U	0.00021 U	0.00028 U	0.00024 U	0.00029 U	0.00017 U
Ethylbenzene	30	390	1	0.00017 U	0.00018 U	0.00017 U	0.00017 U	0.00018 U	0.00017 U	0.00022 U	0.00019 U	0.00026 U	0.00022 U	0.00027 U	0.00015 U
Freon 113	100		6	0.00047 U	0.00051 U	0.00047 U	0.00047 U	0.00048 U	0.00046 U	0.0006 U	0.00053 U	0.00072 U	0.00061 U	0.00073 U	0.00042 U
2-Hexanone	-	-	-	0.0014 U	0.0015 U	0.0014 U	0.0014 U	0.0014 U	0.0014 U	0.0018 U	0.0016 U	0.0021 U	0.0018 U	0.0022 U	0.0013 U
Isopropylbenzene	100		2.3	0.00011 U	0.00012 U	0.00011 U	0.00011 U	0.00011 U	0.00011 U	0.00014 U	0.00013 U	0.00017 U	0.00014 U	0.00017 U	0.0001 U
Methyl Acetate	-	-	-	0.0009 U	0.00097 U	0.00091 U	0.00091 U	0.00092 U	0.00088 U	0.0012 U	0.001 U	0.0014 U	0.0012 U	0.0014 U	0.00082 U
Methylcyclohexane	-	-	-	0.00024 U	0.00026 U	0.00024 U	0.00024 U	0.00024 U	0.00023 U	0.00031 U	0.00027 U	0.00036 U	0.00031 U	0.00037 U	0.00022 U
Methyl Tert Butyl Ether	62	500	0.93	0.00016 U	0.00017 U	0.00016 U	0.00016 U	0.00016 U	0.00016 U	0.00021 U	0.00018 U	0.00024 U	0.00021 U	0.00025 U	0.00015 U
4-Methyl-2-pentanone(MIBK)			1	0.00048 U	0.00052 U	0.00049 U	0.00048 U	0.00049 U	0.00047 U	0.00062 U	0.00055 U	0.00073 U	0.00062 U	0.00075 U	0.00044 U
Methylene chloride	51	500	0.05	0.001 U	0.0011 U	0.001 U	0.001 U	0.0011 U	0.001 U	0.0013 U	0.0012 U	0.0016 U	0.0013 U	0.0016 U	0.00093 U
Styrene				0.00019 U	0.0002 U	0.00019 U	0.00019 U	0.00019 U	0.00018 U	0.00024 U	0.00021 U	0.00028 U	0.00024 U	0.00029 U	0.00017 U
1,1,2,2-Tetrachloroethane	35		0.6	0.00018 U	0.0002 U	0.00018 U	0.00018 U	0.00019 U	0.00018 U	0.00024 U	0.00021 U	0.00028 U	0.00024 U	0.00029 U	0.00017 U
Tetrachloroethene	5.5	150	1.3	0.0183	0.0196	0.0347	0.0448	0.0233	0.0238	0.0139	0.0043	0.00048 U	0.00041 U	0.00049 U	0.00029 U
Toluene	100	500	0.7	0.00022 U	0.00024 U	0.00022 U	0.00022 U	0.00022 U	0.00021 U	0.00028 U	0.00025 U	0.00033 U	0.00028 U	0.00034 U	0.0002 U
1,2,3-Trichlorobenzene				0.00018 U	0.0002 U	0.00019 U	0.00019 U	0.00019 U	0.00018 U	0.00024 U	0.00021 U	0.00028 U	0.00024 U	0.00029 U	0.00017 U
1,2,4-Trichlorobenzene			3.4	0.00018 U	0.00019 U	0.00018 U	0.00018 U	0.00018 U	0.00017 U	0.00023 U	0.0002 U	0.00027 U	0.00023 U	0.00028 U	0.00016 U
1,1,1-Trichloroethane	100	500	0.68	0.00016 U	0.00017 U	0.00016 U	0.00016 U	0.00016 U	0.00015 U	0.0002 U	0.00018 U	0.00024 U	0.0002 U	0.00024 U	0.00014 U
1,1,2-Trichloroethane	-	-	-	0.00015 U	0.00017 U	0.00016 U	0.00016 U	0.00016 U	0.00015 U	0.0002 U	0.00017 U	0.00023 U	0.0002 U	0.00024 U	0.00014 U
Trichloroethene	10	200	0.47	0.00015 U	0.0004 J	0.0007 J	0.00088 J	0.00016 U	0.00039 J	0.00074 J	0.00026 J	0.00023 U	0.0002 U	0.00024 U	0.00014 U
Trichlorofluoromethane	-	-	-	0.00026 U	0.00028 U	0.00026 U	0.00026 U	0.00027 U	0.00026 U	0.00034 U	0.0003 U	0.0004 U	0.00034 U	0.00041 U	0.00024 U
Vinyl chloride	0.21	13	0.02	0.00021 U	0.00022 U	0.00021 U	0.00021 U	0.00021 U	0.0002 U	0.00027 U	0.00023 U	0.00031 U	0.00027 U	0.00032 U	0.00019 U
Xylene (total)	100	500	1.6	0.00029 U	0.00031 U	0.00029 U	0.00029 U	0.00029 U	0.00028 U	0.00037 U	0.00033 U	0.00044 U	0.00037 U	0.00045 U	0.00026 U

All values recorded in units of mg/kg.
U = value not detected above the detection limit.
J = Estimated value below the detection limit.

APEX

Table 2
Historic Soil Analytical Results Summary

Analyte VOCs	NY SCO - Residential w/CP-51 (10/10) (6 NYCRR 375-6 12/06)	NY SCO - Commercial w/CP-51 (10/10) (6 NYCRR 375-6 12/06)	NY SCO - Protection of Groundwater w/CP-51 (10/10) (6 NYCRR 375-6 12/06)	March 2016 Investigation						
				MW-5 22.5 ft 3/8/2016	MW-5 30 ft 3/8/2016	MW-5 35 ft 3/8/2016	MW-6 23 ft 3/8/2016	MW-6 30 ft 3/8/2016	MW-7 23 ft 3/8/2016	MW-7 34 ft 3/8/2016
Acetone	100	500	0.05	0.0129 J	0.0029 U	0.0029 U	**0.203**	**0.283**	0.029 U	0.033 U
Benzene	2.9	44	0.06	0.00017 U	0.00017 U	0.00017 U	0.0022 U	0.003 U	0.0017 U	0.002 U
Bromochloromethane	-	-	-	0.0004 U	0.0004 U	0.0004 U	0.0052 U	0.0069 U	0.004 U	0.0045 U
Bromodichloromethane	-	-	-	0.0002 U	0.0002 U	0.0002 U	0.0026 U	0.0035 U	0.002 U	0.0023 U
Bromoform	-	-	-	0.00031 U	0.00031 U	0.00031 U	0.004 U	0.0053 U	0.003 U	0.0035 U
Bromomethane	-	-	-	0.00048 U	0.00048 U	0.00048 U	0.0061 U	0.0082 U	0.0047 U	0.0053 U
2-Butanone (MEK)	100	500	0.3	0.0025 U	0.0025 U	0.0025 U	0.032 U	0.043 U	0.024 U	0.028 U
Carbon disulfide	100		2.7	0.0003 U	0.0003 U	0.0003 U	0.0038 U	0.0051 U	0.0029 U	0.0034 U
Carbon tetrachloride	1.4	22	0.76	0.0003 U	0.0003 U	0.0003 U	0.0039 U	0.0052 U	0.0029 U	0.0034 U
Chlorobenzene	100	500	1.1	0.0002 U	0.0002 U	0.0002 U	0.0026 U	0.0035 U	0.002 U	0.0023 U
Chloroethane			1.9	0.00063 U	0.00063 U	0.00063 U	0.0081 U	0.011 U	0.0062 U	0.0071 U
Chloroform	10	350	0.37	0.00019 U	0.00019 U	0.00019 U	0.0025 U	0.0033 U	0.0019 U	0.0022 U
Chloromethane	-	-	-	0.00034 U	0.00034 U	0.00034 U	0.0044 U	0.0059 U	0.0034 U	0.0039 U
Cyclohexane	-	-	-	0.00041 U	0.00041 U	0.00041 U	0.0053 U	0.0071 U	0.004 U	0.0046 U
1,2-Dibromo-3-chloropropane	-	-	-	0.00071 U	0.00071 U	0.00071 U	0.0091 U	0.012 U	0.007 U	0.008 U
Dibromochloromethane				0.00027 U	0.00027 U	0.00027 U	0.0034 U	0.0046 U	0.0026 U	0.003 U
1,2-Dibromoethane	-	-	-	0.00017 U	0.00017 U	0.00017 U	0.0022 U	0.0029 U	0.0017 U	0.0019 U
1,2-Dichlorobenzene	100	500	1.1	0.00016 U	0.00016 U	0.00031 J	0.002 U	0.0027 U	0.0016 U	0.0018 U
1,3-Dichlorobenzene	17	280	2.4	0.00021 U	0.00021 U	0.00021 U	0.0026 U	0.0035 U	0.002 U	0.0023 U
1,4-Dichlorobenzene	9.8	130	1.8	0.00029 U	0.00029 U	0.00029 U	0.0038 U	0.005 U	0.0029 U	0.0033 U
Dichlorodifluoromethane	-	-	-	0.00047 U	0.00047 U	0.00047 U	0.0061 U	0.0081 U	0.0046 U	0.0053 U
1,1-Dichloroethane	19	240	0.27	0.00018 U	0.00018 U	0.00018 U	0.0024 U	0.0032 U	0.0018 U	0.0021 U
1,2-Dichloroethane	2.3	30	0.02	0.00018 U	0.00018 U	0.00018 U	0.0023 U	0.003 U	0.0017 U	0.002 U
1,1-Dichloroethene	100	500	0.33	0.00077 U	0.00077 U	0.0025	0.0099 U	0.013 U	0.0076 U	0.0087 U
cis-1,2-Dichloroethene	59	500	0.25	0.001 U	**2.44**	**3.67**	0.013 U	0.017 U	0.01 U	0.011 U
trans-1,2-Dichloroethene	100	500	0.19	0.00078 U	0.00078 U	0.0044	0.01 U	0.013 U	0.0076 U	0.0087 U
1,2-Dichloropropane				0.00031 U	0.00031 U	0.00031 U	0.004 U	0.0053 U	0.003 U	0.0035 U
cis-1,3-Dichloropropene	-	-	-	0.00015 U	0.00015 U	0.00015 U	0.002 U	0.0026 U	0.0015 U	0.0017 U
trans-1,3-Dichloropropene	-	-	-	0.00023 U	0.00023 U	0.00023 U	0.003 U	0.004 U	0.0023 U	0.0026 U
Ethylbenzene	30	390	1	0.0053	0.00021 U	0.00021 U	0.01 J	0.0088 J	0.0021 U	0.0024 U
Freon 113	100		6	0.00059 U	0.00059 U	0.00059 U	0.0075 U	0.01 U	0.0057 U	0.0066 U
2-Hexanone	-	-	-	0.0018 U	0.0018 U	0.0018 U	0.023 U	0.03 U	0.017 U	0.02 U
Isopropylbenzene	100		2.3	0.00014 U	0.00014 U	0.00015 J	0.0018 U	0.0024 U	0.0014 U	0.0016 U
Methyl Acetate	-	-	-	0.0011 U	0.0011 U	0.0011 U	0.014 U	0.019 U	0.011 U	0.013 U
Methylcyclohexane	-	-	-	0.0003 U	0.0003 U	0.0003 U	0.0038 U	0.0051 U	0.0029 U	0.0033 U
Methyl Tert Butyl Ether	62	500	0.93	0.0002 U	0.0002 U	0.0002 U	0.0026 U	0.0034 U	0.002 U	0.0022 U
4-Methyl-2-pentanone(MIBK)			1	0.0006 U	0.0006 U	0.0006 U	0.0077 U	0.01 U	0.0059 U	0.0067 U
Methylene chloride	51	500	0.05	0.0013 U	0.0013 U	0.0013 U	0.016 U	0.022 U	0.013 U	0.014 U
Styrene				0.00023 U	0.00023 U	0.00023 U	0.003 U	0.004 U	0.0023 U	0.0026 U
1,1,2,2-Tetrachloroethane	35		0.6	0.00023 U	0.00023 U	0.00023 U	0.0029 U	0.0039 U	0.0022 U	0.0026 U
Tetrachloroethene	5.5	150	1.3	0.0114	**2.74**	**3.35**	0.0051 U	0.0067 U	0.0039 U	0.0076 J
Toluene	100	500	0.7	0.117	0.00027 U	0.00027 U	0.143	0.124	0.0027 U	0.0031 U
1,2,3-Trichlorobenzene				0.00023 U	0.00023 U	0.00023 U	0.003 U	0.0039 U	0.0023 U	0.0026 U
1,2,4-Trichlorobenzene			3.4	0.00022 U	0.00022 U	0.00022 U	0.0028 U	0.0038 U	0.0022 U	0.0025 U
1,1,1-Trichloroethane	100	500	0.68	0.00019 U	0.00019 U	0.00019 U	0.0025 U	0.0033 U	0.0019 U	0.0022 U
1,1,2-Trichloroethane	-	-	-	0.00019 U	0.00019 U	0.00019 U	0.0025 U	0.0033 U	0.0019 U	0.0022 U
Trichloroethene	10	200	0.47	0.00019 U	0.101	**0.636**	0.0025 U	0.0033 U	0.0019 U	0.0022 U
Trichlorofluoromethane	-	-	-	0.00033 U	0.00033 U	0.00033 U	0.0042 U	0.0056 U	0.0032 U	0.0037 U
Vinyl chloride	0.21	13	0.02	0.00026 U	0.00026 U	0.00026 U	0.0033 U	0.0044 U	0.0025 U	0.0029 U
Xylene (total)	100	500	1.6	0.0265	0.00036 U	0.00036 U	0.0564	0.0436	0.0035 U	0.004 U

All values recorded in units of mg/kg.
U = value not detected above the detection limit.
J = Estimated value below the detection limit.

APEX

Table 2
Historic Soil Analytical Results Summary

Analyte VOCs	NY SCO - Residential w/CP-51 (10/10) (6 NYCRR 375-6 12/06)	NY SCO - Commercial w/CP-51 (10/10) (6 NYCRR 375-6 12/06)	NY SCO - Protection of Groundwater w/CP-51 (10/10) (6 NYCRR 375-6 12/06)	June 2016 Investigation									
				MW-5I 20 ft 6/22/2016	MW-5I 23 ft 6/22/2016	MW-5I ft 6/22/2016	MW-5I 50 ft 6/22/2016	MW-8 19.5 ft 6/22/2016	MW-8 30 ft 6/22/2016	MW-9 19.4 ft 6/22/2016	MW-9 30 ft 6/22/2016	MW-10 19.5 ft 6/22/2016	MW-10 30 ft 6/22/2016
Acetone	100	500	0.05	0.0022 U	0.0022 U	0.0024 U	0.0026 U	0.0023 U	0.0296	0.0077 J	0.002 U	0.0027 U	0.0025 U
Benzene	2.9	44	0.06	0.00014 U	0.00014 U	0.00016 U	0.00017 U	0.00015 U	0.00013 U	0.00015 U	0.00013 U	0.00017 U	0.00016 U
Bromochloromethane	-	-	-	0.00038 U	0.00038 U	0.00041 U	0.00044 U	0.0004 U	0.00036 U	0.0004 U	0.00035 U	0.00046 U	0.00042 U
Bromodichloromethane	-	-	-	0.00018 U	0.00018 U	0.0002 U	0.00021 U	0.00019 U	0.00017 U	0.00019 U	0.00017 U	0.00022 U	0.0002 U
Bromoform	-	-	-	0.00032 U	0.00032 U	0.00034 U	0.00037 U	0.00033 U	0.0003 U	0.00033 U	0.00029 U	0.00039 U	0.00035 U
Bromomethane	-	-	-	0.00058 U	0.00058 U	0.00063 U	0.00067 U	0.00061 U	0.00054 U	0.0006 U	0.00053 U	0.00071 U	0.00064 U
2-Butanone (MEK)	100	500	0.3	0.0021 U	0.0021 U	0.0023 U	0.0024 U	0.0022 U	0.002 U	0.0022 U	0.0019 U	0.0026 U	0.0023 U
Carbon disulfide	100		2.7	0.0002 U	0.0002 U	0.00022 U	0.00023 U	0.00021 U	0.00019 U	0.00021 U	0.00018 U	0.00025 U	0.00022 U
Carbon tetrachloride	1.4	22	0.76	0.0002 U	0.0002 U	0.00022 U	0.00023 U	0.00021 U	0.00019 U	0.00021 U	0.00018 U	0.00024 U	0.00022 U
Chlorobenzene	100	500	1.1	0.00019 U	0.00019 U	0.00021 U	0.00022 U	0.0002 U	0.00018 U	0.0002 U	0.00018 U	0.00024 U	0.00021 U
Chloroethane			1.9	0.00051 U	0.00051 U	0.00056 U	0.00059 U	0.00054 U	0.00048 U	0.00053 U	0.00047 U	0.00063 U	0.00056 U
Chloroform	10	350	0.37	0.00028 U	0.00028 U	0.00031 U	0.00033 U	0.0003 U	0.00027 U	0.0003 U	0.00026 U	0.00035 U	0.00031 U
Chloromethane	-	-	-	0.00025 U	0.00025 U	0.00027 U	0.00029 U	0.00026 U	0.00024 U	0.00026 U	0.00023 U	0.00031 U	0.00028 U
Cyclohexane	-	-	-	0.00065 U	0.00065 U	0.00071 U	0.00075 U	0.00068 U	0.00061 U	0.00068 U	0.00059 U	0.0008 U	0.00072 U
1,2-Dibromo-3-chloropropane	-	-	-	0.00058 U	0.00057 U	0.00063 U	0.00067 U	0.00061 U	0.00054 U	0.0006 U	0.00053 U	0.00071 U	0.00064 U
Dibromochloromethane				0.00018 U	0.00018 U	0.00019 U	0.00021 U	0.00019 U	0.00017 U	0.00019 U	0.00016 U	0.00022 U	0.0002 U
1,2-Dibromoethane	-	-	-	0.00029 U	0.00029 U	0.00031 U	0.00033 U	0.0003 U	0.00027 U	0.0003 U	0.00026 U	0.00035 U	0.00032 U
1,2-Dichlorobenzene	100	500	1.1	0.0002 U	0.0002 U	0.00022 U	0.00024 U	0.00021 U	0.00019 U	0.00021 U	0.00019 U	0.00025 U	0.00022 U
1,3-Dichlorobenzene	17	280	2.4	0.00016 U	0.00016 U	0.00018 U	0.00019 U	0.00017 U	0.00015 U	0.00017 U	0.00015 U	0.0002 U	0.00018 U
1,4-Dichlorobenzene	9.8	130	1.8	0.00018 U	0.00018 U	0.0002 U	0.00021 U	0.00019 U	0.00017 U	0.00019 U	0.00017 U	0.00022 U	0.0002 U
Dichlorodifluoromethane	-	-	-	0.00065 U	0.00065 U	0.00071 U	0.00075 U	0.00068 U	0.00061 U	0.00068 U	0.00059 U	0.00079 U	0.00072 U
1,1-Dichloroethane	19	240	0.27	0.00022 U	0.00022 U	0.00024 U	0.00026 U	0.00023 U	0.00021 U	0.00023 U	0.0002 U	0.00027 U	0.00025 U
1,2-Dichloroethane	2.3	30	0.02	0.0002 U	0.0002 U	0.00022 U	0.00024 U	0.00021 U	0.00019 U	0.00021 U	0.00019 U	0.00025 U	0.00022 U
1,1-Dichloroethene	100	500	0.33	0.00018 U	0.00018 U	0.0002 U	0.00021 U	0.00019 U	0.00017 U	0.00019 U	0.00017 U	0.00022 U	0.0002 U
cis-1,2-Dichloroethene	59	500	0.25	0.0308	0.00052 U	0.00057 U	0.0006 U	0.00055 U	0.00049 U	0.00054 U	0.00082 J	0.00064 U	0.00058 U
trans-1,2-Dichloroethene	100	500	0.19	0.00019 U	0.00019 U	0.0002 U	0.00022 U	0.0002 U	0.00018 U	0.0002 U	0.00017 U	0.00023 U	0.00021 U
1,2-Dichloropropane				0.00037 U	0.00037 U	0.0004 U	0.00043 U	0.00039 U	0.00035 U	0.00038 U	0.00034 U	0.00045 U	0.00041 U
cis-1,3-Dichloropropene	-	-	-	0.00023 U	0.00023 U	0.00025 U	0.00027 U	0.00025 U	0.00022 U	0.00024 U	0.00021 U	0.00029 U	0.00026 U
trans-1,3-Dichloropropene	-	-	-	0.00026 U	0.00026 U	0.00029 U	0.0003 U	0.00028 U	0.00025 U	0.00027 U	0.00024 U	0.00032 U	0.00029 U
Ethylbenzene	30	390	1	0.00018 U	0.00018 U	0.00019 U	0.00021 U	0.00019 U	0.00017 U	0.00018 U	0.00016 U	0.00022 U	0.0002 U
Freon 113	100		6	0.00058 U	0.00057 U	0.00063 U	0.00067 U	0.00061 U	0.00054 U	0.0006 U	0.00053 U	0.00071 U	0.00064 U
2-Hexanone	-	-	-	0.0017 U	0.0017 U	0.0018 U	0.0019 U	0.0017 U	0.0016 U	0.0017 U	0.0015 U	0.002 U	0.0018 U
Isopropylbenzene	100		2.3	0.00018 U	0.00018 U	0.0002 U	0.00021 U	0.00019 U	0.00017 U	0.00019 U	0.00017 U	0.00022 U	0.0002 U
Methyl Acetate	-	-	-	0.0024 U	0.0024 U	0.0026 U	0.0028 U	0.0025 U	0.0023 U	0.0025 U	0.0022 U	0.003 U	0.0027 U
Methylcyclohexane	-	-	-	0.0006 U	0.0006 U	0.00065 U	0.0007 U	0.00063 U	0.00057 U	0.00063 U	0.00055 U	0.00074 U	0.00066 U
Methyl Tert Butyl Ether	62	500	0.93	0.00032 U	0.00031 U	0.00034 U	0.00036 U	0.00033 U	0.0003 U	0.00033 U	0.00029 U	0.00039 U	0.00035 U
4-Methyl-2-pentanone(MIBK)			1	0.001 U	0.001 U	0.0011 U	0.0012 U	0.0011 U	0.00095 U	0.0011 U	0.00092 U	0.0012 U	0.0011 U
Methylene chloride	51	500	0.05	0.0014 J	0.0011 J	0.00098 J	0.0011 J	0.0012 J	0.00051 J	0.0015 J	0.0012 J	0.0012 J	0.0012 J
Styrene				0.00017 U	0.00017 U	0.00019 U	0.0002 U	0.00018 U	0.00016 U	0.00018 U	0.00016 U	0.00021 U	0.00019 U
1,1,2,2-Tetrachloroethane	35		0.6	0.00029 U	0.00028 U	0.00031 U	0.00033 U	0.0003 U	0.00027 U	0.0003 U	0.00026 U	0.00035 U	0.00031 U
Tetrachloroethene	5.5	150	1.3	0.736	0.0036	0.0022 J	0.0026 J	0.00035 U	0.00048 J	0.00035 U	0.0028	0.00077 J	0.0011 J
Toluene	100	500	0.7	0.00015 U	0.00015 U	0.00016 U	0.00017 U	0.00016 U	0.00014 U	0.00015 U	0.00014 U	0.00018 U	0.00016 U
1,2,3-Trichlorobenzene				0.00027 U	0.00027 U	0.00029 U	0.00031 U	0.00028 U	0.00025 U	0.00028 U	0.00025 U	0.00033 U	0.0003 U
1,2,4-Trichlorobenzene			3.4	0.00022 U	0.00022 U	0.00024 U	0.00025 U	0.00023 U	0.0002 U	0.00023 U	0.0002 U	0.00027 U	0.00024 U
1,1,1-Trichloroethane	100	500	0.68	0.0002 U	0.0002 U	0.00022 U	0.00023 U	0.00021 U	0.00019 U	0.00021 U	0.00018 U	0.00024 U	0.00022 U
1,1,2-Trichloroethane	-	-	-	0.00039 U	0.00038 U	0.00042 U	0.00044 U	0.0004 U	0.00036 U	0.0004 U	0.00035 U	0.00047 U	0.00042 U
Trichloroethene	10	200	0.47	0.0039	0.00026 J	0.00025 U	0.00026 U	0.00024 U	0.00021 U	0.00024 U	0.00021 U	0.00028 U	0.00025 U
Trichlorofluoromethane	-	-	-	0.00075 U	0.00075 U	0.00082 U	0.00087 U	0.00079 U	0.00071 U	0.00078 U	0.00068 U	0.00092 U	0.00083 U
Vinyl chloride	0.21	13	0.02	0.00024 U	0.00024 U	0.00026 U	0.00028 U	0.00025 U	0.00023 U	0.00025 U	0.00022 U	0.00029 U	0.00027 U
Xylene (total)	100	500	1.6	0.00024 U	0.00024 U	0.00026 U	0.00028 U	0.00025 U	0.00023 U	0.00025 U	0.00022 U	0.00029 U	0.00027 U

