Guidelines for Meteorological Station Reconnaissance And Meteorological Sensor Height Measurements

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1.0 Introduction

Meteorological observations are collected at over 200 water level gauges or at some stand-alone locations in support of several operational observing system programs. These observations may consist of one or more of the following data types: wind speed, gust, and direction, barometric pressure, air temperature, relative humidity and visibility. The meteorological data are used for various purposes such as navigation services, storm surge warning, and marine weather forecasting.

1.1 Background

The Physical Oceanographic Real-Time System (PORTS®) water level stations were among the first to measure meteorological parameters, primarily to supplement oceanographic observations required for safe navigation. The location and type of meteorological sensors installed are almost exclusively determined by the local users to best meet their needs. PORTS® was also the first program for which CO-OPS installed stand-alone meteorological packages separate from water level stations.

Meteorological sensors were first systematically added to National Water Level Observation Network (NWLON) in support of the NOAA National Weather Service (NWS) Southern Region. In addition to PORTS® users and the NWS, partnerships were subsequently established with other NOAA offices and state and local governments to increase the spatial density of meteorological observations, especially important in efforts to mitigate the impacts of coastal storms.

There is a growing demand for meteorological data at CO-OPS water level gauges. Recently, CO-OPS acquired funding from the NWS to install meteorological sensors on existing NWLON gauges. The increasing amount of meteorological data collection is attracting a wider audience beyond oceanographers. Therefore, it is imperative that CO-OPS adheres to NWS installation and metadata measurement standards wherever possible, to meet user needs.

Previous to this document, meteorological sensor heights were referenced above station datum, consistent with oceanographic metadata collection methods. However, NWS and other meteorological data users require heights above the ground, rather than above station datum for models, research and other purposes. Therefore, meteorological sensor heights will now be measured above a Temporary Bench Mark (TBM), or Bench Mark (BM) located near the sensor support tower base and reported above the TBM and above the station datum, where possible, to accommodate all user requests. By connecting the sensors to a TBM that is surveyed into the network these sensors can easily be referenced to either height above ground or station datum.

1.2 Reference Documents

CO-OPS:
Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual (NGWLMS Manual), January 1991

Barometer Calibration Guidelines for Sutron Xpert DCP Systems, updated November 2008

Wind Sensor Alignment Procedure for the R.M. Young Wind Monitor, October 2005

Sutron Accubar Barometer Field Calibration Procedures, Updated February 2008

CO-OPS Water Level and Meteorological Site Reconnaissance Procedures, Updated May 2009

NWS:
National Weather Service Instruction 10-1302
Operations and Services
Surface Observing Program (Land)
Instrument Requirements and Standards for the NWS Surface Observing Programs (Land)
http://www.weather.gov/directives/010/010.htm

OFCM:
Federal Meteorological Handbook No. 1 (FHM-1)
Surface Weather Observations and Reports, 2005
http://www.ofcm.gov/fmh-1/fmh1.htm

WMO:
Guide to Meteorological Instruments and Methods of Observation, 2007
http://www.wmo.int/pages/prog/www/IMOP/publications/CIMO-Guide/CIMO_Guide-7th_Edition-2008.html

2.0 Meteorological Sensor Reconnaissance and Siting Requirements

Background and details regarding *general* site reconnaissance can be found in the Water Level and Meteorological Site Reconnaissance Procedures, referenced above. Information specific to meteorological sensor reconnaissance are included in this document. **Complete the Meteorological Sensor Reconnaissance site and obstruction form (See Appendix A) and submit to Operational Engineering Team of the Engineering Division.**

Even if the site is an existing NWLON station, some advance notice for maintenance or inspection may be required or appreciated by the owner. A statement involving partnerships with the NOAA National Weather Service (NWS) and others should be included in that communication. For example, if NWS has special requirements or needs with the meteorological sensors at a particular site, CO-OPS needs to give the nearest Weather Forecasting Office (WFO) advance notice of the reconnaissance so that they can consider having a representative on site to better articulate their needs and verify proper placement for winds.

