Standing Project Instructions For CO-OPS Observing Systems

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Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration

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Introduction

The National Oceanic & Atmospheric Administration (NOAA) is a bureau of the U.S. Department of Commerce (DOC). The NOAA mission is to understand and predict changes in the Earth's environment, and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs. NOAA's vision in supporting this mission is that of an informed society that uses a comprehensive understanding of the role of the oceans, coasts, and atmosphere in the global ecosystem to make the best social and economic decisions.

The Center for Operational Oceanographic Products and Services (CO-OPS) of the National Ocean Service (NOS) is an organizational element of NOAA. CO-OPS operates and maintains a network of long-term observing system measurement stations around the coastal United States and the Great Lakes as part of the National Water Level Observation Network (NWLON). The NWLON supports the NOAA Mission of Science, Service, and Stewardship:

- To understand and predict changes in climate, weather, oceans, and coasts.
- To share that knowledge and information with others.
- To conserve and manage coastal and marine ecosystems and resources.

CO-OPS also installs and operates other long term and short-term water level stations in support the following programs:

- Hydrographic and Photogrammetric Surveys
- Marine Boundary Determinations
- Treaty Regulation
- Harbor Dredging
- Climate Change
- Long-Term Sea Level Rise
- Habitat Restoration
- Real Time Navigation
- NOS VDatum Program

The Physical Oceanographic Real-Time System (PORTS®) is a partnership between NOS and local maritime communities to identify and satisfy community needs for improving the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. PORTS® have different sizes and configurations, each designed to meet local user requirements. PORTS® includes sensors, hardware, and associated communications systems, which allow the centralized, real-time data acquisition and the dissemination of water levels, currents, and other oceanographic and meteorological data. The modular design of each PORTS® installation allows the flexibility for integration of additional sensors to meet user requirements.

In carrying out the mission, CO-OPS performs the following:

- Establishes the standards for the acquisition and processing of water level and current data.
- Collects and documents user requirements that serve as the foundation for all resulting program activities.
- Designs new and improved oceanographic, meteorological, and current meter observing systems.
- Maintains and operates oceanographic, meteorological and current meter observing systems.
- Develops software to improve water level data processing capabilities.
- Performs operational data analysis and quality control.
- Produces and disseminates oceanographic products.
- Archives the resulting oceanographic data.

These Standing Project Instructions provide the recurring requirements for installation, operation, maintenance, and removal of observing systems (e.g. water level, meteorological and/or current meter stations) in support of the NWLON, PORTS®, Coastal Hazards (formerly the Resilience Program), hydrographic and photogrammetric survey operations, NOS VDatum and reimbursable special projects. These stations provide critical data to support the following activities:

- Ensure safe navigation
- Determine flow rates to support International treaties in the Great Lakes region
- Determine tidal datums for the National Nautical Charting Program and the National Shoreline Mapping Program
- Determine the baseline from which marine boundaries are delineated
- National Weather Service tsunami and storm surge warning programs
- Coastal resource restoration and management
- Analyses of high tide flooding and long-term sea level trends

Objective

The objective of these Standing Project Instructions is to ensure all the deployed observing systems are maintained in an effective and consistent manner for collecting continuous, reliable, and defect-free data. A major focus of this and future standing project instructions is to install stations and collect data as per the specific standards required to prevent equipment failures that result in data loss, and to monitor the long-term vertical motion of the sensor and bench mark network.

CO-OPS wishes to determine the mean time between failures of every major component deployed and to predict when that component will more than likely fail based on the operational history, location, deployment time, field performance and calibration test and results, the environment, manufacturer recommendations, and field party experience. Determining the mean time between failures will be an iterative process with the Engineering Division (ED) and the

Field Operations Division (FOD) working closely to refine the process and analyze the findings. We will modify our procedures in future years based on the analysis. Following these Standing Project Instructions as documented will support the analysis.

References

The following documents and engineering bulletins are referenced in various sections of the Standing Project Instructions. The latest version of the documents and bulletins can be found on the CO-OPS publication page http://tidesandcurrents.noaa.gov/pub.html, the CO-OPS Field Library http://tidesandcurrents.noaa.gov/fieldlibrary/Welcome, and/or the CO-OPS Reliable Operating Systems Library http://intranet.nos-tcn.noaa.gov/roslibrary/Welcome.

Water Level and Meteorological Observing Systems

Data Collection Platform (DCP) References

- Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, 1991.
- Sutron® Xpert Data Logger Operations and Maintenance Manual, 2012.
- Sutron® Xpert2 Data Logger Operations and Maintenance Manual, 2012.
- Sutron® 9210 XLite Operations and Maintenance Manual, 2006.
- Sutron® 9210B XLite Operations and Maintenance Manual, 2012.
- Sutron® Satlink 2 Logger & Transmitter Operations and Maintenance Manual, 2011.
- Xpert and Xpert Dark Internal Battery Replacement, 2011.
- Procedures for Requesting GOES Platform ID Allocations, 2014.
- NWLON GOES MESSAGE FORMAT
- NGWLMS GOES Message Formatting for Hourly Transmissions
- Attachment of Conduits to Enclosures, 2010.
- Engineering Bulletin 10-002 Standardize Battery Type for CO-OPS Water Level and Meteorological Stations with Photovoltaic Charging Systems, 2015.
- Engineering Bulletin 07-007 Downloading (Exporting) Data from the Xpert Log Files using Xterm, 2007.
- Engineering Bulletin 07-006 Exporting Data from Xpert Family DCP

Sensor References

- User's Guide for Model 4100/4110 Series Aquatrak®, 2006.
- Aquatrak® Calibration Procedure
- BEI® Series MT40 Multi-Turn Absolute Position Encoder
- Waterlog® H-334 Shaft Angle Encoder Manual
- ParoScientific® Digiquartz Pressure Instrumentation
- KPSI® Level and Pressure Transducer User's Manual
- Water Level Sensor Using the Sutron® Data Collection Platform, Ver 1.0

- WaterLog® H-3551 Gas Purge Bubbler Owner's Manual
- WaterLog® H3661 SDI-12 Radar Water Level Sensor
- Miros® Microwave Range Finder Technical Handbook
- Universal Laser® Sensor Hardware/Software Interface Specification
- Sutron® Accubar Barometric Pressure Multiple Interface Sensor Operations & Maintenance Manual, 2011.
- SOP 3.2.3.6.F3 RBR-CTD Setup and Data Retrieval, 2010.
- Castaway® CTD User's Manual
- Sutron® Barometer Calibration Procedure, 2020.
- RM Young® Model 05103 Wind Monitor User Manual, 2001.
- R.M. Young® Model 05103-45 Wind Monitor User Manual, 2000.
- Vaisala® FS11 User's Guide, 2002.
- Wind Sensor Alignment Procedures for the R.M. Young® Wind Monitor, 2005.
- YSI® Precision Thermistors and Probes
- Rotronic® Humidity Temperature Probe
- CO-OPS Sensor Specifications and Measurement Algorithms

Geodetic References

- User's Guide to Vertical Control and Geodetic Leveling for CO-OPS Observing Systems, 2018.
- User's Guide for Writing Bench Mark Descriptions, 2011.
- User's Guide for Electronic Levels with Translev and WinDesc, 2014.
- User's Guide for GPS Observations at Tide and Water Level Station Bench Marks, 2013.
- CO-OPS GPS Observations Implementation Plan, 2003.
- Standards and Specifications for Geodetic Control Networks
- NGS Attachment R, Requirements for Digital Photographs of Survey Control
- NGS Attachment T, Setting a Concrete Mark
- NGS Attachment U, Setting a Survey Disk in Bedrock
- NGS Attachment V, Setting a NGS 3-D Monument
- NGS Attachment X, Performing Bench Mark Ties
- Preliminary Step by Step Leveling Instrument Procedures, 2009.
- Leveling Frequency Requirements for Water Level Stations, 2011.
- Creating a Bench Mark Diagram in PDF Format, 2012.
- Procedure to Establish a Meteorological Sensor Reference Mark and to Measure Meteorological Sensor Heights, 2012.
- Level Rod Re-Calibration, 2011.
- SOP 3.2.3.12.3-L2 cGNSS Level Method, 2020

Installation and Maintenance Specifications and References

- National Water Level Observation Network (NWLON) Requirements
- Desktop Reconnaissance Procedure for Observing System Installation Planning, 2020.
- Field Reconnaissance Procedures for Observing System Installation Planning, 2020.

- CO-OPS Water Level and Meteorological Site Reconnaissance Procedures, 2012.
- Latest Project Instructions for Coastal and Great Lakes Water Level Stations
- CO-OPS Specifications and Deliverables for Installation, Operation, and Removal of Water Level Stations, 2017.
- Review Protocol for Contractor Submitted Deliverables from the Installation and Maintenance of CO-OPS Water Level and PORTS® Stations
- Upgrading an Existing Station or Installing a New Water Level Station, 2011.
- CO-OPS Evaluation Criteria for Water Level Station Documentation
- Annual Inspection Pre-Trip Coordination Meeting
- SOP 7.0.1 Updating Database Information after Annual Inspection or Unscheduled Maintenance
- Inside/Outside Water Level Check for the Great Lakes Gauging Station SOP
- Procedure to Establish a Meteorological Sensor Reference Mark and to Measure Meteorological Sensor Heights, 2012.
- Field Installation Procedures for Design Analysis WaterLog® H3611i Microwave Radar, 2013.
- SOP 6.3.2.1.4 Water Temperature Comparison, 2011.
- SOPs 5.4.1.4(A1) and 5.4.1.4(A2) Barometer Calibration Procedures, 2020.
- SOP 6.3.2.1.3 Maintenance Procedure for Visibility Sensor Cleaning and Calibration Check, 2011.
- SOP 6.3.2.1.12 Battery Load Testing Procedures for CO-OPS Water Level Observation Systems
- CO-OPS Guide to Declaring a Newly Installed Water Level Station Operational, 2017.
- Guide for Declaring Newly Installed Meteorological and Physical Oceanographic Sensors and Stations Operational
- CO-OPS Meteorological Reconnaissance Form
- SOP 2.2.2.2.A Air Gap Field Installation Guide, 2014.
- SOP 4.3.1.1 (A34) Universal® Laser Sensor
- SOP 4.3.1.1 (A33) Miros® Microwave Range Finder
- SOP 3.1.1.5 Conductivity, Temperature, and Density (CTD) Observations Analysis, 2015.
- SOP 3.2.3.9.132 Engineering Bulletin 17-003 Standardize the Number of Digits for Transmitting Conductivity Data, 2017.
- Requirements and Guidelines for Equipment Shipping, 2008.
- CO-OPS eSite User's Guide, 2013.
- CO-OPS Equipment Return Form
- Engineering Bulletin 09-001 *Create Water Temperature Sensor Replacement Cycle*
- Engineering Bulletin 09-003 *Update to Xpert Log File Sizes*, 2009.
- SOP 3.2.3.12.3-L3 cGNSS Metadata Documentation, 2020.
- 3.2.3.12.3-L1 NOAA CO-OPS Continuous Global Navigation Satellite Systems at NWLON Stations - System Design Description, 2020.

Current Meter Observing Systems

Data Collection Platform (DCP) References

- CO-OPS Current Meter Reconnaissance Procedures, 2008.

Sensor References

- User's Guide for the Nortek® Aquadopp Current Profiler, 2008.
- User's Guide for the TRDI® Workhorse Sentinel Acoustic Doppler Current Profiler
- SonTek® Acoustic Doppler Profiler Operations Manual, 2001.

Installation and Maintenance Specifications and References

- Field Installation Guide for Current Profiler-Xpert Interface
- Equipment and Tools for Installation of Real-Time Currents, 2012.
- Site Preparation and Checklist for Real-Time Currents, 2012.
- *From Step 3* (B14) HFRSCM Computer Setup Checklist
- *From Step 3* (B20) HFRSCM Seasonde Initial Startup Checklist
- Anti-Fouling Procedures for Current Meters, 2011.
- Aton Assembly Checklist

Safety References

- Department of Commerce Occupational Safety and Health Manual
- NOAA Safety Policy, NAO 209-1
- NAO xxx-xxx NOAA Charter Vessel Safety (rev.1)
- Survey Safety Handbook, Florida Department of Transportation
- OSHA Diving Safety Regulations

Environmental Compliance References

- NOAA NAO 216-6A Companion Manual-1-13-2017
- CO-OPS Environmental Compliance Policy
- CO-OPS Environmental Compliance Handbook
- CO-OPS Environmental Checklist, 2020

Part A: REQUIREMENTS FOR RECONNAISSANCE, INSTALLATION, OPERATION, MAINTENANCE, AND REMOVAL OF WATER LEVEL AND METEOROLOGICAL STATIONS

The following sections point to the requirements for the reconnaissance, installation, operation, maintenance, and removal of water level and/or meteorological stations.

The term field party is defined as a person or field team that performs any of the following tasks: reconnaissance, installation, maintenance, repair, relocation, or removal of a water level and/or meteorological station. The field party could be CO-OPS personnel, NOAA ship personnel, Office of Coast Survey (OCS) Navigational Response Teams (NRT), other NOAA personnel and commercial contractors, or Indefinite Deliverables Indefinite Quantity (IDIQ) Contractors.

Reconnaissance

The reconnaissance for new stations installations and major modifications at existing for water level and meteorological stations shall be performed in accordance with *Desktop Reconnaissance Procedure for Observing System Installation Planning* and *Field Reconnaissance Procedures for Observing System Installation Planning*. A detailed reconnaissance report is required and shall be submitted to the CO-OPS Configuration and Operational Engineering Team (COET), the supporting Field Operations Division (FOD), and Contracting Officer's Representative (COR), if applicable, within ten calendar days of the end of the reconnaissance trip or as defined in the agreement or contract. This report shall contain all relevant information to include station design heights, photographs, sketches, and field notes. A detailed installation plan must be submitted to the COET, the supporting FOD office, and the COR, if applicable, at least 90 calendar days prior to station installation. The installation plan shall detail the objective, scope, permits (if applicable) and permissions, materials, procedures, the installation schedule and communications plan.

All new CO-OPS station installations and major modifications will undergo an engineering design and review. FOD and CO-OPS' IDIQ contractor engineered design packages for station installations and upgrades; shall be reviewed and approved by the CO-OPS Field Engineering Review Subcommittee (FERS) before any work actually begins on the site.

Safety

The field party shall be responsible for security and/or protective measures, as required, for protecting the government furnished equipment, field party, and the facility while installing, maintaining or removing a station. Field parties are required to adhere to all OSHA safety regulations including wearing personal protective equipment (PPE) and using required specialized safety equipment when performing maintenance tasks at CO-OPS observing stations and completing the required specialized training such as tower climbing, confined space entry NOAA Working Diver, etc.

Permits

The field party, or the Project Lead as appropriate, shall obtain all required agreements, permits and permissions using CO-OPS approved agreement templates (found on the ROS web page for in-house projects, or available via the COR for contract installations) for the installation of the water level sensor(s), DCPs, bench marks, and utilities, as required. The field party or the Project Lead as appropriate must also provide copies of signed agreements, permits, and permissions to CO-OPS COET and the supporting FOD office as part of the observing system installation metadata deliverables.

Environmental Compliance

Field parties are responsible for conducting an environmental impact analysis and preparing the appropriate environmental compliance documentation. CO-OPS FOD is responsible for discussing with the Environmental Compliance Coordinator (ECC) any compliance requirements and documentation required related to the installation, relocation, maintenance and/or upgrade of an observing system. FOD is responsible for completing and submitting the Best Management Practice (BMPs) as part of the station package deliverable for all types of station visits (install, scheduled maintenance, unscheduled maintenance, relocation, upgrade, or removal). For IDIQ Contractor field installation and/or maintenance, the IDIQ Contractor is responsible for ensuring all compliance requirements are met, documented, and submitted to CO-OPS as part of the installation, relocation, or upgrade station package deliverable. Refer to the CO-OPS Environmental Compliance Policy for further guidance.

Water Level Sensor Specifications

The following sections describe the specifications for the water level sensors used at CO-OPS water level stations. Refer to the *Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual* for more information. For sensor averaging and sampling specifications, refer to *CO-OPS Sensor Specifications and Measurement Algorithms*. CO-OPS NWLON and long-term water level stations are configured with a primary and a backup DCP and water level sensors, GOES transmitter, and may include oceanographic and/or meteorological sensors. If an NWLON or long-term water level station uses any other configuration, a waiver request for Non-standard Sensor Configuration must be submitted to the CO-OPS Observing System Manager (OSM) prior to installation.

Primary Water Level Sensor

The following primary water level sensors are approved for use at CO-OPS water level stations:

- WaterLOG® Microwave Water Level (MWWL) Radar sensor (Model NOAA Nile, NILE 502, NILE 517, H-3611, H-3612)
- ParoScientific® pressure sensor(s) tied into a single or dual orifice gas purged bubbler system (Model 6000-30G/P/N 1612-002)
- BEI Motion Systems Absolute Shaft Angle Encoder® (SAE) with Electronic Tape Gauge (ETG) (Model M40D-X-HSS1024N-64TXD13-X-S-C14-X-12) (Great Lakes only)

- Aquatrak® self-calibrating air acoustic sensor (Model 3003-XCR-4)

For NWLON water level data, the water level sensor resolution requirement is 1mm or better for the approved sensors. For hydrographic and photogrammetry surveys, the required water level sensor resolution is a function of the tidal range in the area where water level data is collected. When the tidal range is less than or equal to 5 m, the required water level sensor resolution shall be 1mm or better; when the tidal range is between 5 m and 10 m, the required water level sensor resolution shall be 3 mm or better; and when the tidal range is greater than 10 m, the required water level sensor resolution shall be 5mm or better.

