Waquoit Bay (WQB) National Estuarine Research Reserve Meteorological Metadata
January 2016 – December 2016
Last updated: August 31, 2017

I. Data Set & Research Descriptors

1) Principal Investigator(s) & contact persons

Jordan Mora, Research Associate, Jordan.mora@state.ma.us, 508-457-0495 x 128
Megan Tyrrell, Research Coordinator, megan.tyrrell@state.ma.us, 508-457-0495 x 105

Address:
Waquoit Bay NERR
131 Waquoit Highway
PO Box 3092
Waquoit, MA 02536
Phone: (508)-457-0495
Homepage: http://www.waquoitbayreserve.org

2) Entry Verification

System I: CR1000, CR10X

The initial weather station and CR10X program was installed in late October 2003. The old program (ner30.csi) was revised (NERR_4.CSI) to standardize the program for all sites. The revision was necessary to meet new data reporting requirements of CDMO to eliminate instantaneous data sample reporting, add cumulative daily rainfall and additional sensors.

Starting July 12, 2006 at 17:45, WQBNERR weather station was changed from the CR10X Datalogger to a CR1000 Datalogger and associated software program. The sensors for Air Temperature (C), Relative Humidity (%), Barometric Pressure (mb), Wind Speed, Wind Direction, Total Precipitation (mm), Total Photosynthetically Available Radiation (PAR), and Total Solar Radiation (SoRAD) remain the same. See section 9: Sensor specifications, operating range, accuracy, date of last calibration for sensor specifications.

On February 10th, 2005, a new EPLAB© Black and White Pyranometer was installed. It was mounted on the same structure as the PAR instrument approximately within one meters distance. This Pyranometer is an Eppley 10-and 50-junction 180^{O} pyrheliometer originally introduced by Kimball and Hobbs in 1923. The detector is a differential thermopile with the hot-junction receivers blackened and the cold-junction receivers whitened. The element is of radial wire-wound-plated construction. Built in temperature compensation with thermistor circuitry is incorporated to free the instrument from the effects of ambient temperature. A precision ground optical glass hemisphere of Schott glass WG295 uniformly transmits energy from 285 to 2,800 millimicrons. This hemispherical envelope seals the instrument from the weather, but is readily removable for instrument repair. The cast aluminum case carries a circular spirit level and adjustable leveling screws. Also supplied is a desiccator, which can be inspected readily. See section 9 for most recent calibration dates.

Although the Eppley pyranometer was installed in 2005 and collected data until 2014, in October 2014 research staff at Waquoit Bay realized the sensor was collecting total solar radiation data in Watt-hours per meter-squared (a measure of maximums within a 15 minute period). CDMO (Central Database Management Office) protocols require the total solar radiation data to be displayed in Watts per meter-squared (a measure of 5-second averages over a 15 minute period). Because of the discrepancy, these data have been removed from the national database but are available by request. Please contact the WBNERR research staff for total solar radiation data series (contact information on page 1 of this document).

The meteorological information is sampled every 5 seconds from each instrument on the weather station and stored on a Campbell Scientific CR1000 data logger. Data are output to a file in three file formats: CR1000_A5Min.dat stores 5 minute data; CR1000_GOESout.dat stores 15 minute averages that are transmitted hourly for Satellite upload; and CR1000_SWMP.dat files stores the 15 minute average and total data that is submitted to CDMO on a quarterly basis for primary QAQC review. The CDMO Data Logger (NERR_4.CSI) was loaded into the CR1000 and controls the sensors.

Data are uploaded from the CR1000 data logger to a Personal Computer (IBM-compatible) . Files are exported from LoggerNet in a comma-delimited format and uploaded to the CDMO where they undergo automated primary QAQC and become part of the CDMO's online provisional database. During primary QAQC, data are flagged if they are missing or out of sensor range. The edited file is then returned to the Reserve where it is opened in Microsoft Excel and processed using the CDMO's NERRQAQC Excel macro. The macro inserts station codes, creates metadata worksheets for flagged data and summary statistics, and graphs the data for review. It allows the user to apply QAQC flags and codes to the data, append files, and export the resulting data file to the CDMO for tertiary QAQC and assimilation into the CDMO's authoritative online database. For more information on QAQC flags and QAQC codes, see Sections 11 and 12.

Jordan Mora, Research Associate, error checked and compiled the meteorological data in 2016.

3) Research objectives

The principal objectives are to record meteorological information for the Waquoit Bay NERR's site that can be used: 1) as a vital reference of atmospheric data for various research projects at the reserve - an integral part of our general NERR mission is to provide a platform for estuarine research; 2) to give meteorological context (atmospheric-forcing) for our fifteen minute SWMP water quality data, and other long-term environmental monitoring programs at the Reserve (including nutrients and shoreline change); 3) to observe and characterize important events, such as storms, heat and cold waves, droughts and heavy rainfall; and 4) to detect trends and characterize climate variability over the long term.

4) Research Methods

The Campbell Scientific weather station samples every 5 seconds continuously throughout the year. These data are used by the CR1000 to produce 15 minute, hourly and daily averages of those measurements of air temperature, relative humidity, barometric pressure, wind speed, and

wind direction. Precipitation and PAR are recorded as totals for each interval. As mentioned above, we generally upload data from the CR1000 storage module about once a month. CR1000 raw data are currently stored on one data storage module capable of storing about 3 months of data. The CR1000 is also cabled directly to a desktop PC where the instantaneous 5 sec data are displayed (in a LoggerNet window) and can be viewed at any time. During quarterly review, the error/anomaly reports and all monthly parameter graphs are printed and reviewed. Any error/anomaly messages are further investigated and the data is either corrected/rejected (if necessary) or commented on and left unchanged. All data are collected in Eastern Standard Time (EST).

Sensors on the weather station are inspected monthly for damage or debris. See section 9 for most recent calibration dates. Also, once a month at the time of uploading, we obtain ancillary weather data from a handheld device, Kestrel 5500, to check against the Campbell Scientific Inc. sensors. We also compare the current sensor readings to the weather information available online for the Hyannis airport. All data are recorded with monthly maintenance report.