When conducting a site reconnaissance for meteorological sensors, the following equipment, forms, and information are needed:

- Digital Camera/Camcorder
- Published Bench Mark Sheet, if available, or historical bench mark descriptions
- Historical station information, if available
- NGS Datasheets for area - required in the lakes to reference NAVD88/Dynamic Heights for the International Great Lakes Datum
- Shovel and other digging equipment
- Bench Mark recovery items (survey ribbon, marking paint)
- Metal detector
- Sample License or Lease Agreement/Letter of Permission
- Weighted tape
- 50 or 100 m survey tape for Bench Mark recovery
- Engineering sketch pad
- Inclinometer
- Carpenters level or plumb bob
- Hand-held GPS
- Compass
- IP Modem Kit which consists of a Verizon IP Modem, AT&T IP Modem, Small Battery, and an Antenna
- Chart section
- Meteorological Sensor Reconnaissance forms
- All contact information

Make the following observations:

- Direction of prevailing winds.
- For wind sensor installations, choose an area free of obstructions that affect the path of the wind (see section 2.1). Verify positioning with any associated partnership representatives.
- IP Modem signal strength. Connect the IP Modem Kit to your laptop or a loopback, then contact the instrument lab and let them communicate to the modem and determine signal strength. Perform this for each service provider IP Modem in the kit. Record the service provider and the respective signal strength.
- GPS latitude/longitude of station & bench mark locations. Record position to the tenth of a second.
- *Take digital photographs of the proposed DCP/sensor location and benchmarks.*

To obtain data representative of a station's surroundings, local conditions must not be artificially influenced by surrounding materials and/or obstructions (e.g., concrete, buildings, snow, etc). The sensor exposure will strive to minimize or eliminate the effects of manmade or geographical obstructions. Sensors should be located as far as practicable from cultivated land to reduce contamination by dust and dirt.

These sensor siting requirements are adopted from the Office of the Federal Coordinator for Meteorology (OFCM) standards, with which all federal agencies, including the NWS, comply. Proper siting of meteorological sensors may be difficult depending on station location, but every effort should be made to meet these requirements, thus ensuring that the sensor is representative of local conditions. If any questions arise regarding the requirements, contact OET for guidance.

2.1 Wind

- The standard mounting elevation is 9 - 10 m (30 - 33 ft) above the ground in open, level terrain. Small gradual slopes are acceptable. If local restrictions prevent installing the sensors at the 10 m (33-ft) standard, install them no less than 6 m (20 ft) above the ground.
- A horizontal distance of ten times the height of an obstruction should be maintained, between the wind sensor and the obstruction, for the surrounding area to be considered open terrain. An obstruction can be manmade (building) or natural (tree).
- If the sensor is to be mounted on the roof of a building, it should be mounted at a height of 6 m (20 ft) above the highest structure. This is to remove the sensor from the area in which the air flow is affected by the building. For tall buildings where this guideline cannot be met, a 3 to 5 m (10 to 15 ft) mast should be mounted on the side of the building with the prevailing wind.
    - If the 6-m guideline cannot be met then the sensor should be mounted 1.5 times the building height above ground. E.g. if the building height is 15 ft above the ground then the sensor should be 23 ft above ground (8 ft above the building roof), though higher elevation, if possible, is preferable.
- If the sensor is to be mounted on a tower, the sensor should be above the tower or on a boom. The boom should be twice as long as the maximum diameter or diagonal of the tower, and should be directed into the prevailing wind.

2.2 Air temperature/Relative humidity

- Standard mounting elevation is 1.2 to 2.0 m (4.0 to 6.5 ft) above grade.
- The sensor should be mounted over a plot of open level ground at least 9 m (30 ft) in diameter. The ground beneath the sensor should be short grass or natural earth, not asphalt, concrete, areas of standing water, etc.
- The distance between the sensor and any obstruction should be at least 4 times the height of the obstruction (40 m for a 10-m obstruction). It should be at least 30 m (100 ft) from large paved areas and not close to steep slopes.
- If mounted on a tower, the sensor should be on a tower boom at least as long as the tower diameter.
- Temperature sensors should have downward facing aspirated shields.
    - Try to avoid mounting on a rooftop, but if there is no other location then mount at least 1.5 times the height of the building. E.g. if the building height is 15 ft above

the pier then the sensor should mounted 23 ft above ground (~8 ft above the building roof), though higher elevation, if possible, is preferable.

