QUALITY ASSURANCE PROJECT PLAN

for

Bioremediation Pilot Test at Bangor Site F

Naval Base Kitsap-Bangor  
Kitsap County, WA

Prepared by

U.S. ARMY CORPS OF ENGINEERS

Engineer Research and Development Center and Seattle District



**DRAFT**

**June 23, 2021**

# QAPP Worksheet #1 & 2: Title and Approval Page

*(UFP-QAPP Manual Section 2.1)*

|  |  |
| --- | --- |
| **Document Title:** | Quality Assurance Project Plan for Bioremediation Pilot Test at Bangor Site F |
| **Site Location:** | Naval Base Kitsap-Bangor, Kitsap County, WA |
| **Preparation Date:** | June 23, 2021 |
| **Lead Organization:** | Naval Facilities Engineering Command Northwest (NAVFAC NW) |
| **Investigative Organization:** | United States Army Engineer Research and Development Center (ERDC) and United States Army Corps of Engineers (USACE) Seattle District |

QAPP Approval Signatures:

|  |  |
| --- | --- |
| **Lead Organization Project Manager** | Malcolm Gander, Remedial Project Manager  Naval Facilities Engineering Command Northwest (NAVFAC NW) |
| **Investigative Organization Project Manager** | Briana Niestrom, Project Manager  USACE Seattle District |
| **Investigative Organization Project Chemist** | Alison M. Suess, Ph.D. Chemist  USACE Seattle District |
| **Regulatory Agency Project Manger** | Mahbub Alam  Washington State Department of Ecology (Ecology) |
| **Regulatory Agency Project Manger** | Harry Craig  U.S. Environmental Protection Agency (EPA) |

Plans and reports from previous investigations relevant to this project: See References.

# Executive Summary

USACE Seattle District and U.S. Army ERDC (collectively USACE) have completed multiple rounds of *in situ* bioremediation (ISB) pilot testing at Naval Base Kitsap-Bangor Site F, which collectively show (1) that ISB is capable of achieving RDX cleanup concentrations, and (2) that implementing ISB could significantly reduce aquifer cleanup time and cost at Site F. The purpose of this study to perform an ISB pilot to simulate a portion of a full-scale ISB remedy in the Site F aquifer, which would provide (1) full-scale bioremediation performance information for the Navy and the Navy’s remediation contractor to use when developing the full-scale ISB design, and (2) extended ISB performance monitoring to directly answer remaining questions regarding transient nature of the RDX breakdown intermediates, ability to achieve cleanup levels, and longevity of treatment.

**Contractor Preparation Work:** A contractor for USACE will prepare the site, install an 8-inch diameter test well for injection, acquire fructose and sodium bicarbonate, and install a metering station for injection solutions. The contractor will be available for maintenance and troubleshooting. USACE personnel will perform the injections and groundwater monitoring.

**Phase I:** In the first phase of the ISB pilot study, beginning October 2022, USACE will establish an *in situ* bioreactor by injecting a large quantity of fructose-amended groundwater to stimulate growth and activity of indigenous RDX degrading microbes in the Site F aquifer. A portion of the water currently extracted from well F-EW5 will be diverted to the ISB test location, fructose and bicarbonate will be added to F-EW5 groundwater, and then the amended F-EW5 groundwater will be injected into a newly constructed injection well. The injection is expected to last 43 days and subsequent groundwater monitoring will be performed for 90 days.

**Phase II:** In the second phase of the ISB pilot study, beginning February 2023, USACE will “challenge” the *in situ* bioreactor by injecting a large quantity of RDX-containing groundwater into the injection well. This “challenge” phase will use RDX-containing groundwater from F-MW44 that is amended with fructose, bicarbonate, and anion tracer, and then the amended groundwater will be injected into the injection well. The injection is expected to last 10 days and subsequent groundwater monitoring will be performed for 120 days.

Based on previous site-specific bioremediation test results, results of this pilot are expected to provide confirmation that full-scale bioremediation can achieve RDX cleanup objectives. Any deleterious findings, though not anticipated, will empower Navy with required information to ensure the full-scale system is properly designed and implemented. Buffered injections are planned to prevent aquifer acidification, which has been observed to inhibit RDX degradation in the Site F aquifer.

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# Acronyms and Abbreviations

µg/L micrograms per liter

µm micrometer

1,3,5-TNB 1,3,5-trinitrobenzene

DNT 2,4-dinitrotoluene

DNX 1,3-dinitroso-5-nitro-1,3,5-triazacyclohexane

DoD Department of Defense

Ecology Washington State Department of Ecology

EPA United States Environmental Protection Agency

ERDC United States Army Engineer Research and Development Center

GW groundwater

HDPE high density polyethylene

ISB *in situ* bioremediation

mg/L milligrams per liter

mL milliliter

MNX hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine

NA not applicable

NAVFAC Naval Facilities Engineering Command

Navy United States Navy

PPT push-pull test

QAPP Quality Assurance Project Plan

QC quality control

QSM Quality Systems Manual

RDX hexahydro-1,3,5-trinitro-1,3,5-triazinane

RPM remedial project manager

Site F Naval Base Kitsap, Bangor Site F

S soil

SD sediment

SOP Standard Operating Procedure

SS surface soil

TOC total organic carbon

TNT 2,4,6-trinitrotoluene

TNX hexahydro-1,3,5- trinitroso-1,3,5-triazine

UFP-QAPP Uniform Federal Policy Quality Assurance Project Plan

USACE United States Army Corps of Engineers

VOA volatile organics analysis

# QAPP Worksheet #3 & 5: Project Organization and QAPP Distribution

*(UFP-QAPP Manual Section 2.3 and 2.4)*

\*QAPP Recipient Lines of Authority (solid) Lines of Communication (dashed)

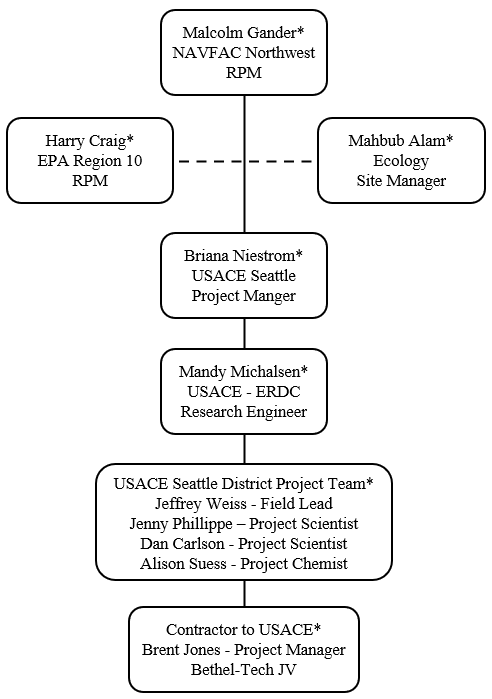


Figure 1. Project Organization Chart

# QAPP Worksheet #4, 7 & 8: Personnel Qualifications and Sign-off Sheet

*(UFP-QAPP Manual Sections 2.3.2 – 2.3.4)*

Project Execution:

|  |  |  |
| --- | --- | --- |
| Name/Organization | Project Role | Contact Information |
| Malcolm Gander, RPM  NAVFAC Northwest | Manage project for NAVFAC Northwest | malcolm.gander@navy.mil  206-321-5110 |
| Briana Niestrom, Project Manager  USACE – Seattle District | Responsible for project oversight, coordination, and execution for USACE Seattle District | Briana.C.Niestrom@usace.army.mil  206-764-3498 |
| Mandy Michalsen, Research Engineer, Senior Technical Advisor  USACE – ERDC | Oversees technical work and deliverables for USACE-ERDC | Mandy.M.Michalsen@usace.army.mil  206-764-3324 |
| Jeffrey Weiss, Geologist, Field Lead  USACE – Seattle District | Leads fieldwork and contractor oversite, contributes to data analysis and writing reports | Jeffrey.M.Weiss@usace.army.mil  206-764-3312 |
| Jenny Phillippe, Physical Scientist, Project Scientist | Coordinates USACE project team work and deliverables, contributes to data analysis and writing reports | Jennifer.E.Phillippe@usace.army.mil  206-764-6965 |
| Dan Carlson, Physical Scientist, Project Scientist  USACE – Seattle District | Coordinates USACE project team work and deliverables, contributes to data analysis and writing reports | Daniel.J.Carlson@usace.army.mil  206-764-6899 |
| Alison Suess, Project Chemist  USACE – Seattle District | Primary Work Plan and QAPP author; Coordinates QAPP and sampling/data needs, contributes to data analysis and writing reports | Alison.M.Suess@usace.army.mil  206-764-3263 |

Contractor for USACE:

|  |  |  |
| --- | --- | --- |
| Name/Organization | Project Role | Contact Information |
| Brent Jones, Project Manager  Bethel-Tech JV | Responsible for execution of contractor work and communication with USACE | Brent.Jones@tetratech.com  206-499-8846 |

Laboratory:

|  |  |  |
| --- | --- | --- |
| Name/Organization | Project Role | Contact Information |
| Tim Witrzek  Environmental Monitoring and Technologies, Inc (EMT) | Primary lab contact:  Federal Program Manager | 847-324-3320  twitrzek@emt.com  Environmental Monitoring and Technologies, Inc.  509 N. 3rd Ave. Des Plaines, IL. 60016 |
| Nicki Ryan  EMT | Backup prime laboratory contact:  Federal Project Manager | 847-324-3326  nryan@emt.com |
| Jason Cristino  EMT | Backup prime laboratory contact:  Business Development – Federal Market | 847-324-3309  jcristino@emt.com |

Project Review:

|  |  |  |
| --- | --- | --- |
| Name/Organization | Project Role | Contact Information |
| Harry Craig, RPM  EPA Region 10 | Provide regulatory oversight | Craig.Harry@epa.gov  503-326-3689 |
| Mahbub Alam, Site Manager  Ecology | Provide regulatory oversight | mahbub.alam@ecy.wa.gov  360-407-6913 |

Signatures and qualifications available upon request.

