

NOAA's Ocean Service
Center for Operational Oceanographic Products and Services (CO-OPS)
Environmental Measurement Systems
Sensor Specifications and Measurement Algorithm

Section 1: Water Level Sensors

- All water level sensors shall have a minimum resolution of 0.001m
- All water level sensors shall sample and be configured to support the transmission of data at a six minute interval

CO-OPS Sensor Specifications -- Water Level Sensors				
Measurement Parameter	Sensor Type	Sensor Manufacturer & Model	Estimated Accuracy	Measurement Algorithm
Water Level (Primary)	Air acoustic sensor mounted in protective well	Aquatrak 3003-XCR-4 Model 3000 Transducer w/ Impulse connector and Model 4110 Controller	Relative to Datum ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. (3 minute water level average) Note - Tsunami Ready stations also send 6 - 1 minute average water level measurements per 6-minute Tx.
Water Level (Primary)	Pressure - Dual Orifice Bubbler	Two (2) Paroscientific Digiquartz® Intelligent Transmitters - Model # 6000-30G with RS-232/485 interface	Relative to Datum ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	36 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. Note - Tsunami Ready stations also send 6 - 1 minute average water level measurements per 6-minute Tx.

CO-OPS Sensor Specifications -- Water Level Sensors				
Measurement Parameter	Sensor Type	Sensor Manufacturer & Model	Estimated Accuracy	Measurement Algorithm
Water Level (Primary)	Pressure - Single Orifice Bubbler	Paroscientific Digiquartz® Intelligent Transmitter - Model # 6000-30G with RS-232/485 interface	Relative to Datum ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	36 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. Note - Tsunami Ready stations also send 6 - 1 minute average water level measurements per 6-minute Tx.
Water Level (Primary) (Backup) (Short Term)	Microwave Radar	<ul style="list-style-type: none"> • YSI WaterLog® H-3611 • YSI Nile 502 • YSI NOAA Nile (item # 203360) 	Relative to Datum ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	359 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. Note - Tsunami Ready stations also send 6 - 1 minute average water level measurements per 6-minute Tx. (Primary only)
Great Lakes Water Level Stations (Primary)	Absolute Shaft Angle Encoder (Float)	BEI Model # MT-40D (Float) Part No. 802-05-0143, MT40D-X-HSS1024N-64T-XD13-X-SC14-X-12, Multi-turn Absolute-Position Encoder	Relative to Datum ± 0.006 m (Individual measurement) ± 0.003 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers.
Great Lakes Water Level Stations (Backup)	Shaft Angle Encoder (Float)	WaterLOG Shaft Angle Encoder H-344-2N	Relative to Datum ± 0.006 m (Individual measurement) ± 0.003 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers.

CO-OPS Sensor Specifications -- Water Level Sensors

Measurement Parameter	Sensor Type	Sensor Manufacturer & Model	Estimated Accuracy	Measurement Algorithm
Great Lakes Water Level Stations (Backup)	Pressure – Submersible hydrostatic level transducer	KPSI 500T 500T1CA0A-0021	Relative to Datum ± 0.05 m (Individual measurement) ± 0.02 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. (3 minute water level average)
Water Level (Backup) <i>Generally used to fill Primary WL sensor data gaps.</i>	Pressure – Single Orifice Bubbler Strain Gauge Sensor	GE Druck UNIK PDCR 5031 Pressure Transducer, p/n PDCR5031-TB-A3-CC-H1-PE-30PSIG-7	Relative to Datum ± 0.05 m (Individual measurement) ± 0.02 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. (3 minute water level average)
Water Level (Backup) <i>Generally used to fill Primary WL sensor data gaps.</i>	Pressure - Single Orifice Bubbler	Paroscientific Digiquartz® Intelligent Transmitter - Model # 6000-30G with RS-232/485 interface	Relative to Datum ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	36 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers.

CO-OPS Sensor Specifications -- Water Level Sensors				
Measurement Parameter	Sensor Type	Sensor Manufacturer & Model	Estimated Accuracy	Measurement Algorithm
Water Level (Short Term)	Air acoustic sensor mounted in protective well	Aquatrak 3003-XCR-4 Model 3000 Transducer w/ Impulse connector and Model 4110 Controller	Relative to Datum ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. (3 minute water level average)
Water Level (Short Term)	Pressure - Single Orifice Bubbler	Paroscientific Digiquartz® Intelligent Transmitter - Model # 6000-30G with RS-232/485 interface	Relative to Datum ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	36 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers.

Section 2: Air Gap Sensors

- All Air Gap sensors shall sample and be configured to support the transmission of data at a six minute interval

CO-OPS Sensor Specifications -- Air Gap Sensors				
Measurement Parameter	Sensor Manufacturer & Model	Estimated Accuracy	Resolution	Measurement Algorithm
Air Gap (Bridge Clearance)	<ul style="list-style-type: none"> Miros SM094 YSI WaterLog® H-3612 YSI Nile 517 	±0.15 m (individual measurement)	0.01 m	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation is recalculated and reported along with the number of outliers.