The primary sensor measurement range shall be greater than the expected range of water level and the installation shall be designed to measure the full range of extreme water levels such as highest observed and lowest observed water level data. The highest observed water level may have an additional wave allowance value added as determined by CO-OPS' Engineering Division (ED) or as obtained from the NWS SLOSH models.

The orientation and elevation of the primary sensor shall be carefully documented in elevation (side) view sketches and photographs, as required. The orientation of the protective well, orifice, or sump and intake (applicable to the Great Lakes stations only) with reference to nearby pilings, bulkheads, or other structures in the water shall be photographed and documented. All features in the vicinity of the protective well such as, pilings, other wells, decking, buildings (tide house), etc., which might cause uneven sun/shading of the well and resulting in non-uniformity of temperature inside the well shall also be well photographed and documented. For MWWL sensors, features or potential interferences with the MWWL beam shall be documented with photos and measurements. This should include the Envelope Curve and sensor parameters. The envelope curve should be collected during any new MWWL installation, after changes to sensor mounting/location, or if any changes to the physical area below the MWWL is made (such as installation of conduit or other components) such that it has potential to impact the MWWL beam and could cause interference.

Known error sources for each sensor shall be handled appropriately through ancillary measurements and/or correction algorithms. Examples of such errors are water density variations for pressure gauges, sound path air temperature differences for acoustic systems, physical obstructions and ice buildup for microwave sensors, and high-energy wave climate and high velocity currents for all sensor types. At a number of NWLON stations, dual air purged orifices which are mounted a fixed vertical distance apart and connected to two vented ParoScientific® pressure transducers are used to calculate a density correction for each sample based on the pressure difference and known gravity.

The appropriate sensor type will be determined after the reconnaissance of the site is completed and the site is approved. CO-OPS' approval (Branch Chiefs and Chief Scientist) of the water level sensor type selected for each project is mandatory.

Aquatrak® Sensor

The Aquatrak® acoustic sensor is configured at some of the tidal NWLON water level

stations as the primary water level sensor. This sensor is being replaced with the MWL sensor as per the MWWL Transition to Operations (TOP) plan. The sensor and calibration tube are located in CO-OPS designed top hat and protective well assembly with parallel plates installed at the bottom of the well to reduce wave and currents effects. The Aquatrak® must be mounted to a structure with substantial vertical stability that allows the protective well to be properly secured to avoid sensor movement. Aquatrak® sensors are calibrated prior to deployment, and connected to the bench mark network via leveling during the installation. A sensor calibration check is performed following the removal of the sensor. The calibration standard accuracy of the sensor is traceable to the National Institute of Standards and Technology (NIST) http://www.nist.gov/calibrations/.

ParoScientific® Sensor

At NWLON stations where the acoustic or microwave radar sensor cannot be used as the primary water level sensor due to the freezing of the waters' surface or the lack of a suitable support structure, a dual ParoScientific® intelligent pressure sensor with a gas purged bubbler system is a standard method to meet CO-OPS NWLON water level measurement accuracy requirements. If a dual orifice Paros system cannot be installed at a particular location, an alternative solution may be proposed as a non-standard configuration. This may include utilizing a combination of microwave and ParosScientific® sensors or the installation of a CT sensor to measure in situ density for a minimum of 1 year to demonstrate that climatological density enables meeting the NWLON accuracy requirements. If significant climatological density monthly variation is observed after collecting and analyzing 1-year CT sensor data, or the difference between the primary sensor (MWWL/Aquatrak) and the pressure sensor exceeds average monthly water level means (or datums) by 2cm, additional instructions will be provided on a case by case basis in the Dynamic Project Instructions.

At VDatum, Hydro/Remote Sensing, partner stations, PORTS, and special project stations, a single orifice ParoScientific® sensor with a gas purged bubbler system is authorized to be installed as a primary water level sensor.

Microwave Radar Sensor

A WaterLog® microwave radar sensor (aka, Microwave Water Level Sensor, or MWWL) can be installed when suitable support infrastructure is available and environmental conditions permit (i.e. no icing, etc.). The sensor must be installed with a clear, unobstructed view of the water surface and away from any structure that could cause multipath problems with the sensor readings. The sensor mount, cone length and top hat design will be identified during the review of the reconnaissance report.

CO-OPS is implementing the MWWL transition to operations plan. For an existing water level station, the MWWL transition involves three parts:

- Year 1: equipment is procured; site reconnaissance is performed; station and system designed; system test completed; station installation design is approved by FERS.

- Year 2: MWWL sensor installed and leveled; simultaneous data comparison of the MWWL sensor and existing primary water level sensor begins.
- Year 3: Simultaneous data comparison is complete and transition of the sensor approved; stability of both sensors validated; legacy primary water level sensor is removed and MWWL sensor is assigned as primary.

BEI® Motion Systems Absolute Shaft Angle Encoder (SAE)
A sump with a float driven absolute shaft angle encoder is used as the primary water level sensor at the Great Lakes stations. The BEI SAE shall be set to read the same as the ETG and checked against the ETG during each site visit.

Sensor Data Requirements for Tsunami Measurement
NWLON and other water level stations installed and supporting the NOAA Tsunami Program shall have 1-minute averaged water level data collected in addition to the 6-minute data in the primary DCP.. The 1- minute averaged data will be derived from the primary water level sensor during non-storm surge events. In addition, 15-second data from the backup or redundant sensor shall also be made available in the event of a tsunami, or on request from the National Weather Service (NWS) Tsunami Warning Centers, or Pacific Marine Environmental Laboratory of NOAA's Office of Atmospheric Research (OAR).

Due to the sump and intake providing a natural dampening to wave action, 1-minute data are not collected at stations in the Great Lakes.

As field crews update the Platform ID on site, the tsunami warning center that queries 1-minute water level data directly via the Platform ID will experience data-loss. Therefore, when transmission parameters are updated and/or changed at a NWLON or long-term water level stations, an email must be sent to nos.co-ops.platformid-updates@noaa.gov, in accordance with SOP 7.0.1 Updating Database Information after Annual Inspection or Unscheduled Maintenance.

Backup or Redundant Water Level Sensor
The backup and redundant sensors used at a CO-OPS water level station is one of the following:

Backup Sensors
- Druck® pressure sensor tied into a single gas purged bubbler system (Model DPI 740)
- KPSI® pressure sensor (Model 500-T)
- Compact Constant Flow Bubbler (Part #56-0133-25-1ST)

Redundant Sensors
- ParoScientific® pressure sensor with a single orifice gas purged bubbler system (Model 6000-30G/P/N 1612-002)
- WaterLOG Microwave Radar (MWWL) sensor (Model NOAA NILE, NILE 502, NILE 517, H-3611, H-3612)
- WaterLOG Shaft Angle Encoder (H-344-2N)

Generally, CO-OPS requires and uses a different sensor technology for the backup sensor

than one used for the primary sensor. There are cases where a redundant sensor (e.g. two ParoScientific sensors or two MWWL sensors) may need to be installed based upon the unique situation at a site, environmental constraint, or cost. In those cases, a waiver from this general requirement shall be submitted to the ED chief through the Observing System Manager (OSM).

At tidal water level stations, the redundant water level bubbler orifices shall be secured structurally independent of the primary water level sensors (i.e. on a separate piling, etc.) so in case of a failure of one structure, the other sensor installed on a different piling will survive and provide continuous data till repairs are made. At Great Lakes stations, the Waterlog SAE shall be set to read the same as the ETG and the primary SAE.

Data Collection Platform

The primary Data Collection Platform (DCP) shall acquire and store water level measurements every 6 minutes. The water level measurements shall be an average of discrete water level samples with the average centered on the six-minute mark (e.g. 00, 06, 12, etc.). In addition to the average measurement, the standard deviation of the discrete water level samples and outliers that comprise the six-minute measurements shall be computed, stored, and transmitted. The six-minute, centered average, water level data and the standard deviation provide valuable data quality information regarding each measurement. Refer to the *CO-OPS Sensor Specifications and Measurement Algorithms* for details on the averaging schema for each CO-OPS approved sensor.

The backup and/or redundant DCP shall be installed in case of a failure of the primary DCP. The DCP also shall acquire and store water level measurements every six-minutes. The backup and redundant water level sensor measurements shall be consistent with the measurement algorithms for the discrete water level samples with the period of the average centered about the six-minute mark (e.g. 00, 06, 12, etc.) in accordance with the reference *CO-OPS Sensor Specifications and Measurement Algorithms*. In remote locations the redundant DCP may be equipped with a means to transmit data independent from the primary DCP.

The primary and redundant DCPs shall have a capacity to store at least 18 months of six-minute water level data and meteorological sensor data, as applicable. Flash memory storage devices may be appropriate for storing the 15-second data. The sizes of the data files (minimum number of day's data) for 6-minute water level data (SSP.LOG), 1-minute tsunami data (TSU1MIN.LOG), 15-second tsunami data (15SECTSU.LOG), and system log data shall be collected according to *Engineering Bulletin 09-003 Update to Xpert Log File Sizes*. Sizes of the Xpert Log Files (SSP.log, TSU1MIN.log, and System.log) shall be configured according to the Engineering Bulletin 09-003 *Update to Xpert Log File Sizes*.

GOES Satellite Transmissions

The ability to monitor system performance for near real-time quality assurance is essential for operations. Water level data transmitted via satellite in NOS format is retrieved and monitored by CO-OPS, and in the case of data gaps, sensor or gauge problems, corrective actions are taken immediately. Per CO-OPS policy, at all sites where access to the GOES satellite is available,

the measurement system shall be equipped with a GOES transmitter to telemeter the data to CO-OPS. When GOES is not accessible, a phone line (POTS), IP modem,, or Iridium® data modem may be installed for data transmission.

NWLON, PORTS® and long-term stations generally have GOES transmissions as the primary means of communications and phone lines, cellular technology (IP modems), Iridium® data modems, etc., as secondary means of telemetry and remote communications with the DCP for diagnostics and data retrieval. CO-OPS is planning to use SBD Iridium modems as the primary means of data communication and transmission and the effort was started in FY 20 and will be estimated to be completed by the end of FY 29 on the assumption that the GOES systems will not accommodate data transmission at that time.

Data not transmitted by GOES but submitted to CO-OPS via secured electronic media (i.e. flash memory storage cards) must also conform to the format specified in accordance with *CO-OPS Specifications for the Installation, Operation, Maintenance, and Removal of the Water Level Stations* so data can be loaded properly into Data Management System (DMS).

The Continuous Operational Real-Time Monitoring System (CORMS) is a 24 x 7 data monitoring operation. It monitors all water level measurement system data transmitted via GOES, IP modem, BGAN, POTS etc., to ensure the gauges are operating properly.

Data Transmission Initiation and Station Database Configuration Requirements

The CO-OPS' ED Systems Support and Evaluations Branch (SSEB) maintains the GOES platform ID list for all observing systems. For new stations, once the location, type of sensors, and number of DCPs are selected, COET will assign a station ID and SSEB will assign the GOES platform ID and provide the satellite configuration data for the deployment.

When the station location (latitude and longitude) along with the local name and body of water being measured have been identified at least 15 business days before required throughput testing of the observing system, COET will assign and provide a station number(s) for the water level station. At a later date, if the field party determines the initial location is not suitable, then the field party shall identify a new location and provide COET the GPS derived latitude and longitude for the calculation of a new station id (if the location is greater than 0.5 mile from the original location).

Requests for GOES platform IDs shall be submitted to CO-OPS Plat ID Manager and the Chesapeake Instrument Lab (CIL) at least three business days before throughput testing to allow sufficient time to receive assignments. Refer to the *Procedures for Requesting GOES Platform ID Allocations* for procedures on requesting a platform ID.

The field party shall follow the appropriate throughput testing requirements as described in *SOP 3.2.3.5 Upgrading and Installing a New Water Level Station*. A standard 24-hr

duration of data throughput where the ingested data is continuous is required to complete a throughput test.

Obtaining and Recording Positions of Stations, DCP, Sensors, and Bench Marks Using a Hand-Held GPS Receiver

Latitude and longitude of the station, DCP, all sensors, and bench marks shall be obtained using a hand-held GPS receiver and recorded in degrees, minutes, seconds, and tenth of seconds (e.g. 45 degrees, 34 minutes, 32.6 seconds). The positions of the primary and backup DCP and all sensors that are installed in a tide house (gauge house) shall be recorded as that of the station. For barometers that are generally installed in the tide house, report the latitude and longitude as that of the station, and report the elevation of the sensor above station datum derived from leveling. This position will be obtained in front of the tide house (gauge house) at the center of the front door/front wall of the tide house (gauge house). The front portion of the roof of the tide house (gauge house) may also be used, as applicable, if the GPS satellites are blocked by the structure.

For Aquatrak® or Microwave Water Level sensors, obtain the positions of the sensors at the center of the sensor. For ParoScientific® sensors, obtain the position of the sensor(s) at the sensor Leveling Point (LP). If the Aquatrak® sensor, ParoScientific® sensor, BEI® Motion Systems Absolute Shaft Angle Encoder® sensor, or Waterlog® Relative Shaft Angle Encoder sensor is installed inside a tide house (gauge house), then report the position as that of the station, but report the elevation of the sensor (s) above station datum (or IGLD for Great Lakes stations).

For the bench marks, obtain positions using the handheld GPS receiver by placing the receiver on the (horizontal) bench mark. For a bench mark that is installed vertically, obtain the positions as close to the mark as satellite coverage will allow.

Handheld GPS units come with either patch antennas or quadrifilar antennas. The proper method for holding the GPS unit is vertically if the unit has a quadrifilar antenna, or horizontally if the unit has a patch antenna. Holding the unit otherwise will degrade the reception of the satellite signals and reduce the accuracy of the position obtained.

Take a photo of the GPS unit display for each location acquired and submit it with other documents. This will provide verification of the latitude and longitude entered into the eSite report.

Photographs

Photographs of the observing system (station, DCP(s), sensor(s), well, supporting structure, equipment, and bench marks) shall be taken and submitted. See Appendix A for example photographs of the water level station components. Station photos shall be taken when significant station configuration upgrade/downgrade has taken place or if the station has been relocated.

GPS photos shall be taken according to the *User's Guide for GPS Observations at Tides and*

Water Level Station Bench Marks.

A minimum of four photos for each bench mark shall be taken: close-up of the disk face featuring the handheld GPS device for verification of coordinates; chest or waist level view of the disk and setting; and horizontal views of the location of the bench mark from two different (perpendicular) cardinal directions. All digital bench mark photo files should be named such that the name of the file will indicate the station number, dash, PID number (if available), dash, stamping or designation, dash, photo type, dash, date,.jpg. For a new mark, the PID is not applicable. A close-up photo showing the face and stamping of the bench mark is photo type 1; a chest or waist level photo showing the bench mark and its setting is photo type 2; and a horizontal view of the bench mark showing nearby landmarks are photo type 3 and type 4. For photo type 3 and type 4 include the cardinal direction (N, NE, S, SE, etc.) that the camera is pointing. If more than one type of photo is taken for a given view, then rename them as 1A, 1B, 2A, 2B, 3A, 3B, etc. If a PID is available, then use the designation instead of the stamping for the naming of the file. Use a maximum of 30 alphanumeric characters to the left of the dot of the file name. If you are exceeding 30 alphanumeric characters in the name, then truncate the stamping or designation so that the maximum number of characters in the name are 30 (including spaces and hyphens). For example, the bench mark E close-up photo for the Seattle water level station should be named as 9447130-7130E1990-1-20090101.jpg.

Sample file names for photo files:

Disk face photo of a new bench mark without a PID	9414290-4290A2008-1-20090101.jpg
Eye level view photo of an existing bench mark with a PID	9410660-DY2512-BM N-2-20090101.jpg
North direction photo of an existing bench mark without a PID	9447130-7130E1990-3N-20090101.jpg

In addition, place a caption on each photograph, indicating the stamping or designation of the mark, the PID, the photo type with cardinal direction, and the date of photograph taken.

Photos shall also be taken of station components such as protective wells, staffs, tide house(s), shelter(s), met towers, DCPs, sensors, etc. One general location photo shall be taken showing the observing system in relationship to its supporting structure and the local body of water.

All digital station and equipment photographs shall be submitted in JPEG format. All digital station photo files should be named such that the name of the file will indicate the station number and the type of photo taken. For example, the acoustic sensor photo for DCP1 at Los Angeles shall be named as 94106601D.jpg. Refer to Appendix A and Appendix B for sample images of station photos.

The station components and bench mark photographs are required when a new station is

installed. For existing stations, the station and/or bench mark photographs shall be updated whenever any changes are noticed, such as damaged infrastructure, damaged bench mark disk, or changes to settings, scenery, etc., or as requested in the station specific requirements section of the Dynamic Project Instructions. Photographs of the underwater components showing the amount of marine fouling shall be taken when dive operations or wading is performed.

Bench mark, station, sensor and equipment photographs shall be free of persons, tools, vehicles, debris, graffiti and other materials, to the best of the photographer's ability. Personnel appearing in photographs should be properly clothed and equipped with the proper Personal Protective Equipment (PPE) as required for the task executed. These photographs are often placed on the CO-OPS website, included in outreach materials and disseminated to the public for various purposes, and should be appropriate for such uses. Photos must be taken during daylight and must be properly focused.

