



CO-OPS SPECIFICATIONS AND DELIVERABLES FOR INSTALLATION, OPERATION, AND REMOVAL OF WATER LEVEL STATIONS

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**Engineering Division
Center for Operational Oceanographic Products and Services
National Ocean Service
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1.0 Introduction

1.1 NOS National Water Level Observation Network

The Center for Operational Oceanographic Products and Services (CO-OPS), a part of the National Ocean Service (NOS) manages the National Water Level Observation Network (NWLON) of approximately 200 (as of October 2008) continuously operating water level observation stations in the U.S. coastal zone, including the Great Lakes. As most of these stations are equipped with satellite radios, near real-time (within about 30 minutes of collection) raw data are made available to all users through the CO-OPS Web homepage at www.tidesandcurrents.noaa.gov. Verified products, such as edited 6-minute data, hourly heights, high and low waters, and monthly means are made available over the Web within one to four weeks after data collection. NWLON data and accepted tidal datums are used in hydrographic and photogrammetry surveys either to provide tide reducers directly or for control for datum determination at subordinate (short-term) stations. Preliminary and verified data are made available over the Web relative to MLLW datum, station datum, or special water level datum (such as Columbia River datum) as a user option in the interface.

1.2 Data Quality Monitoring

CO-OPS has the Continuous Operational Real-Time Monitoring System (CORMS) that provides quality control and system monitoring functions on a 24 hours/day, 7 days/week for CO-OPS monitored gauges. CORMS will monitor the status and performance of all in-house water level gauges equipped with satellite radios using the NOS satellite message format and that are installed by CO-OPS, NOAA Ships, Navigational Response Teams (NRT), or CO-OPS IDIQ contractors for CO-OPS all of in-house projects including NWLON and NOAA in-house hydrographic or photogrammetry survey projects. Once these gauges are listed on the hydro hot list or COASTAL hot list by CO-OPS, CORMS starts monitoring. CORMS is a NOS provided support function to the operational field parties and does not relieve the contractor of responsibility for performing QC and ensuring proper gauge operation. For NOAA hydrographic or photogrammetry contract surveys, the contractor is responsible for all data monitoring, repairs, and proper functioning of the subordinate gauges.

1.3 General Data and Reference Datum Requirements

All of the water level data for each water level station shall be collected on a station datum and various datums are determined on the station datum.

The present NOAA Nautical Chart Reference Datum for tidal waters is Mean Lower Low Water (MLLW) (<http://tidesandcurrents.noaa.gov/publications/glossary2.pdf>) based on the latest NOAA National Tidal Datum Epoch (NTDE) of 1983-2001. The present NOAA shoreline reference datums are MLLW and Mean High Water (MHW) (<http://tidesandcurrents.noaa.gov/publications/glossary2.pdf>). All tidal datum computations and water level reductions for shoreline mapping surveys shall be referenced to these datums. In

non-tidal areas, including the Great Lakes, special low water datums have been defined for specific areas and are used as chart datum in these locations. In some cases where historical sites are re-occupied, site datum shall be zeroed to a pre-established MLLW/MHW datum held on a bench mark. In that case, data can be acquired relative to MLLW/MHW for immediate application during the shoreline mapping surveys.

For non-tidal such as in Great Lakes areas, a unique Low Water Datum (LWD) for each lake relative to 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 Mean Water Level (MWL) (equivalent to Mean Sea Level (MSL)) observed at the water level stations.

In some cases where historical sites are re-occupied, every effort shall be made to collect the new data series on the historical Station Datum (SD).

Leveling and GPS connections to geodetic datums are required at each water level station, as described in Section 4.0 Geodetic connections and Ties.

2.0 Water Level Station Requirements

2.1 Data Collection and Field Work

The contractor shall collect continuous, high quality and valid data series. Accurate datums cannot be computed for a month of data with a break in the water level measurement series in excess of three days. Even breaks of significantly less than three days duration will not allow for interpolation during times when strong meteorological conditions are present and in areas with little periodic tidal influence. Any break in the water level measurement series affects the accuracy of datum computations. At any measurement site where the water level measurement data cannot be transmitted or monitored during project operations, an independent backup sensor or a complete redundant water level collection system should be installed and operated during the project.

2.2 Water Level Sensor and Data Collection Platform

The water level sensor shall be a self-calibrating air acoustic, pressure (vented), or other suitable type that is approved by CO-OPS. The sensor measurement range shall be greater than the expected range of water level. Gauge/sensor systems shall be calibrated prior to deployment, and the calibration shall be checked after removal from operations. The calibration standard's accuracy must be traceable to National Institute of Standards and Technology (NIST). The required water level sensor resolution is a function of the tidal range of the area in which hydrographic surveys are planned. For tidal range less than or equal to 5 m, the required water level sensor resolution shall be 1 mm or better; for tidal range between 5 m and 10 m, the required water level sensor resolution shall be 3 mm or better; and for tidal range greater than 10 m, the required water level sensor resolution shall be 5 mm or better.

The Data Collection Platform (DCP) shall acquire and store water level measurements every 6-minutes. The water level measurements shall consist of an average of at least three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.). In addition to the average measurement, the standard deviation of the discrete water level samples which comprises the 6-minute measurements shall be computed and stored. The 6-minute centered average water level data is required for compatibility with the NWLON stations, and the standard deviation provides valuable data quality information regarding each measurement. The clock accuracy of a satellite radio system shall be within 5 seconds per month for 3-hourly transmissions, or within 1 second for hourly or 6 minute transmissions, so that channel “stepping” does not occur. Non-satellite radio systems shall have a clock accuracy of within 30 seconds per month. 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, and high frequency wave action and high velocity currents for all sensor types.

The NOS is currently using the Aquatrak® self-calibrating air acoustic sensors at the majority of the NWLON stations. (For further information refer to *Next Generation Water level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual*, NOAA/NOS, January 1991, which is available at CO-OPS web page at the following url: <http://tidesandcurrents.noaa.gov/publications/NextGenerationWaterLevelMeasurementSystemMANUAL.pdf> and *User’s Guide for 8200 Acoustic Gauges*, NOAA/NOS, Updated August 1998 which is available at http://tidesandcurrents.noaa.gov/publications/hy8200aco_manual.pdf).

