

Attachment F  
Survey QAPP Addendum

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FINAL

# ***Lower Duwamish Waterway Group***

*City of Seattle / King County / The Boeing Company*

## QUALITY ASSURANCE PROJECT PLAN ADDENDUM:

### PRE-DESIGN SURVEYS OF THE LOWER DUWAMISH WATERWAY MIDDLE REACH

FINAL

**Prepared for:**

**The U.S. Environmental Protection Agency**

Region 10

Seattle, WA

**June 12, 2024**

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**ABBREVIATIONS**

DQO	data quality objective
EPA	U.S. Environmental Protection Agency
LiDAR	light detection and ranging
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MHHW	mean higher high water
MLLW	mean lower low water
NAD	North American Datum
PDI	Pre-Design Investigation
QAPP	Quality Assurance Project Plan
QC	quality control
RD	Remedial Design
RAL	Remedial Action Level
ROD	Record of Decision
RM	river mile
RTK	real-time kinematic
True North	True North Land Surveying, Inc.

# 1 Introduction

This Quality Assurance Project Plan (QAPP) addendum describes the methods and quality control (QC) proposed for use in conducting a topographic survey for selected bank areas of the Lower Duwamish Waterway (LDW) middle reach (river miles [RM] 1.6 to RM 3.0), consistent with the LDW Fifth Amendment of the Administrative Order on Consent (EPA 2021). The results of the proposed topographic survey will augment data collected during the bathymetric surveys conducted in 2021 and 2023. The data from the project-specific surveys will be combined and augmented with publicly available survey data to support the remedial design (RD) in the middle reach of LDW.

This addendum supplements the *Quality Assurance Project Plan: Pre-Design Surveys of the Lower Duwamish Waterway Middle Reach* (herein after referred to as the Survey QAPP) (Anchor QEA and Windward 2021), which focused on bathymetric surveying methods and associated QC. This addendum is a standalone document that addresses topographic surveying (or land surveying) where needed to inform RD. Areas selected for topographic surveying are where remedial action level (RAL) exceedance areas include banks up to the mean higher high water (MHHW). MHHW is equal to +11.3 feet mean lower low water (MLLW).

Prior surveys were unable to provide sufficient coverage for RD. Additional information to be collected includes elevations and limits of structures, woody vegetation, bank armoring, surface debris, visible utilities, and other bank features that may affect remedial construction.

U.S. Environmental Protection Agency (EPA) guidance for QAPPs was followed in the preparation of this addendum (EPA 2002). This addendum is organized into the following sections:

- Section 2 – Project Management and Data Quality Objectives
- Section 3 – Data Generation and Acquisition
- Section 4 – Assessment and Oversight
- Section 5 – Data Validation and Usability
- Section 6 – References

## 2 Project Management and Data Quality Objectives

### 2.1 Project Organization

The topographic survey will be conducted by True North Land Surveying, Inc. (True North) under the direction of Anchor QEA. Anchor QEA will be responsible for overall project coordination, and for performing the administrative tasks needed to ensure timely and successful completion of the project. Anchor QEA will also be responsible for communicating with King County, the Lower Duwamish Waterway Group (LDWG), and EPA on schedule, any significant deviations from the Survey QAPP Addendum, and administrative details. True North will be responsible for conducting the survey, conducting post-processing of the survey data, and reporting deviations from the Survey QAPP to the Anchor QEA project manager, Tom Wang.

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### 2.2 Problem Definition and Background

The bathymetric survey of the middle reach was completed in 2023 (Anchor QEA and Windward 2023a, Appendix C). The bathymetric survey was performed at high tide, to the extent practicable, to obtain the greatest coverage of the width of the river bottom. In locations with RAL exceedance areas that include waterway banks, topographic surveying will provide data that will be used to extend elevation contours up the banks to at least the top of bank, and to define the limits of features that may affect construction. Specifically, the topographic data will be used to:

- Extend the current waterway bed elevation contours in Phase I Pre-Design Investigation (PDI) RAL exceedance areas to approximately 50 feet landward of the MHHW elevation, where needed to inform RD

- Complete the development of an accurate base map, representative of current bathymetric and topographic conditions, which will be needed to develop engineering drawings and quantity calculations

## 2.3 Project Description

Topographic surveying will be completed using traditional land-surveying methods supplemented with photogrammetric methods where access is limited. Topographic surveying will be performed in locations where the RAL exceedance areas include the banks of the waterway. These areas are shown in the PDI QAPP Addendum for Phase II, Figures 5-1a through 5-1h (Anchor QEA and Windward 2023b). Elevation data will be obtained to extend contours from the limits of the bathymetric survey to those required for RD, which at a minimum will require elevation data to the top of the bank. Typically, the elevations required for RD will be higher than the MHHW elevation that defines the shoreline boundary of the LDW middle reach.