Meteorological and Ancillary Sensors Specifications

All meteorological and ancillary sensors shall be installed and maintained according to the sensor reference provided in the Sensor Reference section above.

Meteorological and Ancillary Sensors

For more comprehensive list of approved sensors specifications and measurement algorithms, see https://tidesandcurrents.noaa.gov/publications/CO-OPS_Measurement_Spec.pdf

Below is a summary of the approved sensors listed in the CO-OPS_Measurement_Spec.pdf mentioned above.

- R.M. Young® Wind Monitor (Model 05103), the R.M. Young® Alpine Monitor (Model 05103-45), and Vaisala Ultrasonic® Wind sensor (Model WS425 or WMT700)
- Sutron Accubar® Barometric Pressure Sensor (Model 5600-0120-1)
- Yellow Springs Instrument Company® (YSI) water temperature thermistor
- Yellow Springs Instrument Company® (YSI) air temperature thermistor
- Greenspan® Analog Conductivity (CT) sensor (Model EC3000) or a Sea-Bird® digital CT sensor (Model 37 SMP)
- WaterLOG® (Model H-3612 and NILE 517) and Miros® Air Gap sensor (Model SM094 with a Universal Laser (Model 7005400)
- Vaisala® visibility sensor (Model FSA11 or FDA13) or Vaisala® visibility sensor (Model PWD20/22)
- Rotronic® Hygroclip humidity and temperature sensor (Model HC2-S3 or E3-05XX-ACT/01), Vaisala® HMT337 or HMP243, or Sutron® HC2-S3

Wind Sensor

The anemometer is the R.M. Young® Wind Monitor, and/or the R.M. Young® Alpine Monitor, and/or Vaisala WINDCAP® Wind sensor. The wind sensors shall be installed in a dual wind configuration such that they are not obstructed in the direction of the prevailing winds. The arm

structure or goal post shall be also mounted perpendicular to the prevailing wind to ensure either sensor does not block the other sensor. The arm structure or goal post shall also be mounted at a distance far enough away from obstructions so turbulent wind coming off the obstructions does not affect the data. Wind sensors shall be aligned according to the reference document *Wind Sensor Alignment Procedure for the R. M. Young Wind Sensors*. The sensor height is measured above the MET Sensor Reference Mark (MET SRM).

Barometric Pressure Sensor

The barometer is a Sutron Accubar® gauge. The barometer shall be installed such that it is properly vented to the outside air. The sensor height is measured above Station Datum.

Water Temperature and Air Temperature Sensors

The water temperature is measured using a standard YSI® water temperature sensor probe. The sensor height is measured above Station Datum. The air temperature is measured using a standard shielded YSI® thermistor. The air temperature sensor height is measured above MET SRM.

Air Gap Sensor

The WaterLOG® or the Miros® pulsed radar water level sensor with frequency range of 26 GHz is installed with a clear, unobstructed view of the water surface. The range finder waveguide / antenna for the H-3612/Nile 517 uses a standard 8.3"/11.10" horn that produces a 10°/8° beam angle. Air Gap systems are also installed with a Universal Laser® Sensor (ULS) used for real-time monitoring and system verification. For new PORTS installations, the standard air gap configuration is two microwave radar sensors with data collection platform each; mounted side-by-side or near each other (preferably within 2 feet); the second microwave sensor will be used as a backup sensor. The installation location of the air gap sensor with respect to the channel must be documented in the eSite report, and a sketch indicating the location of the sensor relative to the center of the channel must be documented. The sensor height is measured above the agreed upon Low Steel structure as described in the *SOP # 3.2.3.5 (E23) Air Gap Database Configuration and Offset Calculation.*

Conductivity Sensor (CT)

A Pentair/Greenspan® analog conductivity sensor, Seabird® or Falmouth® digital conductivity sensor is used to obtain water temperature and conductivity for salinity and specific gravity calculations. The CT sensor shall be installed such that it can be easily raised and lowered through a protective well for cleaning and servicing. The sensor height is measured above MET SRM.

Visibility Sensors

Meteorological optical range is measured using a Vaisala® optical visibility sensor. The visibility sensors used both must employ the same optical sensor and principle of measurement. The sensor height is measured above MET SRM.

The FS11 sensor consists of a transmitter and receiver mounted at a fixed distance from each

other that measure the visibility of a volume of air in front of the sensor. The sensor head contains an external temperature sensor that is used as a reference and to control the hood heaters that house the transmitter and receiver. This sensor has hood and lens heaters for operations through weather events (sleet, ice, snow). The sensor head is mounted on an 8-foot sensor mast with mounting base. An electronics/controller box is used for power and is mounted midway on the mast.

The PWD20/22 is a fixed J-shaped sensor with the transmitter and receiver units with lens heaters on each end. The system includes a mounting bracket with an adjustable circular opening that can be attached to a range of different size cylindrical masts.

Meteorological and Ancillary Sensor Metadata

The meteorological sensor site selection and measurement guidelines are listed in the *CO-OPS Water level and Meteorological Site Reconnaissance Procedures* and the *Procedure to Establish a Meteorological Sensor Reference Mark and to Measure Meteorological Sensor Heights*.

Specific metadata for ancillary sensors is required as detailed below. The field party shall make note of this metadata in the Ancillary Sensor fields in the eSite report, the sensor elevation drawing and the scheduled maintenance checklist.

Metadata documentation shall be completed during the installation, scheduled maintenance, or unscheduled maintenance visits, as appropriate, for all stations with meteorological and ancillary sensors.

A unique MET SRM, representing the ground, must be selected at stations with meteorological sensors and all the required measurements can be referenced to the SRM. The SRM must be connected via digital leveling to the bench mark network. For stand-alone/remote MET stations where there are no bench marks to connect, the field party shall relate the SRM to MSL as described in the above mentioned reference. Ancillary sensor heights shall be updated in eSite report and the sensor elevation drawing with each leveling to the SRM and/or if the sensor is relocated. The SRM shall be included in the leveling run when a new SRM is established or the original SRM is relocated. The mark must be located within 10 feet of the sensors and no more than 0.5 ft. above grade. The MET SRM can be a bench mark disk or an identifiable feature (bolt, notch, etc.). In any case, the MET SRM must be identified and described in the WinDesc file.

Ancillary Sensor	**Sensor Elevation Reference Point**
Air temperature	Center of the sensor above MET SRM to the nearest +/- 15 centimeter.
Water temperature	Center of the sensor above the Station Datum as derived from subtracting the distance from the leveling point to the center of the sensor from the primary sensor datum offset, to the nearest centimeter.

Barometric pressure	Surface of the pressure port above Station Datum to the nearest +/- 15 centimeter. This sensor's height is derived via leveling.
Wind Speed/Direction/Gust	Center of the sensor above MET SRM to the nearest +/- 15 centimeter. Note any major physical obstructions near the sensor on the eSite report and scheduled maintenance checklist.
Conductivity	Center of the loop above Station Datum to the nearest centimeter.
Relative humidity	Center of the sensor above MET SRM to the nearest +/- 15 centimeter.
Air Gap	Sensor zero above the structure's low steel is determined from tape down measurements or from trigonometric levels to the nearest centimeter (if done by CO-OPS). Low Steel location and Offset information is generally provided by the PORTS partner coordinated by the PORTS Program Manager.
Visibility	Center of the sensor above the MET SRM (or above the water surface) to the nearest +/- 15 centimeter.

Photographs

Photos shall be taken of the supporting structure and all of the sensors installed. The photos should include as many of the four cardinal compass directions as possible, with the file name indicating the direction of the view, e.g. 87617241 Met tower south.jpg. Photos, MET SRM elevation and sensor elevations must be submitted by CO-OPS to the National Data Buoy Center (NDBC) in a timely manner before NDBC will accept the met data into its quality control process. Annual photos of the met tower and ancillary sensors are not required once the sensors have been installed. See Appendix A for examples of photos of the supporting structure and ancillary sensors.

cGNSS

CO-OPS has begun to install co-located continuous Global Navigation Satellite System (cGNSS) sensors at permanent water level stations. CO-OPS cGNSS is a unique and separate continuously operating real time vertical reference system from the Continuously Operating Reference System known as CORS operated by our sister program office, National Geodetic Survey (NGS). The unique proximity to the coastal environment with potential multipath signal errors and localized subsidence and uplift movement makes compliance with the rigorous CORS guidelines and post processing quality assurance analysis difficult. It is not the intention of CO-OPS to create a CORS compliant system. All CO-OPS GNSS antenna leveling must follow the leveling guide *NOAA CO-OPS Continuous Global Navigation Satellite Systems at NWLON Stations -*

System Design Description, 2020. All metadata collection should follow *cGNSS Metadata Documentation, 2020*.

There are 6 items to consider for CO-OPS installed GNSS systems.

A Site ID - the site ID is unique for every cGNSS sensor and differs from the station ID and is dependent on the region the sensor is located in. A Site ID is created and stored in the database by COET.

Data Telemetry - ISD configures the database with the IP address and Port # in order to allow GNSS data to be collected from the station and ingested into the database.

Site Log - contains crucial metadata that is made available to the public and partners through a standardized file that is located with the data files and is published to a FTP site that is made available to partners. The Site Log must be updated after any and all site visits where the cGNSS equipment is impacted. The file name for the site log must follow a standard format in order to be easily loaded onto the FTP site. Refer to the SOP *cGNSS Metadata Documentation* to properly populate the Site Log.

Photos - CO-OPS has adopted the photo requirements for cGNSS sensors that NGS requires as noted here: https://www.ngs.noaa.gov/CORS/SitePhotos/Html/description.html. Depending on the mounting of the sensors, between 9 and 12 photos are required for each site.

Level Files (database) - The cGNSS sensor is to be included in the leveling survey at the installation visit, during the next scheduled maintenance, and at (to be determined) interval. The leveling point of the ARP and any other noted reference points shall be included in the abstract file and have unique SSN numbers.

Level files (partner) - In addition to the level files for inclusion in the database, an additional level file is to be generated by COET to be sent to SONEL for inclusion on their website. This level file is only to be generated and sent for Global Sea Level Observing System (GLOSS) stations.

Station Installation

The installation of a water level station DCPs and sensors shall be accomplished according to the *NGWLMS Site Design, Preparation, and Installation Manual, Xpert DCP User's Manual*, *SOP 3.2.3.5 Upgrading and Installing a New Water Level Station,* contract documents, sensor installation guides and per the manufacturer's instructions, as applicable. Installation guides and manuals can be found in the ROS Library and the CO-OPS Field Library.

When the water level or meteorological station and its various components are designed and/or installed by IDIQ contractors, then those shall be installed and maintained as prescribed by manufacturers' installation manuals, appropriate local building codes, or as specified by the COR in the contract documents. The station and all installed components shall be structurally sound

for the intended application, secure, and safe to use for NOS, local partners, and the public, as appropriate.

A complete water level measurement station installation consists of the following:

- The installation of the water level measurement system [water level sensor(s), primary and redundant DCPs, satellite transmitter and/or additional telemetry equipment and service as appropriate, meteorological and ancillary sensor(s) if applicable, connection to appropriate utilities or addition of a suitable power source, all other equipment as necessary and any supporting structures].
- The documenting of the cable lengths of all water level, meteorological and ancillary sensors (to the nearest meter) on the eSite report.
- The documenting of the position (dd/mm/ss.x) of the station, equipment and sensors on the eSite report.
- Install rubber flaps over all locks on gauge shelters for protection against the weather. (Great Lakes stations only)
- A "red-lined" copy of the station design documents showing all relevant as-built dimensions and any deviations from the FERS approved design documents.
- The recovery and/or installation of the required minimum number of bench marks and a level connection between the bench marks, including the Primary Bench Mark (PBM), the water level sensor(s), meteorological and ancillary sensor MET SRM, and/or the tide staff as appropriate. The minimum number of bench marks or specific marks to be leveled will be specified in the station specific section of the Dynamic Project Instructions, contract documents, or in accordance with the references, the *User's Guide to Vertical Control and Geodetic Leveling for CO-OPS Observing Systems* and *the User's Guide to Electronic Levels with TRANSLEV and WINDESC*. The bench mark position (and description) must also be documented in dd/mm/ss.x in Windesc file.
- The collection of GPS observations for a minimum of four hours on at least one suitable bench mark and the submission of the data through OPUS DB for publishing is required; refer to *the User's Guide for GPS Observations at Tide and Water Level Station Bench Marks*.
- Validation of complete data transmissions and the proper data ingestion into DMS, as evidenced by the data display on the CO-OPS Diagtool. (See section for One-Day eSite Report and Level Requirements for information on accessing the Diagtool.)
- NOAA identification signage with an emergency phone number (800) 367-6622 or (301) 713-2540 or 206-526-6360 or 888.PAC.TIDE shall be placed on each tide house or shelters. Replace illegible signs.
- The submission of the installation documentation and data to COET and the supporting FOD field office. The field party shall have all forms and figures submitted using metric units and referenced to the appropriate datum. Other references (e.g. orifice zero or tide staff zero) shall also be shown on the forms with

reference to the SD. Refer to the Schedule, Reports and Deliverables section of this document.

Preliminary Station Configuration
Prior to the installation of a station and initiation of GOES data transmissions from the field, critical information required for database configuration shall be emailed to COET.

If COET support is required during the installation of the station, either after COET core hours and/or on the weekend, coordinate at least three business days in advance with COET for after hours and/or weekend support via email providing with the planned date of installation, proposed time of leveling, and the times the weekend support is needed.

The critical information required for water level and/or meteorological station database pre-configuration in DMS are:

- Station Number and Name
- Proposed Installation Date
- Station Latitude/Longitude
- Platform ID, Transmit time, Channel
- All sensors planned to be installed

This station information must be configured for data to be ingested in DMS and for the eSite report.

One-Day eSite Report and Level Requirements
The field party shall submit the one-day eSite report and the leveling files (and water level transfer form, applicable to the Great Lakes stations) to COET within 24 hours of the completion of the installation of a station and leveling. The one-day eSite report and supporting documentation are required for the purposes of:

- Communicating the critical information to COET for the database configuration and providing feedback to the field party if the critical information is missing or needs verification.
- Ensuring timely corrective actions can be taken if the system and/or sensor fail shortly after installation.

At the completion of the station installation, the field party shall submit to the COET the one-day eSite report, and the level files via email, the following:

- Station Number and Name
- Installation Date
- Latitude/Longitude
- Platform ID, Transmit time, GOES Channel
- Make and/or Model, and Serial numbers of all DCPs, and sensors

- Level abstract with steel-tape measurement(s) inserted as a run (if applicable)
- Sensor offset C1 (SNS) and Datum Offset C2 (DAT) as entered in the DCP for acoustic sensor, MWWL sensor, DAT for SAE; and orifice offset(s) for pressure sensors
- Staff-to-Gauge Observations (when required)
- Water Level Transfer form (Great Lakes observing systems only)

Upon receipt of the one-day deliverable if any deficiencies are present, COET will respond to the field party within 24 hours or 1 business day if the one-day is submitted over the weekend. The one-day eSite report submission requirement applies to all water level and meteorological stations and all sensors for every type of maintenance - installation, regular scheduled maintenance, unscheduled maintenance and removal.

The effective starting date of all operational sensor data series is the date and time when the data is first received after the DMS configuration. It is the responsibility of the field party to ensure that the required documentation is provided to COET in a timely manner.

The field crew is required to contact COET via email and CORMS via telephone or e-mail before and after the following activities:

- Station installation
- Station removal
- For scheduled maintenance visit (24-hr site report and leveling abstract submission is sufficient)

If the notifications are not provided prior to the beginning of data transmission, data losses may occur. When the station sensors are properly configured in DMS and the data is reviewed for dissemination, the data is accessible through the CO-OPS' Tides and Currents web page and the diagnostic tool web page - DiagTool. Generally, CO-OPS field parties and IDIQ contractors will be given access to the DiagTool prior to the scheduled installation, if access to the DiagTool is needed; please request access via the button on the CO-OPS Access management Page https://access.co-ops.nos.noaa.gov/am/login.do. There is a link to this site and instructions on the DiagTool login page.

Station Maintenance Requirements

Pre-Trip Coordination Meeting

CO-OPS FOD and IDIQ contractors are required to schedule a pre-trip coordination meeting with COET:

- 30 days prior to the scheduled maintenance event performed by CO-OPS FOD
- 45 days prior to the scheduled maintenance event performed by IDIQ Contractors,
- At least 10 business days prior to the meeting to allow COET preparation time to gather and document any additional requirements identified after the publishing the

current FY Project Instructions.
- At least 90 days prior to the scheduled installation date of all new NWLON stations.

The equipment request form shall be submitted to the appropriate Instrument Lab 45 days prior to the date required of scheduled maintenance. Contractors should adhere to the lead time required in their contract. Refer to the *Annual Inspection Pre Coordination Meeting SOP* for more information.

Station Maintenance

A major focus of station maintenance is equipment failure prevention, sensor and bench mark network stability monitoring. To accomplish this, the field party, Technical Representative (TR) or COR will check with COET and the appropriate Instrument Lab to determine if any component is scheduled for replacement because it may be close to the time when the component is predicted to fail. If a component is scheduled for replacement, then that component will be swapped out with a good component provided by the appropriate Instrument Lab.