All values recorded in units of mg/kg.
U = value not detected above the detection limit.
J = Estimated value below the detection limit.

APEX

Table 3
Historic Groundwater Sampling Results Summary (VOCs)

Analyte VOCs	NYSDEC Class GA Groundwater Quality Standard	February 2016 Investigation Summary												March 2016 Supplemental Data						July 2016 Supplemental Data							
		MW-1I 2/10/2016		MW-1S 2/10/2016		MW-2 2/10/2016		MW-3 2/10/2016		MW-4S 2/10/2016		MW-4I 2/10/2016		MW-5S 3/18/2016		MW-6 3/18/2016		MW-7 3/18/2016		MW-5I 7/8/2016		MW-8 7/8/2016		MW-9 7/8/2016		MW-10 7/8/2016	
Acetone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.8	U	3.8	U	3.8	U	3.8	U
Acrolein	5	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	16	U	1.6	U	1.6	U	-	-	-	-	-	-	-	-
Acrylonitrile	5	2.6	U	2.6	U	2.6	U	2.6	U	2.6	U	2.6	U	26	U	2.6	U	2.6	U	-	-	-	-	-	-	-	-
Benzene	1	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	1	U	0.1	U	0.1	U	0.14	U	0.14	U	0.66		0.14	U
Bromochloromethane	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.46	U	0.46	U	0.46	U	0.46	U
Bromodichloromethane	-	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	1	U	0.1	U	0.1	U	0.55	U	0.55	U	0.55	U	0.55	U
Bromoform	-	0.17	U	0.17	U	0.17	U	0.17	U	0.17	U	0.17	U	1.7	U	0.17	U	0.17	U	0.34	U	0.34	U	0.34	U	0.34	U
Bromomethane	5	0.57	U	0.57	U	0.57	U	0.57	U	0.57	U	0.57	U	5.7	U	0.57	U	0.57	U	0.46	U	0.46	U	0.46	U	0.46	U
2-Butanone (MEK)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9	U	1.9	U	1.9	U	1.9	U
Carbon disulfide		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33	U	0.33	U	0.33	U	0.33	U
Carbon tetrachloride	5	0.096	U	0.096	U	0.096	U	0.096	U	0.096	U	0.096	U	0.96	U	0.096	U	0.096	U	0.54	U	0.54	U	0.54	U	0.54	U
Chlorobenzene	5	0.093	U	0.093	U	0.093	U	0.093	U	0.093	U	0.093	U	0.93	U	0.093	U	0.093	U	0.17	U	0.17	U	0.17	U	0.17	U
Chloroethane	5	0.21	U	0.21	U	0.21	U	0.21	U	0.21	U	0.21	U	2.1	U	0.21	U	0.21	U	0.44	U	0.44	U	0.44	U	0.44	U
2-Chloroethyl vinyl ether	-	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	5	U	0.5	U	0.5	U	-	-	-	-	-	-	-	-
Chloroform	7	0.89	J	0.49	J	0.62	J	0.51	J	0.56	J	0.52	J	0.91	U	0.091	U	1.5		0.78	J	0.23	U	0.23	U	0.33	J
Chloromethane	5	0.11	U	0.11	U	0.11	U	0.11	U	0.11	U	0.11	U	1.1	U	0.11	U	0.11	U	0.96	U	0.96	U	0.96	U	0.96	U
Cyclohexane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.73	U	0.73	U	0.73	U	0.73	U
1,2-Dibromo-3-chloropropane	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.69	U	0.69	U	0.69	U	0.69	U
Dibromochloromethane	-	0.15	U	0.15	U	0.15	U	0.15	U	0.15	U	0.15	U	1.5	U	0.15	U	0.15	U	0.23	U	0.23	U	0.23	U	0.23	U
1,2-Dibromoethane	0.0006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22	U	0.22	U	0.22	U	0.22	U
1,2-Dichlorobenzene	3	0.19	U	0.72	J	0.19	U	0.19	U	0.19	U	0.19	U	1.9	U	0.19	U	0.19	U	0.23	U	0.23	U	0.23	U	0.23	U
1,3-Dichlorobenzene	3	0.19	U	0.19	U	0.19	U	0.19	U	0.19	U	0.19	U	1.9	U	0.19	U	0.19	U	0.19	U	0.19	U	0.19	U	0.19	U
1,4-Dichlorobenzene	3	0.11	U	0.11	U	0.11	U	0.11	U	0.11	U	0.11	U	1.1	U	0.11	U	0.11	U	0.21	U	0.21	U	0.21	U	0.21	U
Dichlorodifluoromethane	5	0.29	U	0.29	U	0.29	U	0.29	U	0.29	U	0.29	U	2.9	U	0.29	U	0.29	U	0.7	U	0.7	U	0.7	U	0.7	U
1,1-Dichloroethane	5	0.12	U	0.12	U	0.12	U	0.12	U	0.12	U	0.12	U	1.2	U	0.12	U	0.12	U	0.21	U	0.21	U	0.21	U	0.21	U
1,2-Dichloroethane	0.6	0.09	U	0.09	U	0.09	U	0.09	U	0.09	U	0.09	U	0.9	U	0.09	U	0.09	U	0.39	U	0.39	U	0.39	U	0.39	U
1,1-Dichloroethene	5	0.16	U	0.16	U	0.16	U	0.16	U	0.16	U	0.16	U	1.6	U	0.16	U	0.16	U	0.2	U	0.2	U	0.2	U	0.2	U
cis-1,2-Dichloroethene	5	0.12	U	6.7		1.5		0.24	J	0.12	U	0.12	U	687		2.1		0.34	J	1.3		0.31	U	1.1		2.9	
trans-1,2-Dichloroethene	5	0.14	U	0.14	U	0.14	U	0.14	U	0.14	U	0.14	U	1.4	U	0.14	U	0.14	U	0.36	U	0.36	U	0.36	U	0.36	U
1,2-Dichloropropane	1	0.11	U	0.11	U	0.11	U	0.11	U	0.11	U	0.11	U	1.1	U	0.11	U	0.11	U	0.33	U	0.33	U	0.33	U	0.33	U
cis-1,3-Dichloropropene	-	0.12	U	0.12	U	0.12	U	0.12	U	0.12	U	0.12	U	1.2	U	0.12	U	0.12	U	0.19	U	0.19	U	0.19	U	0.19	U
trans-1,3-Dichloropropene	-	0.15	U	0.15	U	0.15	U	0.15	U	0.15	U	0.15	U	1.5	U	0.15	U	0.15	U	0.26	U	0.26	U	0.26	U	0.26	U
Ethylbenzene	5	0.22	U	0.22	U	0.22	U	0.22	U	0.22	U	0.22	U	2.2	U	0.22	U	0.22	U	0.2	U	0.2	U	0.2	U	0.2	U
Freon 113	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	U	1.2	U	1.2	U	1.2	U
2-Hexanone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	U	1.5	U	1.5	U	1.5	U
Isopropylbenzene	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16	U	0.16	U	0.16	U	0.16	U
Methyl Acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	U	1.5	U	1.5	U	1.5	U
Methylcyclohexane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.78	U	0.78	U	0.78	U	0.78	U
Methyl Tert Butyl Ether	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34	U	0.34	U	0.34	U	0.34	U
4-Methyl-2-pentanone(MIBK)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	U	1.2	U	1.2	U	1.2	U
Methylene chloride	5	0.22	U	0.22	U	0.22	U	0.22	U	0.22	U	0.22	U	2.2	U	0.22	U	0.22	U	0.35	U	0.35	U	0.35	U	0.35	U
Styrene	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27	U	0.27	U	0.27	U	0.27	U
1,1,2,2-Tetrachloroethane	5	0.12	U	0.12	U	0.12	U	0.12	U	0.12	U	0.12	U	1.2	U	0.12	U	0.12	U	0.39	U	0.39	U	0.39	U	0.39	U
Tetrachloroethene	5	0.72	J	740		249		11.9		0.29	J	0.26	J	3490		3.7		4		18.7		0.52	J	7.5		17.6	
Toluene	5	0.25	U	0.25	U	0.25	U	0.25	U	0.25	U	0.25	U	2.5	U	0.25	U	0.25	U	0.23	U	0.23	U	0.23	U	0.23	U
1,2,3-Trichlorobenzene	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	U	0.2	U	0.2	U	0.2	U
1,2,4-Trichlorobenzene	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	U	0.25	U	0.25	U	0.25	U
1,1,1-Trichloroethane	5	0.086	U	0.086	U	0.086	U	0.086	U	0.086	U	0.086	U	0.86	U	0.086	U	0.086	U	0.47	J	0.22	U	0.22	U	0.22	U
1,1,2-Trichloroethane	1	0.13	U	0.13	U	0.13	U	0.13	U	0.13	U	0.13	U	1.3	U	0.13	U	0.13	U	0.28	U	0.28	U	0.28	U	0.28	U
Trichloroethene	5	0.12	U	9.7		2.4		0.3	J	0.12	U	0.12	U	106		1.5		0.74	J	2.1		0.26	U	0.87	J	3.4	
Trichlorofluoromethane	5	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	2	U	0.2	U	0.2	U	0.58	U	0.58	U	0.58	U	0.58	U
Vinyl chloride	2	0.13	U	0.13	U	0.13	U	0.13	U	0.13	U	0.13	U	1.3	U	0.13	U	0.13	U	0.33	U	0.33	U	0.33	U	0.33	U
Xylenes (total)	5	0.22	U	0.22	U	0.22	U	0.22	U	0.22	U	0.22	U	2.2	U	0.22	U	0.22	U	0.21	U	0.21	U	0.21	U	0.21	U

Footnotes:

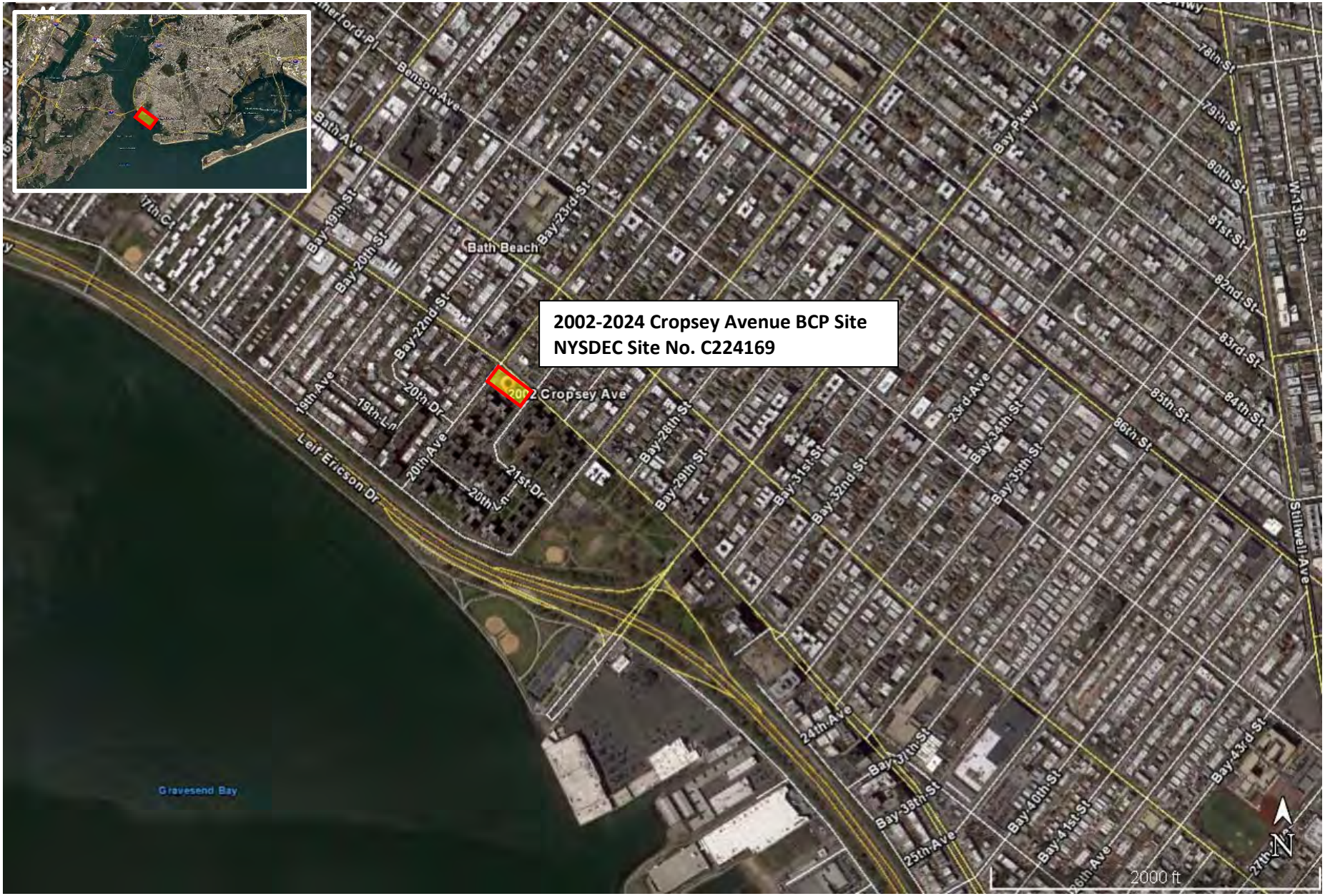
All values recorded in units of ug/l

[a] This compound outside control limits biased high in the associated BS.

U - Value reported under the detection limit

J - Approximated value

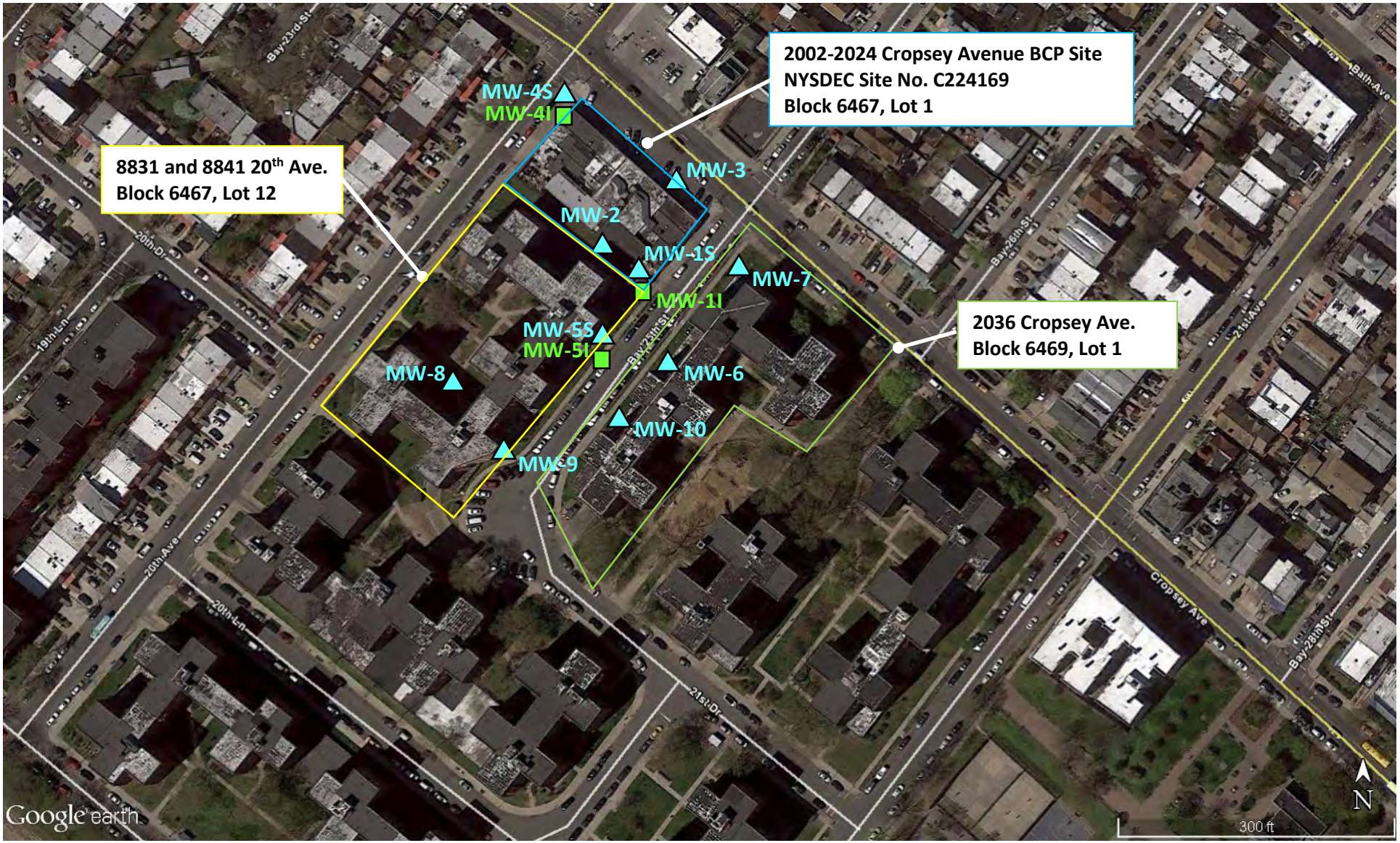
Figures



APEX

Figure 1
Site Location Map
2002-2024 Cropsey Avenue, Brooklyn, NY

Client:	2002 Cropsey Associates
Project No.:	85265
Project:	2002-2024 Cropsey BCP
Date:	August 11, 2017