To obtain the needed survey coverage, the topographic survey will continue approximately 50 feet landward from the MHHW elevation, assuming access is available. The 50-foot distance may be adjusted during surveying on an area-by-area basis, considering site access and bank geometry and height. The topographic survey will also extend approximately 50 feet upstream and downstream along the bank of the preliminary RAL exceedance area limits. An Anchor QEA engineer will accompany the surveyors to identify bank features of interest for surveying, and to address questions that may arise in the field. Additional bank features to be surveyed (if applicable) to document horizontal positions and extents include the following:

- Limits of structures
- Limits of bank armoring
- Limits of woody vegetation
- Observed utilities
- Presence of underwater cable crossing terminus points
- Limits of observed large debris
- Other features that may affect RD and application of potential remedial actions

To assist the topographic surveyor in defining the limits of its survey coverage, Anchor QEA has obtained publicly available light detection and ranging (LiDAR) data from the 2016 King County survey;<sup>1</sup> that survey provided elevation data above approximately +4 feet MLLW to better define the MHHW elevation line. The LiDAR data will be useful in supplementing the topographic survey information if the topographic survey is unable to obtain full coverage in RAL exceedance area banks.

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<sup>1</sup> [http://pugetsoundlidar.ess.washington.edu/lidardata/restricted/projects/2016king\\_county.html](http://pugetsoundlidar.ess.washington.edu/lidardata/restricted/projects/2016king_county.html)



The topographic survey will be performed as soon as practical after receiving EPA approval of this Survey QAPP Addendum, and after receiving signed site access agreements with property owners. The survey timing will consider various factors, such as daytime low tides and weather conditions. The schedule for completing the survey is presented in Section 2.7.

## 2.4 Data Quality Objective and Criteria

The DQO for the topographic surveying is to complete the base map for RD. The data collection and targeted methods selected for this survey will be implemented using state-of-the-art equipment and technology, and will meet the specific data needs presented in Sections 2.2 and 2.3. The completeness of final data (i.e., areal coverage) will be evaluated in consultation with EPA to determine if there are data gaps requiring further topographic surveying to support RD.

The DQO for the topographic surveying builds upon the three survey DQOs previously established in the 2021 Survey QAPP (Anchor QEA and Windward 2021), which were developed in conformance with the *Guidance for the Data Quality Objectives Process* (EPA 2000). DQOs 1 and 2<sup>2</sup> were specific to the bathymetric survey. DQO 3 applies to both the bathymetric and topographic surveys and is summarized in Table G-1.

**Table G-1**  
**DQO Process for Topographic Survey**

DQO Step	DQO No. 3: Complete the Base Map for RD
1. State the Problem	The current site base map contains only bathymetric survey data. In areas where Phase I PDI RAL exceedances indicate the potential need for remedial action on banks, additional survey data are needed to expand the areal extent of the base map for RD.
2. Identify the Decision	Current topography between the bathymetry survey coverage and top of bank (above MHHW), mapped to a contour interval of 1.0 foot, will be used in RD to define extents of remedial construction activities on applicable bank areas and calculate quantities.
3. Identify the Inputs to the Decision	Horizontal and vertical coordinate data are required to define ground surface contours and the spatial limits of obstructions and other features that may affect remedial construction. The sources of the data are land surveying and visual observation. Since the topographic survey will be combined with the existing three-dimensional model of the bathymetric surface, the survey methods and equipment will be selected to yield data comparable to those developed from the bathymetric survey.

<sup>2</sup> DQO 1: Provide the bathymetric data to generate new sun illumination maps that identify areas with scour from propellers and other vessel interactions with the sediment; this information potentially will be used to modify the recovery category area designations.

DQO 2: Define the current bathymetry of the LDW middle reach with sufficient confidence to inform the selection of sampling locations for PDI data collection to support the RD.