The water level station standard scheduled maintenance shall be accomplished in accordance with:

- These Standing Project Instructions
- Appendix F of the *NGWLMS Site Design, Preparation, and Installation Manual*
- SOP 3.2.3.5 (E3) Upgrading an Existing Water Level Station or Installing a New Water Level Station
- The most recent version of the Dynamic Project Instructions
- The CO-OPS IDIQ Statement of Work provided by the Contracting Officer's Representative (COR), and/or the TR.

Sensor and equipment specific maintenance guidance and references can be found in the ROS Library and the CO-OPS Field Library.

The specific maintenance requirements for each water level station will be documented in the Station Specific Requirements Section of the Dynamic Project Instructions and in individual task orders for the IDIQ contracted station maintenance. Currently, scheduled maintenance is done within 11.5 - 12.5 months from the previous scheduled maintenance when completed annually. Maintenance tasks performed shall be documented on the eSite report and the scheduled maintenance checklist.

A complete station visit for maintenance (scheduled or unscheduled) consists of the following:

- The inspection and maintenance, sensor checks, or repair of the water level measurement system (water level sensor(s), DCPs, communication and data transmission components, meteorological and ancillary sensors (when applicable), power components, other equipment as necessary and the supporting structure(s), and as specified here in the Standing Project Instructions, the station specifics section of the Dynamic Project Instructions, reference documents, and/or as specified in the contract documents.
- All applicable sensor serial numbers shall be recorded and verified by the field party. The serial numbers of the DCP modules and sensors are recorded during the installation, verified during each scheduled maintenance and updated when equipment is replaced.
- The recovery and/or installation of the required minimum number of bench marks and a level connection are required between the bench marks, PBM, and the water level sensor(s) leveling point and a measurement to the sensor zero (when applicable), and the MET SRM and ancillary sensors (when applicable). Specific bench marks required to be leveled will be specified in the Station Specific Requirements section of the Dynamic Project Instructions, and/or contract documents. Refer to the *User's Guide to Vertical Control and Geodetic Leveling for CO-OPS Observing Systems.*
- For unscheduled maintenance, recovery of bench marks and levels are generally not required, unless maintenance is done which may affect the elevation of the water level sensor(s), in which case leveling to the PBM, water level sensor(s), and at least two other marks, is required.
- Dive operations to clean and inspect the submerged sensors, underwater components and the infrastructure. Diving may not be required each year; consult the Station Specific Requirements section of the Dynamic Project Instructions for details. At some stations, diving is not performed due to environmental conditions (e.g. Tacoma) or due to dual MWWL sensors, or other approved reasons.
- GPS observations on one bench mark as specified in the Station Specific Requirements section of the Dynamic Project Instructions, or in the contract documents.
- Verification of complete data transmission following the maintenance visit, from the station to the DMS ingestion.
- The preparation and submission of the maintenance documentation deliverables (i.e. station package) and data to COET and the supporting FOD field office. Refer to the Schedule, Reports, and Deliverables section for the requirements timelines, documentation deliverables, and points of contacts.
- The requirement to download the DCP configuration files and the data stored on the DCP SD card is on as-needed basis and when requested in pre-trip meetings or in specific work request tickets (Jira) to fill data gaps. Furthermore, the DCP configuration files and the data stored on DCP SD card should be downloaded in

its entirety when transitioning the primary water level sensor to the Microwave sensor or when the station is relocated or completely removed from site.

Water Level Sensor Maintenance

During scheduled maintenance visits to a station with an acoustic sensor, a ping test on the Aquatrak sensor shall be done and the Aquatrak® sensor and matching calibration tube shall be replaced with a newly calibrated sensor and matching calibration tube. The time of the sensor swap shall be recorded in UTC time on the eSite report. The matched pair of Aquatrak® sensor and calibration tube shall be returned to CIL for post calibration. The protective well, brackets, and mounting infrastructure shall be cleaned, inspected, and the condition documented and photographed. CO-OPS, in the past has swapped Aquatrak sensors annually, but recently CO-OPS has started swapping the Aquatrak sensors biannually (every 2 years or so).

For the MWWL sensor, the sensor mount and cables, sensor protective cover and horn antenna shall be cleaned and inspected, and the condition documented and photographed. The sensor configuration file will be verified, downloaded, and submitted as a deliverable. The sensor performance shall be evaluated 5 years after the installation date and shall be replaced if the relevant Instrument Lab and/or OSTEP identify issues with sensor performance impacting data collection. The time of the sensor swap shall be recorded in UTC time on the eSite report. The removed sensor shall be returned to CIL for calibration, performance check, and re-certification for operational field use.

For single or dual Paros configurations, the mounting assembly for the orifice(s) shall be checked for structural integrity and the orifices shall be cleaned of biofouling. The orifices and any bubbler tubing fittings will be purged to check for any cracks or leaks. The condition of the orifices, bubbler tubing and conduit, and leveling point shall be documented and photographed. If a dive is performed, the distance from the sensor leveling point to orifice opening will be measured and documented on the eSite report and the level abstract. The sensor configuration file will be verified, downloaded, and submitted as a deliverable.

As discussed in the pre-trip coordination meeting if a data gap exists, then 6 minute and 1 minute water level data for the gap period shall be downloaded during the maintenance trip and the data shall be included in the station package. If 15 second data has been requested by a partner that data shall also be downloaded and submitted. Refer to the *Engineering Bulletin* # 07-007 *Downloading (Exporting) Data from the Xpert Log Files using Xterm* provides information regarding how to download the data from Xpert DCP. Submission of screen captures of the DCP configuration setup and a copy of the configuration file(s) are required to be submitted with the station package.

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented (refer to the Schedule, Reports, and Deliverables section for the requirements for the station documentation deliverables and timelines) and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date and time (UTC) of the

beginning and the end of the maintenance activity; date and time of adjustments of the sensors; changes in the configuration of the DCP - such as a new datum or sensor offset, or setting the time; personnel conducting the work; parts, sensors or components replaced; sensor and component serial numbers; sensor tests performed and test results; and documentation of any sensor and equipment failures, etc.

Necessary repairs or alterations to the stations and equipment shall be made and documented on the eSite report. Repairs or alterations required by these Standing Project Instructions or the Station Specific Requirements section of the Dynamic Project Instructions but not completed shall also be documented, along with the reasons for the incompletion on the eSite report. Each field party chief shall provide COET and the supporting FOD a one-day eSite report along with all the leveling files, within one day of the completion of maintenance and leveling.

The one-day eSite report and level files shall be completed by the field party prior to leaving each station. The complete station package shall then be submitted to COET and the supporting FOD field office within 30 days after the completion of the maintenance, or as specified in the contract documents.

Battery Performance Check

When arriving at a station to perform the scheduled maintenance, perform a load test and record the voltage for each battery on all DCPs. The battery load testing shall be performed in accordance with *SOP 6.3.2.1.12 Battery Load Testing Procedures for CO-OPS Water Level Observation Systems.* See *Engineering Bulletin 10-002 Standardized Battery Type for CO-OPS Water Level and Meteorological Stations with Photovoltaic Charging Systems* for specifications of standardized battery replacements. All new batteries shall meet the type and specifications mentioned in this Engineering Bulletin.

Check all marine grade batteries to ensure that adequate water is in each cell. Use only distilled water during replacement. Write the date of the installation with permanent marker on each battery when newly installed, and record this date on the eSite report.

Batteries shall be replaced every four years during the scheduled maintenance trip, when practical, or arrangements shall be made to replace them at another time. The condition of a newly installed battery shall be checked using the procedure described in the above paragraph during the scheduled maintenance trip. Even if the battery condition passes the test, replace the battery during the 4th year after the installation. If a battery does not pass the test during any maintenance visit, then it shall be replaced immediately during that trip and the date of replacement shall be noted on the eSite Report.

Meteorological and Ancillary Sensor Maintenance Requirements

Where installed, wind sensor nose cones shall be replaced during scheduled maintenance. The Ultrasonic wind sensor leads shall be cleaned with a contact cleaner with a zero residue base.

The water temperature probe shall be placed in water and compared to a NIST certified thermometer according to reference document *SOP 6.3.2.1.4 Water Temperature Comparison*. The air temperature sensor shall be compared in the same environment to a NIST certified thermometer. The differences between the operational thermistors and the certified thermometers shall be less than 1.0 °C. If the difference is greater than 1.0 °C, then the sensor shall be replaced. Water temperature sensors shall be replaced after 10 years regardless of performance as required by *Engineering Bulletin 09-001 Create Water Temperature Sensor Replacement Cycle.*

Conductivity sensor heights should be remeasured above station datum every 5 years to ensure accuracy. These heights are utilized for modeling purposes and shall be consistent.

The barometer offset shall be updated in the DCP during the scheduled maintenance. Refer to SOPs 5.4.1.4 (A1) and 5.4.1.4 (A2) Sutron Accubar Barometer Field Calibration Procedures for additional information.

The visibility sensor should be cleaned after installation and then inspected and cleaned every six months. The visibility sensor receiver and detector shall be rinsed with Deionized (D.I.) or distilled water, then cleaned using lint free lens cleaning paper. The sensor should be cleaned and calibrated in the field once per year. When the sensor is being serviced, the calibration kit should have the proper interface cable. The sensor shall be maintained in accordance with the *SOP 6.3.2.1.3 Maintenance Procedure for Visibility Sensor Cleaning and Calibration Check*.

Air-Gap and laser sensors shall be cleaned and inspected every year. Clean the sensor face and windows in accordance with the *SOP 5.2.2.2.A Air Gap Field Installation Guide*.

Additional Maintenance Requirements for NOAA Sentinels and Stations with Elevated Frames

NOAA Sentinels are water level observing stations that have been designed to withstand and deliver real-time water level data during severe coastal storm events. Elevated atop substantial single pile platforms, these stations are specifically designed to withstand category four hurricanes. NOAA Sentinels measure and transmit real-time water level and meteorological observations.

Stations with elevated frames are designed to place the sensors and equipment above the maximum observed water level with a goal of being above the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) Maximum of Maximum (MOM) for category 2 or 3. For more information on the SLOSH MOM, go to http://www.nhc.noaa.gov/surge/slosh.php.

The following are the additional maintenance requirements for the NOAA Sentinel stations, Single Pile Instrumentation Platforms (SPIP), and elevated frames as applicable.

Every Year:

- Connect the water level sensor(s) leveling points to the nearest land bench mark via trigonometric leveling using the Total Station leveling equipment.
- Examine the anode and the anode attachment points. Inspect the attachment points for excess corrosion and inability to remove fasteners. Provide measurements of the smallest cross sectional area of the anode. Provide underwater photos of the anode and close-ups of any excessive anode shrinkage or attachment point corrosion. Document findings on the eSite report and scheduled maintenance checklist.

Every 2 years:

- Inspect all painted surfaces for rust. Document in the eSite report and the scheduled maintenance checklist significant rust areas and provide photos of the occurrences. The repair of significant rust areas shall be added to the following year's project instructions along with procedures for coating repair.
- Inspect all galvanized surfaces for rust. Document in the eSite report significant rust areas and provide photos of the occurrences. Repair spot rust with a wire brush and cold galvanizing.
- Inspect all welds for rust and cracks. Provide photos and document excessive rust and cracks.
- Check all fasteners on the protective well clamps, including half-moon clamps, adjustable arms, and the attachment to the clamp brackets. Tighten if loose.
- Check the fasteners holding the solar panel mount to the railing. Tighten if loose.
- Check all fasteners holding the enclosure to the support stand and the stand to the deck grating. Also, check the bracketing system along the upper portion of the enclosure. Tighten if loose.
- Check all fasteners on the Rohn® tower. Tighten if loose.
- Examine the underside of the high platform. Inspect the high platform bridge bolts for looseness and rust. Document the condition of the underside and tighten any loose bolts.
- Examine the galvanized conduit for rust and cracks. Check if water in the conduit is entering the bottom of the enclosure.
- Examine the solar panel and Rohn tower flexible conduits for cracks and loose fitting/tubing connections.
- Grease the davit and winch. Examine for corrosion.

Every 5 Years:

- Replace the battery pack in the Aid to Navigation light.

Additional Maintenance Requirements for Great Lakes Stations

CO-OPS and NGS along with the USACE and Canadian counterparts are in the midst of upgrading the International Great Lakes Datum 1985 (IGLD 85) to IGLD 2020. All 53 Great Lakes water level stations will be used as part of the update process. As part of the update, water level data must be collected at all stations from 2017 through 2023 and must fall within

bracketed levels (2016 and 2024). COVID-19 has affected this schedule. The 53 stations need to be maintained each year during the collection period to ensure the stations are working properly and less likely to fail.

- Scheduled maintenance includes levels, pumping of the sump, an inside-outside check, sensor checks, and ETG/sensor matching. NGS will be conducting another joint GPS/GNSS survey in 2021 coordinated with Canada. CO-OPS will need to coordinate with NGS to ensure that the bench marks that NGS conducts GPS/GNSS data collection are leveled to that corresponding year. Additional GPS/GNSS data collection will be required and will be determined on an annual basis. The additional data collection requirements (length, quantity, and bench mark(s)) will be documented in the Station Specific Requirements section of the Dynamic Project Instructions. This additional data collection will be determined based on the need for additional data to lower the uncertainty in the geoid models being developed.
- The shaft angle encoders shall be inspected to insure the offset pulleys are not binding.
- Lift the float tape off the offset pulley and free spin the unit. If any binding occurs, replace the bearing in the center of the gear. In addition, and while the float tape is off the encoder gear and pulley, spin the encoder shaft to represent both a 2-meter increase and a 2-meter decrease in the readings from the present reading. Then match the reading with the ETG reference and reset the tape back on the gear and pulley.

After this process, remember to check the tape at the float connection to ensure that it has not kinked. This rotation procedure will ensure that the oil lubrication around the enclosed encoder bearings remains fluid.

NOTE: This check should only be performed during the time that the DCP is not calculating the water level reading. This time for computing the water level reading, is 90 seconds before and after the allotted 6-minute interval. Check to ascertain that the float tape length has been installed such that the float neither tops out nor the counterweight bottoms out before reaching its extreme limitations. Do not perform this check at the top of the hour.

- The float shall be inspected for corrosion and leaks; replace as necessary.
- When closing off the intake valve, note the number of turns it takes to close off the intake and the number of turns it takes to fully open it. This shall be reported in the remarks on the inspection sheet, the eSite report, scheduled maintenance checklist, and on a tag placed on the valve handle. Document the difficulty in turning the valve such that it can be predicted when the valve would become unusable and need replacement.
- A water level transfer (inside/outside check) shall be performed and documented on the eSite report and the water transfer form. The water level transfer is performed at the location of the intake or the spike. The inside/outside water level

must agree within 0.006 m. The best time to perform a transfer is in the early morning or late evening when the water level is most calm. The check must be completed and actions taken to correct any discrepancies. Refer to the Inside/Outside Water Level Check for the Great Lakes Gauging Station SOP. If there are concerns with meeting the requirement due to weather conditions on-site, contact COET.

- When diving at the station measure and report the elevation of the intake invert and valve invert on IGLD 85, if not previously noted. NOTE: The invert elevation is the point where the water level can no longer be measured accurately. If the intake has a gooseneck at the end, this measurement should be taken at the lowest point in the curve at the top of the gooseneck, not the opening.
- The locks shall be inspected and lubricated to enable easy access.
- Check gauge house structure, door, and frame for rust and paint chips. Scrape and paint as necessary. Check gauge house inside, outside, and around the doorframe for openings in the mortar and caulk as required.
- For stations containing a sump, pump the water out of the sump while the intake valve is closed off. Clean off the bottom of the sump removing any debris. When refilling the sump, the valve should be opened 100% to check the flow through the intake as well as monitoring how clear the water is to determine if the intake is collecting dirt/debris that may result in clogging. Pump the sump multiple times until clear water is coming in through the intake. If pumping the sump lasts past the hourly readings, a reading from the TBM spike must be performed and submitted to COET on the one-day eSite report, including the date and the time in LST, and the value of the reading. The floats are to be tied off during the pumping of the sump.

Gauge Removal

A complete removal of the water level measurement station consists of the following:

- Closing levels – a level connection between the PBM and all the bench marks in the local leveling network at the station, the water level sensor(s), and/or staff, if applicable. The closing levels shall be submitted to COET for review and confirmation of the sensor stability prior to removal of the water level sensor. If the removal of the sensor is after COET core hours, please coordinate in advance at least three business days with COET for after hours and/or weekend support by emailing with the planned date of removal and proposed time of leveling. COET will be available 8 am to 5 pm EST on weekends unless otherwise discussed.
- Removal of the station and restoration of the premises, assuming reasonable wear and tear. The property owner shall be notified prior to removal and thanked for supporting our programs.
- GPS observations shall be performed if the documented requirement is found in the Station Specific Requirements section of the Dynamic Project Instructions or in the contract documents.
- The preparation of all documentation and data and submission to CO-OPS COET and the

supporting FOD field office within 30 calendar days of the station removal (refer to the Schedule, Reports, and Deliverables section on the requirements for timelines, documentation, and points of contacts).

Return of all government equipment to appropriate supporting CO-OPS' FOD field office(s) within 15 calendar days of station removal is required.

Bench Marks

Reference Documents

Bench marks and level operations shall be performed in accordance with the *User's Guide to Vertical Control and Geodetic Leveling for CO-OPS Observing Systems.* CO-OPS electronic/barcode level operations shall be performed in accordance with the User's *Guide for Electronic Levels with Translev and WinDesc* and the Leica Manual for the DNA03 level. Help files for the TOPCON and Trimble level instruments can be found in the WinDesc and Translev programs available from NGS.