At stations where the acoustic sensor can not be used due to freezing or the lack of a suitable structure, either a ParoScientific intelligent pressure (vented) sensor incorporated into a gas purge system, or a well/float with absolute shaft angle encoder (Great Lakes Stations) shall be used for water level measurements. (For further information refer to *User’s Guide for 8200 Bubbler Gauges*, NOAA/NOS, Updated February 1998 which is available at CO-OPS web page at the following url: http://tidesandcurrents.noaa.gov/publications/hy8200bub_manual.pdf . Also refer to *User’s Guide for 8210 Bubbler Water Level Gauge for Hydrographic Surveying Applications (Installation and Operation)* February 2001 which is available at CO-OPS web page at the following URL: http://tidesandcurrents.noaa.gov/publications/8210_guide.pdf).

For 6 minute water level data, the water leveling sampling/averaging scheme shall be as described above. For short term subordinate stations which are installed to support NOS hydrographic surveys, the use of air acoustic sensor is preferred over pressure sensor whenever possible. When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start, (2) at frequent intervals during deployment, and (3) at the end of a deployment. Frequent gauge/staff comparisons (Refer to Section 2.5.2 for details) during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations shall be at least three hours long at the beginning and end of deployment and the periodic observations during deployment shall be at least 1 hour long. Along with the averaging procedure described above which works as a digital filter, NOS uses a combination protective well/parallel plate assembly on the acoustic sensor and a parallel plate assembly (with 2" orifice

chamber) on the bubbler orifice sensor to minimize systematic measurement errors due to wave effects and current effects, as shown in figure 1.

When pressure sensors are used to collect the water level data, the orifice should be mounted on a vertical surface such as the piling of a wharf so that the precise elevation of the orifice below a staff stop could be measured with a steel tape, and the elevation of the staff stop can be measured via differential leveling to the nearest benchmark and with the primary bench mark. If the orifice is mounted vertically and its elevation can be determined precisely with reference to the primary bench mark, then staff to gauge readings may not be necessary, and the requirement for staff-to-gauge readings may be waived in sea water environment as described in Sections 2.5.1 and 2.5.2, provided periodic (every week or 2 weeks during the project duration) density measurements are taken and submitted to CO-OPS . If the orifice can not be mounted to a vertical surface i.e. if the elevation of the orifice can not be determined precisely with the primary bench mark, then staff-to-gauge readings are required to relate the water level datums to the bench marks.

2.3 Data Transmissions

The data transmissions requirements are applicable where CO-OPS is monitoring the gauges. This section is not applicable to OCS contract hydrographic surveys, or to NGS contract shoreline mapping surveys. The ability to monitor water level measurement system performance for near real-time quality assurance is essential for operations. Therefore, it is required that, where access to the satellite is available, the measurement system shall be equipped with a GOES transmitter to telemeter the data to CO-OPS, the frequency of data transmissions could be every six minutes, hourly, or three hours. The data transmissions must use a message format identical to the format as currently implemented in NOS CO-OPS' *"NGWLMS GOES MESSAGE FORMATTING"*. This is required to assure direct compatibility with the NOS Data Management System (DMS). This data format is detailed in the reference document *"NGWLMS GOES MESSAGE FORMATTING"*. Once station and gauge information are configured in DMS and the station is listed on the Hydro Hot List (HHL), CORMS will monitor all water level measurement system GOES transmissions to assure the station is operating properly, provided that the GOES data transmitted is compatible with CO-OPS format and CO-OPS is monitoring the data. Data that is not transmitted by GOES, or data transmitted but not in CO-OPS compatible GOES format, or is submitted to CO-OPS via diskette, CD-ROM, or such other digital media, must also conform to the format specified in the above document and as specified in Section 5 under "Water Level Data" so that data can be loaded properly into DMS software. Refer to Section 5 for further details about the water level data format specifications.

Close coordination is required between the contractor and the Engineering Division (ED) of CO-OPS for all water level installations with satellite transmission capability. NOS will assist in acquiring assigned platform ID's, time slots, etc., for approved parties, as appropriate. At least ten business days prior to the initiation of GOES data transmission in the field, information about the station number, station name, latitude, longitude, platform-ID, transmit time, channel, and serial numbers of sensors, and DCP shall be faxed, phoned, or e-mailed to the Operational Engineering Team (OET) of ED. The e-mail address for OET is nos.coops.oetteam@noaa.gov. Test transmissions conducted on site are outside this requirement. This station and DCP information must be configured in DMS before data transmissions begin so that the data will be

accepted in DMS. The documentation required prior to transmission in field is defined in the NGWLMS Site Report, Field Tide Note, or Water Level Station Report, as appropriate. (Refer to Section 5 Data Submission Requirements).

2.4 Station Installation, Operation, Maintenance, and Removal

Contractors shall obtain all required permits and permissions for installation of the water level sensor(s), Data Collection Platforms (DCP), bench marks, and utilities, as required. The contractor shall be responsible for security and/or protective measures, as required, for protecting the equipment and facility while installing, maintaining or removing a water level station.

Water level station and its various components (tide house, DCP, all sensors, meteorological tower, bench marks, and pertinent access facilities such as railings, steps, etc., as appropriate), when designed or installed by contractors, shall be installed and maintained as prescribed by manufacturers, installation manuals, appropriate local building codes, or as specified by the Contracting Officer's Technical Representative (COTR), if applicable. The water level station and all installed components shall be structurally sound, secure, and safe to use for NOS, local partners, contractors, and general public, as appropriate.

The contractor shall provide CO-OPS the position of all tide gauges installed before data collection begins, including those that were not specified in the Statement of Work or Project Instructions, but were later added to the scope, as appropriate. The positions of bench marks, stations, DCP, and sensors installed or recovered shall be obtained using a hand-held GPS receiver as latitudes and longitudes and reported to as degrees, minutes, seconds, and tenth of a second (e.g. bench mark position as latitude as 37 degrees 45 minutes 34.1 seconds and longitude as 75 degrees 25 minutes 32.5 seconds).

The following paragraphs provide general information regarding requirements for station installation, operations and maintenance, and station removal.

2.4.1 Station Installation

A complete water level measurement gauge installation shall consist of the following:

The installation of the water level measurement system (water level sensor(s), DCP, and satellite transmitter) and its supporting structure and a tide staff if required.