# QAPP Worksheet #6: Communication Pathways

*(UFP-QAPP Manual Section 2.4.2)*

|  |  |  |  |
| --- | --- | --- | --- |
| Communication Driver | Organization and Role | Name and Contact Information | Procedure  (timing, pathway, documentation, etc.) |
| NAVFAC management for this project  Regulatory agency interface  Overall direction and Point of Contact for public | NAVFAC Northwest RPM | Malcolm Gander  malcolm.gander@navy.mil  206-321-5110 | Assures that the overall direction of the project is consistent with NAVFAV goals  Communicates with regulatory agency  Liaison with the Public and EPA. |
| Schedule, budget and technical issues  Coordinates USACE Seattle District meetings and funding | USACE Project Manger | Briana Niestrom  Briana.C.Niestrom@usace.army.mil  206-764-3498 | Coordinates meetings, tracks budget and schedule  Consults Mandy Michalsen regarding schedule, budget, and technical issues. |
| Guides USACE project team to develop technical objectives and methods of execution  Changes to schedule and budget; adaptive management during field work execution | USACE ERDC Research Engineer, Senior Technical Advisor | Mandy Michalsen  Mandy.M.Michalsen@usace.army.mil  206-764-3324 | Contributes to and approves all technical project documents  Coordinates with Briana Niestrom to pass along any schedule/budge changes proposed due to adaptive management |
| Project Safety and Occupational Health Plan (PSOHP) and Activity Hazard Analysis (AHA)  Contractor oversight  Sampling Supplies  Provide direction to field teams on sample collections, ensures compliance with PSOHP  Delivery of samples to laboratory  Sampling activities summary, Project Final Report | USACE Field Lead | Jeff Weiss  Jeffrey.M.Weiss@usace.army.mil  206-764-3312 | Ensures PSOHP and AHA are approved prior to fieldwork.  Performs contractor oversight and logs well boring.  Plans sampling supplies and coordinates with Project Coordinator for purchase.  Daily communication with field team members during sampling events  Coordinates with Project Chemist, Project Coordinator, and laboratory for sample delivery  Writes field activities summary for Project Final Report with input from USACE technical team, contributes to data analysis in Final Report |
| Project Safety and Occupational Health Plan (PSOHP) and Activity Hazard Analysis (AHA)  Sampling Supplies  Field sampling  Delivery of samples to laboratory  Project Final Report | USACE Field Project Scientists | Dan Carlson  Daniel.J.Carlson@usace.army.mil  206-764-6899  Jenny Phillippe  Jennifer.E.Phillippe@usace.army.mil  206-764-6965 | Coordinates writing, review, and approval of PSOHP and AHA.  Coordinates purchases sampling supplies.  Assists with field sampling and coordinating team for field sampling  Coordinates with Project Chemist, Field Team Lead, and laboratory for sample delivery  Coordinates writing and review of Project Final Report, contributes to data analysis in Final Report |
| Writes Work Plan and QAPP with input from USACE technical team  Laboratory and data validation  Sampling coordination  Project Final Report | USACE Project Chemist | Alison Suess  Alison.M.Suess@usace.army.mil  206-764-3263  Backup: Jake Williams  Jacob.A.Williams@usace.army.mil  (206) 316-3157 | Coordinates with technical team on Work Plan and QAPP and prepares final versions  Coordinates and oversees laboratory work  Coordinates with Field Lead and Project Coordinator to carry out sampling event  With Project Coordinator, coordinates writing and review of Project Final Report, contributes to data analysis in Final Report |
| Perform contracted activities  Coordinate with USACE | Contractor to USACE  Project Manager  Bethel-Tech JV | Brent Jones  Brent.Jones@tetratech.com  206-499-8846 | Carry out site preparation, well installation, fructose and bicarbonate acquisition, metering system installation, and other work as defined by the Performance Work Statement.  Coordinate with USACE Field Lead, Project Manager, and Senior Technical Advisor to carry out work activities according to the project schedule; notify of daily activities. |
| Regulatory oversight | EPA Region 10 RPM | Harry Craig  Craig.Harry@epa.gov  503-326-3689 | Provide oversight, including stakeholder meetings and review of the draft Work Plan, QAPP, and project report. |
| Regulatory oversight | Ecology Site Manager | Mahbub Alam  mahbub.alam@ecy.wa.gov  360-407-6913 | Provide oversight, including stakeholder meetings and review of the draft Work Plan, QAPP, and project report. |

# QAPP Worksheet #9: Project Planning Session Summary

*(UFP-QAPP Manual Section 2.5.1 and Figures 9-12)*

Not used.

# QAPP Worksheet #10: Conceptual Site Model

*(UFP-QAPP Manual Section 2.5.2)*

**Site Description:**

Between approximately 1957 and 1972, wastewater produced during the demilitarization of ordnance items at Naval Base Kitsap, Bangor Site F (Site F, Figure 2) was discharged to an unlined wastewater lagoon and overflow ditch. The wastewater contained mostly 2,4,6-trinitrotoluene (TNT) and 1,3,5-trinitro-1,3,5-triazine (RDX) with lower concentrations off other explosives compounds. Infiltration through approximately 15 meters of unsaturated soil to groundwater resulted in an RDX groundwater plume in the shallow aquifer that extends approximately 1,500 meters downgradient of the former lagoon. Because TNT is less mobile in groundwater, it has formed a much smaller plume present near the original lagoon source area. The maximum RDX concentration within the plume observed in recent years was 2,900 μg/L in monitoring well F-MW48. The primary COCs driving remediation at Site F are TNT, RDX, and 2,4-dinitrotoluene (DNT) in soil and TNT, RDX, DNT, and 1,3,5-trinitrobenzene (1,3,5-TNB) in groundwater.

The shallow aquifer at Site F consists of Vashon Advance Outwash sand, overlain by approximately 5 to 14 meters of Vashon Till and underlain by Lawton Clay. Outwash deposits are upward coarsening with very silty, fine sand at the base, overlain by medium to coarse sand throughout much of the unit, then grading to gravelly sand at the top. Saturated thickness of the shallow aquifer ranges from 18 to 30 meters across the site, and has a horizontal hydraulic conductivity of 25 to 60 feet per day, based a groundwater model calibrated to site conditions (Sealaska, 2015). The overlying Vashon till forms a low permeability “veneer” over the site, which limits the rate of infiltration to the shallow aquifer. The Lawton Clay aquitard has a low permeability with vertical hydraulic conductivity in the 1 x 10-4 meters/day range. Groundwater flows at an approximate linear velocity of 37 – 43 meters/year in a northwest direction near the former lagoon source area, then in a northward direction further downgradient. The shallow aquifer discharges to seeps that feed tributaries flowing to the Hood Canal.

**Bioremediation Pilot at Bangor Site F:**

USACE Seattle District and U.S. Army ERDC (collectively USACE) have completed multiple rounds of *in situ* bioremediation (ISB) pilot testing at Naval Base Kitsap, Bangor Site F, which collectively show (1) that ISB is capable of achieving RDX cleanup concentrations, and (2) that implementing ISB could significantly reduce aquifer cleanup time and cost at Site F. USACE previously developed and used a site-specific groundwater model to simulate performance of a full-scale bioremediation remedy at Site F (USACE 2014), which featured a number of new injection and extraction wells throughout the RDX plume that would circulate bioremediation amendment throughout targeted aquifer treatment areas. NAVFAC NW has expressed interest in performing an ISB pilot to simulate a portion of a full-scale ISB remedy in the Site F aquifer, which would provide (1) full-scale bioremediation performance information for the Navy and the Navy’s remediation contractor to use when developing the full-scale ISB design, and (2) extended ISB performance monitoring to directly answer remaining questions regarding transient nature of the RDX breakdown intermediates, ability to achieve cleanup levels, and longevity of treatment.

**Phase I:** The ISB pilot study will first establish an in situ bioreactor by injecting a large quantity of fructose-amended groundwater to stimulate growth and activity of indigenous RDX degrading microbes in the Site F aquifer. The contractor to USACE will construct a new 8-inch injection well at Bangor Site F (Figure 3). A portion of the water currently extracted from well F-EW5 will be diverted to the ISB test location, fructose and bicarbonate will be added to F-EW5 groundwater, and then the amended F-EW5 groundwater will be injected into the newly constructed injection well. The injection solution will be sampled periodically and analyzed for total organic carbon (TOC). Groundwater monitoring will be performed at nine monitoring wells: F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, and F-MW48, which are within 15 feet of the injection well; F-MW44, which is the well with the highest concentration of RDX; and F-PT-05, which is located between the injection site and the nearest extraction well (Figure 3). The injection is expected to last 43 days and subsequent groundwater monitoring will be performed for 90 days.

**Phase II:** After the amended groundwater injection has occurred and after reducing geochemical conditions have been achieved in the interrogated portion of the aquifer, indicating that the in situ “bioreactor” has been established, the bioreactor will be “challenged” by injecting a large quantity of RDX-containing groundwater, amended with fructose, bicarbonate, and anion tracer, into the injection well. This “challenge” phase will use RDX-containing groundwater from F-MW44 (contains roughly 350 μg/L RDX), and then the amended groundwater will be injected into the injection well. The injection is expected to last 10 days and subsequent groundwater monitoring (at the same wells as in Phase I) will be performed for 120 days.

Based on previous site-specific bioremediation test results, results of this pilot are expected to provide confirmation that full-scale bioremediation can achieve RDX cleanup objectives. Any deleterious findings, though not anticipated, will empower Navy with required information to ensure the full-scale system is properly designed and implemented. Note that we have included buffered injections to prevent aquifer acidification, which has been observed to inhibit RDX degradation in the Site F aquifer. The buffer quantity required herein was based on excess acid production measured during previous biostimulation tests performed in the Site F aquifer.



