

WELLS (WEL) National Estuarine Research Reserve
Provisional Water Quality Metadata
January-December 2018
Latest Update: June 21, 2021

I. Data Set and Research Descriptors

1) Principal investigator(s) and contact persons:

Address:

Wells NERR, 342 Laudholm Farm Road Wells, ME 04090

Phone: (207)646-1555

FAX: (207)646-2930

Contact Persons:

Dr. Jason Goldstein

E-mail: jgoldstein@wellsnerr.org

Phone: (207) 646-1555 ext.136

Jeremy Miller, Research Associate

E-mail: jmiller@wellsnerr.org

Phone: (207) 646-1555 ext. 122

2) Entry verification –

Deployment data are uploaded from the YSI data logger to a Personal Computer (IBM compatible). Files are exported from EcoWatch in a comma-delimited format (.CDF), EcoWatch Lite in a comma separated file (CSV) or KOR Software in an Excel File (.XLS) and uploaded to the CDMO where they undergo automated primary QAQC; automated depth/level corrections for changes in barometric pressure (cDepth or cLevel parameters); and become part of the CDMO's online provisional database. All pre- and post-deployment data are removed from the file prior to upload. During primary QAQC, data are flagged if they are missing or out of sensor range. The edited file is then returned to the Reserve for secondary QAQC 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, remove any overlapping deployment data, append files, and export the resulting data file for upload to the CDMO. Upload after secondary QAQC results in ingestion into the database as provisional plus data, recalculation of cDepth or cLevel parameters, and finally tertiary QAQC by the CDMO and assimilation into the CDMO's authoritative online database. Where deployment overlap occurs between files, the data produced by the newly calibrated sonde is generally accepted as being the most accurate. For more information on QAQC flags and codes, see Sections 11 and 12.

3) Research objectives:

The Webhannet River estuary is located in proximity to heavily used beaches in Wells, Maine. It has a shoreline that is highly developed with residential and commercial structures. The estuary receives water from a 14 sq. mi. watershed that is well forested. We are measuring variations in hydrologic variables in the Webhannet River estuary at the Head of Tide and at the Inlet. Data from Head of Tide will integrate surface and ground water inputs (from both point and non-point sources) from the freshwater watershed into the estuary. Data from the Inlet will integrate surface and ground water inputs from the freshwater

watershed and the estuarine watershed. Differences in data between the Head of Tide and the Inlet will indicate inputs from the estuarine portion of the watershed (on the ebb tide), and inputs from the Gulf of Maine on the flood tide. The instruments will track runoff events via salinity, and will measure pollutant-carrying sediment particles via turbidity. Our working hypothesis is that the freshwater watershed is the primary source of sediment and therefore potential NPS pollutants in the estuary. These two variables will indicate the potential for non-point source pollutants to enter the estuary, and whether they are of upland, estuarine, or Gulf of Maine origin. Other variables measured by the data loggers (DO, temperature, pH, specific conductivity, and water level) will provide important baseline data to track changes in the estuary's physicochemical parameters over the long term. These variables can be affected by changes in human water use, and by natural or human induced changes in Inlet and river channel morphology, climate, and organic loadings. The Inlet site is heavily impacted at the Wells Harbor dock and is our long-term monitoring site. The Head of Tide site is relatively un-impacted, located just east of the US Route One Bridge, and is our roving site. We also collect data at the Skinner Mill site (SM) which acts as the head of tide site for the Little River/Merriland river estuary and at the mouth of the Little River (LM) to have comparative data for a less developed estuary.

4) Research methods:

The Wells NERR YSI monitoring program began in April 1995 at one site (Head of Tide site-HT) and May 1995 at a second site (Inlet site-IN) in the Webhannet River estuary. Two additional sites were added in 2002, Mile Road (ML) site began in March in the Webhannet River estuary and Little River Mouth (LM) in April in the Merriland/Branch/Little River Estuary. For 2004, the Mile Road (ML) site was eliminated and a new site at Skinner Mill (SM) in the Merriland/Branch/Little River Estuary was added. All data loggers have 1/4 inch black vexar mesh wrapped on the outside of the probe protective housing (using rubber bands) of the sonde guard to prevent fouling and unwanted animals. All deployment structures (PVC tubes) described below, are labeled with the Wells NERR information.

A Sutron Sat-Link2 transmitter was installed at the Skinner Mill (welsmwq) station on 5/30/2006 and transmits data to the NOAA GOES satellite, NESDIS ID #3B035008. The transmissions are scheduled hourly and contain four (4) data sets reflecting fifteen minute data sampling intervals. 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>.

A YSI/Xylem STORM telemetry system was installed at the Inlet (welinwq) station on 01/15/2014 and transmits data to the NOAA GOES satellite, NESDIS ID #3B04A2B8. The transmissions are scheduled hourly and contain four (4) data sets reflecting fifteen minute data sampling intervals. 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>.

***IMPORTANT CHANGE TO ALL SITES:** In 2004, the YSI Extended Deployment System was used for all deployments. This system consists of a small brush that sweeps all the probes (except for depth) prior to each reading, greatly reducing the problem of biofouling. The Extended Deployment System is reflected in the “EDS” in the sonde model number.

***IMPORTANT CHANGE TO ALL SITES:** As of 2014 all sites were upgraded to the EXO2 datasondes and the use of 6600 series sondes for SWMP data collection was discontinued.

*** IMPORTANT CHANGE TO THE SKINNER (SM) SITE:**

On 5/30/2006 the location of the Skinner Mill (SM) was changed to better reflect a head of tide and head of estuary scenario. The site was moved approximately 100 meters downstream from the original site described in 2004-5 metadata. In addition, a Sutron Sat-Link2 transmitter was installed at this station, and transmits data to the NOAA GOES satellite, NESDIS ID #3B035008. The transmissions are scheduled hourly and contain four (4) datasets reflecting fifteen-minute data sampling intervals. The telemetry data is "Provisional" data and not the "Authentic" dataset used for long term monitoring and study. This data can be viewed by going to <http://cdmo.baruch.sc.edu>."