Real-time Data Methods:

In July 2006, our meteorological station was linked to a NOAA GOES © satellite system, which allowed near real-time access to our meteorological data over the internet. Campbell Scientific data telemetry equipment is used at this station to transmit to the NOAA GOES satellite, NESDIS ID #3B022462. The transmissions are scheduled hourly and contain four (4) datasets reflecting the fifteen minute data sampling interval. Upon receipt by the CDMO, the data undergoes the same automated primary QAQC process detailed in Section 2 above. The "real time" telemetry data become part of the provisional dataset until undergoing secondary and tertiary QAQC and assimilation in the CDMO's authoritative online database. Provisional and authoritative data are available at http://cdmo.baruch.sc.edu.

The 15-minute data are collected in the following formats for the CR1000:

Air Temperature (°C)
- 15 minute average (averages from 5-second data over previous 15 minutes)
- Maximum (over previous 15 minutes)*
- Minimum (over previous 15 minutes)*
- Time Maximum (from 5-second data)*
- Time Minimum (from 5-second data)*

Relative Humidity (%)
- 15 minute average (averages from 5-second data over previous 15 minutes)

Barometric Pressure (mb)
- 15 minute average (averages from 5-second data over previous 15 minutes)

Wind Speed (m/s)
- 15 minute average (averages from 5-second data over previous 15 minutes)
- Maximum (over previous 15 minutes)
- Time Maximum (over previous 15 minutes)

Wind Direction
- 15 minute average (averages from 5-second data over previous 15 minutes)
- Standard Deviation (over previous 15 minute period)

Total Precipitation (mm)
- previous 15 minute total

Cumulative precipitation (mm)

- running total of daily precipitation sum of 15 minute totals over a 24 hour period

Total Photosynthetically Available Radiation (PAR)

- previous 15 minute total (millimoles/m^2)

**Available from the Waquoit Bay Reserve (see contact information on page 1). Not a standard CDMO parameter.*

Recommended calibration frequency for the MET station sensors:

Temperature/Humidity – yearly calibration
Rain Gauge – yearly calibration
Wind speed/direction – yearly or every 2 year inspection (depending on sensors)
Barometric Pressure – every 2 years recalibration
PAR – every 2 years recalibration
CR1000 – every 5 years (required beginning of 2014, one year initial grace period)

5) Site Location and Character

The weather station is located beside the Carriage House, an historic building which is part of the Waquoit Bay Reserve Headquarters, a 24-acre parcel of Reserve land. Wind (speed and direction), temperature and relative humidity sensors are mounted on a 10-m aluminum tower next to the Carriage House, which houses our education classroom and research laboratory. As of April 18th, 2016, the temperature, relative humidity, and wind sensors are mounted approximately 28ft above ground level. Before April 18th, the wind sensor was mounted at the top of the tower (30ft); however, it was lowered to a cross-arm in order to accommodate a lightening rod installation needed to better protect the weather equipment (see Figure 1).

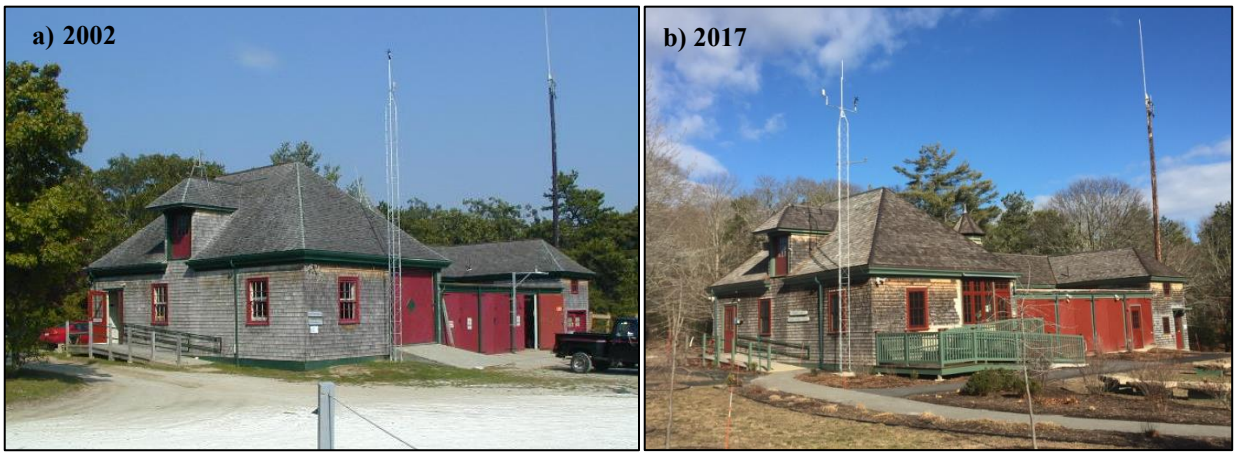

Figure 1: Photos of before (a) and after (b) the 2015 Carriage House renovation and the 2016 tower upgrade. The tower upgrade in 2016 involved a new lightening rod, grounding wire, cross bar, and upgraded temperature/relative humidity and photosynthetically active radiation sensors.

Prior to August 11th, 2015, the weather tower, which supports the wind, temperature, and relative humidity sensors, was located at 41° 34’54.12 N, 70° 31’ 30.36 W. Starting on November 16th, 2015, the tower location changed to 41° 34’54.09” N, 70° 31’30.65”W. The move occurred in response to a renovation project on the Carriage House; a new ADA-compliant (Americans with Disabilities Act of 1990) ramp was built on the side of the building where the tower was

previously installed (see Figure 1). The current location is roughly 6.5 meters northwest of the past location, and instead of being on the south side of the Carriage House, the tower is now on the west side (see Figure 2). The top of the tower exceeds the height of the building; its attached probes stand approximately 2.5 m above the roof peak of the adjacent building and are separated from any trees by 10 m. A crushed shell parking area (bleach white in color) is located to the south (20m) and west (8m) of the current tower. The tower base is 10.39 m above sea level (NGVD), approximately 100 m north from Waquoit Bay's northern shoreline. The location is most exposed to winds from the west and south.