Figure 2. Bangor Site F Vicinity Map

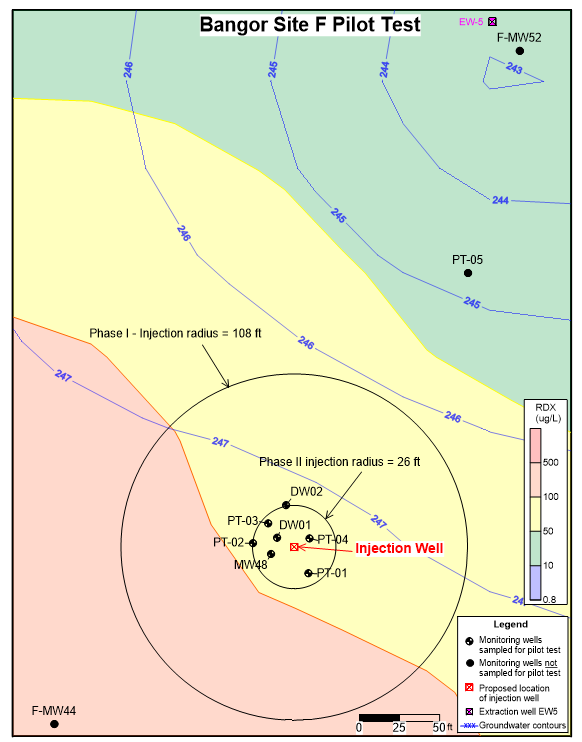


Figure 3. Pilot Test Wells and Anticipated Radius of Influence

# QAPP Worksheet #11: Project/Data Quality Objectives

*(UFP-QAPP Manual Section 2.6.1)*

| **Step 1:**  **State the Problem** | **Step 2:**  **Identify the Goals of the Study** | **Step 3:**  **Identify Information Inputs** | **Step 4:**  **Define the Boundaries of the Study** | **Step 5:**  **Develop the Analytic Approach** | **Step 6:**  **Specify Performance or Acceptance Criteria** | **Step 7:**  **Develop the Detailed Plan for Obtaining Data** |
| --- | --- | --- | --- | --- | --- | --- |
| 1) What are water levels in wells associated with the pilot test over the course of the test? | Water levels will contribute to analysis of groundwater gradient, flow direction, radius of influence of injections, and hydraulic conductivity of the aquifer between the injection well and monitoring wells. | Information from automated recording by pressure transducer and manual recordings using an electronic water level indicator will be used. | Water levels will be measured in the ten wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-PT-05, F-DW01, F-DW02, F-MW44, F-MW48 and injection well) | Pressure transducers will record the water level every 15 minutes to monitor the change in water level during the test.  Manual readings of the monitoring wells using an electronic water level indicator will be collected prior to installing the transducers and during every groundwater sampling event. | A difference greater than 0.1 ft will be documented and an additional manual water level will be collected.  See Worksheet #37. | See Worksheet #17 and 18. |
| 2) What is the water temperature of the injected solution and in wells associated with the pilot test over the course of the test? | Temperature monitoring will contribute to analysis of groundwater flow direction, velocity, depth, and vertical anisotropy. Temperature is more sensitive to vertical anisotropy than the anion tracer. Injected water will be warmed, compared to groundwater. | Information from automated recording by temperature data loggers will be used. | Temperature will be measured in the ten wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-PT-05, F-DW01, F-DW02, F-MW44, F-MW48 and injection well) | Temperature data loggers will record the temperature every 15 minutes to monitor the change in temperature during the test.  During the test, results will allow adjustment of the depth of groundwater sampling to capture the portion of the aquifer that is most affected by the nutrient injections, and allow adjustments to sampling frequency and wells that are sampled. | The temperature data will be plotted to look for drift after each monthly download. If there appears to be drift the temperature loggers will be removed and calibration checked.  See Worksheet #37. | See Worksheet #17 and 18. |
| 3) What are the water quality parameters in wells associated with the pilot test over the course of the test? | Water quality monitoring will contribute to analysis of the time until reducing conditions start and length reducing conditions last, which will affect the degradation of RDX. | Multiparameter water quality meter with flow through cell and Hach Iron II Test will be used to measure dissolved oxygen, conductivity, temperature, pH, and iron(II) concentration. | Water quality parameters will be recording during sampling of the monitoring and background wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-PT-05, F-DW01, F-DW02, F-MW44, F-MW48). | Water quality parameters will be recording each time the monitoring and background wells are sampled; see Worksheet 18 for the schedule. | See Worksheet #37. | See Worksheet #17 and 18. |
| 4) What are the concentrations of explosives analytes in wells associated with the pilot test over the course of the test, and in the injection solution during Phase II? | Explosives monitoring will contribute to the analysis of the rate of RDX degradation. Appearance of MNX, TNX, and DNX support the anaerobic pathway. | Results obtained from laboratory analysis of the water samples using EPA Method 8330B will be used. | Samples will be obtained from the Phase II injection solution and from the monitoring and background wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-PT-05, F-DW01, F-DW02, F-MW44, F-MW48). | Water samples for explosives analysis will be obtained from the Phase II injection solution during injection, and each time the monitoring and background wells are sampled; see Worksheet 18 for the schedule. | See Worksheet #37. | See Worksheet #17 and 18. |
| 5) What is the concentration of the anion (conservative tracer) in the injection solution and in wells associated with the pilot test over the course of the test during Phase II? | Anion monitoring will contribute to the analysis of groundwater flow direction and velocity. The conservative tracer will have a longer residence time then temperature and is more accurate for calculating volume of injected water present at monitoring wells. | Results obtained from laboratory analysis of the water samples using EPA Method 300.0 will be used. | Samples will be obtained from the injection solution and from the monitoring and background wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-PT-05, F-DW01, F-DW02, F-MW44, F-MW48). | Water samples for anion analysis will be obtained from the Phase II injection solution during injection, and each time the monitoring and background wells are sampled during Phase II; see Worksheet 18 for the schedule. | See Worksheet #37. | See Worksheet #17 and 18. |
| 6) What is the concentration of total organic carbon (TOC) in the injection solution and in wells associated with the pilot test over the course of the test? | TOC monitoring will contribute to the analysis of fructose dispersal and residence time in groundwater. | Results obtained from laboratory analysis of the water samples using EPA Method 9060 will be used. | Samples will be obtained from the injection solution and from the monitoring and background wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-PT-05, F-DW01, F-DW02, F-MW44, F-MW48). | Water samples for TOC analysis will be obtained from the injection solution during injection, and each time the monitoring and background wells are sampled; see Worksheet 18 for the schedule. | See Worksheet #37. | See Worksheet #17 and 18. |
| 7) What are the concentrations of per- and polyfluoroalkyl substances (PFAS) in Site F groundwater wells, and do those concentrations change over the course of this test? | Annual sampling of PFAS will indicate concentrations and changes over time. | Results obtained from annual sampling efforts by the Navy’s contractor will be reviewed by USACE (CH2M HILL, 2021). | Samples will be obtained from Site F wells (CH2M HILL, 2021). | USACE will compare concentrations of PFAS in Site F groundwater from the annual sampling events and evaluate if there were changes in concentrations over the course of the test. | See the dedicated Sampling and Analysis Plan (CH2M HILL, 2021). | See the dedicated Sampling and Analysis Plan (CH2M HILL, 2021). |

# QAPP Worksheet #12: Measurement Performance Criteria

*(UFP-QAPP Manual Section 2.6.2)*

Table 1. Measurement Performance Criteria for Water Samples

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Method**  **(Analysis/Prep/Cleanup)**  Analyte  *Surrogate* | **MS/MSD, RPD** | **LCS/LCSD, RPD** | **Blank** | **Surrogate** | **Field Duplicate** | **Equipment Blanks** |
| **Total Organic Carbon (SW-846 9060; NA)** | | | | | | |
| TOC | %R laboratory-specific at time of analysis; RPD ± 20% of true value | % R laboratory-specific at time of analysis | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). |  | ≤ 40% RPD | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). |
| **Anions (EPA 300.0, NA)** | | | | | | |
| Chloride | %R laboratory-specific at time of analysis; RPD ≤ 15% | %R laboratory-specific at time of analysis; RPD ≤ 15% | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). |  | ≤ 40% RPD | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). |
| **Explosives with Additional Analytes MNX, TNX, and DNX (EPA 8330B, NA)** | | | | | | |
| RDX | laboratory-specific at time of analysis | laboratory-specific at time of analysis | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). |  | ≤ 40% RPD | No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). |
| 1,3,5-TNB |  |
| 1,3-DNB |  |
| 2,4,6-TNT |  |
| 2,4-DNT |  |
| 2,6-DNT |  |
| DNX (Project-Specific) |  |
| MNX (Project-Specific) |  |
| TNX (Project-Specific) |  |

% R = percent recovery

Table 2. Explosives Analyte Names, Abbreviations, CAS Numbers

| **Analyte** | **Abbreviation** | **CAS Number** |
| --- | --- | --- |
| **Method 8330B Analytes** | | |
| Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine | HMX | 2691-41-0 |
| Hexahydro-1,3,5-trinitro-1,3,5-triazine  222.12 g/mol C3H6N6O6 | RDX | 121-82-4 |
| 1,3,5-Trinitrobenzene | 1,3,5-TNB | 99-35-4 |
| 1,3-Dinitrobenzene | 1,3-DNB | 99-65-0 |
| 2,4,6-Trinitrotoluene | 2,4,6-TNT | 118-96-7 |
| 2,4-Dinitrotoluene | 2,4-DNT | 121-14-2 |
| 2,6-Dinitrotoluene | 2,6-DNT | 606-20-2 |
| **Additional Project-Specific Analytes** | | |
| 1-nitro-3,5-dinitroso-1,3,5-triazinane  1,3-dinitroso-5-nitro-1,3,5-triazacyclohexane  190.12 g/mol C3H6N6O4 | DNX | 80251-29-2 |
| hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine  1,3-dinitro-5-nitroso-1,3,5-triazacyclohexane  206.12 g/mol C3H6N6O5 | MNX | 5755-27-1 |
| 1,3,5-trinitroso-1,3,5-triazacyclohexane  hexahydro-1,3,5- trinitroso-1,3,5-triazine  174.12 g/mol C3H6N6O3 | TNX | 13980-04-6 |

# QAPP Worksheet #13: Secondary Data Uses and Limitations

*(UFP-QAPP Manual Section 2.7)*

No secondary data used.

# QAPP Worksheet #14/16: Project Tasks & Schedule

*(UFP-QAPP Manual Section 2.8.2)*

| **Task Name** | **Duration** | **Start** | **Finish** | **Notes** |
| --- | --- | --- | --- | --- |
| **Project Safety and Occupational Health Plan (PSOHP) Preparation** | **(Work Days)** |  |  |  |
| Draft PSOHP | 22 | 10/1/2020 | 10/30/2020 |  |
| PSHOP Internal Review | 10 | 11/2/2020 | 11/13/2020 | HSP will be reviewed by NWS Safety Office. |
| Revise Draft PSHOP | 10 | 11/16/2020 | 11/27/2020 |  |
| Final PSHOP | 1 | 11/30/2020 | 11/30/2020 |  |
| **QAPP / Work Plan Preparation** | **(Work Days)** |  |  |  |
| DQO meeting | 1 | 8/21/2020 | 8/21/2020 |  |
| Preliminary Draft QAPP / Work Plan | 25 | 7/27/2020 | 8/28/2020 |  |
| Preliminary Draft QAPP / Work Plan Internal Review | 5 | 5/5/2022 | 6/5/2022 | QAPP will be reviewed by NWS internally. |
| Revision of Preliminary Draft QAPP / Work Plan | 20 | 5/5/2022 | 6/5/2022 |  |
| Stakeholders (Navy, Ecology, and EPA) Review Draft QAPP / Work Plan | 22 | 6/6/2022 | 7/6/2022 |  |
| Meeting with stakeholders | 1 | 7/6/2022 | 7/6/2022 |  |
| Revision of Draft QAPP / Work Plan | 10 | 7/7//2022 | 7/14/2022 |  |
| Stakeholders Backcheck | 10 | 7/15/2022 | 7/24/2022 |  |
| Final QAPP / Work Plan | 1 | 7/27/2022 | 7/31/2022 |  |
| **Field Work** | **(Total Days)** |  |  |  |
| Site Visit w/ drillers | 1 | 9/8/2020 | 9/8/2020 |  |
| Well installation | 15 | 10/1/2020 | 10/16/2020 | Drill, install and develop well. |
| Installation of injection equipment and proof of operability | 21 | 9/13/2022 | 10/9/2022 |  |
| Phase I injection (build the reactor) | 43 | 10/12/2022 | 11/23/2022 | Collect TOC, and water quality parameters |
| Phase I monitoring and sampling | 90 | 11/24/2022 | 2/21/2023 |  |
| Fill tanks with water from MW44 | 40 | 1/4/2023 | 2/8/2023 | 25 days to fill 10 tanks at 5 gpm, extra time for delays in filling |
| Phase II Injection (test the reactor) | 10 | 2/22/2023 | 3/3/2023 |  |
| Phase II sampling and monitoring | 120 | 3/4/2023 | 7/2/2023 |  |
| **Reporting** | **(Work Days)** |  |  |  |
| Preliminary Draft Report | 45 | 8/1/2023 | 10/3/2023 | The report will include a data usability assessment based on the data validation report received. |
| Internal Review of Preliminary Draft Report | 10 | 10/3/2023 | 10/17/2023 |  |
| Revise Preliminary Draft Report | 10 | 10/17/2023 | 10/31/2023 |  |
| Stakeholders Review of Draft Report | 21 | 10/31/2023 | 11/29/2023 |  |
| Revise Draft report | 10 | 11/29/2023 | 12/13/2023 |  |
| Final Report | 1 | 12/13/2023 | 12/14/2023 |  |

# QAPP Worksheet #15: Project Action Limits and Laboratory-Specific Detection/Quantitation Limits

*(UFP-QAPP Manual Section 2.6.2.3 and Figure 15)*

Table 3. Detection and Quantitation Limit Definitions

|  |  |
| --- | --- |
| **Limit** | **Definition** |
| DL | Detection Limit: The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration with 99% confidence. At the DL, the false positive rate (Type I error) is 1%. A DL may be used as the lowest concentration for reliably reporting a detection of a specific analyte in a specific matrix with a specific method with 99% confidence. |
| LOD | Limit of Detection: The smallest concentration of a substance that must be present in a sample in order to be detected at the DL with 99% confidence. At the LOD, the false negative rate (Type II error) is 1%. A LOD may be used as the lowest concentration for reliably reporting a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence. A LOD is typically 2x to 4x the DL. |
| LOQ | Limit of Quantitation: The smallest concentration that produces a quantitative result with known and recorded precision and bias. For DoD/DOE projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard and within the calibration range. |

