Lower Duwamish Waterway Upper Reach Remediation Action
King County Contract KC001065

INSTRUMENTATION & MONITORING PLAN

Revision	Date	Comment
0	June 10, 2024	Original
1	July 13, 2024	Revisions based on KC comments.
2	July 19, 2024	Revisions based on KC comments (006A)
3	August 20, 2024	Revisions based on EPA comments
4	September 4, 224	Revisions based on LDWG comments
5	October 7, 2024	Revisions based on EPA comments

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Prepared For:

Pacific Pile&Marine

Scope of Work

The scope of work is to monitor and report the positions of the structures at two monitoring sites, before, during and after construction activities per Specification 31 09 00. The monitoring will use precise field techniques for determination of elevations, horizontal coordinates and distances to determine and measure structure displacement, if any, during construction activities.

The two locations are:

- IM F – Sheet Pile Wall (Sheet IM103)
- IM I – Pier 2 Structure, Slip 6 (Sheet IM105)

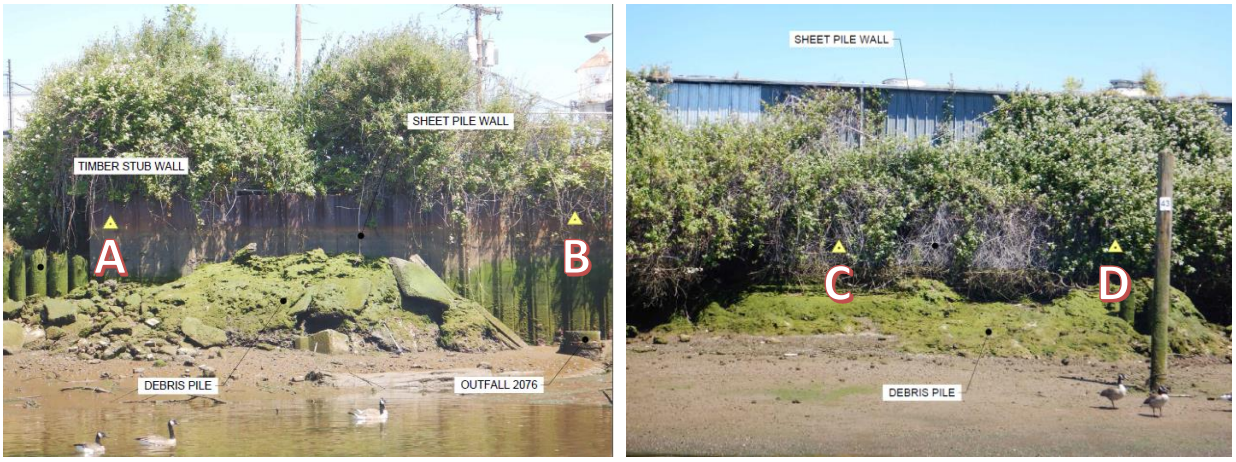


Figure 1: Four monitoring locations at site IM F, A-D from downstream to upstream.

Figure 2: Two monitoring locations at site IM I, A and B.

System Accuracy

The system accuracy requirements are provided in 31 09 00 2.03 (A) and are as follows.

A. System Accuracy Requirements:

1. The accuracy requirements established in this Section apply to the final data, including the composite effects of reflectors, readout instruments, measurement methods, temperature, operator variability, and other contributing factors.

2. Maintain an associated confidence level of 90% for all accuracies specified in this Section.
3. Surveyed Monitoring Points shall be as follows:
    a. Within 0.01 foot vertical
    b. Within 0.01 foot horizontal

Personnel

Monitoring Surveyor & Superintendent: The monitoring surveyor and monitoring superintendent in responsible charge is Chris Kemp, WA PLS 44344, Principal at Marker Offshore LLC. Mr. Kemp has performed a wide array of precise metrology and monitoring projects in both the marine and terrestrial environment including monitoring long-term, multi-year, diffuser elevations of the Brightwater Marine Outfall, relative deformation of instrument locations on large oceanographic vessels, regional vertical uplift and water level changes with respect to tidal datums, 3D laser scanning to measure deformation of 12' steel breasting piling and dam structure monitoring. He has implemented a variety of technologies including total stations, laser scanners, differential optical levels, GNSS receivers, precise quartz crystal resonators and Inertial Motion Units.

The work will be supported by Marker Offshore field survey technicians as required, and will be under the direct supervision of Mr. Kemp.

Equipment

Table 1: Equipment List.

Device	Model	Specifications
Total Station	Trimble S7	Angular Accuracy: 1" Distance Accuracy (Prism): 0.0065ft +2PPM (Manufacturers datasheet is located as Attachment C))
Prisms	Trimble	Trimble Mini Monitoring, 25mm -17mm Prism Constant
Data Collector	Trimble TSC7	Trimble Access with Monitoring Module
RTK GNSS	Trimble R12i	Horizontal Accuracy: 0.03 ft Vertical Accuracy: 0.05 ft

Schedule

The final schedule will be based on PPM's schedule, but the order of events will be as follows.

Table 2: Schedule of Events.

Event	Timing
1. GNSS control survey	30 Days prior to construction
2. Install remaining backsights, benchmarks and check points 3. Install monitoring points at IM103 and IM105	28 Days Prior to construction
4. Survey positions of all backsights, monitoring points, and check points using the Total Station.	21 Days Prior to construction
5. Re-observe monitoring points, and check points.	20 Days Prior to construction

6. Re-observe monitoring points, and check points.	19 Days Prior to construction
7. Production Readings	Per 31 09 00 3.04 (E)

MONITORING GROUP	STRUCTURE	RELATIVE READING SEQUENCE	READING FREQUENCY	READING SEQUENCE DURATION
A	STA 234+50 | Structure IM-F (Sheet Pile Wall)	Day Before Planned Excavation Start	1 Time per Day	1 Day
		During Excavation and New Bulkhead Wall Installation	1 Time per Day	Until Excavation Completion
		During Backfill	2 Times per Week	Until Backfill Completion
		After Backfill	1 Time per Week	Until Obtaining Three Consecutive Stable Readings
B	STA 251+00 | Structure IM-I (Pier 2, Slip 6)	Day Before Planned Excavation Start	1 Time per Day	1 Day
		During Excavation	2 Times per Week	Until Excavation Completion
		During Backfill	1 Time per Week	Until Backfill Completion
		After Backfill	1 Time per Week	Until Obtaining Two Consecutive Stable Readings

Figure 3: Production Reading Schedule per 31 09 00 3.04 (E)

Survey Control

Seven control points will be set at each monitoring location, excluding the actual monitoring points themselves. Two primary control points at each monitoring site, the instrument point and the primary backsight (BS 1) will be surveyed with a static GNSS network and the Trimble R12 receivers.