*** IMPORTANT INFORMATION PERTAINING TO THE INLET (IN) SITE:**

The Inlet site (IN) deployment methods are different than the other sites (SM, HT, LM). A 23 foot, 4 inch diameter high grade PVC tube was installed against a dock piling. Four steel flat bars with bolts were used to attach this 23 foot PVC tube against the dock piling. A stainless steel bolt was inserted through the bottom of the PVC tube to allow the sonde to sit exactly 1.0 meter (3.28 ft) from the bottom, and to increase vertical stability of the depth sensor. Several vertical holes, representative of the sonde guard, were cut out the circumference near the bottom of the PVC pipe to allow water flow to the probes. An "L" shaped steel bar with two end-holes is placed through two created slits about a half of foot from the top of the PVC tube. A stainless steel wire (1/16") is attached to the sonde bail using two stainless steel clips; and to one end of the "L" shaped steel bar for sonde deployment and retrieval. A marine lock is attached through the other end of the "L" shaped steel bar to hold the bar, wire, and sonde in place and for security.

All other sites, Head of Tide (HT), Little River Mouth (LM), and Skinner Mill (SM) are deployed similarly to each other as of 5/30/2006. These sites use a 5 foot, 4 inch diameter, high grade PVC tube. The PVC tube is attached to a 12 foot, heavy steel sign post using a stainless steel bolt at the bottom of the tube, a stainless steel cable wrap at the top, and several thick electrical cable ties in between. The steel signpost was pounded in about 6 feet into the river bottom, such that the bottom of the PVC tube was flat on the river bottom. The PVC tube has one 3 by 1.5 inch PVC transducer glued on the inside bottom of the PVC tube to allow the sonde to sit exactly at a certain height off the bottom (see below). Several vertical holes, representative of the sonde guard, were cut out the circumference near the bottom of the PVC pipe to allow water flow to the probes. An "L" shaped steel bar with two end-holes is placed through two created slits about a half of foot from the top of the PVC tube. A stainless-steel wire (1/16") is attached to the sonde bail using two stainless steel clips; and to one end of the "L" shaped steel bar for sonde deployment and retrieval. A marine lock is attached through the other end of the "L" shaped steel bar to hold the bar, wire, and sonde in place and for security. A flotation buoy is tied to the PVC tubes incase the deployment structure ever gets dislodged. The deployment depth for these sites is such that the probe-end of the data logger is secured 0.15 meters (6 inches) off the bottom.

The Head of Tide (HT) and Inlet (IN) sites report level (m). A sensor offset is entered during pre-deployment calibration to enable depth data to be referenced to the North American Vertical Datum of 1988. The height of a vertical reference point (VRP) on the station is measured annually relative to a nearby geodetic benchmark using survey grade equipment. A sensor offset is then measured as the distance from the VRP to the height of the depth sensor with the sonde resting on the bottom bolt of the well. The sensor offset is then subtracted from the orthometric height of the VRP to calculate the station offset used during calibration. See Section 14) Other Remarks/Notes for more information about station offsets. Information on physical infrastructure, survey methods, and benchmarks is included in the table below.

Site Name	Head of Tide (HT)	Inlet (IN)
-----------	-------------------	------------

Infrastructure Description	Schedule 40 PVC pipe was mounted to the US Highway One Bridge Abutment at the head of tide of the Webhannet river, using custom made stainless steel clamps and brackets which were drilled and anchored into the concrete abutment.	Schedule 40 PVC pipe was mounted to a large dock piling at Wells Harbor at the mouth of the Webhannet river, using custom made stainless steel clamps and brackets which were drilled and anchored into the piling.
Surveying Equipment	Total Station	Total Station
Equipment Model	Leica 1205 TPS	Leica 1205 TPS
Equipment Accuracy	5", 0.002 mm/100 m	5", 0.002 mm/100 m
Equipment Target	Leica Circular Prism	Leica Circular Prism
Survey Mount Used (benchmark)	HT31	9317 C
Survey Mount Description (benchmark)	Nail driven into pavement	NOAA Tidal Benchmark
Survey Occupation Date (benchmark)	9/1/2011	THIS BENCHMARK MAINTAINED BY NOAA Survey metadata is not available.
Survey Occupation Duration (benchmark)	3:49:00	NA
Ellipsoid Height (benchmark)	-22.541 m	NA
Vertical RMS (benchmark)	0.047 m	NA
Reference Frame (benchmark)	NAD83(CORS96)	NA
"Quick Check" marker for deployment tube (Done at beginning of each deployment)	Permanent Marker (industrial sharpie) and "physical mark" were tube meets brackets.	Permanent Marker (industrial sharpie) and "physical mark" were tube meets brackets.
"Quick Check" for sonde being deployed at the same location (Done at beginning of each deployment)	Bolt at bottom of tube and mark on deployment rope.	Bolt at bottom of tube and mark on deployment rope.
Annual resurveying of VRP (include dates of surveys)	7/10/2018, 4/17/2019	4/11/2019

Deployment and Data Intervals:

Four to five week variable sampling periods were chosen for all data sondes due to probe fouling, Sensor drift, limited battery power, and to minimize risk of lost data in the event of a malfunction. Measurements of temperature, specific conductivity, salinity, percent saturation, dissolved oxygen, depth, pH, and turbidity are recorded at 15 minute intervals throughout the deployment period.

Calibration and Standards Used:

After the deployment period, the data logger is brought back into the Wells NERR Laboratory for downloading, cleaning, and calibration. These procedures are carried out to the methods described in the YSI Operating Manual. Calibration standards are used for specific conductivity (10 mS/cm), pH (buffer solutions of pH 4, 7, and 10), and turbidity (126 NTU). All calibration standards are purchased from YSI.

Conductivity and turbidity standards are purchased from YSI, Inc. During periods when we have an idle YSI logger, the deployments are continuous (retrieved logger is immediately swapped with a newly deployed logger). If no idle logger is available (for example, it is away for repair), after approximately 6-24 hours of down time for cleaning, maintenance and recalibration, the YSI Data logger is redeployed for another sampling period.