DQO Step	DQO No. 3: Complete the Base Map for RD
4. Define the Boundaries of the Study	The boundaries of the LDW site were defined by the ROD, and the boundaries of the middle reach were defined by the Fifth Amendment to the Administrative Order on Consent. The topographic survey coverage will include the bank areas of Phase I PDI RAL exceedance areas. Within each RAL exceedance area that has a bank, the topographic survey coverage will extend approximately 50 feet landward of the MHHW elevation line and 50 feet upstream and downstream of the RAL exceedance areas limits.
5. Develop a Decision Rule	Established techniques for collecting and processing topographic survey data, including QC and quality assurance, will be used. The techniques are described in Sections 3 through 5.
6. Specify Tolerable Limits on Decision Errors	The probability of decision errors will be minimized through strategies to reduce statistical sampling errors and measurement errors. Sampling errors—which, in the context of a topographic survey, are failures to account for the variability of the topography—are addressed by the data density in the design of the survey. Measurement errors can be detected and corrected using several techniques, such as performing multiple check shots during setup and maintaining calibrations. Survey design is described in Section 3.1, QC techniques are described in Section 3.4, and data validation is described in Section 5.
7. Optimize the Design for Obtaining Data	The topographic survey methods, equipment, and spacing of survey lines were selected to provide data that meet the needs of the RD project. The details of the survey design are described in Section 3.1.
8. Applicable Survey Methods to Meet DQO	The applicable methods will be the topographic survey, including photogrammetric methods, and potential use of publicly available LiDAR data to fill coverage gaps.

Notes:

- DQO: data quality objective
- LDW: Lower Duwamish Waterway
- LiDAR: light detection and ranging
- MHHW: mean higher high water
- PDI: Pre-Design Investigation
- QC: quality control
- RAL: remedial action level
- RD: remedial design
- ROD: Record of Decision

Parameters used to assess data quality include precision, accuracy, representativeness, comparability, and completeness. The details of these data quality parameters are as follows:

- **Precision:** Refers to how closely repeated measurements or observations come to duplicating measured or observed values. True North will constantly perform check shots throughout the topographic survey to confirm the initial baseline is maintained.
- **Accuracy:** Based on the equipment used to perform the topographic survey. The horizontal and vertical accuracies of work performed with the total station and GPS are identified in Table G-2 (Section 5.2). The stated accuracies are all limited to certain variable conditions, such as solid surfaces, to set up the total station or overhead blockages or multipath for GPS.
- **Representativeness:** Horizontally, not more than 10% of the points tested shall be in error by more than 1/30 of an inch. Vertically, not more than 10% of the elevations tested shall be in error by more than one-half the contour interval.

- **Comparability:** The topographic survey is designed to provide results as comparable as possible with those of the bathymetric survey. The two surveys will be performed using the same horizontal and vertical datums, and the topographic survey will be performed with a level of precision at least as fine as that of the bathymetric survey. Finally, the topographic survey will overlap with the bathymetric survey to the extent necessary (if possible) to provide a basis of comparison for fitting the two surveys together in the final design surface. The topographic survey will be performed at low tide to facilitate collecting the low-elevation data.
- **Completeness:** The objective of the topographic survey is to provide topographic data of the selected areas with sufficient coverage to support RD without gaps. The survey has been designed to accomplish this objective, with the following limits:
  - The low elevation of the topographic survey is approximately +2 feet MLLW to overlap with data from the bathymetric survey along the complete shoreline, if possible. The presence of bulkheads or other structures may obstruct access for land surveying. In such areas, the areal limits of bulkheads or other structures will be recorded.
  - The topographic survey will extend 50 feet upstream and 50 feet downstream of the limits of the Phase I PDI RAL exceedance areas wherever possible. In areas where structures or other obstacles prevent surveying to these extents, the areal limits of such obstacles will be recorded.
  - The topographic survey will extend approximately 50 feet landward of MHHW. In areas where structures or other obstacles prevent surveying to this extent, the areal limits of such obstacles will be recorded.

## 2.5 Special Training and Certification

True North will conduct work under the supervision of a Washington State-licensed Professional Land Surveyor.

## 2.6 Documentation and Records

Prior to mobilization for the topographic survey, the approved Survey QAPP Addendum will be provided to all field personnel for review. The Anchor QEA project manager or his designee will confirm that all field personnel receive the final Survey QAPP Addendum, including any addenda and modifications. The True North party chief will be responsible for conducting the survey in conformance with the requirements of the approved Survey QAPP Addendum, and the True North project manager will be responsible for overall quality assurance of the topographic survey product.