GNSS Network Control

Project Survey control will be established at each monitoring location through GNSS static observations and least-squares network adjustment using Trimble Business Center. The adjustment will be minimally constrained holding WSDOT monument GP17099-223 as fixed. Elevations of all control will be adjusted to NAVD88 with the Geoid 18 model and adjusted to MLLW with a fixed 2.34 offset.

Monitoring Control

The five remaining benchmarks (4 additional backsights and 1 check point) at each site will be surveyed with a Trimble S7, 1-second Total Station using multiple distance and angle measurements in both faces. Trimble refers to these measurements as “Rounds”.

Three “Rounds” will be measured. Each round will consist of three horizontal and vertical angle measurements and three slope distance measurements at each BS point in both FACE 1 and FACE 2 – a total of 18

measurements at each point. The position and standard deviation of each backsight coordinate will be reported.

Following the establishment of the backsight and checkpoint coordinates, the monitoring points (MPs) will be surveyed using a resection setup using all five backsight benchmarks with the instrument over the primary control point. The resection setup location will be compared to the primary control point to verify the stability. Please reference the Easements and Right-of-Entry Agreements for access for the monitoring access.

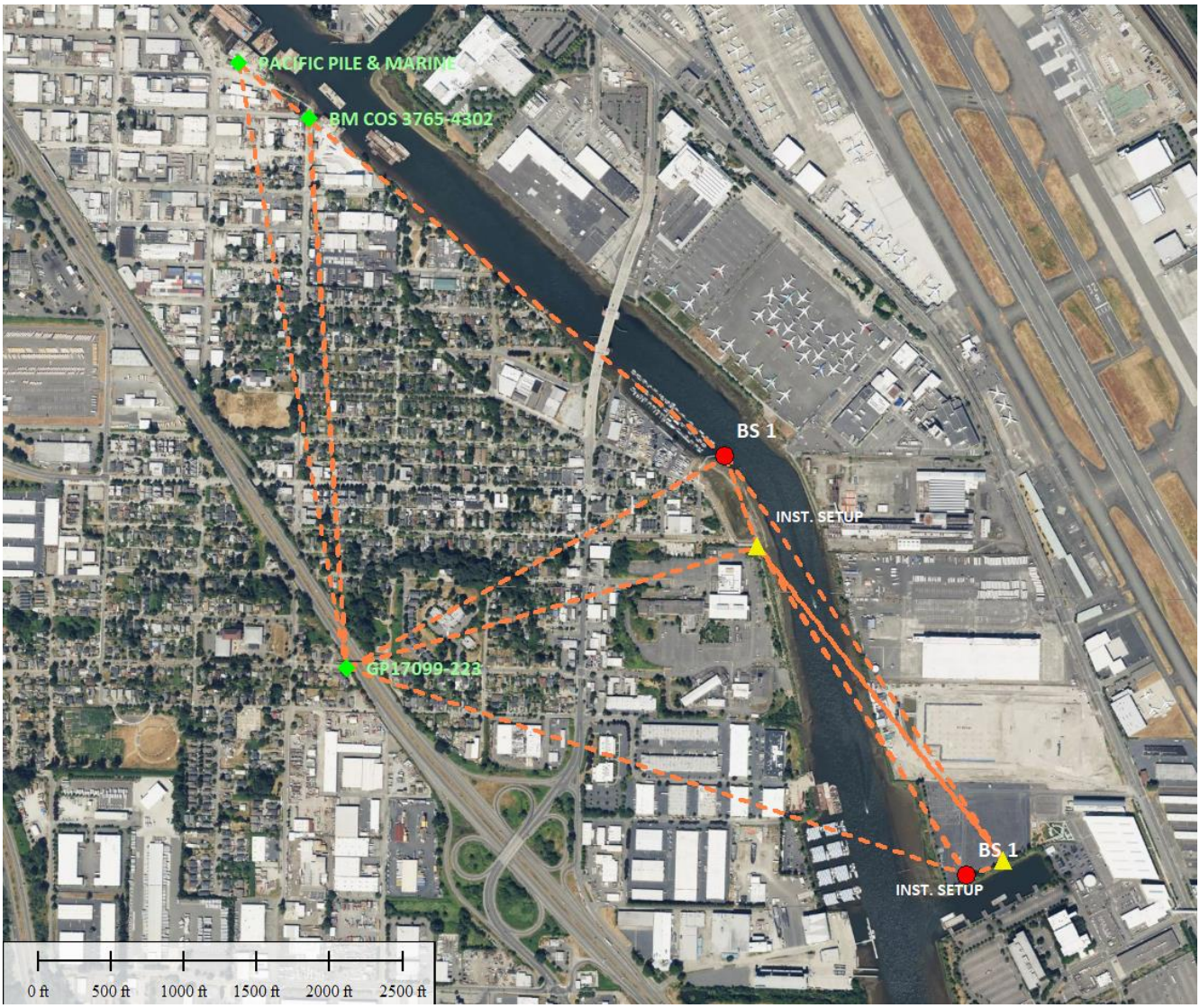


Figure 4: GNSS Network Control Diagram.