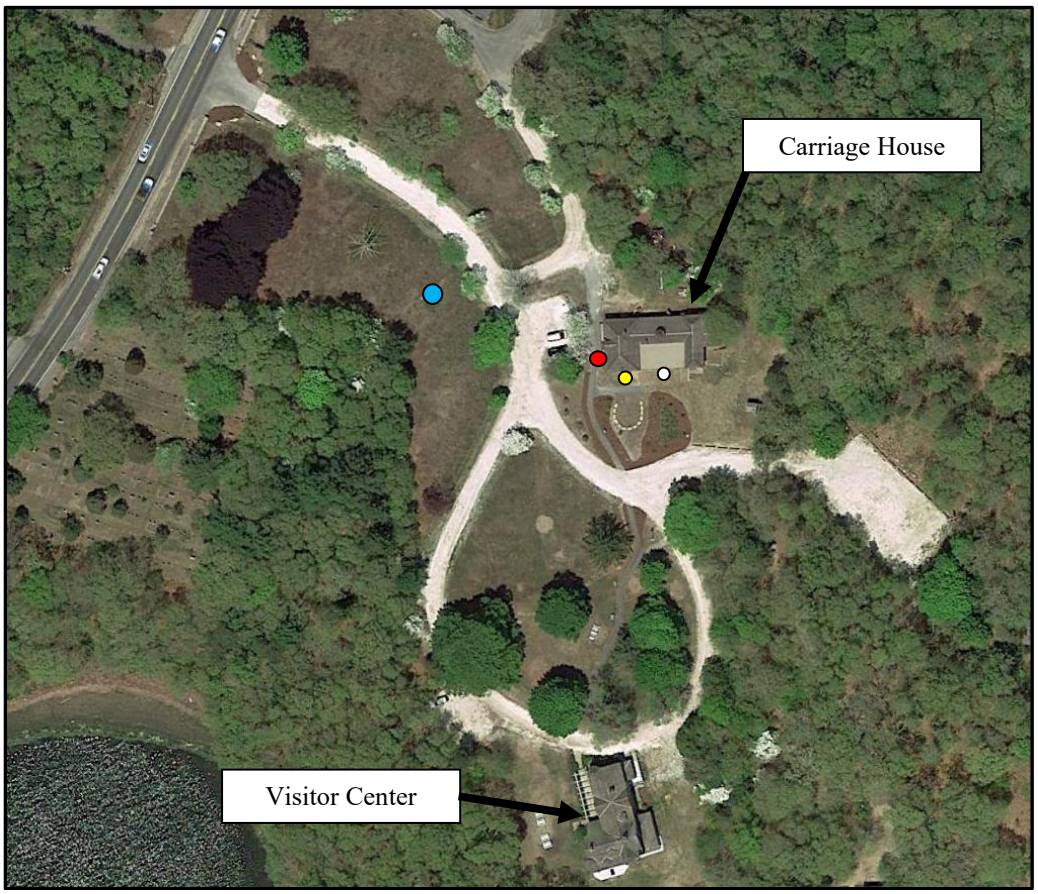

Figure 2: The image above shows the Waquoit Bay NERR Headquarters. The red circle marks the location of the current 30-foot tower location (November 2015 – present). The yellow circle marks the past location of the wind/temperature/relative humidity tower (2006 – August 2015). The white circle marks the location of the photosynthetically active radiation sensor prior to April 18th, 2016, when the sensor was moved to the 30-foot tower (red dot). The larger blue circle indicates the location of the precipitation gauge in the open field. The barometric pressure sensor is located inside the Carriage House in the laboratory along with the CR1000 logger. Aerial provided by Google Earth (spring 2015).

Before April 18th, 2016, the PAR Sensor (for photosynthetically active radiation readings) was mounted about 10 m east from the weather tower, where the temperature/relative humidity and wind sensors are installed. The PAR sensor pole included an extended aluminum arm at a height of 3 m (~ 10 ft) above the ground level. On April 18th, 2016, a new PAR sensor (see sensor details in Section 9) was installed on the weather tower at a height of approximately 4m (~14 ft) above ground level. Thus, current PAR readings are taken roughly 16m westward and roughly 1m higher in relation to readings taken before April 18th, 2016. However, photon scatter related to the roofline and ground should be similar between pre- and post-sensor location change. Due

to shading interference in the summer months from a nearby tree, the PAR sensor was moved 10 ft higher (~24ft above ground level) on October 25th, 2016.

The air pressure sensor, which is mounted next to the CR1000 in the laboratory, is approximately 1.5meters in height above ground level. The rain gauge is located in an open field away from trees about 55 m northwest of the laboratory and tower and 11.2 m above sea level (NGVD). The top of the gauge is 1 meter above ground.

As for its general setting, the Waquoit Bay National Estuarine Research Reserve (WQBNERR) is located in the northeastern United States on the southern coast of Cape Cod, Massachusetts. Climatically, this region is considered temperate maritime, and experiences relatively mild winters and cool summers relative to the rest of New England because of its exposed oceanic location. Typical of the mid-latitudes (41 N), prevailing winds are from the southwest, while storm winds tend to be from the east.

The area is adjacent to one of the world's most active regions for cyclogenesis (extra-tropical cyclone formation) off the East coast of North America. These generally winter season storms are most frequent (almost weekly) from late October until late April and are locally called Nor'easters because of the NE wind direction typical to the area during the period of peak wind speeds. These storms generally develop rapidly as secondary lows off the mid-Atlantic coast (Carolinas to New Jersey) and track northeastward passing Cape Cod either directly overhead, or to the southeast or northwest. These winter season storms are important agents of coastal erosion and shoreline alteration in the region, particularly for easterly facing coasts.

Hurricanes are also important phenomena in the region. Most years, during the period from July to November, the Cape experiences some interaction with a passing tropical storm. About once every decade the area experiences a nearby landfall, with winds exceeding hurricane threshold (>33 m/s), usually from the southerly quarter. Hurricanes are particularly important agents of change for the Cape's southern coastal areas, and can have profound effects on local estuaries, including Waquoit Bay. Typically, barrier beach over-wash (with salt marsh burial) and breaching (with new tidal inlet formation) occur during these extreme events.

Meteorological data from Waquoit Bay NERR can be compared to that from other nearby meteorological stations. These stations are located at Otis Air Force Base (10 km to the north), Falmouth Water Department-Long Pond (8 km to the west), Woods Hole Oceanographic Institution–Quisset Campus (13 km to the southwest), Hyannis Airport (23 km to the northeast), and Buzzards Bay Texas Tower (41 km to the southwest) – this latter station being a particularly valuable reference site because it is offshore and southwest with at least 15 km of unobstructed open water around it and it also records other useful sea surface parameters (wave height and direction, and ocean temperatures).