QA/QC of Instruments:

At each deployment and retrieval, a YSI Model PRO2030 handheld unit collects temperature, DO mg/L, DO %, and salinity. These parameters are recorded on the calibration/deployment/retrieval data sheets and compared to the sonde data. In addition, at the end of each deployment, the data is immediately downloaded and a graph viewed of the data to look for periods of missing or anomalous data. "Post-calibration" data (using calibration standards) are also recorded, to verify that the probes are still measuring accurately after retrieval. Wells NERR staff follows all post-deployment procedures outlined in the CDMO's Water Quality Monitoring SOP.

5) Site location and character

The Wells National Estuarine Research Reserve is located in York County, within the Town of Wells, on the coast of southern Maine and faces the Atlantic Ocean. The Wells NERR is approximately 31 km (20 miles) south of Portland, Maine and 110 km (70 miles) north of Boston, Massachusetts. The Reserve encompasses 1,690 acres along the Gulf of Maine coastline of tidally-flushed wetlands, riparian and transitional upland fields and forests within the Little River Estuary and the larger Webhannet River Estuary. Both estuaries arise in the sandy glacial outwash plain about eight miles inland. Both rivers empty into Wells Bay, a sandy basin stretching for approximately ten miles along the Atlantic coast. Bordering each river's Inlet are double spit barrier beaches attached to the mainland. The backbarrier system in the Webhannet River Estuary is approximately 5 sq. km and is composed of large intertidal marshes (predominantly *S. patens* and *S. alterniflora*), intertidal sand and mud flats, and tidal channels. The watershed for the Webhannet River estuary covers an area of 35 sq. km and has a total of 6 streams, brooks or creeks, which enter the estuary. These tributaries flow across sand and gravel deposits near the headwaters and the impermeable sandy muds of the Presumpscot Formation in the lower reaches. The watershed for the Little River estuary covers an area of 84 sq. km and has a total of 2 tributaries. The backbarrier system in the Little River Estuary is approximately 2.51 sq. km and is composed of large intertidal marshes (predominantly *S. patens* and *S. alterniflora*), intertidal sand and mud flats, and tidal channels. The Webhannet River is connected to the ocean via Wells Inlet, which has a spring tidal prism of 28,200,000 cub. m (Ward 1993).

The Little River is connected to the ocean by an unstructured, double spit system and is one of the few tidal Inlets along the southern Maine coast that is not stabilized by either natural outcrops or artificial jetties. The force and volume of tidal action affect the salinity level of both rivers. In the Wells region, the annual mean wave height is almost 20 inches. These estuarine systems are dominated by semi-diurnal tides having a range of 8.5 to 9.8 feet. The volume of freshwater influx into both estuaries is moderate to low (on the order of 0.5 cubic meters/second), especially in the summer, because of the rivers' relatively small drainage areas and the presence of deep glacial deposits. The relatively low flows from these two rivers taken in with the 20 inch per year average runoff of the area surrounding the estuaries combine to form a fresh water flow which is dwarfed by tidal flushing. Twelve-foot tides dwarf the freshwater flow into the Webhannet estuary, which has a drainage area of 14.1 square miles. The Merrilland River and Branch Brook meet south of Route 9 to form the Little River which drains an area of 10.75 sq. miles. The Webhannet estuary, fed by both Blacksmith and Depot Brooks, is adjacent to the harbor and greatly developed land. It offers a valuable opportunity for comparison with the relatively pristine Little River estuary. The land use of the Webhannet estuary include a total of 15% for wetland, fresh water, and tidal marsh; a total of 63.7 % for woodland; and a total of 18.6% for developed land compared to a total of 5.7% development in the Little River estuary (WNERR RMA 1996; Holden 1997).

The following information regarding annual weather patterns in the area was supplied by Maine State Climatologist Professor Gregory A. Zielinski extracted from "Monthly Station Normals of Temperature, Precipitation, Heating and Cooling Degree Days 1971-2000", Climatology of the United States No. 81, National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC. and "Daily Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1971-2000", Climatology of the United States No. 84: "Average monthly temperatures range from 21.6F in January to 66.7F in July with daily highs averaging just below freezing in January and lows around 11F. Daily highs in July average around 76F and daily lows around 57F. The sea breeze often keeps daily highs lower during the summer than areas inland. Annual average temperature is 44.6F. Annual precipitation is 47.07 inches, including the water equivalent of snowfall, with monthly averages ranging from 3.01 inches in July to 4.77 inches in October. August receives just 3.02 inches on average. Annual snowfall is around 66 inches." According to Zielinski, "cool ocean temperatures keep down the number of afternoon showers and especially thunderstorms resulting in low summer precipitation amounts."

There are two sampling sites in the Webhannet River estuary. These are located at the Head of Tide (HT) and at the Webhannet Harbor Inlet (IN). The tidal range at each of these sites is 2.6-2.9 meters.

The Head of Tide site (43 deg 17' 54.05" North, 70 deg 35' 13.54" West) is located 4 miles south of the Wells Reserve, just downstream of the Webhannet Falls (freshwater) and 10 feet east of U.S. Route One. U.S. Route One is used heavily by traffic all year, especially during the summer tourist months. This site has soft mud, sand, and a rocky substrate, and the low and high tide depth is relatively shallow. Depth at mean high water is 1.1 meters. Max and min measured depths are 0.2 to 1.6 meters, giving a max tidal range of 1.4 meters. The salinity range here is 0-31 ppt, with a mean of 3.6 ppt. These headwaters of the Webhannet are relatively undeveloped. This site is located just 10 feet east of the U.S. Route One bridge, and is our roving site.