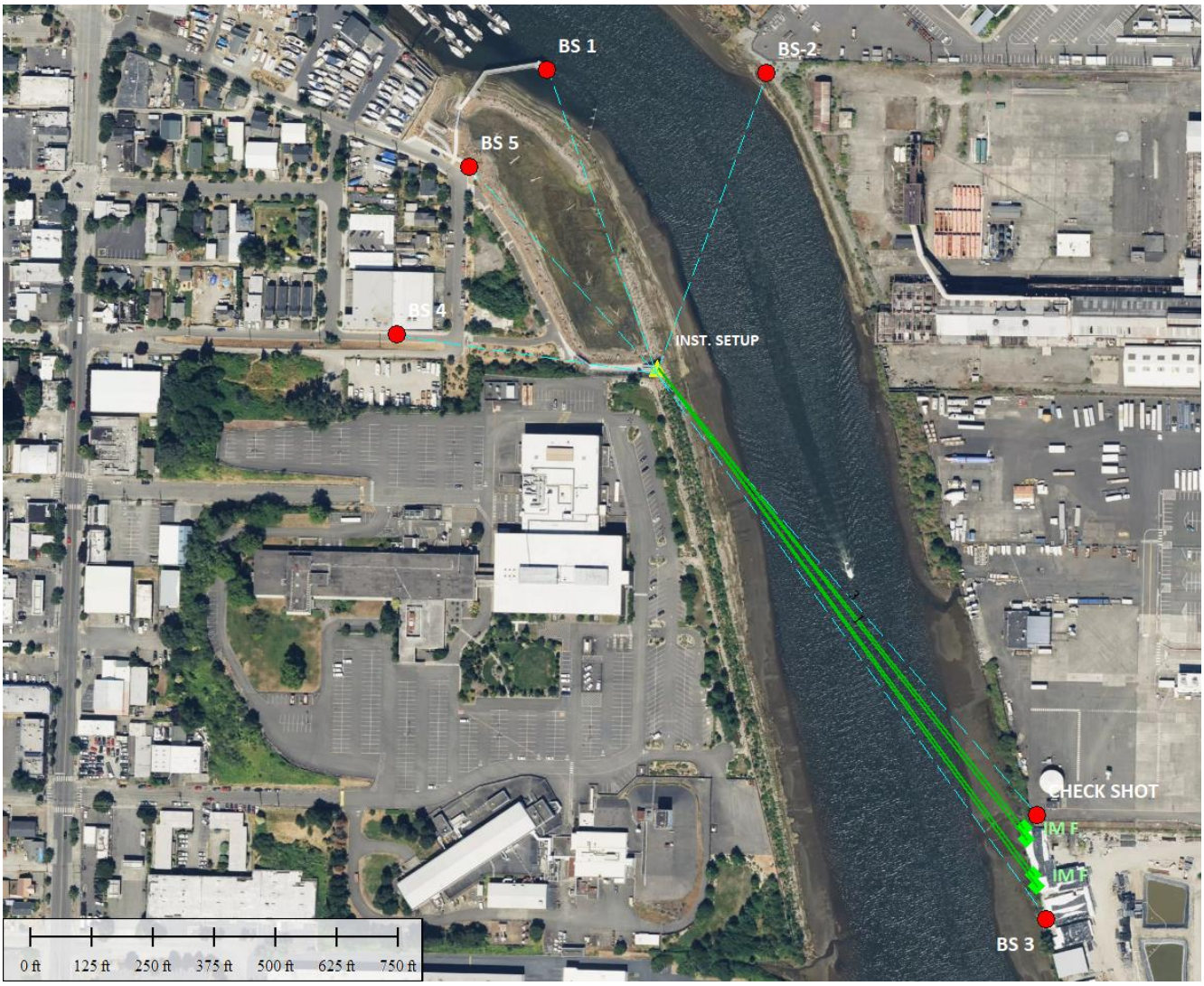


Figure 5: Control Diagram at monitoring location IM-F

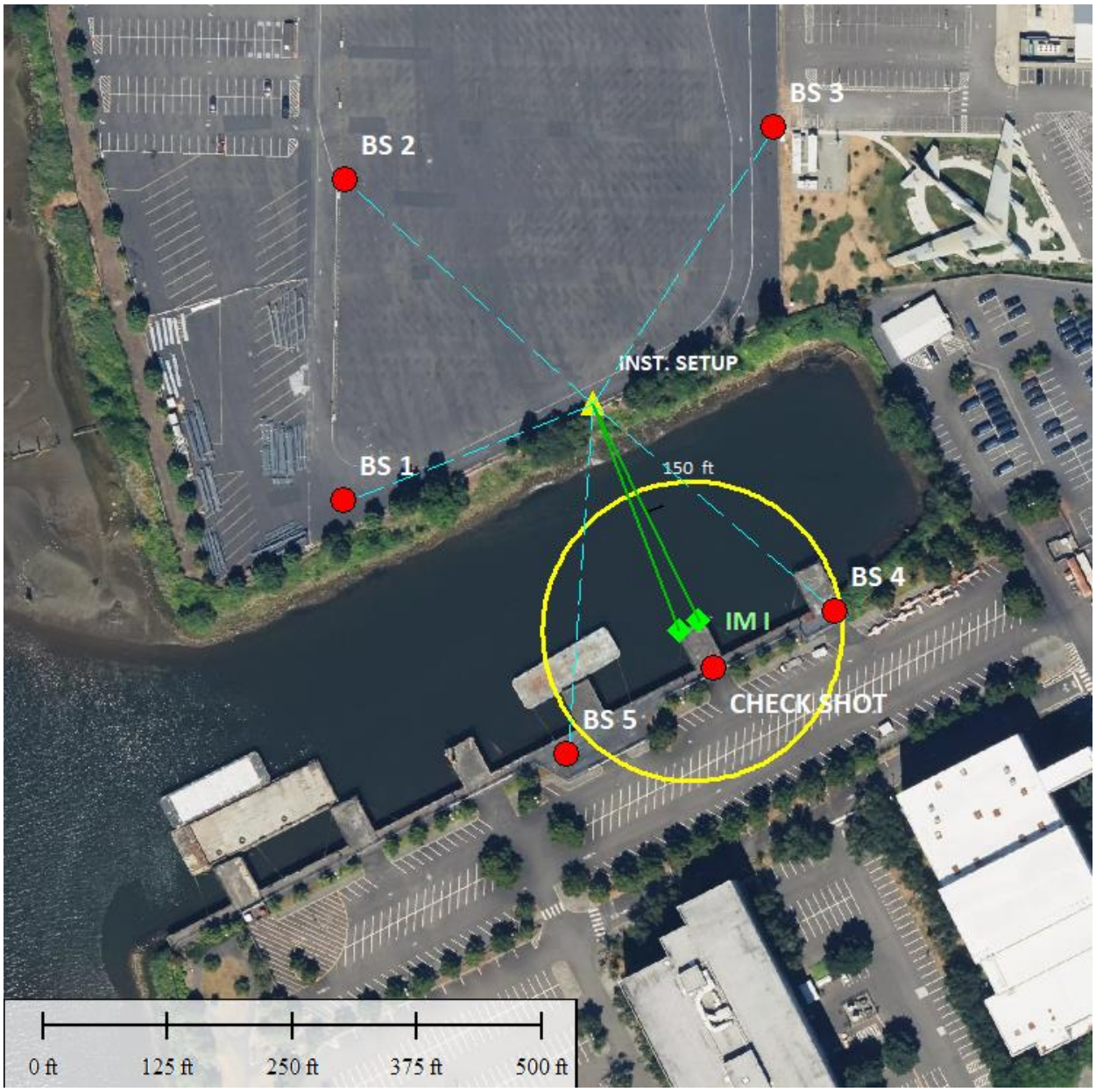


Figure 6: Control Diagram at monitoring location IM I.