Other stations which are also used for reference include the Menauhant Yacht Club weather station operated and maintained by Dr. Richard Taylor as a Local National Weather Service Reporting Station (Data Garrison https://datagarrison.com/). Since December 2002, the National Weather Service Reporting Station has been recording daily observations at 0700 and 1900 for the following weather parameters: Temperature (°F; minimum and maximum), Precipitation (inches; rain and melted snow, snow fall, initial and endpoint times of events), Sky Conditions and Wind Direction (mph; gusts).

SWMP Station Timeline:

Station Code	Station Name	SWMP Status	Location	Active Dates	Reason Decommissioned	Notes
WQBCHMET	Carriage House	P	41° 34' 54.09 N, 70° 31' 30.65 W	01/01/2002 - current	NA	NA

6) **Data Collection Period**

Weather data has been collected at the Waquoit Bay NERR Carriage House since December 2001.

Program Reloads in 2016 (EST):

April 18th, 2016 at 8:47
June 7th, 2016 at 11:00
October 25th, 2016 at 11:52

Weather data was downloaded from the station for the following periods 2016 (EST):

START	END	
12/31/2015 10:00	01/29/2016 09:15	
01/29/2016 09:30	02/25/2016 15:00	
02/25/2016 15:15	03/31/2016 14:15	
03/31/2016 14:30	04/18/2016 08:00	
04/18/2016 09:00	05/26/2016 13:30	
05/26/2016 13:45	06/07/2016 09:15	
06/07/2016 13:00	07/05/2016 16:00	*(Data recording check, no monthly maintenance)*
07/05/2016 16:15	07/20/2016 09:45	
07/20/2016 10:00	08/26/2016 09:00	
08/26/2016 09:15	09/28/2016 10:15	
09/28/2016 10:30	10/25/2016 11:00	
10/25/2016 11:00	11/23/2016 11:45	
11/23/2016 12:00	12/20/2016 12:30	
12/20/2016 12:45	01/25/2016 10:15	

7) Distribution

NOAA retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data. The NERRS retains the right to be fully credited for having collected and process the data. Following academic courtesy standards, the NERR site where the data were collected should be contacted and fully acknowledged in any subsequent publications in which any part of the data are used. The data set enclosed within this package/transmission is only as good as the quality assurance and quality control procedures outlined by the enclosed metadata reporting statement. The user bears all responsibility for its subsequent use/misuse in any further analyses or comparisons. The Federal government does not assume liability to the

Recipient or third persons, nor will the Federal government reimburse or indemnify the Recipient for its liability due to any losses resulting in any way from the use of this data.

Requested citation format:
NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org/; *accessed* 12 October 2016.

NERR meteorological data and metadata can be obtained from the Research Coordinator at the individual NERR site (please see Principal Investigators and Contact Persons), from the Data Manager at the Centralized Data Management Office (please see personnel directory under the general information link on the CDMO home page) and online at the CDMO home page www.nerrsdata.org. Data are available in comma delimited format.

8) Associated Researchers and Projects

The Waquoit Bay Meteorological Station located at the Carriage House satisfies the weather data collection requirement of a broader nationwide program, the System-Wide Monitoring Program (SWMP). Within the SWMP, additional required parameters include water quality and nutrient monitoring.

1) Water quality monitoring involves continuous measurements of water temperature, specific conductivity, salinity, dissolved oxygen (percent saturation and concentration in mg/L), depth, pH, turbidity, and chlorophyll fluorescence. These measurements are taken every 15 minutes and stored on a submersible YSI multi-parameter sonde (i.e., data logger). Sondes are rotated every 2-3 weeks for cleaning and calibration.

2) To meet the nutrient sampling requirements of the SWMP, monthly grab samples, in tandem with a 24-hour ISCO water sampler, are collected and processed for various nutrient compounds. The chemical analyses mainly focus on levels of nitrogen, phosphorous, and carbon in the water column.

The water quality monitoring and nutrient sampling occur at four water quality stations located throughout the Waquoit Bay Estuary: Childs River (tidal riverine system with high nitrogen load), Menauhant Yacht Club (closest proximity to ocean influence from Vineyard Sound), Sage Lot Pond (tidal pond surrounded by polyhaline salt marshes), and Metoxit Point (open water location inside Waquoit Bay).

II. Physical Structure Descriptors

9) Sensor specifications, operating range, accuracy, date of last calibration

Temperature

January 1, 2015 – December 4, 2015 (WBNERR unit)

Units: Celsius

Sensor Type: Platinum Resistance Thermometer (PRT), Thermistor (100kΩ @ 25°C)
Model #: HMP35C
Operating Temperature: -35 to +60°C
Temperature Measurement Range: -35 to +55°C
Temperature Accuracy: ±0.4°C

S/N: A4940008
Date of last calibration: 6/27/2012
Dates of Sensor Use: 6/27/2012 – 12/04/2015

Starting December 4, 2015 (Great Bay NERR unit on loan)

Units: Celsius
Sensor Type: Platinum Resistance Thermometer (PRT) 1000 Ω, IEC 751 1/3 Class B Model #: HMP45AC
Operating Temperature: -40 to +60°C
Temperature Measurement Range: -40 to +60°C
Temperature Accuracy: ±0.4°C

S/N: Z2220075
Date of last calibration: 02/05/2014
Dates of Sensor Use: 12/04/2015 – 04/18/2016

Starting April 18th, 2016

Units: Celsius
Sensor type: PT100 RTD, IEC 751 1/3 Class B, with calibrated signal conditioning
Model #: HC2-S3 Temperature and Relative Humidity Probe
Operating Temperature: -40°C to +60°C
Range: -40°C to +60°C
Accuracy: ± 0.1 °C @ 23°C

S/N: 0020052725
Date of last calibration: 07/27/2015
Dates of sensor use: 04/18/2016 – current as of 12/31/2016

Relative Humidity (RH)

June 27, 2012 – December 4, 2015 (WBNERR unit)

Units: Percent
Sensor Type: Sensor Type: Vaisala capacitive polymer H chip
Model #: HMP35C
Relative Humidity Measurement Range: 0 to 100%
RH Accuracy:
±2% RH (0 to 90%)
±3% RH (90-100%)
Stability: 1% per year
Uncertainty of calibration: 0.3% RH

S/N: A4940008
Date of last calibration: 6/27/2012
Dates of Sensor Use: 6/27/2012 – 12/04/2015

