Water Column Sampling Work Plan
(Appendix E to PDI WP)
Remedial Design – Lower 8.3 Miles of the Lower Passaic River
Operable Unit Two of the Diamond Alkali Superfund Site
In and About Essex, Hudson, Bergen and Passaic Counties – New Jersey
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(Appendix E to PDI WP)
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Operable Unit Two of the Diamond Alkali Superfund Site
In and About Essex, Hudson, Bergen and Passaic Counties – New Jersey

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# REVISION RECORD

Revisions to this Water Column Sampling Work Plan will be reviewed and approved by someone qualified to have prepared the original document. All revisions must be authorized by the Tetra Tech Project Manager and the Glenn Springs Holdings, Inc. Project Coordinator, or their designee(s) and documented below.

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<td>Acoustic Doppler Current Profiler</td>
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<td>Chlorophyll-a</td>
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<td>contaminant of concern</td>
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<td>DDD</td>
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<td>DDE</td>
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<td>fluorescent dissolved organic matter</td>
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<td>The Louis Berger Group</td>
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<td>LISST</td>
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<td>Site Wide Monitoring Plan</td>
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1 INTRODUCTION

This Water Column Sampling Work Plan (WP) has been prepared as part of the Pre-Design Investigation Work Plan (PDI WP) pursuant to the requirements set forth in the Administrative Settlement Agreement and Order on Consent for Remedial Design (Settlement Agreement) between the U.S. Environmental Protection Agency (EPA) and Settling Party, effective September 30, 2016, for the lower 8.3 miles of the Lower Passaic River (Operable Unit Two [OU 2]) of the Diamond Alkali Superfund Site (the Site), located in and about Essex, Hudson, Bergen, and Passaic Counties, New Jersey (the Project); refer to Figure 1-1.

The Settling Party, as defined in the Settlement Agreement, is Occidental Chemical Corporation. Communications associated with, and execution of, the Settlement Agreement are being led by Glenn Springs Holdings, Inc. (GSH) on behalf of Occidental Chemical Corporation.

The Settlement Agreement provides that the Settling Party shall undertake a Remedial Design (RD), including various procedures and technical analyses, to produce a detailed set of plans and specifications for implementation of the Remedial Action (RA) selected in the EPA’s March 3, 2016 Record of Decision (ROD; EPA, 2016a). RD activities include the completion of all pre-design and design activities and deliverables associated with implementation of the RD for the remedy selected in the ROD. The selected remedy was chosen by the EPA in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 United States Code §§9601-9675, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan.

As stated in the EPA Statement of Work, pre-design investigation (PDI) activities are to be conducted to gather additional site-specific information that is required to develop the RD, as outlined in the Remedial Design Work Plan (RDWP; Tetra Tech, 2017b). The PDI activities include baseline water column sampling and the measurement of discharge, current velocities, and water level to support development of the engineering performance standards.

This Water Column Sampling WP provides background information on the available water column data and studies, and outlines the study objectives, preliminary monitoring locations, proposed measurement instrumentation, methods for sample collection and analysis, and schedule for the monitoring. Deployment locations for the mooring arrays may be adjusted after the reconnaissance survey. Results from this baseline water column monitoring will be used along with the results from the sediment core sampling and dredge elutriate testing to develop criteria for dredge performance monitoring during the implementation of the remedy. The monitoring and sampling outlined in this WP is primarily for establishing engineering performance standards and shall stand on their own; however, attempts will be made to gain efficiencies by coordinating data collection conducted to support data use objectives developed under the Site Wide Monitoring Plan (SWMP; Tetra Tech 2017e).

This WP is organized as follows:

Section 1—Introduction: Presents a brief description of the Project background, previous surface water investigations, and objectives of water column sampling.

Section 2—Existing Surface Water Data: Presents existing surface water data, relevant discharge flow data, and water level data.

Section 3—Water Column Sampling and Testing: Presents the field methodology for sampling of the water column, measuring water current velocity and water levels, the technical approach, and a description of the methodology for conducting water column measurements.
Section 4—Data Evaluation and Analyses: Presents discussion of how the water column testing results will inform the RD and engineering performance standards.

Section 5—Quality Control: Describes the approach for quality control during water column sampling and testing.

Section 6—Deliverables: Presents a description of the water column sampling report to summarize the findings of the investigations.

Section 7—Schedule: Provides the schedule for field work, testing, and reporting.

Section 8—References: Cites references used in compiling this planning document.

1.1 PROJECT BACKGROUND

OU 2 consists of approximately 650 acres located in northeastern New Jersey and extends from the confluence of the Lower Passaic River (LPR) with Newark Bay at river mile (RM) 0 to RM 8.3, which is near the City of Newark and Belleville Township border. The EPA selected the remedy for OU 2 in the March 3, 2016, ROD to address contaminated sediments found in the lower 8.3 miles of the LPR (EPA, 2016a).

Contaminants of concern (COC) in the sediment include dioxins and furans, polychlorinated biphenyls (PCBs), mercury, copper, lead, DDT (dichlorodiphenyltrichloroethane) and its primary breakdown products dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyl dichloroethylene (DDE) [denoted as DDx], dieldrin, and polycyclic aromatic hydrocarbons (PAHs).

Pre-design activities will be conducted in accordance with the PDI WP. The primary objective of the PDIs is to gather the additional site-specific information that is required to develop the RD for the selected remedy as identified in the ROD and in the Statement of Work (EPA, 2016b).

1.2 WATER COLUMN SAMPLING OBJECTIVES

One of the components of the draft engineering performance standards for the lower 8.3 miles of the LPR (EPA, 2017) identifies evaluation of resuspension of sediments during dredging and capping to ensure that increases in TSS and contaminant concentrations are within acceptable limits. Other components include contingency thresholds for additional monitoring or implementation of additional engineering controls to reduce resuspension. Thresholds for the contingency actions will be determined during the development of the engineering performance standards using the data collected under this plan, the column settling/dredge elutriate testing, and historical data collected at the Site. The draft engineering performance standards note that there is a time lag for the reporting of laboratory analysis. This time lag limits the application of monitoring results to implementing additional monitoring or engineering controls during the remedial activities. The use of real-time monitoring with in-water sensor technologies allows for field adjustments to be more quickly made, reducing the amount of resuspension and limiting the potential transport of contamination from the site. The RD will use the data collected from the water column monitoring to determine the accuracy and representativeness of the in-water sensor data for different conditions/instruments in the river. In addition, the data collection will be used to identify which of the selected in-water instruments are best suited for deployment during the remedial actions, or if an alternative approach will need to be developed for performance monitoring.

Implementation of the water column sampling for OU 2 will support the RD. The primary objectives of data collection are:

- Develop a relationship between the in situ water quality measurements (conductivity, temperature,
dissolved oxygen, pH, optical turbidity, Chlorophyll-a [Chl-a] and phycoerythrin, and fluorescent dissolved organic matter [FDOM]) and analyzed water sample suspended sediment concentration (SSC) and COC concentrations across the range of typical annual conditions at five monitoring locations within OU 2, one location upstream of the OU 2 boundaries, and one downstream. Correlations will be established for the baseline conditions relating the in situ measurements and water sample analyses for SSC and total COC concentrations.