- A. The installation of the water level measurement system (water level sensor(s), DCP, and satellite transmitter) and its supporting structure and a tide staff, if required.
- B. The recovery and /or installation of a minimum number of bench marks and a level connection between the bench marks and the water level sensor(s), or tide staff, as appropriate.
- C. The preparation of all documentation and submission of the same.

2.4.2 Station Operation and Maintenance

Contractor shall monitor the near-real time water level gauge data daily for indications of sensor malfunction or failure, and for other causes of degraded or invalid data, such as marine fouling. When GOES telemetry and NOS satellite message format are used, and when CO-OPS is monitoring the gauges for NOS in-house projects, this monitoring can be performed by accessing the COOPS web page (<http://www.tidesandcurrents.noaa.gov>). The data over this system are typically available for review within 30 minutes to four hours after collection, depending upon the frequency of transmissions. For NOS contract projects, contractors are responsible for monitoring the gauges and for taking the proper corrective actions, as necessary.

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in writing using appropriate maintenance forms (see Section 5.3 on water level station documentation below) 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 of start and completion of the maintenance activity; date and time of adjustments in sensor/DCP, datum offset/sensor offset/orifice offset changes and date and time of the change; personnel conducting the work; parts or components replaced; component serial numbers before and after the maintenance; tests performed; purpose of the trip, and recommended actions that could not be completed and reason for the incompleteness, etc.

2.4.3 Station Removal

A complete removal of the water level measurement gauge shall consist of the following:

- A. Closing levels - a level connection between the minimum number bench marks and the water level sensor(s) and tide staff as appropriate.
- B. Removal of the water level measurement system and restoration of the premises, reasonable wear and tear accepted.
- C. The preparation of all documentation, forms, data, and reports; and submission of the same.

2.5 Tide Staffs and Staff Observations

2.5.1 Staff

The contractor shall install a tide staff at a station if the reference measurement point of a sensor (zero of a gauge) cannot be directly connected via levels to the local bench marks, e.g. orifice is laid over sea floor in case of pressure based bubbler gauges. Even if a pressure gauge can be leveled to directly, staff readings are still required for assessment of variations in gauge performance due to density variations in the water column over time. The tide staff shall be mounted on a separate piling other than the piling on which the water level sensor is installed so that independent stability of the staff and sensor is maintained. The staff shall be plumb when

installed and used. When two or more staff scales are joined to form a long staff, the contractor shall take extra care to ensure the accuracy of the staff throughout its length. The distance between staff zero and the rod stop shall be measured before the staff is installed and after it is removed and the rod stop above staff zero height shall be reported on the documentation forms.

In areas of large tidal range and long sloping beaches (i.e. Cook Inlet and the Gulf of Maine), the installation and maintenance of tide staffs can be extremely difficult and costly. In these cases, the physical installation of a tide staff(s) may be substituted by systematic leveling to the water's edge from the closest bench mark. The bench mark becomes the "staff stop" and the elevation difference to the water's edge becomes the "staff reading".

2.5.2 Staff Observations

When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle (minimum 3 hours) shall be required (1) at the start of water level data collection, (2) at frequent intervals during deployment, and (3) at the end of a deployment before gauge has been removed. Frequent gauge/staff comparisons during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations at the start and end of deployment shall be at least each three hours long and the periodic observations during the deployment shall be at least 1 hour long. The staff to gauge observations shall be performed three times per week, during each week of the project, with at least an hour long observations of 6 minute interval for each time. The observations shall be done at the same time when the gauge is collecting data i.e. 6 minute interval (starting with 0 minutes, e.g. 0, 6, 12, 18, 24, 30, 36, 42, 48, and 54 minutes after the hour). Where staff to gauge observations can not be performed three times a week as required, then an explanation is required for the deficiency of number of observations, and staff to gauge observations shall be performed at least (a) minimum eight times spread out over each month (e.g. two times per week) and at each time at least 1 hour of observations at 6 minute interval, or (b) minimum of four times spread out over each month (e.g. one time per week) and at each time at least 2 hours of observations at 6 minute interval, whichever is convenient.

The staff-to-gauge differences shall remain constant throughout the set of observations and shall show no increasing or decreasing trends. After the water level data has been collected, the averaged staff-to-gauge shall be applied to water level measurements to relate the water level data to staff zero. A higher number of independent staff readings decrease the uncertainty in transferring the measurements to station datum and the bench marks. Refer to Figure 2 for an example pressure tide gauge record.

If the old staff is found destroyed by elements during the deployment, then a new staff shall be installed for the remainder period of the deployment and a new staff to gauge constant needs to be derived by new sets of staff to gauge observations. Also when a staff or an orifice is replaced or re-established, check levels shall be run to minimum of three bench marks including the PBM. Refer to Section 3 for leveling frequency and other leveling requirements.

For water level historic stations that are reoccupied, CO-OPS will provide the Station Datum (SD) information for the station. This information is generally given about the Primary Bench Mark (PBM)

above the historic SD. In that case, for pressure sensors that require staff-to-gauge observations, all the water level data shall be placed on the SD using the following equation:

Water level data on the SD = (Preliminary pressure water level data on an arbitrary datum as collected by the gauge) + (PBM above SD) - (Staff zero below PBM) - (weighted staff-to-gauge constant)

Staff zero below PBM = (Staff stop below PBM) + (Staff zero below Staff stop)

The staff-to-gauge constant shall be derived as a weighted average of all the staff-to-gauge readings done for the project. The staff zero below PBM is obtained generally by (a) leveling from PBM to staff stop and (b) then measuring the staff stop to staff zero elevation with a steel tape and (c) then combining the two (a and b) elevation values. The staff zero below PBM is obtained by averaging the elevations differences during the opening (installation) and closing (removal) leveling runs for short term occupations.

The orifice elevation above station datum is also defined as accepted orifice offset in CO-OPS Data Management System (DMS).

3.0 Bench Marks and Leveling

3.1 Bench Marks

A bench mark is a fixed physical object or marker (monument) set for stability and used as a reference to the vertical and/or horizontal datums. Bench marks in the vicinity of a water level measurement station are used as the reference for the local tidal datums derived from the water level data. The relationship between the bench marks and the water level sensor or tide staff shall be established by differential leveling.