All bench mark descriptions and positions shall be written in accordance with *User's Guide for Writing Bench Mark Descriptions* for bench marks that are connected using electronic, optical, and/or trigonometric levels and documented in the Windesc file.

Bench Marks

Unless specified otherwise in the contract statement of work, the total number of bench marks in the leveling network shall be a minimum of ten marks for the NWLON stations and a minimum of 5 marks for non-NWLON stations, unless otherwise directed by CO-OPS ED. All bench marks shall be of NGS stability class C or greater and for NWLON stations at least three marks shall be of NGS stability class B or greater; refer to the *User's Guide to Vertical Control and Geodetic Leveling for CO-OPS Observing Systems* for the bench mark installation requirements.

If the current bench mark network does not have the sufficient number of marks, or sufficient class of marks (e.g. Class A or B etc.), then before establishing a new mark, a 1.6 kilometer (1 mile) radial search shall be performed from the tide station (DCP) location in the NGS web site to check if any NAVD 88 bench marks are available for inclusion into the local bench mark network. Inclusion of an existing mark(s) that has a NAVD 88 elevation, if it is located within a 1.6 km (1 mile) leveling distance of the station location, is desirable and shall be preferred over installing a new mark. If the bench mark is new, then the stamping of the bench mark shall have a new letter designation excluding I, L, and O (assigned by COET the next available letter in the alphabet) and the present year so that the new stamping is distinct from the stamping of other marks in the local leveling network.

Bench mark descriptions shall be checked annually by verifying distances with tape measurements in metric units and verifying cited landmarks and using a compass to

confirm the directions. Changes in the bench mark descriptions will be documented in the WinDesc file submitted with each bench mark network leveling event.

The handheld GPS coordinates of each mark shall be entered in the WinDesc file. The latitude and longitude fields of the bench mark shall be reported in the following format: degrees/minutes/seconds and tenths of seconds. For example, 40 degrees, 45 minutes, 35.2 seconds.

If a bench mark is discovered disturbed or mutilated during the visit to a station, include it in the level run to determine if it is holding its elevation relative to the PBM and report it to COET and the supporting FOD field office. After leveling, if a bench mark's elevation has changed by greater than **+/- 0.006** meters when compared to the elevation history, then notify COET via the Windesc file and note the movement in the Leveling section of the eSite report. COET may request the bench mark be included in the following year's level run to confirm the noted movement.

COET will make a decision and inform the field party via the next set of Dynamic Project Instructions Station Specific Requirements regarding the action that needs to be taken: destroying the mark if it is a NOS mark, or dropping the mark from the bench mark network for non-NOS marks. If the PBM has been disturbed, contact COET immediately for further direction. Provide photos of any bench marks found disturbed or mutilated.

Bench mark sketches shall use CO-OPS' standard bench mark sketch title block. Submit a digital file of the bench mark sketch, in PDF format. Submission of the bench mark sketch is required only at the installation of a new water level station or when the area surrounding the bench mark network changes or bench marks are added or removed from the network.

CO-OPS requires photos of all bench marks (e.g. disk, metal rods, 3D marks etc.,) stamping, setting, and location photos. The Station Specific Requirements section of the Dynamic Project Instructions shall note any additional photos needed to achieve a complete photo gallery of each mark and will identify when the location photos require an update. Location photos shall be retaken if the area around the bench mark changes or if 5 years have elapsed since the last submission of photos for the mark. COET will inform the field party via the annual project instructions of which bench marks require new pictures.

Digital photographs of bench marks shall be taken as described in the Station Installation Photographs section of this document.

Leveling

All differential leveling shall be performed with electronic/barcode systems, to Second Order, Class I or Third Order standards, in accordance with NGS standards for geodetic leveling, and the CO-OPS *User's Guide for the Installation of Bench Marks and*

Leveling Requirements for Water Level Recording Stations. All field parties are required to use the latest approved version of WinDesc and Translev software. Refer to the *User's Guide for Electronic Levels with Translev and WinDesc*.

Digital barcode leveling systems should have been previously evaluated by the Federal Geodetic Control Subcommittee (FGCS). These systems include the Leica NA3003, Leica DNA03, Leica LS-15, Topcon DL101C, Trimble DiNi 12, Zeiss DiNi 10, DiNi 11, DiNi 12 and DiNi 12T. Bench mark descriptions and leveling output must be in an NGS-supported format to enable processing and adjustment of the levels by NGS. Bench mark descriptions and recovery notes shall be submitted using WinDesc software. The WinDesc instructions are built into the program under the HELP menu. Translev is an NGS program that facilitates the process of editing, formatting and checking digital leveling observation data and creates abstracts, .bok files, and VERTOBS datasets for submission to the NGS. WinDesc and Translev are the two programs currently being used by CO-OPS to submit leveling data to NGS. NGS training is available if needed. These NGS programs are available online at http://www.ngs.noaa.gov/PC_PROD/pc_prod.shtml.

Two or three-meter barcode rods shall be used for Second Order levels at all stations. At stations where two or three-meter level rods cannot be utilized due to airline size restrictions, justification for the use of No order Leveling equipment (including multi piece and/or folding rods) and waiver (see Section 3.20 of the User's Guide for Vertical Control) shall be documented and provided to the COET for review prior to the leveling and documented in the eSite Report. For stations where the use of Third Order leveling equipment is allowable, leveling equipment and closure tolerances shall use Second Order leveling methodologies, i.e. three wire leveling equipment is acceptable but single wire leveling is not acceptable. The use of Third Order leveling is acceptable for stations in AK, HI, and Pacific Island areas.

When abstracting the raw level data using the electronic digital level system, the PBM shall always be selected as the starting mark, and the primary water level sensor (Aquatrak Leveling Point (AQLP), the MWWL LP, orifice staff stop, or ETG, as the case may be) shall always be selected as the ending mark. If the original RAW file is edited before processing, the original file (XXXXXXXo.RAW or XXXXXXX.GSI) shall be stored in a separate subdirectory named "Original RAW", and submitted with the edited RAW (XXXXXXX.RAW or XXXXXXX.GSI) file and other level files.

While using the electronic levels, any changes made to the description file (XXXXXXX.DES) require that the levels be reprocessed and submitted. Dates of the DES file must be chronologically consistent with the abstract ABS and other files generated. The date of the DES file cannot be more recent than the date of the abstract file.

Second-order Class I level connections shall be made from the primary water level sensor (AQLP, MWWL LP, or pressure sensor orifice leveling point, and in the Great

Lakes the ETG RM and the Spike RM) to a minimum of five bench marks during scheduled maintenance, including the PBM. In the case of ParoScientific® pressure sensors, the elevation of orifice zero to orifice leveling point(s) shall be measured annually using a National Institute of Standards and Technology (NIST) approved steel-tape measure with millimeter graduations steel tape with millimeter graduations, elevation of the orifice leveling point(s) to the PBM shall be determined using conventional leveling equipment. In the event a connection from the leveling point to the orifice zero cannot be made, a note in the eSite report must be made justifying the reason why the connection was not made.

As described in the *User's Guide to Vertical Control and Geodetic Leveling for CO-OPS Observing Systems,* levels are required and shall be performed for the seven cases listed. Particular emphasis is placed on performing check levels as per the Station Specific Requirements section of the Dynamic Project Instructions, or preferably 2 months but no later than 6 months after the installation of a new water level station. This is required for declaring a newly installed water level station fully operational.

All of the bench marks in the station network shall be leveled within a two-year period. This may be accomplished by leveling to the PBM and four marks one year, then to the PBM and the remaining marks the next year. In some cases, it may be practical to level to all the marks the second year to reach the marks furthest from the station. The field party performing the operations and maintenance shall be responsible for ensuring that every mark in the station bench mark network is leveled at least once every two years. If a station is not visited one year for any reason, all marks are to be leveled to during the next scheduled visit.

A level connection to the Continuously Operating Reference Station CORS marks shall also be made once every two years, if those marks are within 1.6 km (1 mile) leveling distance from the water level station.

Leveling to Sensors on a SPIP/Elevated Platform

There are two ways available to connect the water level sensor on the SPIP or elevated platform to the bench mark network and the PBM, depending upon the equipment available. If the Total Station leveling equipment is available, then Trigonometric leveling can be used, otherwise use the combination of steel tape measurements and digital levels as described below.

Conventional method

Leveling connections on Sentinels and other elevated platforms require a combination of steel- taped height differences between the AQLP, MWWL LP, or a TBM at deck level ("deck" TBM) and a TBM near ground level ("ground" TBM), and a standard level run between the "ground" TBM and bench mark network on the land.

To level from the AQLP or MWWL LP to a ground TBM, the TBM shall be chosen such that it can be leveled to the existing bench mark network using the standard barcode rod. This "ground" TBM shall be named and described per the *User's Guide for Writing*

Bench Mark Descriptions so that field parties can level to the exact same TBM. The standard bench mark photos shall be taken. The point where the taped measurement is made is critical in this description. This TBM shall also be established where a steel-tape measurement can be made from the TBM to the AQLP or MWWL LP. If this is not possible, another TBM at the deck level of the Sentinel or elevated platform shall be chosen, named and described per the *User's Guide for Writing Bench Mark Descriptions*, again to include the point of measurement in the description. This "deck" TBM shall be connected to the AQLP or MWWL LP using standard leveling procedures.

The steel taped distance from the "ground" TBM to the AQLP (or MWWL LP) or "deck" level TBM shall be performed during a lull in the wind activity. A carpenter's level shall be used at the top and bottom of the steel tape. When the tape is dropped from the AQLP (or MWWL LP) or "deck" TBM the tape is held as vertical as possible. A set of three measurements each shall be made by a minimum of two people for six measurements. Each reading shall have the zero of the steel tape positioned at the high point of the "ground" TBM and the elevation shall be read from the tape at the AQLP (or MWWL LP) or the high point of the "deck" TBM. The steel tape shall also be moved away from the TBMs and repositioned for each measurement. The six readings shall be averaged to acquire the height between the "ground" TBM and the AQLP (or MWWL LP) or "deck" TBM. Submit via text file or spreadsheet of the individual measurements along with the time the measurements were taken.

The averaged steel tape measurement shall be entered into the DNA03 so that it is abstracted into the level run. This is done by manually entering a zero for the staff height on the "ground" TBM as the **Backsight**, then entering the **positive** value of the averaged steel tape measurement for the Foresight of the **Forward Run**. During the **Backward Run**, enter zero for the **Backsight**, then a **negative** value of the calculated height for the **Foresight**. This will put the height of the AQLP or "deck" TBM measured into the abstract when the levels are processed using Translev.

Trigonometric Leveling

CO-OPS has currently approved the use of Trigonometric (Trig) leveling only for determining the elevation of the air gap sensor, and the first level section from the sensor leveling point on the SPIP to the nearest temporary bench mark (TBM). As more data are collected in the future, CO-OPS will adjust these requirements as appropriate.

For primary water level sensor(s) installed on CO-OPS Single Pile Instrumentation Platform (SPIP), elevated platform, or for determining the elevation of the air gap sensor, trigonometric leveling using the Total Station leveling equipment can be used to connect to the TBM to the nearest land bench mark. Trigonometric leveling involves measuring a vertical angle from a known distance with a theodolite and computing the elevation of the point. With this method, vertical measurements can be made at the same time horizontal angles are measured for triangulation. For each section of a trigonometric survey, there is one **forward run** and one **backward run**. During each forward and backward run, there are a number of pairs of **direct** and **reverse** readings that must be made and averaged together as described below.

The procedure for trigonometric leveling to the water level sensor or air gap sensor are as follows:

(1) Ascertain that the total station equipment is set up to apply the combined curvature/refraction error automatically to negate the unbalanced measurement error. If this is not possible, then the error must be removed during the post processing of data.

(2) Using good quality and calibrated meteorological sensors, take precise temperature/pressure/humidity readings at either end of the section (TBM to sensor). Then the mean values should be used as an input for the parts per million (ppm) correction into the instrument. The level connection between TBM, PBM and all other BM in the network shall be done using the electronic levels (Second Order Class 1). Temperature sensor should be accurate to +/- 0.1 °C as per the requirement for the leveling thermistors.

(3) For new sensors (where any previous Trig leveling history exists), take at least eight sets of direct and reverse readings for each forward and backward run. Sometimes more than one setup may be necessary for each forward and backward run. All eight of these readings must match within the 6 mm tolerance; if not, take additional readings until at least eight consistent readings are recorded. Readings not meeting the 6 mm tolerance should not be used for computing the mean as per the guidance provided for rejection procedure for levels. The mean (average) value of these eight sets of consistent readings shall be used on the level abstract to derive the elevation of the sensor for the first time.

(4) For sensors where the trigonometric leveling history (i.e. 2nd year onwards) exists, take at least four sets of direct and reverse readings for each forward and backward runs. All four of these readings must match within the 6 mm tolerance, if not; take additional readings until at least four consistent readings are recorded. Readings not meeting the 6 mm tolerance should not be used for computing the mean as per the guidance provided for rejection procedure for levels. The mean (average) value of these four sets of consistent readings shall be used on the level abstract to derive the elevation of the sensor. If a comparison of the previously derived sensor height difference with four sets of readings does not match within the 6 mm tolerance, then treat the section as new, and use the requirements identified in Step 3 to derive the sensor height.

Preference shall be given to using the trigonometric leveling versus steel tape measurements where both measurement types are possible.

All measurements shall be submitted as part of the leveling metadata and as part of the one-day submission.

Electronic Distances Measuring Instruments (EDMI) Calibration Base Line Program
NGS conducts a cooperative program that provides surveyors with a means to detect and correct errors in Electronic Distances Measuring Instruments (EDMI). NGS has established more than 400 EDMI Calibration Base Lines (CBL) throughout the United States in cooperation with various government agencies, universities, professional societies, and others. These highly

accurate base lines provide a locally accessible standard for length measurement. For each state, NGS provides users with location descriptions and the adjusted results of calibration base line measurements". CO-OPS will send our Trigonometric (Total Station) instrumentation to NGS Corbin Facility for this annual EDMI calibration.

Leveling to the Water Level Sensor

The primary water level sensor shall be connected to the bench marks via digital leveling. The levels shall be run during sensor installation, the scheduled maintenance, if sensor movement is noticed during unscheduled maintenance, and prior to sensor removal. The levels to the sensor(s) shall be a spur run(s) from any bench mark(s) in the bench mark network; it is not necessary to have the spur run directly from the PBM to the sensor(s) but the PBM must be included in the level run. If leveling starts at the sensor, then it is not considered a spur run. Note: Leveling from sensor to sensor is not permitted. Each sensor must be spurred from a network bench mark.

For the primary sensor, a leveling connection shall be made between the bench mark network, the PBM and the sensor zero for the purpose of determining the sensor zero height with respect to the appropriate reference datum. The acoustic sensor zero is the AQLP, which is the top edge of the collar on which the Aquatrak® sensor rests. The MWWL LP is the top surface of the geodetic leveling collar, where the sensor rests. On the ETG, the sensor zero is the ETG reading reference mark, also known as the Zero of the Electric Tape Gauge (ZETG). The ParoScientific® pressure sensor zero is the vertex of the V-notch in the side of the bubbler orifice, or the bottom of the upper parallel plate. To make a leveling connection to this sensor zero, a rod stop called the orifice staff stop or leveling point - to be leveled as part of the leveling run- is installed at a point directly above the sensor zero and a calibrated steel tape measurement is made between the sensor zero and the orifice leveling point. Using the height obtained for sensor zero with respect to the appropriate reference datum, the datum offset (also known as Coefficient C2 or DAT), or the orifice offset shall be calculated.

In order to facilitate holding the rod, a prefabricated leveling fixture may be slipped over the acoustic sounding tube to rest on the leveling point. The height of the leveling fixture, as inscribed on the fixture, shall be compensated for in the leveling abstract and documented in the eSite report. The level abstract shall show the elevation of the leveling point only. A barcoded rule or stainless steel rule, with metric graduation (mm) and the zero at the end of the rule, as appropriate, may be used in lieu of the leveling fixture by holding the rule directly on the leveling point. In cases where the leveling point is too high for a rod shot, the leveling fixture designed for a down shot shall be utilized and the readings recorded to reflect the down shot. Use of other leveling fixtures and leveling techniques must be approved in advance by CO-OPS ED.

ParoScientific Sensors

For dual orifice pressure sensor configurations (or single orifice pressure sensor), the elevation to the leveling points from each orifice shall be verified during each scheduled maintenance visit, including the vertical distance between the two orifices. To do so,

measure the distance of each orifice to the leveling point using a NIST calibrated steel-tape graduation in millimeters. Two independent readings shall be taken and they should not vary more than 3 mm, then report the average of the two readings. If the two readings vary more than 3 mm, then take additional readings until two readings are obtained within 3 mm. The sensor leveling point and sensor orifice elevation shall be updated on the level abstract, eSite report, sensor elevation drawing, and the scheduled maintenance checklist with each leveling connection to the bench mark network.

Great Lakes Water Level Sensor

At Great Lakes sites where a spike is unavailable for use in performing a water transfer, (see Datum Offsets and Accepted Orifice Offset section), the water level in the sump shall be compared to the water surface outside the sump by differential leveling and the use of the water level transfer program (h2o-tran). A difference exceeding +/- 0.006 meters indicates a possible restriction in flow, which must be corrected. Note: This procedure can best be accomplished in the early morning or late evening when the water is most likely to be calm.