Instrument Setups

The Trimble S7 used for the monitor observations will be set up on a tripod. This will be a temporary setup for each monitoring event. At each production event, the instrument will be setup using a resection setup from the established backsight points. The proposed setup locations will be finalized in the field to accommodate fences or other line-of-sight obstructions.

IM F Setup

The instrument location will be on top of the viewing platform at the Duwamish River People's Park. There is an unobstructed view of the monitoring points with backsight locations on city and/or county property.

IM I Setup

The instrument location will be in the Container Properties site. The setup will be on the south side of the lot and the monitoring points shot though the chain-link fence. The instrument will be positioned to ensure an unobstructed view through the fence.

Figure 7: Instrument setup location on asphalt (left), view of monitoring points IM I across slip 6 (right).

Figure 8: Instrument setup location on platform (left), view of monitoring points IM F across the Duwamish (right).

BACKSIGHT/BENCHMARK SETUPS

Backsights will consist of Trimble mini monitoring prisms anchored into fixed concrete structures or 3/8" female inserts grouted into curbs or asphalt pavement. Monitoring prisms will stay fixed for the duration of the project. The ultimate location of the backsights will be determined during the initial control survey. Locations that require additional right-of-entry agreements, easements, and site access agreements for access to any properties not obtained by King County as part of the contract, will be obtained by PPM.

MONITORING POINT SETUPS

Trimble 25mm monitoring prisms will be installed at each of the monitoring point locations. The system is composed of a prism and an aluminum L bracket. The prisms will be permanently installed for the duration of

the construction activities and required monitoring activities.

Figure 9: Trimble 25mm monitoring prisms on bracket.

Monitoring Location IM103

Monitoring prisms at location IM103 will be mounted on a 4” length of 3” x 1-3/8” steel channel. The bracket will be welded to the sheetpile wall at the approximate locations shown in the Drawings. The prism will be mounted in the center of the bracket with a 5/16” stainless steel hex bolt and #8 alignment screw. The design allows for replacement of the prism to the exact location (< 0.001ft) in the event of damage or loss.

A redundant bracket will be attached within two feet of the primary bracket at all four monitoring locations in the event of damage to the bracket itself. During the baseline readings, a prism will be installed on this bracket and surveyed in. The prism will not remain in place during construction, and only mounted in event of damage to the primary bracket.

Removal of monitoring location IM103 shall be completed within 30 calendar days following the completion of monitoring, as accepted by the Project Representative. Disturbed or damaged surfaces will be restored to the conditions existing before installation of Monitoring Points, if required per Specification Section 31 09 00, Articles 3.05.A and 3.05B.

Clearing and grubbing of the area will be performed as required to ensure clear visibility of the targets from the proposed set-up locations.

Monitoring Location IM105

Due to the condition of the pier, the identified structural element and precise location of the monitoring points at location IM 105 will be determined after the initial inspection to determine the suitable locations for the targets. The same method of installation as IM103 will be used if there is a suitable structural steel element. Alternatively, wedge anchors secured into the concrete deck or steel piling clamps will be used in the absence

of a suitable structural steel element. A redundant prism mount will be installed at each of the two monitoring locations. Removal of monitoring location IM105 shall be completed within 30 calendar days following the completion of monitoring, as accepted by the Project Representative. Disturbed or damaged surfaces will be restored to the conditions existing before installation of Monitoring Points, if required. (31 09 00 3.05.A, 31 09 00 3.05B)

Security

The monitoring points are in locations along the Duwamish River that are not conducive for securing or controlling access to the prisms. As such, the methods described above for replacement of prisms to original positions and redundant mounting points will be used to ensure continuity of the monitoring activities in the event of damage, vandalism, or theft.

Replacement Procedures

Monitoring Points

Monitoring points will be physically inspected prior to each production reading. Any visible damage or displacement relative to the original setting will be noted. If no damage or displacement is visually noted, any change in the monitoring point position, greater than 0.01 feet, after a production reading will be assumed to be deflection of the structure.

In the event of removal, loss or damage of a monitoring point, the replacement procedures identified in Specification Section 31 09 00 (Article 1.04.B.2.g.1) will be followed. The specific method is identified below.

- If a prism has been damaged or moved, a new prism will be installed in the same mounting holes on the original mounting bracket.
- If the bracket has been damaged, the redundant bracket will be used. A replacement bracket of the original will be installed at this time.
- In the event the monitoring target needs to be reset/restored, the underlying cause of the damage will be identified.
- Baseline measurements to the monitoring point will be repeated. The restored coordinates of the monitoring point will be submitted to the County within 24 hours of the initial damage/loss observation.
- Restoration will be done at no cost to the County.

Methods to protect against future damage of new prisms will be evaluated on a case-by-case basis.

Instrument Movement, replacement, repair

As noted in the Instrument Setup Section above, the instrument will be setup on a tripod for each monitoring event and will be attended at all times. The position of the instrument is established through resection from the known backsights and will allow for some amount of repositioning within the general monitoring location in the event of a change of conditions of the immediate instrument location or temporary obstructions on the waterways blocking line of sight.

In the event of loss or damage to the instrument that requires replacement or repair, the instrument will be replaced with an instrument of equal, or higher, technical specifications. Marker Offshore will submit a report with the following:

- The reason for replacement, repair or relocation.
- New location of the instrument location
- Technical specifications and calibration certificates of the replacement instrument.
- Dates the instrument was replaced and operational.

Production Measurements and Frequency

The production readings will be taken at the frequency outlined in Figure 3: Production Reading Schedule per 31 09 00 3.04 (E). The highest frequency of measurements is once per day during excavation. During backfill, the frequency is reduced to two times per week. After backfill, monitoring will be reduced to once per week until two consecutive stable readings are made (less than 0.01 ft).

After the initial setup and orientation of the instrument on the day of the readings, the monitoring points will be measured using "Rounds". Three Rounds will be measured: each round consisting of three horizontal and vertical angle measurements and three slope distance measurements at each monitoring point in both FACE 1 and FACE 2 – a total of 18 measurements at each point. After the measurements are taken, the residuals from the baseline position and standard deviation of each monitoring point are reported on the data collector.

