CHAPTER 7

MAINTENANCE CONSIDERATIONS TO ENSURE DATA QUALITY

7.1 INTRODUCTION

To ensure good quality data during a water quality monitoring project a maintenance program must be in place for the monitoring sondes, platforms and equipment employed. There are three basic types of maintenance procedures (U.S. Department of Energy):

- **Reactive or corrective maintenance** is an unscheduled action performed on a system, equipment or one of its components in the attempt to restore it to a specified performance condition. Basically, the system or product is fixed once it brakes down or fails to perform as desired.

- **Preventive maintenance** is a scheduled action performed on a system, equipment or one of its components to detect or mitigate performance problems, degradations, functional or potential failures, *etc*. with the goal of maintaining the systems' or product's performance and it's level of reliability.

- **Predictive maintenance** is the action performed on a system, equipment or one of its components to determine their performance and act in accordance of the results. For example, instead of changing the oil in the car every X miles (preventive), the oil is analyzed to determine its performance and depending on the results, the oil will be kept or changed. Thus the oil can be changed before the X miles or kept for extra miles. The need for maintenance is determined by the condition of the system, equipment or component analyzed.

Even though, it is most probable that in a water quality monitoring endeavor all three of these types of maintenance procedures are going to be applied, the maintenance program must be focused on preventive and predictive maintenance.

To implement a successful maintenance program, the following three areas must be covered:

a) Training: the personnel that perform maintenance activities (*e.g*. calibration and post calibration of monitoring sensors, equipment and station inspections, cleaning and replacement of instruments or parts) must have the adequate training to ensure that they possess the necessary competence to do an effective and efficient job.

b) Procedures and record management: procedures and record management must be in place to ensure that (among other things):

- → The maintenance activities are well documented.
- → All instruments calibrated will conform to required specifications.
- → The operation and control of the processes are effective.
- → Methodologies to assess the root cause of problem are known.
- → Maintenance schedules are established.
- → Maintenance records are well kept and easily accessed and traceable.
- → Evidence of conformity of calibration is provided.

c) Procurement and spare parts management: to ensure the reliability of the monitoring endeavor, each monitoring equipment or system must have an adequate spare parts procedure to guarantee the availability of resources.

There are three main hardware systems that need to be addressed in a water quality monitoring maintenance program:

→ Monitoring sondes
→ Monitoring stations
→ Verification equipment

When addressing the maintenance program of these systems, it is important to consider that:

→ Not all equipment or components have equal importance and equal impact on data quality.

→ The probability of failure or mal-function is different between equipment, parts, and structures.

→ Service or maintenance cycles differ between equipment.

→ There is limited financial and personnel resources.

NOTE: To assure data quality, a quality assurance/control & maintenance program for the monitoring data must be in place. To obtain guidelines on how to approach this issue, the reader should consult EPA QA/G-5, EPA QA/G-8 and Helsel and Hirsch (2002).

7.2 SONDE MAINTENANCE

Data quality is directly related to the monitoring sonde performance. Therefore, it is crucial to have a sonde maintenance program.

In general, the maintenance program would be based on "maintenance cycles" correlated to the time frame the sondes can stay deployed without affecting data quality. The cycle will depend on the probes' characteristics, environmental conditions (*i.e.* high fouling environments), battery life, and any other factors that affect the sonde's performance. In most monitoring situations the maintenance cycles follow a seasonal pattern. For example, in high fouling environments, the length of time the sonde can remain deployed will decrease as water temperature increases; monitoring sondes that can be deployed for three weeks to one month in winter may need to be changed on a weekly basis in summer.

The sonde maintenance program must address at least the following procedures:

- Prepare the sonde for deployment
- Calibration for deployment
- Post-deployment performance verification

7.2.1 PREPARE THE SONDE FOR DEPLOYMENT

The sonde must be adequately prepared to handle the environmental factors that could influence data quality. These physical, biological, and chemical factors are characteristic of the monitoring site location. Therefore, no unique solution exists to address these factors and the best approach to control them will have to take into account, not only the site characteristics, but also, the deployment cycle and the design of the monitoring station.

Among the environmental factors, special attention must be given to biofouling given that is one of the main factors affecting the operation, maintenance and data quality of the sondes (some examples of common and extreme biofouling are displayed in Figure 7.1). Among the many methods employed to reduce or prevent biofouling, the most common ones are:

- Painting the housing of the sensors with anti-fouling coatings.
- Covering the housing of the sensors with anti-fouling copper tape.
- Using the adequate anti-fouling probes' wiper/wipers.
- Painting the entire wiper body, including the undersides with anti-fouling paint.
- Using sensors with copper alloy housings.
- Using copper-alloy sonde guard or painting the sensor guard with anti-fouling coatings (do not paint the threads).