Existing Shallow Zone Monitoring Well (MW-#, MW-#S)

Existing Intermediate Zone Monitoring Well (MW-#I)

APEX

Figure 2
PDI Area Plan

Client:	2002 Cropsey Associates
Project No.:	Cropsey1701
Project:	2002-2024 Cropsey BCP
Date:	March 27, 2019

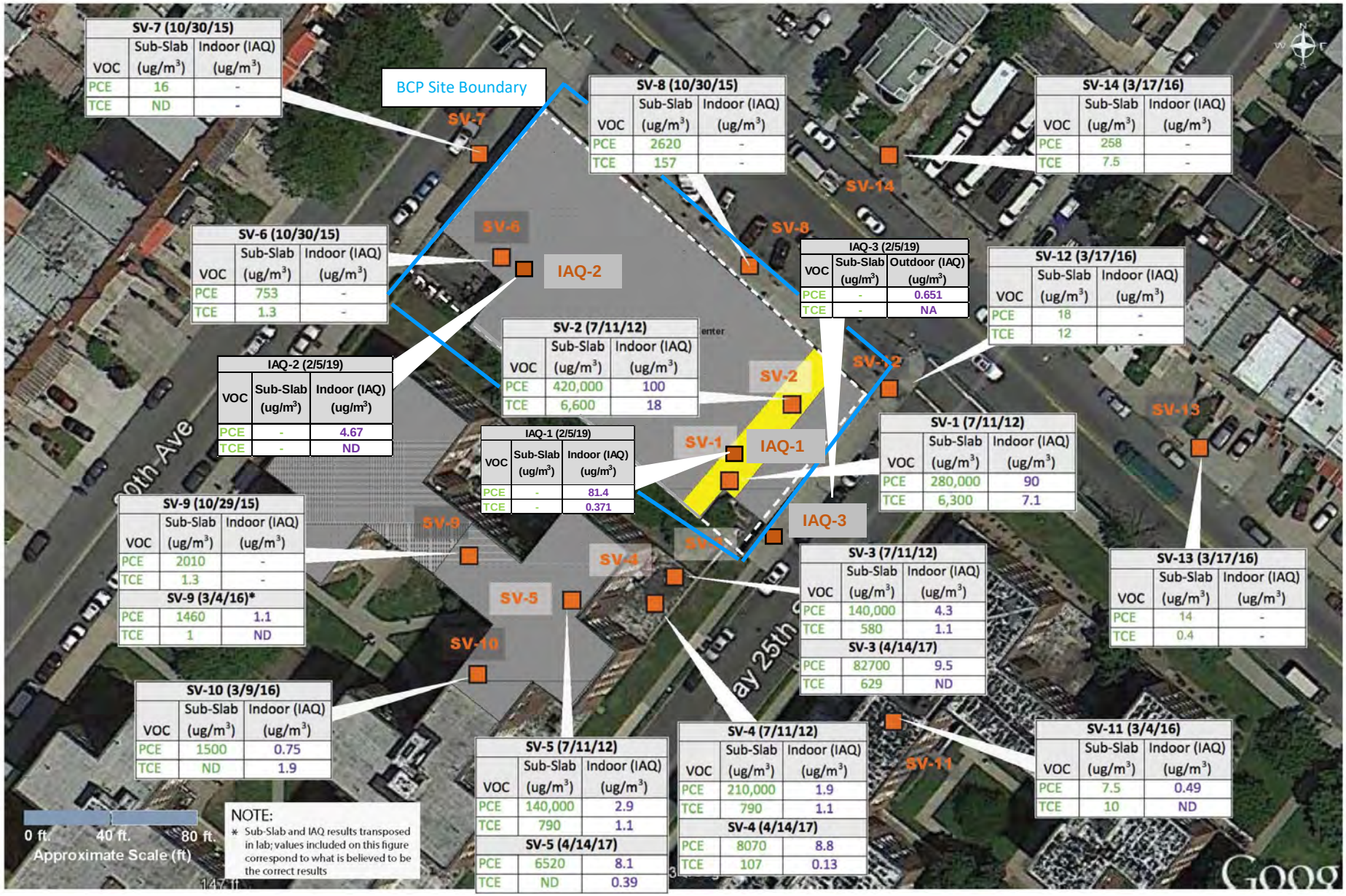


Figure 4

Soil Vapor / Indoor Air Sample Results Summary

(All Events 2012 - 2019)

APEX

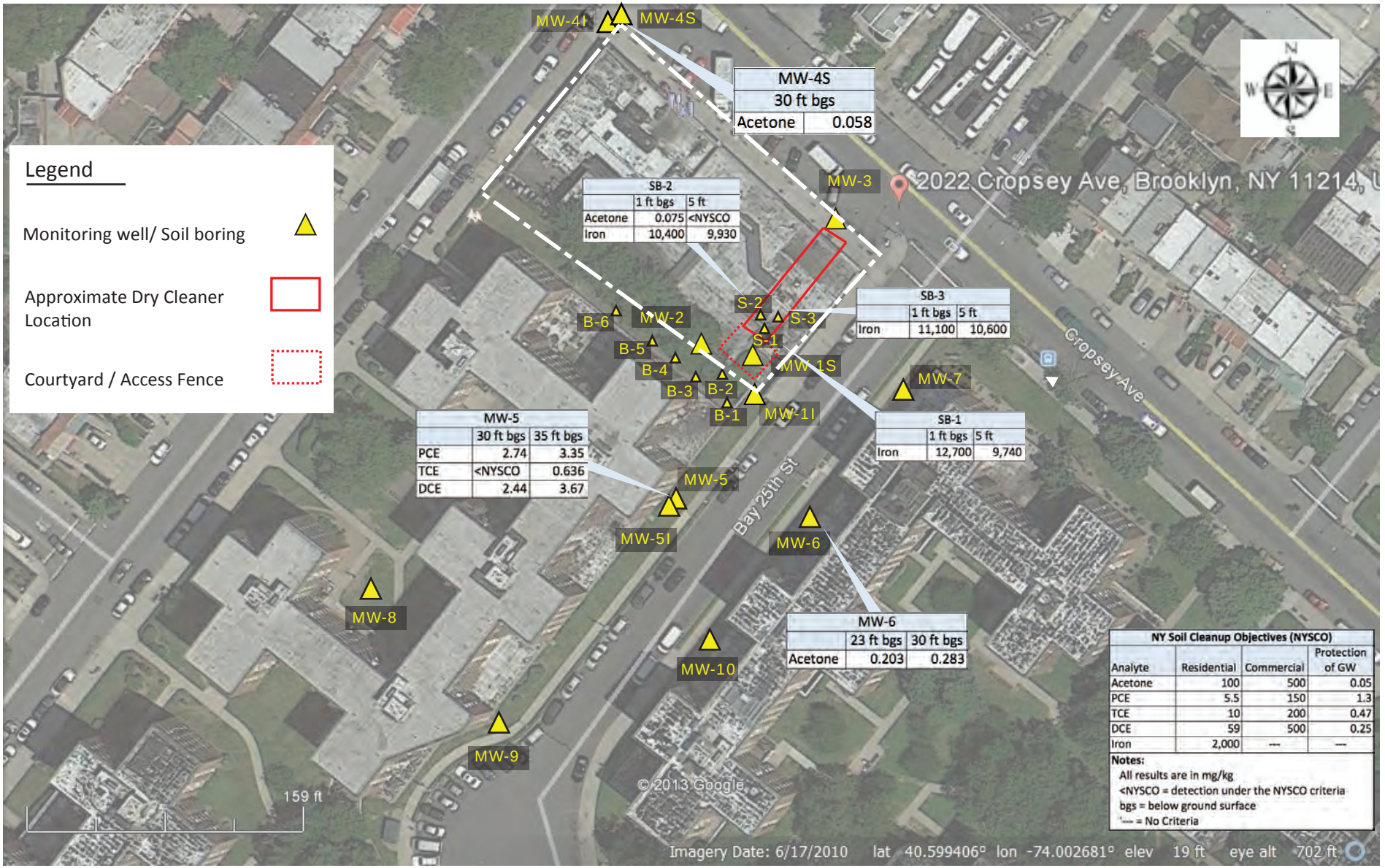
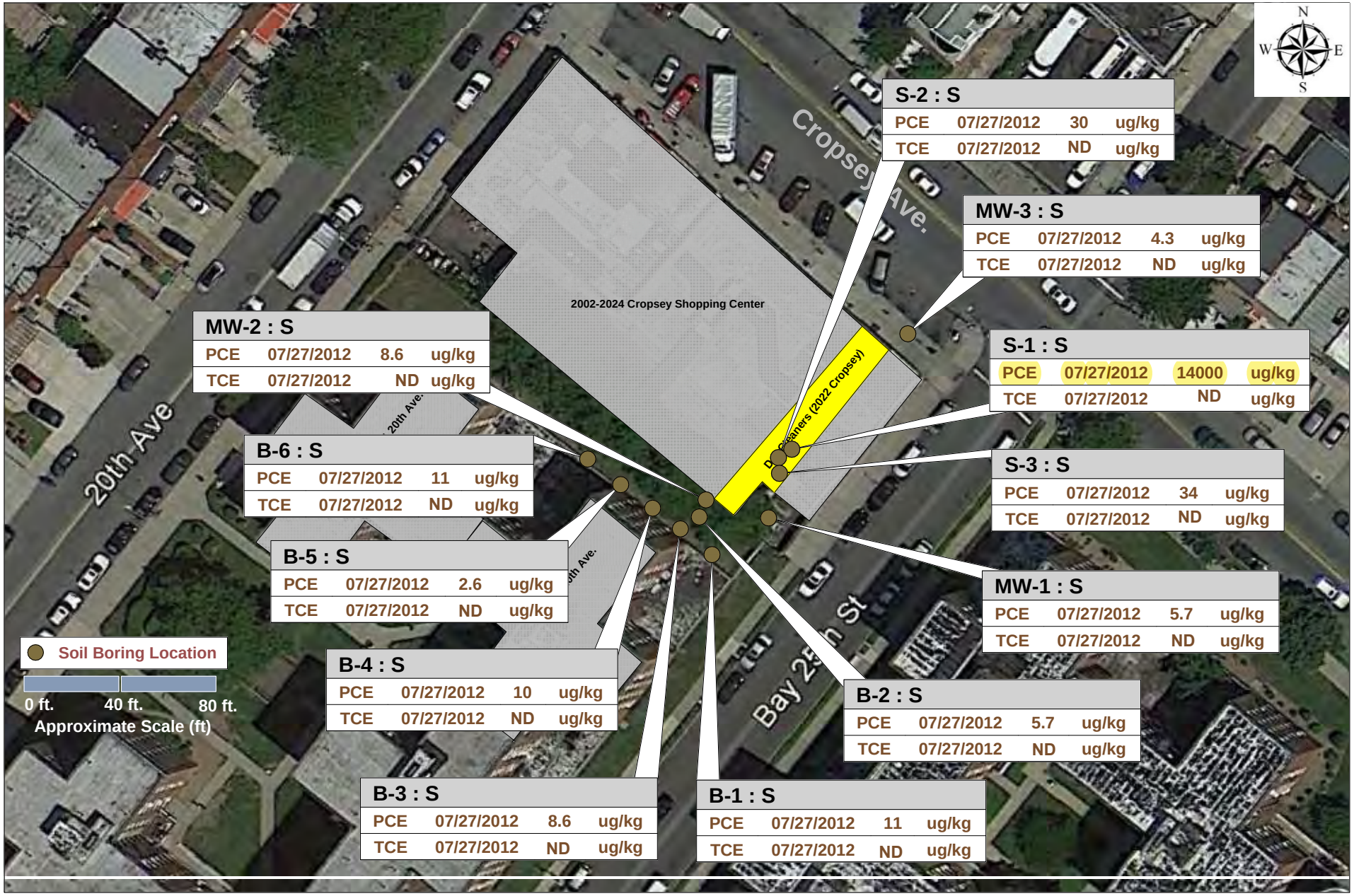


Figure 4
Soil Investigation Results Summary (RI 2015-2017)
(only exceedances of SCOs indicated)

APEX



APEX

Figure 5
Soil Sample Results Summary
(Phase II Investigation, 2012)

Data highlighted exceeds NYSDEC Protection of GW SCO for that parameter

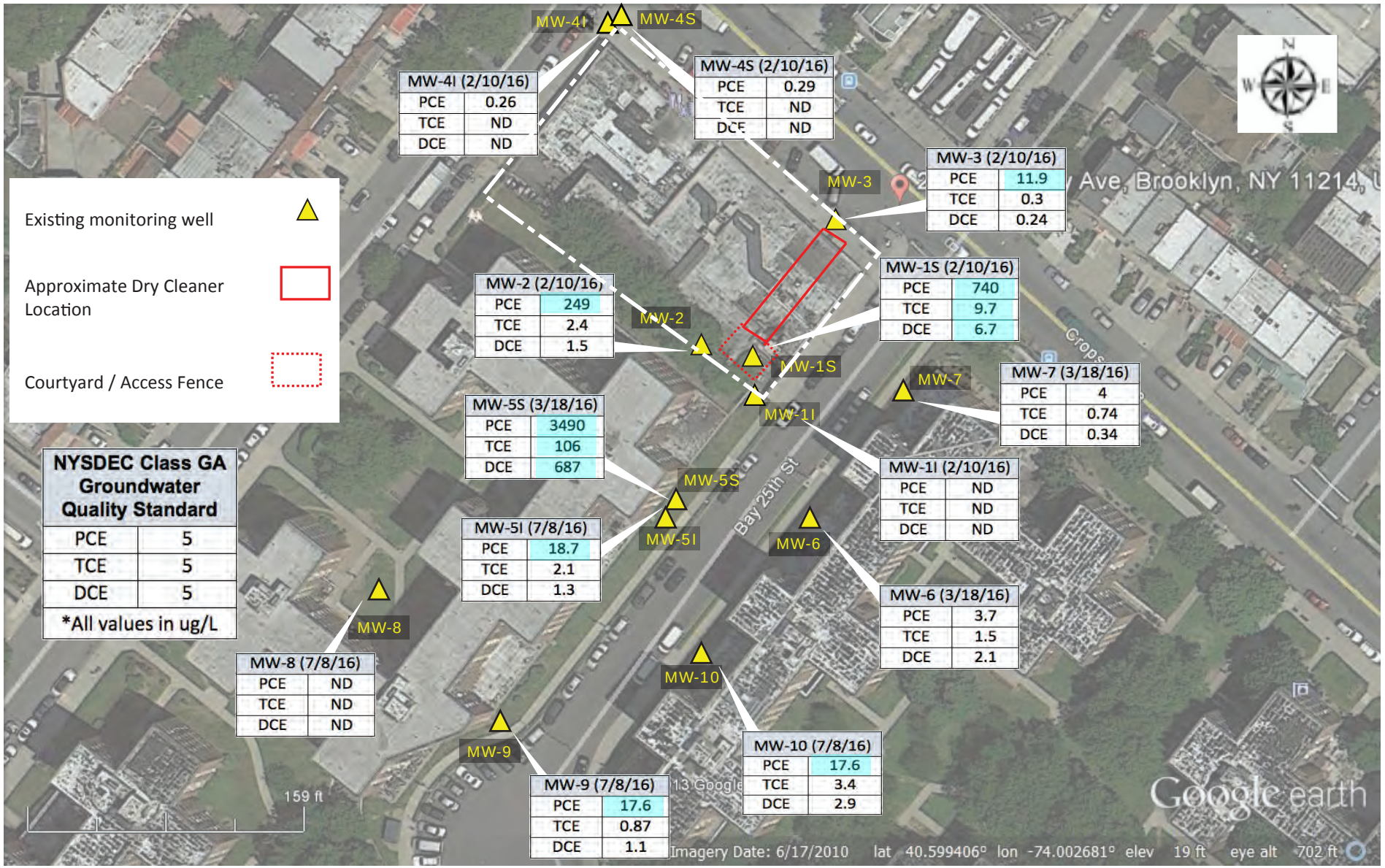


Figure 6
RI Groundwater Investigation Results Summary
(only COCs indicated, 2016 composite data set)

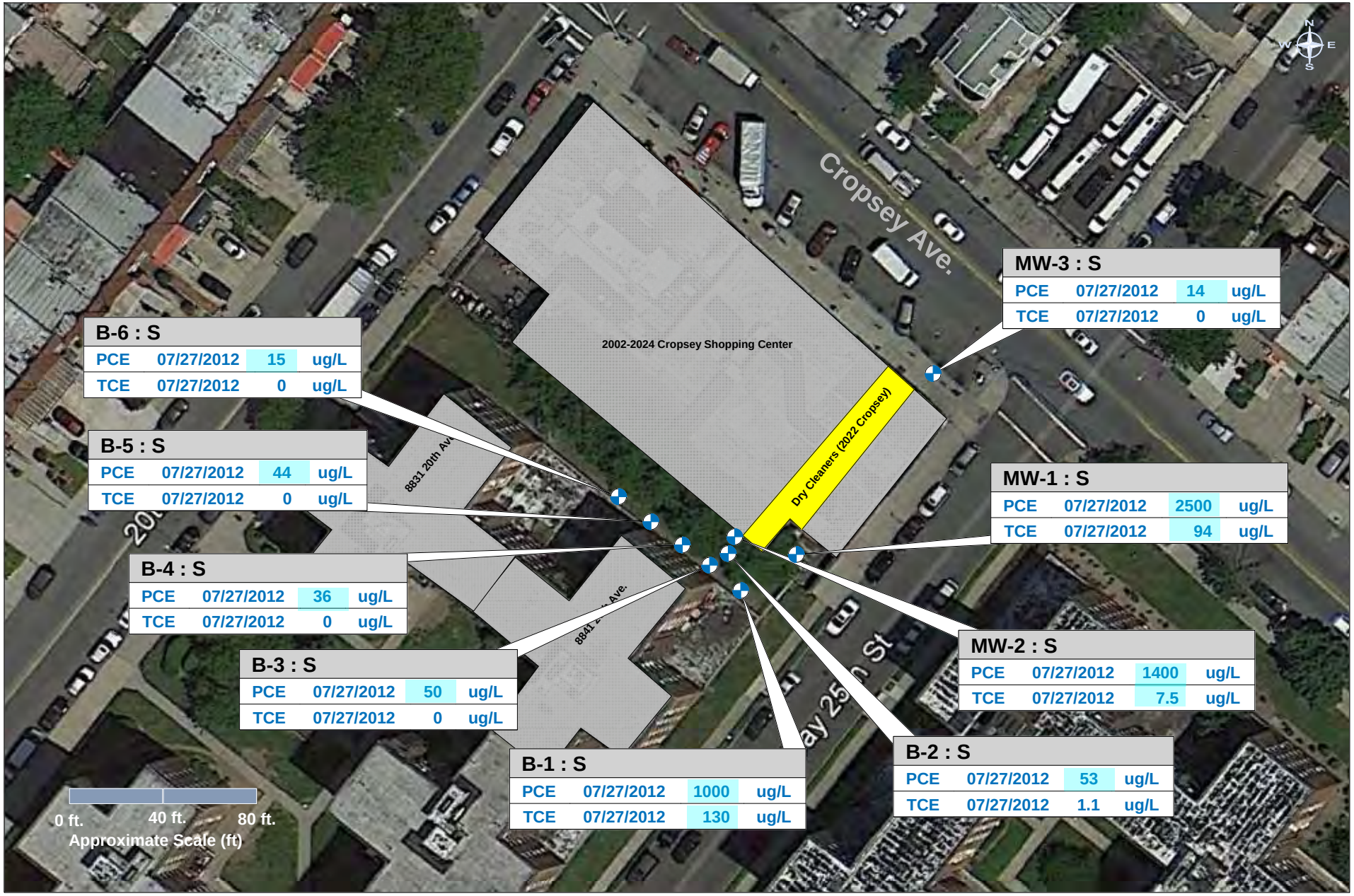
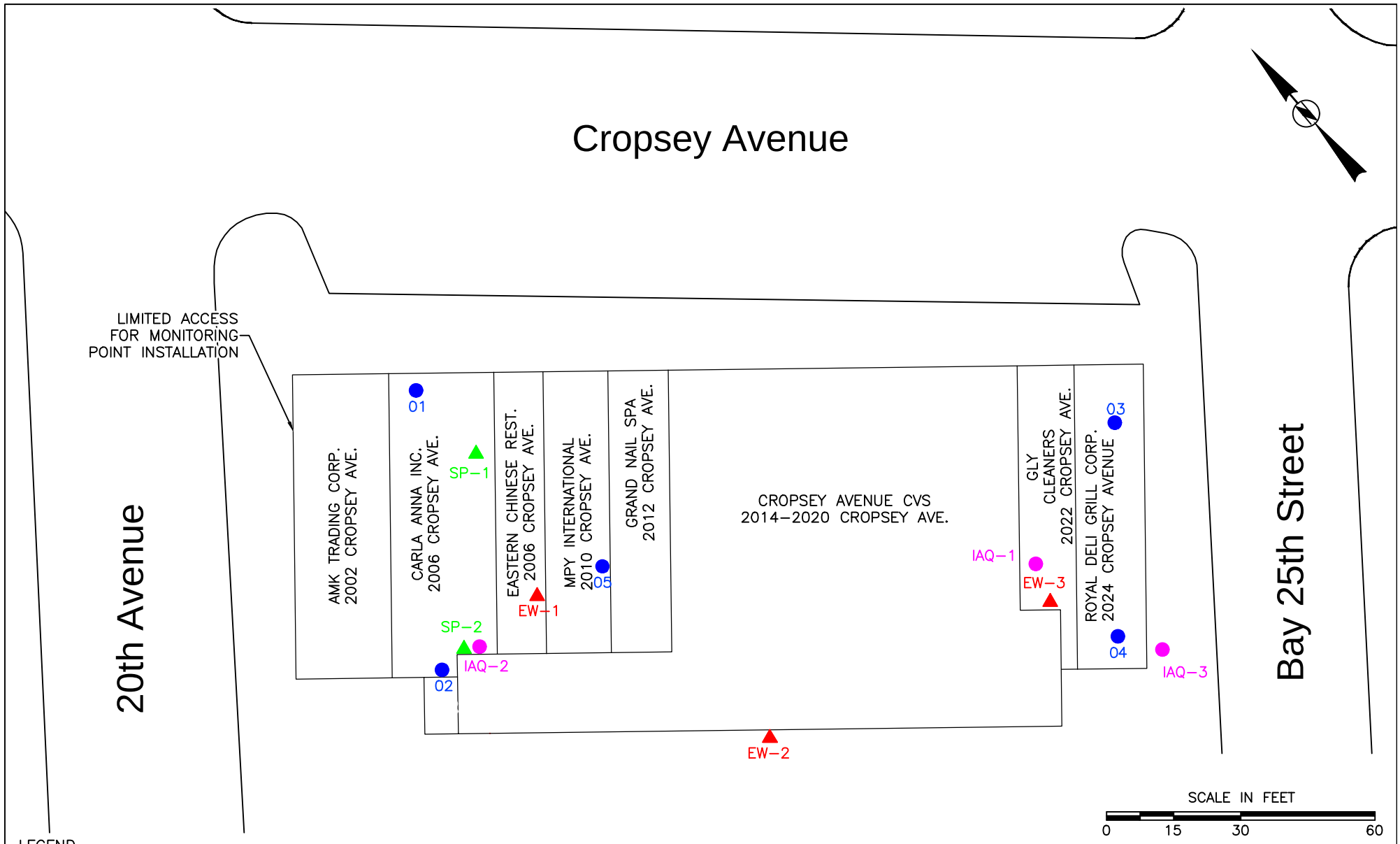