The total time to make all the measurements on the monitoring points is approximately ten minutes, so unless movement or deflection is occurring during this ten-minute period (which would be evidenced by high standard deviations during the rounds), any movement would be captured after the movement event. This could be any time during the intervening 24-hour, 3-day, or 7-day period between successive measurements during excavation, backfill or post-backfill events, respectively.

Accuracy Estimates

The estimated uncertainty of the monitoring points based on the proposed equipment is presented below. The expected accuracy will meet or exceed 0.01 feet (horizontally and vertically) as defined in 31 09 00 2.03.

Table 3: Accuracy estimates.

MP	Max Range	Angular Error Component (1" error)	Slope Distance Measurement Component	Propagated Uncertainty (95%)
IM - F	1310 ft	0.0064 ft	0.0066 ft	0.009 ft
IM - I	242 ft	0.0006 ft	0.0066 ft	0.006 ft

Data Reporting

Positions of the monitoring points and their residuals from the initial position will be available immediately following the measurement.

At the end of each production measurement and within 30 minutes of the final readings, Marker will provide a report to PPM like the examples below. PPM will provide the reports to the Project Representative by the end of the shift immediately following that during which the readings were taken. Electronic monitoring data will be readable in Microsoft Excel.

The report will consist of the following:

- Page 1: Daily observation.
- Page 2: Summary of all observations to date.
- Page 3: Plots of all observations to date.

Structure Monitoring Daily Reading

Location IM I
Point IMI - A

Monitoring Location:	IM I		
Monitoring Point:	IM I -A		
Project:	Lower Duwamish Waterway Upper Reach Remedial Action		
Project Owner:	King County		
Date of Reading	11-Nov-24	**Temperature: (F)**	59
Time of Reading:	13:14	**Pressure: (in. HG)**	29.96
Event:	During Excavation	**Rain:**	None
Surveyors:	Chris Kemp	**Wind:**	10kt SSE
	Lars Lindblad	**Tide (Ft):**	5.6
Damage to Backsights	None	**Trigger Level:**	1.0" (0.083')
Damage to Monitoring Points	None	**Maximum Level:**	1.5" (0.125')

	Northing	Easting	Elevation	Vector Sum
Measured	1432843.554	602757.571	12.469	
Delta (From Baseline 1)	0.004	0.004	-0.002	0.006
Action				None

Structure Monitoring Summary

Location IM I
Point IMI - A

Event	Date	Northing	Easting	Elevation	Delta Northing	Delta Easting	Delta Elevation	Construction Activities to Instrument (feet)	Construction Activities to Monitoring Point (Feet)
Baseline Reading 1	19-Oct-24	1432843.550	602757.567	12.471	NA	NA	NA	NA	NA
Baseline Reading 2	20-Oct-24	1432843.546	602757.564	12.473	-0.004	-0.003	0.002	NA	NA
Baseline Reading 3	21-Oct-24	1432843.551	602757.568	12.470	0.001	0.001	-0.001	NA	NA
Day Before Planned Excavation	11-Nov-24	1432843.550	602757.566	12.476	0.000	-0.001	0.005	450	750
During Excavation	13-Nov-24	1432843.554	602757.571	12.469	0.004	0.004	-0.002	450	750

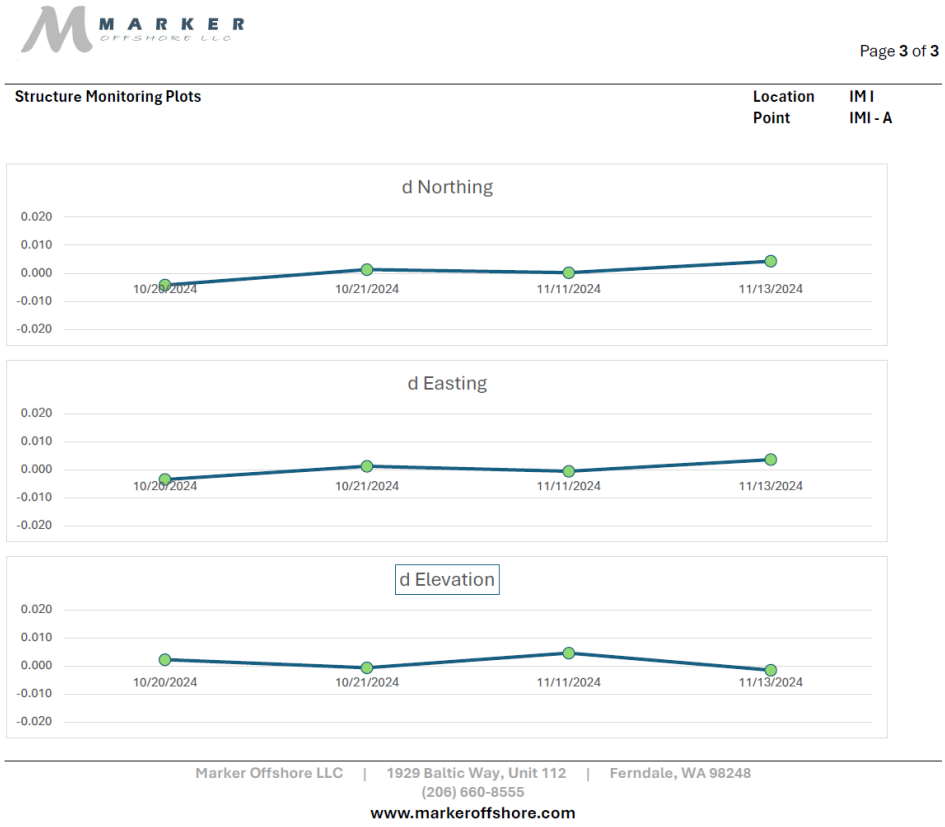


Figure 10: Data reporting sample.

Corrective Action Plan

In the event an action level is exceeded, PPM will be notified and the measurement repeated immediately. If the results of the two measurements are within the expected repeatablity of the instrument (+/- 0.01 ft), the backsights and monitoring points will again be checked for damage or movement both visualy and against the known refernece marks. If the measurements are confirmed to be valid, PPM will implement the corrective action plan (Attachment A).

STRUCTURE TYPE/ID	TRIGGER LEVEL	MAXIMUM LEVEL
Piers and Docks	1.0 inch	1.5 inches
Soldier Pile and Sheet Pile Walls	1.2 inches	2.0 inches

Figure 11: Action levels 31 09 00, 3.04 (F)

Pre-Construction and Post-Construction Structural Condition Inspections

Pre-Construction Inspections

1. **Objective**: Document the existing condition of all structures that could be affected by construction activities.
2. **Scope**: Include all structures within the designated area as specified in the project documents.