Figure 7.1 Copper tape on guard and probes

NOTE:

→ Black anti-fouling paint is strongly recommended. The black color will eliminate any chance of stray reflection from the infrared light source when the probe is making measurements (YSI, 2009).

→ Painting the body of the instrument is not recommended. Instead of using paint, the body can be wrapped with plastic wrap and secure with duck tape or with plastic electrical tape.

→ In addition to the use of anti-fouling paint or copper product, during long-term deployments in extreme fouling environments, the deployment cycle must be adjusted to the appropriate length to ensure data integrity.

Figure 7.2 Biofouling examples (Source: CBNERRVA, NIW - NERR, CICORE)

7.2.2 CALIBRATION FOR DEPLOYMENT

It is crucial that all sensors are calibrated following strictly the manufacturer's calibration procedures. Therefore, management must assure that:

- Laboratory personnel have the necessary competence for the effective and efficient application of the calibration procedures.
- Systems are in place to assure sensor's performance verification.
- Records are kept to provide evidence that the requirements have being met.

  Two examples of calibration logs are presented in Figure 7.3 and 7.4.
- Critical parts, components and chemicals are in stock to ensure proper maintenance activities.

NOTE:

→ Many multiparameter sondes are equipped with depth sensors that measure water depth using a differential strain gauge transducer with one side of the transducer exposed to water and the other to a vacuum. The transducer measures the pressure of the water column plus the atmospheric pressure (YSI, 2008). During calibration, the depth is calibrated in air and a depth offset must be used if the pressure is different than 760 mm Hg.

To determine the correct depth offset, record the barometric pressure at the time of calibration from a meteorological station at the calibration site or a reliable local station. Tables 7.1 to 7.3 show offset correction as a function of atmospheric pressure. These tables can be use to determine the offset to use during calibration (CDMO, 2207).

→ When using a plastic or copper screen (or copper tape) at the bottom of the sensor guard there is a possibility that interference with turbidity readings could result from the screen. To cancel any affects it might have, it is necessary to calibrate the turbidity probe (1 point) in the zero standard with the deployment sensor guard installed.

The amount of offset is generally determined by the reflectivity of the guard and screen. In case of using plastic screens, it is a good practice to use black screens or paint the screen with black antifouling paint. For copper screens, once the copper has taken on the patina color the amount of offset decreases. Another option would be to soak the parts in salt water to patina them before your calibration

(Source: NIW Bay NERR)

If copper tape is used and replaced every deployment, then new offset must be determined every time the guard is re-taped.

Pressure mm Hg	Offset meter	Pressure mm Hg	Offset meter	Pressure mm Hg	Offset meter
680	-1.088	730	-0.408	780	0.272
681	-1.074	731	-0.394	781	0.285
682	-1.060	732	-0.381	782	0.299
683	-1.047	733	-0.367	783	0.313
684	-1.033	734	-0.353	784	0.326
685	-1.020	735	-0.340	785	0.340
686	-1.006	736	-0.326	786	0.353
687	-0.992	737	-0.313	787	0.367
688	-0.979	738	-0.299	788	0.381
689	-0.965	739	-0.285	789	0.394
690	-0.952	740	-0.272	790	0.408
691	-0.938	741	-0.258	791	0.421
692	-0.924	742	-0.245	792	0.435
693	-0.911	743	-0.231	793	0.449
694	-0.897	744	-0.218	794	0.462
695	-0.884	745	-0.204	795	0.476
696	-0.870	746	-0.190	796	0.489
697	-0.856	747	-0.177	797	0.503
698	-0.843	748	-0.163	798	0.517
699	-0.829	749	-0.150	799	0.530
700	-0.816	750	-0.136	800	0.544
701	-0.802	751	-0.122	801	0.557
702	-0.789	752	-0.109	802	0.571
703	-0.775	753	-0.095	803	0.585
704	-0.761	754	-0.082	804	0.598
705	-0.748	755	-0.068	805	0.612
706	-0.734	756	-0.054	806	0.625
707	-0.721	757	-0.041	807	0.639
708	-0.707	758	-0.027	808	0.653
709	-0.693	759	-0.014	809	0.666
710	-0.680	760	0.000	810	0.680
711	-0.666	761	0.014	811	0.693
712	-0.653	762	0.027	812	0.707
713	-0.639	763	0.041	813	0.721
714	-0.625	764	0.054	814	0.734
715	-0.612	765	0.068	815	0.748
716	-0.598	766	0.082	816	0.761
717	-0.585	767	0.095	817	0.775
718	-0.571	768	0.109	818	0.789
719	-0.557	769	0.122	819	0.802
720	-0.544	770	0.136	820	0.816
721	-0.530	771	0.150	821	0.829
722	-0.517	772	0.163	822	0.843
723	-0.503	773	0.177	823	0.856
724	-0.489	774	0.190	824	0.870
725	-0.476	775	0.204	825	0.884
726	-0.462	776	0.218	826	0.897
727	-0.449	777	0.231	827	0.911
728	-0.435	778	0.245	828	0.924
729	-0.421	779	0.258	829	0.938