3.2 Number and Type of Bench Marks

The number and type of bench marks required depends on the duration of the water level measurements. The *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations*, dated October 1987, (http://tidesandcurrents.noaa.gov/publications/users_guide_for_installation_of_Bench_Mark.pdf) specifies the installation and documentation requirements for the bench marks. Each station will have one bench mark designated as the PBM, which shall be connected via levels during every level run. The PBM is typically the most stable mark in close proximity to the water level measurement station. The contractor shall select a PBM at sites where the PBM has not already been designated. For historic NOS station reoccupations, CO-OPS will furnish the name of the PBM and PBM elevation above station datum, if available.

If the PBM is determined to be unstable, another mark shall be designated as PBM. The date of change and the elevation difference between the old and new PBM shall be documented. NOAA will furnish the contractor the individual NOS standard bench mark disks to be installed. Bench mark descriptions shall be written according to *User's Guide for Writing Bench Mark Descriptions*, updated January 2002 (<http://tidesandcurrents.noaa.gov/publications/bmguid5.pdf>).

3.3 Leveling

Second Order Class I geodetic levels are preferred but at least Third Order geodetic levels shall be run at short-term subordinate stations operated for less than one-year. Requirements for higher order levels will be specified in individual project instructions, or contract documents, as appropriate. Standards and specifications for leveling are found in *Standards and Specifications for Geodetic Control Networks and Geodetic Leveling (NOAA Manual NOS NGS 3)*. Additional field requirements and procedures used by NOS for leveling at tide stations can be found in the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations*. Electronic digital/barcode level systems are acceptable. Specifications and standards for digital levels can be found in *Standards and Specifications for Geodetic Control Networks* and additional field requirements and procedures used by NOS for electronic leveling at water level stations can be found in the *User's Guide for Electronic Levels*, updated January 2003. (<http://tidesandcurrents.noaa.gov/publications/laserlevelsguide.pdf>)

3.4 Leveling Frequency

Levels shall be run between the water level sensor(s), or tide staff (depending upon the type of gauge), and the required number of bench marks when the water level measurement station is installed, modified (e.g., water level sensor serviced, staff, or orifice replaced), for time series bracketing purposes, or prior to removal. In any case, levels are required at a maximum interval of six (6) months during the station's operation, and are required after severe storms, hurricanes, or earthquakes to document stability (see stability discussed below).

Bracketing levels to appropriate number of marks (five for subordinate stations) are required (a) if smooth tides (water level data reducers) are required 30 days or more prior to the planned removal of a applicable gauge(s) (for hydrographic/photogrammetry survey projects, or (b) after 6 months for stations collecting data for long term projects.

3.5 Stability

If there is an unresolved movement of the water level sensor or tide staff zero relative to the PBM, from one leveling to the next, of greater than 0.006 m, the contractor shall document the movement. In some special cases, CO-OPS may require the contractor to verify the apparent movement by re-running the levels between the sensor(s) zero or tide staff to the PBM. This threshold of 0.006 m should not be confused with the closure tolerances used for the order and class of leveling.

3.6 Additional Field Requirements

- A. Generally upon completion of the data acquisition for each gauge installed, the water level data must be submitted as one package for 30-day minimum stations unless the data are transmitted via satellite. For long term stations running more than three months, the data shall be submitted periodically (monthly) unless the data are transmitted via satellite.
- B. All water level data from a gauge shall be downloaded and backed up at least weekly on a digital media (e.g. diskettes, CD-ROM, DVD, FTP site) whether the gauge data are sent via satellite or not.
- C. For new stations that do not have station numbers assigned, once the location of the gauge has been finalized then contact CO-OPS or COR and provide latitude and longitude of the gauge site at least five business days prior to actual installation of the gauge in field. CO-OPS will assign a new station number within three business days and inform the installer.
- D. At each water level station, GPS observations on one tidal or water level bench mark shall be performed according to the most recent copy of the CO-OPS' "User's Guide for GPS Observations at Tide and Water Level Station Bench Marks".

4.0 Geodetic Connections and Ties

The water level datums are local vertical datums which may vary at different stations within a geographical area. A geodetic datum is a fixed plane of reference for vertical control of land elevations. The North American Vertical Datum of 1988 (NAVD 88) is the accepted geodetic reference datum of the National Geodetic 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 NOS Vertical Datum (VDatum) transformation tool, etc.

Existing Geodetic Bench Marks (GBM) in the vicinity (up to 1.6 km (1 mile) leveling distance) of a water level station (primary and subordinate) shall be searched for and recovered. If a mark is either not recovered or not used in the survey/project, a separate report shall be made using the NGS on-line Mark Recovery Entry Form at http://www.ngs.noaa.gov/ngs-cgi-bin/recvy_entry_www.prl

The connection to geodetic datums involves the following three ties:

- (1) NAVD88 Level Tie
- (2) NAD 83 GPS Tie
- (3) NAVD88 GPS Tie

An orthometric level connection and ellipsoidal GPS tie is required at each water level station (primary and subordinate) which has at least one GBM located nearby (within 1.6 km (1 mi) leveling distance of a water level station).

The required “NAVD 88 Level Tie” is described in this document and the required “NAD 83 GPS Tie” and “NAVD GPS Tie” are described in the “User’s Guide for GPS Observations At Tide and Water Level Station Bench Marks”, which is available on CO-OPS’ web page at <http://tidesandcurrents.noaa.gov/pub>.

4.1 NAVD 88 Level Tie

There are two parts for this requirement as described below in A and B.

(A) NAVD 88 Level Tie: At all water level stations, a valid level tie to at least two GBM is required on each set of levels, where appropriate GBM marks are available within 1.6 KM (1 mi) leveling distance of the station location. A GBM is defined as a bench mark that exists, is useable, is available in the NGS database, has a Permanent ID (PID), and has a NAVD 88 elevation published on the datasheet. At many NWLON stations, the Primary Bench Mark (PBM) is a GBM. At the majority of NWLON stations, there are two or more tidal bench marks that are also GBM, thus increasing the chance that the geodetic level tie would be valid.

Make a Second-Order, Class I tie for all NWLON stations in the conterminous United States and Caribbean Islands. A Third-Order tie is used for all NWLON stations in Alaska, Hawaii, and Pacific Island areas.