3. **Documentation**: Prepare detailed reports with high-resolution photographs, sketches, and notes on the current condition of structures.
4. **Inspection Procedures:**
    1. Perform visual inspections of all accessible structural elements.
    2. Use non-destructive testing methods as necessary to assess the condition of hidden or covered structural components.
    3. Document any existing damage, wear, or deterioration.
5. **Data Collection:**
    1. Record measurements of any cracks, deflections, or other signs of structural movement.
    2. Note environmental conditions that could affect the structural integrity (e.g., corrosion due to proximity to saltwater).
    3. Include information on the materials and construction methods used in the existing structures.
6. **Comparison to Standards:**
    1. Compare findings to relevant structural standards and guidelines to determine if any conditions are outside acceptable limits.
    2. Provide recommendations for any immediate repairs or monitoring requirements.
7. **Professional Requirement**: Inspections must be conducted by a licensed engineer in the State of Washington, with experience in structural inspections.
8. **Submission**: Submit the pre-construction inspection reports to the Project Representative for review at least 14 calendar days prior to the passage of PPM equipment or materials by a structure identified for inspection, or the start of any In-Water Work proximate to the identified structure.
9. **Follow-Up Actions:**
    1. Based on the inspection findings, outline any necessary follow-up actions or further inspections.
    2. Coordinate with the Project Representative to address any issues that will affect project progress or safety.

Post-Construction Inspections

1. **Objective**: Verify that no damage has occurred to existing structures as a result of construction activities.
2. **Scope**: Re-inspect all structures included in the pre-construction inspection.
3. **Documentation**: Prepare detailed reports comparing pre- and post-construction conditions, noting any changes or damage.
4. **Professional Requirement**: Inspections must be conducted by the same licensed engineer who performed the pre-construction inspections.
5. **Submission**: Complete Post-Construction Structural Condition Inspections of existing structures and facilities, as identified in the Drawings and Specification Section 31 09 00, within 10 working days after all dredging and material placement Work proximate to the identified structure has been completed and accepted by the Project Representative and no further passage of equipment or materials by the identified structure is planned.
6. Submit Post-Construction Structural Condition Reports, for Project Representative acceptance, for each structure within 5 working days after completing each Post-Construction Structural Condition Inspection.

Steps for Compliance

- **Engage a Licensed Engineer**: Ensure the engineer is licensed in Washington and has experience with structural condition inspections, especially in waterfront or marine environments.
- **Conduct Thorough Inspections**: Use industry standard tools and methods to document the condition of structures before and after construction.
- **Prepare Detailed Reports**: Include all necessary documentation and submit reports timely to the Project Representative.
- **Address Any Findings**: If any structural issues are identified, take immediate corrective actions as per project requirements.

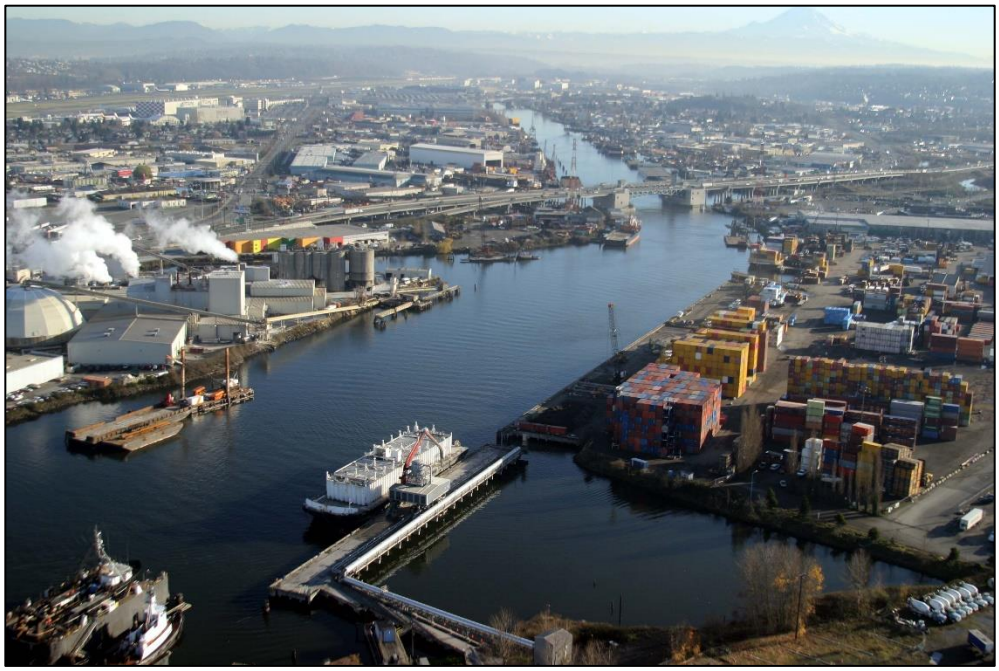
Structural Condition Inspections Personnel Qualifications

Sam deMers will be responsible for performing Structural Condition Inspections, both before and after construction activities. Mr. deMers is licensed in the State of Washington per Section 02 21 00 (Site Surveys and Positioning Control) and has experience with structural condition inspections on at least three projects, including a minimum of two projects involving waterfront and/or marine structures. Please see Attachment B for their qualifications.

Attachment A- Corrective Action Plan

Preliminary Corrective Action Plan

Revision: 2
August 22, 2024



LOWER DUWAMISH WATERWAY
Upper Reach Remedial Action
Contract KC001065

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1.0 Investigation Procedures for Action Level exceedance..... 3
2.0 Probable Actions for Exceeding Trigger Level 3
3.0 Probable Actions for Exceeding Maximum Level 4

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3.0 Probable Actions for Exceeding Maximum Level

1. **Immediate Response**:
    - Immediately stop the construction activity causing the exceedance.
    - Notify the Project Representative without delay.
2. **Implementation of Preliminary Actions**:
    - Immediate cessation of all related construction activities.
    - Comprehensive structural assessment and reinforcement.
    - Develop and implement advanced stabilization strategies and engineering controls.
    - Engage in frequent and intensive monitoring and reporting until conditions stabilize.
3. **Site-Specific Corrective Action Plan**:
    - Develop and submit to the Project Representative a Site-Specific Corrective Action Plan within 24 hours, including the identified cause of the exceedance.
4. **Verification**:
    - Verify the accuracy of the measurement.
    - For instruments read less frequently than every other day, increase the frequency to daily. For all other readings, double the frequency.
    - Continue increased monitoring until the relative incremental change of movement returns to the pre-action Trigger Level rate or stabilizes as determined by the Project Representative.
5. **Additional Corrective Actions**:
    - If the Site-Specific Corrective Action Plan suggests different or additional corrective actions, implement them accordingly.
6. **Success Verification**:
    - Verify the effectiveness of the corrective actions.
7. **Work Suspension and Alternative Proposals**:
    - The Project Representative may suspend Work activities at the location of exceedance and request alternative proposals to minimize further movements.
    - Obtain approval from the Project Representative before resuming Work activities, following approved procedures.