- Identify in-water instruments that are durable and reliable for use during the remedial action activities to monitor water quality and provide usable data for near real-time decision making purposes.
- Utilize the collected data to quantify suspended sediment concentration flux and establish baseline criteria, based on river current velocity, river discharge, and tide cycles. Data will be used to develop resuspension engineering performance standards for comparison of water quality monitoring data to be collected during dredging and capping activities.

These primary objectives will be achieved by collecting in situ time series of current velocity, discharge data and water quality parameter measurements (e.g., turbidity) on deployed moorings. Discharge measurement data recorded at the U.S. Geological Survey (USGS) Dundee Dam station will be combined with the discharge data collected during seasonal transect surveys and at the monitoring locations closest to RM 0 and RM 8.3 for the duration of the water column monitoring program.

The in situ data will be correlated with co-located discrete water samples collected during periodic site visits. Measurements will be collected at five stations within OU 2 as well as upstream and downstream locations at discrete water depths. To the extent feasible, correlations will be established between the in situ monitoring data and the laboratory results of SSC and COC analyses of the discrete water samples. The development of a correlation will enable the in situ water quality from the real-time monitoring stations to be used to estimate near-continuous, high temporal resolution concentrations of SSC and COCs in the water column. The collective laboratory-based and in situ water quality data sets will be used, as appropriate, to quantify suspended sediment contaminant flux and establish the baseline range of SSC in association with particulate and dissolved COC concentrations in the water column across the range of typical conditions within OU 2.

In addition to the data collection efforts for this baseline water column sampling task, water quality sampling will be conducted as part of the SWMP (Tetra Tech, 2017e) for long-term post-remedial action monitoring, which entails collection of co-located water column data to establish seasonal and tidal data for the particulate and dissolved concentration of COCs in the water column in OU 2.

1.3 DATA QUALITY OBJECTIVES

This investigation will be performed per the Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP; Tetra Tech, 2017c), which is the basis for the quality assurance and quality control elements of the entire Project. The UFP-QAPP serves as a “project-specific quality plan” for the Project and encompasses elements of a Field Sampling Plan and a Quality Assurance Project Plan. The plan integrates technical and quality aspects for OU 2 to ensure scientifically sound data of known and documented quality are collected to meet the data quality objectives (DQOs) for the Project. Development of DQOs for this water column monitoring task followed the seven-step process outline in Worksheet #11 of the UFP-QAPP. The DQOs include:

- Steps 1 and 2 – Problem statement and goals of the study are presented in Section 1.2. Data will be collected to establish baseline conditions for SSC and COC concentrations in the water column.
• Step 3 – Information inputs, prior water column data collected are summarized in Section 2, along with an analysis of data gaps. Flow and water level data is available from several monitoring stations in and near OU 2. Prior data collection from a pilot dredge study conducted in OU 2 and data collected for the OU 3 Remedial Investigation provide preliminary information for the water column. The data gaps analysis in Section 2.5 includes the relative short duration of prior data collection. To support the RD and future remedial activities, water column data will be collected at a minimum to cover the entire potential in-water work window for OU 2.

• Steps 4, 5, 6, and 7 – The water column sampling and analytical testing program, the performance and acceptance criteria, and any specific QC requirements of this proposed investigation were developed based on the data gap identified in Step 3, the RD objectives, and additional data needs (Sections 3, 4, and 5). Data will be collected from five monitoring stations in OU 2, one station upstream of RM 8.3, and one station downstream of RM 0 using in situ instruments with sampling for analysis of SSC and COC concentrations. The data will be used to develop correlations between the in situ instrument measurements and results from analysis for SSC and the COCs.
2 EXISTING SURFACE WATER DATA

GSH has reviewed pertinent background data provided in the Remedial Investigation (EPA, 2014a) and Focused Feasibility Study (EPA, 2014b). Data from established monitoring stations for river discharge and surface water levels provide data on the Passaic river system. Surface water studies that include chemical analysis of suspended particulates are the pilot dredge project in 2005 (USGS, 2007; The Louis Berger Group [LBG], 2012) and in 2009/2010 (AECOM, 2010).

2.1 FLOW DISCHARGE DATA

Flow discharge data from the USGS monitoring station at Dundee Dam from 2007 through 2017 are shown in Figure 2-1. The average monthly discharge flows show that the discharge is highest in the spring and lowest during the summer months.

2.2 WATER LEVEL DATA

The USGS maintains a series of gages to measure water level and other parameters at different locations along the Passaic River. The closest currently operational gage, Station 01392650, is located at the Passaic Valley Sewage Commission (PVSC) facility, which is near RM 0.5 at the southern end of OU 2. Until August 2003, the gage was located a few miles upstream, where it was designated Station 01392590. The USGS website provides water elevation and temperature data for the newer Station 01392650, and water elevation and tide stage data for Station 01392590. The data from the PVSC gage show that the water level at the lower end of OU 2 close to the confluence with Newark Bay is dominated by tidal currents (Figure 2-2). The water level at the upper end of OU 2 is influenced by river discharge, although tidal currents still dominate the water level fluctuations (Figure 2-3).

2.3 IN SITU MEASUREMENT DATA CORRELATIONS

A water quality monitoring program was implemented as part of an Environmental Dredging Pilot Study implemented by the New Jersey Department of Transportation and U.S. Army Corps of Engineers (USACE) in 2005 (USGS, 2007; LBG, 2012). The pilot study was conducted between RM 2.6 and RM 3.0 from December 5 to 10, 2005 to assess the impact of resuspension on the water column and suspended sediment transport up flow and down flow of dredging operations. Pre-dredging data for the water column were collected on December 1, 2005. Water samples were collected for analysis of total suspended solids (TSS), particulate organic carbon (POC), dissolved organic carbon (DOC), chloride/bromide, dissolved and total metal and mercury concentrations, polychlorinated dibenzodioxins and furans (PCDD/F) congeners, PCB congeners, and pesticides. The data collected were used to evaluate the suspended solids contaminant concentrations in the water column during the dredging pilot activities.

To characterize LPR and Newark Bay estuarine dynamics and the movement of suspended sediments, moorings were deployed in the fall of 2009 (LPR) and the spring and summer of 2010 (Newark Bay) (AECOM, 2010). The 2009 and 2010 deployments in the lower 17.5 miles of the Passaic River consisted of moored acoustic Doppler current profiler (ADCP); measurements of conductivity, temperature, and depth (CTD); and optical backscatter (OBS) sensors at 3 feet above the sediment and 3 feet below the water surface, with near-continuous in situ measurements (every 12 minutes) of various physical parameters at RMs 1.4, 4.2, 6.7, 10.2, and 13.5 within the Lower Passaic River Study Area (LPRSA). The fall 2009 deployment lasted from October 10 to December 16, 2009, and the spring 2010 deployment was conducted from March 22 to July 23, 2010. Data presented in Attachment A for the two monitoring periods show the influence of the tides and river discharge on the salinity in the upper and lower parts of the water column.
The influence of the river discharge is strongest at RM 6.7 though the influence is seen at RM 1.4. Correlations between SSC and salinity, tides, and river discharge are not found to be present in the data.

Water column samples were collected during the monitoring program for laboratory analysis of SSC, DOC, and POC. Boat-based ADCP surveys were conducted during the mooring deployment in the LPR to obtain velocity profiles. Water column samples for SSC, DOC, and POC analyses were collected during the ADCP transect surveys.

Data collected for the water column monitoring in 2009 and 2010 over the 17.5 miles of the LPR provide a preliminary data set for evaluating the correlation between in situ measurements and SSC in the water column. Summaries of the data for the monitoring locations in the lower 8.3 miles are included in Attachment A.