Topographic data will be presented as a series of maps. Drawings will be compiled in AutoCAD at a mutually agreed-upon scale, to be determined during design. The maps will be projected in North

American Datum (NAD) 83 through the 1991 adjustment (NAD83/91) Washington State Plane North (feet), and will include 1-foot elevation contours in feet MLLW.

The topographic survey data report, which will be submitted as part of the Phase II data evaluation report, will provide the following information:

- Written report of the topographic survey describing survey methodology, equipment (including the sensitivity[ies] of the equipment), and analysis methodology
- Documentation of QC checks and identification of QC issues
- Deviations from this Survey QAPP Addendum
- Contour maps
- Electronic versions of data products, including Portable Document Format (PDF) files for reports, AutoCAD files (DWG format) of contours and imagery, ArcMap shape files of contours, and georeferenced TIFF files of imagery. The electronic versions of data products, including the ArcMap shape files and georeferenced TIFF imagery, will include applicable metadata in order for the data to be useful in GIS platforms.
- ASCII files of 1-foot binned datasets

## 2.7 Survey Schedule

It is anticipated that the topographic survey will be conducted in late spring 2024, and field work is expected to require approximately 40 to 60 days, subject to factors such as tide conditions. Work will be performed during daytime low tide events to obtain access to the greatest extent possible of the shoreline within the work areas.

## 3 Data Generation and Acquisition

### 3.1 Survey Design

Land survey data will be collected by GPS or total station on a 25-foot grid-like pattern, as well as at break lines (tops and toes of slopes) and significant changes in the existing surfaces.

Photogrammetric survey data will be acquired at a nominal resolution of 0.1-foot using a gyroscopically stabilized Vexcel<sup>®</sup> UltraCam Falcon precision digital imaging sensor. To support photogrammetric data collection, six field-surveyed ground control points will be established during land survey activities.

Extents of significant surface bank features (such as structures, bank armoring, vegetation, utilities, and debris) will be determined by taking survey shots at corners of rectilinear features or at changes of curvature for curvilinear features. An Anchor QEA engineer will be on site during the survey to identify significant bank features and concur with the data collection relative to such bank features.

The survey will be conducted on an established coordinate system, referenced by monuments established or recovered during a geodetic control survey of the site. The same horizontal and vertical datums will be used for the 2024 topographic survey as were used in the bathymetric surveys performed in 2021 and 2023. The horizontal datum for this survey will be NAD83 through the 1991 adjustment (NAD83/91), State Plane Coordinate System, Washington North Zone, measured in U.S. Survey Feet. Vertical datum for this survey will be MLLW.

### 3.2 Survey Methods

This section describes the methods and equipment that will be used to obtain topographic survey data.

#### 3.2.1 Control Network

Prior to the 2021 bathymetric survey, True North established a control network along the LDW. This control network is based on NAD83/91, Washington North Zone horizontal positions, and MLLW elevations. True North will establish a control point at each RAL exceedance area where topographic surveying is to be performed and where an existing control point has not already been established.

A geodetic control survey will be conducted using GPS techniques from monuments with published positions and elevations. A network of observations will be made with redundant comparisons to document the accuracy of the survey. The details of the geodetic control survey will be reported with the results of the combined topographic survey.

### 3.2.2 Topographic Data Acquisition

All survey data will be acquired by establishing QC points in areas where topography data are needed. The control points will be set by GPS after thorough checks of existing control points have occurred. The topography points will overlap with the existing bathymetry to the extent practical. Land survey data will be collected by GPS and/or total station, on a 25-foot grid-like pattern, as well as at break lines (tops and toes of slopes) and significant changes in existing surfaces.

## 3.3 Data Processing Methods

Processing the topography points will consist of confirming that the raw data match the field notes and checking that the crew correctly input the instrument and rod heights. These tasks will be performed in C3D with the Carlson Survey program. This process will cancel out horizontal and vertical errors. True North will provide a digital terrain model for each RAL exceedance area included in the topographic survey and a complete coordinate data file.

## 3.4 Quality Control

The surveyors will conduct QC by confirming that the raw data match the field notes written at the time of the survey field work. Errors in the surface elevation data will be corrected when creating the elevation contours.

## 3.5 Instrument/Equipment Testing, Inspection, and Maintenance

The equipment to be used for the land survey (and the associated precision of each instrument) are as follows:

- Leica TS16 (Total Station), precision of 1 inch horizontally and vertically
- Leica GS16 (GPS real-time kinematic [RTK] Unit), precision of 8 mm +1 parts per million horizontally and 15 mm +1 parts per million vertically
- Leica LS10 (Digital Level with Bar Code Rod), precision of 0.3 mm vertically

All equipment will be routinely inspected by True North and maintained annually by the instrument dealer.