Table 4. Measurement Limits

| **Method**  **(Analysis/Prep/Cleanup)**  Analyte | **Cleanup Level** | **Project Quantitation Limit** | **LOQ** | **LOD** | **DL** |
| --- | --- | --- | --- | --- | --- |
| **Total Organic Carbon (SW-846 9060; NA), mg/L** | | | | | |
| TOC | Not Applicable | Not Specified | 1 | 0.8 | 0.4 |
| **Anions (EPA 300.0; NA), µg/L** | | | | | |
| Chloride | Not Applicable | Not Specified | 0.05 | 0.04 | 0.02 |
| **Explosives with Additional Analytes MNX, TNX, and DNX (EPA 8330B, NA), µg/L** | | | | | |
| RDX | 0.8 | 0.7 | 0.50 | 0.065 | 0.030 |
| 1,3,5-Trinitrobenzene | 0.8 | 0.7 | 0.25 | 0.125 | 0.060 |
| 1,3-Dinitrobenzene | 1.6 | 1.0 | 0.25 | 0.125 | 0.035 |
| 2,4,6-Trinitrotoluene | 2.9 | 1.0 | 0.25 | 0.125 | 0.050 |
| 2,4-Dinitrotoluene | 0.13\* | 0.25 | 0.25 | 0.125 | 0.050 |
| 2,6-Dinitrotoluene | 0.13\* | 0.25 | 0.25 | 0.125 | 0.055 |
| DNX (Project-Specific) | Not Applicable | 1.0 | 0.25 | 0.20 | 0.066 |
| MNX (Project-Specific) | Not Applicable | 1.0 | 0.50 | 0.125 | 0.055 |
| TNX (Project-Specific) | Not Applicable | 1.0 | 0.25 | 0.20 | 0.060 |
| 2-Amino-4,6-dinitrotoluene | Not Applicable | 1.0 | 0.50 | 0.065 | 0.030 |
| 2-Nitrotoluene | Not Applicable | 1.0 | 0.50 | 0.125 | 0.040 |
| 3,5-Dinitroaniline | Not Applicable | 1.0 | 0.50 | 0.065 | 0.025 |
| 3-Nitrotoluene | Not Applicable | 1.0 | 0.50 | 0.125 | 0.060 |
| 4-Amino-2,6-dinitrotoluene | Not Applicable | 1.0 | 0.50 | 0.065 | 0.030 |
| 4-Nitrotoluene | Not Applicable | 1.0 | 0.50 | 0.125 | 0.050 |
| HMX | Not Applicable | 1.0 | 0.50 | 0.125 | 0.030 |
| Nitrobenzene | Not Applicable | 1.0 | 0.50 | 0.125 | 0.050 |
| Nitroglycerin | Not Applicable | 1.0 | 0.50 | 0.125 | 0.050 |
| PETN | Not Applicable | 1.0 | 0.50 | 0.125 | 0.035 |
| Tetryl | Not Applicable | 1.0 | 0.50 | 0.065 | 0.030 |

1 Full explosive analyte names and CAS numbers are provided in Worksheet 12, Table 2.

2 The cleanup levels are 0.8 ug/L for RDX, 0.8 ug/L for 1,3,5-TNB, 1.6 ug/L for 1,3-DNB, 2.9 ug/L for 2,4,6-TNT, and 0.13 ug/L for DNT (EPA 1994a, 1994b). The cleanup level for DNT applies to the combined total of 2,4-DNT and 2,6-DNT.

3 Explosives LOD/LOQ/DL shown are for a 1-L sample size concentrated to 1.0 mL during analysis.

# QAPP Worksheet #17: Sampling Design and Rationale

*(UFP-QAPP Manual Section 3.1.1)*

## Contractor Site Preparation and Injection Well Installation

A contractor for USACE will prepare the site and install an 8-inch diameter test well for injection (Figure 3). The contractor will acquire fructose and sodium bicarbonate, and install a metering station for injection solutions. The contractor will be available for maintenance and troubleshooting. USACE personnel will perform the injections and groundwater monitoring.

## Phase I: Build the Reactor

In the first phase of the ISB pilot study, beginning October 2022, USACE will establish an in situ bioreactor by injecting a large quantity of fructose-amended groundwater to stimulate growth and activity of indigenous RDX degrading microbes in the Site F aquifer. A portion of the water currently extracted from well F-EW5 will be diverted to the ISB test location, fructose and bicarbonate will be added to F-EW5 groundwater, and then the amended F-EW5 groundwater will be injected into a newly constructed injection well. The amended-water injection is expected to last 43 days and subsequent groundwater monitoring will be performed for 90 days.

USACE personnel will carry out monitoring and sampling of the injection water and groundwater as described in Worksheet #18. In Phase I, the injection water will be analyzed for TOC. Groundwater from monitoring wells will be analyzed for TOC and explosives from the Method 8330B analytes list, with additional analytes MNX, DNX, and TNX. USACE will perform field measurements of water quality parameters: dissolved oxygen, conductivity, temperature, and pH, and will test groundwater for Iron(II) with a Hach kit. The temperature in the screened areas of the injection and monitoring wells will be recorded over time in order to provide more information regarding injection delivery and duration. Water levels will be measured with pressure transducers, and manual water level measurement will be performed prior to pressure transducer installation and during every groundwater sampling event.

## Phase II: Test the Reactor

In the second phase of the ISB pilot study, beginning February 2023, USACE will “challenge” the in situ bioreactor by injecting a large quantity of RDX-containing groundwater into the injection well. This “challenge” phase will use RDX-containing groundwater from F-MW44 that is amended with fructose, bicarbonate, and anion tracer, and then the amended groundwater will be injected into the injection well. The amended-water injection is expected to last 10 days and subsequent groundwater monitoring will be performed for 120 days.

USACE personnel will carry out monitoring and sampling of the injection water and groundwater as described in Worksheet #18. In Phase II, the injection water will be analyzed for TOC, anions (chloride tracer), and explosives from the Method 8330B analytes list, with additional analytes MNX, DNX, and TNX. Groundwater from monitoring wells will be analyzed for TOC, anions (chloride tracer), and explosives from the Method 8330B analytes list, with additional analytes MNX, DNX, and TNX. USACE will perform field measurements of water quality parameters: dissolved oxygen, conductivity, temperature, and pH, and will test groundwater for Iron(II) with a Hach kit. The temperature in the screened areas of the injection and monitoring wells will be recorded over time in order to provide more information regarding injection delivery and duration. Water levels will be measured with pressure transducers, and manual water level measurement will be performed prior to pressure transducer installation and during every groundwater sampling event.

## Assessing Pilot Performance and RDX Degradation

Data will be evaluated using multiple approaches in order to accomplish project objectives. The first approach will involve using tracer-corrected time course RDX concentrations measured during Phase II in the injection well and standard push-pull test data analysis methods (Istok et al. 1997, Haggerty et al. 1998) to extract a localized RDX degradation rate coefficient. The second approach will involve integrating RDX concentrations measured during Phase II in the interrogated portion of the aquifer over time to extract a “bulk” RDX degradation rate coefficient. Single well and integrated time series RDX nitroso derivative (MNX, DNX and TNX) concentrations measured in the injection well and all monitoring wells will be evaluated by to determine their fate over extended timeframes under biostimulated conditions. Radius of influence will be analyzed using the Theis method and similar pumping test analysis to fit observed data with analytical solutions. Collectively, this large-scale bioremediation pilot will provide additional performance data to inform design and performance monitoring of a future full-scale ISB system.

## Per- and Polyfluoroalkyl Substances Assessment

The Navy’s long term monitoring contractor will sample groundwater from Site F wells and analyze the samples for per-and polyfluoroalkyl substances (PFAS). The PFAS sampling will occur in April 2022 and annually thereafter (CH2M Hill, 2021). The PFAS sampling is addressed in a separate Sampling and Analysis Plan (CH2M Hill 2021). The Navy’s contractor will analyze for 18 PFAS analytes, including PFOS, PFOA, and PFBS, using liquid chromatography tandem mass spectrometry (LC-MS/MS) compliant with DoD Quality Systems Manual Table B-15. The contractor’s laboratory holds DoD and state accreditation. Third party data validation will be performed.

USACE will compare the concentrations of the analyzed PFAS obtained from the Navy’s annual sampling over the course of the test and will describe the results and any changes in concentrations over the course of the test. This analysis will be included in the final report.

# QAPP Worksheet #18: Sampling Locations and Methods

*(UFP-QAPP Manual Section 3.1.1 and 3.1.2)*

## Phase I: Build the Reactor

**Water Level Monitoring:** USACE will install pressure transducers in the eight wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48, and the injection well), as well as two background wells outside the area of influence of the test (F-PT-05 and F-MW-44), and record the water level every 15 minutes to monitor the change in water level during the test. The pressure transducers will be installed a minimum of two week prior to injection starting to collect background water levels. The data loggers will be downloaded once a week during the injection and once a month during the monitoring period. Manual readings of the monitoring wells using an electronic water level indicator will be collected prior to installing the transducers and during every groundwater sampling event.

**Injection Samples:** USACE personnel will collect nine water samples from the injection water periodically throughout injection (Tables 4 and 8). USACE will perform field measurements of groundwater parameters: dissolved oxygen, conductivity, temperature, and pH, and will test groundwater for Iron(II) with a Hach kit. USACE will collect samples for laboratory analysis of total organic carbon (TOC).

**Groundwater Temperature Monitoring:** USACE personnel will install temperature loggers every three feet in the screened portion of the injection and monitoring wells. The temperature loggers will be installed at least one month prior to the injections in test wells (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48, and the injection well). The loggers will record the water temperature every 15 minutes and the data will be downloaded once a week during the injection and once a month during the monitoring period.

The injection water will be heated to create a temperature differential that can be observed in the test wells. The water will be heated by attaching heat tracer tape with a set temperature of 60 °C to the injection line that conveys the water from the mixing tanks to the injection well. The length of pipe that will have heat tape attached will be determined during the proof of operability stage. The goal is to increase the water temperature by 5 °C to create a signal that can be observed in the observation wells without significantly changing the viscosity of the water. The groundwater at the injection site is approximately 10 °C and the injection water prior to heating will be similar depending on the air temperature at the time of injection

Temperature data will be collected and used to observe the depth in the monitoring wells with the quickest response to the injection, and the longest duration of temperature increase.

**Groundwater Monitoring Samples:** USACE personnel will collect groundwater monitoring samples from the eight wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48, and the injection well). Background samples (Round of Phase I) will be collected from all wells prior to injection, Rounds 2 through 5 of samples will be collected periodically during and after injection from the seven test wells, and a final round, which is also Round 1 of Phase II of samples will be collected from all wells approximately two months after the end of the injection (Tables 4 and 8). USACE will collect samples for laboratory analysis of TOC and explosives from the Method 8330B analytes list, with additional analytes MNX, DNX, and TNX.

**Groundwater Parameters:** USACE personnel will collect groundwater parameters from the test wells prior to collecting groundwater samples and several times during and after the injection. USACE personnel will perform field measurements of groundwater parameters: dissolved oxygen, conductivity, temperature, and pH, and will test groundwater for Iron(II) with a Hach kit.