Figure 7
Groundwater VOCs Results Summary (2012 Phase II)
2002-2024 Cropsey Avenue and Adjacent Properties

Highlighted exceeds NYSDEC Class GA Std.



LEGEND

- MONITORING POINT
- EXISTING EXTRACTION WELL
- SUCTION PIT
- IAQ SAMPLE LOCATION

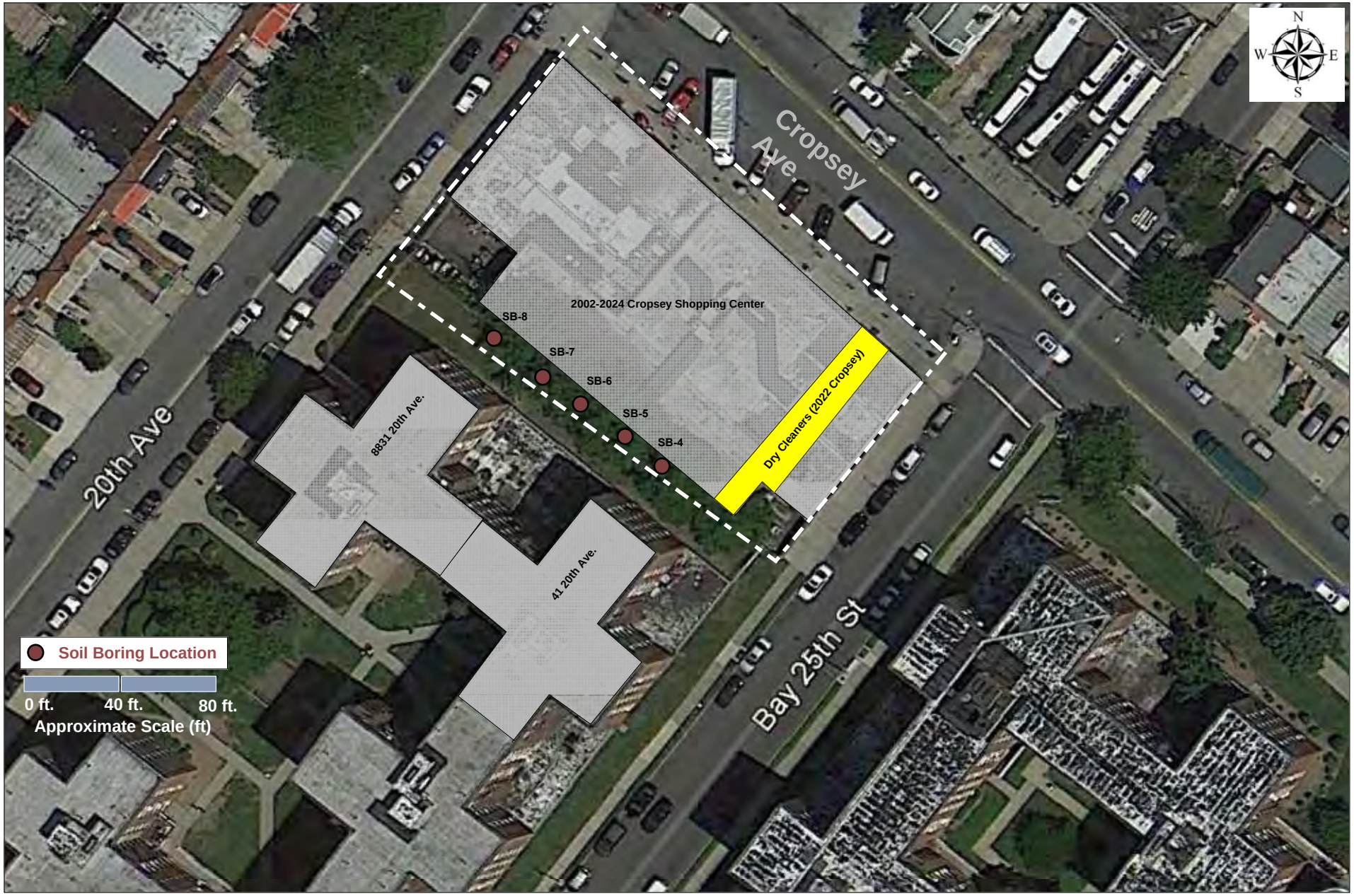
CHK BY	DS
DWN BY	WG
DATE	02–06–19
SCALE	AS SHOWN
CAD NO.	CROPSEY1701.03A
PRJ NO.	CROPSEY1701.003

SSDS SYSTEM LAYOUT AND SAMPLE LOCATIONS

CROPSEY AVENUE SITE
BROOKLYN, NEW YORK

APEX

FIGURE 8



APEX

Figure 9
Proposed Supplemental Soil Boring Locations

Appendix A

Metes and Bounds Survey

DPK Land Surveying, LLC
Certificate of Authorization No. 0012585

Date: June 19, 2019
Job No. 19-8383

Lot 1 Block 6467
Borough of Brooklyn
Kings County, New York

All that certain Lot, piece or parcel of land, with the buildings and improvements thereon erected, situate, lying and being in the Borough of Brooklyn, County of Kings, City and State of New York, bounded and described as follows:

BEING shown in accordance with a plan entitled "Boundary Survey, Tax Lot 1, Block 6467, 2002-2024 Cropsey Avenue, Borough of Brooklyn, Kings County, New York," prepared by DPK Land Surveying, dated April 4, 2019, last revised June 19, 2019 as revision 2.

METES AND BOUNDS DESCRIPTION

BEGINNING at a point on the southerly side of Cropsey Avenue (varied width, per tax map) where the same is intersected by the easterly side of 20th Avenue (80' wide per tax map) and running, thence;

1. Southerly, along the easterly side of 20th Avenue, 116.03 feet to a point, thence;
2. Easterly, at right angles to 20th Avenue and along the dividing line between Tax Lot 1 and Tax Lot 12 in Block 6467, 193.33 feet to the westerly side of Bay 25th Street (60' wide per tax map), thence;
3. Northerly, along the westerly side of Bay 25th Street, 103.56 feet to the southerly side of Cropsey Avenue, thence.
4. Westerly, along the southerly side of Cropsey Avenue, 193.73 feet to the point and place of beginning.

Containing 21,226 square feet or 0.4873 acres of land.

Jonathan A. Stuhl
Professional Land Surveyor
N.Y. License No. 050879

220 Old New Brunswick Rd., Suite 201, Piscataway, NJ 08854
P: 732-764-0100 F: 732-764-0990
www.dpkconsulting.net

SYMBOL LEGEND

CONC. MONUMENT FND	MAIL BOX
I.P. / I.B. FND	CABLE TV BOX
TACK / STAKE FND	TELEPHONE BOX
SPOT ELEVATIONS	A/C UNIT
TRAFFIC SIGNAL POLE	TRANSFORMER
UTILITY POLE	ELECTRIC METER
GUY WIRE	GAS METER
UTILITY POLE W/LIGHT	WATER METER
LIGHT POLE	WATER VALVE
SIGN	GAS VALVE
FIRE HYDRANT	CLEAN OUT
D.W.P. DETECTABLE WARNING PAD	GAS
D.C. DEPRESSED CURB	WATER
L.S.A. LANDSCAPED AREA	ELECTRIC
WELL	TELEPHONE
MANHOLE	CABLE TV
"A"-INLET	TREE
"B"-INLET	SHRUB
"E"-INLET	BOLLARD
YARD INLET	MONITORING WELL
FLARED END SECTION	WETLAND FLAG

DESCRIPTION OF PROPERTY
(AND ENVIRONMENTAL EASEMENT AREA)

ALL THAT CERTAIN LOT, PIECE OR PARCEL OF LAND, WITH THE BUILDINGS AND IMPROVEMENTS THEREON ERECTED, SITUATE, LYING AND BEING IN THE BOROUGH OF BROOKLYN, COUNTY OF KINGS, CITY AND STATE OF NEW YORK, BOUNDED AND DESCRIBED AS FOLLOWS:

BEGINNING AT THE CORNER FORMED BY THE INTERSECTION OF THE SOUTHERLY SIDE OF CROPSEY AVENUE WITH THE EASTERLY SIDE OF 20TH AVENUE;

RUNNING THENCE SOUTHERLY ALONG THE EASTERLY SIDE OF 20TH AVENUE, 116.03;

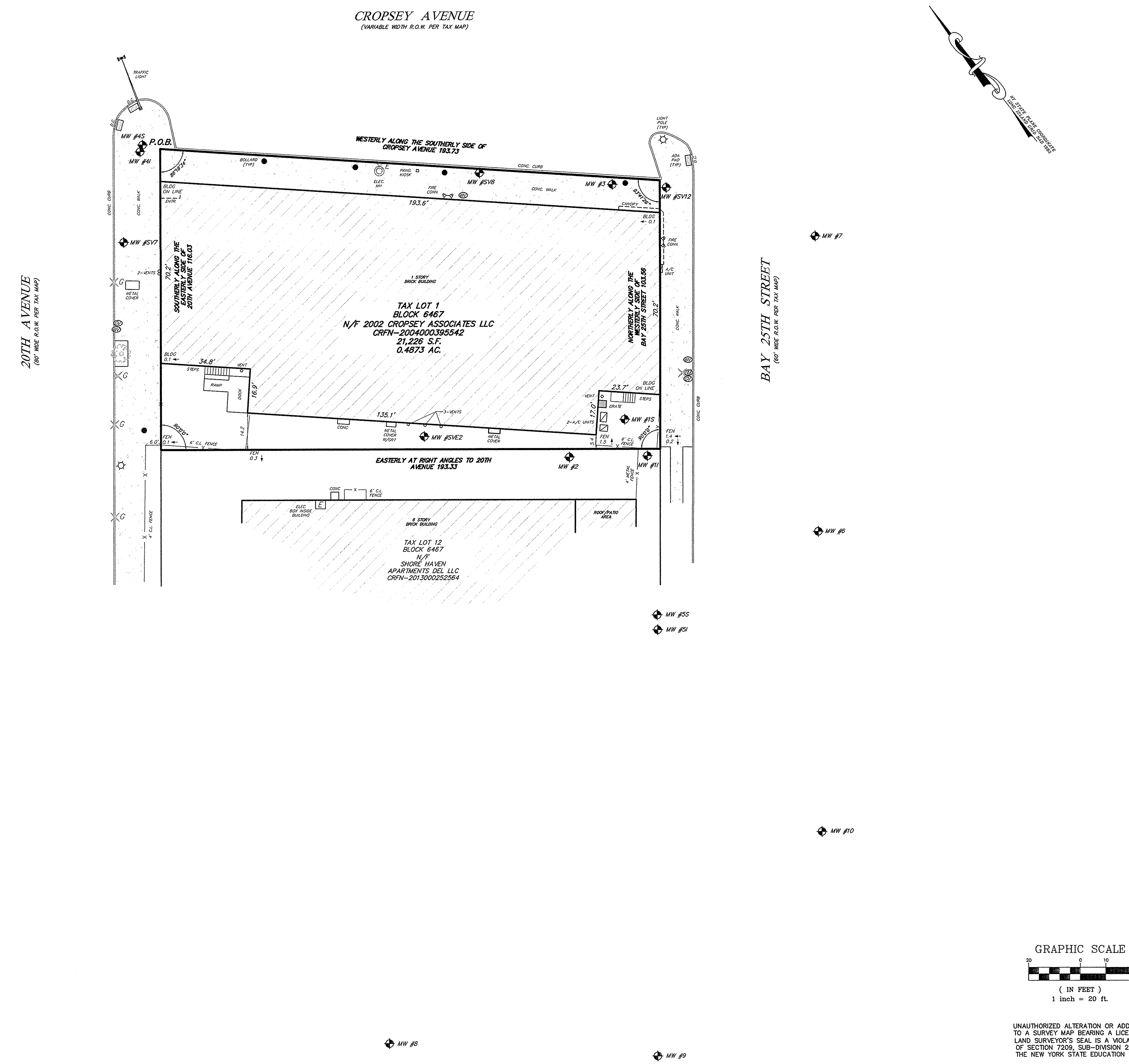
THENCE EASTERLY AT RIGHT ANGLES TO 20TH AVENUE 193.33 FEET TO THE WESTERLY SIDE OF BAY 25TH STREET;

THENCE NORTHERLY ALONG THE WESTERLY SIDE OF BAY 25TH STREET 103.56 FEET TO THE SOUTHERLY SIDE OF CROPSEY AVENUE, THENCE; AND

THENCE WESTERLY ALONG THE SOUTHERLY SIDE OF CROPSEY AVENUE 193.73 FEET TO THE CORNER, THE POINT AND PLACE OF BEGINNING.

CONTAINING 21,226 SQUARE FEET OR 0.4873 ACRES OF LAND.

THIS PROPERTY IS SUBJECT TO AN ENVIRONMENTAL EASEMENT HELD BY THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION PURSUANT TO TITLE 36 OF ARTICLE 71 OF THE NEW YORK ENVIRONMENTAL CONSERVATION LAW. THE ENGINEERING AND INSTITUTIONAL CONTROLS FOR THIS EASEMENT ARE SET FORTH IN THE SITE MANAGEMENT PLAN (SMP). A COPY OF THE SMP MUST BE OBTAINED BY ANY PARTY WITH AN INTEREST IN THE PROPERTY. THE SMP CAN BE OBTAINED FROM NYS DEPARTMENT OF ENVIRONMENTAL CONSERVATION, DIVISION OF ENVIRONMENTAL REMEDIATION, SITE CONTROL SECTION, 625 BROADWAY, ALBANY, NY 12233 OR AT DERWEB@DEC.NY.GOV



GENERAL NOTES:

1. THIS SURVEY IS PREPARED IN ACCORDANCE WITH DOCUMENTS SUPPLIED BY THE CLIENT AND THOSE OBTAINED THROUGH SUPPLEMENTAL RESEARCH BY DPK LAND SURVEYING. THE DOCUMENTS UTILIZED MAY OR MAY NOT REPRESENT ALL THE TITLE DOCUMENTS RELEVANT TO THE SUBJECT PROPERTY. IT IS STRONGLY SUGGESTED THAT A COMPLETE TITLE SEARCH BE SUPPLIED TO THE SURVEYOR FOR REVIEW PRIOR TO THE PLACEMENT OF OR ALTERATION TO IMPROVEMENTS ON THE PROPERTY.
2. THIS SURVEY IS SUBJECT TO ANY EASEMENTS OF RECORD AND ANY OTHER PERTINENT FACTS THAT A COMPLETE TITLE SEARCH MIGHT DISCLOSE.
3. THIS SURVEY REPRESENTS FIELD CONDITIONS AS OF MARCH 28, 2019.
4. THE UTILITIES SHOWN HAVE BEEN LOCATED FROM EVIDENCE OBSERVED ON THE SURFACE ONLY OR HAVE BEEN SHOWN GRAPHICALLY PER SUPPLIED MATERIALS. DPK LAND SURVEYING MAKES NO GUARANTEES THAT THE UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN-SERVICE OR ABANDONED. DPK LAND SURVEYING FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED. DPK LAND SURVEYING HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES.
5. PREMISES ARE COMMONLY KNOWN AS 2002–2024 CROPSEY AVENUE, BROOKLYN, NEW YORK.
6. ALSO KNOWN AS LOT 1 IN BLOCK 6467 AS SHOWN ON THE OFFICIAL TAX MAPS OF THE BOROUGH OF BROOKLYN, KINGS COUNTY, NEW YORK.
7. PROPERTY CORNERS WERE NOT SET AS PART OF THIS SURVEY.

MAP REFERENCES:

1. DIAGRAM (NOT A SURVEY) PREPARED BY BARTLETT, LUDLAM & DILL ASSOCIATES DATED AUGUST 1, 1962.
2. SECTION MAP SHEET 92 PROVIDED BY THE TOPOGRAPHICAL BUREAU OF THE BROOKLYN PRESIDENT'S OFFICE.

UNAUTHORIZED ALTERATION OR ADDITION TO A SURVEY MAP BEARING A LICENSED LAND SURVEYOR'S SEAL IS A VIOLATION OF SECTION 7209, SUB-DIVISION 2, OF THE NEW YORK STATE EDUCATION LAW.

REV	DATE	DESCRIPTION	BY	CHKD
2	06/19/2019	REVISED DESCRIPTIONS ON FACE OF SURVEY	B.D.B.	JAS
1	04/22/2019	ADDED DESCRIPTIONS TO FACE OF SURVEY	JAS	JAS

James J. Heiser
Professional Land Surveyor
N.J. Lic: 24GS04331100 N.Y. Lic: 050932-1
JHEISER@DPKCONSULTING.NET C.T. Lic: 70476

date

Jonathan A. Stuhl
Professional Land Surveyor
N.J. Lic: 24GS04331400 N.Y. Lic: 050879-1
JSTUHL@DPKCONSULTING.NET

In consideration of the mutual covenants between the client listed above and the undersigned, I declare that this plan is based on a field survey made under my direct supervision on the date listed above and to the best of my professional knowledge, information and belief, correctly represents the conditions found on the date of the survey, except easements, if any, below and/or above the surface of the lands and not visible. Underground utilities and/or determination of environmentally sensitive areas were not located or made by this survey. This survey is subject to conditions which an accurate title search might disclose. This plan is made to provide relevant information to the title insurer and the mortgage holder named above. This declaration is given solely to the above named parties for this transaction only and is not transferable, except as provided herein.