At stations supporting hydrographic or shoreline mapping surveys, or other special projects, the tie shall be consistent with the accuracy of the levels required for the project (e. g. 2nd order class 1 or 3rd order levels, etc.).

Information on performing a valid level tie is provided in the Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks, listed at the following website:

http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm#3.5

Also, *Section 3.4 of "User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987"* provides the same information regarding how to perform a valid level tie. The information in User's Guide is easier to follow as it is written in layman's terms.

The Second-Order, Class I 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) is required at each site.

A note shall be made in the remarks of the leveling section of the Site 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 (10 for NWLON and 5 for subordinate stations) 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.

(B) NAVD 88 Level connection: An orthometric level connection is required at each water level station (primary and subordinate) which has at least one GBM located within 1.6 km (1 mi) leveling distance of a water level station. If the water level station has two or more GBM within 1.6 km (1 mi) of radial distance of the station location, then perform NAVD 88 Level Tie (as described above in A) which fulfills the requirement for NAVD 88 level connection.

A successful NAVD 88 level connection to a GBM will help determine the approximate NAVD 88 elevations for the all the bench marks in the local leveling network (10 for NWLON and 5 for subordinate stations) for the NOS VDatum program.

If there are no GBM within 1.6 km (1 mi) leveling distance of the station location, then the requirement for NAVD 88 level connection requirement is waived.

4.2 GPS Observations

An orthometric level connection and ellipsoidal GPS tie is required at each water level station (primary and subordinate) which has at least one GBM located nearby (within 1.6 km (1 mi) leveling distance of a water level station).

GPS connections involve the following two ties

- (1) NAD 83 GPS Tie
- (2) NAVD88 GPS Tie

The required “NAD 83 GPS Tie” and “NAVD GPS Tie” are described in the User’s Guide for GPS Observations At Tide and Water Level Station Bench Marks, which is available on CO-OPS’ web page at <http://tidesandcurrents.noaa.gov/pub>.

5.0 Deliverables – Timelines, Water Level Data, Documentation, and Points of Contacts

Data submission requirements for water level measurement stations are comprised of two parts – (a) formatted digital water level data collected by the water level measurement system, and (b) supporting documentation for the installation, maintenance, and removal of stations.

5.1 Timeline Requirements

Within 24 hours after (a) installation of a water level station (b) completion of regular scheduled annual maintenance (c) completion of emergency maintenance (d) completion of check levels (e) removal of a water level station, the one-day draft E-Site Report (Xpert Site Report or Tide Station Report) along with level abstract shall be forwarded to the Engineering Division or COR.

The purpose of one-day draft E-Site Report submission requirement is to standardize the requirements for all of CO-OPS’ field efforts, to provide feedback by the Operational Engineering Team (OET) of the Engineering Division (ED) to Installer while at site, so that critical information is verified and appropriate timely and corrective actions and required maintenance actions as described in the station specific Project Instructions could be accomplished by Installer while at site. This requirement applies to all types of water level stations and all types of sensors for every type of maintenance - installation, regular scheduled maintenance, emergency maintenance and removal of a water level station, where CO-OPS is expected to receive and/or process the data.

CO-OPS has developed a web-based electronic site report (E-Site Report) that interacts with DMS. Refer to Reference 25 and 26 for Users Guide and SOP for use of E-Site report. As stated in the contract when appropriate Installer shall follow the SOP for using the E-Site report as described in reference 26.

The installer is required to submit the required water level data as described below in Section 5.2 and documentation as described in Section 5.3 to CO-OPS ED or COR within 30 calendar days of completion of water level station installation, maintenance, repair, removal, or as specified in the contract documents. The station documentation shall be submitted in digital format only.

All data and documentation submitted to CO-OPS shall be retained by the installer for a period of not less than three years or as stipulated in the contract, whichever is longer.

5.2 Water Level Data

The final observed water level measurements shall be reported as heights in meters to three decimal places (i.e. 0.001 m). All heights shall be referenced to station datum and shall be referenced to UTC. The contractor shall provide the water level data in the format specified below from all water level gauges installed.

The original raw water level data and also the correctors used to convert the data to chart datum shall be retained until notified in writing or at least three years after the project is completed. All algorithms and conversions used to provide correctors shall be fully supported by the calibrations, maintenance documentation, leveling records, and sound engineering/oceanographic practices. Sensors for measurements used to convert data (e.g. pressure to heights) shall be calibrated and maintained for the entire water level collection period.

All digital water level and ancillary data shall be transmitted to CO-OPS in a format dependent on the DCP configuration. If GOES satellite is used, the data shall be transmitted and received using the NOS compressed pseudo binary format (see NGWLMS GOES Message Formatting, Libraro, 1/2003 http://tidesandcurrents.noaa.gov/publications/newgoes_format.pdf). These satellite messages are then decoded by NOS DMS upon receipt from NESDIS before further processing and review by CORMS can be completed.

If satellite transmission configurations cannot be installed, the data shall be manually downloaded from the DCP and submitted to NOS, as shown in the format below, in a digital format, (diskettes, CD-ROM, DVD or FTP site) as an ASCII data attachment. It may be prudent to submit data at more frequent intervals under specific circumstances.

Data download files shall be named in the following format: xxxxxxxy.w1.DAZ, where xxxxxxx is the seven digit station number, y is the DCP number (usually 1), w1 is the product code for 6 minute water level data, and DAZ is the extension (where Z = 1,2,3...if more than one file is from the same station and DCP). This is the format needed when the data is loaded into DMS.

The 6-minute interval data (acoustic sensor and pressure sensor examples follow) shall have the following format for CO-OPS database to accept.

Each input record (including the final record) ends with a carriage return and excludes any extraneous characters such as trailing blank spaces for both types of water level data.