**Groundwater Monitoring Methods:** See Worksheet #21, Field SOPs, for methods.

**Analytical Methods:** Samples will be analyzed for TOC using SW-846 Test Method 9060A. Samples will be analyzed for the anion tracer (chloride) using EPA Method 300.0. RDX and its transformation product concentrations will be determined by high performance liquid chromatography (HPLC) using EPA Method 8330B. At a minimum, the laboratory required method detection limit (MDL ) shall be 0.25 microgram/liter (μg/L) and the reporting limit (RL) shall be 0.5 μg/L. One field duplicate will be collected for every 10 samples. One matrix spike (MS) and matrix spike duplicate (MSD) sample will be collected for every 20 samples. See Worksheets #12, #15, and #20 for further detail.

## Phase II: Test the Reactor

**Water Level Monitoring:** USACE will install pressure transducers in the eight wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48, and the injection well), as well as two background wells outside the area of influence of the test (F-PT-05 and F-MW-44), and record the water level every 15 minutes to monitor the change in water level during the test. The pressure transducers will be installed a minimum of two weeks prior to injection starting to collect background water levels. The data loggers will be downloaded once a week during the injection and once a month during the monitoring period. Manual readings of the monitoring wells using an electronic water level indicator will be collected prior to installing the transducers and during every groundwater sampling event.

**Injection Samples:** USACE personnel will collect ten water samples from the injection water periodically throughout injection (Tables 5 and 9). USACE will perform field measurements of groundwater parameters: dissolved oxygen, conductivity, temperature, and pH, and will test water for Iron(II) with a Hach kit. USACE will collect samples for laboratory analysis of TOC, anions (chloride tracer), and explosives from the Method 8330B analytes list, with additional analytes MNX, DNX, and TNT, from all injection samples.

**Groundwater Temperature Monitoring:** USACE personnel will install temperature loggers every three feet in the screened portion of the injection and monitoring wells. The temperature loggers will be installed at least one month prior to the injections in in test wells (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48, and the injection well). The loggers will record the water temperature every 15 minutes and the data will be downloaded once a week during the injection and once a month during the monitoring period.

The injection water will be heated to create a temperature differential that can be observed in the test wells. The water will be heated by attaching heat tracer tape with a set temperature of 60 °C to the injection line that conveys the water from the mixing tanks to the injection well. The length of pipe that will have heat tape attached will be determined during the proof of operability stage. The goal is to increase the water temperature by 5 °C to create a signal that can be observed in the observation wells without significantly changing the viscosity of the water. The groundwater at the injection site is approximately 10 °C and the injection water prior to heating will be similar depending on the air temperature at the time of injection

Temperature data will be collected and used to observe the depth in the monitoring wells with the quickest response to the injection, and the longest duration of temperature increase.

**Groundwater Monitoring Samples:** USACE personnel will collect groundwater monitoring samples from the eight wells used during the test (F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48, and the injection well) (Tables 5 and 9). A total of 10 rounds of samples, including one background round prior to injection, will be collected from all 8 wells used during the test over the course of Phase II. Additionally, 15 samples will be collected from a subset of well (two test wells and the injection well, on days without injections) during and immediately following injection, within 20 days after injection, with samples weighted toward the days directly after injection. This high-frequency sampling of subset wells allows for analysis of tracer-corrected time course RDX concentrations and standard push-pull test data analysis methods (Istok et al. 1997, Haggerty et al. 1998) to extract a localized RDX degradation rate coefficient. USACE will collect samples for laboratory analysis of TOC, anions (chloride tracer), and explosives from the Method 8330B analytes list, with additional analytes MNX, DNX, and TNT.

The Phase I and II sample schedules are based on USACE knowledge at the time of UFP-QAPP finalization. USACE does not anticipate any deviations to the Phase I sample schedule. Learnings from Phase I results could prompt optimization in the Phase II sampling schedule to ensure the best data possible is obtained to meet data quality objectives. Any alterations to the Phase II sampling schedule will be proposed to all UFP-QAPP recipients in advance of Phase II sampling.

**Groundwater parameters:** USACE personnel will collect groundwater parameters, using methods described in section 4.10, from the test wells prior to collecting groundwater samples and several times during and after the injection. USACE personnel will perform field measurements of groundwater parameters: dissolved oxygen, conductivity, temperature, and pH, and will test groundwater for Iron(II) with a Hach kit.

**Groundwater Monitoring Methods:** See Worksheet #21, Field SOPs, for methods.

**Analytical Methods:** Samples will be analyzed for TOC using SW-846 Test Method 9060A. Samples will be analyzed for the anion tracer (chloride) using EPA Method 300.0. RDX and its transformation product concentrations will be determined by high performance liquid chromatography (HPLC) using EPA Method 8330B. At a minimum, the laboratory required method detection limit (MDL ) shall be 0.25 microgram/liter (μg/L) and the reporting limit (RL) shall be 0.5 μg/L. One field duplicate will be collected for every 10 samples. One matrix spike (MS) and matrix spike duplicate (MSD) sample will be collected for every 20 samples. See Worksheets #12, #15, and #20 for further detail.

Table 5. Phase I Sampling Schedule

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Phase** | **Date** | **Injection Sample Location, Round, and Analytes** | **GW Monitoring Sample Location, Round, and Analytes** | **Groundwater Quality Parameter**  **Monitoring Performed?** |
| Prior to Phase I Injection | Prior to 3/15/2022 | NA | Round 1:  Background, Injection, and Test Wells  (TOC, Explosives) | Yes,  Background Wells,  Test and Injection Wells |
| Phase I Injection | 3/15/2022 | Round 1:  Injection Solution  (TOC) | NA | Yes,  Test and Injection Wells |
| Day 1 |
| Phase I Injection | 3/17/2022 | Round 2:  Injection Solution  (TOC) | NA | Yes,  Test and Injection Wells |
| Day 3 |
| Phase I Injection | 3/21/2022 | Round 3:  Injection Solution  (TOC) | NA | Yes,  Test and Injection Wells |
| Day 7 |
| Phase I Injection | 3/24/2022 | Round 4:  Injection Solution  (TOC) | NA | Yes,  Test and Injection Wells |
| Day 10 |
| Phase I Injection | 3/28/2022 | Round 5:  Injection Solution  (TOC) | NA | Yes,  Test and Injection Wells |
| Day 14 |
| Phase I Injection | 3/31/2022 | Round 6:  Injection Solution  (TOC) | Round 2:  Subset Wells  (TOC, Explosives) | Yes,  Test and Injection Wells |
| Day 17 |
| Phase I Injection | 4/7/2022 | Round 7:  Injection Solution  (TOC) | NA | Yes,  Test and Injection Wells |
| Day 24 |
| Phase I Injection | 4/12/2022 | Round 8:  Injection Solution  (TOC) | NA | Yes,  Test and Injection Wells |
| Day 29 |
| Phase I Injection | 4/26/2022 | Round 9:  Injection Solution  (TOC) | Round 3:  Subset Wells  (TOC, Explosives) | Yes,  Test and Injection Wells |
| Day 43 |
| Phase I GW Monitoring  Day 24 | 5/18/2022 | NA | Round 4:  Injection and Test Wells  (TOC, Explosives) | Yes,  Test and Injection Wells |
| Phase I GW Monitoring | 6/22/2022 | NA | Round 5:  Injection and Test Wells  (TOC, Explosives) | Yes,  Test and Injection Wells |
| Day 58 |
| Phase I GW Monitoring | 7/20/2022 | NA | Round 1 (Phase II):  Background, Test and Injection Wells  (TOC, Explosives) | Yes,  Background Wells,  Test and Injection Wells |
| Day 89 |

1. Test Wells: F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48
2. Background Wells: F-PT-05, F-MW44
3. Subset Wells: Two selected test wells (likely DW-01 and PT-04) plus the injection well (on days when injection is not occurring.) The purpose of the subset wells is to get high-resolution data of aquifer changes over a short time after injection.

Table 6. Phase II Sampling Schedule

| **Phase** | **Date** | **Injection Sample Location, Round, and Analytes** | **GW Monitoring Sample Location, Round, and Analytes** | **Groundwater Quality Parameter**  **Monitoring Performed?** |
| --- | --- | --- | --- | --- |
| Phase I GW Monitoring  Day 89 (Background Sampling) | 7/20/2022 | NA | Round 1:  Background, Test and Injection Wells  (TOC, Anions, Explosives) | Yes,  Background Wells,  Test and Injection Wells |
| Phase II Injection  Day 1 | 7/27/2022 | Round 1:  Injection Solution  (TOC, Anions, Explosives) | NA | Yes,  Test Wells |
| Phase II Injection  Day 2 | 7/28/2022 | NA | NA | Yes,  Test Wells |
| Phase II Injection  Day 3 | 7/29/2022 | Round 2:  Injection Solution  (TOC, Anions, Explosives) | Round 2:  Subset Wells  (TOC, Anions, Explosives) | Yes,  Test Wells |
| Phase II Injection  Day 4 | 7/30/2022 | NA | NA | Yes,  Test Wells |
| Phase II Injection  Day 5 | 7/31/2022 | NA | NA | Yes,  Test Wells |
| Phase II Injection  Day 6 | 8/1/2022 | NA | Round 3:  Subset Wells  (TOC, Anions, Explosives) | Yes,  Test Wells |
| Phase II Injection  Day 7 | 8/2/2022 | NA | NA | Yes,  Test Wells |
| Phase II Injection  Day 8 | 8/3/2022 | NA | NA | Yes,  Test Wells |
| Phase II Injection  Day 9 | 8/4/2022 | Round 4:  Injection Solution  (TOC, Anions, Explosives) | NA | Yes,  Test Wells |
| Phase II Injection  Day 10 | 8/5/2022 | NA | Round 4:  Subset Wells  (TOC, Anions, Explosives) | Yes,  Test Wells |
| Phase II GW Monitoring  Day 1 | 8/6/2022 | NA | Round 5:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 2 | 8/7/2022 | NA | Round 6:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 3 | 8/8/2022 | NA | Round 7:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 4 | 8/9/2022 | NA | Round 8:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 5 | 8/10/2022 | NA | Round 9:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 6 | 8/11/2022 | NA | Round 10:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 9 | 8/12/2022 | NA | Round 11:  Test and Injection Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 11 | 8/15/2022 | NA | Round 12:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 13 | 8/17/2022 | NA | Round 13:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 15 | 8/19/2022 | NA | Round 14:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 19 | 8/24/2022 | NA | Round 15:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 26 | 8/31/2022 | NA | Round 16:  Test and Injection Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 33 | 9/7/2022 | NA | Round 17:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 40 | 9/14/2022 | NA | Round 18:  Test and Injection Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 54 | 9/28/2022 | NA | Round 19:  Injection and Subset Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 68 | 10/12/2022 | NA | Round 20:  Test and Injection Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 81 | 10/25/2022 | NA | Round 21:  Test and Injection Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 98 | 11/11/2022 | NA | Round 22:  Test and Injection Wells  (TOC, Anions, Explosives) | Yes,  Test and Injection Wells |
| Phase II GW Monitoring  Day 119 | 12/2/2022 | NA | Round 23:  Background, Test and Injection Wells  (TOC, Anions, Explosives) | Yes,  Background Wells,  Test and Injection Wells |

1. Test Wells: F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48
2. Background Wells: F-PT-05, F-MW44
3. Subset Wells: Two selected test wells (likely DW-01 and PT-04) plus the injection well (on days when injection is not occurring.) The purpose of the subset wells is to get high-resolution data of aquifer changes over a short time after injection.