Starting December 4, 2015 (Great Bay NERR unit on loan)

Units: Percent
Sensor Type: HUMICAP® 180
Model #: HMP45AC
Relative Humidity Measurement Range: 0 to 100% non-condensing
RH Accuracy:
±2% RH (0 to 90%)
±3% RH (90-100%)
Stability: 1% per year
Uncertainty of calibration: 0.3% RH

S/N: Z2220075
Date of last calibration: 02/05/2014
Dates of Sensor Use: 12/04/2015 – 04/18/2016

Starting April 18th, 2016

Units: Percent
Sensor type: ROTRONIC® Hygromer IN-1
Model #: HC2-S3 Temperature and Relative Humidity Probe
Range: 0-100% non-condensing
Accuracy at 23°C: +/- 0.8% RH with standard configuration settings
Temperature dependence of RH measurement +/- 3% (-40 to 60C)

S/N: 0020052725
Date of last calibration: 07/27/2015
Dates of Sensor Use: 04/18/2016 – current as of 12/31/2016

Photosynthetically Active Radiation (PAR)

Starting September 9, 2011

Units: millimoles/m^2 (total flux)
Sensor Type: LiCor Quantum Sensor (PAR)
Model #: LI-L1190SZ
Stability: < ±2% change over a 1 year period
Operating Range
Temperature: -40°C to 65°C
Humidity: 0 to 100%
Sensitivity: typically 5µA per 1000 µmoles $s^{-1}m^{-2}$
Light spectrum wavelength: 400 to 700 nm

S/N: Q45963
Date of last calibration: 09/09/2011
Multiplier: -264.77 (millivolt adapter)
Dates of Sensor Use: 9/9/2011 – 04/18/2016

Starting April 18th, 2016

Units: mmoles m^2 (total flux)
Sensor type: anodized aluminum with cast acrylic diffuser
Model #SQ110 Apogee Quantum Sensor
Light spectrum waveband: 410 to 655 nm
Temperature dependence: 0.06+/-0.06% per °C
Stability: <±2% change over 1 yr
Operating Temperature: -40°C to 70°C; Humidity 0 to 100%
Cosine Response: 45° zenith angle: +/- 2%; 75° zenith angle: +/- 5%
Sensitivity: 0.2mV per µmol s-1 m-2

S/N: 20507
Date of last calibration: 03/31/2016
PAR Multiplier: 0.025 (multiplier never changes with this model)
Dates of Sensor Use: 04/18/2016 – current as of 12/31/2016

Wind Speed

Units: meter per second (m/s)
Sensor type: 18 cm diameter 4-blade helicoids propeller molded of polypropylene
Model: RMY 05103
Range:
0-60 m/s (134 mph)
gust survival 100 m/s (220 mph)
Direction Range: 360° Threshold Sensitivity: 0.5 m/s (1.1 kts) at 10° displacement
Accuracy: +/- 0.3 m/s

S/N: 05178A (Great Bay NERR unit on loan)
Date of last calibration: New in 2015
Dates of Sensor Use: 12/04/2015 – 10/25/16

S/N: 09834 (WBNERR unit)
Date of last calibration: 06/29/2016
Dates of Sensor Use: 6/27/2012–12/04/2015, 10/25/2016–current as of 12/31/16

Wind Direction

Units: degrees
Sensor type: balanced vane, 38 cm turning radius
Model: RMY 05103
Direction Range: 360° Threshold Sensitivity: 0.5 m/s (1.1 kts) at 10° displacement

S/N: 05178A (Great Bay NERR unit on loan)
Date of last calibration: New in 2015
Dates of Sensor Use: 12/04/2015 – 10/25/2016

S/N: 09834 (WBNERR unit)
Date of last calibration: 06/29/2016
Dates of Sensor Use: 6/27/2012–12/04/2015, 10/25/2016–current as of 12/31/16

Barometric Pressure

Units: millibars (mb)
Sensor Type: Vaisala Barocap © silicon capacitive pressure sensor
Model #: CS 105 Vaisala PTB101B
Operating Range:
Pressure: 600-1060 mb
Temperature: -40 to +60°C
Humidity: non-condensing
Accuracy: ±0.5 mb @ +20°C
Stability: ± 0.1 mb per year

S/N: P5240006 (WBNERR unit)
Date of last calibration: 6/27/2012
Dates of Sensor Use: 6/27/2012 – 06/07/2016

S/N: Z3720039 (loan from Campbell Scientific)
Date of last calibration: May 2016
Dates of Sensor Use: 06/07/2016 – current as of 12/31/2016

Precipitation

Units: millimeters (mm)
Sensor Type: Heated Tipping Bucket Rain Gauge
Model #: 385L
Rainfall per tip: 0.01 inch
Operating range: Temperature: 0° to 50°C; Humidity: 0 to 100%
Accuracy:
±0.5% @ < 0.5" (1.25 cm)/hr rate
±2.0% @ < 3.0" (7.50 cm)/hr rate

S/N: C1521
Date of last calibration: 06/06/2016 (previous calibration 09/09/2011)
Dates of Sensor Use: 9/9/2011 - current as of 12/31/2016

The CR1000 has two MB Flash EEPROM that are used to store the Operating System. Another 128 K Flash is used to store configuration settings. A minimum of 2 MB SRAM is (4 MB optional) is available for program storage (16K), operating system use, and data storage. Additional storage is available by using a compact flash card in the optional CFM100 Compact Flash Module. This station was installed on 7/12/2006. Additional CR1000 specification can be found at: http://www.campbellsci.com/documents/lit/s_cr1000.pdf.

S/N: 5287
Manufacture Year: 2006
Date CR1000 Installed: 07/12/2006 – 06/07/2016, 10/25/2016 – current as of 12/31/2016
Date CR1000 Calibrated: 06/21/2016
CR1000 Firmware Version: CR1000.Std.29 (date: 04/18/2016)
CR1000 Program Version: wqbchmet_6.3_060316.cr1
Campbell Charger for CR1000: Model # CH 100, 12 V

06/07/2016 – 10/25/2016
S/N: 55704 (Campbell Scientific loan while WBNERR's is being recalibrated)
Date CR1000 Installed: 06/07/2016 - 10/25/2016
Date CR1000 Calibrated: May 2016
CR1000 Firmware Version: CR1000.Std.29
CR1000 Program Version: wqbchmet_V6_060316.cr1
Campbell Charger for CR1000: Model # CH 100, 12 V

10) Coded variable indicator and variable code definitions

Site definitions: CH = Carriage House
Station code: wqbchmet

11) QAQC flag definitions

QAQC flags provide documentation of the data and are applied to individual data points by insertion into the parameter's associated flag column (header preceded by an F_). During primary automated QAQC (performed by the CDMO), -5, -4, and -2 flags are applied automatically to indicate data that is above or below sensor range, or missing. All remaining data are then flagged 0, as passing initial QAQC checks. During secondary and tertiary QAQC 1, -3, and 5 flags may be used to note data as suspect, rejected due to QAQC, or corrected.