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1.0 Investigation Procedures for Action Level exceedance

The Action Level term in this plan refers to the indications of structural instability. Please note this term is not associated with Remedial Action Levels.

1. **Cause Investigation**:
    - Conduct an immediate investigation to determine the cause(s) of the Action Level exceedance.
    - Identify the specific construction activities or structural factors contributing to the exceedance.

2.0 Probable Actions for Exceeding Trigger Level

1. **Immediate Response**:
    - Cease the construction activity causing the exceedance immediately.
    - Notify the Project Representative without delay.
2. **Implementation of Preliminary Actions**:
    - Modify or halt specific construction activities causing displacement.
    - Implement additional structural support or stabilization measures.
    - Adjust equipment usage or operational techniques to reduce impacts.
    - Redistribute or remove any loads on the structure that may be contributing to the instability.
3. **Site-Specific Corrective Action Plan**:
    - Develop and submit to Project Representative a Site-Specific Corrective Action Plan within 24 hours, including details on the Cause Investigation, and identified cause of the exceedance.
4. **Verification**:
    - Verify the accuracy of the measurement.
    - For instruments read less frequently than every other day, increase the frequency to daily. For all other readings, double the frequency.
    - Continue increased monitoring until the relative incremental change of movement returns to the pre-action Trigger Level rate or stabilizes as determined by the Project Representative.
5. **Additional Corrective Actions**:
    - If the Site-Specific Corrective Action Plan suggests different or additional corrective actions, implement them accordingly.
    - Modify construction procedures if necessary.
6. **Success Verification**:
    - Verify the effectiveness of the corrective actions.

Attachment B- Structural Condition Inspections Personnel Qualifications

Attachment C- Trimble Total Station Literature

Trimble S7

TOTAL STATION

THE MOST PRODUCTIVE TOTAL STATION

The Trimble® S7 Total Station combines scanning, imaging and surveying into one powerful solution.

The Trimble S7 is the system for efficient surveying, allowing you to adapt to any situation and increasing your productivity in the field. The combination of SureScan, Trimble VISION™, FineLock™ and DR Plus technology, along with many other features, means you'll be able to collect data faster and more accurately than ever before.

Integrated Scanning

Save time in the field and in the office with Trimble SureScan technology. Now you have the flexibility to perform scans every day. Capture the information you need to create digital terrain models (DTMs), perform volume calculations and make topographic measurements faster than with traditional surveying methods. SureScan technology enables you to collect and process data faster by focusing on collecting the right points, not just more points.

Trimble VISION Technology

Trimble VISION technology gives you the power to direct your survey with live video images on the controller as well as create a wide variety of deliverables from collected imagery. Capture measurements to prisms or reflectorless with point-and-click efficiency via video. Document your site and add notes directly to the pictures in the field to ensure you never miss that critical information. Back in the office, you can use your Trimble VISION data for measurements, or to process panoramas and high dynamic range (HDR) images for even clearer deliverables.

Trimble DR Plus EDM

Trimble DR Plus range measurement technology provides extended range of Direct Reflex measurement without a prism. Now you can measure further with fewer instrument set-ups and enhance your scanning performance. Trimble DR Plus, combined with the smooth and silent MagDrive™ servo technology, creates unmatched capability for quick measurements, without compromising on accuracy.

Manage Your Assets

Know where your total stations are 24 hours a day with Trimble L2P technology. See where your equipment is at any given time and get alerts if your instrument leaves a job site or experiences unexpected equipment shock or abuse.

Powerful Field and Office Software

Choose from a variety of Trimble controllers operating the feature rich, intuitive Trimble Access field software. Streamlined workflows like Roads, Utilities and Pipelines guide crews through common project types, helping to get the job done faster with less distractions. Trimble Access workflows can also be customized to fit your needs.

Back in the office, trust Trimble Business Center to help you check, process and adjust your optical and GNSS data in one software solution.

Key Features

- Surveying, imaging and scanning in one powerful solution
- Trimble VISION technology for video robotic control, scene documentation and photogrametric measurements
- Trimble L2P real-time location information
- Trimble DR Plus for long range and accuracy
- Intuitive Trimble Access Field Software
- Trimble Business Center Office Software for quick data processing

PERFORMANCE

Angle measurement

Sensor type ..... Absolute encoder with diametrical reading
Accuracy[1] ..... 1" (0.3 mgon)
2" (0.6 mgon), 3" (1.0 mgon), or 5" (1.5 mgon)
Display (least count) ..... 0.1" (0.01 mgon)
Automatic level compensator
Type ..... Centered dual-axis
Accuracy ..... 0.5" (0.15 mgon)
Range ..... ±5.4' (±100 mgon)

Distance measurement

Accuracy (ISO)
Prism mode
Standard[2] ..... 1 mm + 2 ppm (0.003 ft + 2 ppm)
Accuracy (RMSE)
Prism mode
Standard ..... 2 mm + 2 ppm (0.0065 ft + 2 ppm)
Tracking ..... 4 mm + 2 ppm (0.013 ft + 2 ppm)
DR mode
Standard ..... 2 mm + 2 ppm (0.0065 ft + 2 ppm)
Tracking ..... 4 mm + 2 ppm (0.013 ft + 2 ppm)
Extended range ..... 10 mm + 2 ppm (0.033 ft + 2 ppm)

Measuring time

Prism mode
Standard ..... 1.2 sec
Tracking ..... 0.4 sec
DR mode
Standard ..... 1–5 sec
Tracking ..... 0.4 sec

Measurement range

Prism mode[6, 7]
1 prism ..... 2,500 m (8,202 ft)
1 prism Long Range mode ..... 5,500 m (18,044 ft) (max. range)
Shortest possible range ..... 0.2 m (0.65 ft)
DR mode