Table 7.1 Depth Offset (mm Hg) (Source: CDMO, 2207)

Pressure mb	Offset meter	Pressure mb	Offset meter	Pressure mb	Offset meter
930	-0.849	980	-0.340	1030	0.170
931	-0.839	981	-0.329	1031	0.180
932	-0.829	982	-0.319	1032	0.191
933	-0.819	983	-0.309	1033	0.201
934	-0.809	984	-0.299	1034	0.211
935	-0.798	985	-0.289	1035	0.221
936	-0.788	986	-0.278	1036	0.231
937	-0.778	987	-0.268	1037	0.242
938	-0.768	988	-0.258	1038	0.252
939	-0.758	989	-0.248	1039	0.262
940	-0.747	990	-0.238	1040	0.272
941	-0.737	991	-0.227	1041	0.282
942	-0.727	992	-0.217	1042	0.293
943	-0.717	993	-0.207	1043	0.303
944	-0.707	994	-0.197	1044	0.313
945	-0.696	995	-0.187	1045	0.323
946	-0.686	996	-0.176	1046	0.333
947	-0.676	997	-0.166	1047	0.344
948	-0.666	998	-0.156	1048	0.354
949	-0.656	999	-0.146	1049	0.364
950	-0.645	1000	-0.136	1050	0.374
951	-0.635	1001	-0.125	1051	0.384
952	-0.625	1002	-0.115	1052	0.395
953	-0.615	1003	-0.105	1053	0.405
954	-0.605	1004	-0.095	1054	0.415
955	-0.594	1005	-0.085	1055	0.425
956	-0.584	1006	-0.074	1056	0.435
957	-0.574	1007	-0.064	1057	0.446
958	-0.564	1008	-0.054	1058	0.456
959	-0.554	1009	-0.044	1059	0.466
960	-0.544	1010	-0.034	1060	0.476
961	-0.533	1011	-0.023	1061	0.486
962	-0.523	1012	-0.013	1062	0.497
963	-0.513	1013	-0.003	1063	0.507
964	-0.503	1014	0.007	1064	0.517
965	-0.493	1015	0.017	1065	0.527
966	-0.482	1016	0.028	1066	0.537
967	-0.472	1017	0.038	1067	0.548
968	-0.462	1018	0.048	1068	0.558
969	-0.452	1019	0.058	1069	0.568
970	-0.442	1020	0.068	1070	0.578
971	-0.431	1021	0.079	1071	0.588
972	-0.421	1022	0.089	1072	0.599
973	-0.411	1023	0.099	1073	0.609
974	-0.401	1024	0.109	1074	0.619
975	-0.391	1025	0.119	1075	0.629
976	-0.380	1026	0.130	1076	0.639
977	-0.370	1027	0.140	1077	0.650
978	-0.360	1028	0.150	1078	0.660
979	-0.350	1029	0.160	1079	0.670

Table 7.2 Depth Offset (mb) (Source: CDMO, 2207)