### 2.4 WATER COLUMN DATA

Suspended solids in the water column are expected to possess the same contaminant pattern as the recently deposited surface sediments. To evaluate tidal and river flow influence on re-suspended and redeposited sediments in relation to recently-deposited surface sediments across the LPR, suspended solids data collected from large volume water samples were collected during the water column sampling event in 2005 (EPA, 2014a). Concentrations and patterns of contamination in suspended solids collected during large volume water column sampling were statistically compared to corresponding results in recently-deposited sediments to assess their similarity. Beryllium-7 (Be-7) sample analysis is an indication of sediment solids transported through the water column within 6 months prior to sample collection (EPA, 2014a). The suspended-phase concentrations approximate the Be-7 surficial sediment concentrations, demonstrating the close link between the two media due to tidally-driven resuspension and settling. Summaries of the relationships between TSS and contaminant concentrations for surface water samples are included in Attachment A.

Water column data collected between 2011 and 2012 (AECOM, 2012a, 2012b) at locations in the lower 8.3 miles of the LPR show good correlations between TSS and COC (PCDD/Fs, PCBs, DDX, and mercury) concentrations (Attachment A). These relationships are strong for samples collected across the whole site and at different water depths. These results indicate a strong association of COCs in the water column to the suspended sediment.

### 2.5 DATA GAP ANALYSIS

GSH has reviewed the existing water column data and developed the water column monitoring program based on the data needs. Preliminary observations and data gaps are summarized as follows:

- Water column data have been collected for durations of one to four months.
- Prior monitoring work has shown correlations between in situ instrument measurements and results for suspended sediment analysis.
- Data covering the entire potential in-water work window have not been collected for the OU 2 area.
3 WATER COLUMN SAMPLING AND TESTING

Water column hydrodynamic and water quality parameter data will be collected through deployment of in situ moored instrumentation to establish the range of baseline conditions within OU 2 over the established RA project area. Discrete water column samples will be collected along with water column physical data parameters at select RM transects to establish the composition of the total water column. In addition, discrete water column samples will be collected at a location upstream of OU 2 and downstream of OU 2 to collect a baseline data set outside of the RA project area. Measurement techniques and discrete sample data will be used to support the establishment of water column baseline conditions across a range of river conditions prior to the RA. This baseline dataset will be used to compare the water column conditions during the RA implementation to assess potential water column particulate exceedances during dredge and capping operations.

Measurements and samples will be collected at five locations across OU 2 at approximately RM 0, RM 2.1, RM 4.2, RM 6.7, and RM 8.2 (Figure 3-1). Final monitoring locations will be based on where equipment can be safely and securely deployed in the river. Monitoring equipment within OU 2 will be deployed for a minimum of one year to collect data during representative river conditions with particular focus on the period when dredging and capping could occur (June to March). In addition to the monitoring locations within OU 2, measurements and samples will be collected periodically at one monitoring location upstream and one location downstream of the OU 2 boundary at approximately RM 8.6 and RM -0.3 to provide baseline data for resuspension engineering performance monitoring outside of the RA project area. The water column data collection will include the following elements:

- Pre- and Initial Deployment Activities
  - Field reconnaissance survey to identify accessible, secure, and usable locations for moored instrument array deployments. The reconnaissance will include the evaluation of monitoring locations used for the LPRSA study.
  - Initial deployment for one year of moored in situ instruments including an ADCP collocated with multi-sonde sensor arrays deployed at two depths at each location within the RA project area.

- Routine Maintenance and Sample Collection Activities
  - Monthly servicing of the moored ADCP and water quality instruments.
  - Periodic (planned as monthly) collection of whole water samples for SSC and total and dissolved contaminant analysis at the moored instrument locations at both instrument depths across a range of site conditions to calibrate and validate water quality instrument measurements.
  - Collection of particulates for the analysis of particulate COC concentrations, collected from the planned monthly samples filtered for the dissolved-phase samples. Twenty percent of samples collected for dissolved-phase analysis will have the particulate-phase analysis completed.
  - Monthly collection of whole water samples for SSC and COC contaminant analysis at one upstream and one downstream location at discrete depths across a range of site conditions.
  - Monthly collection of water samples for dissolved COC contaminant analysis at one upstream and one downstream location at discrete depths across a range of site conditions.
  - Completion of boat transect surveys using a downward-facing ADCP.
Collection of vessel-based vertical profiles using a multi-parameter water quality instrument, cast Laser In Situ Scattering and Transmissometry (LISST), and CTD instruments.

- **Collection of Data from Other Sources**
  - Compilation of water level and discharge data from the USGS Passaic River, Dundee Dam station for the duration of instrument deployment.
  - Compilation of water level data from the USGS Passaic River, PVSC station for the duration of instrument deployment.

Instruments used for this data collection program include the following:

- **ADCP.** An ADCP measures three-dimensional water column current velocities at multiple vertical bins throughout the water column using acoustic Doppler principles. In addition, the ADCP acoustic backscatter data can, to some degree, be related to SSC. These meters will be part of the moored instrument arrays and will also be used from vessels during transect surveys. The moored meters will be either up or down looking and will provide depth-resolved velocity profiles several times per hour. Vessel-based, cross-channel ADCP transects will collect near-continuous velocity profiles across the entire navigable width of the river. Cross-channel, depth-resolved velocities will be used to estimate total discharge (flow rate) at each mooring location, which will be correlated with moored depth- and time-resolved velocity profiles. The index-velocity (USGS, 2012) will be used to develop a relationship between the velocity observed at the moored ADCP location and the total discharge of the channel at the monitoring station location. The resulting data will provide a sub-hourly time series of total discharge (flow rate) of the river.

- **Multi-parameter sonde.** Multi-parameter water quality sondes will be deployed with a CTD, which provides measurements of conductivity (C; for derivation of salinity), temperature (T), and pressure (which is related to depth, D). Additional probes for measurements of dissolved oxygen, pH, optical turbidity, Chl-a and phycoerythrin fluorescence, and FDOM will also be integrated with the multi-parameter sonde for deployment.

In addition to the CTD, the following ancillary parameters will, at a minimum, be measured either as part of a multi-parameter sonde or as independent sensors, depending on final instrument availability and selection:

- **Optical turbidity.** An optical turbidity sensor provides a measurement of water clarity at a single point in the water column. The optical turbidity sensor is typically calibrated to output measurements in turbidity units (formazin nephelometric/turbidity units or nephelometric turbidity units), which can be directly related to SSC.

- **Chl-a.** The Chl-a sensor measures the fluorescence of Chl-a pigment, which can be directly related to the concentration of Chl-a in the water column. The measurement of Chl-a thus provides a basis for understanding the contribution of organic matter in the water column. The collected Chl-a data will support the development of the relationship between suspended sediment concentrations, contaminant concentrations, and in situ instrument measurements.

- **FDOM.** The FDOM sensor measures the fluorescence of dissolved organic matter or humic and fulvic substances that fluoresce. These compounds can be indicative of a salt water and a freshwater organic matter source and when measured across the water column over time can indicate the amount of mixing occurring over tidal cycles. FDOM can also be used to derive DOC concentration. The collected FDOM data will support the development of the relationship between
suspended sediment concentrations, contaminant concentrations, and in situ instrument measurements.