The Inlet site is located 1.5 miles south of the Wells Reserve, at the Wells Harbor pier (43 deg 19' 12.32" North, and 70 deg 33' 48.39" West). The mouth of the Webhannet estuary forms an extensive wetland/salt marsh area which is surrounded by development. Wells Harbor, which was most recently dredged in 1971, has moorings for approximately 200 commercial fishing and recreational boats. The mouth of the river flows between two jetties to the Atlantic Ocean. This channel was dredged in 1974. This site has a predominately sand substrate and is characterized by strong current during incoming and outgoing tides. Max and min measured depths at the Inlet site are 1.2 to 5.9 meters, giving a max tidal range of 4.7 meters. The maximum depth of the Inlet site is 6.8 meters. The salinity range here is 7-35 ppt, with a mean of 31 ppt. The Inlet site is heavily impacted at the Wells Harbor dock and is our long-term monitoring site.

The Skinner Mill (SM) site is located approximately 100 meters downstream from the intersection of the Merriland River (tributary to Merriland/Branch/Little River estuary) and Skinner Mill Road (at 43 deg 20' 40.96" north and 70 deg 32' 57.18" West). This site is approximately 70 meters downstream from the Watershed Evaluation Team (Educational water quality program at Wells NERR) site L5. Substrate is mud/sand bottom, salinities range from 0 ppt on low or outgoing tides and as high as 27ppt on high tides. Max and min measured depths are 0.1 to 1.9 meters, giving a max tidal range of 1.8 meters. Depth at mean high water is 1.3 meters. Data prior to 5/30/2006 is from the original SM site located approximately 70 meters upstream from the current site, which is approximately 20-30 meters beyond the head of the estuary where mixing between fresh and marine waters occur. Please see the 2005 Water quality metadata for a better description of the original site.

The Little River Mouth site is located 0.4 miles from the Wells Reserve. Due to problems with heavy sediment movement in the Inlet of the Little River, we were forced to relocate the site (see 2002 metadata). We designated a new location for the 2003 sampling season, and it has remained since then. It is located just off the bank of the marsh, in the main channel of the river (43 deg 20' 24.55" North, and 70 deg 32' 26.17" West). The first location attempted in 2002 (N 43 deg 20.176 Latitude, W 70 deg 32.497 Longitude) was located in the main channel of the river, just inland of a spit, beside a bank. The second location attempted

in 2002 (N 43 deg 20.083 Latitude, W 70 deg 32.585 Longitude) was located 1/8 mi. southwest of the first site, within an Inlet, just inland of a spit. The second site was located in an area of much lower current than the first site and often drains completely during low tides. It was also placed within a pool next to incipient low marsh peat that retains calm water during low tides. Max and min measured depths at this site are 0.3 to 2.4 meters, giving a max tidal range of 2.1 meters. The Little River sites exist in a shallow and relatively pristine system with a sandy to mud bottom and a salinity range of 0-32 ppt. There are two major freshwater inputs, the Merriland and Branch Brook Rivers, which converge to form the Little River.

SWMP Station Timeline

Station Code	SWMP Status	Station Name	Location	Active Dates	Reason Decommissioned	Notes
welhtwq	P	Head of Tide	43° 17' 54.05 N, 70° 35' 13.54 W	04/01/1995 00:00 - current	NA	NA
welinwq	P	Inlet	43° 19' 12.32 N, 70° 33' 48.39 W	05/01/1995 00:00 - current	NA	NA
wellmwq	P	Little River Mouth	43° 20' 24.55 N, 70° 32' 26.17 W	04/01/2002 00:00 - current	NA	NA
welsmwq	P	Skinner Mill	43° 20' 40.96 N, 70° 32' 57.18 W	04/01/2004 00:00 – current	NA	NA
weldnwq	P	Drake Island Downstream	43° 19' 44.04 N, 70° 33' 37.08 W	04/01/1996 00:00 - 12/01/1997 00:00	Moved to other WEL projects	The Wells NERR two Drakes Island sites were monitored after 1997 for another project (CICEET-Wells Harbor dredge); they were no longer collecting the dissolved oxygen, percent saturation, and pH parameters.
welmlwq	P	Mile Road	43° 18' 18.00 N, 70° 34' 35.04 W	03/01/2002 00:00 - 12/01/2003 00:00	Unknown	No information available
welupwq	P	Drake Island Upstream	43° 19' 50.16 N, 70° 33' 25.92 W	04/01/1996 00:00 - 12/01/1997 00:00	Moved to other WEL projects	The Wells NERR two Drakes Island sites were monitored after 1997 for another project (CICEET-Wells Harbor dredge); they were no longer collecting the dissolved oxygen, percent saturation, and pH parameters.

6) Data collection period –

Head of tide (welhtwq)

Deploy Date	Deploy Time	Retrieve Date	Retrieve Time	Sonde Model Number (Nickname)
4/2/2019	11:00	5/2/2019	11:30	EXO2 (EXO 9)
5/2/2019	11:45	5/29/2019	13:00	EXO2 (EXO5)
5/29/2019	13:15	6/27/2019	12:00	EXO2 (EXO1)
6/27/2019*	12:15	7/23/2019	12:15	EXO2 (EXO5)
7/24/2019	14:00	8/20/2019	10:15	EXO2 (EXO1)
8/20/2019	11:15	9/17/2019	12:00	EXO2 (EXO3)
9/17/2019	12:15	10/29/2019	10:30	EXO2 (EXO5)
10/29/2019	10:45	11/12/2019	13:15	EXO2 (EXO 9)

* There was a sonde deployed but no data was collected due to an issue with the sonde.