DRAWN BY: MJR | SCALE: 1" = 20'
CHK'D BY: JAS | DATE: 04/04/2019

DPK LAND SURVEYING

DPK LAND SURVEYING, LLC
220 OLD NEW BRUNSWICK RD-STE. 201, PISCATAWAY, NJ 08854
P:732-764-0100 F: 732-764-0990
NEW YORK CERTIFICATE OF AUTHORIZATION NO. 0012585

BOUNDARY SURVEY
TAX LOT 1
BLOCK 6467
2002–2024 CROPSEY AVENUE
BOROUGH OF BROOKLYN
KINGS COUNTY NEW YORK

DRAWING FILE: 19-8383LS02
PROJECT NUMBER: 19-8383
SHEET 1 / 1
REV. 2

Appendix B:

QAPP Addendum for Emerging Contaminant Sampling & Analysis

June 20, 2019

Mr. Manfred Magliore
Regional Hazardous Waste Remediation Engineer
New York State Department of Environmental Conservation
Division of Environmental Remediation, Region 2
47-40 21st Street
Long Island City, New York 11101

Re: Quality Assurance Project Plan Addendum
2002-2024 Cropsey Avenue
Brooklyn, New York
NYSDEC BCP # C224169

Dear Mr. Magliore:

This letter represents an addendum to the Quality Assurance Project Plan (QAPP) previously submitted to the New York State Department of Environmental Conservation (NYSDEC) as an appendix to the Remedial Action Work Plan (RAWP) and the Pre-Design Investigation (PDI), for the above referenced project site. This QAPP Addendum serves to address the request, in a letter, from the NYSDEC requesting the sampling of groundwater for analysis of the "emerging contaminants" (i.e., 1,4-dioxane and per- and polyfluoroalkyl substances [PFAS]). Additionally, this QAPP Addendum includes subsequent analytical soil sampling as required by the NYSDEC. This addendum shall be used in conjunction with the existing QAPP on the project.

Scope of Work

At the request of NYSDEC, Apex will conduct PFAS and 1,4-dioxane sampling and analysis during the PDI activities, although Apex has no knowledge of past use of PFAS at the site. Though the PFAS and 1,4-dioxane sampling will be conducted concurrently with PDI activities for groundwater, Apex intends to have separate chains of custody, analytical laboratory reports, and documentation reporting results for the requested sampling and PDI activities.

Consistent with the NYSDEC provided guidance document *Groundwater Sampling for Emerging Contaminants* dated March 2019 and NYSDEC memorandum *Sampling for 1,4-dioxane and Per- and Polyfluoroalkyl Substances Under DECs Part 375 Remedial Programs,* dated February 2019, laboratory analysis for 1,4-dioxane will be completed by United States Environmental Protection Agency (USEPA) Method 8270 with Selective Ion Monitoring (SIM). PFAS analysis will be completed by modified USEPA Method 537 (or International Organization for Standardization 25101) with quantification of the following twenty-one (21) compounds, summarized on the attached **Table 1** (for water samples) and **Table 2** (for soil samples).

- Perfluorobutanoic Acid (PFBA)
- Perfluoropentanoic Acid (PFPeA)
- Perfluorobutanesulfonic Acid (PFBS)
- Perfluorohexanoic Acid (PFHxA)
- Perfluoroheptanoic Acid (PFHpA)
- Perfluorohexanesulfonic Acid (PFHxS)
- Perfluorooctanoic Acid (PFOA)
- 1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)
- Perfluoroheptanesulfonic Acid (PFHpS)
- Perfluorononanoic Acid (PFNA)
- Perfluorooctanesulfonic Acid (PFOS)
- Perfluorodecanoic Acid (PFDA)
- 1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)
- N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)
- Perfluoroundecanoic Acid (PFUnA)
- Perfluorodecanesulfonic Acid (PFDS)
- Perfluorooctanesulfonamide (FOSA)
- N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)
- Perfluorododecanoic Acid (PFDoA)
- Perfluorotridecanoic Acid (PFTrDA)
- Perfluorotetradecanoic Acid (PFTA)

Please note, that PFAS and 1.4-Dioxane sampling is not proposed for soil sampling at this time. However, if these parameters are detected in groundwater above action levels in place at the time of sampling, the need for additional soil sampling will be discussed with the NYSDEC and completed, if necessary, as part of the PDI.

Scope of Work: Additional Soil Sampling

Additionally, the NYSDEC requested subsequent soil sampling to serve as confirmatory data to document subsurface soil quality along the southern most property boundary. Soil samples will be collected as outlined in the PDI Work Plan.

As stated in the PDI Work Plan, the primary volatile organic compounds (VOCs) that were detected in soil above SCGs include acetone, tetrachloroethene (PCE), trichloroethene (TCE) and cis-1,2 Dichloroethene (c12DCE). In addition, the soil data collected during the Phase II ESA and the Remedial Investigation indicate that soil impacts have been delineated and are limited to a small area beneath the basement of the Dry Cleaner. Based on the fact that the primary VOCs are associated with dry cleaner solvents (due to prior use) and that previous extensive soil investigations were completed delineating soil contamination, the laboratory analysis for the supplemental soil samples will be limited to VOCs only.

Laboratory Analysis

Soil and groundwater samples and associated QA/QC samples will be analyzed in accordance with the following methods, as indicated below:

- PFAS – USEPA Method 537 (modified) with a reporting limit equal to or below 2.0 nanograms/liter (ng/L or parts per trillion (ppt) (groundwater initially and soil only if groundwater concentrations detected exceed action levels in place at the time of sampling);
- 1,4-Dioxane – USEPA Method 8270 SIM with a reporting limit equal to or below 0.35 parts per billion (ppb) (groundwater initially and soil only if groundwater concentrations detected exceed action levels in place at the time of sampling); and
- VOCs – USEPA Method 8260B (soil only).

A standard turnaround time will be requested, with analytical results available within approximately 20 business days from sample receipt by the laboratory. A New York State Analytical Services Program (ASP) Category B analytical data deliverable will be obtained from the laboratory to support data validation (i.e., Data Usability Summary Report). An EQuIS™ 4-file electronic data deliverable (EDD) will also be obtained.

Sampling Procedures and Precautions

Prior to the scheduled sampling event the following precautions will be discussed and implemented:

- No clothing or boots containing Gore-Tex®, Tyvek® or other water-resistant/proofing material will be worn;

- Wet weather gear may be made of polyurethane or polyvinyl chloride (PVC) only;
- Fabric softener will not be used on clothing to be worn during sampling event;
- No cosmetics, moisturizers, hand cream or similar will be used the day of the sampling event;
- No food or drink, other than bottled water or hydration drinks (i.e., Gatorade/Powerade) is permitted on-site.
- No plastic clipboards, binders, spiral cover books or adhesives (sticky note pad) will be used;
- Only regular ballpoint pens will used; no sharpie permanent markers are permitted;

PFAS and 1,4-Dioxane Sample Collection and Handling

PFAS free bailers and/or high-density polyethylene (HDPE) tubing (groundwater sampling), equipment (trowels, etc.) (soil sampling) and PFAS free gloves (nitriles) will be used during sampling. The groundwater wells will be purged and sampled consistent with the RAWP and PDI Work Plan, prepared by Apex, previously submitted to the NYSDEC.

Polypropylene or HDPE, Teflon®-free, bottles (provided by the analytical laboratory) will be used to collect the PFAS sample, and the PFAS sample will be collected before the 1,4-dioxane sample at each location. Samples will be collected as outlined in the NYSDEC provided guidance documents. Groundwater will be purged and sampled consistent with the RAWP / PDI Work Plan prepared by Apex.

Once filled, each water sample bottle will be immediately placed into a cooler containing regular ice and shipped to Alpha Analytical, Inc. (Alpha) a New York State Department of Health (NYSDOH) Environmental Laboratory Approval Program (ELAP) certified laboratory for analysis and reporting for both PFAS and 1,4-dioxane in accordance with NYSDEC requirements. Alpha's Standard Operating Procedure (SOP) for PFAS analysis, including information on the Method Detection Limit (MDL) for the 21 PFAS compounds, is included as **Attachment A**. The samples to be analyzed for PFAS will be placed in a separate cooler and no chemical (blue) ice packs will be used, only ice.

For equipment decontamination, PFAS-free water (to be supplied by Alpha) will be used, no other water sources (hoses, domestic water, bottled, etc.) are to be utilized. Only Alconox® will be used for decontamination.

Quality Control Samples

The following Quality Assurance / Quality Control (QA/QC) samples will also be collected per a second NYSDEC provided guidance document, *Collection of Groundwater Samples for PFOA*

and Perfluorinated Compounds (PFCs) from Monitoring Wells Sample Protocol dated August 2018, as further detailed below. QA/QC soil samples will be collected as outlined in the QAPP previously submitted to the NYSDEC as an appendix to the RAWP.

- One equipment blank;
- One field duplicate; and
- One matrix spike/matrix spike duplicate (MS/MSD).

Reporting

Following receipt of the complete analytical data package, a letter report will be prepared for submittal to NYSDEC presenting PFAS and 1,4-dioxane results (groundwater, and if necessary based upon groundwater results, soil). VOC results for the additional soil sampling requested by NYSDEC will be summarized in the PDI Report.

This PFAS and 1.4-Dioxane letter report will document the sampling activities, provide the completed field forms and field measurements, provide sampling locations on a site figure and summarize the results of the analyses. The complete analytical data packages will be provided in an appendix to the report. As requested by NYSDEC, the reporting limit for 1,4-Dioxane shall be 0.35 ug/l. The reporting limit for all 21 PFAS compounds shall be 2 nanogram/liter (ppt). A Data Usability Summary Report (DUSR) will be provided with the Category B data package.

Implementation of Schedule

As stated above, it is anticipated that the sampling will be conducted during PDI activities (exact date to be determined). Apex will provide NYSDEC ten (10) business days' notice prior to sampling. The letter report will follow within two (2) months of sampling.

If you have any questions, please do not hesitate to contact the undersigned at (631)-567-1777, extension 6501.

Sincerely,
Apex Companies, LLC.

Daniel J. Smith, P.E.
Vice President

Cc: Jane O'Connell – NYSDEC
Sondra Martinkat – NYSDEC
John Nehila – NYSDEC
Justin Deming – NYSDOH

Renata Ockerby – NYSDOH
Jennifer Coghlan – Sive, Paget & Riesel, PC

Attachments

cropsey qapp add pfas - final 062019

Tables

Table 1
Method Detection Limits for Per- and Polyfluoroalkyl Substances
for Water Samples

Analyte via EPA 537(M) - Isotope Dilution	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria	Holding Time	Container/Sample Preservation:
Perfluorobutanoic Acid (PFBA)	375-22-4	1	0.0213	ng/g	89-128	30	89-128	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorobutanoic Acid (PFBA)	375-22-4	2	0.3732	ng/l	67-148	30	67-148	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoropentanoic Acid (PFPeA)	2706-90-3	1	0.01035	ng/g	93-127	30	93-127	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoropentanoic Acid (PFPeA)	2706-90-3	2	0.464	ng/l	63-161	30	63-161	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	2	0.38	ng/l	65-157	30	65-157	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	1	0.0635	ng/g	88-135	30	88-135	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorohexanoic Acid (PFHxA)	307-24-4	2	0.492	ng/l	69-168	30	69-168	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorohexanoic Acid (PFHxA)	307-24-4	1	0.064	ng/g	95-131	30	95-131	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroheptanoic Acid (PFHpA)	375-85-9	1	0.064	ng/g	83-120	30	83-120	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroheptanoic Acid (PFHpA)	375-85-9	2	0.372	ng/l	58-159	30	58-159	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	2	0.436	ng/l	69-177	30	69-177	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	1	0.057	ng/g	83-124	30	83-124	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanoic Acid (PFOA)	335-67-1	1	0.04105	ng/g	88-121	30	88-121	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanoic Acid (PFOA)	335-67-1	2	0.46	ng/l	63-159	30	63-159	30	30	---	28 days	1 - Plastic 8oz unpreserved
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	27619-97-2	2	0.194	ng/l	49-187	30	49-187	30	30	---	28 days	1 - Plastic 8oz unpreserved
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	27619-97-2	1	0.198	ng/g	83-150	30	83-150	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroheptanesulfonic Acid (PFHpS)	375-92-8	2	0.52	ng/l	61-179	30	61-179	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroheptanesulfonic Acid (PFHpS)	375-92-8	1	0.136	ng/g	85-145	30	85-145	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorononanoic Acid (PFNA)	375-95-1	2	0.436	ng/l	68-171	30	68-171	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorononanoic Acid (PFNA)	375-95-1	1	0.083	ng/g	89-126	30	89-126	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanesulfonic Acid (PFOS)	1763-23-1	2	0.56	ng/l	52-151	30	52-151	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanesulfonic Acid (PFOS)	1763-23-1	1	0.1205	ng/g	74-111	30	74-111	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorodecanoic Acid (PFDA)	335-76-2	1	0.072	ng/g	90-137	30	90-137	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorodecanoic Acid (PFDA)	335-76-2	2	0.62	ng/l	63-171	30	63-171	30	30	---	28 days	1 - Plastic 8oz unpreserved
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	39108-34-4	2	0.2908	ng/l	56-173	30	56-173	30	30	---	28 days	1 - Plastic 8oz unpreserved
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	39108-34-4	1	0.275	ng/g	81-156	30	81-156	30	30	---	28 days	1 - Plastic 8oz unpreserved
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	2355-31-9	2	0.2504	ng/l	60-166	30	60-166	30	30	---	28 days	1 - Plastic 8oz unpreserved
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	2355-31-9	1	0.103	ng/g	80-129	30	80-129	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	2	0.424	ng/l	60-153	30	60-153	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	1	0.056	ng/g	78-128	30	78-128	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	2	0.386	ng/l	38-156	30	38-156	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	1	0.097	ng/g	64-142	30	64-142	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanesulfonamide (FOSA)	754-91-6	2	0.556	ng/l	46-170	30	46-170	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanesulfonamide (FOSA)	754-91-6	1	0.1025	ng/g	79-123	30	79-123	30	30	---	28 days	1 - Plastic 8oz unpreserved
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	1	0.09	ng/g	73-134	30	73-134	30	30	---	28 days	1 - Plastic 8oz unpreserved
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	2	0.3728	ng/l	45-170	30	45-170	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorododecanoic Acid (PFDoA)	307-55-1	2	0.592	ng/l	67-153	30	67-153	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorododecanoic Acid (PFDoA)	307-55-1	1	0.086	ng/g	83-128	30	83-128	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	2	0.314	ng/l	48-158	30	48-158	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	1	0.062	ng/g	73-123	30	73-123	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorotetradecanoic Acid (PFTA)	376-06-7	1	0.07	ng/g	91-141	30	91-141	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorotetradecanoic Acid (PFTA)	376-06-7	2	0.988	ng/l	59-182	30	59-182	30	30	---	28 days	1 - Plastic 8oz unpreserved

Notes:
As per Alpha, the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)
Please Note that this information was provided to Apex Companies, LLC by Alpha Analytical, Inc. a New York State Department of Health Environmental Laboratory Approval Program certified laboratory.
MDL - Method Detection Limit
ng/g - nanogram per gram
ng/l - nanogram per liter
LCS - Laboratory Contol Sample
MS - Mass Spectrometry
RPD - Relative Percent Differnece

Table 2
Method Detection Limits for Per- and Polyfluoroalkyl Substances
for Soil Samples

Analyte via EPA 537(M) - Isotope Dilution	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria	Holding Time	Container/Sample Preservation:
Perfluorobutanoic Acid (PFBA)	375-22-4	1	0.0213	ng/g	89-128	30	89-128	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoropentanoic Acid (PFPeA)	2706-90-3	1	0.01035	ng/g	93-127	30	93-127	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	1	0.0635	ng/g	88-135	30	88-135	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorohexanoic Acid (PFHxA)	307-24-4	1	0.064	ng/g	95-131	30	95-131	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroheptanoic Acid (PFHpA)	375-85-9	1	0.064	ng/g	83-120	30	83-120	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	1	0.057	ng/g	83-124	30	83-124	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanoic Acid (PFOA)	335-67-1	1	0.04105	ng/g	88-121	30	88-121	30	30	---	28 days	1 - Plastic 8oz unpreserved
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	27619-97-2	1	0.198	ng/g	83-150	30	83-150	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroheptanesulfonic Acid (PFHpS)	375-92-8	1	0.136	ng/g	85-145	30	85-145	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorononanoic Acid (PFNA)	375-95-1	1	0.083	ng/g	89-126	30	89-126	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanesulfonic Acid (PFOS)	1763-23-1	1	0.1205	ng/g	74-111	30	74-111	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorodecanoic Acid (PFDA)	335-76-2	1	0.072	ng/g	90-137	30	90-137	30	30	---	28 days	1 - Plastic 8oz unpreserved
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	39108-34-4	1	0.275	ng/g	81-156	30	81-156	30	30	---	28 days	1 - Plastic 8oz unpreserved
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSA	2355-31-9	1	0.103	ng/g	80-129	30	80-129	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	1	0.056	ng/g	78-128	30	78-128	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	1	0.097	ng/g	64-142	30	64-142	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorooctanesulfonamide (FOSA)	754-91-6	1	0.1025	ng/g	79-123	30	79-123	30	30	---	28 days	1 - Plastic 8oz unpreserved
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	1	0.09	ng/g	73-134	30	73-134	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorododecanoic Acid (PFDoA)	307-55-1	1	0.086	ng/g	83-128	30	83-128	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	1	0.062	ng/g	73-123	30	73-123	30	30	---	28 days	1 - Plastic 8oz unpreserved
Perfluorotetradecanoic Acid (PFTA)	376-06-7	1	0.07	ng/g	91-141	30	91-141	30	30	---	28 days	1 - Plastic 8oz unpreserved
PFOA/PFOS, Total		1	0.04105	ng/g				30	30	---	28 days	1 - Plastic 8oz unpreserved

Notes:

As per Alpha, the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that this information was provided to Apex Companies, LLC by Alpha Analytical, Inc. a New York State Department of Health Environmental Laboratory Approval Program certified laboratory.

MDL - Method Detection Limit

ng/g - nanogram per gram

ng/l - nanogram per liter

LCS - Laboratory Contol Sample

MS - Mass Spectrometry

RPD - Relative Percent Differnece

Attachment A
Laboratory SOP for PFAS Analysis

Determination of Selected Perfluorinated Alkyl Substances by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry Isotope Dilution (LC/MS/MS)

Reference: EPA Method 537, Version 1.1, September 2009, EPA Document #: EPA/600/R-08/09

EPA Method 537.1, Version 1, November 2018, EPA Document #: EPA/600/R-18/352

Department of Defense, Quality Systems Manual for Environmental Laboratories, Version 5.1, .2017

1. Scope and Application

Matrices: Non-potable Water and Soil Matrices

Definitions: Refer to Alpha Analytical Quality Manual.

1.1 This is a liquid chromatography/tandem mass spectrometry (LC/MS/MS) method for the determination of selected perfluorinated alkyl substances (PFAS) in Non-Drinking Water and soil Matrices. Accuracy and precision data have been generated in reagent water, and finished ground and surface waters for the compounds listed in Table 1.

1.2 The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

1.3 This method is restricted to use by or under the supervision of analysts experienced in the operation of the LC/MS/MS and in the interpretation of LC/MS/MS data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

2. Summary of Method

2.1 A 250-mL water sample is fortified with extracted internal standards (EIS) and passed through a solid phase extraction (WAX) cartridge containing a mixed mode, Weak Anion Exchange, reversed phase, water-wettable polymer to extract the method analytes and isotopically-labeled compounds. The compounds are eluted from the solid phase in two fractions with methanol followed by a small amount of 2% ammonium hydroxide in methanol solution. The extract is concentrated with nitrogen in a heated water bath, and then adjusted to a 1-mL volume with 80:20% (vol/vol) methanol:water. A 3 µl injection is made into an LC equipped with a C18 column that is interfaced to an MS/MS. The analytes are separated and identified by comparing the acquired mass spectra and retention times to reference spectra and retention times for calibration standards acquired under identical LC/MS/MS conditions. The concentration of each analyte is determined by using the isotope dilution technique. Extracted Internal Standards (EIS) analytes are used to monitor the extraction efficiency of the method analytes.

2.2 Method Modifications from Reference

None.