Figure 3-2 summarizes the sample and instrumentation data collection for the program according to sample collection task, sample handling, and sample analysis.

All measurement probes and/or independent water quality sensors will be outfitted with automatic anti-biofouling wipers to periodically clean the sensing windows. The water quality sondes and sensors will be included in the moored instrument arrays and also used during vessel-based transect surveys to collect cross channel vertical profiles.

- LISST. The LISST-100X is an in situ submersible laser-diffraction based particle size analyzer designed to measure particle size distribution in surface water bodies. The LISST-100X will only be deployed during the transect surveys and will be cast from the vessel to collect full water column particle size and distribution data.

### 3.1 FIELD ACTIVITIES

#### 3.1.1 Reconnaissance Survey

A reconnaissance survey will be completed to assess the locations for mooring the instrument arrays to assess local conditions including but not limited to accessibility and security, presence of interfering structures and appropriate water depth. After assessment of the potential mooring locations is complete, a summary of the selected locations will be finalized with location coordinates, general description and photographs, and a summary figure. All agency notifications (USGS, USACE, EPA, New Jersey Department of Environmental Protection, and Sheriff) will be made when the final mooring locations are selected.

Elements to be determined during the reconnaissance survey to plan system array installation include, but are not limited to:

- Commercial and recreational boat activity
- Water depth fluctuations, ensure there is sufficient water depth to deploy the two sets of arrays
- Local turbidity sources such as outfalls, boat launch sites
- Obstructions, distance from structures (two to three times water depth distance)
- Presence of U.S. Coast Guard aids to navigation
- Accessibility and vulnerability of mooring array to public
- Sampling vessel accessibility
- Associated PDI activity objectives

Following the reconnaissance survey a final table summarizing the mooring locations with figures for each location and transects will be prepared noting where locations have been moved from those proposed in this WP with a summary of the conditions requiring the adjustment to the location. The location summary will include cross sectional profiles for the transect showing the instrument array deployment depths and transect monitoring points as shown for the initial transect locations (Attachment B).
3.1.2 Moored Instrument Arrays and Water Column Sampling

Near-continuous water column data will be collected at the five locations across OU 2 at approximately RM 0, RM 2.1, RM 4.2, RM 6.7, and RM 8.2. The monitoring stations are expected to be placed within 0.2 mile of these locations after review of the 2017 bathymetry and completion of a site reconnaissance. At each location, an array of instruments will be deployed adjacent to or in the main channel to collect in situ measurements of the water column conditions for one year to collect data during the entirety of a representative RA work window. Each moored monitoring station will include a bottom-mounted ADCP and two CTD multi-parameter instruments on a mooring, one at 3 feet above the river bed and one at 3 feet below the water surface adjacent to the main channel. The CTD/multi-parameter instruments will include conductivity, temperature, depth, optical turbidity, Chl-a, and FDOM sensors. In addition to data collected at the five locations within OU 2, periodic water column data will be collected at one upstream and one downstream location, at approximately RM 8.6 and RM -0.3, using two CTD multi-parameter instruments with conductivity, temperature, depth, optical turbidity, Chl-a, and FDOM sensors, one at 3 feet above the river bed and one at 3 feet below the water surface adjacent to or in the main channel.

The ADCP will be deployed in a bottom-mounted, upward-facing configuration to measure the depth-profile of current velocity and acoustic backscatter. The final configuration of the ADCP will be determined after the site reconnaissance survey and may vary by location. All moored instrumentation will be calibrated according to manufacturer specifications prior to initial deployment. Example instrument array configurations are presented in Attachment C; field standard operating procedures (SOPs) are provided in Appendix L of the PDI WP.

After initial deployment of the discrete depth instruments, the arrays will be frequently checked, every two to three weeks, to ensure correct instrument performance and moored station safety, and to ensure high-quality data collection. Once the instruments are considered successfully deployed and collecting optimal data, the moored instrument arrays will be maintained monthly to ensure proper operation and high quality data collection to meet the Project objectives. Monthly instrumentation maintenance includes sensor cleaning, data download, battery change, and recalibration activities. During the monthly instrument maintenance, whole water samples for SSC and COC analyses, and samples for filtered dissolved-phase COC analyses, will be collected at each water quality instrumentation array location after instrument maintenance and redeployment. The whole water samples will be collected by attaching the vessel-mounted pump to the dedicated tubing installed at each moored instrument array; the dissolved-phase water samples will be collected concurrently with the whole water samples by pumping through the same dedicated tubing into a large-volume sample container to be filtered by the testing laboratory. Water samples for analysis of SSC and COC concentrations will be collected at the moored array locations for the purpose of relating the in situ measurements with SSC and COC concentrations.

In addition to the monthly sample collection, discrete water samples will be collected hourly for 12-hour periods over a tidal cycle during a minimum of two of the monthly maintenance visits, one to occur during maximum tide condition variations (spring tide) and one during a neap tide. These data will be used to calibrate the in situ instrument array datasets.

3.1.3 Vessel Transect Surveys and Water Column Sampling

In situ measurements and discrete water column samples will be collected during cross-river transects at the five moored locations across OU 2 at approximately RM 0, RM 2.1, RM 4.2, RM 6.7, and RM 8.2. Final monitoring locations will be based on field reconnaissance observations and where vessels can safely deploy equipment and traverse an uninterrupted sample collection transect. Vessel transect surveys and associated water column surveys will be conducted during three distinct flow conditions between May and March to collect
data during a representative in-water work window. The vessel transect surveys and water column sampling will generate data that will help better interpret the baseline water column conditions of the complete river cross section in addition to the fixed location near continuous in situ moored instrument datasets. Fulfillment of this objective will provide the RD team the necessary data to establish the most effective approach for RA construction monitoring.

Based on the historical flow data of the LPR, the three events would be conducted in July to August to measure the sustained summer low flow; December to January to measure the rising winter discharge, and; March to April to capture the decreasing discharge conditions of the river. Multiple transects will be conducted over the course of the full tidal cycle, ideally covering spring and neap tide conditions, during each sampling event.

Vessel-based transecting surveys will employ a downward-facing ADCP and integrated global positioning system to collect cross-channel, depth-resolved current velocity data across the full river width. Additionally, vessel-based vertical profiles of water quality and particle size distribution will be performed using a multi-parameter sonde and a LISST (as described above in Section 3.0). These instruments will be lowered and raised through the water column at locations positioned ½ way between the moored monitoring station and the shoreline along the cross-channel transect, along with the moored instrumentation array.

Discrete water samples will be collected at the locations of the moored instrumentation array for laboratory-based analysis of SSC and COCs during transect survey activities with the goal of obtaining samples that cover the widest range of flow and tidal conditions. These discrete samples will be analyzed to establish the actual composition of the whole water conditions at the time of transect analyses and to assist with suspended particulate COC concentration determinations.

### 3.2 WATER DISCHARGE DATA

Discharge measurements from the USGS station at Dundee Dam will be compiled to include in the evaluation of the in situ monitoring and water column sampling data. In addition, discharge measurement data will be collected at the monitoring locations closest to RM 0 and RM 8.3 for the duration of the water column monitoring program. The index-velocity method will be used to develop a relationship between the velocity observed at the moored ADCP location and the total discharge of the channel measured during the transect surveys at the mooring station location.