Inlet (welinq)

Deploy Date	Deploy Time	Retrieve Date	Retrieve Time	Sonde Model Number (Nickname)
12/4/2018	15:15	1/7/2019	14:00	EXO2 (EXO 8)
1/7/2019	14:15	3/20/2019	9:00	EXO2 (EXO2)
3/20/2019	9:15	4/29/2019	10:00	EXO2 (EXO 8)
4/29/2019	10:15	5/10/2019	9:45	EXO2 (EXO2)
5/10/2019	10:15	6/19/2019	10:15	EXO2 (EXO 8)
6/19/2019	10:45	7/18/2019	13:45	EXO2 (EXO2)
7/18/2019	14:00	8/19/2019	9:30	EXO2 (EXO 8)
8/19/2019	10:45	9/16/2016	10:30	EXO2 (EXO2)
9/16/2019	10:45	10/24/2019	11:30	EXO2 (EXO 8)
10/24/2019	11:45	12/9/2019	12:45	EXO2 (EXO2)
12/9/2019	18:00	1/9/2020	18:15	EXO2 (EXO 9)

Little River Mouth (wellmwq)

Deploy Date	Deploy Time	Retrieve Date	Retrieve Time	Sonde Model Number (Nickname)
4/12/2019	13:00	5/22/2019	8:15	EXO2 (EXO1)
5/22/2019	8:30	6/10/2019	10:30	EXO2 (EXO7)
6/10/2019	10:45	7/8/2019	10:45	EXO2 (EXO3)
7/8/2019	11:00	8/6/2019	9:15	EXO2 (EXO7)
8/6/2019	9:30	9/11/2019	14:45	EXO2 (EXO5)
9/11/2019	15:00	10/3/2019	9:15	EXO2 (EXO1)
10/3/2019	9:30	11/8/2019	14:15	EXO2 (EXO3)
11/8/2019	14:30	12/5/2019	11:45	EXO2 (EXO5)

Skinner Mill (welsmwq)

Deploy Date	Deploy Time	Retrieve Date	Retrieve Time	Sonde Model Number (Nickname)
4/11/2019	10:15	5/30/2019	13:15	EXO2 (EXO6)
5/30/2019	13:45	7/24/2019	10:15	EXO2 (EXO 9)
7/24/2019	10:30	8/24/2019	12:15	EXO2 (EXO6)
8/27/2019	11:45	10/3/2019	10:30	EXO2 (EXO 9)
10/3/2019	10:45	11/12/2019	15:00	EXO2 (EXO7)

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 2018.

Also include the following excerpt in the metadata which will address how and where the data can be obtained.

NERR water quality 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

Please visit our website: www.wellsreserve.org/research.htm for further information on the Wells NERR research program and for specific research projects and reports.

The Research Program at the Wells NERR conducts and supports research, monitoring, workshops, and research/resource management planning of relevance at local, regional and national levels. The overall aim of our work is to produce science-based information needed to sustain or restore Gulf of Maine coastal habitats and resources, especially those found in salt marsh estuaries and watersheds. During 2016 many different studies involving scores of scientists, students, staff and volunteers focused on several related themes: 1) the quality of water resources in salt marsh estuaries and watersheds 2) land conservation strategies to protect coastal watersheds 3) factors controlling salt marsh accretion, erosion and plant community vigor 4) the value of salt marsh as habitat for fish, shellfish and birds, 5) restoration of salt

marsh habitat degraded through human actions, and 6) understanding the ecology and functions of salt marsh habitat.

NERRS SWMP Program

As part of the SWMP long-term monitoring program, WEL NERR also monitors meteorological and nutrient/chlorophyll data which may be correlated with this water quality dataset. These data are available from the Research Coordinator or online at <http://cdmo.baruch.sc.edu/>.

Salt Marsh Habitats and Communities

Factors that control the dynamics and vigor of salt marsh plant communities and marsh peat formation consequently determine the ability of a salt marsh to persist in the face of sea level rise. Through a combination of experimental manipulations and long term monitoring, a number of multi-year studies are currently producing data to answer questions concerning the sustainability of salt marsh habitats in this region. These studies are looking at nutrient-plant relations, plant community responses to physical and hydrologic disturbance, and the relative contribution of short-term natural events (e.g. storms) and human activities (dredging, tidal restriction) on patterns of sediment accretion and erosion. The Reserve's marshes and beaches are already among the best studied sites in the U.S. with regard to long term accretion and erosion (over thousands of years).

II. Physical Structure Descriptors

9) Sensor specifications –

WEL NERR deployed EXO2 datasondes only during 2018 at all 4 monitoring locations.

Sequence of EXO2 dataloggers:

date, time, temperature, specific conductivity, salinity, dissolved oxygen %, dissolved oxygen mg/L, Depth (in meters) or level, pH, turbidity, Chl_a*, and battery voltage.

*(collected at IN site only)

Following specifications for EXO2 data sondes and probes were taken from the EXO manual.

YSI EXO2 probe specifications:

Parameter: Temperature

Units: Celsius (C)

Sensor Type: Thermistor

Model#: 599870-01

Range: -5 to 50 C

Accuracy: -5 to 35: +/- 0.01, 35 to 50: +/- .005

Resolution: 0.01 C

Parameter: Conductivity

Units: milli-Siemens per cm (mS/cm)

Sensor Type: 4-electrode cell with autoranging

Model#: 599870-01

Range: 0 to 200 mS/cm

Accuracy: 0 to 100: +/- 0.5% of reading or 0.001 mS/cm; 100 to 200: +/- 1% of reading
Resolution: 0.001 mS/cm to 0.1 mS/cm (range dependant)

Parameter: Salinity

Units: practical salinity units (psu)/parts per thousand (ppt)

Sensor Type: Calculated from conductivity and temperature

Range: 0 to 70 psu

Accuracy: +/- 1.0% of reading pr 0.1 ppt, whichever is greater

Resolution: 0.01 psu

Parameter: Dissolved Oxygen % saturation

Sensor Type: Optical probe w/ mechanical cleaning

Model#: 599100-01

Range: 0 to 500% air saturation

Accuracy: 0-200% air saturation: +/- 1% of the reading or 1% air saturation, whichever is greater 200-500% air saturation: +/- 5% of reading

Resolution: 0.1% air saturation

Parameter: Dissolved Oxygen mg/L (Calculated from % air saturation, temperature, and salinity)

Units: milligrams/Liter (mg/L)

Sensor Type: Optical probe w/ mechanical cleaning

Model#: 599100-01

Range: 0 to 50 mg/L

Accuracy: 0-20 mg/L: +/-0.1 mg/l or 1% of the reading, whichever is greater

20 to 50 mg/L: +/- 5% of the reading

Resolution: 0.01 mg/L

Parameter: Non-vented Level - Shallow (Depth)