-5	Outside High Sensor Range
-4	Outside Low Sensor Range
-3	Data Rejected due to QAQC
-2	Missing Data
-1	Optional SWMP supported parameter
0	Passed Initial QAQC Checks
1	Suspect Data
2	*Open – reserved for later flag*
3	*Open – reserved for later flag*
4	Historical Data: Pre-Auto QAQC
5	Corrected Data

12) QAQC code definitions

QAQC codes are used in conjunction with QAQC flags to provide further documentation of the data and are also applied by insertion into the associated flag column. There are three (3) different code categories: general, sensor, and comment. General errors document general problems with the CR1000 data logger, sensor errors are sensor specific, and comment codes are used to further document conditions or a problem with the data. Only one general or sensor error and one comment coded can be applied to a particular data point, but some comment codes (marked with an * below) can be applied to the entire record in the F_Record column.

General Errors

GIM Instrument Malfunction
GIT Instrument Recording Error, Recovered Telemetry Data
GMC No Instrument Deployed due to Maintenance/Calibration
GMT Instrument Maintenance
GPD Power Down
GPF Power Failure / Low Battery
GPR Program Reload
GQR Data Rejected Due to QA/QC Checks
GSM See Metadata

Sensor Errors

SDG Suspect due to sensor diagnostics
SIC Incorrect Calibration Constant, Multiplier or Offset
SIW Incorrect Wiring
SMT Sensor Maintenance
SNV Negative Value
SOC Out of Calibration
SQR Data rejected due to QAQC checks
SSD Sensor Drift
SSN Not a Number / Unknown Value
SSM Sensor Malfunction
SSR Sensor Removed

Comments

CAF Acceptable Calibration/Accuracy Error of Sensor
CCU Cause Unknown
CDF Data Appear to Fit Conditions
CML Snow melt from previous snowfall event
CRE* Significant Rain Event
CSM* See Metadata
CVT* Possible Vandalism/Tampering
CWE* Significant weather event

13) Comments/Remarks (*All times appear in Eastern Standard Time)*

a) General Comments:

Data are missing due to equipment or associated specific sensors not being deployed, equipment failure, time of maintenance or calibration of equipment, or repair/replacement of a sampling station platform. Any NANs in the dataset stand for "not a number" and are the result of low power, disconnected wires, or out of range readings. If additional information on missing data is needed, contact the Research Coordinator at the reserve submitting the data.

Small negative PAR values are within range of the sensor and are due to normal errors in the sensor and the CR1000 Datalogger. The Maximum signal noise error for the Licor sensor is +/-

2.214 mmoles/m2 over a 15 minute interval. These values are automatically flagged and coded as <1> (CAF). Please see note below regarding rejected PAR data.

Relative Humidity data greater than 100 are within range of the sensor accuracy of +/-3% and are flagged and coded as suspect, <1> (CAF). Values greater than 103 are rejected <-3>.

Data recorded for all parameters (with the exception of cumulative precipitation) at the midnight timestamp (00:00) are the 15 minute averages and totals for the 23:45-23:59 time period of the previous day. Cumulative precipitation data at the midnight timestamp (00:00) are the sum of raw (unrounded) precipitation data from 00:00 to 23:59 of the previous day. Summing each individual 15-minute total precipitation value from the same period will result in small differences from cumulative precipitation due to rounding. It is especially important to note how data at the midnight timestamp are recorded when using January 1st and December 31st data. **Note: Cumulative precipitation is no longer available via export from the CDMO. Please contact the Reserve or the CDMO for more information or to obtain these data.**

b) Program Reloads (GPR):

- 04/18/2016 09:00 – Jeff Adams edited the CR1000 program to adjust for new Apogee PAR sensor and new temperature/RH probe.

- 06/07/2016 13:00 – Uploaded new program (edited by Jeff Adams) to adjust for barometric pressure sensor, which is on loan from Campbell Scientific.

- 10/25/2016 11:00 – Uninstalled the loaned CR1000 (SN 55704), and uploaded program from June 2016 (wqbchmet_V6_060316.cr1) to the recalibrated CR1000, SN 5246.

c) Specific 2016 Notes:

General:

- <1> [SOC] {CSM} - Because the data logger, CR1000, had surpassed the recommended 5-year calibration deadline and grace period, all data following February 15th, 2015 until June 7th, 2016 09:15 are flagged as suspect (<1>) and out of calibration (SOC) with the F_Record comment with {CSM}. In addition, the barometric pressure sensor was considered out of calibration from January 1st, 2016 00:00 through the sensor swap on June 7th, 2016 09:15. Also, from the beginning of 2016 through April 18th, 2016 08:00, the PAR sensor elapsed calibration standards. The precipitation gauge also elapsed calibration standards until June 6th, 2016 12:45. Data collected with these out of calibration sensors are considered suspect and are flagged and coded as <1> [SOC] (CSM). **It's important to note that while these sensors do not meet recommended calibration standards, the data appear to fall within acceptable ranges and are comparable to local weather reports. Please contact Jordan Mora (contact information on page 1) for more information and maintenance log reports.**

- 02/15/2016 21:45 to 02/16/2016 21:00 (through 2/17/2017 00:00 for cumulative precipitation) and 02/17/2016 6:45 to 02/19/2016 06:45 <-3> [GPF](CSM) – Following

an extreme cold weather event, the CR1000 lost power. Power was not stable again until 02/19/2016. All data are rejected (air temperature and relative humidity are rejected due to sensor malfunction) during these periods.