# QAPP Worksheet #19 & 30: Sample Containers, Preservation, and Hold Times

*(UFP-QAPP Manual Section 3.1.2.2)*

**Laboratory:**

**Prime Contract Lab: Analytes**

Environmental Monitoring and Technologies, Inc.

509 N. 3rd Ave., Des Plaines, IL. 60016

Primary POC: Tim Witrzek, twitrzek@emt.com, 847-324-3320

**Sample Delivery Method:** FedEx

Table 7. Containers, Preservation, and Holding Time Requirements

| **Laboratory Performing Analysis** | **Matrix** | **Analyses** | **Extraction; Cleanup; Analysis Method Numbers** | **Sample Containers1** | **Sample Minimum Volume** | **Preservation (depends on holding time)** | **Maximum Holding Time**  **(extraction/analysis)** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| EMT | Water | TOC | EPA 9060A | one 40-mL VOA vial with HCl | HCl | 40 mL | 28 days |
| Anions | EPA 300.0 | one 250-mL HDPE | none | 50 mL | 28 days |
| Explosives | EPA 8330B | two 1-L amber glass | none | 1 L (2 L preferred for breakage) | 7 days to extract/40 days to analysis |

1 –WMGJ – wide-mouth glass jar with Teflon-lined cap

# QAPP Worksheet #20: Field QC Summary

*(UFP-QAPP Section 3.1.1 and 3.1.2)*

Table 8. Phase I Sample Quantities

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Phase Component** | **Analytes** | **Number of sampling events** | **Wells sampled per event** | **Sample locations** | **Number of Field Samples (no FD or MS/MSD)** | **Number of Matrix Spike/Matrix Spike Duplicates (MS/MSD)** | **Number of Field Duplicates (FD)** | **Number of Total Samples (With FD and MS/MSD)** |
| Phase I Injection Solution | TOC | 9 | 1 | Injection Port | 9 | see below | see below | see below |
| Phase I GW Monitoring During Injection (Two Background Wells) | TOC | 1 | 2 | Background Wells | 2 | see below | see below | see below |
| Explosives | 1 | 2 | Background Wells | 2 | see below | see below | see below |
| Phase I GW Monitoring Before and After Injection (Test and Injection Wells) | TOC | 3 | 8 | Test Wells | 24 | see below | see below | see below |
| Explosives | 3 | 8 | Test Wells | 24 | see below | see below | see below |
| Phase I GW Monitoring During Injection (Two Test Wells) | TOC | 2 | 2 | Subset Wells | 4 | see below | see below | see below |
| Explosives | 2 | 2 | Subset Wells | 4 | see below | see below | see below |
| Total for all Phase I in order to calculate MS/MSD/FD | Explosives | see above | see above | see above | 30 | 4 | 3 | 37 |
| TOC | see above | see above | see above | 39 | 4 | 4 | 47 |
| **Total Explosives** | | | | | | | | **37** |
| **Total TOC** | | | | | | | | **47** |

* 1. Field Duplicate (FD) samples will be collected at a rate of 1 per every 10 field samples.
* 2. Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples will be collected at a rate of 1 pair per every 20 field samples.
* 3. Test Wells: F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48
* 4. Background Wells: F-PT-05, F-MW44
* 5. Subset Wells: Two selected test wells (likely DW-01 and PT-04) plus the injection well (on days when injection is not occurring.) The purpose of the subset wells is to get high-resolution data of aquifer changes over a short time after injection.

Table 9. Phase II Sample Quantities

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Phase** | **Analytes** | **Number of sampling events** | **Number of sample location** | **Sample locations** | **Number of Field Samples (no FD or MS/MSD)** | **Number of Matrix Spike/Matrix Spike Duplicates (MS/MSD)** | **Number of Field Duplicates (FD)** | **Number of Total Samples (With FD and MS/MSD)** |
| Phase II Injection Solution | Explosives | 4 | 1 | Injection Port | 4 | see below | see below | see below |
| TOC | 4 | 1 | Injection Port | 4 | see below | see below | see below |
| Anions | 4 | 1 | Injection Port | 4 | see below | see below | see below |
| Phase II GW Monitoring Before Injection and at Project End (Two Background Wells) | Explosives | 2 | 2 | Background Wells | 4 | see below | see below | see below |
| TOC | 2 | 2 | Background Wells | 4 | see below | see below | see below |
| Anions | 2 | 2 | Background Wells | 4 | see below | see below | see below |
| Phase II GW Monitoring Subset Wells (Two Test Wells + Injection Well) | Explosives | 15 | 3 | Subset Wells | 45 | see below | see below | see below |
| TOC | 15 | 3 | Subset Wells | 45 | see below | see below | see below |
| Anions | 15 | 3 | Subset Wells | 45 | see below | see below | see below |
| Phase II GW Monitoring (Test and Injection Wells) | Explosives | 8 | 8 | Test Wells, Injection Well | 64 | see below | see below | see below |
| Anions | 8 | 8 | Test Wells, Injection Well | 64 | see below | see below | see below |
| TOC | 8 | 8 | Test Wells, Injection Well | 64 | see below | see below | see below |
| Total for all Phase II in order to calculate MS/MSD/FD | Explosives | see above | see above | see above | 117 | 12 | 12 | 141 |
| Anions | see above | see above | see above | 117 | 12 | 12 | 141 |
| TOC | see above | see above | see above | 117 | 12 | 12 | 141 |
| **Total Explosives** | | | | | | | | **141** |
| **Total TOC** | | | | | | | | **141** |
| **Total Anions** | | | | | | | | **141** |

* 1. Field Duplicate (FD) samples will be collected at a rate of 1 per every 10 field samples.
* 2. Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples will be collected at a rate of 1 pair per every 20 field samples.
* 3. Test Wells: F-PT-01, F-PT-02, F-PT-03, F-PT-04, F-DW01, F-DW02, F-MW48
* 4. Background Wells: F-PT-05, F-MW44
* 5. Subset Wells: Two selected test wells (likely DW-01 and PT-04) plus the injection well (on days when injection is not occurring.) The purpose of the subset wells is to get high-resolution data of aquifer changes over a short time after injection.

# QAPP Worksheet #21: Field SOPs

*(UFP-QAPP Manual Section 3.1.2)*

## USACE Groundwater Collection and Analysis Procedures

Background samples will be collected using a submersible pump using low-flow sampling techniques (subsequent samples will be collected at a low-flow rate after purging for an adequate amount of time, which is determined by the stabilization time during background sampling). The low flow sampling will be conducted in accordance with the USEPA “*Low Stress (low flow) purging and sampling procedure for the collection of groundwater sampled from monitoring wells*” (EPA 2017), which is attached for reference. Water levels will be monitored during low-flow sampling. Stabilization parameters pH, specific conductivity, temperature, dissolved oxygen, and oxidation reduction potential will be measured using an in-line flow cell (QED MicroPurge® Flow Cell Model MP20) that will be calibrated each morning prior to use. Turbidity, while not considered a stabilization parameter, will also be measured. Fe (II) will be measured using a Hach Iron (Ferrous) Color Disc Test Kit, Model IR-18C following stabilization.

The initial flow rates will be closely monitored during purging. Well purge flow rates will be calculated by dividing volume purged by elapsed time. After determining the optimum flow rate, the controller will be adjusted, or throttled to the desired pump flow rate. For low-flow sampling, the flow rate should be no greater than 500 milliliters/minute. Micropurge flow cell data will be recorded every two minutes while monitoring for stabilization prior to sample collection.

At each well, low-flow purging will continue until three consecutive measurements of the stabilization parameters meet stabilization requirements. Stabilization parameter requirements are as follows:

pH +/- 0.2 units

Specific Conductivity +/- 0.020 mS/cm

Temperature +/- 0.2 ºC

DO +/- 0.2 mg/l

ORP +/- 20 mV

Samples of injected test solutions and groundwater for laboratory analysis will be collected in amber glass or HDPE bottles as appropriate, shipped on ice, and stored at 2-6 °C until analysis.

RDX and its transformation product concentrations will be determined by high performance liquid chromatography (HPLC) using EPA Method 8330B. At a minimum, the laboratory required method detection limit (MDL[[1]](#footnote-2)) shall be 0.25 microgram/liter (μg/L) and the reporting limit (RL) shall be 0.5 μg/L. Samples will be analyzed for chloride and bromide using EPA Method 300.0. Samples will be analyzed for TOC using SW-846 Test Method 9060A.

Samples will be packaged in insulated coolers for shipment to the lab. Each cooler will be lined with plastic bubble wrap for shock absorption, and sample bottles will be individually protected by bubble wrap to protect against breakage. Each sample bottle will be placed in its own plastic Ziploc bag. A large plastic garbage bag will be used inside the cooler to contain the sample bottles in case of breakage. All samples will be placed in the shipping coolers and denoted on the Chain of Custody (COC) form accompanying each cooler. A photo of each completed COC form will be taken. Completed COC forms will be taped to the inside of each cooler lid. The coolers will be shipped via standard overnight FedEx service to the analytical laboratory. The sampling team lead shall call or email the laboratory POC each day samples are shipped in order to alert the lab to samples to arrive the next day. The laboratory point-of-contact shall call or email USACE, Seattle District confirming receipt of each shipment.

The nearest FedEx shipment location is the FedEx Office Print and Ship Center in Silverdale, Washington at 10854 NW Myhre Pl, Silverdale, WA 98383. The business is open 7:30 AM to 9:00 PM during the week, with the latest drop-off time for express shipments at 4:05 PM. Coolers will be shipped to the appropriate lab, cooled from 2-6 °C with wet ice, in a timeline that will meeting the sample holding times, under chain of custody control.

Instructions for sample handling and custody are listed in Worksheet #26/27.

## Sample Collection Equipment

* Stainless steel bowls
* Stainless steel spoons
* Aluminum foil
* Rulers or calipers for size measurement
* Ziploc® bags
* Clam shovel or rake
* Field quality rulers to measure up to 10 cm
* Pre-cleaned sample containers and labels
* Distilled water
* 5-gallon buckets
* Coolers with ice
* Camera for photo documentation
* GPS
* Field notebook

## Decontamination and Investigation-Derived Waste

Certified clean sample jars will be provided from the laboratory. Dedicated sample pumps will be used in each well, so there will be no reusable sampling equipment that would require decontamination.

Well purge water (approximately 5 gallons per sample) will be put into 1,100-gallon poly tanks onsite and then run through the site treatment system.

Personnel protective equipment and other solid wastes (paper towel, e.g.) will be placed in trash bags and disposed of in a dumpster.

## Field Documentation

### Photographs

Digital photographs will be taken to document sample locations. The subject of each photograph is the sampling location and the collection activity associated with the sample. Digital photographs will be provided electronically to the USACE PM with the associated field logbook information. Information about each photograph will be recorded in the field logbook. The information will include:

* Date and time;
* Subject;
* Purpose for photograph being taken;
* Number of photograph;

### Field Logbooks

Permanently bound field books with waterproof paper will be used as field logbooks because of their compact size, durability, and secure page binding. The pages of the logbook will be numbered consecutively and will not be removed for any reason. Logbooks will document the procedures performed by field personnel. Each entry will be dated and contain legible, accurate, and complete documentation of the sampling activities. Documentation in the field logbook will be at a level of detail sufficient to explain and reconstruct field activities without relying on recollection by the field team members.