Units: feet or meters (ft or m)

Sensor Type: Stainless steel strain gauge

Range: 0 to 33 ft (10 m)

Accuracy: +/- 0.013 ft (0.004 m)

Resolution: 0.001 ft (0.001 m)

Parameter: pH

Units: pH units

Sensor Type: Glass combination electrode

Model#: 599701(guarded) or 599702(wiped)

Range: 0 to 14 units

Accuracy: +/- 0.01 units within +/- 10° of calibration temperature, +/- 0.02 units for entire temperature range

Resolution: 0.01 units

Parameter: Turbidity

Units: formazin nephelometric units (FNU)

Sensor Type: Optical, 90 degree scatter

Model#: 599101-01

Range: 0 to 4000 FNU

Accuracy: 0 to 999 FNU: 0.3 FNU or +/-2% of reading (whichever is greater); 1000 to 4000 FNU +/-5% of reading

Resolution: 0 to 999 FNU: 0.01 FNU, 1000 to 4000 FNU: 0.1 FNU

Parameter: Chlorophyll

Units: micrograms/Liter

Sensor Type: Optical probe

Model#: 599102-01

Range: 0 to 400 ug/Liter

Accuracy: Dependent on methodology

Resolution: 0.1 ug/L chl a, 0.1% FS

Depth Qualifier:

The NERR System-Wide Monitoring Program utilizes YSI data sondes that can be equipped with either vented or non-vented depth/level sensors. Readings for both vented and non-vented sensors are automatically compensated for water density change due to variations in temperature and salinity; but for all non-vented depth measurements, changes in atmospheric pressure between calibrations appear as changes in water depth. The error is equal to approximately 1.02 cm for every 1 millibar change in atmospheric pressure, and is eliminated for vented sensors because they are vented to the atmosphere throughout the deployment time interval.

Beginning in 2006, NERR SWMP standard calibration protocol calls for all non-vented depth sensors to read 0 meters at a (local) barometric pressure of 1013.25 mb (760 mm/hg). To achieve this, each site calibrates their depth sensor with a depth offset number, which is calculated using the actual atmospheric pressure at the time of calibration and the equation provided in the SWMP calibration sheet or digital calibration log. This offset procedure standardizes each depth calibration for the entire NERR System. If accurate atmospheric pressure data are available, non-vented sensor depth measurements at any NERR can be corrected.

In 2010, the CDMO began automatically correcting depth/level data for changes in barometric pressure as measured by the Reserve's associated meteorological station during data ingestion. These corrected depth/level data are reported as cDepth and cLevel, and are assigned QAQC flags and codes based on QAQC protocols. Please see sections 11 and 12 for QAQC flag and code definitions.

NOTE: older depth data cannot be corrected without verifying that the depth offset was in place and whether a vented or non-vented depth sensor was in use. No SWMP data prior to 2006 can be corrected using this method. The following equation is used for corrected depth/level data provided by the CDMO beginning in 2010:
$$((1013-BP)*0.0102)+Depth/Level = cDepth/cLevel.$$

Salinity Units Qualifier:

In 2013, EXO sondes were approved for SWMP use and began to be utilized by Reserves. While the 6600 series sondes report salinity in parts per thousand (ppt) units, the EXO sondes report practical salinity units (psu). These units are essentially the same and for SWMP purposes are understood to be equivalent, however psu is considered the more appropriate designation. Moving forward the NERR System will assign psu salinity units for all data regardless of sonde type.

Turbidity Qualifier:

In 2013, EXO sondes were approved for SWMP use and began to be utilized by Reserves. While the 6600 series sondes report turbidity in nephelometric turbidity units (NTU), the EXO sondes use formazin nephelometric units (FNU). These units are essentially the same but indicate a difference in sensor methodology, for SWMP purposes they will be considered equivalent. Moving forward, the NERR System will use FNU/NTU as the designated units for all turbidity data regardless of sonde type. If turbidity units and sensor methodology are of concern, please see the Sensor Specifications portion of the metadata.

Chlorophyll Fluorescence Disclaimer:

YSI chlorophyll sensors (6025 or 599102-01) are designed to serve as a proxy for chlorophyll concentrations in the field for monitoring applications and complement traditional lab extraction methods; therefore, there are accuracy limitations associated with the data that are detailed in the YSI manual including interference from other fluorescent species, differences in calibration method, and effects of cell structure, particle size, organism type, temperature, and light on sensor measurements.

10) Coded variable definitions

Site definitions:

Sampling Station: Inlet at Webhannet River Mouth, at Wells Harbor

Sampling Site Code: IN

Station Code: welinwq

Sampling Station: Head of Tide of Webhannet River

Sampling Site Code: Sampling Site Code: HT

Station Code: welhtwq

Sampling Station: Little River Mouth (Merriland/Branch/Little River estuary)

Sampling Site Code: LM

Station Code: wellmwq

Sampling Station: Skinner Mill (on Merriland R, tributary to Merriland/Branch/Little R estuary)

Sampling Site Code: SM

Station Code: welsmwq

File definitions: 3 letter NERR site code (WEL for Wells NERR); 2 letter YSI deployment site code (see above); data type code (WQ for water quality), month, day, year of deployment (ex: WELINWQ071406 = Webhannet Inlet water quality data from 14 July 2006).