Pressure in Hg	Offset meter	Pressure in Hg	Offset meter	Pressure in Hg	Offset meter
27.40	-0.870	28.90	-0.352	30.40	0.166
27.43	-0.860	28.93	-0.342	30.43	0.176
27.46	-0.849	28.96	-0.332	30.46	0.186
27.49	-0.839	28.99	-0.321	30.49	0.197
27.52	-0.829	29.02	-0.311	30.52	0.207
27.55	-0.818	29.05	-0.300	30.55	0.218
27.58	-0.808	29.08	-0.290	30.58	0.228
27.61	-0.798	29.11	-0.280	30.61	0.238
27.64	-0.787	29.14	-0.269	30.64	0.249
27.67	-0.777	29.17	-0.259	30.67	0.259
27.70	-0.767	29.20	-0.249	30.70	0.269
27.73	-0.756	29.23	-0.238	30.73	0.280
27.76	-0.746	29.26	-0.228	30.76	0.290
27.79	-0.736	29.29	-0.218	30.79	0.300
27.82	-0.725	29.32	-0.207	30.82	0.311
27.85	-0.715	29.35	-0.197	30.85	0.321
27.88	-0.704	29.38	-0.186	30.88	0.332
27.91	-0.694	29.41	-0.176	30.91	0.342
27.94	-0.684	29.44	-0.166	30.94	0.352
27.97	-0.673	29.47	-0.155	30.97	0.363
28.00	-0.663	29.50	-0.145	31.00	0.373
28.03	-0.653	29.53	-0.135	31.03	0.383
28.06	-0.642	29.56	-0.124	31.06	0.394
28.09	-0.632	29.59	-0.114	31.09	0.404
28.12	-0.622	29.62	-0.104	31.12	0.414
28.15	-0.611	29.65	-0.093	31.15	0.425
28.18	-0.601	29.68	-0.083	31.18	0.435
28.21	-0.591	29.71	-0.073	31.21	0.445
28.24	-0.580	29.74	-0.062	31.24	0.456
28.27	-0.570	29.77	-0.052	31.27	0.466
28.30	-0.559	29.80	-0.041	31.30	0.477
28.33	-0.549	29.83	-0.031	31.33	0.487
28.36	-0.539	29.86	-0.021	31.36	0.497
28.39	-0.528	29.89	-0.010	31.39	0.508
28.42	-0.518	29.92	0.000	31.42	0.518
28.45	-0.508	29.95	0.010	31.45	0.528
28.48	-0.497	29.98	0.021	31.48	0.539
28.51	-0.487	30.01	0.031	31.51	0.549
28.54	-0.477	30.04	0.041	31.54	0.559
28.57	-0.466	30.07	0.052	31.57	0.570
28.60	-0.456	30.10	0.062	31.60	0.580
28.63	-0.445	30.13	0.073	31.63	0.591
28.66	-0.435	30.16	0.083	31.66	0.601
28.69	-0.425	30.19	0.093	31.69	0.611
28.72	-0.414	30.22	0.104	31.72	0.622
28.75	-0.404	30.25	0.114	31.75	0.632
28.78	-0.394	30.28	0.124	31.78	0.642
28.81	-0.383	30.31	0.135	31.81	0.653
28.84	-0.373	30.34	0.145	31.84	0.663
28.87	-0.363	30.37	0.155	31.87	0.673

Table 7.3 Depth Offset (in Hg) (Source: CDMO, 2207)

NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

NERRS SWMP Water Quality Calibration Log

Reserve: ____________ **Site Name:** ____________ **File Name:** ____________

Datasonde Maintenance

Date of Calibration: ____________ mm/dd/yyyy **Technician(s):** ____________

	TURB	ODO		TURB	ODO
Wipers replaced	____	____	Wipers park 180° from optics	____	____
Batteries replaced	____		DO membrane replaced	____	
Format flash disk	____		Membrane integrity test	____	

Datasonde and Probe Identification Numbers

Datasonde	____	DO/ODO	____
pH	____	Conductivity	____
Turbidity	____		

Comments ____________

Pre/Post Deployment Calibration: (turn on pH mV and DO Chrg in Report menu)

Pre-Deployment				Post-Deployment		Sensor Diagnostics	
Standards	**Before Cal**	**Calibrated**	**Error**			**Pre-Deployment**	
%DO @ 100% sat	____ %	____ %	____	____ %	____ %	RP DO chrg (range 25-75)	____
BP @ cal (Rapid Pulse)	____ mm Hg	____	____	____ mm Hg		RP DO gain (0.8-1.7)	____
Optical %DO @ 100% sat	____ %	____ %	____	____	____ %	Optical DO gain	____
BP @ cal (Optical)	____ mm Hg			____ mm Hg		DO warm up test (hi/lo)	____
Baro. Pres. (Depth Calib)	760.0 mm Hg	(760.0 for vented sonde)	____	760.0 mm Hg	(760.0 for vented)	Cell const (4.6-5.45)	____
Depth ____ offset	____ m	____ m	____	____ m	____ offset	pH 7 (0 +/- 50 mV)	____
	____	____	____	____		pH 10 (-180 +/- 50 mV)	____
SpCond ____ mS/cm	____ mS/cm	____ mS/cm	____	____ mS/cm		pH 4 (+180 +/- 50 mV)	____
	____	____	____	____		Calculated pH slope	____
pH 7 ____	____	____	____	____			
pH 10 ____	____	____	____	____		**Post-Deployment**	
pH 4 ____	____	____	____	____		DO chrg (range 25-75)	____
	____	____	____	____		DO warm up test (hi/lo)	____
Turb ____ NTU	____ NTU	____ NTU	____	____ NTU		pH 7 (0 +/- 50 mV)	____
Turb ____ NTU	____ NTU	____ NTU	____	____ NTU		pH 10 (-180 +/- 50 mV)	____
				____		pH 4 (+180 +/- 50 mV)	____
Battery voltage	____ V (remove ext. power -650, 6038)			____ V (remove ext. power)		Calculated pH slope	____