Leveling to Barometric Pressure Sensors

Barometric pressure sensors shall be included in the level run as a spur. Barometric pressure sensors shall be leveled, or the height of the sensor otherwise determined in relationship to station datum, during installation, or if the barometer is moved to a new location. Since small changes in elevation do not change the height correction, the original requirement to re-level the barometer every five years is no longer required. The elevation of Mean Sea Level (MSL) above Station Datum in the header information for the specific annual requirements for each station is based upon the 1983-2001 tidal datum epoch. The Barometer offset shall be computed to include both the calibration corrections and height corrections. The field party shall ensure that the new elevation is documented on the eSite Report in the barometric pressure sensor comment section.

Leveling to Temporary Bench Marks (TBM)

When leveling to meteorological sensors and water level sensors connected to DCPs other than DCP 1, the designation for TBMs shall be changed to include the full 8-digit station number: XXX XXXXY, where XXX XXXX is the Station ID and Y is the DCP number. For example, if the barometer is installed on DCP 1 at 8410140 Eastport, the designation shall be TBM 841 01401 Barometer. If the barometer is installed on DCP 2, the designation shall be TBM 841 01402 Barometer. This format shall be used for all sensor TBMs.

Use the designations below to correctly identify the orifice and MWWL leveling point at a water level station. Due to the character limitations in WinDesc and Translev, it may also be necessary to assign an alias.

Leveling Point (LP) Designation	Leveling Point Alias	Sensor Zero Measurement Point Designation

TBM xxx xxxxy Aquatrak® LP	Aquatrak® LP	N/A
TBM xxx xxxxy Primary Pressure Orifice LP	Primary Pressure Single Orifice LP	Primary Pressure Orifice Zero
TBM xxx xxxxy Upper Pressure Orifice LP	Upper Orifice LP	Upper Pressure Orifice Zero
TBM xxx xxxxy Lower Pressure Orifice LP	Lower Orifice LP	Lower Orifice Zero
TBM xxx xxxxy MWWL LP	MWWL LP	N/A
TBM xxx xxxx ETG LP	ETG LP	N/A

The following convention is used for numbering bench marks at water level stations: The SSNs at a station shall be numbered ZZ## where ZZ is the station part number from the current year's Station Specific Requirements section of the Dynamic Project Instructions, and ## is an incremental ID number increasing by 1 with additional SSNs at a station. ID numbers below ten are preceded with a zero, e.g. 01, 02, etc. The first ten SSNs (ZZ01 - ZZ10) have been standardized as ETGs, staffs, spikes, acoustic sensor leveling point, etc. SSN ZZ11 shall always be used for the PBM. Bench marks after the PBM begin with SSN ZZ12 and increase by 1 for each new bench mark. For additional information on surveying a GPS antenna, refer to *NOAA CO-OPS Continuous Global Navigation Satellite Systems at NWLON Stations: System Level Method Description*. See the table below:

SSN ZZ01	**TBM XXX XXXX ETG READ MK** - Existing (old) ETG or ETG to be replaced.
SSN ZZ02	**TBM XXX XXXX ETG READ MK** - New or replacement ETG.
SSN ZZ03	**TBM XXX XXXX Staff** - Existing (old) staff or staff to be replaced.
SSN ZZ04	**TBM XXX XXXX Staff** - New or replacement staff.
SSN ZZ05	**TBM XXX XXXX Spike/SRM** - Existing (old) spike or spike to be replaced (lakes only); or SRM -temporary sensor reference mark (tides only) that is not a bench mark.
SSN ZZ06	**TBM XXX XXXX Spike** - New or replacement spike (Lakes only).
SSN ZZ07	**TBM XXX XXXX Aquatrak®**- Existing (old) Aquatrak® or Aquatrak® to be replaced.
SSN ZZ08	**TBM XXX XXXX Aquatrak®**- New or replacement Aquatrak.
SSN ZZ09	**TBM XXX XXXX Aquatrak® level fix** - Aquatrak® bullet-shaped levelling fixture held on old Aquatrak® or Aquatrak® sensor head to be replaced.
SSN ZZ10	**TBM XXX XXXX Aquatrak® level fix** - Aquatrak® levelling fixture held on new or replacement Aquatrak® sensor head.
SSN ZZ11	Primary bench mark for a station.

SSN ZZ78	**TBM XXX XXXX Barometer 1**
SSN ZZ79	**TBM XXX XXXX Barometer 2 (if applicable)**
SSN ZZ80	**TBM GNSS ARP** - GNSS Antenna Reference Point
SSN ZZ81	**TBM GNSS ANTENNA #** - one of the GNSS antenna's outer edge numbered and marked survey points
SSN ZZ93	**TBM XXX XXXX MWWL** – Existing (old) or Redundant MWWL or MWWL.
SSN ZZ94	**TBM XXX XXXX MWWL** - New or replacement MWWL
SSN ZZ95	**TBM XXX XXXX MWWL** - New or redundant MWWL.
SSN ZZ96	**TBM XXX XXXX NO1** - Generic TBM for breaking up long level runs.
SSN ZZ97	**TBM XXX XXXX NO2** - Generic TBM for breaking up long level runs.
SSN ZZ98	**TBM XXX XXXX Primary Pressure LP** - New or replacement orifice leveling point.
SSN ZZ99	**TBM XXX XXXX Secondary Pressure LP**- New or replacement orifice leveling point.

Water Level Data Reference Datum

In cases where historic sites are reoccupied, every effort shall be made to collect the new data series on the historic Station Datum (SD). In non-tidal areas, including the Great Lakes, special low water datums have been defined and are used as chart datum in these locations. For the Great Lakes, a unique Low Water Datum (LWD) for each lake, and for each individual station on each river based on the International Great Lakes Datum of 1985 (IGLD 85) is the reference datum. In other non-tidal coastal areas, LWD is determined by subtracting 0.5 ft. from the Mean Water Level (MWL), as calculated from the water level data collected in these locations.

Datum Offsets and Accepted Orifice Offset

When using the electronic/barcode leveling system, all five decimal places shall be used to determine the Datum/Orifice Offset. Engineering rounding shall be used, for example: 1.53455 is rounded to 1.5346, or 1.53445 is rounded to 1.5344. A note shall be made on the eSite report documenting the existing Datum/Orifice Offset was retained in the DCP, or provide the date and UTC time when a new Datum Offset was entered. When a new Datum Offset is entered into the DCP, additional notification is required as described in the Station Installation section under Critical Information. The Translev program does not use engineering rounding. If optical leveling equipment is used, then all elevations shall be recorded to the tenth of a millimeter (e.g. 12.3457 m) on the leveling abstract.

At coastal water level stations, the accepted PBM elevation above the SD in meters shall

be used as the starting elevation on the level abstract. This method results in all bench mark elevations referenced directly to the SD. All primary water level sensor connections shall be treated as spurs. Leveling to the primary sensor shall be done after the sounding tube has been cleaned and everything is put back in place. Upon initial inspection of the station, if the field party suspects sensor or orifice movement, movement of the sensor mounting structure, obstructions in the well, damage to the calibration tube, etc., then leveling shall be done twice, before disturbing the sensor and after the repair, repositioning, and/or re-securing of the sensor.

The accepted (and published) PBM elevation above IGLD85 in meters shall be used as the starting elevation on the level abstract at Great Lakes stations. This method results in all bench mark elevations referenced directly to IGLD85.

The AQLP and MWWL LP elevation above station datum is defined as the Datum Offset and is computed by algebraically adding the PBM elevation above SD to the sensor elevation above/below the PBM. The Datum Offset is also referred to as Coefficient 2 (C2) or DAT coefficient. Datum offset (C2) will not be changed unless the elevation differs by **greater than +/- 0.006 meters** from the previous elevation and only then after notification and review of the level abstract by COET.

The orifice zero elevation for the ParoScientific® pressure sensor(s) above or below the SD is defined as the Accepted Orifice Offset and is computed by algebraically adding the PBM elevation above SD to the orifice zero elevation above/below the PBM. The orifice zero elevation is considered to be the vertex point of the V-notch on the brass orifice or the bottom of the top parallel plate. For dual orifice systems the orifice offsets are established for both lower (N1) and upper (T1) pressure sensors. Accepted Orifice Offset(s) will not be changed unless the elevation differs by **greater than +/- 0.006** meters and then only after notification and review of the level abstract by COET.

The leveling connection to an ETG shall be done at the reading mark (RM). A barcoded rule (60 cm scale) or stainless steel rule, with metric graduation (mm) and the zero at the end of the rule, as appropriate, may be used by holding the rule directly on the RM.

At all Great Lakes stations, the hydraulic corrector defines the IGLD 85 datum offset and represents an adjustment to treat each Lake as geopotentially flat. The IGLD 85 datum offset is derived by algebraically subtracting the hydraulic corrector from the Dynamic Height of the ETG RM. At the Great Lakes Rivers and Connecting Channels stations the "Dynamic Height = IGLD 85", and Hydraulic Correctors are not applied. This datum offset is applied to the primary water level sensor datum offset and should only be changed by COET after reviewing the abstract and Water Level Transfer form.

After documenting the dynamic elevation for the ETG and SPIKE at Great Lakes stations, round the height to four places and apply these elevations to the "Water Level Transfer" program. Then apply the Hydraulic Corrector utilizing the sign, negative or positive in the program. This elevation is now the hydraulically corrected reference elevation, Zero

Electric Tape Gauge (ZETG) and is then rounded to three places and entered in the DCP as primary water level datum offset. The Datum Offset will not be changed unless the elevation differs by **greater than +/- 0.003 meters** and then only after notification and review of the level abstract by COET.

Movement

The movement of a sensor, such as (a) AQLP, (b) MWWL LP, (c) pressure orifice leveling point or zero, or (d) change in elevation of a bench mark with the PBM that is greater than 0.0060 m (0.020 foot) when compared to the previous difference in elevation of the bench mark with the PBM and the PBM has remained stable. For acoustic and MWWL sensors, the sensor elevation shall be compared to what is stored in the DCP and in DMS. For pressure, sensor orifices this difference shall be compared with the accepted orifice offset as listed on the eSite report (and stored in DMS) because the accepted orifice offset is not stored in the DCP. COET and the supporting FOD field office shall be notified by phone and/or sent an email immediately with the level files when the Datum Offset is changed in the DCP, or the accepted orifice offset is changed greater than **+/- 0.006 m**. An e-mail must be received by COET and the supporting FOD field office within 24 hours of observing the change.

At Great Lakes stations, if the primary water level datum offset determined from the latest levels indicates a difference greater than **+/-0.003 m** from the DAT value presently stored in the DCP and the PBM has remained stable, contact COET and the supporting FOD field office by phone or e-mail immediately and provide the leveling abstract and Water Level Transfer.

All movement shall be noted in the leveling section of the eSite report. For coastal water level stations, if the Datum Offset determined from the latest level run indicates a difference **greater than +/- 0.006 meters** from the elevation presently stored in the DCP, and the PBM has remained stable, the new Datum Offset shall be entered into the DCP after consultation with COET. If the differences of the bench marks in the network remain within the **+/- 0.006 m** allowable tolerance, then the PBM is determined to be unstable and the Datum Offset in the DCP shall not be changed. The suspected movement of the PBM shall be specifically noted in the eSite report and WinDesc file, for further action by COET.

Geodetic Connections

Water level datums are local vertical datums, which may vary considerably within a geographical area. A geodetic datum is a relative reference surface to which heights are referenced. At present, the North American Vertical Datum of 1988 (NAVD 88) is the accepted vertical datum of the National Spatial Reference System (NSRS) for the conterminous United States and Alaska and is officially supported by NGS. The relationships of tidal datums to geodetic datums such as NAVD 88 and to ellipsoid heights (above GRS 80 ellipsoid) support many hydrographic, coastal mapping, and engineering applications including monitoring of sea level changes, the deployment of GPS Electronic Chart Display and Information Systems (ECDIS), and the NOS Vertical Datum (VDatum) transformation tool.

A Geodetic Bench Mark (GBM) is defined as a bench mark that exists, is usable, is

available in the NGS database, has a Permanent ID (PID), and has a NAVD 88 elevation published on the datasheet. At the majority of NWLON stations, there are two or more tidal bench marks available that are also GBM increasing the chance that the geodetic level tie would be valid if those marks were located at least 500 m apart from one another. Existing GBMs in the vicinity (up to 1.6 km (1 mile) leveling distance) of a water level station shall be searched for and recovered. If a mark is found, a separate report shall be submitted to NGS using the NGS on-line Mark Recovery Entry Form available at http://www.ngs.noaa.gov/cgi-bin/recvy_entry_www.prl.

The connection to geodetic datums involves the following three leveling ties:

- NAVD 88 Level Tie
- NAD 83 GPS Tie
- NAVD 88 GPS Tie

An orthometric level connection and ellipsoidal GPS tie are required at each water level station.

The required "NAVD 88 Level Tie" is described in this document and the required "NAD 83 GPS Tie" and "NAVD 88 GPS Tie" are described in the *User's Guide for GPS Observations at Tide and Water Level Station Bench Marks*.

NAVD 88 Level Tie

At all NWLON stations, NAVD 88 level tie is required with a valid level tie to at least two GBM that are at least 500 m apart, where appropriate GBM marks are available within 1.6 km (1 mi) leveling distance of the station location. The two GBM selected for the two-mark tie must be a minimum of 500 m apart as per NGS requirement for blue- booking and acceptance into NSRS.

The leveling tie to NAVD 88 for all NWLON stations in the conterminous United States and Caribbean Islands shall be performed using Second Order, Class I leveling techniques. A Third-Order tie is used for all NWLON stations in Alaska, Hawaii, and Pacific Island areas. Note that Third Order Levels cannot be submitted for Blue-booking.

The Second Order, Class 1 tie is a requirement for digital levels to be accepted into the NGS database. Short level runs to the sensor, PBM, and two marks are excluded from this requirement since they are usually meant to verify sensor stability only. Since a level connection to GBMs with dynamic heights defines the International Great Lakes Datum of 1985 (IGLD 85) datum offset at each station in the Great Lakes, a valid connection to at least two GBMs (within a mile of station location and minimum 500 m apart) is required at each site.

A note shall be made in the comments of the leveling section of the eSite report that a valid tie was achieved or not achieved. If a valid tie is not achieved, an explanation shall be provided and/or recommendations made for making a valid tie in the future.

If a successful NAVD 88 level tie is performed, then NAVD 88 elevations for all the bench marks in the local leveling network can be determined for the NOS Vertical Datum transformation (VDatum) program.

If the water level station does not have two or more GBMs within 1.6 km (1 mi) leveling distance of the station location, then the NAVD 88 level tie requirement is waived.

The Translev leveling program includes a check function that will tell the user if a two-mark tie to NAVD 88 has been successful. Information on performing a valid level tie is also provided in the Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks, listed at the following website: https://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.pdfhttps://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.pdf

Leveling at CORS

For any NGS Continuously Operating Reference System (CORS) reference bench mark that is located within 1.6 km (1 mi) leveling distance of a water level station DCP, a leveling connection shall be made to the bench mark network every two years.

Information about NGS CORS stations can be obtained at http://www.ngs.noaa.gov/CORS/.

Schedule, Reports, and Deliverables

Schedule and Reports

Field schedules are expected to be made available for all observing systems in the first quarter of the upcoming fiscal year. Schedules for FOD and IDIQ contractor operations are combined to produce one composite plan.

IDIQ contractors shall provide the COR, TR, COET, the supporting Instrument Lab and FOD field office a proposed annual schedule for accomplishing the work documented in the Station Specific Requirements section of the Dynamic Project Instructions, the task orders, and work discussed at the beginning of the contract year with updates on a monthly basis, or as specified in the contract documents. Changes to the schedule must be requested in advance and approved by the COR or Technical Representative (TR).

Field activities shall be discussed in a monthly activities report, or as specified in the contract documents. IDIQ contractors shall submit a monthly report, for each task order, via Task Order Management Information System (TOMIS) no later than the 10th day of the month.

Deliverables – Timelines, Documentation, and Points of Contacts

Timeline Requirements
The one-day (24 hr.) eSite report along with the level files shall be forwarded to COET within 24 hours after the completion of the following maintenance activities:

- Installation of a station
- Completion of regular scheduled maintenance
- Completion of unscheduled maintenance
- Completion of check levels
- Removal of a station

The field party shall submit the following to the COET via the eSite report:

- Station Number and Name
- Date of the Site visit
- Latitude/Longitude
- Platform ID, Transmit time, Channel (if changed)
- Serial numbers of all DCPs, and sensors
- Level files with Steel-tape measurement(s) (if applicable) Note: Submit via email
- Sensor Offset C1 (SNS) and Datum Offset C2 (DAT) as entered in the DCP for acoustic sensor, MWWL sensor, and SAE; and Orifice Offset(s) for pressure sensors.
- Staff-to-Gauge Observations (when required)
- Water Level Transfer form (if applicable)

This requirement applies to all stations and all sensors for every type of maintenance - installation, regular scheduled maintenance, unscheduled maintenance and removal.

CO-OPS has developed a web-based electronic site report (eSite report) that interacts with DMS. Refer to the *eSite User's Guide* for a complete description of the usage of this interface for the submission of site reports to COET for review.

Generally, COET will provide feedback within 24 hours, or earlier during normal business hours, if/when there are questions, concerns or missing information found in review of the 24 hour deliverables.

Required Station Documentation
The field party is required to submit a complete station documentation package deliverable within 30 calendar days of the site visit. All data and documentation submitted to CO-OPS shall be retained by the field crew for a period of not less than three years or as stipulated in the contract, whichever is longer.