### 3.3 SURFACE WATER ELEVATION DATA

Surface water gaging data from the USGS stations at Dundee Dam and PSVC will be compiled to include in the evaluation of in situ monitoring and water column sampling data. In addition, surface water elevations will be determined at the monitoring locations near RM 0 and RM 8.3 from the ADCP and CTD probe data for the duration of the water column monitoring program.

### 3.4 ANALYTICAL ACTIVITIES

The river system is expected to be variable from the tidal influences and river discharge throughout OU 2. The spacing of the data collection monitoring locations is designed to identify the variabilities to allow for the development of accurate water quality performance standards to be included in the RA water quality monitoring program. The data collected will be used to develop a water quality monitoring program that will ensure efficient dredging and capping operations are achieved while complying with water quality standards with near real time implementation of corrective actions as needed.

All collected water sample data will be used to develop correlations between the continuous instrument measurements and the discrete sample data for SSC and COC concentrations. A minimum of two high
frequency sampling events are planned to collect data for model development and instrument calibration. Water sampling on a monthly basis will provide data from a range of river conditions to verify the models for SSC and COC concentrations. Deviations in the water sample analysis data from the model and instrument data will initiate potential additional evaluations and water sample collection to identify conditions that impact correlations in the data. Water column samples will be collected during the following activities:

- **Instrument calibration**: collection of moored array discrete depth whole water samples over at least two full tidal cycles at each OU 2 location for in situ instrument calibration (Table 3-2).
- **Monthly maintenance visits**: monthly collection of moored array discrete depth whole water and dissolved phase samples from the OU 2 locations. Dissolved sample filtration will be conducted by the analytical laboratory, the filter captured particulates will be analyzed from a subset of the filters (20%) for SSC COC comparative analyses. Monthly collection of discrete depth whole water samples from upstream and downstream locations (Table 3-3).
- **Transect surveys**: collection of moored array discrete depth whole water samples during three seasonal events at each OU 2 location (Table 3-4).

An outline of the sampling schedule is presented below;

- Month 1 – Calibration collection of whole water samples (Table 3-2)
- Month 2 – Monthly maintenance visit (Table 3-3)
- Month 3 – Calibration collection of whole water samples (Table 3-2)
- Month 4 – Monthly maintenance visit (Table 3-3)
- Month 5 – Monthly maintenance visit (Table 3-3) and transect survey (Table 3-4)
- Month 6 – Monthly maintenance visit (Table 3-3)
- Month 7 – Monthly maintenance visit (Table 3-3)
- Month 8 – Monthly maintenance visit (Table 3-3) and transect survey (Table 3-4)
- Month 9 – Monthly maintenance visit (Table 3-3)
- Month 10 – Monthly maintenance visit (Table 3-3)
- Month 11 – Monthly maintenance visit (Table 3-3) and transect survey (Table 3-4)
- Month 12 – Monthly maintenance visit (Table 3-3)

During monthly maintenance visits, water samples will be collected prior to and after the instrument retrieval and maintenance. Water samples will be collected after the completion of each OU 2 location transect cast during the seasonal transect surveys. Calibration water samples will be collected across at least two full tidal cycles to calibrate the in situ moored instrument arrays. Table 3-1 lists the period of maximum spring tide mean tidal variation for each month; the calibration sampling events will be, at a minimum, collected during the first two months’ maximum tidal variance periods at the onset of the water column sampling. Full tide prediction charts for the Point-No-Point river station 8530743 at RM 2 are presented in Attachment D. If further calibration events are required, the calibration samples will also be collected during subsequent full tidal cycles or during storm conditions that may cause extreme water level and flow condition variations.
Table 3-1. Water Column Calibration Sampling Schedule

<table>
<thead>
<tr>
<th>2018 Month</th>
<th>Start Date</th>
<th>End Date</th>
<th>MLLW (ft) 2/</th>
<th>MHHW (ft) 2/</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>January 29</td>
<td>February 4</td>
<td>-1</td>
<td>5.8</td>
</tr>
<tr>
<td>February</td>
<td>February 27</td>
<td>March 6</td>
<td>-0.8</td>
<td>6</td>
</tr>
<tr>
<td>March</td>
<td>March 28</td>
<td>April 3</td>
<td>-0.55</td>
<td>6.1</td>
</tr>
<tr>
<td>April</td>
<td>April 24</td>
<td>May 1</td>
<td>-0.25</td>
<td>5.8</td>
</tr>
<tr>
<td>May</td>
<td>May 13</td>
<td>May 20</td>
<td>-0.24</td>
<td>6</td>
</tr>
<tr>
<td>June</td>
<td>June 11</td>
<td>June 18</td>
<td>-0.35</td>
<td>6.1</td>
</tr>
<tr>
<td>July</td>
<td>July 10</td>
<td>July 17</td>
<td>-0.46</td>
<td>6.3</td>
</tr>
<tr>
<td>August</td>
<td>August 8</td>
<td>August 15</td>
<td>-0.45</td>
<td>6.4</td>
</tr>
<tr>
<td>September</td>
<td>September 6</td>
<td>September 13</td>
<td>-0.44</td>
<td>6.6</td>
</tr>
<tr>
<td>October</td>
<td>October 5</td>
<td>October 12</td>
<td>-0.36</td>
<td>6.4</td>
</tr>
<tr>
<td>November</td>
<td>November 3</td>
<td>November 10</td>
<td>-0.37</td>
<td>6</td>
</tr>
<tr>
<td>December</td>
<td>December 2</td>
<td>December 9</td>
<td>-0.38</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Notes:
1/ Each monthly maximum tidal variation extends over at least seven days to enable sampling at each of the five OU 2 transect sampling points and the upstream/downstream locations.
2/ NOAA Tidal predictions for 2018: https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=8530743
MHHW = mean higher high water; MLLW = mean lower low water

Samples collected during the monitoring program for SSC and COC will be analyzed following the analytical methods and procedures outlined in the UFP-QAPP (Tetra Tech, 2017c).

Standardized analytic laboratory methods will be used for all analyses for the following COCs: dioxins/furans (EPA 1613), PCB congeners (EPA 1668), DDx and dieldrin (EPA 1699), mercury (EPA 1631), PAHs (EPA 8270SIM), copper and lead (EPA 6020), suspended sediment (SM 2540), DOC (EPA 9060), and POC (Lloyd Kahn). For the TSS analysis, the laboratory will use the entire sample container. Laboratory analytical methodologies are referenced in Worksheet #23 of the UFP-QAPP (Tetra Tech, 2017c). Measurement performance criteria for each of these analyses are detailed in Worksheet #12 of the UFP-QAPP.

The laboratory will use one sample for the SSC, DOC, and POC analyses. The entire sample container will be filtered through a 0.7 micrometer glass fiber filter, and the elutriate collected for the analysis of DOC. The SSC and POC will be analyzed using the collected suspended sediment. For 20 percent of the samples, the filter will be extracted for the analysis of the organic COCs (PCDD/Fs, PCB congeners, DDx and dieldrin, and PAHs) to evaluate particulate concentrations with the dissolved concentrations and whole water concentrations. In the first two sampling rounds (months 2 and 4), where dissolved and particulate samples will be collected, 60 percent of the samples will have the collected particulate analyzed. This initial set of sample analyses will allow for the evaluation of the relationship for the whole water sample concentrations to the combination of dissolved and particulate concentrations. From this initial evaluation, it will be determined if there is a need to increase the size of the whole water, dissolved, and particulate sample data set. For rounds 3 through 10 (months 5 through 12), 20 percent of the samples will have the particulates analyzed along with the whole water and dissolved samples. All sample filtering will be performed at the laboratory following the same procedure whether the samples are for analysis of the dissolved phase or for the analysis of the dissolved and particulate phases.