2.3 Barometer

Site selection is not required for the sensor as it is mounted inside the unit and vented to the outside.

2.4 Visibility

The sensor location is vital because the visibility sensor measures a small sample volume between the transmitter and receiver heads, and thus only represents the visibility at a single location. Therefore, a site survey via discussions with the local Port Authority and/or Weather Forecast Office personnel is crucial in order to make an informed siting decision.

- Standard mounting elevation is 2.5 – 3.5 m (8 – 11.5 ft) above ground (3 m is preferred).
- The sensor should be a minimum of 100 m from any large buildings or constructions that radiate heat and/or obstruct precipitation droplets. Avoid trees, which can cause changes in the microclimate.
- Avoid obstacles in line-of-sight of the transmitter and receiver units. For a 2.5- m pole, a radius of approximately 9 m should be free of obstacles.
- The sensor should be as far as possible from strobe lights and other modulated light sources. (The FS11 sensor can be mounted over water, according to the manufacturer).
- Do not locate in an area that is subject to localized obstructions to vision, such as smoke or soot.
- Mount on a platform as free as possible from jarring and vibration.
- Point the receiver in a northerly direction.

2.5 Water Temperature

- For location that has acoustic sensor installed, the thermistor should be sited inside the well and attached to the end of the sounding tube. For location that has pressure or ParoScientific sensor installed, the thermistor should be installed close to the bubbler orifice. For Great Lakes, install at a standard depth of 1.5 m (5 ft) below LWD.
- For water temperatures at a station to represent most the thermal patterns, the sensor should be sited in a central location where there is sufficient flow and water is not stagnant.
- Do not place water temperature sensor in direct sunlight as it may cause the sensor to register high.

3.0 Meteorological Sensor Height Measurement Requirements

The following requirements specify that **sensor heights be measured to the nearest 30 cm (1 ft)** and that measurements for meteorological sensors (wind, air temperature, relative humidity and barometer) are to be made to the middle of the sensor. For visibility, measure to the inward

facing bottom edge of the transmitter or receiver unit. All meteorological sensors shall be measured, recorded on paper, and reported on site reports in metric units only. All meteorological sensor measurements shall be conducted every 5 years, or when a sensor has been relocated.

Methods to obtain these sensor heights depend upon the type of station that the sensors are located at (a tide/water level station or a stand-alone met station).

3.1 Water Level stations

These stations include a meteorological tower (Rohn tower or a Shakespeare pole) generally installed in the immediate vicinity of the water level station and its associated benchmark network.

The requirements for measuring the meteorological sensor heights are:

- A temporary bench mark (TBM) shall be established at the base of the meteorological tower or pole, for standard installations where the meteorological tower is in proximity to the station, if there is not already a nearby benchmark to define 'ground'. Further guidance on defining ground on all installations is provided below.
    - "Nearby" is defined as within a 3 m (10 ft) radius of the met tower on a flat surface (less than +/- 15 cm (0.5 ft) elevation change between the tower/pole and benchmark).
    - A bolt used to anchor the structure can be used as the reference TBM. This bolt shall be marked in such a manner so that it can be described and recovered by others in the future.
    - If a nearby benchmark is substituted for TBM, document the name of the benchmark used in the comments field in E-Site and the site report.
- All heights of meteorological sensors on the tower/pole will be measured down to the TBM or to the nearby benchmark in order to establish the height of the sensor above ground.
    - The following sensors shall ONLY be measured down to the TBM / nearby benchmark:

        Winds
        Air Temperature
        Rainfall
        Relative Humidity
        Solar Radiation
        Dew Point
        Visibility

If a Met TBM is not established or cannot be leveled then the field crew may substitute a nearby benchmark in as the Met TBM.

Only barometer and water temperature heights are entered as height above Station Datum in e-site (the guidelines listed below under documentation provide information about how to determine sensor heights above station datum).