The standard water level station documentation package includes the following:

1) Transmittal letter (PDF format) – Note: CO-OPS FOD provides this notification via email
2) eSite Report (eSite report in web based electronic format)
3) Sensor Well Drawing (PDF format) (required for newly installed stations or any modification to sensor well – PDF format)
4) Sensor elevation drawing (PDF format) showing sea floor, pier (deck) elevation, and each sensors' elevation above the appropriate datum (required for newly installed sensor(s), any sensor elevation change – PDF format)
5) Water level transfer form (for Great Lakes stations only - PDF format)
6) Bench mark Diagram (PDF format) – Large-scale bench mark location sketch of the station site showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The bench mark diagram shall include an arrow indicating north direction, a title block that includes: the station name and number, NOAA chart number, USGS Quad name (from a 15" x 15" map), field unit, date created, drawn by, and latitude and longitude (obtained from hand-held GPS receiver) of the gauge, and label of the body of water
7) Bench mark descriptions with handheld GPS coordinates (dd/mm/ss.x format) (electronic file - WinDesc)
8) "Station to Reach" statement in Microsoft Word format if the eSite Report application is not used.
9) Digital photographs of each bench mark disk (four views: face, setting, and 2 cardinal directions), station, DCP, equipment, underwater components, and the location to include the body of water being observed (JPEG format)
10) Levels (electronic files) including leveling equipment information and field notes of precise leveling, if applicable
11) Abstract of precise leveling (electronic format)
12) Datum offset computation worksheet or Staff/Gauge difference worksheet as appropriate showing how sensor "zero" measurement point is referenced to the bench marks
13) Staff to gauge observations, if applicable (Microsoft Excel format)
14) Calibration certificates for Invar leveling rods, if applicable (PDF format)
15) Calibration records for sensors, if applicable (PDF format)
16) Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (PDF format)
17) Environmental Compliance Best Management Practices checklist/documentation (Microsoft Word or PDF format)
18) Water level data download in specified format, if applicable
19) DCP configuration files (for MWWL, Paros, and Aquatrak sensors), if applicable
20) GPS Deliverables - the visibility diagram, GPS solution (email), OPUS published datasheet and four photos of the GPSBM in electronic format for each observation session as described in the User's Guide for *GPS Observations at Tide and Water Level Bench Marks*

21) Scheduled Maintenance Checklist
22) Diving Documents (DAMP, Dive Plan, etc.)
23) Confined Space Permit, if required
24) As-Built Engineering Drawings and Design Documents (PDF format)
25) Other information as appropriate, or as specified in the contract (PDF format)

The station documentation shall be submitted in digital format only. All GPS data and documentation shall be published to NGS OPUS. All of the documentation listed above is required at the installation of a water level station (as applicable). After the completion of a scheduled maintenance, unscheduled maintenance or removal site visit, only the documents that have changed are required.

Water level data downloaded for NWLON, PORTS, Tsunami, Coastal Hazards, or in-house projects shall be in accordance with the *Engineering Bulletin 07-006 Exporting Data from Xpert Family DCP*. Data downloads request will be provided to the field party and/or the appropriate lab during the pre-trip coordination meeting, via the operational JIRA ticket, the current year Dynamic Project Instructions, or documented in the Project Instructions section of the scheduled maintenance checklist. Field parties are required to provide a copy of the DCP configuration files after each maintenance.

The "Station to Reach" statement, the bench mark diagram, the sensor elevation drawing, and the sensor well drawing need only be submitted if these items have been revised during the station maintenance, unscheduled maintenance, upgrade, relocation, or removal.

When using the electronic/barcode system, all digital files created using the WinDesc and Translev programs shall be submitted. At stations where the automated or manual levels are used, Precise Leveling sheets of actual runs (NOAA Form 75-29) and the Abstract of Precise Levels (NOAA Form 76-183) shall be completed and submitted along with the WinDesc description file.

For submission in electronic format, the station documentation shall be organized by various subfolders and file names under the main station number folder. Then pertinent information shall be placed in the various folders and submitted on a digital media. The level files, photographs, GPS data, and dive documents shall be submitted in subfolders under the main station folder. All other files are saved under the main station folder.

Below is an example of a submission of the electronic folders for San Francisco tide station. The abbreviations in parentheses should be used to name the electronic files and subfolders. Empty folders or folders with no deliverable documents do not need to be included.

9414290 San Francisco 2017 Annual Inspection

- Transmittal letter via email for CO-OPS FOD (Transmittal)
- eSite Report (9414290 12-10-17 SM)
- Sensor Well Drawing (9414290 2017 Well Drawing)
- Sensor elevation drawing (9414290 2017 Sensor Elevation)

- Water level transfer form (9414290 2017 Inside-Outside)
- Bench mark Diagram (9414290 2017 BM Diagram)
- Bench mark descriptions (WinDesc - 9414290) and (9414290 12-10-17.txt)
- "Station To Reach" Statement (9414290 2017 To Reach)
- Photographs of bench marks, station, DCP, equipment, and vicinity in digital format (Photos)
- Levels (raw electronic files) and field notes of precise leveling (Levels)
- Abstract of precise leveling (9414290 12-10-17)
- Datum offset computation worksheet or Staff/Gauge difference worksheet (elevation of sensor zero measurement point referenced to bench marks) (DAT WKS)
- Staff to gauge observations, if applicable (STG Obs)
- Calibration certificates for Invar leveling rods, if applicable (Rod Cal Certs)
- Calibration records for sensors, if applicable (Sen Cal Certs)
- Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (Docs)
- Environmental Compliance documentation (9414290 2017 Enviro Comp)
- Water level data (6-minute, hourly heights, high/low, monthly means, station datum) (WL Data)
- DCP configuration files (DCP Config)
- GPS deliverables (GPS) - 9414290 2017 HT2253
- Scheduled Maintenance Checklist (SM Checklist)
- Diving Documents (Dive Docs)
- Confined Space Permit (CS Prmts)
- As Built Drawing (As Built)
- Other information as appropriate, or as specified in the contract (Other)

Part B: REQUIREMENTS FOR RECONNAISSANCE, INSTALLATION, OPERATION, MAINTENANCE, AND REMOVAL OF CURRENT METER STATIONS

Current Meter Station Installation Specifications

Bottom Mounted Acoustic Doppler Current Profiler (ADCP)
Bottom-mounted water current observations are conducted with RD Instruments (RDI) Workhorse ADCP's, SonTek Acoustic Doppler Profilers (ADP), and Nortek 3D (AWACs, Aqadopp 3 beam and Signature 3 to 5 beams) (ADCP). The current meter is mounted in a diver-serviced trawl-resistant platform designed for shallow water. The lightweight platforms are designed for ease of handling and may be deployed from a small vessel capable of safely handling a dynamic load of 1500 lbs. in air and a reel holding an armored cable. The ADCP/ADP is connected via an underwater cable to a power/data relay station using logging cable and standardized underwater pluggable connectors. A Datasonics® UAT-376-EL underwater acoustic transponder is fitted to the ADCP/ADP platform to facilitate raising and lowering of the sensor during inspection and service visits. At the power/data relay station, an interface circuit designed by CO-OPS is used to connect the ADCP/ADP to an IP modem. The data are then polled through the IP modem, ingested in the DMS, and disseminated. (Note: the interface circuit is no longer being fabricated and has been replaced by the Sutron® ADCP-X DCP.

Buoy Mounted Acoustic Doppler Current Profiler (AQD)
CO-OPS installs the Nortek 1 MHz Aquadopp Current Profiler, usually oriented downward, on U.S. Coast Guard Aid to Navigation (ATON) buoys. The Aquadopp current meter uses a custom designed clamping device ("Clamparatus"). The ATON current meter observing system works in conjunction with a shore station that collects and stores the current data. The data are polled and ingested in the DMS and disseminated. CO-OPS has developed and deployed a new Iridium® based ATON system (called iATON) in some locations. This system includes two enclosures-one for the data collection platform and telemetry system, the other for the batteries, thus eliminating the need for shore stations.

Side-Looking (e.g. Pier Mounted) Acoustic Doppler Current Profiler (SL-ADCP)
CO-OPS installs the SonTek YSI Side-Looking Acoustic Doppler Profiler (SL-ADCP), the Teledyne RDI Workhorse Horizontal Acoustic Doppler Current Profiler (H-ADCP), or the Nortek AWAC or Aquadopp 2D Horizontal Profiler on piers and similar structures. These sensors can be mounted to vertical or sloped surfaces to measure the currents at a single depth across a channel . These instruments are connected via a cable to a DCP on the pier. These sensors are typically installed approximately 15 ft. below MLLW (or one-half the distance between the harbor bottom and the MLLW for water depths less than 30 feet, or about ⅔ the water depth). A critical component of these installations is that the instrument's orientation (pitch and roll) in either axis be as close to zero degrees as possible to reach maximum profiling range, as measured by the SL-ADP, H-ADCP, or 2D AWAC.

There are several types of mounts for side-looking sensors. The first is mounted on a stainless steel ladder that is raised and lowered vertically by a synthetic line. The sensor is fixed to a mounting plate on the bottom section of the ladder.

There are also two primary types of I-Beam side-looker mounts, one utilizes a synthetic line to raise and lower a weighted sled. This mounting structure requires monitoring of the ADCP pressure sensor to ensure that the sensor is returned to the same depth after being raised. The second I-Beam mount utilizes a chain hoist to both raise and lower the sensor sled and was developed for I-Beams mounted on a slope.

Reconnaissance and Engineering Design

Current meter observing systems reconnaissance shall be performed in accordance with *Desktop Reconnaissance Procedures for Planning Current Meter Deployments to Update the Tidal Current Tables, SOP 3.2.3.6 (F5) CO-OPS Current Meter Reconnaissance Procedures.*

Bottom Mounted Current Meter

The site reconnaissance field notes and log(s) must include descriptions of buoys or large ships passing that characterize the vessel traffic, description of the pier and other nearby structures, CTD casts, and photographs of the bottom grab sample or the gravity core sample to characterize the bottom structure. These items shall be submitted to ED and the supporting Field Office within five calendar days of the end of the reconnaissance trip.

Buoy Mounted Current Meters

Buoy structure is important in determining whether ATON and iATON mounted current meter stations can be installed in a given location. There are two different sizes of "Clamparatus" used, depending on buoy diameter. The 8 ft. and 9 ft. diameter buoys use the same clamp but different length tube (10 ft. or 12 ft.). The 6 ft. and 7 ft. diameter buoys use a smaller clamp and a 10 ft. long tube with an adapter plate that attaches the battery case in the superstructure. The color of the buoy must also be documented, as the color of the Clamparatus must match the color of the buoy. The top of the buoy must be flat; older buoys have rounded tops and cannot be used.

The buoy should be inspected to see that there is no additional welding or patches around the offset lifting eye. (Note: the eyes that are opposite each other in the top of the buoy correspond to the mooring eyes that are used to attach the mooring bridle below the surface for 6, 8, and 9 ' buoys. 7 ft buoys should be inspected to determine the keel location and appropriate lifting eye should be chosen based on the on-site inspection). Document whether the superstructure is too near the lifting eye. The lifting eye can not extend more than three inches horizontally outside of the buoy hull. Note that the configuration of eyes is not the same for each buoy, as it depends on buoy size. If no bouy can be identified for use, then discuss other options with the U.S. Coast Guard (USCG). If a shore station is planned, then perform a reconnaissance for a location to install a DCP within directional radio distance of the buoy. The shore station is not required if

an Iridium® based iATON observing system is installed.

When installing iATON stations, a "Hoistaratus" is used. The Hoistaratus is a system of rope, pulleys, and clips designed by CO-OPS.

Side-Looking (e.g. Pier Mounted) Acoustic Doppler Current Profiler (SL-ADCP)
Once the site is identified and agreed upon, complete a small vessel survey of the area to identify standing sandbars or waves, or structures that could interfere with or impede the performance of the sensor. If a vertical station is proposed, then a gravity-lowered I-beam installation is preferred. If a sloped station is proposed, then the chain hoist model is required. Vertical installations are less complex as they do not require the chain hoist. Refer to the field and desktop reconnaissance SOPs for all side-looker installations.

Permits

The field party shall be responsible for security and/or protective measures, as required, for protecting the government furnished equipment and the facility while installing, maintaining or removing a current meter station. The field party shall obtain all required permits and permissions using CO-OPS approved templates (found on the ROS web page for in-house projects or available via the COR for contract installations) for the installation of the current meters and utilities, as required. The field party must also provide copies of signed agreements, permits, and permissions to ED and the supporting FOD office as part of the observing system installation station package documentation deliverable.

Field teams are required to adhere to all OSHA safety regulations to include wearing the required gear when performing maintenance tasks at CO-OPS observing stations.

Environmental Compliance

Field parties are responsible for conducting an environmental impact analysis and preparing the appropriate environmental compliance documentation. CO-OPS field parties are responsible for discussing with the Environmental Compliance Coordinator (ECC) any compliance requirements and documentation required related to the installation, relocation, maintenance and/or upgrade of an observing system. The IDIQ Contractor is responsible for ensuring all compliance requirements are met, documented and submitted to CO-OPS as part of the installation, relocation, or upgrade station package documentation deliverable. Refer to the CO-OPS Environmental Compliance Policy for further guidance.

Station Maintenance Requirements

The majority of current meters are maintained by contracts and therefore should adhere to the maintenance schedules described in the Statement of Work (SOW). For current meters maintained in-house, the schedule for maintenance is as follows:

Sensor	2 Mo	6 Mo	Yearly	2 Year	4 Year
Side-Looking ADCP		D/C		R	
Bottom-Mounted ADCP, Platform, and Relocation Pinger		D/C		R	
Bottom-Mounted ADCP, Cable					R
Buoy-Mounted ADCP		R		R/L	
Radio Base Station			I		

Key: C-Clean, D-Dive, I-Inspect, K-Calibrate On Site, L-CO-OPS Calibrate, R-Replace, S-Service

Bottom Mounted Acoustic Doppler Current Profiler (ADCP)
The field party shall inspect and clean all above-water components of the station (e.g., enclosures, locks, antennas, solar panels, stands, mounts, poles and standoffs; conduit, cables, connectors, and desiccant). The field party with the support of divers shall repair and replace components as necessary. The field party shall clean the bottom-mounted current meter and platforms, and visually inspect them for damage. The divers shall also visually inspect the acoustic transceivers. Digital photographs or video before and after cleaning are required. All maintenance activity shall be documented on the Current Meter Station Log.

The field party shall replace expired gel cell batteries in the DCP and topside electronics with approved replacements, per *Engineering Bulletin 10-002: Standardize Battery Type for CO-OPS Water Level and Meteorological Stations with Photovoltaic Charging Systems*. Batteries shall be labeled with the installation date, shall be load tested annually, and shall be replaced every four years as listed earlier in Part A, Station Maintenance: Battery Performance Check. The field party shall properly dispose of all old batteries.

Every two years, the field party shall remove the bottom-mounted current meter and replace it with a Government Furnished Equipment (GFE) spare current meter. The field party shall return the recovered cleaned current meter to CO-OPS, and CO-OPS will conduct a "tow test" and verify functionality of the current meters if necessary, prior to reinstallation.

Buoy Mounted Acoustic Doppler Current Profiler (AQD)
The field party shall inspect and clean all above-water components of the shore station (e.g., enclosures, locks, antennas, solar panels, stands, mounts, poles and standoffs; conduit, cables, connectors, and desiccant). The clamparatus and associated electronics shall be inspected. The field party shall repair and replace components as necessary. The field party shall replace the buoy-mounted current meter system with a complete replacement system at approved time interval or per the contract documents. Batteries shall be replaced and the current meter and Clamparatus shall be cleaned for redeployment in the future.

The field party shall replace expired batteries in the shore station or buoy mounted battery

enclosure and topside electronics with approved replacements, per the *Engineering Bulletin 10-002: Standardize Battery Type for CO- OPS Water Level and Meteorological Stations with Photovoltaic Charging Systems*. Batteries shall be labeled with the installation date, shall be load tested annually, and shall be replaced every four years as listed earlier in Part A, Station Maintenance: Battery Performance Check. The field party shall properly dispose of all old batteries.

The field party shall return the recovered cleaned current meter to the supporting FOD. CO-OPS will conduct a "tow test" and verify functionality of the current meter approximately every two years or prior to reinstallation of the sensor. All maintenance activity shall be documented on the Current Meter Station Report.

Side-Looking (e.g. Pier Mounted) Acoustic Doppler Current Profiler (SL-ADCP)
For side-looking current meter stations, the field party shall inspect and clean all above-water components of the station (e.g., enclosures, locks, antennas, solar panels, stands, mounts, poles and standoffs; conduit, cables, connectors, and desiccant). The field party shall repair and replace components as necessary. The side-looking current meter shall be raised, inspected and any fouling cleaned off the chain, sensor, sled, mount, and cable to ensure proper chain movement and data collection. Digital photographs or video are required before and after cleaning. All maintenance activity shall be documented on the Current Meter Station Report.

Replace expired gel cell batteries in the DCP and top side electronics with approved replacements, per the *Engineering Bulletin 10-002: Standardize Battery Type for CO-OPS Water Level and Meteorological Stations with Photovoltaic Charging Systems*. Batteries shall be labeled with the installation date, shall be load tested annually, and shall be replaced every four years as listed earlier in Part A in the Station Maintenance: Battery Performance Check section. The Contractor shall properly recycle all old batteries.