Table 1

Parameter	Acronym	CAS
PERFLUOROALKYL ETHER CARBOXYLIC ACIDS (PFECAs)		
Tetrafluoro-2-(heptafluoropropoxy)propanoic acid	HFPO-DA	62037-80-3
Dodecafluoro-3h-4,8-dioxanonoate	ADONA	958445-44-8
PERFLUOROALKYLCARBOXILIC ACIDS (PFCAs)		
Perfluorobutanoic acid	PFBA	375-22-4
Perfluoropentanoic acid	PFPeA	2706-90-3
Perfluorohexanoic acid	PFHxA *	307-24-4
Perfluoroheptanoic acid	PFHpA *	375-85-9
Perfluorooctanoic acid	PFOA *	335-67-1
Perfluorononanoic acid	PFNA *	375-95-1
Perfluorodecanoic acid	PFDA *	335-76-2
Perfluoroundecanoic acid	PFUnA *	2058-94-8
Perfluorododecanoic acid	PFDoA *	307-55-1
Perfluorotridecanoic acid	PFTrDA *	72629-94-8
Perfluorotetradecanoic acid	PFTA *	376-06-7
Perfluorohexadecanoic acid	PFHxDA	67905-19-5
Perfluorooctadecanoic acid	PFODA	16517-11-6
PERFLUOROALKYLSULFONATES (PFASs)		
Perfluorobutanesulfonic acid	PFBS *	375-73-5
Perfluoropentanesulfonic acid	PFPeS	2706-91-4
Perfluorohexanesulfonic acid	PFHxS *	355-46-4
Perfluoroheptanesulfonic acid	PFHpS	375-92-8
Perfluorooctanesulfonic acid	PFOS *	1763-23-1
Perfluorononanesulfonic acid	PFNS	68259-12-1
Perfluorodecanesulfonic acid	PFDS	335-77-3
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid	9Cl-PF3ONS	756426-58-1
PERFLUOROOCTANESULFONAMIDES (FOSAs)		
Perfluorooctanesulfonamide	PFOSA	754-91-6
TELOMER SULFONATES		
1H,1H,2H,2H-perfluorohexane sulfonate (4:2)	4:2FTS	27619-93-8
1H,1H,2H,2H-perfluorooctane sulfonate (6:2)	6:2FTS	27619-97-2
1H,1H,2H,2H-perfluorodecane sulfonate (8:2)	8:2FTS	39108-34-4
PERFLUOROOCTANESULFONAMIDOACETIC ACIDS		
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA *	2355-31-9
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA *	2991-50-6

*** also reportable via the standard 537 method**

3. Reporting Limits

The reporting limit for PFAS's is 2 ng/L for aqueous samples (4ng/L for HFPO-DA) and 1 ng/g for soil samples.

4. Interferences

4.1 PFAS standards, extracts and samples should not come in contact with any glass containers or pipettes as these analytes can potentially adsorb to glass surfaces. PFAS analyte and EIS standards commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be prepared and stored in polypropylene containers.

4.2 Method interferences may be caused by contaminants in solvents, reagents (including reagent water), sample bottles and caps, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the chromatograms. The method analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) products, LC solvent lines, methanol, aluminum foil, SPE sample transfer lines, etc. All items such as these must be routinely demonstrated to be free from interferences (less than 1/3 the RL for each method analyte) under the conditions of the analysis by analyzing laboratory reagent blanks as described in Section 9.2. **Subtracting blank values from sample results is not permitted.**

4.3 Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending upon the nature of the water. Humic and/or fulvic material can be co-extracted during SPE and high levels can cause enhancement and/or suppression in the electrospray ionization source or low recoveries on the SPE sorbent. Total organic carbon (TOC) is a good indicator of humic content of the sample.

4.4 SPE cartridges can be a source of interferences. The analysis of field and laboratory reagent blanks can provide important information regarding the presence or absence of such interferences. Brands and lots of SPE devices should be tested to ensure that contamination does not preclude analyte identification and quantitation.

5. Health and Safety

5.1 The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

5.2 All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.3 PFOA has been described as "likely to be carcinogenic to humans." Pure standard materials and stock standard solutions of these method analytes should be handled with

suitable protection to skin and eyes, and care should be taken not to breathe the vapors or ingest the materials.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection for Aqueous Samples

6.1.1 Samples must be collected in two (2) 250-mL high density polyethylene (HDPE) container with an unlined plastic screw cap.

6.1.2 The sample handler must wash their hands before sampling and wear nitrile gloves while filling and sealing the sample bottles. PFAS contamination during sampling can occur from a number of common sources, such as food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will aid in minimizing this type of accidental contamination of the samples.

6.1.3 Open the tap and allow the system to flush until the water temperature has stabilized (approximately 3 to 5 min). Collect samples from the flowing system.

6.1.4 Fill sample bottles. Samples do not need to be collected headspace free.

6.1.5 After collecting the sample and cap the bottle. Keep the sample sealed from time of collection until extraction.

6.1.6 Field Reagent Blank (FRB)

6.1.6.1 A FRB must be handled along with each sample set. The sample set is composed of samples collected from the same sample site and at the same time. At the laboratory, fill the field blank sample bottle with reagent water and preservatives, seal, and ship to the sampling site along with the sample bottles. For each FRB shipped, an empty sample bottle (no preservatives) must also be shipped. At the sampling site, the sampler must open the shipped FRB and pour the reagent water into the empty shipped sample bottle, seal and label this bottle as the FRB. The FRB is shipped back to the laboratory along with the samples and analyzed to ensure that PFAS's were not introduced into the sample during sample collection/handling.

The reagent water used for the FRBs must be initially analyzed for method analytes as a MB and must meet the MB criteria in Section 9.2.1 prior to use. This requirement will ensure samples are not being discarded due to contaminated reagent water rather than contamination during sampling.

6.2 Sample Collection for Soil and Sediment samples.

Grab samples are collected in polypropylene containers. Sample containers and contact surfaces containing PTFE shall be avoided.

6.3 Sample Preservation

Not applicable.

6.4 Sample Shipping

Samples must be chilled during shipment and must not exceed 10 °C during the first 48 hours after collection. Sample temperature must be confirmed to be at or below 10 °C when the samples are received at the laboratory. Samples stored in the lab must be held at or below 6 °C until extraction, but should not be frozen.

NOTE: Samples that are significantly above 10° C, at the time of collection, may need to be iced or refrigerated for a period of time, in order to chill them prior to shipping. This will allow them to be shipped with sufficient ice to meet the above requirements.

6.5 Sample Handling

6.5.1 Holding Times

6.5.1.1 Water samples should be extracted as soon as possible but must be extracted within 14 days. Soil samples should be extracted within 28 days. Extracts are stored at < 10 ° C and analyzed within 28 days after extraction.

7. Equipment and Supplies

7.1 SAMPLE CONTAINERS – 250-mL high density polyethylene (HDPE) bottles fitted with unlined screw caps. Sample bottles must be discarded after use.

7.2 POLYPROPYLENE BOTTLES – 4-mL narrow-mouth polypropylene bottles.

7.3 CENTRIFUGE TUBES – 15-mL conical polypropylene tubes with polypropylene screw caps for storing standard solutions and for collection of the extracts.

7.4 AUTOSAMPLER VIALS – Polypropylene 0.7-mL autosampler vials with polypropylene caps.

7.4.1 NOTE: Polypropylene vials and caps are necessary to prevent contamination of the sample from PTFE coated septa. However, polypropylene caps do not reseal, so evaporation occurs after injection. Thus, multiple injections from the same vial are not possible.

7.5 POLYPROPYLENE GRADUATED CYLINDERS – Suggested sizes include 25, 50, 100 and 1000-mL cylinders.

7.6 Auto Pipets – Suggested sizes include 5, 10, 25, 50, 100, 250, 500 and 1000-µL syringes.

7.7 PLASTIC PIPETS – Polypropylene or polyethylene disposable pipets.

7.8 ANALYTICAL BALANCE – Capable of weighing to the nearest 0.0001 g.

7.9 SOLID PHASE EXTRACTION (SPE) APPARATUS FOR USING CARTRIDGES

7.9.1 SPE CARTRIDGES – 0.5 g SPE cartridges containing a reverse phase copolymer characterized by a weak anion exchanger (WAX) sorbent phase.

7.9.2 VACUUM EXTRACTION MANIFOLD – A manual vacuum manifold with large volume sampler for cartridge extractions, or an automatic/robotic sample preparation system designed for use with SPE cartridges, may be used if all QC requirements discussed in Section 9 are met. Extraction and/or elution steps may not be changed or omitted to accommodate the use of an automated system. Care must be taken with automated SPE systems to ensure the PTFE commonly used in these systems does not contribute to unacceptable analyte concentrations in the MB (Sect. 9.2.1).

7.9.3 SAMPLE DELIVERY SYSTEM – Use of a polypropylene transfer tube system, which transfers the sample directly from the sample container to the SPE cartridge, is recommended, but not mandatory. Standard extraction manifolds come equipped with PTFE transfer tube systems. These can be replaced with 1/8" O.D. x 1/16" I.D. polypropylene or polyethylene tubing cut to an appropriate length to ensure no sample contamination from the sample transfer lines. Other types of non-PTFE tubing may be used provided it meets the MB (Sect. 9.2.1) and LCS (Sect. 9.3) QC requirements. The PTFE transfer tubes may be used, but an MB must be run on each PFTE transfer tube and the QC requirements in Section 13.2.2 must be met. In the case of automated SPE, the removal of PTFE lines may not be feasible; therefore, MBs will need to be rotated among the ports and must meet the QC requirements of Sections 13.2.2 and 9.2.1.

7.10 Extract Clean-up Cartridge – 5 g 6ml SPE Cartridge containing graphitized polymer carbon

7.11 EXTRACT CONCENTRATION SYSTEM – Extracts are concentrated by evaporation with nitrogen using a water bath set no higher than 65 °C.

7.12 LABORATORY OR ASPIRATOR VACUUM SYSTEM – Sufficient capacity to maintain a vacuum of approximately 10 to 15 inches of mercury for extraction cartridges.

7.13 LIQUID CHROMATOGRAPHY (LC)/TANDEM MASS SPECTROMETER (MS/MS) WITH DATA SYSTEM

7.13.1 LC SYSTEM – Instrument capable of reproducibly injecting up to 10-µL aliquots, and performing binary linear gradients at a constant flow rate near the flow rate used for development of this method (0.4 mL/min). The LC must be capable of pumping the water/methanol mobile phase without the use of a degasser which pulls vacuum on the mobile phase bottle (other types of degassers are acceptable). Degassers which pull vacuum on the mobile phase bottle will volatilize the ammonium acetate mobile phase causing the analyte peaks to shift to earlier retention times over the course of the analysis batch. The usage of a column heater is optional.

NOTE: During the course of method development, it was discovered that while idle for more than one day, PFAS's built up in the PTFE solvent transfer lines. To prevent long delays in purging high levels of PFAS's from the LC solvent lines, they were replaced with PEEK tubing and the PTFE solvent frits were replaced with stainless steel frits. It is not possible to remove all PFAS background contamination, but these measures help to minimize their background levels.

7.13.2 LC/TANDEM MASS SPECTROMETER – The LC/MS/MS must be capable of negative ion electrospray ionization (ESI) near the suggested LC flow rate of 0.4 mL/min. The system must be capable of performing MS/MS to produce unique product ions for the method analytes within specified retention time segments. A minimum of 10 scans across the chromatographic peak is required to ensure adequate precision.

7.13.3 DATA SYSTEM – An interfaced data system is required to acquire, store, reduce, and output mass spectral data. The computer software should have the capability of processing stored LC/MS/MS data by recognizing an LC peak within any given retention time window. The software must allow integration of the ion abundance of any specific ion within specified time or scan number limits. The software must be able to calculate relative response factors, construct linear regressions or quadratic calibration curves, and calculate analyte concentrations.

7.13.4 ANALYTICAL COLUMN – An LC BEH C_{18} column (2.1 x 50 mm) packed with 1.7 µm d_p C_{18} solid phase particles was used. Any column that provides adequate resolution, peak shape, capacity, accuracy, and precision (Sect. 9) may be used.

8. Reagents and Standards

8.1 GASES, REAGENTS, AND SOLVENTS – Reagent grade or better chemicals should be used.

8.1.1 REAGENT WATER – Purified water which does not contain any measurable quantities of any method analytes or interfering compounds greater than 1/3 the RL for each method analyte of interest. Prior to daily use, at least 3 L of reagent water should be flushed from the purification system to rinse out any build-up of analytes in the system's tubing.

8.1.2 METHANOL (CH_3OH, CAS#: 67-56-1) – High purity, demonstrated to be free of analytes and interferences.

8.1.3 AMMONIUM ACETATE ($NH_4C_2H_3O_2$, CAS#: 631-61-8) – High purity, demonstrated to be free of analytes and interferences.

8.1.4 ACETIC ACID (H_3CCOOH, CAS#: 64-19-7) - High purity, demonstrated to be free of analytes and interferences.

8.1.5 1M AMMONIUM ACETATE/REAGENT WATER – High purity, demonstrated to be free of analytes and interferences.

8.1.6 2mM AMMONIUM ACETATE/METHANOL:WATER (5:95) – To prepare, mix 2 ml of 1M AMMONIUM ACETATE,1 ml ACETIC ACID and 50 ml METHANOL into I Liter of REAGENT WATER.

8.1.7 2mM AMMONIUM ACETATE/METHANOL – To prepare, mix 2 ml of 1M AMMONIUM ACETATE and 1 ml ACETIC ACID into 1L METHANOL.

8.1.8 Methanol/Water (80:20) – To prepare a 1 Liter bottle, mix 200 ml of REAGENT WATER with 800 ml of METHANOL.

8.1.9 AMMONIUM HYDROXIDE (NH_3, CAS#: 1336-21-6) – High purity, demonstrated to be free of analytes and interferences.

8.1.10 Sodium Acetate ($NaOOCCH_3$, CAS#: 127-09-3) – High purity, demonstrated to be free of analytes and interferences.

8.1.11 25 mM Sodium Acetate Buffer – To prepare 250mls, dissolve .1 grams of sodium acetate into 100 mls of reagent water. Add 4 mls Acetic Acid and adjust the final volume to 250 mls with reagent water.

8.1.12 NITROGEN – Used for the following purposes: Nitrogen aids in aerosol generation of the ESI liquid spray and is used as collision gas in some MS/MS instruments. The nitrogen used should meet or exceed instrument manufacturer's specifications. In addition, Nitrogen is used to concentrate sample extracts (Ultra High Purity or equivalent).

8.1.13 ARGON – Used as collision gas in MS/MS instruments. Argon should meet or exceed instrument manufacturer's specifications. Nitrogen gas may be used as the collision gas provided sufficient sensitivity (product ion formation) is achieved.

8.2 STANDARD SOLUTIONS – When a compound purity is assayed to be 96% or greater, the weight can be used without correction to calculate the concentration of the stock standard. PFAS analyte and IS standards commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be prepared and stored in polypropylene containers. Standards for sample fortification generally should be prepared in the smallest volume that can be accurately measured to minimize the addition of excess organic solvent to aqueous samples.

NOTE: Stock standards (Sect. 8.2.1 and 8.2.3) are stored at ≤4 °C. Primary dilution standards (Sect. 8.2.2 and 8.2.4) are stored at room temperature to prevent adsorption of the method analytes onto the container surfaces that may occur when refrigerated. Storing the standards at room temperature will also minimize daily imprecision due to the potential of inadequate room temperature stabilization.

8.2.1 ISOTOPE DILUTION Extracted Internal Standard (ID EIS) STOCK SOLUTIONS - ID EIS stock standard solutions are stable for at least 6 months when stored at 4 °C. The stock solution is purchased at a concentration of 1000 ng/mL.

8.2.2 ISOTOPE DILUTION Extracted Internal Standard PRIMARY DILUTION STANDARD (ID EIS PDS) – Prepare the ID EIS PDS at a concentration of 500 ng/mL. The ID PDS is prepared in 80:20% (vol/vol) methanol:water. The ID PDS is stable for 6 months when stored at ≤4 °C.

Table 2

Isotope Labeled Standard	Conc. of EIS Stock (ng/mL)	Vol. of EIS Stock (mL)	Final Vol. of EIS PDS (mL)	Final Conc. of EIS PDS (ng/mL)
M4PFBA	1000	1.0	2.0	500
M5PFPeA	1000	1.0	2.0	500
M5PFHxA	1000	1.0	2.0	500
M4PFHpA	1000	1.0	2.0	500
M8PFOA	1000	1.0	2.0	500
M9PFNA	1000	1.0	2.0	500
M6PFDA	1000	1.0	2.0	500
M7PFUdA	1000	1.0	2.0	500
MPFDoA	1000	1.0	2.0	500
M2PFTeDA	1000	1.0	2.0	500
M2PFHxDA	50,000	.02	2.0	500
M8FOSA	1000	1.0	2.0	500

Isotope Labeled Standard	Conc. of EIS Stock (ng/mL)	Vol. of EIS Stock (mL)	Final Vol. of EIS PDS (mL)	Final Conc. of EIS PDS (ng/mL)
d3-N-MeFOSAA	1000	1.0	2.0	500
d5-N-EtFOSAA	1000	1.0	2.0	500
M3PFBS	929	1.0	2.0	464.5
M3PFHxS	946	1.0	2.0	473
M8PFOS	957	1.0	2.0	478.5
M2-4:2FTS	935	1.0	2.0	467.5
M2-6:2FTS	949	1.0	2.0	474.5
M2-8:2FTS	958	1.0	2.0	479
M3HFPO-DA	50,000	.4	2.0	10,000

8.2.3 ANALYTE STOCK STANDARD SOLUTION – Analyte stock standards are stable for at least 6 months when stored at 4 °C. When using these stock standards to prepare a PDS, care must be taken to ensure that these standards are at room temperature and adequately vortexed.

8.2.4 ANALYTE PRIMARY SPIKING STANDARD – Prepare the spiking standard at a concentration of 500 ng/mL in 80:20% (vol/vol) methanol:water. The spiking standard is stable for at least six months when stored at ≤4 °C.

Table 3

Analyte	Conc. of Stock (ng/mL)	Vol. of Stock (mL)	Final Vol. of PDS (mL)	Final Conc. of PDS (ng/mL)
HFPO-DA	50,000	.04	4	500
ADONA	50,000	.04	4	500
PFBA	2000	1	4	500
PFPeA	2000	1	4	500
PFHxA	2000	1	4	500
PFHpA	2000	1	4	500
PFOA	2000	1	4	500
PFNA	2000	1	4	500
PFDA	2000	1	4	500
PFUdA	2000	1	4	500
PFDoA	2000	1	4	500
PFTrDA	2000	1	4	500
PFTeDA	2000	1	4	500
PFHxDA	50,000	.04	4	500
PFODA	50,000	.04	4	500
FOSA	2000	1	4	500
N-MeFOSAA	2000	1	4	500
N-EtFOSAA	2000	1	4	500
L-PFBS	1770	1	4	442.5
L-PFPeS	1880	1	4	470
L-PFHxSK	1480	1	4	370
Br-PFHxSK	344	1	4	86
L-PFHpS	1900	1	4	475
L-PFOSK	1460	1	4	365
Br-PFOSK	391	1	4	97.75

Analyte	Conc. of Stock (ng/mL)	Vol. of Stock (mL)	Final Vol. of PDS (mL)	Final Conc. of PDS (ng/mL)
L-PFNS	1920	1	4	480
L-PFDS	1930	1	4	482.5
11Cl-PF3OUdS	50,000	1	4	500
9Cl-PF3ONS	50,000	1	4	500
4:2FTS	1870	1	4	467.5
6:2FTS	1900	1	4	475
8:2FTS	1920	1	4	480

8.2.5 LOW, MEDIUM AND HIGH LEVEL LCS – The LCS's will be prepared at the following concentrations and rotated per batch; 2 ng/L, 40 ng/L, 500 ng/l. The analyte PDS contains all the method analytes of interest at various concentrations in methanol containing 20% water. The analyte PDS has been shown to be stable for six months when stored at ≤4 °C.

8.2.6 Isotope Dilution Labeled Recovery Stock Solutions (ID REC) – ID REC Stock solutions are stable for at least 6 months when stored at 4 °C. The stock solution is purchased at a concentration of 1000 ng/mL.

8.2.7 Isotope Dilution Labeled Recovery Primary Dilution Standard (ID REC PDS) - Prepare the ID REC PDS at a concentration of 500 ng/mL. The ID REC PDS is prepared in 80:20% (vol/vol) methanol:water. The ID REC PDS is stable for at least six months when stored in polypropylene centrifuge tubes at ≤4 °C.

Table 4

Analyte	Conc. of REC Stock (ng/mL)	Vol. of REC Stock (mL)	Final Vol. of REC PDS (mL)	Final Conc. of REC PDS (ng/mL)
M2PFOA	2000	1	4	500
M2PFDA	2000	1	4	500
M3PFBA	2000	1	4	500
M4PFOS	2000	1	4	500

8.2.8 CALIBRATION STANDARDS (CAL) –

Current Concentrations (ng/mL): 0.5, 1.0, 5.0, 10.0, 50.0, 125, 150

Prepare the CAL standards over the concentration range of interest from dilutions of the analyte PDS in methanol containing 20% reagent water. 20 µl of the EIS PDS and REC PDS are added to the CAL standards to give a constant concentration of 10 ng/ml. The lowest concentration CAL standard must be at or below the RL (2 ng/L), which may depend on system sensitivity. The CAL standards may also be used as CCVs (Sect. 9.8). To make calibration stock standards:

Table 5

Calibration Standard Concentration	**Final Aqueous Cal STD Level Concentration**	**Final Soil Cal STD Level Concentration**	**24 compound stock added (ul)**	**PFHxDA Stock added (ul)**	**500 ng/ml PFHxDA dilution added (ul)**	**PFODA Stock added (ul)**	**500 ng/ml PFODA dilution added (ul)**	**ADONA, HFPO-DA,** 11Cl-PF3OUdS, 9Cl-PF3ONS **Stock added (ul)**	**500 ng/ml ADONA dilution added (ul)**	**Final Volume in MeOH/H_2O (82:20)**
.5 ng/ml	2 ng/L	.25 ng/g	6.25		25		25		25	25 mls
1 ng/ml	4 ng/L	.5 ng/g	12.5		50		50		50	10 mls
5 ng/ml	20 ng/L	1 ng/g	25		100		100		100	10 mls
10 ng/ml	40 ng/L	5 ng/g	125	5		5		5		25 mls
10 ng/ml	200 ng/L	25 ng/g	250	10		10		10		10 mls
125 ng/ml	500 ng/L	62.5 ng/g	625	25		25		25		10 mls
150 ng/ml	600 ng/L	75 ng/g	750	30		30		30		10 mls

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 MINIMUM REPORTING LIMIT (MRL) CONFIRMATION

9.1.1 Fortify, extract, and analyze seven replicate LCSs at 2 ng/l. Calculate the mean measured concentration (*Mean*) and standard deviation for these replicates. Determine the Half Range for the prediction interval of results (HR_{PIR}) using the equation below

$$HR_{PIR} = 3.963s$$

Where:

s = the standard deviation
3.963 = a constant value for seven replicates.