Programming

Interval	____ min	Start date	____ mm/dd/yyyy	Start time (std.time)	____ hh:mm:ss
Duration	____ days	Data file name	____	Battery life	____ days
Free memory	____ days	Set clock (status)	____ Y or N	Free bytes (status)	____ K

Parameters recorded: Date, Time, Temp°C, SpCon, Sal, DO%, DO mg/L, Depth, pH, Turb, Batt

Comments - Pre: ____________

Comments - Post: ____________

Figure 7.3 NERRS 6-series calibration log

HYDROLAB MULTIPROBE CALIBRATION/MAINTENANCE LOG

Date:	Calibration ____ Post Calibration ____ Initials: Time: Instrument: Battery Voltage: If this is a post calibration, give date of original calibration ______				
Function	**Temp. of Standard**	**Value of Standard**	**Initial Reading**	**Calibrated to**	**Comments**
Specific conductance					
pH calibrated (~7)					
pH slope (~ 4/10)					
Dissolved oxygen					
DATA NEEDED FOR DISSOLVED OXYGEN CALIBRATION					
Altitude (A)=______________feet above msl	Barometric pressure _________ inches				
Barometric Pressure (BP) Options	**Barometric Pressure Formulas**				
Barometer	Barometric pressure (inches) ________ x 25.4 = BP ________mm				
From local source after correction (CBP)	BP _________ mm = CBP _______mm - 2.5 (altitude ____/100)				
Estimated from altitude only	BP _________ mm= 760 mm - 2.5 (altitude _____/100)				
For older Hydrolabs: Table DO value______ x ALTCORR______ x BAROCORR ______= DO standard _______					
Date:	Calibration ____ Post Calibration ____ Initials: Time: Instrument: Battery Voltage: If this is a post calibration, give date of original calibration ______				
Function	**Temp. of Standard**	**Value of Standard**	**Initial Reading**	**Calibrated to**	**Comments**
Specific conductance					
pH calibrated (~7)					
pH slope (~ 4/10)					
Dissolved oxygen					
DATA NEEDED FOR DISSOLVED OXYGEN POST CALIBRATION					
Barometric Pressure (BP) Options	**Barometric Pressure Formulas**				
Barometer	Barometric pressure (inches) ________ x 25.4 = BP ________mm				
From local source after correction (CBP)	BP _________ mm = CBP _______mm - 2.5 (altitude ____/100)				
Estimated from altitude only	BP _________ mm= 760 mm - 2.5 (altitude _____/100)				
For older Hydrolabs: Table DO value______ x ALTCORR______ x BAROCORR ______= DO standard _______					

Check previous maintenance and use; do the following before calibration:		
Polish conductivity electrodes. Must be polished within the last two months or once every 15 field trips	Date:	Name/comments:
Change pH reference probe solution. Must be renewed within last two months or once every 15 field trips.	Date:	Name/comments:
Inspect DO membrane for nicks or bubbles. Must be changed within last six months or once every 15 field trips.	Date:	Name/comments:
Change battery in 400 series sonde. Change once a year. Change internal batteries for newer generation products according to guidelines in product manual.	Date:	Name/comments:

Figure 7.4 Multiprobe calibration log (Source: Texas Commission on Environmental Quality, 2003)

7.2.3 POST-DEPLOYMENT PERFORMANCE VERIFICATION

Sonde post-deployment performance verification should include: post-calibration or field performance assessment and field verification activities.

Post-calibration: activity done in a controlled laboratory environment after retrieval of the monitoring sensor. The sensor readings are compared to standard solutions to determine its performance. On-site post-calibration can be performed following the same procedures as laboratory calibrations.

Field performance assessment: activity conducted in the field. As soon as the sensor is retrieved it is placed in a standard solution and readings are recorded.

Field verification: indirect measurements of sonde performance. Using field-measuring equipment, water quality measurements are taken and compared to sonde readings.

Probe performance records are used for continual improvement, data analysis and nonconformity management. As an example, a post-calibration log is presented in Figure 7.5.