Every two years, the field party shall replace the side-looking current meter and return the cleaned recovered current meter to the appropriate supporting FOD office. CO-OPS will test and verify functionality of the current meter, if necessary, prior to reinstallation.

Station Removal

Prior to the removal of any current meter, CORMS must be notified so that data dissemination can be turned off.

Bottom Mounted Acoustic Doppler Current Profiler (ADCP)
This removal should be performed using a vessel with a dynamic lifting capacity that is equal to or exceeds the weight of the mount in air. The communication cable can be used for recovery. If the cable becomes compromised, then a synthetic line that is capable of lifting the mount needs to be connected by divers to the mount. For recovery of the mount, tension should be taken on the recovery line allowing the buoyancy of the vessel to dislodge the mount from the bottom.

Buoy Mounted Acoustic Doppler Current Profiler (AQD)
Using a small vessel, the field party will use the Hoistaratus and transfer the mount to the vessel; and pivot and drain water from the sensor tube and secure the sensor on the vessel. The field party will remove the shore station, if applicable, and revert the site back to its original condition prior to the installation.

Side-Looking (e.g. Pier Mounted) Acoustic Doppler Current Profiler (SL-ADCP)
The field party will remove the observing system and revert the site back to its original condition prior to the installation.

Schedule, Reports, and Deliverables

Schedule and Reports

Field schedules are prepared for all observing systems in the first quarter of the upcoming fiscal year. Schedules for FOD and IDIQ contractor operations are combined to produce one composite plan.

IDIQ contractors shall provide COET and the supporting Instrument Lab and FOD field office a proposed annual schedule for accomplishing the indicated work in the station specific requirements section of the Dynamic Project Instructions, or task orders, at the beginning of the contract year with updates on a monthly basis, or as specified in the contract documents. Changes to the schedule must be requested in advance and approved by the COR or TR.

Operations related to the Station Specific Requirements section of the Dynamic Project Instructions, and/or task orders, shall be discussed in a monthly activities report, or as specified in the contract documents. IDIQ contractors shall submit a monthly report, for each task order, via TOMIS no later than the 10th day of the month.

Deliverables – Timelines, Documentation, and Points of Contacts

Deliverables Timeliness
The field party shall submit the one-day station report via email notification within one day of the completion of the site visit. The IDIQ Contract field party shall submit the complete station package deliverable to TOMIS within 5 business days of the completion of the site visit. The CO-OPS FOD field party shall submit the complete station package deliverable to within 5 business days of the completion of the site visit.

Documentation Requirements

Transmittal letter
A letter of transmission of the documentation must be submitted with all complete station package deliverables.

Current Meter Station Report

Station reports are required for all station visits. When a swap occurs, two station reports must be submitted- one for the recovery of the old sensor and one for the deployment of the new sensor. The following metadata is required:

- Station name
- Station ID
- Y-axis direction (horizontally mounted)
- X-axis direction (horizontally mounted)
- Sensor pressure coefficients (horizontally mounted)
- Sensor manufacturer
- Sensor type
- Sensor serial numbers
- Sensor specific parameters (blanking distance, # of bins, bin size, ping interval, center to bin 1 distance, ambiguity velocity (if TRDI instrument))
- Exact deployment/recovery time of the current meter in UTC
- Time zone of station and offset to UTC
- Sensor position (hand held or vessel GPS readings) in degrees, minutes, and seconds to the tenth of a second (dd/mm/ss.x)
- Shore station position (handheld GPS readings) in degrees, minutes, and seconds to the tenth of a second (dd/mm/ss.x)
- Station depth at time of deployment, referenced to MLLW (from vessel sounding/fathometer, depth in meters)
- Sensor depth at time of deployment (reference to MLLW)
- Part installation/remove date and time (UTC)
- Height of the sensor above the bottom, if applicable
- Type of mounting information
- Field personnel names
- Vessel name
- Compass (magnetic declination) – Verify this is correct by comparing the log provided value to the World Magnetic Model (WMM) or International Geomagnetic Reference Field (IGRF). This can be done on NOAA's National Centers for Environmental Information (NCEI) web tool. (http://www.ngdc.noaa.gov/geomag-web/#declination).
- Include in station notes: any required security clearances and contact points for clearances, advanced notice requirement and contact point, and other logistics information.
- Include in field notes: description of the maintenance performed and additional information regarding the status of the station.
- Transmission parameters. These are often added into the notes section.
- Transponder information for bottom mounted sensors.

Maintenance/Installation Checklist

A maintenance checklist exists to address the three main configurations for real- time current meters:

Due to the difference in retrieval and the general configurations of these stations, the checklists have slight differences. However, the following details should be evaluated and be consistent across all types:

- The maintenance checklist should be completed and submitted in electronic format.
- Ensure CORMS and CIL/SIL were notified of the field party presence during the time of maintenance.
- For a sensor swap or new sensor installation, the sensor that is being deployed must have completed a 48-hour bench test.
- Battery voltages should show values greater than 12.6 volts. The batteries should be no older than 4 years old. If the battery shows less than 12.6 volts or is older than 4 years old, then it must be replaced.
- Ensure sensor manufacturer specific instructions (Nortek, SonTek, and TRDI) are met.
- If the IP modem is swapped, send an email to the TR, COR, supporting Instrument Lab and COET. This email should contain both the old and new phone and IP information.
- If a sensor is swapped, verify that an email was submitted to the TR, COR, supporting Instrument Lab and COET. This email should contain the sensor manufacturer, frequency, serial number, bin size, number of bins, blanking distance, measurement coordinate system, pressure coefficients, and latitude/longitude. This information must also be included in the Current Meter Station Report.
- If the sensor configuration is changed or there were changes to communication settings, verify that an email was submitted to TR, COR, supporting Instrument Lab and COET. This email should contain specifics on the changes to the setup. This information must also be included in the Current Meter Station Report.
- Note any field comments in the maintenance checklist. It is acceptable to have other metadata or information included.

Chartlet

- The station location should clearly be indicated by a symbol. If the station has an associated shore station for communications and transmission that should also be clearly indicated by another symbol.
- A standard title block includes station number, station name, latitude/longitude as degrees/minutes/seconds (dd, mm, ss.x), NOAA Chart number, and USGS quad name in all caps.
- A compass accurately depicting the orientation of the image should be included.
- The chartlet should be in .PDF or .JPG format.

Sensor Elevation Drawing

New station installs typically include a sensor elevation diagram to give height references

between different components of a real-time currents station. The most important heights are the sensor depth and water depth, as these two heights are taken into account during data ingestion. Water depth is obtained via a boat sounder/fathometer. The sensor elevation diagrams should contain the following:

- All heights given in meters.
- Proper header and descriptive information (station name, station number, date of drawing, revisions, and names of drafters).
- Sensor depth (relative to MLLW)
- Water depth (relative to MLLW)
- Other component heights (e.g. GPS antenna, IP antenna, GOES antenna, winch box, pier deck)

The sensor elevation drawing should be in .PDF or .JPG format.

Sensor Test Worksheet and Compass Calibration

- A screen capture of the compass calibration for the deployment of the sensor should be included, if completed during the maintenance. The compass calibration error should be no larger than 5.0 degrees.
- A screen capture of the deployed configuration details for the current meter is acceptable.
- The worksheet should be submitted in .PDF or .JPG format.
- For all Up or Down looking ADCPs, a compass calibration must be performed on installation or replacement (or replacement of batteries). Manufacturer's instructions should be followed and a record of the procedure should be captured. i.e. a screen capture of the calibration.

Photographs

- Photos must be clearly in focus; photos are required for new stations, when noted in the Station Specific Requirements section of the Dynamic Project Instructions or if the existing equipment or the environment has changed.
- For routine maintenance and unscheduled maintenance, submit photos documenting the maintenance performed (before/after cleaning, swapped parts, etc.).
- Name the current meter observing system photos with the following format: station number followed by the specific view description, and the date (YYYYMMDD) of the photo (e.g. cb0101_ADCP close-up_20151125). Most photos should be in .JPG or .PNG format.
- For new station installations, the typical photos include the following:
    - General view (shore station enclosure for electronics)
    - Open view (view inside of station electronics enclosure)
    - DCP (if used)
    - General view (current meter/ADCP)
    - Close-up view (current meter/ADCP)
    - Mount (I-beam, Clamparatus (ATON), bottom-mount, etc.)

- Waterway (view of measured waterway, in direction of current meter)

See Appendix B for a sample set of current meter observing system station photos.

Magnetic Declination
A screenshot should be provided of the magnetic declination value at the latitude and longitude of the sensor when the sensor is deployed. This can be done on NOAA's National Centers for Environmental Information (NCEI) web tool (https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#declination). The time used for this tool should be the deploy date of the new sensor.

Station To Reach Statement
This should be provided in proper NOS format in a text document or in the current meter station report. The To Reach Statement should start from a readily found prominent landmark, use the mode of transportation most common to the area, and guide the user to the station via the most direct and major route. This Station To Reach Statement shall be provided when a new station is installed or if there is a change to the station location or surrounding area.

A separate To Reach Statement should be provided for both the shore station and the sensor if they are established a significant distance apart. For offshore sensor deployments that require a vessel to reach, nearby landmarks should be included in the To Reach description.

Agreements (if applicable)
Include the land use agreements, utilities/pier agreements, leases, licenses, etc. in the submission of the initial station installation package deliverable.

Data Downloads (upon request)
If needed or requested, current meter data is to be provided in the station package deliverables. For current meter installations, include the instrument setup files as part of the documentation submission.

Other information/documentation (if applicable)
This can include information that is contract specific or to address station specific requests (e.g. GPS observations, specific configuration setups, additional Google Earth files (.kmz, kml), and engineering drawings).

Task Order Deliverables
Deliverables include any additional requirements specified in the task order. Paper documentation shall be scanned and sent digitally.

For submission in digital format, the station documentation shall be organized by filenames under the main station number folder. Photographs shall be placed in a subfolder under the main folder.

Below is a sample submission given for n03020 The Narrows current meter station. The abbreviations in parentheses should be used to name the electronic file folders.

n03020 The Narrows
(main folder) Transmittal
Letter (Transmittal) Station
Report (Stn Report)
Maintenance/Installation Checklist
(Checklist) Chartlet (Chartlet)
Sensor elevation diagram (Sen
Elev DWG) Sensor test worksheet
(Sen Test WKS) Photographs
(Photos)
Compass Calibration and Magnetic Declination (Compass Cal)
Calibration Records - Note: May contain configuration screenshots (Cal Records) Station To Reach Statements (STR Stmt)
Agreements
(Docs) Data
Downloads
(Data)
Other information (Other)
Task Order Deliverables (Task Del)

Appendix A - Sample Station Photos

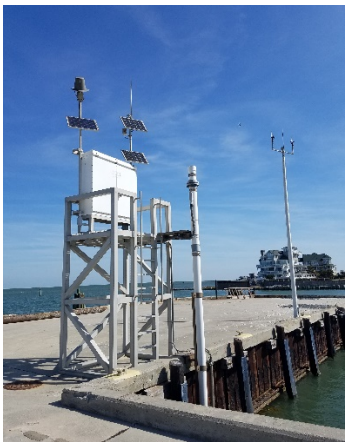

Figure A - General View 1

Figure D – Primary Sensor

Figure B - Enclosure/Shelter

Figure E – Protective Well

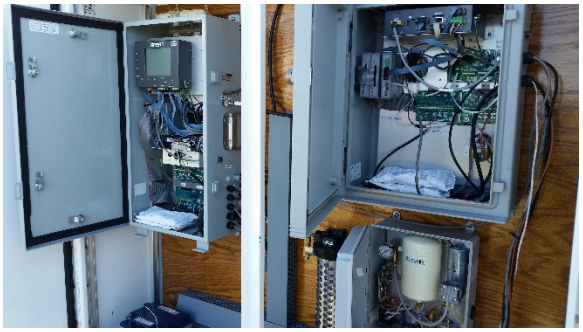

Figure C - DCPs

Figure F – Met Mast

Figure G - Wind Sensor(s)

Appendix B - Great Lakes Sample Station Photos

Figure A - General Great Lakes Station View

Figure C – DCP

Figure B - Shelter/Enclosure

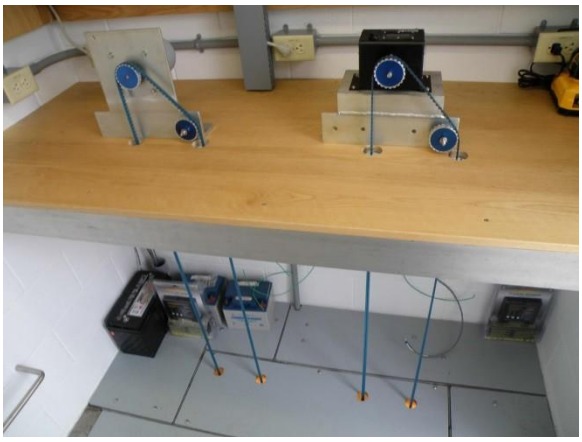

Figure D – Shaft Angle Encode

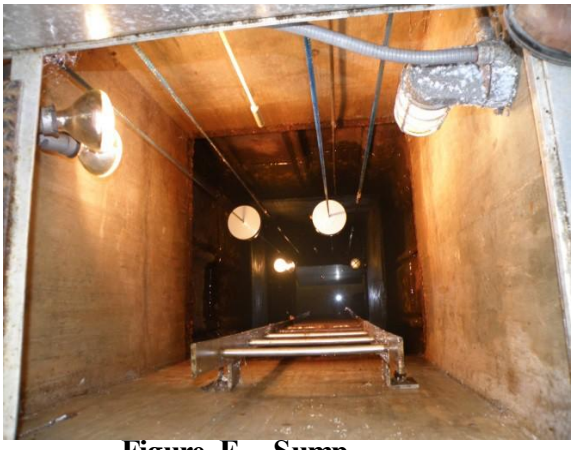

Figure E – Sump

Figure H - Electric Tape Gauge

Figure F - Met Mast

Figure J - Communication Antenna

Figure G - Wind Sensor(s)

Appendix C – Sample Current Meter Photos (Side-looker)

Figure A – General View

Figure D – Current Meter

Figure B – Enclosure/Shelter

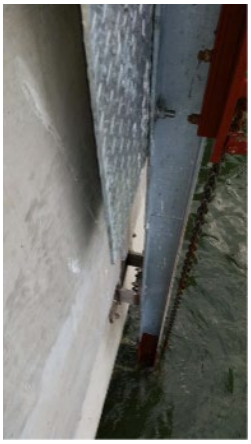

Figure E – Foundation (I-Beam Mount)

Figure C – DCPs in General (inside of enclosure/shelter)

Figure F – Waterway (across from sensor)

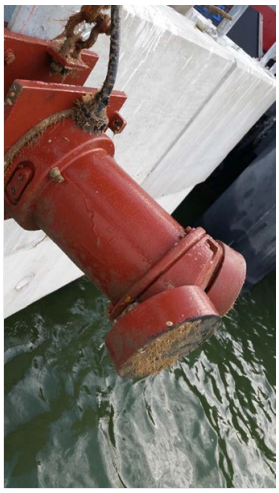

Figure G –Unique structure (i.e. sled)

Figure H –ATON

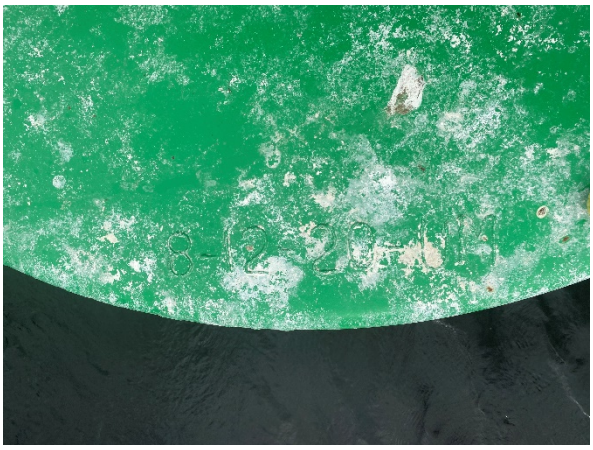

Figure I –ATON Serial Number

Appendix D – Sample Current Meter Photos
(Buoy Mounted, Bottom Mounted)

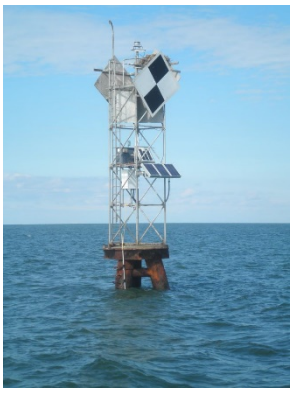

Figure A - General View (Current Meter)

Figure D – Current Meter (Close-Up)

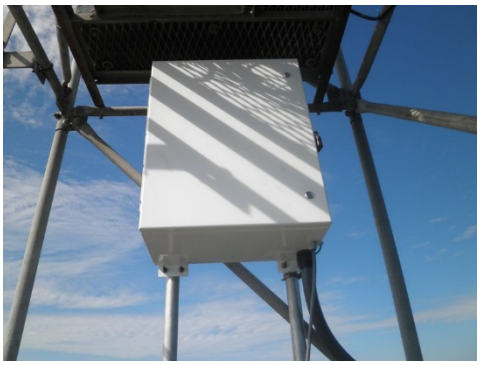

Figure B – Shore Station – Enclosure/Shelter

Figure E – Foundation (eg. Clamparatus, Bottom Mount)

Figure C – DCPs

Figure F – Waterway Being Measured