- 04/18/2016 08:15 - 13:45 <-3> [SMT] (CSM) – Download and maintenance associated with the PAR, wind speed and direction, temperature, and relative humidity sensors began at 8:12 EST. The weather tower was lowered around 9:00 EST. The temperature and relative humidity sensor and the PAR sensor were disconnected around 9:10 EST. The temperature and relative humidity and PAR sensors were replaced with new sensors. An Apogee PAR sensor replaced the LiCor that had been installed. The wind sensor and temperature/RH sensor were moved to a cross-arm to make room for a lightning rod. The PAR sensor was moved from a mounting pole located on the south side of the Carriage House (between the garage doors) to the weather tower. The sensors were reconnected around 12:45 EST, but the weather tower was not resurrected until 13:30 EST. The only reliable data collected between 8:12 and 12:15 EST were barometric pressure and precipitation. All other data within this timeframe are rejected.

- 06/07/2016 9:30 to 14:30 <-2>[GMT](CSM), <-3>[GMT](CSM), <-3>[GPR](CSM) – Data missing or rejected due to maintenance and a program upload. WBNERR received a barometric pressure sensor and CR1000 on loan from Campbell Scientific. These were installed and a new program was uploaded.

  The following equipment was sent to Campbell Scientific for recalibration and repair while units are loaned: 05103-45-L ATO RM YOUNG wind sensor (SN: 09834), old Li-COR PAR sensor (SN: Q45963), old HMP45C temperature probes (SN: Z2220075 from GBNERR and SN: A4940008), CS105 barometric pressure sensor (SN: P5240006), and CR1000 (SN:5287).

- 10/25/2016 08:45 to 10:45, <-3>[SMT](CSM) – Tower was lowered to remove the loaned wind sensor (SN 05178A) and replace it with the recently calibrated WBNERR sensor (SN 09834). While tower was lowered, the PAR sensor was also moved 10ft higher on the tower to reduce shading impacts in the summertime from nearby trees. The temperature and relative humidity shield was cleaned with a brush to remove any debris. The PAR sensor was cleaned with DI and kimwipes as advised by manufacturer. Precipitation and barometric pressure were not affected by this maintenance. Tower was back up at 10:33 EST.

- 10/25/2016 11:00 to 13:15, <-3>[GPR](CSM), <-3>[GMT](CSM) and <-2> and <-3> [GPD](CSM) – Exchanged CR1000 units. The logger had to power down during the exchange. Installed WBNERR's recalibrated CR1000 and uploaded program "WQBCHMET_V6_060316.CR1" After download, the loaned CR1000 logger (SN 55704) was sent back to Campbell Scientific Inc.

Temperature and Relative Humidity (RH):

- 2/1/2016 11:45 to 12:30 <-3> [GMT](CSM) – The tower was lowered to tighten bolts where the sections attach. The tower was swaying considerably in the wind. Some of the bolts were loose and tightening seemed to help the stability. All temperature and relative humidity data are rejected for this period.

- 02/15/2016 21:45 to 04/04/2016 19:45 for air temperature and 02/15/2016 18:30 - 04/18/2016 08:00 for RH ,<-3>[SSM](CSM) – Sensor failed following a night of very low temperatures in February; possibly due to moisture and corrosion on the electrical terminals. All temperature and relative humidity data rejected.

- 3/3/2016 9:15 to 13:30 <-3> [SMT](CSM) – The tower was lowered to troubleshoot the failed temperature and relative humidity probe. Corrosion was found on the pins inside the port, however, after cleaning the corroded surfaces, there was no improvement.

- 04/04/2016 20:00 to 04/18/2016 08:00 <1> [SOC](CSM) – The temperature sensor (but not the relative humidity sensor) starting working again randomly on April 4th. These data are flagged as suspect since the sensor was malfunctioning since mid-February and are still considered SOC due to being collected with an out of calibration CR1000.

Wind Speed and Direction (Wspd, MaxWSpd, Wdir and SDWDir):

- 2/1/2016 11:45 to 12:30 <-3> [GMT](CSM) – The tower was lowered to tighten bolts where the sections attach. The tower was swaying considerably in the wind. Some of the bolts were loose and tightening seemed to help the stability. All wind data are rejected for this period.

- 3/3/2016 9:15 to 13:30 <-3> [SMT](CSM) – The tower was lowered to troubleshoot the failed temperature and relative humidity probe. All wind data are rejected during this time.

- 10/25/2016 08:45 to 10:45, <-3>[SMT](CSM) – Tower was lowered to remove the loaned wind sensor (SN 05178A) and replace it with the recently calibrated WBNERR sensor (SN 09834).

PAR (Photosynthetically Active Radiation)

- The PAR sensor was considered out of calibration from 01/01/2016 00:00 through the sensor swap on 04/18/2016 08:00. In addition, all sensors are flagged and coded as out of calibration from 1/1/2016 - 6/7/2016 09:15 due to an out of calibration CR1000. **It's important to note that while these sensors do not meet recommended calibration standards, the data appear to fall within acceptable ranges and are comparable to local weather reports. Please contact Jordan Mora(contact information on page 1) for more information and maintenance log reports.**

- <1> [SOC] (CSM) - Elevated PAR nighttime measurements (>0.0) are marked as suspect. The elevated numbers are likely caused my moisture seeping into the sensor overnight. Nights showing elevated PAR readings are listed below:

  01/23/2016 23:30
  02/16/2016 21:45

- 04/18/2016 to 10/25/2016 08:30 – During these months, the PAR sensor experienced shading around 16:30 EST in the summertime. There is a precipitous drop in PAR

readings from approximately 850 mmol/m^2 to approximately 200 mmol/m^2 in less than one hour. However, on 10/25/2016 the PAR was moved 10ft higher on the weather tower to avoid continued shading impacts. PAR are flagged as suspect and coded as CSM from 15:30-17:30 from 04/18/2016 - 10/24/2016.

Barometric Pressure

- The barometric pressure sensor was considered out of calibration from 01/01/2016 00:00 through the sensor swap on 06/07/2016 09:15. In addition, all sensors are flagged and coded as out of calibration from 1/1/2016 - 6/7/2016 09:15 due to an out of calibration CR1000. **It's important to note that while these sensors do not meet recommended calibration standards, the data appear to fall within acceptable ranges and are comparable to local weather reports. Please contact Jordan Mora(contact information on page 1) for more information and maintenance log reports.**

- 04/18/2016 12:30 to 14:00 <-3>[SMT] (CSM) – The barometric pressure sensor was accidentally disconnected when closing up the meteorological station box. The sensor was reconnected at 13:55.