Entries in the logbook or other relevant sampling forms for sampling events will include, but not necessarily be limited to, the following:

* Project name, location, and number
* Field crew personnel, subcontractors, other personnel names
* Safety briefing and day schedule plan conducted
* Rationale for collecting the sample
* Date and time of sampling
* Sample numbers
* Cross-reference of numbers for duplicate and blank samples
* Media sampled
* Geographical location of the sampling area
* Method of sampling, including procedures, equipment, and any departure from the procedures specified in the management plan.
* Rationale for any deviations from management plan procedures and documentation
* Sample preservation
* Type and quantity of container used for each sample.
* Weather conditions at the time of sampling and previous events that may influence the representative nature of a sample - at a minimum, the temperature, approximate wind speed and direction, and sky cover
* Photographic information - a brief description of what was photographed and why, the date and time, the compass direction of the picture, and digital file name
* Analyses requested
* Disposition of the sample (i.e., where the sample is being shipped)
* Airbill number of sample shipment, when applicable
* Other pertinent observations, such as the presence of other persons on the site (those associated with the job or members of the press, special interest groups, or passersby) and actions by others that may affect performance of site tasks
* Type of health and safety clothing and type of equipment used
* Name(s) of sampling personnel.

Additional details may be recorded in the field logbook for all sampling locations.

## Sample Numbering

Every sample collected in the field will be labeled and accompanied by a chain-of-custody form when delivered to the laboratory for analysis. Information on the sample label shall contain, at a minimum, sample identification number, analysis requested, and sampling date and time. All samples collected will be assigned a unique identification code based on a consistent sample designation scheme.

Sample numbers are generally assigned as follows:

21F-P(number)-(injection or well)-sample number-QC if applicable

where 21F is for Bangor Site F, 2021, and P is for Phase.

Examples:

21F-P1-INJ-09: Phase I, Injection sample #9

21F-P2-PT01-02: Phase II, monitoring well F-PT-01, sample #2

21F-P2-PT01-02-FD: Phase II, monitoring well F-PT-01, sample #2, field duplicate

21F-P2-PT01-02-MS: Phase II, monitoring well F-PT-01, sample #2, matrix spike

21F-P2-PT01-02-MSD: Phase II, monitoring well F-PT-01, sample #2, matrix spike duplicate

Samples designated in the field for MS/MSD will be collected at triple the required mass or volume. “MS or MSD” will be indicated on the sample label and chain-of-custody.

## Cooler Packing for Shipping

**At the sampling location:**

1. Samples should be iced as soon as they are sampled. Place the collected samples in a cooler with ice. Samples may be prepared for shipping at the sample location, or later at a convenient location, as long as samples are iced throughout.

**When using wet ice – How to prepare the samples and cooler for shipment:**

1. So that leaks will not escape the cooler, seal the cooler drain with tape on the inside of the cooler, if it is not already sealed.
2. Line the bottom and sides of the cooler with thick bubble wrap.
3. Place a large, heavy-duty trash bag inside the cooler. All samples and ice will go inside this trash bag.
4. Double-bag ice inside gallon-sized Ziploc bags. Each cooler should have 4 to 5 bags of ice. Ice from water is preferred to gel packs because the gel packs are very hard when frozen and may break bottles, and also due to chemical contamination concerns with some sample types. If the ice was used earlier in the day during sampling, it is good practice to top off the ice bags with additional ice, pouring out any water, to ensure the samples stay cold during shipping.
5. Place all sample bottles in individual Ziploc bags. Place the bagged samples inside bubblewrap sleeves, or wrap with bubblewrap and secure with rubber bands or tape.
6. Put the bagged, bubble-wrapped samples and the double-bagged ice inside the trash bag in the cooler. Each sample should be in contact with ice. A common way to arrange the contents is to lay 2 bags of ice on the bottom of the cooler, put the samples on top of the ice, and then put additional bags of ice on top of the samples, and also vertically between the bottles. Arrangement may vary so that all samples will fit in the cooler.
7. Place an additional piece of bubblewrap on top of the samples.
8. Gather the ends of the trash bag together, fold over several times, and seal with tape. All samples and ice will be sealed in the trash bag, so any leaks should not escape the cooler.
9. If there is too much extra space, stuff bubblewrap around the trash bag to limit motion inside the cooler.

**At the shipping location (for example, FedEx store):**

1. Sign off the chain of custody (COC) with the date and time you are relinquishing the samples to the shipping company. Include the airbill number/tracking number on the COC. It is good practice to take a picture of the COC and email it to the laboratory, along with the tracking number.
2. Place the signed COC in a Ziploc bag and tape it to the inside of the cooler lid.
3. Shut the cooler. Seal the cooler by wrapping filament tape around the cooler. Wrap the filament tape around the cooler on the right and left sides, with two layers of tape on each wrapping.
4. Cut two ~8-10 inch pieces of custody tape. Use the pieces of custody tape to seal the cooler lid to the cooler body, placing the pieces of tape at the front right and back left of the cooler.
5. Fill out the airbill, then keep the top copy of the airbill and return it to the Visa card holder who provided the shipping company account number. Scan a copy and email, if needed.
6. Attach the rest of the airbill to the cooler handle, or tape to the top lid of the cooler.
7. If shipping biological specimens (and assuming they are non-infectious), put a label on the cooler that says “exempt animal specimen.” This label can simply be a piece of paper taped to the cooler. Put on the same side as any other labels.

# QAPP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection

*(UFP-QAPP Manual Section 3.1.2.4)*

Multiparameter Water Quality Meter

* 1. Before each use inspect the instruments to ensure there are no signs of damage or wear that requires repair.
  2. Check the battery life of the meter and ensure the battery will last for the entire sampling event.
  3. If the instrument has been calibrated during the previous week then check the calibration of the pH, and conductivity using the calibration confidence solution. If the calibration is outside of the range listed on the confidence solution, then calibrate according to manufacturer’s directions.
  4. Calibrate the pH and conductivity a minimum of once a week according to the manufacturer’s directions.
  5. Use a three-point calibration for the pH.
  6. Calibrate the dissolved oxygen daily according to the manufacturer’s directions.
  7. Record the daily calibration checks and calibration of the sampling logs.
  8. Record any anomalies, such as if a probe is not calibrating.
  9. Store equipment correctly with probes in the correct solution recommended by manufacturer.
  10. Ensure equipment is decontaminated, dry and properly stored with all parts and manuals after each use.
  11. Store equipment in a dry location that does not have temperature extremes.

Water Level Indicator (WLI)

1. Before each use check the batteries on the WLI by pressing the test button.
2. Inspect the instrument for damage especially along the cable for exposed wires.
3. Inspect the instrument for dirt or debris that may contaminate a well.
4. After each use clean off the portion of the WLI that was in the well and decontaminate the bottom five feet of the WLI.
5. Store WLI in a dry location.

# QAPP Worksheet #23: Analytical SOPs

(UFP-QAPP Manual Section 3.2.1)

|  |  |  |  |
| --- | --- | --- | --- |
| SOP # | Matrix/Analytical Group | Title, Date, and URL (if available) | Modified for Project?  Y/N |
| EMT | TOC in Water  EPA 9060A | EMT-SOP-I-063. Inorganic Ions by Ion Chromatography Rev. 14 March 24, 2021 | N |
| Anions in Water  EPA 300.0 | EMT-SOP-I-063. Total Organic Carbon Using the Schimadzu TOC-LCPH/CPN Analyzer Rev. 15, 01/08/2021 | N |
| Explosives in Water  EPA 8330B | EMT-SOP-O-8330. Analysis of Explosives by Method 8330B Rev 11 December 14, 2020. | N |

# QAPP Worksheet #24: Analytical Instrument Calibration

*(UFP-QAPP Manual Section 3.2.2)*

Analytical instrument calibration will be performed according to laboratory SOPs, and according to the principles of the DoD Quality Systems Manual (QSM) for DoD ELAP-accredited methods.

# QAPP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection

*(UFP-QAPP Manual Section 3.2.3)*

Analytical instrument and equipment maintenance, testing, and inspection will be performed according to the laboratory quality manual.

EMT: Quality Assurance Manual, Rev 18, Nov. 18, 2019.

# QAPP Worksheet #26 & 27: Sample Handling, Custody, and Disposal

*(UFP-QAPP Manual Section 3.3)*

**Sampling Organization:** USACE Seattle District

**Laboratory Address and Scope:**

**Prime Contract Lab: Analytes**

Environmental Monitoring and Technologies, Inc.

509 N. 3rd Ave.

Des Plaines, IL. 60016

Primary POC: Tim Witrzek, twitrzek@emt.com, 847-324-3320

**Method of Sample Delivery (shipper/carrier):** FedEx

## Sample Delivery

Samples will be packed in coolers using bubble wrap along with ice packs, blue ice, or crushed ice for transport to the laboratory. A temperature blank will be placed in each sample cooler. All samples will be accompanied by chain-of custody forms. Chain-of-custody records will be maintained by the Field Lead to document and verify sample transfer to laboratory.

## Sample Custody

After sample collection, samples will be maintained in the custody of field personnel until formally transferred to the laboratory or storage area. For the purposes of this work, custody will be defined as follows:

* Samples will be in plain view of the field personnel.
* Samples will be stored inside an appropriate container that is in plain view of the field personnel.
* Samples will be stored inside any locked space such as a cooler, locker, car, truck, or trailer to which field personnel have the only immediately available key(s) or lock combination.

Custody records will be maintained for all samples recovered. Custody records are defined as formal chain-of-custody forms. The information on the chain-of-custody form shall contain, at a minimum, the following:

* Project Name
* Sample identification number
* Date and time of sample collection
* Sample location identification and/or description
* Sample matrix type
* Signatures sample handlers
* Type of analyses requested
* Number of containers used to hold the sample
* Temperature blank listed on form (if using)
* Method of shipment
* Signatures indicating relinquishment and acceptance of samples including date and time of sample transfer
* Phone number and name of person to whom results should be reported

If samples leave the custody of the designated person as defined above, custody seals will be affixed to the sample or shipping containers. The custody seals will contain, at a minimum, the name and title of the person responsible for the samples, the signature of that person, and the date when the custody seal was applied.

The Field Lead will be responsible for sample tracking and chain-of-custody procedures in the field. The Field Lead, or designee, will prepare field notebook entries prior to removing samples from sampling equipment. At the end of the work day, chain-of-custody forms will be prepared by the Field Lead, or designee, prior to transfer of the samples into shipping coolers. All information on the chain-of-custody forms will be cross-checked against field notebook entries and sample labels prior to sample transfer.

## Laboratory Custody Procedures

A designated sample custodian at the laboratory will accept custody of the shipped samples from the carrier and enter the preliminary information about the samples into a sample receipt log, including the initial of the person delivering the samples and the status of the custody seals on the coolers (i.e., broken versus unbroken), if affixed. The custodian responsible for sample log-in will follow the laboratory’s SOP for opening the coolers, checking cooler temperature, checking the contents, and verifying that the information on the chain-of-custody agrees with the samples received.

## Laboratory Sample Disposal

The laboratory will dispose of samples in accordance with their appropriate waste streams.

# QAPP Worksheet #28: Analytical Quality Control and Corrective Action

*(UFP-QAPP Manual Section 3.4 and Tables 4, 5, and 6)*

Quality control and corrective actions will follow laboratory SOPs and, if the analysis is according to the DoD ELAP accreditation, the principles of the DoD Quality Systems Manual (QSM) for each method.