Section 3: Auxiliary Meteorological & Oceanographic Sensors

- All Met/Ocean sensors shall sample and be configured to support the transmission of data at a six minute interval

CO-OPS Sensor Specifications -- Auxiliary Meteorological & Oceanographic Sensors				
Measurement Parameter	Sensor Manufacturer & Model	Estimated Accuracy	Resolution	Measurement Algorithm
Air Temperature	YSI (Yellow Springs Instruments) 44032 Thermistor with Carol Brand C1202 Cable (or equivalent cable)	± 0.2 Deg.C	0.1 Deg.C	20 equally spaced samples collected over a 2 minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth hour at PORTS® sites or centered on the hour otherwise.
Water Temperature	YSI (Yellow Springs Instruments) 44032 Thermistor with Carol Brand C1202 Cable (or equivalent cable)	± 0.2 Deg.C	0.1 Deg.C	20 equally spaced samples collected over a 2 minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth hour at PORTS® sites or centered on the hour otherwise.
Wind (Speed, direction, and gusts) ¹	<ul style="list-style-type: none"> R.M. Young Wind Monitor 05103 R.M Young Heavy Duty Wind Monitor-HD-Alpine 05103-45 Vaisala WINDCAP® Ultrasonic Wind Sensor WS4250 Vaisala WINDCAP® Ultrasonic Wind Sensor WMT700 	Speed: ± 0.3 m/sec. Direction: ± 3 Deg. Speed Threshold: 1 m/sec	Speed: 0.1 m/sec. Direction: 1 Deg.	Wind Speed - 2 minute scalar average of 1 second wind speed measurements collected prior to each tenth hour. Wind Direction - 2 minute unit vector average of wind direction collected prior to each tenth hour. Wind Gust - The maximum 5 second moving scalar average of wind speed that occurred during the previous 6 minutes for PORTS® stations, during the previous hour otherwise.
Barometric Pressure	Sutron Accubar® Barometric Pressure Sensor 5600-0120	± 0.5 mbar	0.1 mbar	20 equally spaced samples collected over a 2 minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth hour at PORTS® sites or centered on the hour otherwise.

¹ Ideally installed at least 10m above sea level and 10m above and away from any obstacles

CO-OPS Sensor Specifications -- Auxiliary Meteorological & Oceanographic Sensors				
Measurement Parameter	Sensor Manufacturer & Model	Estimated Accuracy	Resolution	Measurement Algorithm
Water Conductivity	<ul style="list-style-type: none"> Falmouth Scientific, Inc. (FSI) NXIC CTD (legacy only) Greenspan MP47-3000 (formerly EC3000) Electrical Conductivity and Temperature Sensors, part number 50091 SeaBird SBE 37SMP MicroCAT C & T Recorder 	Conductivity: ± 0.1 mS/cm Temperature: ± 0.05 Deg C		20 equally spaced samples collected over a 2 minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth hour at PORTS® sites or centered on the hour otherwise.
Water Density	Derived from Conductivity and Water Temp.			
Visibility	<ul style="list-style-type: none"> Vaisala FS11 Vaisala PWD22 (with approved waiver request) 	± 10 % at 10-10,000 m ² (32-32,800 ft)	1.0 m	13 equally spaced samples collected over a 3 minute period are averaged for each measurement using the internal sensor processing. The samples are collected starting one minute prior to each tenth hour at PORTS® sites or centered on the hour otherwise. (3 minute visibility range average)

² CO-OPS limits the maximum reported visibility sensor range to 10,000m (5.4NM). Sensor operational ranges are generally much greater.

Section 4: Current Sensors

- Current sensors used for the support of the National Current Observation Program, tides and currents tables, and mapping and charting activities normally use internal data storage and have no real-time data telemetry capability.
- Current sensors used for the real-time support of maritime navigation and port activities installed for real-time data telemetry shall sample and be configured to support the transmission of data at a six minute interval.