9.1.2 Confirm that the upper and lower limits for the Prediction Interval of Result (*PIR* = *Mean* ± HR_{PIR}) meet the upper and lower recovery limits as shown below

The Upper PIR Limit must be ≤150% recovery.

$$\frac{Mean + HR_{PIR}}{Fortified\ Concentration} \times 100\% \leq 150\%$$

The Lower PIR Limit must be ≥ 50% recovery.

$$\frac{Mean - HR_{PIR}}{Fortified\ Concentration} \times 100\% \geq 50\%$$

9.1.3 The RL is validated if both the Upper and Lower PIR Limits meet the criteria described above. If these criteria are not met, the RL has been set too low and must be determined again at a higher concentration.

9.2 Blank(s)

9.2.1 **METHOD BLANK (MB)** - A Method Blank (MB) is required with each extraction batch to confirm that potential background contaminants are not interfering with the identification or quantitation of method analytes. If more than 20 Field Samples are included in a batch, analyze an MB for every 20 samples. If the MB produces a peak within the retention time window of any analyte that would prevent the determination of that analyte, determine the source of contamination and eliminate the interference before processing samples. Background contamination must be reduced to an acceptable level before proceeding. Background from method analytes or other contaminants that interfere with the measurement of method analytes must be below the RL. If the method analytes are detected in the MB at concentrations equal to or greater than this level, then all data for the problem analyte(s) must be considered invalid for all samples in the extraction batch. Because background contamination is a significant problem for several method analytes, it is highly recommended that the analyst maintain a historical record of MB data.

9.2.2 **FIELD REAGENT BLANK (FRB)** - The purpose of the FRB is to ensure that PFAS's measured in the Field Samples were not inadvertently introduced into the sample during sample collection/handling. Analysis of the FRB is required only if a Field Sample contains a method analyte or analytes at or above the RL. The FRB is processed, extracted and analyzed in exactly the same manner as a Field Sample.

9.3 Laboratory Control Sample (LCS) and Laboratory Control Sample Duplicates (LCSD)

9.3.1 An LCS is required with each extraction batch. The fortified concentration of the LCS may be rotated between low, medium, and high concentrations from batch to batch. Default limits of 50-150% of the true value may be used for analytes until sufficient replicates have been analyzed to generate proper control limits. Calculate the percent recovery (%*R*) for each analyte using the equation

$$\%R = \frac{A \times 100}{B}$$

Where:

A = measured concentration in the fortified sample
B =fortification concentration.

9.3.2 Where applicable, LCSD's are to be extracted and analyzed. The concentration and analyte recovery criteria for the LSD must be the same as the batch LCS The RSD's must fall within ≤30% of the true value for medium and high level replicates, and ≤50% for low level replicates. Calculate the relative percent difference (RPD) for duplicate MSs (MS and MSD) using the equation

$$RPD = \frac{|LCS - LCSD|}{(LCS + LCSD) / 2} \times 100$$

9.3.3 If the LCS and or LCSD results do not meet these criteria for method analytes, then all data for the problem analyte(s) must be considered invalid for all samples in the extraction batch.

9.4 Labeled Recovery Standards (REC)

9.4.1 The analyst must monitor the peak areas of the REC(s) in all injections during each analysis day. The REC responses (peak areas) in any chromatographic run must be within laboratory generated control limits generated from the analysis of control spike samples. Default limits of 50-150% may be used for analytes until sufficient replicates have been analyzed to generate proper control limits. If the REC areas in a chromatographic run do not meet these criteria, inject a second aliquot of that extract into a new capped autosampler vial. Random evaporation losses have been observed with the polypropylene caps causing high REC(s) areas.

9.4.1.1 If the reinjected aliquot produces an acceptable REC response, report results for that aliquot.

9.4.1.2 If the reinjected extract fails again, the analyst should check the calibration by reanalyzing the most recently acceptable CAL standard. If the CAL standard fails the criteria of Section 9.8, recalibration is in order per Section 10.6. If the CAL standard is acceptable, extraction of the sample may need to be repeated provided the sample is still within the holding time. Otherwise, report results obtained from the reinjected extract, but annotate as suspect. Alternatively, collect a new sample and re-analyze.

9.5 Extracted Internal Standards (EIS)

9.5.1 The EIS standard is fortified into all samples, CCVs, MBs, LCSs, MSs, MSDs, FD, and FRB prior to extraction. It is also added to the CAL standards. The EIS is a means of assessing method performance from extraction to final chromatographic measurement. Calculate the recovery (%R) for the EIS using the following equation

$$\%R = (A / B) \times 100$$

Where:

A = calculated EIS concentration for the QC or Field Sample
B = fortified concentration of the EIS.

9.5.2 Default limits of 50-150% may be used for analytes until sufficient replicates have been analyzed to generate proper control limits. A low or high percent recovery for a sample, blank, or CCV does not require discarding the analytical data but it may indicate a potential problem with future analytical data. When EIS recovery from a sample, blank, or CCV are outside control limits, check 1) calculations to locate possible errors, 2) standard solutions for degradation, 3) contamination, and 4) instrument performance. For CCVs and QC elements spiked with all target analytes, If the recovery of the corresponding target analytes meet the acceptance criteria for the EIS in question, the data can be used but all potential biases in the recovery of the EIS must be documented in the sample report. If the associated target analytes do not meet the acceptance criteria. The data must be reanalyzed.

9.6 Matrix Spike (MS)

9.6.1 Analysis of an MS is required in each extraction batch and is used to determine that the sample matrix does not adversely affect method accuracy. Assessment of method precision is accomplished by analysis of a Field Duplicate (FD) (Sect. 9.6); however, infrequent occurrence of method analytes would hinder this assessment. If the occurrence of method analytes in the samples is infrequent, or if historical trends are unavailable, a second MS, or MSD, must be prepared, extracted, and analyzed from a duplicate of the Field Sample. Extraction batches that contain MSDs will not require the extraction of a field sample duplicate. If a variety of different sample matrices are analyzed regularly, for example, drinking water from groundwater and surface water sources, method performance should be established for each. Over time, MS data should be documented by the laboratory for all routine sample sources.

9.6.2 Within each extraction batch, a minimum of one Field Sample is fortified as an MS for every 20 Field Samples analyzed. The MS is prepared by spiking a sample with an appropriate amount of the Analyte Stock Standard (Sect. 8.2.4). Use historical data and rotate through the low, mid and high concentrations when selecting a fortifying concentration. Calculate the percent recovery (%*R*) for each analyte using the equation

$$\%R = \frac{(A - B)}{C} \times 100$$

Where:

A = measured concentration in the fortified sample

B = measured concentration in the unfortified sample
C = fortification concentration.

9.6.3 Analyte recoveries may exhibit matrix bias. For samples fortified at or above their native concentration, recoveries should range between 50-150%. If the accuracy of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the LCS, the recovery is judged to be matrix biased. The result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.7 Laboratory Duplicate

9.7.1 FIELD DUPLICATE OR LABORATORY FORTIFIED SAMPLE MATRIX DUPLICATE (FD or MSD) – Within each extraction batch (not to exceed 20 Field Samples), a minimum of one FD or MSD must be analyzed. Duplicates check the precision associated with sample collection, preservation, storage, and laboratory procedures. If method analytes are not routinely observed in Field Samples, an MSD should be analyzed rather than an FD.

9.7.2 Calculate the relative percent difference (*RPD*) for duplicate measurements (*FD1* and *FD2*) using the equation

$$RPD = \frac{|FD1 - FD2|}{(FD1 + FD2) / 2} \times 100$$

9.7.3 RPDs for FDs should be ≤30%. Greater variability may be observed when FDs have analyte concentrations that are within a factor of 2 of the RL. At these concentrations, FDs should have RPDs that are ≤50%. If the RPD of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the CCV, the recovery is judged to be matrix biased. The result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.7.4 If an MSD is analyzed instead of a FD, calculate the relative percent difference (RPD) for duplicate MSs (MS and MSD) using the equation

$$RPD = \frac{|MS - MSD|}{(MS + MSD) / 2} \times 100$$

9.7.5 RPDs for duplicate MSs should be ≤30% for samples fortified at or above their native concentration. Greater variability may be observed when MSs are fortified at analyte concentrations that are within a factor of 2 of the RL. MSs fortified at these concentrations should have RPDs that are ≤50% for samples fortified at or above their native concentration. If the RPD of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the LCSD where applicable, the result is judged to be matrix biased. If no LCSD is present, the associated MS and MSD are to be re-analyzed to determine if any analytical has occurred. If the resulting RPDs are still outside control limits, the result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.8 Initial Calibration Verification (ICV)

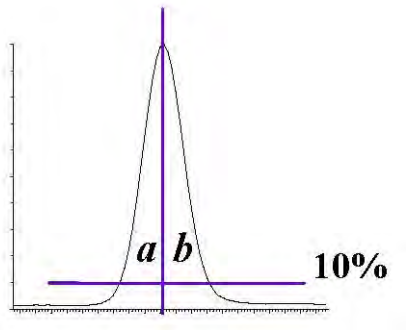
9.8.1 As part of the IDC (Sect. 13.2), each time a new Analyte Stock Standard solution (Sect. 8.2.4) is used, and at least quarterly, analyze a QCS sample from a source different from the source of the CAL standards. If a second vendor is not available, then a different lot of the standard should be used. The QCS should be prepared and analyzed just like a CCV. Acceptance criteria for the QCS are identical to the CCVs; the calculated amount for each analyte must be ± 30% of the expected value. If measured analyte concentrations are not of acceptable accuracy, check the entire analytical procedure to locate and correct the problem.

9.9 Continuing Calibration Verification (CCV)

9.9.1 CCV Standards are analyzed at the beginning of each analysis batch, after every 10 Field Samples, and at the end of the analysis batch. See Section 10.7 for concentration requirements and acceptance criteria.

9.10 Method-specific Quality Control Samples

9.10.1 PEAK ASYMMETRY FACTOR – A peak asymmetry factor must be calculated using the equation below during the IDL and every time a calibration curve is generated. The peak asymmetry factor for the first two eluting peaks in a midlevel CAL standard (if only two analytes are being analyzed, both must be evaluated) must fall in the range of 0.8 to 1.5. Modifying the standard or extract composition to more aqueous content to prevent poor shape is not permitted. See guidance in Section 10.6.4.1 if the calculated peak asymmetry factors do not meet the criteria.



$$A_s = b / a$$

Where:

A_s = peak asymmetry factor
b = width of the back half of the peak measured (at 10% peak height) from the trailing edge of the peak to a line dropped perpendicularly from the peak apex
a = the width of the front half of the peak measured (at 10% peak height) from the leading edge of the peak to a line dropped perpendicularly from the apex.

9.11 Method Sequence

- CCV-LOW
- MB
- LCS
- LCSD
- MS

- Duplicate or MSD
- Field Samples (1-10)
- CCV-MID
- Field Samples (11-20)
- CCV-HIGH

10. Procedure

10.1 Equipment Set-up

10.1.1 This procedure may be performed manually or in an automated mode using a robotic or automatic sample preparation device. If an automated system is used to prepare samples, follow the manufacturer's operating instructions, but all extraction and elution steps must be the same as in the manual procedure. Extraction and/or elution steps may not be changed or omitted to accommodate the use of an automated system. If an automated system is used, the MBs should be rotated among the ports to ensure that all the valves and tubing meet the MB requirements (Sect. 9.2).

10.1.2 Some of the PFAS's adsorb to surfaces, including polypropylene. Therefore, the aqueous sample bottles must be rinsed with the elution solvent (Sect 10.3.4) whether extractions are performed manually or by automation. The bottle rinse is passed through the cartridge to elute the method analytes and is then collected (Sect. 10.3.4).

10.1.3 **NOTE:** The SPE cartridges and sample bottles described in this section are designed as single use items and should be discarded after use. They may not be refurbished for reuse in subsequent analyses.

10.2 Sample Preparation and Extraction of Aqueous Samples

10.2.1 Samples are preserved, collected and stored as presented in Section 6.

The entire sample that is received must be sent through the SPE cartridge. In addition, the bottle must be solvent rinsed and this rinse must be sent through the SPE cartridge as well. The method blank (MB) and laboratory control sample (LCS) must be extracted in exactly the same manner (i.e., must include the bottle solvent rinse). It should be noted that a water rinse alone is not sufficient. This does not apply to samples with high concentrations of PFAS that are prepared using serial dilution and not SPE.

10.2.2 Determine sample volume. An indirect measurement may be done in one of two ways: by marking the level of the sample on the bottle or by weighing the sample and bottle to the nearest 10 g. After extraction, proceed to Section 10.5 for final volume determination.

NOTE: Some of the PFAS's adsorb to surfaces, thus the sample volume may **NOT** be transferred to a graduated cylinder for volume measurement.

10.2.3 The MB, LCS and FRB may be prepared by measuring 250 mL of reagent water with a polypropylene graduated cylinder or filling a 250-mL sample bottle to near the top.

10.2.4 Adjust the sample pH to 3 by adding a 1:1 solution of acetic acid in water dropwise

10.2.5 Add 20 µL of the EIS PDS (Sect. 8.2.2) to each sample and QC, cap and invert to mix.

10.2.6 If the sample is an LCS, LCSD, MS, or MSD, add the necessary amount of analyte PDS (Sect. 8.2.4). Cap and invert each sample to mix.

10.3 Cartridge SPE Procedure

10.3.1 CARTRIDGE CLEAN-UP AND CONDITIONING – DO NOT allow cartridge packing material to go dry during any of the conditioning steps. Rinse each cartridge with 3 X 5 mL of 2% ammonium hydroxide in methanol, followed by 5mls of methanol. Next, rinse each cartridge with 5 mls of the 25 mM acetate buffer, followed by 15 mL of reagent water, without allowing the water to drop below the top edge of the packing. If the cartridge goes dry during the conditioning phase, the conditioning must be started over. Add 4-5 mL of reagent water to each cartridge, attach the sample transfer tubes (Sect. 7.9.3), turn on the vacuum, and begin adding sample to the cartridge.

10.3.2 SAMPLE EXTRACTON – Adjust the vacuum so that the approximate flow rate is 10-15 mL/min. Do not allow the cartridge to go dry before all the sample has passed through.

10.3.3 SAMPLE BOTTLE AND CARTRIDGE RINSE – After the entire sample has passed through the cartridge, rinse the sample bottles with 4 ml reagent water followed by 4 ml 25 mM acetate buffer at pH 4 and draw the aliquot through the sample transfer tubes and the cartridges. Draw air or nitrogen through the cartridge for 5-10 min at high vacuum (10-15 in. Hg). **NOTE: If empty plastic reservoirs are used in place of the sample transfer tubes to pass the samples through the cartridges, these reservoirs must be treated like the transfer tubes. After the entire sample has passed through the cartridge, the reservoirs must be rinsed to waste with reagent water.**

10.3.4 SAMPLE BOTTLE AND CARTRIDGE ELUTION, Fraction 1 – Turn off and release the vacuum. Lift the extraction manifold top and insert a rack with collection tubes into the extraction tank to collect the extracts as they are eluted from the cartridges. Rinse the sample bottles with 4 mls of methanol and draw the aliquot through the sample transfer tubes and cartridges. Use a low vacuum such that the solvent exits the cartridge in a dropwise fashion. Repeat sample bottle rinse and cartridge elution with 2 more 4-mL methanol.

SAMPLE BOTTLE AND CARTRIDGE ELUTION, Fraction 2 In a separate collection vial, rinse the sample bottles with 4 mL of 2% ammonium hydroxide in methanol and elute the analytes from the cartridges by pulling the 4 mL of methanol through the sample transfer tubes and the cartridges. Use a low vacuum such that the solvent exits the cartridge in a dropwise fashion. Repeat sample bottle rinse and cartridge elution with 2 more 4-mL aliquots of 2% ammonium hydroxide in methanol. To the final extract, add 50 ul of acetic acid.

NOTE: If empty plastic reservoirs are used in place of the sample transfer tubes to pass the samples through the cartridges, these reservoirs must be treated like the transfer tubes. After the reservoirs have been rinsed in Section 10.3.3, the elution solvent used to rinse the sample bottles must be swirled down the sides of the reservoirs while eluting the cartridge to

ensure that any method analytes on the surface of the reservoirs are transferred to the extract.

10.3.5 Fractions 1 and 2 are to be combined during the concentration stage (section10.6)

10.4 Sample Prep and Extraction Protocol for Soils

10.4.1 2 grams of sample (measured to the nearest hundredth of a gram) is placed in a 15 ml polypropylene centrifuge tube. For laboratory control blanks and spikes, 2 grams of clean sand is used.

10.4.2 Add 20 µL of the EIS PDS (Sect. 8.2.2) to each sample and QC.

10.4.3 If the sample is an LCS, LCSD, MS, or MSD, add the necessary amount of analyte PDS (Sect. 8.2.4). Cap and invert each sample to mix.

10.4.4 To all samples, add 10 mls of methanol, cap and mix of 30 minutes using a shaker table of tumbler.

10.4.5 Following mixing, sonicate each sample for 30 minutes

10.4.6 Centrifuge each sample at 15,000g for 5 minutes.

10.4.7 Remove supernatant, and reserve for clean-up.

10.5 Extract Clean-up

10.5.1 CARTRIDGE CLEAN-UP AND CONDITIONING –. Rinse each cartridge with 15 mL of methanol and discard. If the cartridge goes dry during the conditioning phase, the conditioning must be started over. Attach the sample transfer tubes (Sect. 7.9.3), turn on the vacuum, and begin adding sample to the cartridge.

10.5.2 Adjust the vacuum so that the approximate flow rate is 1-2 mL/min. Do not allow the cartridge to go dry before all the sample has passed through.

10.5.3 SAMPLE BOTTLE AND CARTRIDGE RINSE – After the entire sample has passed through the cartridge, rinse the sample collection vial with two 1-mL aliquots of methanol and draw each aliquot through the cartridges. Draw air or nitrogen through the cartridge for 5 min at high vacuum (10-15 in. Hg).

10.5.4 If extracts are not to be immediately evaporated, cover collection tubes and store at ambient temperature till concentration.

10.6 Extract Concentration

10.6.1 Concentrate the extract to dryness under a gentle stream of nitrogen in a heated water bath (60-65 °C) to remove all the water/methanol mix. Add the appropriate amount of 80:20% (vol/vol) methanol:water solution and 20 µl of the ID REC PDS (Sect. 8.2.7) to the collection vial to bring the volume to 1 mL and vortex. Transfer a small aliquot with a plastic pipet (Sect. 7.6) to a polypropylene autosampler vial.

NOTE: It is recommended that the entire 1-mL aliquot not be transferred to the autosampler vial because the polypropylene autosampler caps do not reseal after injection. Therefore, do not store the extracts in the

autosampler vials as evaporation losses can occur occasionally in these autosampler vials. Extracts can be split between 2 X 700 µl vials (Sect. 7.4).

10.7 Sample Volume Determination

10.7.1 If the level of the sample was marked on the sample bottle, use a graduated cylinder to measure the volume of water required to fill the original sample bottle to the mark made prior to extraction. Determine to the nearest 10 mL.

10.7.2 If using weight to determine volume, weigh the empty bottle to the nearest 10 g and determine the sample weight by subtraction of the empty bottle weight from the original sample weight (Sect. 10.2.2). Assume a sample density of 1.0 g/mL. In either case, the sample volume will be used in the final calculations of the analyte concentration (Sect. 11.2).

10.8 Initial Calibration - Demonstration and documentation of acceptable initial calibration is required before any samples are analyzed. After the initial calibration is successful, a CCV is required at the beginning and end of each period in which analyses are performed, and after every tenth Field Sample.

10.8.1 ESI-MS/MS TUNE

10.8.1.1 Calibrate the mass scale of the MS with the calibration compounds and procedures prescribed by the manufacturer.

10.8.1.2 Optimize the [M-H]- for each method analyte by infusing approximately 0.5-1.0 µg/mL of each analyte (prepared in the initial mobile phase conditions) directly into the MS at the chosen LC mobile phase flow rate (approximately 0.4 mL/min). This tune can be done on a mix of the method analytes. The MS parameters (voltages, temperatures, gas flows, etc.) are varied until optimal analyte responses are determined. The method analytes may have different optima requiring some compromise between the optima.