Acoustic Sensor Data (XXX.ACO format)

Column 1- 7 Station ID (7 digits, assigned in the project instructions)
Column 8- 8 1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column 9-19 Date (MMM DD YYYY format, e.g. JAN 01 2009)
Column 20-20 Blank
Column 21-22 Hours in 24 hour format (i.e. 00, 01,, 23)
Column 23-23 : (colon)
Column 24-25 Minutes (00,06,12, . . . , 54)
Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
Column 33-38 Sigma (standard deviation in millimeters in integer format)
Column 39-44 Outlier (integer format)
Column 45-50 Temperature 1 (tenth of degrees C in integer format)
Column 51-56 Temperature 2 (tenth of degrees C in integer format)
Column 57-58 Sensor type (Ax for acoustic type, "x" is a number 1-9)
Column 59-60 blank
Column 61-61 Data Source (S for Satellite, D for Diskette)

Sample data:

```
85169901AUG 17 2008 05:00 1138 23 0 308 297A1 D
85169901AUG 17 2008 05:06 1126 26 0 308 298A1 D
85169901AUG 17 2008 05:12 1107 26 1 309 298A1 D
```

Pressure Sensor or Generic Data (XXX.BWL format)

Column 1- 7 Station ID (7 digits, assigned in the project instructions)
Column 8- 8 1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column 9-19 Date (MMM DD YYYY format, e.g. JAN 01 2009)
Column 20-20 Blank
Column 21-22 Hours in 24 hour format (i.e. 00, 01, . . . , 23)
Column 23-23 : (colon)
Column 24-25 Minutes (00-54)
Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
Column 33-38 Sigma (standard deviation in millimeters in integer format)
Column 39-44 Outlier (integer format)
Column 45-50 DCP temperature (tenth of degrees C in integer format)
Column 51-52 Sensor type (Z1 for generic or pressure)
Column 53-53 blank
Column 54-54 Data Source (S for Satellite, D for Diskette)

Sample data:

```
85169901AUG 17 2007 05:00 1138 23 0 308Z1 D
85169901AUG 17 2007 05:06 1126 26 0 308Z1 D
85169901AUG 17 2007 05:12 1107 26 1 309Z1 D
```

Note: pressure data must be accompanied by documented staff observations as listed in Section 2.5.2, if applicable.

5.3 Station Documentation

The standard water level station documentation package includes the following:

- (1) Transmittal letter (PDF format)
- (2) E-Site Report, or Water Level Station Xpert Site Report, or Tide Station Report (E-Site report in web based electronic format, Water Level Station Xpert Site Report or Tide Station report in Microsoft Excel format)
- (3) Google Chartlet, or NOAA Chartlet with chart number or map name and scale shown. (JPEG format)
- (4) Name of the U.S. Geological Survey quadrangle map (7.5 seconds interval) indicating the exact location of the station, with map name and scale shown (JPEG format)
- (5) Sensor test worksheet (PDF format)
- (6) Sensor elevation drawing (PDF format) showing sea floor, pier elevation, and sensor elevation if the sensor is mounted vertically.
- (7) Water level transfer form (for Great Lakes stations only in PDF format)
- (8) Barometer Installation Worksheet (for Great Lakes stations only in PDF format)
- (9) Bench mark sketch (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 sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (obtained from hand-held GPS receiver) of the gauge.
- (10) Bench mark descriptions with handheld GPS coordinates (d/m/s.x format), and “Station To Reach” statement (in Microsoft Word format) (Refer to User’s Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003).
- (11) Digital photographs of bench mark disk - close-up and eye level view of setting, bench mark locations from two different (perpendicular) cardinal directions, station, DCP, equipment, underwater components, and vicinity (JPEG format)
- (12) Levels (raw) (electronic files) including leveling equipment information and field notes of precise leveling, if applicable.
- (13) Abstract of precise leveling (electronic format)
- (14) Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing how sensor “zero” measurement point is referenced to the bench marks.
- (15) Staff to gauge observations, if applicable (in Microsoft Excel format)
- (16) Calibration certificates for Invar leveling rods, if applicable (in PDF format)
- (17) Calibration records for sensors, if applicable (in PDF format)
- (18) Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (in PDF format)
- (19) Other information as appropriate, or as specified in the contract (in PDF format)
- (20) Water level data download in specified format
- (21) GPS Deliverables - the OPUS results and 4 photos of the GPSBM in electronic format for each observation for each water level station as described in the User’s guide for GPS Observations At Tide and Water Level Bench Marks.

Water level data downloaded for NWLON, PORTS, Tsunami, COASTAL, or in-house projects shall be in accordance with Reference 26 *“Engineering Bulletin 07-006 Exporting Data from*

Xpert Family DCP". Water level data downloaded for contract hydrographic and photogrammetry survey projects and submitted to CO-OPS for validation shall be in accordance with Reference 27 "*NOS Hydrographic Surveys Specifications and Deliverables*" Latest update.

Generally, for established NWLON stations or long term water level stations (more than 1 year), the bench mark sketch, chartlet, and "To Reach" statement need only be submitted if these items have been revised during the station maintenance or removal, because these items are required and are generally submitted with the installation station package.

When using the electronic/barcode system, the data disk and hard copies of the abstract and bench mark description or recovery notes shall be submitted. At stations where the automated or manual levels are used, Precise Leveling sheets of actual runs (NOAA Form 75-29) and Abstract of Precise Levels (NOAA Form 76-183) shall be completed and submitted.

All digital 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 94106601 sensor A1.jpg.

All digital station 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, dot.jpg. For new mark, the PID is not applicable as it is unavailable. Close-up photo vertically taken of the bench mark is photo type 1, eye level photo vertically taken of the bench mark is photo type 2, and the horizontal view taken of the bench mark is photo type 3. For photo type 3 include the cardinal direction (N, NE, S, SE, etc) that the camera is pointing. If there are more than one type of photo is taken then re-name them as 1A, 1B, 2A, 2B, 3A, 3B, etc. If a PID is available, then use designation instead of stamping for the naming of the file. Use a maximum of 30 alpha numeric characters to the left of the dot. So if you are exceeding 30 alpha numeric characters in the name, then truncate the stamping or designation so that maximum characters in the name are 30. For example, the bench mark E close-up photo for Seattle water level station should be named as 9447130-7130E1990-1-20090101.jpg.

Sample file names for photo files

New bench mark without a PID and disk face photo	9414290-4290A2008-1-20090101.jpg
Existing bench mark with a PID and eye level view photo	9410660-DY2512-BM N-2-20090101.jpg
Existing bench mark without a PID and north direction photo	9447130-7130E1990-3N-20090101.jpg

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

For submission in electronic format, the station documentation shall be organized by various

folders under the main station number folder, and then pertinent information shall be placed in the various folders and submitted on a digital media, such as DVD/CD-ROM, FTP sites, etc.