DEPLOYMENT INFORMATION

	DATE	TIME	WEATHER	TIDE	WIND SPEED	HUMIDITY
DEPLOYMENT:						
RETRIEVAL:						

VERIFICATION INFORMATION

	DO mg/l	Water Temp	Air Temp	Secchi Depth	Salinity	pH
DEPLOYMENT:						
RETRIEVAL:						

POST DEPLOYMENT DATA RETRIEVAL

DATE OF DOWNLOAD: ____________ NAME OF *.dat FILE: ____________

TIME YSI STOP LOGGING: ____________ NAME OF *.txt FILE: ____________

POST DEPLOYMENT CALIBRATION

DATE OF POST CALIBRATION: ____________ Spcond ____________

Battery Volts: ____________ pH 7 ____________ pH mV: ____________ mV range (-50 <-> 50) Optimum 0

Time Corrected: Y N pH 10 ____________ pH mV: ____________ mV range (-230 <-> -140) Optimum -180

Faster Slower Difference in seconds: ____________ pH 4 ____________ pH mV: ____________ mV range (130 <-> 230) Optimum 180

Notes pH:

TURBIDITY 0 ____________ 123 ____________

CHLOROPHYLL 0 ____________ Rd WT ____________

FLUORESCENCE 0 ____________

Temp C sonde is reading in Rd WT: ____________ Corrected reading from Rd WT Table: ____________

Notes :

DEPTH Barometric Pressure: ____________ mm Hg ____________ millibars Depth Offset at date's pressure: ____________

Notes : Depth Reading: ____________

% DO Theoretical %DO based on date's pressure: ____________ DO % Reading: ____________ DO Membrane Puncture: Y N

Notes :

CALIBRATION CONSTANTS Conductivity: ____________ (Range: 4.6 to 5.45) DO Gain: ____________ (Range: 0.8 to 1.7) DO Charge: ____________ (Range: 25 to 75)

FOULING CONDITIONS

Possible Fouling Description: Slime, Mud/Sediment (slimy, sticky, rusty, thick), Worm tubes, Seaweed, Grasses, Algae, Amphipods, amphipod tubes, Barnicles, Mussels, Branching Bryozoan, Encrusting Bryozoan, Coral Lattice, Tunicates, etc.

Wipers Condition:		TURBIDITY	CHLOROPHYLL	ODO
	Parked	Y N	Y N	Y N
	Fouled	Y N	Y N	Y N

Animals of Physical Fouling Found in Guard: ____________

SONDE BODY:

THERMISTOR:

OPTICAL PROBE FACES:

CONDUCTIVITY CHAMBERS:

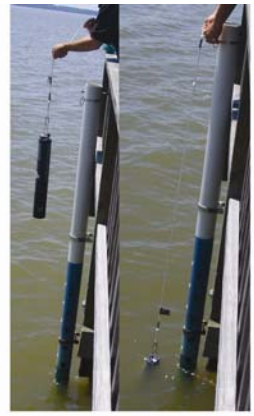
pH BULB:

DEPTH CHANNEL:

Figure 7.5 YSI 6-series post-calibration log

During field verification, it is a good practice to take an independent measurement for each sensor parameter. Generally, field verification is performed during the monitoring sonde exchange phase. A possible sonde switch-out process could be:

1 Set the replacement sonde in the water to allow the probes to equilibrate to ambient conditions.



- The replacement sonde is deployed in a temporary position at the same depth as the deployed sonde to:
  - Allow the sonde a few minutes to equilibrate to the water temperature before taking the readings.
  - Obtain simultaneous readings with the deployed sonde.
- It is good practice to place a snap hook in the station to hang the replacement sonde. The rope to hang the replacement sonde will have the necessary length to ensure the sonde is placed at the monitoring depth.

2 Perform the field verification activities

- Field verification activities are performed following established measuring procedures.
- A field verification log must be filled. (*e.g.* Figure 7.6)

3 The monitoring sondes are exchanged

- It is good practice to obtain at least two simultaneous readings between the deployed sonde and the replacement sonde before the switch-out.
  - This ensures that there will be two common water quality measurements that can be used for data quality control and assurance purposes.
- Perform a visual inspection of the retrieved sonde and record anything that it is considered important for post-calibration or data quality purposes (*e.g.* fouling conditions, animals in the sonde guard, broken probes, physical fouling).
  - In highly fouling conditions or broken probes, it is good practice to take pictures of the deployed sonde for future addition to the MetaData or assist the scientist in understanding the data.

For on stream & river bank platforms, a different method to obtain simultaneous readings between the replacement sonde and deployed sonde must be used if the station has only one guard-pipe. Possible reasons for using only one guard-pipe are:

- → The guard-pipe is placed where there is a small pooling of water or the sampling area is not big enough to accommodate two sondes.
- → Due to high flow conditions, cost or maintenance issues it was decided to put only one guard-pipe.