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 missing and above or below sensor range. All remaining data are then flagged 0, 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 Data Passed Initial QAQC Checks
- 1 Suspect Data
- 2 *Open - reserved for later flag*
- 3 Calculated data: non-vented depth/level sensor correction for changes in barometric pressure
- 4 Historical Data: Pre-Auto QAQC

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 deployment or YSI datasonde, 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 code 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

GIC	No instrument deployed due to ice
GIM	Instrument malfunction
GIT	Instrument recording error; recovered telemetry data
GMC	No instrument deployed due to maintenance/calibration
GNF	Deployment tube clogged / no flow
GOW	Out of water event
GPF	Power failure / low battery
GQR	Data rejected due to QA/QC checks
GSM	See metadata

Corrected Depth/Level Data Codes

GCC	Calculated with data that were corrected during QA/QC
GCM	Calculated value could not be determined due to missing data
GCR	Calculated value could not be determined due to rejected data
GCS	Calculated value suspect due to questionable data
GCU	Calculated value could not be determined due to unavailable data

Sensor Errors

SBO	Blocked optic
SCF	Conductivity sensor failure
SCS	Chlorophyll spike
SDF	Depth port frozen
SDG	Suspect due to sensor diagnostics
SDO	DO suspect
SDP	DO membrane puncture
SIC	Incorrect calibration / contaminated standard
SNV	Negative value
SOW	Sensor out of water
SPC	Post calibration out of range
SQR	Data rejected due to QAQC checks
SSD	Sensor drift
SSM	Sensor malfunction
SSR	Sensor removed / not deployed
STF	Catastrophic temperature sensor failure
STS	Turbidity spike
SWM	Wiper malfunction / loss

Comments

CAB*	Algal bloom
CAF	Acceptable calibration/accuracy error of sensor
CAP	Depth sensor in water, affected by atmospheric pressure
CBF	Biofouling
CCU	Cause unknown

CDA* DO hypoxia (<3 mg/L)
 CDB* Disturbed bottom
 CDF Data appear to fit conditions
 CFK* Fish kill
 CIP* Surface ice present at sample station
 CLT* Low tide
 CMC* In field maintenance/cleaning
 CMD* Mud in probe guard
 CND New deployment begins
 CRE* Significant rain event
 CSM* See metadata
 CTS Turbidity spike
 CVT* Possible vandalism/tampering
 CWD* Data collected at wrong depth
 CWE* Significant weather event

13) Post deployment information –

Inlet (welinq)

Deploy Date	Sonde Nickname	SpCond	ROXDO1	pH7	pH10	Turb	Turb	Level
1/7/2019	EXO2	9.911(10.0)	101.3	6.88	8.72	0.02(0.0)	124.21(124.0)	-2.39(-2.388)
3/20/2019	EXO 8	9.957(10.0)	101.8	7.2	10.21	0.05(0.0)	124.12(124.0)	-2.414(-2.401)
4/29/2019	EXO2	10.18(10.0)	98.6	7.12	10.08	-0.07(0.0)	124.25(124.0)	-2.481(-2.452)
5/10/2019	EXO 8	9.9(10.0)	100.4	7.08	10.03	0.02(0.0)	124.34(124.0)	-2.549(-2.551)
6/19/2019	EXO2	9.987(10.0)	98.8	6.98	10.01	0.32(0.0)	124.85(124.0)	-2.529(2.51)
7/18/2019	EXO 8	10.02(10.0)	100.6	7.01	9.98	0.1(0.0)	124.43(124.0)	-2.61(-2.51)
8/19/2019	EXO2	10.07(10.0)	98.9	7.09	10.02	0.04(0.0)	124.87(124.0)	-2.504(-2.483)
9/16/2019	EXO 8	10.02()	101.5	6.98	9.99	-0.1(0.0)	124.12(124.0)	-2.408(-2.401)
10/24/2019	EXO2	9.98()	99.7	7.04	10.01	-0.3(0.0)	123.67(124.0)	-2.467(-2.469)
12/9/2019	EXO 9	9.712()	103.5			0.37(0.0)	123.87(124.0)	-2.267(-2.306)

Head of Tide (welhtwq)

Deploy Date	Sonde Nickname	SpCond	ROXDO1	pH7	pH4	Turb	Turb	Level
4/2/2019	EXO 9	9.991(10.0)	100.3	7.04		0.23(0.0)	124.2(124.0)	0.444(0.425)
5/2/2019	EXO5	9.99(10.0)	98.4	7.04	4.07	-0.01(0.0)	126.0(124.0)	0.244(0.303)
5/29/2019	EXO1	10.02(10.0)	100.5	7.08	4.09	-0.01(0.0)	123.4(124.0)	0.394(0.405)
6/27/2019	EXO5	9.97(10.0)	97.2	7.12	4.14	0.01(0.0)	124.7(124.0)	0.314(0.316)
7/24/2019	EXO1	9.96(10.0)	101.9	7.12	4.09	-0.03(0.0)	124.3(124.0)	0.385(0.371)
8/20/2019	EXO3	10.1(10.0)	100.1	7.04	4.05	-0.02(0.0)	124.2(124.0)	0.42(0.0)
9/17/2019	EXO5	10.12(10.0)	102	7.08	4.08	0.05(0.0)	120.9(124.0)	0.477(0.488)
10/29/2019	EXO 9	10.04(10.0)	100.7	7.17	4.24	0.05(0.0)	124.6(124.0)	0.253(0.263)

Little River Mouth (wellmwq)

Deploy Date	Sonde Nickname	SpCond	ROXDO1	pH7	pH10	Turb	Turb	Depth
4/12/2019	EXO1	10.08(10.0)	100.5	7.04	9.99	0.09(0.0)	124.7(124.0)	0.036(0.041)
5/22/2019	EXO7	9.99(10.0)	100.9	7.14	10.12	-0.05(0.0)	129.0(124.0)	0.036(0.082)
6/10/2019	EXO3	10.01(10.0)	99.1	7.18		-0.06(0.0)	123.85(124.0)	-0.0040(-0.014)
7/8/2019	EXO7	10.1(10.0)	99.8	7.02	10.09	0.31(0.0)	123.8(124.0)	-0.01(-0.014)
8/6/2019	EXO5	10.03(10.0)	100.9	6.99	10.02	-0.1(0.0)	124.52(124.0)	0.065(0.054)
9/11/2019	EXO1	10.09(10.0)	99.5	6.82	9.75	0.12(0.0)	123.01(124.0)	0.095(0.095)
10/3/2019	EXO3	10.13(10.0)	102.3	7.01	6.55	-0.03(0.0)	126.08(124.0)	-0.0010(-0.012)
11/8/2019	EXO5	10.11(10.0)	99.2	6.95	9.9	0.14(0.0)	124.03(124.0)	-0.141(-0.15)