	Good (Good visibility, low ambient light)	**Normal** (Normal visibility, moderate unlight, some heat shimmer)	**Difficult** (Haze, object in direct sunlight, turbulence)
White card (90% reflective)[4]	1,300 m (4,265 ft)	1,300 m (4,265 ft)	1,200 m (3,937 ft)
Gray card (18% reflective)[4]	600 m (1,969 ft)	600 m (1,969 ft)	550 m (1,804 ft)

Reflective foil 60x60 mm ..... 1,200 m (3,937 ft)
Shortest possible range ..... 1 m (3.28 ft)
DR Extended Range Mode
White Card (90% reflective)[4] ..... 2,200 m (7,218 ft)

Scanning

Range[3, 4] ..... from 1 m up to 250 m (3.28 ft–820 ft)
Speed[5] ..... up to 15 points/sec
Minimum point spacing ..... 10 mm (0.032 ft)
Standard deviation ..... 1.5 mm @ ≤50 m (0.0049 ft @ ≤164 ft)
Single 3D point accuracy ..... 10 mm @ ≤150 m (0.032 ft @ ≤492 ft)

EDM SPECIFICATIONS

Light source ..... Pulsed Laser diode 905 nm
Beam divergence
Horizontal ..... 2 cm/50 m (0.06 ft/164 ft)
Vertical ..... 4 cm/50 m (0.13 ft/164 ft)

SYSTEM SPECIFICATIONS

Leveling

Circular level in tribrach	8'/2 mm (8'/0.007 ft)
Electronic 2-axis level in the LC-display with a resolution of	0.3" (0.1 mgon)

Laser class

EDM	Laser class 1
Laser pointer coaxial (standard)	Laser class 2
Overall product laser class	Laser class 2

Servo system

MagDrive servo technology	Integrated servo/angle sensor electromagnetic direct drive
Rotation speed	115 degrees/sec (128 gon/sec)
Rotation time Face 1 to Face 2	2.6 sec
Positioning speed 180 degrees (200 gon)	2.6 sec
Clamps and slow motions	Servo-driven, endless fine adjustment

Centering

Centering system	Trimble 3-pin
Optical plummet	Built-in optical plummet
Magnification focusing distance	2.3×/0.5 m to infinity (1.6 ft to infinity)

Telescope

Magnification	30×
Aperture	40 mm (1.57 in)
Field of view at 100 m (328 ft)	2.6 m at 100 m (8.5 ft at 328 ft)
Focusing distance	1.5 m (4.92 ft) to infinity
Illuminated crosshair	Variable (10 steps)
Autofocus	Standard

Camera

Chip	Color Digital Image Sensor
Resolution	2048 x 1536 pixels
Focal length	23 mm (0.09 ft)
Depth of field	3 m to infinity (9.84 ft to infinity)
Field of view	16.5° x 12.3° (18.3 gon x 13.7 gon)
Digital zoom	4-step (1x, 2x, 4x, 8x)
Exposure	Spot, HDR, Automatic
Brightness	User-definable
Image storage	Up to 2048 x 1536 pixels
File format	JPEG
Compression ratio	User-definable
Video streaming[9]	5 frames/sec

Power supply

Rechargeable Li-Ion battery	10.8 V, 6.5 Ah
Operating time[10]	
One internal battery	Up to 6.5 hours
Three batteries in multi-battery adapter and one internal	Up to 26 hours

Weight and dimensions

Instrument (Autolock)	5.4 kg (11.35 lb)
Instrument (Robotic)	5.5 kg (11.57 lb)
Trimble TCU5 controller	0.44 kg (0.97 lb)
Tribrach	0.7 kg (1.54 lb)
Internal battery	0.35 kg (0.77 lb)
Trunnion axis height	196 mm (7.71 in)

Other

Operating temperature	–20 °C to +50 °C (–4 °F to +122 °F)
Storage temperature	–40 °C to +70 °C (–40 °F to +158 °F)
Dust and water proofing	IP65
Humidity	100% Condensing
Communication	2.4 GHz, USB, Serial, Bluetooth®[11]
Security	Dual-layer password protection, L2P[12]

Trimble S7 TOTAL STATION

AUTOLOCK AND ROBOTIC SURVEYING

Autolock and Robotic Range[7]
- Passive prisms . . . 700 m (2,297 ft)
- Trimble MultiTrack Target . . . 800 m (2,625 ft)
- Trimble ActiveTrack 360 Target . . . 500 m (1,640 ft)

Autolock pointing precision at 200 m (656 ft) (Standard deviation)[6]
- Passive prisms . . . <2 mm (0.007 ft)
- Trimble MultiTrack Target . . . <2 mm (0.007 ft)
- Trimble ActiveTrack 360 Target . . . <2 mm (0.007 ft)

Shortest search distance . . . 0.2 m (0.65 ft)
Type of radio internal/external . . . . 2.4 GHz frequency-hopping, spread-sprectrum radios
Search time (typical)[8] . . . 2–10 sec

FINELOCK

Pointing precision at 300 m (980 ft)
- (standard deviation)[7] . . . <1 mm (0.003 ft)
- Range to passive prisms (min–max)[7] . . . 20 m–700 m (65 ft–2,297 ft)

Minimum spacing between prisms
- at 200 m (656 ft) . . . 0.5 m (1.65 ft)

GPS SEARCH

GPS Search . . . 360 degrees (400 gon) or defined horizontal and vertical search window
Solution acquisition time[13] . . . 15–30 sec
Target re-acquisition time . . . <3 sec
Range . . . Robotic range limits

1 Standard deviation according to ISO17123-3.
2 Standard deviation according to ISO17123-4.
3 Target color, atmospheric conditions, and scanning angles will impact range.
4 Kodak Gray Card, Catalog number E1527795.
5 Target shape, texture, and color; grid size; and distance and angle to target; will impact speed.
6 Standard clear: No haze. Overcast or moderate sunlight with very light heat shimmer.
7 Range and accuracy depend on atmospheric conditions, size of prisms and background radiation.
8 Dependent on selected size of search window.
9 0.5 frames per second with remote operation.
10 The capacity in –20 °C (–5 °F) is 75% of the capacity at +20 °C (68 °F).
11 Bluetooth type approvals are country specific.
12 Functionality and availability dependent on region.
13 Solution acquisition time is dependent upon solution geometry and GPS position quality

Specifications subject to change without notice.

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