For samples that EPA plans to collect as split sample, adequate water will be collected to complete the analysis of both the plan samples and the split samples. The project team will coordinate with the EPA on the collection of the split samples to ensure that the field teams are prepared for the collection of the additional sample volumes.
### Table 3-2. Water Column Sampling Summary for Laboratory Analysis – Calibration Sampling – All Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sampling Location</th>
<th>Sampling Period 1&lt;sup&gt;st&lt;/sup&gt; Calibration Whole Water Samples Only</th>
<th>Sampling Period 2&lt;sup&gt;nd&lt;/sup&gt; Calibration Whole Water Samples Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Locations</td>
<td>Depths</td>
<td>Samples/Depth /Location</td>
</tr>
<tr>
<td>SSC, PCB Congeners, Dioxins/Furans, DDx, Dieldrin, Mercury, PAHs, Copper, Lead, DOC, POC</td>
<td>Moored Instrument Array</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>SSC, PCB Congeners, Dioxins/Furans, DDx, Dieldrin, Mercury, PAHs, Copper, Lead, DOC, POC</td>
<td>RM -0.3/ RM 8.6</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Notes:
- DDx – DDT, DDE and DDD (6 isomers total)
- DOC – dissolved organic carbon
- PAHs – polynuclear aromatic hydrocarbons
- PCB – polychlorinated biphenyl
- POC – particulate organic carbon
- SSC – suspended sediment concentration
Table 3-3. Water Column Sampling Summary for Laboratory Analysis – Monthly Verification Sampling

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sampling Location</th>
<th>Rounds</th>
<th>Locations</th>
<th>Depths</th>
<th>Sampling Location (Total + Dissolved)</th>
<th>Sampling Interval</th>
<th>Total # of Samples</th>
<th>1st Round</th>
<th>2nd Round</th>
<th>Rounds 3–10</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSC, Mercury, Copper, Lead, DOC, POC</td>
<td>Moored Instrument Array</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>1 (2)</td>
<td>One/Round</td>
<td>100 (whole); 100 (diss)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PCB Congeners, Dioxins/Furans, DDX, Dieldrin, PAHs</td>
<td>Moored Instrument Array</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>1 (2)</td>
<td>One/Round</td>
<td>100 (whole); 100 (diss)</td>
<td>6</td>
<td>6</td>
<td>2/Round</td>
</tr>
<tr>
<td>SSC, PCB Congeners, Dioxins/Furans, DDX, Dieldrin, Mercury, PAHs, Copper, Lead, DOC, POC</td>
<td>RM -0.3/RM 8.6</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>1 (2)</td>
<td>One/Round</td>
<td>40 (whole); 40 (diss)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:
DDx – DDT, DDE and DDD (6 isomers total)
DOC – dissolved organic carbon
PAHs – polynuclear aromatic hydrocarbons
PCB – polychlorinated biphenyl
POC – particulate organic carbon
SSC – suspended sediment concentration
### Table 3-4. Water Column Sampling Summary for Laboratory Analysis – Transect Sampling – All Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sampling Location</th>
<th>Rounds</th>
<th>Transects</th>
<th>Locations</th>
<th>Depths</th>
<th>Samples/Depth/Location (Total + Dissolved)</th>
<th>Total # of Samples</th>
<th>Sampling Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSC, PCB Congeners, Dioxins/Furans, DDX, Dieldrin, Mercury, PAHs, Copper, Lead, DOC, POC</td>
<td>Transects (Non-Array)</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1 (2)</td>
<td>60 (whole); 60 (diss)</td>
<td>One/Round</td>
</tr>
</tbody>
</table>

**Notes:**
- DDX – DDT, DDE and DDD (6 isomers total)
- DOC – dissolved organic carbon
- PAHs – polynuclear aromatic hydrocarbons
- PCB – polychlorinated biphenyl
- POC – particulate organic carbon
- SSC – suspended sediment concentration
4 DATA EVALUATION AND ANALYSES

Data evaluation and analyses will include summary of water column sampling, current velocities, water discharge flows and water level data and discussion of data regarding how to inform the RD. General evaluation and analyses will be focused on the baseline water column data analysis for the engineering performance standards and future monitoring during the dredging and capping operations.

The baseline data for SSC and COCs will be used in the development of the resuspension performance standards for dredging and capping across the range of typical conditions within OU 2. Correlations will be established between the in situ monitoring data and the laboratory results of SSC and COCs of the discrete water samples. The developed correlations will provide the basis for the use of real-time monitoring to estimate near-continuous, high temporal resolution concentrations of SSC and COCs in the water column.

Correlations will be evaluated between water SSC and COC concentrations as well as between the in-water instrumentation measurements, water SSC, and COC concentrations. Simple and multiple regression evaluations will be used to determine the best sensor measurements correlations with the water SSC and COC concentrations. The higher frequency calibration sampling data will be used to evaluate the longer term periodic (monthly) sampling results to confirm the correlations from the calibration sampling data. Correlations will also be compared to those from historical sampling at the site. Evaluations will be ongoing through the duration of the monitoring program to allow for the identification of river conditions that show variation from the calibration correlations and historic observations.

Correlations between the developed models based on the optical measurement data and discrete sample data will be evaluated. Correlations with coefficients of 0.9 or greater would be considered as very strong with high confidence that the optical measurements can be used to represent the concentration of that COC in the water column. Correlations 0.7 or greater and less than 0.9 would be considered as strong, while correlations 0.5 or greater and less than 0.7 would be considered as moderate, and those less than 0.5 as weaker. For the evaluations of COCs with correlations of 0.7 or greater, the optical measurements will be considered usable to represent the concentrations and allow for the large in water data set to be used to establish baseline water column conditions over the range of conditions encountered. These correlations will also provide the basis for the use of optical instrumentation in the water quality monitoring program and allow for the setting of implementable water quality criteria during dredging and capping activities. Correlations of 0.5 or greater and less than 0.7 would have data that will be considered as representative, though additional evaluations, such as for outliers will be completed to determine if there are specific site conditions contributing to variability in the data with correlations less than 0.7. Correlations less than 0.5 will be evaluated, and additional data may be collected in the later rounds of the sampling program specifically for those parameters and site conditions that appear to introduce uncertainty in the data.

All data and evaluations will be included in a summary report prepared at the completion of the monitoring and included in the PDI Evaluation Report.

Future monitoring for the water quality monitoring during the remedial action activities will be developed under the remedial action work plan. The remedial action water quality monitoring will include a calibration phase to collect data to confirm the in-water instrument measurements to contaminant concentrations correlations to the baseline data collected under this work plan.
5 QUALITY CONTROL

This section describes the basic QC procedures and activities to be implemented during the water column monitoring activities. The purpose of establishing QC procedures is to ensure that the data collected will be of the type, quantity, and quality required to meet the Project objectives. In this case, data are being collected to establish a baseline data set for water quality to use in establishing performance standards and to evaluate water column monitoring data collected during the dredging and capping activities. To ensure efficiency and coordination with Project objectives, reliability of data collected, safety, and uniform recording and reporting formats, investigation activities will be conducted using EPA-approved, Project-specific plans, including the Project Management Plan (Tetra Tech 2017a), RDWP (Tetra Tech, 2017b), UFP-QAPP (Tetra Tech, 2017c) and Health and Safety Plan (Tetra Tech, 2017d).