Here is an example of submission of the electronic folders for San Francisco tide station:

- 9414290 San Francisco FY 08 Installation
- /Transmittal letter
- /Calibration records for sensors, if applicable
- /Site Report or tide station report
- /Chartlet and USGS Quad maps
- /Sensor test worksheet
- /Sensor elevation drawing
- /Bench mark sketch
- /Bench mark descriptions and "Station To Reach" statement
- /Photographs of bench marks, station, DCP, equipment, and vicinity in digital and paper format
- /Levels (raw) (electronic files) and field notes of precise leveling
- /Abstract of precise leveling
- /Staff to gauge observations, if applicable
- /Datum offset computation worksheet or Staff/Gauge difference work sheet (elevation of sensor zero measurement point referenced to bench marks)
- /Calibration certificates for Invar leveling rods, if applicable
- /Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable
- /Other information as appropriate, or as specified in the contract
- /Water level data (6-minute, hourly heights, high/low, monthly means, station datum)
- /GPS deliverables, as applicable

Submit required GPS deliverables OPUS results and 4 photos of GPSBM on a separate digital media, such as DVD/CD-ROM, FTP sites, etc. For example, GPS submission for San Francisco tide station will be as follows:

- 9414290 San Francisco FY 08 Annual Inspection
- /GPS deliverables
- /Photos of GPSBM

5.4 Points of Contact for Deliverables

All required deliverables as listed in Section 5.3 above shall be submitted to proper point of contact as listed in the project instructions, contract documents, if applicable; or to NGS or CO-OPS within 30 calendar days of the GPS observations, installation, maintenance, or a removal of a water level station, or as specified in the Statement of Work or contract, whichever is earlier. All GPS data and documentation shall be published to NGS OPUS.

(A) For all work done by NOAA (FOD, NOAA ships, NRT, other NOAA personnel) submit one copy of all the documentation including GPS deliverable in digital media, such as DVD/CD-ROM, FTP sites, etc., to

Chief, Engineering Division
CO-OPS, N/OPS1, SSMC 4
1305 East-West Highway, Station 6531
Silver Spring, MD 20910-3233
Tel: 301-713-2897 x 145

(B) For all CO-OPS' IDIQ contract work deliverables, submit two copies of all the documentation including GPS submission in digital media, such as DVD/CD-ROM, FTP sites, etc. Submit one copy in digital media to

Marty Welch
Contracting Officer's Representative
NOAA/NOS/CO-OPS
SSMC 4, Station # 6544
1305 East-West Highway
Silver Spring, MD 20910-3281
Tel # 301-713- 2897 X 129

Submit the other copy of the completed station package to the Task Manager, or appropriate supporting FOD field office, as listed below:

For East Coast task orders, submit to:
Task XXX Manager, Field Operations Division Atlantic Regional Office
808 Principal Court
Chesapeake, VA 23320
Tel: 757-436-0200

For West Coast task orders, submit to:
Task XXX Manager, Field Operations Division Pacific Regional Office
7600 Sand Point Way, NE
Bin C15700
Seattle, WA 98115
Tel: 206-526-6360

(C) For OCS contract hydrographic survey projects, submit one copy of all the deliverables (water level data, station documentation, and GPS deliverable) in digital media, such as DVD/CD-ROM, FTP sites, etc., to:

Chief, Engineering Division
CO-OPS, N/OPS1, SSMC 4
1305 East-West Highway, Station 6531
Silver Spring, MD 20910-3233
Tel: 301-713-2897 x 145

(D) For NGS contract shoreline mapping survey projects, submit one copy of all the deliverables (water level data, station documentation, and GPS deliverable) in digital media, such as DVD/CD-ROM, FTP sites, etc., to:

Mr. George Leigh
Contracting Officers Representative
NOAA/NOS/National Geodetic Survey
SSMC 3, Station # 8609
1315 East-West Highway
Silver Spring, MD 20910-3281
Tel # 301-713- 3167

6.0 Guidelines and References

Various references for the water level measurement and leveling requirements issued by the NOS Center for Operational Oceanographic Products and Services (CO-OPS) and the National Geodetic Survey (NGS) are listed below.

Some of these documents are available on CO-OPS web site at <http://tidesandcurrents.noaa.gov/pub.html>

1. Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, NOAA/NOS, January 1991.
2. Xpert Operations and Maintenance Manual, October 2006.
3. User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, NOAA/NOS, dated October 1987.
4. User's Guide for Electronics Levels, NOAA/NOS, updated January 2003.
5. User's Guide for Writing Bench Marks Descriptions, NOAA/NOS, Updated January 2003.
6. User's Guide for GPS Observations At Tide and Water Level Station Bench Marks, NOAA/NOS, updated November 2008.
7. CO-OPS GPS Observations Implementation Plan, January 2003.
8. CO-OPS Water Levels and Meteorological Site Reconnaissance Procedures, Updated March 2007.
9. User's Guide for 8200 Acoustic Gauges, NOAA/NOS, updated August 1998.
10. User's Guide for 8200 Bubbler Gauges, NOAA/NOS, updated February 1998.
11. User's Guide for 8210 Bubbler Gauges, NOAA/NOS, updated February 2001.

- 12 NGWLMS GOES MESSAGE FORMATTING, Phil Libraro, 1/2003.
- 13 NOAA Technical Memorandum "NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3", November 1997.
- 14 Standards and Specifications for Geodetic Control Networks, Federal Geodetic Control Committee, September 1984.
- 15 Spatial Data Modifications and Enhancements, FY 05 Functional Requirements Document, August 2005.
- 16 Revised NGS 3-Dimensional (3-D) Rod Mark, National Geodetic Survey, July 1996.
- 17 NWLON/DMS Quality Control Software (QC) Functional Requirements Document, Revised November 2004.
- 18 Attachment R, Requirements for Digital Photographs of Survey Control, NGS, January 2008.
- 19 SOP-06-001 for Upgrading an Existing Water Level Station or Installing a New Water Level Station, Updated August 22, 2007.
- 20 Water Level Records Evaluation Criteria, May 2006.
- 21 Geodetic Leveling, NOAA Manual NOS NGS 3, U.S. Department of Commerce, NOAA, National Ocean Survey, August, 1981.
- 22 Standing Project Instructions for Coastal and Great Lakes Water Level Stations, Updated March 2008.
- 23 Tide and Current Glossary, U.S. Department of Commerce, NOAA, NOS, October 1989.
24. Guidelines for Meteorological Station Reconnaissance and Meteorological Sensor Height Measurements, April 2008.
- 25 "E-Site Report Application User's Guide", Draft Date January 2008.
- 26 SOP for E-Site Report User Access to Build, Submit, Reject, Advance, and Approve Steps, March 2008.