# QAPP Worksheet #29: Project Documents and Records

*(UFP-QAPP Manual Section 3.5.1)*

|  |  |  |  |
| --- | --- | --- | --- |
| Project Documents and Records | | | |
| Record | Generation | Verification | Storage Location/Archival |
| Work Plan | Project Chemist (Alison Suess) | Senior Technical Advisor (Mandy Michalsen) | Project File |
| UFP-QAPP | Project Chemist (Alison Suess) | Senior Technical Advisor (Mandy Michalsen) | Project File |
| Health and Safety Plan | Field Lead (Jeff Weiss)  and Project Coordinator (Dan Carlson) | USACE Seattle District Safety Office | Project File |
| Field Sampling Report | Field Lead (Jeff Weiss) or Project Coordinator (Dan Carlson) | Project Coordinator (Dan Carlson) or Field Lead (Jeff Weiss) | Project File |
| Laboratory Reports | Laboratory Staff | Project Chemist (Alison Suess) | Project File |
| Data Validation Report | Data Validation (Laboratory Subcontract) Staff | Project Chemist (Alison Suess) | Project File |
| Final Data Report | Project Coordinator (Dan Carlson), Field Lead (Jeff Weiss), and Project Chemist (Alison Suess) | Senior Technical Advisor (Mandy Michalsen) | Project File |

# QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action

*(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)*

Assessments:

|  |  |  |  |
| --- | --- | --- | --- |
| Assessment Type | Responsible Party & Organization | Number/Frequency | Assessment Deliverable |
| Work Plan and QAPP Stakeholder Review | Project Manager (Briana Niestrom) | Once | Comments from Reviewers, Responses and Revisions from USACE |
| Field Sampling Daily Safety Briefs and Checks | Field Lead (Jeff Weiss) | Each day of sampling | Field Sampling Report |
| Assessment of Laboratory Data and Data Validation Reports | Project Chemist (Alison Suess) | Upon receipt of reports | Incorporated into Final Data Report |
| Data Usability Assessment | Project Team (See Worksheet #37) | Once | Incorporated into Final Data Report |
| Final Data Report Stakeholder Review | Project Manager (Briana Niestrom) | Once | Comments from Reviewers, Responses and Revisions from USACE |

# QAPP Worksheet #34: Data Verification and Validation Inputs

*(UFP-QAPP Manual Section 5.2.1 and Table 9)*

Planning Documents/Records:

|  |  |  |
| --- | --- | --- |
| Item | Verification (Completeness) | Validation (Conformance to Specifications) |
| Approved Work Plan | X |  |
| Approved QAPP | X |  |

Field Records:

|  |  |  |
| --- | --- | --- |
| Item | Verification (Completeness) | Validation (Conformance to Specifications) |
| Field Logs | X |  |
| Field Sampling Report | X |  |

Analytical Data Package:

|  |  |  |
| --- | --- | --- |
| Item | Verification (Completeness) | Validation (Conformance to Specifications) |
| Case narrative | X | X\* |
| Sample receipt records | X | X\* |
| Sample chronology (i.e. dates and times of receipt, preparation, & analysis) | X | X\* |
| Standards Traceability | X | X\* |
| Instrument calibration records | X | X\* |
| Definition of laboratory qualifiers | X | X\* |
| Results reporting forms | X | X\* |
| QC sample results | X | X\* |
| Raw data | X |  |
| Electronic data deliverables: A1/A3 compatible with ADR | X | X\* |

\*Stage 2B data validation will be performed.

# QAPP Worksheet #35: Data Verification Procedures

*(UFP-QAPP Manual Section 5.2.2)*

|  |  |  |  |
| --- | --- | --- | --- |
| Records Reviewed | Requirement Documents | Process Description | Responsible Person, Organization |
| Work Plan and QAPP | Work Plan and QAPP | Stakeholders will review the QAPP and provide comments. USACE will respond to comments and incorporate revisions to the QAPP if necessary. | Project Manager (Briana Niestrom) |
| Field logbooks | QAPP | Verify that records are present and complete for each day of field activities. Verify that all planned samples including field QC samples were collected and that sample collection locations are documented. Verify that meteorological data were provided for each day of field activities. Verify that changes/exceptions are documented and were reported in accordance with requirements. Verify that any required field monitoring was performed and results are documented. | Daily – Field Lead (Jeff Weiss)  At conclusion of field activities - Project Chemist (Alison Suess) |
| Chain-of-custody forms (CoCs) | QAPP | Verify the completeness of chain-of-custody records. Examine entries for consistency with the field logbook. Check that appropriate methods and sample preservation have been recorded. Verify that the required volume of sample has been collected and that sufficient sample volume is available for QC samples (e.g., MS/MSD). Verify that all required signatures and dates are present. Check for transcription errors. | Daily – Field Lead (Jeff Weiss)  At conclusion of field activities - Project Chemist (Alison Suess) |
| Laboratory Deliverable | QAPP, Field Logbooks or Field Sampling Report | Verify that the laboratory deliverable contains all records specified in the QAPP. Check sample receipt records to ensure sample condition upon receipt was noted, and any missing/broken sample containers were noted and reported according to plan. Compare the data package with the CoCs to verify that results were provided for all collected samples. Review the narrative to ensure all QC exceptions are described. Check for evidence that any required notifications were provided to project personnel as specified in the QAPP. Verify that necessary signatures and dates are present. | Before release - Laboratory Staff  Upon receipt - Project Chemist (Alison Suess) |
| Data Validation Deliverable | QAPP, Laboratory Reports | Verify that the data validation deliverable contains all records specified in the QAPP. Compare the deliverable to the laboratory report and CoCs to verify that results were provided for all collected samples. Review the narrative to ensure that all QC exceptions and flagged data are described. | Before release – Data Validation Staff  Upon receipt - Project Chemist (Alison Suess) |

# QAPP Worksheet #36: Data Validation Procedures

*(UFP-QAPP Manual Section 5.2.2)*

Data will be validated by EMT’s data validation subcontractor, LDC, Inc., as part of the Task Order for the laboratory work. EMT will provide Level 4 laboratory reports.

Data Validator: LDC, Inc.

|  |  |  |  |
| --- | --- | --- | --- |
| Analytical Group | Matrix | Stage1 | Validation Criteria |
| TOC  (EPA 9060A) | Water | 100% Stage 2b  (SV2EM) | Validation performed in accordance with the laboratory analytical methods and the DoD QSM (DoD, 2019a). DoD General Data Validation Guidelines (DoD, 2019b) and EPA National Functional Guidelines (EPA, 2020) will be used for general guidance. |
| Anions  (EPA 300.0) | Water | 100% Stage 2b  (SV2EM) | Validation performed in accordance with the laboratory analytical methods and the DoD QSM (DoD, 2019a). DoD General Data Validation Guidelines (DoD, 2019b) and EPA National Functional Guidelines (EPA, 2020) will be used for general guidance. |
| Explosives  (EPA 8330B) | Water | 100% Stage 2b  (SV2EM) | Validation performed in accordance with the laboratory analytical methods and the DoD QSM (DoD, 2019a). DoD General Data Validation Guidelines (DoD, 2019b) and EPA National Functional Guidelines (EPA, 2020) will be used for general guidance. |

1 DoD General Data Validation Guidelines (DoD, 2019b).

The following data qualifiers will be applied during data validation by a third party. Potential impacts on project-specific data quality objectives will be discussed in the data validation report.

Table 13. Data Qualifiers and Definitions

|  |  |
| --- | --- |
| Qualifier | Definition |
| U | The analyte was not detected and was reported as less than the LOD or as defined by the customer. The LOD has been adjusted for any dilution or concentration of the sample. |
| J | The reported result was an estimated value with an unknown bias. |
| J+ | The result was an estimated quantity, but the result may be biased high. |
| J- | The result was an estimated quantity, but the result may be biased low. |
| N | The analysis indicates the presence of an analyte for which there  was presumptive evidence to make a "tentative identification." |
| NJ | The analyte has been “tentatively identified” or “presumptively” as present and the associated numerical value was the estimated concentration in the sample. |
| UJ | The analyte was not detected and was reported as less than the LOD or as defined by the customer. However, the associated numerical value is approximate. |
| X | The sample results (including non-detects) were affected by serious deficiencies in the ability to analyze the sample and to meet published method and project quality control criteria. The presence or absence of the analyte cannot be substantiated by the data provided. Acceptance or rejection of the data should be decided by the project team (which should include a project chemist), but exclusion of the data is recommended. |

# QAPP Worksheet #37: Data Usability Assessment

*(UFP-QAPP Manual Section 5.2.3 including Table 12)*

This worksheet documents procedures that will be used to perform the data usability assessment. The data usability assessment is performed at the conclusion of data collection activities, using the outputs from data verification and data validation. It is the data interpretation phase, which involves a qualitative and quantitative evaluation of environmental data to determine if the project data are of the right type, quality, and quantity to support the decisions that need to be made. It involves a retrospective evaluation of the systematic planning process, and, like the systematic planning process, involves participation by key members of the project team. The data usability assessment evaluates whether underlying assumptions used during systematic planning are supported, sources of uncertainty have been accounted for and are acceptable, data are representative of the population of interest, and the results can be used as intended, with the acceptable level of confidence.

**Identify personnel (organization and position/title) responsible for participating in the data usability assessment:**

Project Manager – Briana Niestrom

Senior Technical Advisor – Mandy Michalsen

Project Coordinator – Dan Carlson

Project Chemist – Alison Suess

Field Lead – Jeff Weiss

**Describe how the usability assessment will be documented:**

The data usability assessment will be documented as a section of the final report.

**Summarize the data usability assessment process including statistics, equations, and computer algorithms that will be used to analyze the data:**

|  |  |
| --- | --- |
| **Step 1** | **Review the project’s objectives and sampling design:**  Review the DQOs defined during systematic planning to make sure they are still applicable. Review the sampling design for consistency with stated objectives. This provides the context for interpreting the data in subsequent steps. |
| **Step 2** | **Review the data verification and data validation outputs:**  Review available QA reports, including the data verification and data validation reports. Perform basic calculations and summarize the data (using graphs, maps, tables, etc.). Look for patterns, trends, and anomalies (i.e., unexpected results). Review deviations from planned activities (e.g., number and locations of samples, holding time exceedances, damaged samples, non-compliant PT sample results, and SOP deviations) and determine their impacts on the data usability. Evaluate implications of unacceptable QC sample results. |
| **Step 3** | **Verify the assumptions of the selected statistical method:**  Verify whether underlying assumptions for selected statistical methods are valid. Common assumptions include the distributional form of the data, independence of the data, dispersion characteristics, homogeneity, etc. Depending on the robustness of the statistical method, minor deviations from assumptions usually are not critical to statistical analysis and data interpretation. If serious deviations from assumptions are discovered, then another statistical method may need to be selected. |
| **Step 4** | **Implement the statistical method:**  Implement the specified statistical procedures for analyzing the data and review underlying assumptions. |
| **Step 5** | **Document data usability and draw conclusions:**  Determine if the data can be used as intended, considering implications of deviations and corrective actions. Discuss data quality indicators. Assess the performance of the sampling design and Identify limitations on data use. Update the conceptual site model and document conclusions. Summarize data usability in the final report. |

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1. The MDL is equivalent to the limit of detection and the RL is equivalent to the limit of quantification. [↑](#footnote-ref-2)