QC is integral to the reliability of the results of this investigation. Measures that will be taken to ensure reliable data will include the following:

**Personnel Qualifications** – All personnel will be trained and experienced in performing the tasks associated with this effort. All field personnel will be experienced in installing, maintaining and calibrating monitoring instrumentation, and water sample collection.

**Verification of Methods** – All field efforts will be performed in accordance with SOPs generated specifically for activities associated with this water column monitoring program. The field SOPs are included in Appendix L of the PDI WP.

Samples will be analyzed using the methods noted in Section 3.4 and according to the SOPs listed in Worksheets #18 and #23 of the UFP-QAPP.

**Data Collection and Management** – Raw field data will be clearly and concisely recorded manually on data sheets or within logbook(s), or electronically on mobile computer tablets. Original field data sheets will be scanned and hard and electronic copies of all data will be retained in the Project files. The appropriate Task Lead will be responsible for ensuring that all data forms and related materials pertaining to the Project are properly logged, recorded and entered into the Project files following the requirements of Worksheet #29, Project Documents and Records, in the UFP-QAPP (Tetra Tech, 2017c).

Water column samples will be tested using corresponding methods discussed in Section 3.4 and outlined in Worksheet #23 of the UFP-QAPP (Tetra Tech, 2017c). Field QC samples (e.g., field duplicates) will be collected and tested at the frequencies outlined in Worksheet #20. Specifications for sample containers, preservation and holding times are provided in Worksheets #19 and 30 of the UFP-QAPP. Laboratory sample handling and custody are included in Worksheets #26 and 27 of the UFP-QAPP (Tetra Tech, 2107c).

As outlined in Worksheets #26 and #27 of the UFP-QAPP (Tetra Tech, 2017c), to improve data access/usability and data ownership/transferability, GSH has contracted with GHD to serve as the Data Management and Laboratory Program Contractor for the Project. GHD will perform the following:

- Oversee contracted laboratory services.
- Resolve any laboratory quality issues, with input from GSH and Tetra Tech.
- Perform data verification/validation of laboratory data packages (Worksheet #35).
- Perform data quality review/reporting.
- Consolidate Project data into centralized database, including field and laboratory data.
• Provide options for the Project team to access data, including tables, figures, graphs, electronic deliverables, and e:DAT™ (an integrated GIS data access tool/query engine).

Field Instrument/Equipment Calibration, Maintenance, Testing, and Inspection – All field equipment will be used in accordance with manufacturer’s specifications and the requirements of Worksheet #22 of the UFP-QAPP (Tetra Tech, 2017c). All connections and switches will be in good condition to ensure acceptable performance and will be inspected each day by the Field Lead or designee. Malfunctioning and worn parts will be replaced immediately.

Field Supplies/Consumables – Supplies and consumables necessary for the investigation will be obtained through appropriate commercial markets and will meet supply-specific requirements outlined in this WP and corresponding SOPs. All supplies and consumables will be inspected for usability and suitability by field personnel prior to use. Any supplies/consumables that do not meet requirements will be discarded or returned to the supplier. Any certifications/documentation provided by the suppliers will be retained in the project files. Supplies and consumables will be stored so as to be protected from adverse conditions (e.g., weather, heat, etc.) to avoid possible contamination, breakage, etc.

Data Review, Verification, and Validation – All data for the Project will be compiled and summarized with an independent verification at each step in the process to prevent transcription/typographical errors. Information collected in the field through visual observation, manual measurement, and/or field instrumentation will be recorded in field notebooks, on data sheets, and/or via mobile computer tablets, and then forwarded to GHD for entry the Project database. During the investigation, raw field data will be sent to the office daily. The field data will be evaluated to check the consistency and reporting methods. Any inconsistency or incorrect methodology for field testing, sampling, or storage and transportation of samples identified in this evaluation will be corrected immediately.

Inputs to data review, verification and validation are outlined in Worksheet #34 of the UFP-QAPP (Tetra Tech, 2017c). Data verification procedures are provided in Worksheet #35, and Worksheet #36 contains the data validation procedures. The overall quality of data obtained during the water column monitoring will be evaluated and checked for accuracy, consistency, and interpretation of the data following Worksheet #37 of the UFP-QAPP (Tetra Tech, 2017c).
6 DELIVERABLES

A description of field activities including monitoring locations, monitoring data, sampling logs, field sampling data, handling, and laboratory test results will be reported as part of the PDI Evaluation Report. The report will include a description of recent and historical investigation activities, data summary tables and figures depicting water column sampling locations for this investigation, and sample logs, field notes, and observations. Sampling techniques and standard operating procedures implemented at each sampling location will be described in the report. In addition, the report text will include a narrative summarizing the work completed, findings, and conclusions of the investigation. The results will be summarized and evaluated, and how the result would inform the design will be discussed. Data evaluation and analyses of water column discrete sample results, in situ water quality measurements, current velocities, water discharge flows, and water level data will provide the baseline water column conditions considered when developing engineering performance standards and future monitoring during the dredging and capping operations.
## 7 SCHEDULE

The schedule for water column monitoring and sampling is outlined below:

<table>
<thead>
<tr>
<th>Task</th>
<th>Anticipated Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Reconnaissance</td>
<td>Spring 2018</td>
</tr>
<tr>
<td>Initial Instrument Array Deployment</td>
<td>April 2018</td>
</tr>
<tr>
<td>In-Water Instrument Measurements</td>
<td>April 2018 – March 2019</td>
</tr>
<tr>
<td>Sample Collection/Instrument Array Servicing</td>
<td>Monthly May 2018 – March 2019</td>
</tr>
<tr>
<td>Calibration Sample Collection (Full Tide Cycle)*</td>
<td>April 2018</td>
</tr>
<tr>
<td>Calibration Sample Collection (Full Tide Cycle)*</td>
<td>June 2018</td>
</tr>
<tr>
<td>First Transect Survey</td>
<td>August 2018</td>
</tr>
<tr>
<td>Second Transect Survey</td>
<td>November 2018</td>
</tr>
<tr>
<td>Third Transect Survey</td>
<td>February 2019</td>
</tr>
</tbody>
</table>

*Calibration sampling in Months 1 and 3 take the place of the monthly sampling and maintenance for those rounds of monitoring.
8 REFERENCES


FIGURES
Average Monthly Discharge, Dundee Dam (Oct 2007 - March 2017)

Average Monthly Discharge USGS
Station 01389890 Passaic River
Dundee Dam, Clifton, NJ
Lower 8.3 Miles of the Lower Passaic River (OU 2)

Figure 2-1
PVSC Water Level Gage Heights
May 2016 - March 2017

Figure 2-2

Water Gage Heights, USGS Station
01392650 Passaic River PVSC, Newark, NJ
Lower 8.3 Miles of the Lower Passaic River (OU 2)
Dundee Dam Water Level Gage Heights
May 2016 - March 2017

Figure 2-3

Water Gage Heights, USGS Station
01389890 Passaic River Dundee Dam, Clifton, NJ
Lower 8.3 Miles of the Lower Passaic River (OU 2)
Figure 2-3
Sample and In-Water Instrument Data Collection Summary

Lower 8.3 Miles of the Lower Passaic River (OU 2)

**Water Column Sampling Interval (3 ft below water surface or 3 ft above mudline)**

**Periodic (Monthly):** Collect
One container (~2.5 gallons) for laboratory filtering.
One container (~1 gallon) for whole water sample analysis organics.
One 500 ml container for metals analysis.
One 1 L container for SSC, POC and DOC analysis (whole container used).