Skinner Mill (welsmwq)

***Post Deployment is missing for the 10/3/19 retrieval. This was the final pull of the statin and post-calibration did not occur due to ice damage to the sonde.**

Deploy Date	Sonde Nickname	SpCond	ROXDO1	pH7	pH10	Turb	Turb	Depth
4/11/2019	EXO6	9.98(10.0)	99.7	7.09	10.04	0.12(0.0)	124.2(124.0)	0.061(0.068)
5/30/2019	EXO 9	10.01(10.0)	100.6	7.12	10.05	0.03(0.0)	124.1(124.0)	-0.0060(-0.014)
7/24/2019	EXO6	9.987()	101.6	7.01	10	0.51()	124.06()	0.019(0.027)
8/27/2019	EXO 9	9.97(10.0)	99.8	7.3	10.1	0.01(0.0)	124.9(124.0)	0.023(0.027)
10/3/2019	EXO7							

14) Other remarks/notes

Data are missing due to equipment or associated specific probes 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.

Three of our four sites (SM, LM, and HT) are discontinued through the winter months due to icing in the rivers. See section 6 data collection period for times of site deployment

*Webhannet Inlet (IN) site: There has been an anomalous Dissolved Oxygen trend happening at our IN site for a good part of the deployment season. A trend has appeared of very low DO readings during the ebbing tide and hits a low for that tide right about and hour into incoming tide then shoots back up to reasonable readings. This does not seem to be a probe malfunction in most cases, because the trend has been observed with different probes and sondes which all post calibrate acceptably. Given the magnitude of our tidal range here in the Gulf of Maine, we believe that at low tide, anoxic sediments below our deployment tube are being “stirred up” and influencing our DO data. We do not feel as if the periodically low DO values being seen at this site are representative of the larger sampling area (Webhannet Harbor). As of 5/23/08 ROX optical probes were deployed at this site to obtain more accurate data. On 9/6/2011 the tube was removed, cleaned, and additional holes were drilled in the deployment tube to allow better flushing of the water there-in. This seemed to “help” the problem but the trend was continuing to a lesser extent. Further questions regarding DO data from the Inlet site should be directed to the author of this document.

The Head of tide (HT): site switched to reporting level on 10/17/2018 12:00.

The Inlet (IN): The 01/07/2019 deployment ran longer than the 45 days allowed by the current SOPS ending on 03/20/2019.

The Inlet (IN): The pH post for the 01/07/2019 deployment read 6.88 (7) and 8.72 (10). The deployment went longer than the 45 days allowed by the current SOPs ending on 03/20/2019. pH data after 02/23/2019 is marked suspect.

The Inlet (IN):

Reporting of water level began on 9/21/18 and the station offset used subsequently during logger calibration was -2.510 meters. This station offset was calculated in 2016 prior to water level first being reported. Vertical control at the site was improved in 2018, and annual measurements of the vertical reference point have since been made annually. However, the updated station offset was not used during pre-deployment sensor calibration. In coordination with the NERR Data Management Committee and CDMO 2019 level data were subsequently adjusted on 1/14/21 using the station offset calculated from a height measurement of the VRP taken on 7/10/18 for the period from 1/1/19 00:00 to 4/11/19 23:45 and from a height measurement of the VRP taken on 4/11/19 for the period from 4/12/19 00:00 to 12/31/19 23:45.

The sensor offset (measured from the vertical reference point on the top of the well to the depth sensor) was measured in 2016 at -7.350 meters. This value was added to the orthometric height of the station vertical reference point to calculate the station offset.

Data were adjusted by the difference between the station offset used during calibration and the corrected station offset. For data collected during the period from 1/1/19 00:00 to 4/11/19 23:45 the corrected station offset is -2.895 meters, and the data were adjusted by -0.385 meters. For data collected during the period from 4/12/19 00:00 12/31/19 23:45 the corrected station offset is -2.906 meters, and the data were adjusted by -0.396.

Head of tide (HT) Site: pH data is missing from the period 05/15/2018 7:45 to 06/06/2018 11:45 due to the failure of the pH probe hardware. The nut and clip which holds the pH probe in place was defective and failed during deployment causing the pH probe to “fall out” of the port.

Head of tide (HT) Site: All turbidity data from 09/11/2018 15:00 through 09/13/2018 10:30 are considered suspect as readings are generally high for this site and precede a large chunk of rejected data which was clearly caused by a blocked optic.

Little River Mouth (LM) Site: All DO data from 09/11/2018 at 3:15 through 10/04/2018 11:30 were affected by a DO probe malfunction. A period of suspect data from 9/11 to 9/12 precedes a total probe failure. The post for this probe was 33%.

Little River Mouth (LM) Site: Turbidity data from 9/25 at 16:45 through 9/29 at 13:00 was marked suspect as values are unusually high and this data precedes a steady rise in turbidity data associated with a blocked optic. Data was flagged as a precaution as the sensor may have been affected by debris during this period as well.

Little River Mouth (LM) Site: pH probe was retrieved with a cracked bulb. We believe this happened during deployment on 10/26 sometime around 3:30. All data post 3:30 on 10/26 has been flagged as suspect.

Little River Mouth (LM) Site: DO Data from 11/27/2018 6:45 to 12/11/2018 9:45 the DO probe suffered a failure during this deployment. Data proceeding this was impacted by heavy sedimentation.

Head of Tide (HT) Site: The sonde was out of the water from 11/12 13:30-14:15 before retrieval due to ice forming at the site that lifted the sonde out of the tube. Sonde was pulled for winter.

Significant Rain Events: 1/13, 1/23, 2/5, and 2/10-11, 7/17, 7/28, 8/14, 8/22, 9/6, 9/10, 9/18, and 9/29. (Exact times are flagged in the data set as {CRE}).