Guidance on measuring heights (winds, air temperature, humidity, visibility, rainfall, radiation, dew point) for different installation types:

- **Pier**: Ground is considered the base of the met tower/pier surface. The TBM will be the base of the met tower or a nearby benchmark will substitute as the TBM. If sensors are located on a platform above or below the pier, sensor elevations will be measured from sensor to the base of the mounting platform.

- **Rooftop**: Ground is considered the base of the building. Sensor elevations will be measured from the sensor to the base of the building or to a benchmark nearby the base of the building.
- **SPIP Sentinel**: Ground is considered the SPIP sentinel platform. Sensor elevations will be measured from the sensor to standing surface of platform.

- **Lighthouse**: Ground is considered the base of the lighthouse. The TBM will be a nearby benchmark. Sensor elevations will be measured from sensor to the base of the lighthouse or to a benchmark nearby the base of the lighthouse.

Documentation:

- Enter the value in the E-Site report under "Height above TBM" to the nearest 30 cm (1 ft) for the appropriate meteorological sensors, or on the tide station report, as applicable.
- If the TBM is leveled to, enter its elevation in the E-Site "Bench Mark Elevations" tab with a designation of "MET TBM". Add a standard description of this mark to the benchmark description file.
- The TBM shall be included in the leveling run and connected to the Primary Bench Mark (PBM). OET will use the leveling run to help establish the heights of the meteorological sensors above the station datum.
- The TBM shall be connected via line leveling to at least one bench mark at a water level station so that TBM elevation and the meteorological sensor elevation above station datum can be determined. If a nearby benchmark is substituted for the TBM, it must be included in the leveling run.

Barometer:

- The barometer shall be calibrated according to the CO-OPS Barometer Calibration Guidelines, updated November 2008.

3.2 "Stand-alone met" stations

A stand-alone met station consists solely of meteorological sensors and therefore may not be accompanied by a suite of tidal bench marks. All of the measurement requirements for meteorological sensors are referenced to a TBM or nearby benchmark (if applicable) using the same methods explained above for water level/tide stations. If there are no bench marks in the area of the station separate guidelines shall be followed to obtain a tie to datum.

- The following sensors shall ONLY be measured down to the Met TBM / nearby benchmark:

  Winds
  Air Temperature
  Relative Humidity
  Visibility
  Rainfall
  Solar Radiation
  Dew Point

Only barometer and water temperature heights are entered as height above Station Datum in e-site.

For stand-alone met stations that **DO NOT** have a barometer present, the field crew must reference the meteorological sensors above the TBM only. Otherwise, when a barometer **IS** present the field crew must obtain a tie to MSL.

There is no single best fit method to obtain a tie to datum (MSL) without the presence of benchmarks since every stand-alone met station will present unique situations. The following guidelines will provide the field crew with various methods to obtain a TBM height relative to MSL at a stand-alone met station. It will be up to the discretion of the crew chief to choose the method that best fits the situation facing him/her at a particular station.

- In certain situations there may be a published bench mark sheet or a data sheet available (NGS or USGS bench marks that would give a site elevation) in the area of a stand-alone met station. If the bench mark has a published elevation, then the field crew can level to the mark from the TBM to obtain a tie from the barometer to datum.
- In the absence of a published bench mark elevation, level from the TBM to the vicinity of the water surface. Provide the time of measurement in GMT from the TBM to the water surface.

  From this point there are several methods that may be used to obtain a height of the average water level.
  - If there is a bulkhead present use a steel tape to measure down to the water surface.
  - A level rod may be held as close to the water surface as possible. This method may be difficult to obtain a steady elevation but still remains viable.
  - A spike may be set and leveled to the shoreline at a height that best represents the average water level based on the judgment of the crew chief.
  - A "staff" may be driven into the sea/lake floor and leveled to the top of the staff. The instantaneous water level may then be read off the staff.

- If the meteorological tower is located on a pier then the field crew will need to provide the following information:
  - TBM height above the water.
  - Time of measurement in GMT from the TBM to the water.

The time that the instantaneous water level reading is taken shall be noted in the comments section for the meteorological sensors in the e-site report or on the tide station report, as applicable. Then the height above MSL for the barometer could be determined from the time recorded.