Precipitation

- The precipitation gauge was considered out of calibration from 01/01/2016 00:00 through 06/06/2016 12:45 (sensor calibrated this day). In addition, all sensors are flagged and coded as out of calibration from 01/01/2016 through 06/07/2016 09:15 due to an out of calibration CR1000. **It's important to note that while these sensors do not meet recommended calibration standards, the data appear to fall within acceptable ranges and are comparable to local weather reports. Please contact Jordan Mora (contact information on page 1) for more information and maintenance log reports.**

- During the winter months of 2016, the heating cable was NOT connected because it caused miscommunication with the sensor. Because the heating cable was not powered, there may be a delay in precipitation data as snow melted in the bucket. Precipitation data are considered suspect when collected on dates when the air temperature was at or below freezing since we do not know if the amounts and times are accurate due to possibility of snow melt. Dates precipitation occurred when temperatures were less than or equal to 0 are: 01/14/2016, 01/18/2016, 01/20/2016, 01/21/2016, 01/23/2016, 01/27/2016, 01/28/2016, 02/05/2016, 02/08/2016, 02/09/2016, 02/12/2016, 04/05/2016, and 11/23/2016. Due to an out of calibration sensor and corrections for maintenance, these data are also already considered suspect. Also note that because of a temperature sensor failure (February - April, see above) not all freezing temperatures are available and some precipitation values may have been missed in the list of dates above. Precipitation data recorded on 12/17/2016 is more than likely a combination of snowmelt from 12/16/2016 and 12/17/2016, as well as rain on 12/17/2016. Those data have been flagged as suspect, <-1> CSM. According to Dr. Richard Taylor, Local National Weather Service Reporting Station (Menauhant Yacht Club weather station), the only snow that fell in December 2016 was late night on the 16th: 2.8 inches melted to 0.20 inches water. Snow turned to rain at 7 am, on the 17th, and it rained to 1 pm (0.53 inches).

The high temperature on the 16th was a chilly 21 degrees F. The low temperature that night was 16 degrees F and the high on December 17th was 50 degrees F.

- 12/31/2015 10:30 – 01/01/2016 00:00 <5>[SMT](CSM) – The precipitation bucket was accidentally tipped during maintenance. The error was removed from total precipitation and the subsequent readings for cumulative precipitation were adjusted for the remainder of 12/31/2015, this includes the 01/01/2016 00:00 timestamp in the 2016 dataset since precipitation recorded at 00:00 is the total for 23:45 - 00:00.

- 3/31/2016 14:15 – 4/1/2016 00:00 <5>[SMT](CSM) – The precipitation bucket was accidentally tipped during maintenance. The error was removed from total precipitation and the subsequent readings for cumulative precipitation were adjusted for the remainder of 3/31/2016.

- 5/26/2016 13:15 to 5/27/2016 00:00, <5>[SOC](CSM) - The precipitation bucket was accidently tipped during maintenance. The error was removed from total precipitation and the subsequent readings for cumulative precipitation were adjusted for the remainder of 05/26/2016.

- 6/6/2016 13:00 to 16:00 and cumulative to 6/7/2016 00:00, <-3> [SMT](CSM)– The precipitation gauge was calibrated on 6/6/16. All data from manipulating the tipping bucket have been rejected in the total precipitation and cumulative precipitation readings for the remainder of the day.

- 08/26/2016 09:15 to 08/27/2016 00:00 <5>[SMT](CSM) – The precipitation bucket was accidentally tipped during maintenance. The error was removed from total precipitation and the subsequent readings for cumulative precipitation were adjusted for the remainder of 08/26/2016.

- 10/25/2016 13:30 to 10/26/16 00:00, <5> [SMT](CSM)- Accidentally tipped bucket during monthly maintenance check at 11:30 EST. All cumulative precipitation data have been corrected to remove accidental tips from the database.

- 11/23/2016 11:45 to 11/24/2016 00:00, <5>[SMT](CSM) the precipitation bucket was accidently tipped during maintenance. The error was removed from total precipitation and the subsequent readings for cumulative precipitation were adjusted for the remainder of 11/23/2016.

- 12/12/2016 12:30 to 12/13/2016 16:15 (total precipitation) and 00:00 12/14/2016(cumulative precipitation), <-3> [SSM](CSM) – Plugged in heating cable (to melt snow in the precipitation funnel) at 12:30 EST, however, wiring problem caused interference with precipitation gauge readings. Heating cable was disconnected on 12/14/2016 until problem could be resolved. Note, there was rain and wintry mix on 12/12/2016 which was not captured due to the heating cable wiring problem.

- 12/14/2016 9:30 (total precipitation) to 12/15/2016 00:00 (cumulative precipitation), <5>[SMT](CSM) – Tried troubleshooting the heating cable problem; however, the attempt was unsuccessful. The data in error has been removed and total precipitation and cumulative precipitation have been reset to zero.

- 12/20/2016 10:15 to 12/21/2016 00:00, <5>[SMT](CSM) – Fixed the heating cable wiring problem. After rewiring the precipitation gauge and finding no improvement, the junction box in the attic was investigated. The grounding wires had come detached inside the junction box during the Carriage House renovation work. Once the grounding wires were reattached, the precipitation gauge signal was no longer impacted and data returned to normal. However, before the problem was corrected, erroneous precipitation data was recorded at 10:15, 11:15, and 11:45 - 12:30 for total precipitation and for the remainder of the day for cumulative precipitation. This data was removed and reset to zero. There was no rain or snow on 12/20/2016.

- 12/21/2016 00:15 to 12/29/2016 09:30, <-3>[SSM](CSM) – After troubleshooting the heating cable problem on 12/20/16, the tipping bucket was caught on the heating cable wires inside the precipitation funnel. The problem was identified on 12/29/16 and resolved.

- 12/29/2016 9:45 to 12/30/2016 00:00, <5>[SMT](CSM) - The tipping bucket was stuck on heating cable wires inside the funnel, and after adjusting the wires, water was poured into the funnel at 9:45-9:47 EST to confirm that the tipping gauge could move freely. The manipulated data showed 1.8mm of rain at 9:45 and 1.0mm of rain at 10:00; these values were corrected to zero. Also, 2.8mm was removed from the cumulative precipitation for the day. It did start raining at approximately 14:00 EST.