10.8.1.3 Optimize the product ion for each analyte by infusing approximately 0.5-1.0 µg/mL of each analyte (prepared in the initial mobile phase conditions) directly into the MS at the chosen LC mobile phase flow rate (approximately 0.3 mL/min). This tune can be done on a mix of the method analytes. The MS/MS parameters (collision gas pressure, collision energy, etc.) are varied until optimal analyte responses are determined. Typically, the carboxylic acids have very similar MS/MS conditions and the sulfonic acids have similar MS/MS conditions.

10.8.2 Establish LC operating parameters that optimize resolution and peak shape. Modifying the standard or extract composition to more aqueous content to prevent poor shape is not permitted.

Cautions: LC system components, as well as the mobile phase constituents, contain many of the method analytes in this method. Thus, these PFAS's will build up on the head of the LC column during mobile phase equilibration. To minimize the background PFAS peaks and to keep background levels constant, the time the LC column sits at initial conditions must be kept constant and as short as possible (while ensuring reproducible retention times). In addition, prior to daily use, flush the column with 100% methanol for at least 20 min before initiating a sequence. It may be necessary on some systems to flush other LC components such as wash

syringes, sample needles or any other system components before daily use.

10.8.3 Inject a mid-level CAL standard under LC/MS conditions to obtain the retention times of each method analyte. If analyzing for PFTA, ensure that the LC conditions are adequate to prevent co-elution of PFTA and the mobile phase interferants. These interferants have the same precursor and products ions as PFTA, and under faster LC conditions may co-elute with PFTA. Divide the chromatogram into retention time windows each of which contains one or more chromatographic peaks. During MS/MS analysis, fragment a small number of selected precursor ions ([M-H]-) for the analytes in each window and choose the most abundant product ion. For maximum sensitivity, small mass windows of ±0.5 daltons around the product ion mass were used for quantitation. If sufficient sensitivity exists to meet the RL, wider mass ranges may be used to obtain more confirmation ions.

10.8.3.1 NOTE: As the NOTE in Section 10.6.4.1 indicates, PFOS has linear and branched isomers. There have been reports that not all the products ions in the linear PFOS are produced in all the branched PFOS isomers. (This phenomenon probably exists for PFHxS and PFBS also, although it has not been studied to date.) Thus, in an attempt to reduce PFOS bias, it is required that the *m/z* 499 → *m/z* 80 transition be used as the quantitation transition. Some MS/MS instruments, such as conventional ion traps, may not be able to scan a product ion with such a wide mass difference from the precursor ion; therefore, they may not be used for this method if PFOS, PFBS, or PFHxS analysis is to be conducted. Literature reports indicate for the most abundant PFOS isomer, which is the linear isomer, that all the products ions obtained on an ion trap have less than 10% relative abundance. In addition, there is not a single ion trap MS/MS transition that encompasses the linear isomer and the majority of the branch isomers; thus, the bias would be unacceptably high.

10.8.4 Inject a mid-level CAL standard under optimized LC/MS/MS conditions to ensure that each method analyte is observed in its MS/MS window and that there are at least 10 scans across the peak for optimum precision.

10.8.4.1 If broad, split or fronting peaks are observed for the first two eluting chromatographic peaks (if only two analytes are being analyzed, both must be evaluated), change the initial mobile phase conditions to higher aqueous content until the peak asymmetry ratio for each peak is 0.8 – 1.5. The peak asymmetry factor is calculated as described in Section 9.9.1 on a mid-level CAL standard. The peak asymmetry factor must meet the above criteria for the first two eluting peaks during the IDL and every time a new calibration curve is generated. Modifying the standard or extract composition to more aqueous content to prevent poor shape is not permitted.

NOTE: PFHxS, PFOS, NMeFOSAA, and NEtFOSAA have multiple chromatographic peaks using the LC conditions in Table 5 due to chromatographic resolution of the linear and branched isomers of these compounds. Most PFAS's are produced by two different processes. One process gives rise to linear PFAS's only while the other process produces both linear and branched isomers. Thus, both branched and linear PFAS's can potentially be found in the

environment. For the aforementioned compounds that give rise to more than one peak, all the chromatographic peaks observed in the standard must be integrated and the areas totaled. Chromatographic peaks in a sample must be integrated in the same way as the CAL standard.

10.8.5 Prepare a set of CAL standards as described in Section 8.2.5. The lowest concentration CAL standard must be at or below the RL (2 ng/L), which may depend on system sensitivity. It is recommended that at least four of the CAL standards are at a concentration greater than or equal to the RL.

10.8.6 The LC/MS/MS system is calibrated using the IS technique. Use the LC/MS/MS data system software to generate a linear regression or quadratic calibration curve for each of the analytes. This curve **must always** be forced through zero and may be concentration weighted, if necessary. Forcing zero allows for a better estimate of the background levels of method analytes. A minimum of 5 levels are required for a linear calibration model and a minimum of 6 levels are required for a quadratic calibration model.

10.8.6.1 The isotopically labeled IS(s) in this method may undergo suppression in the ESI source if the concentration of the co-eluting unlabeled method analyte(s) is too high. The analyte concentration at which suppression may occur can vary depending on the instrument, LC conditions, ESI conditions, IS concentration, etc. To evaluate whether suppression is occurring during calibration, calculate the relative percent difference (*RPD*) between the high (H) and low (L) areas for each IS using the equation

$$RPD = \frac{(H - L)}{(H + L) / 2} \times 100$$

10.8.6.2 The RPD calculated above must be <20% for each IS during calibration. If the calculated RPD is >20% for any IS, the analyst must recalibrate at lower analyte concentrations until the IS RPDs are <20%.

10.8.7 CALIBRATION ACCEPTANCE CRITERIA – A linear fit is acceptable if the coefficient of determination (r^2) is greater than 0.99. When quantitated using the initial calibration curve, each calibration point, except the lowest point, for each analyte should calculate to be within 70-130% of its true value. The lowest CAL point should calculate to be within 50-150% of its true value. If these criteria cannot be met, the analyst will have difficulty meeting ongoing QC criteria. It is recommended that corrective action is taken to reanalyze the CAL standards, restrict the range of calibration, or select an alternate method of calibration (forcing the curve through zero is still required).

10.8.7.1 CAUTION: When acquiring MS/MS data, LC operating conditions must be carefully reproduced for each analysis to provide reproducible retention times. If this is not done, the correct ions will not be monitored at the appropriate times. As a precautionary measure, the chromatographic peaks in each window must not elute too close to the edge of the segment time window.

10.9 CONTINUING CALIBRATION CHECK (CCV) – Minimum daily calibration verification is as follows. Verify the initial calibration at the beginning and end of each group of analyses, and after every tenth sample during analyses. In this context, a “sample” is

considered to be a Field Sample. MBs, CCVs, LCSs, MSs, FDs FRBs and MSDs are not counted as samples. The beginning CCV of each analysis batch must be at or below the RL in order to verify instrument sensitivity prior to any analyses. If standards have been prepared such that all low CAL points are not in the same CAL solution, it may be necessary to analyze two CAL standards to meet this requirement. Alternatively, the analyte concentrations in the analyte PDS may be customized to meet these criteria. Subsequent CCVs should alternate between a medium and Low concentration CAL standard.

10.9.1 Inject an aliquot of the appropriate concentration CAL standard and analyze with the same conditions used during the initial calibration.

10.9.2 Calculate the concentration of each analyte and EIS in the CCV. The calculated amount for each analyte for medium level CCVs must be within ± 30% of the true value with an allowance of 10% of the reported analytes to be greater than 30%, but less than 40%. The calculated amount for each EIS must be within ± 50% of the true value The calculated amount for the lowest calibration point for each analyte must be within ± 50%. If these conditions do not exist, then all data for the problem analyte must be considered invalid, and remedial action should be taken (Sect. 10.7.4) which may require recalibration. Any Field or QC Samples that have been analyzed since the last acceptable calibration verification should be reanalyzed after adequate calibration has been restored, with the following exception. **If the CCV fails because the calculated concentration is greater than 130% (150% for the low-level CCV) for a particular method analyte, and Field Sample extracts show no detection for that method analyte, non-detects may be reported without re-analysis.**

10.9.3 REMEDIAL ACTION – Failure to meet CCV QC performance criteria may require remedial action. Major maintenance, such as cleaning the electrospray probe, atmospheric pressure ionization source, cleaning the mass analyzer, replacing the LC column, etc., requires recalibration (Sect 10.6) and verification of sensitivity by analyzing a CCV at or below the RL (Sect 10.7).

10.10 EXTRACT ANALYSIS

10.10.1 Establish operating conditions equivalent to those summarized in Tables 6-8 of Section 16. Instrument conditions and columns should be optimized prior to the initiation of the IDC.

10.10.2 Establish an appropriate retention time window for each analyte. This should be based on measurements of actual retention time variation for each method analyte in CAL standard solutions analyzed on the LC over the course of time. A value of plus or minus three times the standard deviation of the retention time obtained for each method analyte while establishing the initial calibration and

completing the IDC can be used to calculate a suggested window size. However, the experience of the analyst should weigh heavily on the determination of the appropriate retention window size.

10.10.3 Calibrate the system by either the analysis of a calibration curve (Sect. 10.6) or by confirming the initial calibration is still valid by analyzing a CCV as described in Section 10.7. If establishing an initial calibration, complete the IDC as described in Section 13.2.

10.10.4 Begin analyzing Field Samples, including QC samples, at their appropriate frequency by injecting the same size aliquots under the same conditions used to analyze the CAL standards.

10.10.5 At the conclusion of data acquisition, use the same software that was used in the calibration procedure to identify peaks of interest in predetermined retention time windows. Use the data system software to examine the ion abundances of the peaks in the chromatogram. Identify an analyte by comparison of its retention time with that of the corresponding method analyte peak in a reference standard.

10.10.6 Comparison of the MS/MS mass spectra is not particularly useful given the limited ±0.5 dalton mass range around a single product ion for each method analyte.

10.10.7 The analyst must not extrapolate beyond the established calibration range. If an analyte peak area exceeds the range of the initial calibration curve, the sample should be re-extracted with a reduced sample volume in order to bring the out of range target analytes into the calibration range. If a smaller sample size would not be representative of the entire sample, the following options is recommended. Re-extract an additional aliquot of sufficient size to insure that it is representative of the entire sample. Spike it with a higher concentration of internal standard. Prior to LC/MS analysis, dilute the sample so that it has a concentration of internal standard equivalent to that present in the calibration standard. Then, analyze the diluted extract.

11. Data Evaluation, Calculations and Reporting

11.1 Complete chromatographic resolution is not necessary for accurate and precise measurements of analyte concentrations using MS/MS. In validating this method, concentrations were calculated by measuring the product ions listed in Table 7.

11.2 Calculate analyte concentrations using the multipoint calibration established in Section 10.6. Do not use daily calibration verification data to quantitate analytes in samples. Adjust final analyte concentrations to reflect the actual sample volume determined in Section 10.6 where:

C_{ex} = (Area of target analyte * Concentration of Labeled analog) / (area of labeled analog * CF)

C_s = (C_{ex} / sample volume in ml) * 1000

C_{ex} = The concentration of the analyte in the extract
CF = calibration factor from calibration.

11.3 Prior to reporting the data, the chromatogram should be reviewed for any incorrect peak identification or poor integration.

11.4 PFHxS, PFOS, PFOA, NMeFOSAA, and NEtFOSAA have multiple chromatographic peaks using the LC conditions in Table 5 due to the linear and branch isomers of these compounds (Sect. 10.6.4.1). The areas of all the linear and branched isomer peaks observed in the CAL standards for each of these analytes must be summed and the concentrations reported as a total for each of these analytes.

11.5 Calculations must utilize all available digits of precision, but final reported concentrations should be rounded to an appropriate number of significant figures (one digit of uncertainty), typically two, and not more than three significant figures.

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

12.1 Section 9.0 outlines sample batch QC acceptance criteria. If non-compliant organic compound results are to be reported, the Organic Section Head and/or the Laboratory Director, and the Operations Manager must approve the reporting of these results. The laboratory Project Manager shall be notified, and may choose to relay the non-compliance to the client, for approval, or other corrective action, such as re-sampling and re-analysis. The analyst, Data Reviewer, or Department Supervisor performing the secondary review initiates the project narrative, and the narrative must clearly document the non-compliance and provide a reason for acceptance of these results.

12.2 All results for the organic compounds of interest are reportable without qualification if extraction and analytical holding times are met, preservation requirements (including cooler temperatures) are met, all QC criteria are met, and matrix interference is not suspected during extraction or analysis of the samples. If any of the below QC parameters are not met, all associated samples must be evaluated for re-extraction and/or re-analysis.

13. Method Performance

13.1 Detection Limit Study (DL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

13.1.1 The laboratory follows the procedure to determine the DL, LOD, and/or LOQ as outlined in Alpha SOP ID 1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

13.2.1 The IDC must be successfully performed prior to analyzing any Field Samples. Prior to conducting the IDC, the analyst must first generate an acceptable Initial Calibration following the procedure outlined in Section 10.6.

13.2.2 INITIAL DEMONSTRATION OF LOW SYSTEM BACKGROUND – Any time a new lot of SPE cartridges, solvents, centrifuge tubes, disposable pipets, and autosampler vials are used, it must be demonstrated that an MB is reasonably free of contamination and that the criteria in Section 9.2.1 are met. If an

automated extraction system is used, an MB should be extracted on each port to ensure that all the valves and tubing are free from potential PFAS contamination.

13.2.3 INITIAL DEMONSTRATION OF PRECISION (IDP) – Prepare, extract, and analyze four to seven replicate LCSs fortified near the midrange of the initial calibration curve according to the procedure described in Section 10. Sample preservatives as described in Section 6.2.1 must be added to these samples. The relative standard deviation (RSD) of the results of the replicate analyses must be less than 20%.

13.2.4 INITIAL DEMONSTRATION OF ACCURACY (IDA) – Using the same set of replicate data generated for Section 13.2.3, calculate average recovery. The average recovery of the replicate values must be within ± 30% of the true value.

13.2.5 INITIAL DEMONSTRATION OF PEAK ASYMMETRY FACTOR – Peak asymmetry factors must be calculated using the equation in Section 9.10.1 for the first two eluting peaks (if only two analytes are being analyzed, both must be evaluated) in a mid-level CAL standard. The peak asymmetry factors must fall in the range of 0.8 to 1.5. See guidance in Section 10.6.4.1 if the calculated peak asymmetry factors do not meet the criteria.

13.2.6 Refer to Alpha SOP ID 1739 for further information regarding IDC/DOC Generation.

13.2.7 The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

14.1 Refer to Alpha's Chemical Hygiene Plan and Hazardous Waste Management and Disposal SOP for further pollution prevention and waste management information.

14.2 This method utilizes SPE to extract analytes from water. It requires the use of very small volumes of organic solvent and very small quantities of pure analytes, thereby minimizing the potential hazards to both the analyst and the environment as compared to the use of large volumes of organic solvents in conventional liquid-liquid extractions.

14.3 The analytical procedures described in this method generate relatively small amounts of waste since only small amounts of reagents and solvents are used. The matrices of concern are finished drinking water or source water. However, laboratory waste management practices must be conducted consistent with all applicable rules and regulations, and that laboratories protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Also, compliance is required with any sewage discharge permits and regulations, particularly the hazardous waste identification rules and land disposal restrictions.

15. Referenced Documents

Chemical Hygiene Plan – ID 2124

SOP ID 1732 Detection Limit (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ) SOP

SOP ID 1739 Demonstration of Capability (DOC) Generation SOP

SOP ID 1728 Hazardous Waste Management and Disposal SOP

16. Attachments

Table 6: LC Method Conditions

Time (min)	2 mM Ammonium Acetate (5:95 MeOH/H_2O)	2 mM Ammonium Acetate (100% Methanol)
Initial	100.0	0.0
1.0	100.0	0.0
2.2	85.0	15.0
11	20.0	80.0
11.4	0.0	100.0
12.4	100.0	00.0
15.5	100.0	0.0
Waters Aquity UPLC ® BEHC_{18} 2.1 x 50 mm packed with 1.7 µm BEH C_{18} stationary phase Flow rate of 0.4 mL/min 2-5 µL injection		

Table 7: ESI-MS Method Conditions

ESI Conditions	
Polarity	Negative ion
Capillary needle voltage	.5 kV
Cone Gas Flow	20 L/hr
Nitrogen desolvation gas	1000 L/hr
Desolvation gas temp.	500 ºC

Table 8: Method Analyte Source, Retention Times (RTs), and EIS References

#	Analyte	Transition	RT	IS	Type
1	M3PBA	216>171	2.65		REC
2	PFBA	213 > 169	2.65	2: M4PFBA	
3	M4PFBA	217 > 172	2.65	1: M3PBA	EIS
4	PFPeA	263 > 219	5.67	4: M5PFPEA	
5	M5PFPEA	268 > 223	5.66	1: M3PBA	EIS
6	PFBS	299 > 80	6.35	6: M3PFBS	
7	M3PFBS	302 > 80	6.35	1: M3PBA	EIS
8	FtS 4:2	327 > 307	7.47	9: M2-4:2FTS	
9	M2-4:2FTS	329 > 81	7.47	1: M3PBA	EIS
10	PFHxA	303 > 269	7.57	10: M5PFHxA	
11	M5PFHxA	318 > 273	7.57	1: M3PBA	EIS
12	PFPeS	349 > 80	7.88	18: M3PFHxS	
13	PFHpA	363 > 319	8.80	14: M4PFHpA	
14	M4PFHpA	367 > 322	8.80	1: M3PBA	EIS
15	L-PFHxS	399 > 80	8.94	18: M3PFHxS	

#	Analyte	Transition	RT	IS	Type
16	br-PFHxS	399 > 80	8.72	18: M3PFHxS	
17	PFHxS Total	399 > 80	8.94	18: M3PFHxS	
18	M3PFHxS	402 > 80	8.94	1: M3PBA	EIS
19	M2PFOA	415 > 370	9.7		REC
20	PFOA	413 > 369	9.7	23: M8PFOA	
21	br-PFOA	413 > 369	9.48	23: M8PFOA	
22	PFOA Total	413 > 369	9.7	23: M8PFOA	
23	M8PFOA	421 > 376	9.7	19: M2PFOA	EIS
24	FtS 6:2	427 > 407	9.66	25: M2-6:2FTS	
25	M2-6:2FTS	429 > 409	9.66	19: M2PFOA	EIS
26	PFHpS	449 > 80	9.78	33: M8PFOS	
27	PFNA	463 > 419	10.41	33: M8PFOS	
28	M9PFNA	472 > 427	10.41	19: PFOA	EIS
29	M2PFOS	501 > 80	10.45		REC
30	PFOS	499 > 80	10.45	33: M8PFOS	
31	br-PFOS	499 > 80	10.27	33: M8PFOS	
32	PFOS Total	499 > 80	10.45	33: M8PFOS	
33	M8PFOS	507 > 80	10.45	29: M4PFOS	EIS
34	FtS 8:2	527 > 507	10.99	38: M2-8:2FTS	
35	M2-8:2FTS	529 > 509	10.99	36: M2PFDA	EIS
36	M2PFDA	515 > 470	11.00		REC
37	PFDA	513 > 469	11.00	38: M6PFDA	
38	M6PFDA	519 > 474	11.00	36: M2PFDA	EIS
39	PFNS	549 > 80	11.02	38: M6PFDA	
40	NMeFOSAA	570 > 419	11.41	41: D3-NMeFOSAA	
41	d3-NMeFOSAA	573 > 419	11.41	36: M2PFDA	EIS
42	PFOSA	498 > 78	11.48	29: M8FOSA	
43	M8FOSA	506 > 78	11.48	19: M2PFOA	EIS
44	PFUnDA	563 > 519	11.51	41: M7-PFUDA	
45	M7-PFUDA	570 > 525	11.51	36: M2PFDA	EIS
46	PFDS	599 > 80	11.51	45: M7-PFUDA	
47	NEtFOSAA	584 > 419	11.68	48: d5-NEtFOSAA	
48	d5-NEtFOSAA	589 > 419	11.68	36: M2PFDA	EIS
49	PFDoA	613 > 569	11.96	50: MPFDOA	
50	MPFDOA	615 > 570	11.96	36: M2PFDA	EIS
51	PFTriA	663 > 619	12.34	50: MPFDOA	
52	PFTeA	713 > 669	12.6	53: M2PFTEDA	
53	M2PFTEDA	715 > 670	12.6	36: M2PFDA	EIS
54	M3HFPO-DA	329>285	7.97	1: M3PFBA	EIS

#	Analyte	Transition	RT	IS	Type
55	HFPO-DA	332>287	7.97	54: M3HFPO-DA	
56	ADONA	377>251		23: M8PFOA	
57	PFHxDA	813>769	13.2	53:M2PFTEDA	
58	PFODA	913>869	13.5	53:M2PFTEDA	