If only one guard-pipe is used, a possible switch-out process could be:

1 Set the replacement sonde in the water to allow the probes to equilibrate to ambient conditions.

- Allow the sonde a few minutes to equilibrate to the water temperature.

2 Obtain at two simultaneous readings between the deployed sonde and the replacement sonde

- Collect stream or river water in a bucket or cooler.
- Place the bucket in a secure area and place the replacement sonde inside the bucket.
- Carefully remove the deployed sonde from the guard-pipe and place it inside the bucket.
  - Perform a visual inspection of the retrieved sonde and record anything that it is considered important for post-calibration or data quality purposes (*e.g.* fouling conditions, animals in the sonde guard, broken probes, physical fouling) in case the fouling is detached or changed while the sonde is in the bucket.
- Let the sondes stand in the bucket until two simultaneous readings are obtained.
  - Even though certain water parameters (*e.g.* temperature) will change inside the bucket while waiting for the readings; the goal here is that the two sondes have two common water quality measurements that can be used for data quality control and assurance purposes.

For monitoring stations with telemetry capabilities, the following procedure is recommended to interchange the field cable connector between the deployed and the replacement sonde.

1. Remove the deployed sonde from the guard-pipe and put it in a horizontal position close to the replacement sonde

2. Clean and dry the field cable connector of the deployed sonde
   - If necessary, use a was bottle to rinse the dirt from the field cable connector and sonde connector.
   - Dry the field cable connector and the sonde connector with a towel, paper towel or kimwipe.

3. Remove the field cable connector from the deployed sonde and clean the inside of the connector
   - Use the cotton tipped sticks or kimwipes to clean and dry the inside of the field cable connector and the outside of the sonde connector.
   - Check that the pins, either in the field cable connector or in the sonde connector, are dry. If not, use the compress gas duster to dry them.

4. Connect the field cable to the replacement sonde
   - Remove the waterproof cap from the replacement sonde and connect the field cable connector.
     - A built-in key will ensure proper pin alignment. Rotate the cable gently until the key engages and then tighten the connector together by rotating clockwise.
   - Attach the strain relief connector to the sonde bail.
   - Put the waterproof cap to the sonde that is going to be serviced.

	WATER QUALITY MONITORING DEPLOYMENT AND RETRIEVAL LOG			
	Identification Number	Revision	Effective Date	Pages
				Page 1 of 1

Field Location		Crew	

DATALOGGER INFORMATION		
	YSI ID Number	Time (EST)
Deployment (in)		
Retrieval (out)		

WEATHER INFORMATION						
Weather Conditions measured with Kestrel		**Wind Speed**			**Cloud Cover**	
Current Wind Speed (m/s)		0	0-1 (knots)	0-1 (m/s)	0	Clear (0-10%)
		1	>1 - 10	1-5	1	Scatter/partly Cloudy (10-50%)
Air Temp (C)		2	>10 - 20	5-10	2	Partly to Broken (50-90%)
		3	>20 - 30	10-15	3	Overcast (>90%)
Relative Humidity (%)		4	>30 - 40	15-21	4	Foggy
		5	> 40	21-26	5	Hazy
					6	Cloud (no percentages)

Precipitation Type		**Wind Direction**			
10	None	E	fr East (90 deg)	S	fr South (180 deg)
11	Drizzle	ENE	fr East NE (67.5 deg)	SE	fr SE (135 deg)
12	Light Rain	ESE	fr East SE (112.5 deg)	SSE	fr South SE (157.5 deg)
13	Heavy Rain	N	fr North (0 deg)	SSW	fr South SW (202.5 deg)
14	Squally	NE	fr NE (45 deg)	SW	fr SW (225 deg)
15	Frozen Precipitation	NNE	fr North NE (22.5 deg)	W	fr West (270 deg)
16	Mixed Rain&Snow	NNW	fr North NW (337.5 deg)	WNW	fr West NW (292.5 deg)
		NW	fr NW (315 deg)	WSW	fr West SW (247.5 deg)

WATER INFORMATION						
Water and Secchi Depths		**Wave Heights**		**Tidal Stage**		**VERIFICATION SAMPLES**
Water Depth (m)		0	0 <0.1m	E	Ebb Tide	Chla Filter Volume
		1	0.1 <0.3m	F	Flood Tide	
Secchi Depth (m)		2	0.3 <0.6m	H	High Tide	
		3	0.6 <1.0m	L	Low Tide	
If Secchi can be seen at the bottom	SD > WD	4	1.0 <1.3m			
		5	>1.3m			

WATER COLUMN DEPTH PROFILE						
Depth m	Temperature	SpCond	Salinity	DO(%Sat)	DO(mg/l)	pH
0.10						
0.25						
0.50						
0.75						
1.00						
1.25						
1.50						
1.75						
2.00						
2.25						
2.50						

Comments:

Figure 7.6 Field verification log

Note:

Two conditions that must be met when transporting multiparameter sondes to and from the monitoring sites are:

- The sondes must be transported in a saturated environment.
- The sondes must be transported in a container that minimizes shocks and vibrations.