**Calibration Sampling or Periodic (Monthly Sampling):**

**Calibration:** Collect every hour for 12 hour tide cycle coverage
One container (~1 gallon) for whole water sample analysis organics
One 500 ml container for metals analysis
One 1 L containers for SSC, POC and DOC analysis (whole container used)

**In Water Instrumentation Sensors (10 - 15 minute measurement intervals):**

CTD
Turbidity
DO
Temperature
Salinity
pH
Chlorophyll-a
Phycocyanin Fluorescence
FDOM
ADCP

**Analysis:**

PCDD/F
PCB congeners
DDT/Dieldrin
PAHs
Cu, Hg, Pb
SSC (1 Liter filtered sample)
DOC (1 Liter filtered sample)
POC (1 Liter filtered sample)

**Filter (0.45 um):**
One container (~2.5 gallons) for laboratory filtering.
One 1 L container for SSC, POC and DOC analysis (whole container used)

**Whole Water**

**Dissolved Phase**

**Particulate**

**Data Evaluations:**
Correlations SSC, COCs, In-Water Measurements

Sample volumes and containers estimated, to be finalized prior to collection.
ATTACHMENTS
Attachment A—Historical Data Summary
RM 6.7 October 19 - December 16, 2009
Discharge at Dundee Dam, RM 17

RM 6.7 June 16 - July 22, 2010
Discharge at Dundee Dam, RM 17
Discharge at Dundee Dam, RM 17

**RM 4.2 October 19 - December 16, 2009**

- Discharge (cf/sec)
- Water Depth (ft)
- Salinity (PSU)
- Turbidity (NTU)

**RM 4.2 June 16 - July 22, 2010**

- Discharge (cf/sec)
- Water Depth (ft)
- Salinity (PSU)
- Turbidity (NTU)
Total Mercury to Total Suspended Solids (Lower 8.3 Miles of LPR)
August 2011 - December 2012

- Suspended Solids Concentration (1.2μm)
- Suspended Solids Concentration (0.7μm)

$R^2 = 0.7404$ 
$R^2 = 0.9259$
Total PCB Congeners to Total Suspended Solids (Lower 8.3 Miles of LPR)
August 2011 - December 2012

R² = 0.7021
R² = 0.6812
Total TCDD to Total Suspended Solids (Lower 8.3 Miles of LPR)
August 2011 - December 2012

Suspension Solids Concentration (1.2μm)
Suspension Solids Concentration (0.7μm)
Total DDx to Total Suspended Solids (Lower 8.3 Miles of LPR)
August 2011 - December 2012

\[ R^2 = 0.8421 \]

\[ R^2 = 0.5235 \]

Suspended Solids Concentration (1.2um)
Suspended Solids Concentration (0.7um)
Attachment B—Monitoring Point Transects
Water Column Monitoring
Cross-Section - River Mile 0.0
Lower 8.3 Miles of the Lower Passaic River (OU 2)

Figure B-1
Notes: Cross-section is perpendicular to the Navigation Channel Center Line at the identified river mile and is looking downstream. Elevations shown at NAVD88 US Foot. Elevations are referenced to NAVD88 datum.

Water Column Monitoring
Cross-Section - River Mile 2.1
Lower 8.3 Miles of the Lower Passaic River (OU 2)

Figure B-2
Figure B-3

Water Column Monitoring
Cross-Section - River Mile 4.2
Lower 8.3 Miles of the Lower Passaic River (OU 2)
Water Column Monitoring
Cross-Section - River Mile 6.7
Lower 8.3 Miles of the Lower Passaic River (OU 2)

Figure B-4
Figure B-5

Water Column Monitoring
Cross-Section - River Mile 8.2
Lower 8.3 Miles of the Lower Passaic River (OU 2)

Notes: Cross-section is perpendicular to the Navigation Channel Center Line at the identified river mile and is looking downstream. Elevations shown at NAVD88 US Foot. Elevations are referenced to NAVD88 datum.
Water Sampling Locations
(Approximate depth)

Notes: Cross-section is perpendicular to the Navigation Channel Center Line at the identified river mile and is looking downstream. Elevations shown at NAVD88. Elevations are referenced to NAVD88 datum.

Water Column Monitoring
Cross-Section - River Mile 8.6
Lower 8.3 Miles of the Lower Passaic River (OU 2)

Figure B-6
Attachment C—Example Instrument Array Configurations
Moored Instrument Arrays and Water Sampling Points

*CTD multi sonde arrays include sensors for; depth (pressure); temperature; conductivity; salinity; DO; optical turbidity; Chlorophyll-a and phycoerythrin fluorescence, and; FDOM.
**LISST, CTD, ADCP** – Transect based water quality data collection. Vessel deployed CTD & LISST instrument casts at each transect point, collected at 3ft above mudline and 3ft below water surface across a full tidal cycle, and vessel mounted ADCP transects conducted at three distinct seasonal flow conditions during a representative work window.

**CTD, ADCP, HV & Tidal Samples** – Long term water quality data collection from moored multi sonde arrays at 3ft above mudline and 3ft below water surface, and bottom mounted ADCP deployed for entire representative work window. Each moored array location includes dedicated tubing for discrete tidal cycle water samples as well as the Site-wide Monitoring Plan high volume water and SSC sample collection.

*CTD multi sonde arrays include sensors for; depth (pressure); temperature; conductivity; salinity; DO; optical turbidity; Chlorophyll-a and phycoerythrin fluorescence, and; FDOM.*
Attachment D—2018 Monthly NOAA Tide Predictions for Station 5830743, Passaic River, NJ
NOAA/NOS/CO-OPS

Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/01/01 00:00 LST/LDT to 2018/01/31 23:59 LST/LDT

Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/02/01 00:00 LST/LDT to 2018/02/28 23:59 LST/LDT
Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/03/01 00:00 LST/LDT to 2018/03/31 23:59 LST/LDT
Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/04/01 00:00 LST/LDT to 2018/04/30 23:59 LST/LDT
Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)

NOAA/NOS/Center for Operational Oceanographic Products and Services
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/06/01 00:00 LST/LDT to 2018/06/30 23:59 LST/LDT
Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/07/01 00:00 LST/LDT to 2018/07/31 23:59 LST/LDT

Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)

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<th>Height (feet)</th>
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<tr>
<td>00:00</td>
<td>7/30</td>
<td>8.0</td>
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</table>
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ

From 2018/08/01 00:00 LST/LDT to 2018/08/31 23:59 LST/LDT

Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/09/01 00:00 LST/LDT to 2018/09/30 23:59 LST/LDT
Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/10/01 00:00 LST/LDT to 2018/10/31 23:59 LST/LDT
Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/11/01 00:00 LST/LDT to 2018/11/30 23:59 LST/LDT
Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)
NOAA/NOS/CO-OPS
Tide Predictions at 8530743, POINT NO POINT, PASSAIC RIVER NJ
From 2018/12/01 00:00 LST/LDT to 2018/12/31 23:59 LST/LDT
Subordinate Station | Ref. Station (The Battery 8518750) | Time offsets (high: 0 min. low: 22 min.) | Height offsets (high: *1.15 ft. low: *1.04 ft.)