Photogrammetric surveys will be performed using a gyroscopically stabilized Vexcel<sup>®</sup> UltraCam Falcon precision digital imaging sensor. The survey will meet or exceed the *ASPRS Positional Accuracy Standards for Digital Geospatial Data* (ASPRS 2015), as follows:

- Planimetric data: 6-cm accuracy class (RMSE<sub>x</sub> and RMSE<sub>y</sub><sup>3</sup>)

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<sup>3</sup> RMSE<sub>x</sub>, RMSE<sub>y</sub>, and RMSE<sub>z</sub> refer to the root-mean-square-error in the horizontal (x and y) and vertical (z) planes.

- Elevation data: non-vegetated, 10-cm accuracy class (RMSEz)
- Orthoimage data: 12-cm accuracy class (RMSE<sub>x</sub> and RMSE<sub>y</sub> or 2 pixels)

### 3.6 Instrument/Equipment Calibration and Frequency

The calibration frequency for each land survey instrument is as follows:

- Leica TS16: Annually maintenance performed by the instrument dealer
- Leica GS16: Smart link worldwide correction every 10 minutes while in use and annual maintenance performed by the instrument dealer
- Leica LS10: Manual “peg” routine performed prior to use; digital “peg” performed annually

### 3.7 Inspection/Acceptance of Supplies and Consumables

No significant consumables will be required because all data will be digitally recorded. The survey equipment will have onboard SD card storage.

### 3.8 Non-Direct Measurements

For the topographic survey, all measurements will be direct. LiDAR data will be used to establish preliminary limits and as a check for survey measurements. If data gathered during the topographic survey differ from the LiDAR data, the survey measurements will be confirmed. LiDAR data are inherently less precise and accurate than those from a ground survey, and LiDAR contours will be overwritten with ground data after confirmation.

### 3.9 Data Management

Data from the survey will be downloaded and backed up to solid-state, cloud-based server at the end of each survey day. Data will not be removed from the data collectors until they have been loaded and verified on the cloud-based data server in the home office.

## 4 Assessment and Oversight

### 4.1 Assessments and Response Actions

EPA or its designees may observe the topographic survey, as needed. If situations arise wherein there is a significant inability to follow the Survey QAPP Addendum methods precisely, the True North project manager will coordinate with the Anchor QEA project manager to determine appropriate actions, and will consult with EPA if the issue is significant. No field audits are proposed for this work. The True North project manager will audit system checks.

### 4.2 Reports to Management

Primary communications will be through correspondence with the True North project manager and Anchor QEA project manager. This correspondence will consist primarily of emails sent by the next business day during survey operations; these emails will include coverage images, a general overview of survey progress, and any problems encountered during surveying. Anchor QEA will provide updates to the City of Seattle project manager and LDWG during weekly progress meetings.



## 5 Data Validation and Usability

### 5.1 Data Review, Verification, and Validation

Data will be reviewed and verified by evaluating the raw data in comparison to field notes. Data collected will overlap with existing contours, and the two datasets will be compared to each other.

### 5.2 Reconciliation with Data Quality Objectives

DQO 3 will be achieved by meeting the target horizontal and vertical accuracies at a 95% confidence level for the survey. Methods outlined here and in Section 3 will verify that the target accuracies are being attained. Final review by the Professional Land Surveyor will include the review of contours and comparison to prior surveys.

Table G-2 summarizes the key targets and related datums for the topographic survey. With the RTK GPS, the horizontal and vertical accuracies of the survey will be affected by several factors, including the positional accuracy of the satellites and factors that can affect their ability to gather data, such as overhead power lines, bridges, and multipath interferences.

**Table G-2**  
**Key Targets and Related Datums**

Description	Quantity or Datum
GPS horizontal positioning accuracy	+/- 0.3-foot minimum
Total station horizontal survey accuracy	+/- 0.10-foot minimum
Horizontal datum	NAD83/91 Washington North Zone
GPS vertical survey accuracy	+/- 0.2-foot minimum
Total station vertical survey accuracy	+/- 0.02-foot minimum
Vertical datum	MLLW

Notes:

MLLW: mean lower low water

NAD: North American Datum

## 6 References

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