I. For Each Water Level Station:

PROJECT DOCUMENTATION AND DATA CHECKOFF LIST

Project Number: _____

Locality: _____

Station Number: _____

Station Name: _____

A. Field Tide Note (Required only for Hydrographic /Photogrammetry Surveys)

	1. Verify station latitude and longitude with handheld GPS.
	2. Verify work dates.

B. Site Report (required for both installation and removal)

	1. All applicable information complete, especially serial numbers of DCP/sensors and dates of installation/removal of DCP/sensors and levels
	2. Verify latitude and longitude of the station (ensure that this is the same as on the field tide note for Hydro/Photo surveys). Provide latitude and longitude in d/m/s.x format as determined by handheld GPS for the primary sensor.
	3.. Note UTC time and date the datum offset and sensor offset entered or changed in the DCP
	4. Provide metadata for ancillary sensors, if installed and as required
	5. Provide notes on results of diving inspection, and cleaning of underwater components.
	6. Provide status of valid tie to NAVD 88 geodetic marks, if applicable, in level section remarks area.
	7. Provide notes of excessive movement of water level sensor or bench marks in level section remarks area.

C. Chart Section

	1. Ensure that station location is clearly depicted with circle and station number.
	2. Standard title block includes : station number, station name, lat/long as d/m/s.x., NOAA chart number, edition, date, and scale, USGS quad name all in caps.
	3. Provide a digital copy of the chart section in jpg format

D. Bench Mark/Station Location Sketch

	1. Ensure Gauge/staff and bench marks are shown, and local body of water is labeled.
	2. Ensure Standard Title block includes: station number and station name, field unit, date of revision
	3. Ensure North arrow depicted.
	4. Include hard copy sketch and a sketch in digital format.
	5. Ensure All active (recovered and not recovered) bench marks are identified by designations
	6. Ensure bench marks that are confirmed as destroyed are removed from the sketch.

	7. Provide a digital copy of the sketch saved in jpg format.
--	--

E. Digital Photographs

	1. Provide digital photographs of gauge, staff, surrounding area, wells and brackets, DCP. Provide tide gauge photos from two perpendicular horizontal directions.
	2. Station component file name starts with station number followed by the specific component view, with jpg extension (e.g. 86610170 well.jpg)
	3. Provide several shots of met towers and sensors from different directions (e.g. 8661070 met tower looking SW.jpg)
	4. Provide digital bench mark photos – 4 photos required as follows: close up of disk face without GPS handheld in view, eye level view looking down, and two photos looking horizontally from different directions (90 degrees apart, if possible) showing general location for all new marks. Follow the digital photo file naming convention as specified.

F. Bench Mark Descriptions/Recovery Notes

	1. Stampings for new and recovered marks verified in all documents.
	2. Descriptions for new marks provided in NOS format (MS Word).
	3. Recovery notes provided for all historical marks. RAD/xxx noted for all marks Recovered As Described, where xxx is party chief, or contractor initial.
	4. Provide handheld GPS position in d/m/s.x format at the end of the text description.
	5. For electronic levels, make sure HA files codes are completed accurately
	6. For electronic levels, text description begins with a statement on how to reach the mark, followed by the description in NOS format
	7. For electronic levels, provide handheld GPS position in d/m/s format at the end of the text in HA file since HA file does not accept decimal seconds s.x

G. Levels

	1. Ensure all information written in ink. Provide model and serial numbers of leveling equipment and level rods.
	2. Cover information complete; station name, number, instrument and rod type, serial numbers, date, personnel.
	3. Note type of levels: installation, bracketing and closing.
	4. Staff information complete (if applicable).
	5. Collimation check shown.
	6. Note that bench mark descriptions are submitted on separate sheets, or as MS Word file.
	7. Headers on all applicable pages complete.
	8. For multi year projects, or for NWLON, all marks in the leveling network must be connected every two years.
	9. Levels include marks specially noted in station specific requirements of the project instructions.
	10. Explanation provided for any marks not leveled during this level run.
	11. Provide sectional and overall closure tolerances and ascertain they are within allowable limits. Show the calculations.

	12. Compute level abstract starting with PBM accepted elevation and ending with primary sensor elevation
	13. Check for valid leveling tie to NAVD 88, if made, and if applicable.
	14. For electronic levels, provide original IN file in separate folder if modified IN file is provided.
	15. For electronic levels, all file dates must be chronologically consistent, i.e. the HA and INX files can not have dates more recent than the ABS file.
	16. For electronic levels, provide Invar rod calibration certificates for the first time digital leveling. For optical levels, provide rod calibration certificates.
	17. For electronic levels, error flags are not allowed on sectional distances of the ABS file.
	18. If check levels are run, ascertain that they are at 6 months interval.

H. Datum Offset Computation Worksheet

	1. Submit for stations that have Vitel or Sutron DCP with Aquatrak sensor.
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I. Data Submitted in electronic media (CD-ROM, or DVD, FTP site, etc.)

	1. Label electronic media with contractor name and list of files on each media.
	2. Data files should be named in the following format: xxxxxxx1.w1.daz, where xxxxxxx = seven digit station number and 1 is the DCP designation. For multiple files from the same station, change the extension, i.e., xxxxxxx1.w1.da1, da2, etc.
	3. Check the beginning and ending dates of data submitted with dates of hydrographic surveys/shoreline mapping surveys, or project duration for special projects.
	4. Check data continuity.

J. Transmittal Letter

	1. Transmittal letter attached with current contractor address, phone number and email.
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K. All Documentation Enclosed in Tide Level Envelope (NOAA Form 75-29A)

	1. Leave "sheets" box blank, complete other information in title boxes.
	2. Verified and completed with signature by contractor and include date.

Figure 3. Project Documentation and Data Check-off List