CO-OPS Sensor Specifications -- Current Sensors				
Measurement Parameter	Sensor Manufacturer & Model	Estimated Accuracy	Resolution	Measurement Algorithm
Water Current (Vertical - Bottom Mount)	RD Instruments (4 beam Configuration with 20° beam angle) 600 or 1200 KHz (depending on water depth and/or specific requirements)	Speed ± 0.25 cm/sec. (1200 & 600 kHz) ± 0.5 cm/s (300 kHz) Tilts: ± 0.5° Compass: ± 2° Max Tilts: ± 15°	Velocity: 0.1 cm/s Heading: 0.01° Tilts: 0.01°	6 minute average comprised of approximately 345 profiles (pings) per measurement. Data includes east, north, and vertical velocities, echo amplitude, correlation magnitude, percent good pings for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water pressure and water temperature. Specs ref - http://www.rdinstruments.com/pdfs/datasheets/workhorse_sentinel_ds_lr.pdf
Water Current Profiler (Vertical - Bottom Mount)	SonTek (3 beam configuration with 25° beam angle). 500 or 1500 KHz (depending on water depth and/or specific requirements)	Speed ± 0.5 cm/sec (± 1% measured velocity) Heading ±2° Pitch, Roll ±1° Profiling range 15-25 meter (1500 kHz) pressure sensor 0.1%	Velocity 0.1 cm/s Heading 0.1° Tilts 0.1°	6 minute average comprised of approximately 2000 profiles (pings) per measurement. Data includes east, north, and vertical velocity, standard deviation, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water pressure and water temperature. Specs ref - http://www.sontek.com/download/brochure/adp.pdf

CO-OPS Sensor Specifications -- Current Sensors				
Measurement Parameter	Sensor Manufacturer & Model	Estimated Accuracy	Resolution	Measurement Algorithm
Water Current Profiler (Horizontal)	Nortek Continental (2 beam, frequency 470 kHz)	Maximum profiling range is 100 meters (470 kHz) ± 0.5 cm/sec (± 1% measured velocity)	Velocity 0.1 cm/s Heading, 0.1° Tilts 0.1°	6 minute average comprised of approximately 500 profiles (pings) per measurement (470kHz) and Data includes east and north velocity, standard deviation, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water temperature and water pressure if Specs ref - http://www.nortek-as.com/en/products/current-profilers/continental
Water Current Profiler (Horizontal)	Sontek (2 beam configuration with 25° beam angle). Frequency 500 kHz and 250 kHz – frequency chosen based on on range required	Maximum profiling range is 70-120 meters (500 kHz) and 120-180 meters (250 kHz) Speed ± 0.5 cm/sec (± 1% measured velocity)	Velocity 0.1 cm/s Heading, 0.1° Tilts 0.1°	6 minute average comprised of approximately 500 profiles (pings) per measurement (250kHz) and 700 profiles (pings) per ensemble (500kHz). Data includes east and north velocity, standard deviation, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water temperature and occasionally water pressure if ADP is equipped with one. Specs ref - http://www.sontek.com/download/brochure/adp.pdf

CO-OPS Sensor Specifications -- Current Sensors				
Measurement Parameter	Sensor Manufacturer & Model	Estimated Accuracy	Resolution	Measurement Algorithm
Water Current Profiler (Horizontal)	RDI (3 beam configuration with 25° beam angle for a 600 kHz system and 20° beam angle for a 300 kHz system – frequency chosen based on range required)	Maximum profiling range is 85meters (600 kHz) Speed ± 0.25 cm/sec ($\pm 1\%$ measured velocity) And 250 meters (300kHz) ± 0.5 cm/sec ($\pm 1\%$ measured velocity)	Velocity 0.1 cm/s Heading, 0.1° Tilts 0.1°	6 minute average comprised of approximately 300 profiles (pings) per measurement (300kHz) and 300 profiles (pings) per ensemble (600kHz). Data includes east and north velocity, standard deviation, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water temperature and occasionally water pressure if ADP is equipped with one. Specs ref – Workhorse H-ADCP http://www.rdinstruments.com
Water Current Profiler (Horizontal)	Nortek 400kHz Aquadopp Profiler (3 beam configuration with 25° beam angle).	Profiling range 15-25 meters Speed ± 0.5 cm/sec ($\pm 1\%$ of measured velocity) Horizontal vel range ± 10 m/s Max tilts $\pm 30^\circ$	1 mm/s (Velocity) Heading, 0.1° Tilts 0.1° Pressure sensor 1mm Water Temp 0.01 Deg C	6 minute average comprised of approximately 1800 profiles (pings) per measurement. Data includes east, north, and vertical velocity, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll, water temperature, and water pressure. Specs ref - http://nortekusa.com/hardware/AquadoppProfiler.html

CO-OPS Sensor Specifications -- Current Sensors				
Measurement Parameter	Sensor Manufacturer & Model	Estimated Accuracy	Resolution	Measurement Algorithm
Water Current Profiler (Vertical - Buoy Mount)	Nortek Aquadop Profiler (3 beam configuration with 25° beam angle). Frequency 1 MHz.	Profiling range 15-25 meters Speed ± 0.5 cm/sec ($\pm 1\%$ of measured velocity) Horizontal vel range ± 10 m/s Max tilts $\pm 30^\circ$	1 mm/s (Velocity) Heading, 0.1° Tilts 0.1° Pressure sensor 1mm Water Temp 0.01 Deg C	6 minute average comprised of approximately 1800 profiles (pings) per measurement. Data includes east, north, and vertical velocity, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll, water temperature, and water pressure. Specs ref - http://nortekusa.com/hardware/AquadoppProfiler.html