Two commonly employed methods are:

→ The sonde is transported wrapped up within a wet towel (CDMO, 2007).

- Soak a towel (large enough to wrap around the entire sonde) in tap water and wring out most of the water (check that it is wet; humid, not damp).
- Wrap the sonde in the towel, leaving some excess towel at the bottom of the sensor guard so it can be folded to ensure the guard is completely covered.
- Place the towel-wrapped sonde in a bucket, a cooler or other container for transportation to the monitoring site.
- It is good practice to transport the sondes in a container of sufficient size to allow the sondes to lie horizontally across the bottom.

→ The sonde is transported in a 5-gallon bucket filled with tap water.

- Drill one or two holes on the lid about 3½ - 4 inches in diameter.
- Place some type of cushion on the bottom of the bucket to minimize shocks and vibrations.
- If necessary, place some kind of weight on the bottom to prevent the bucket to tip over during transit due to the sonde's weight.
- Fill the bucket with tap water so that the probes stay submerged.
- Some kind of structure can be built to accommodate several buckets in a stable position during transit (in this case there is no need to place a weight inside the bucket).

7.3 STATION MAINTENANCE

The following activities must be included in the station maintenance program:

- Verification of station conditions during deployment-retrieval of monitoring sensors.
- Schedule on-site verification and cleaning of guard-pipes.
- Schedule retrieval of guard-pipes for cleaning and painting (once a year minimum).
- Schedule cleaning and rebuilding of monitoring platforms.
- Maintenance procedures and spare parts management.

IT IS A GOOD PRACTICE TO CLEAN THE INSIDE AND OUTSIDE OF THE GUARD-PIPE AFTER THE DEPLOYED SONDE IS RETRIEVED AND BEFORE THE NEWLY CALIBRATED SONDE IS DEPLOYED.

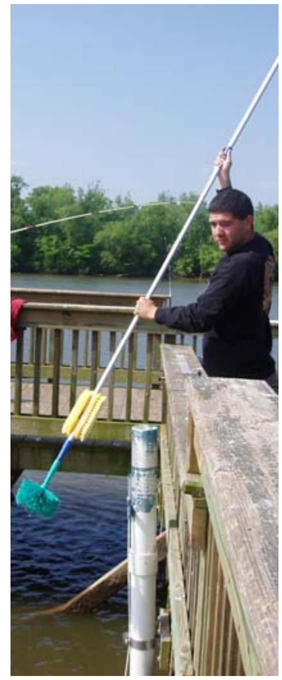


Figure 7.7 Cleaning inside the guard-pipe

The guard pipe must be cleaned on a frequent basis to minimize the influence of biological fouling and to eliminate any physical fouling that could be interfering with the measurements.

The best way to clean the inside of the guard-pipe is by using some kind of brush or mop. The brush can be purchased in any retail store or easily assembled. For example, a cleaning brush can be constructed using a 16 foot extension pole (Figure 7.7 and 7.8). To add extra cleaning power two scrub brushes can be bolted to the extension pole. Care must be taken when brushing the guard-pipe to minimize brushing off the anti-fouling paint. If cleaning is performed on a regular basis, minimum fouling will occur on the guard-pipe, therefore, a medium-soft brush will be enough to maintain the guard-pipe in good condition.

Figure 7.8 Guard-pipe cleaning brushes

To clean the outside of the guard-pipe, also a particular brush can be purchased in any retail store or easily assembled. For example, Figure 7.8 displays a brush to clean the outside of the guard-pipe constructed by bolting two scrub brushes to a 8 inch long – half 6 inch PVC pipe.

In some situation a chimney sweep brush is a good option. Even though the brush is tough on the anti-fouling paint, many pipes stay in year after year and in these cases the anti-fouling paint is not an issue and a chimney brush works well to clear the pipe of hard and soft biological fouling.

In certain types of guard-pipe installations (*e.g.* on river or stream bank) it is a good practice after brushing the pipe to rinse it by pouring a bucket of surface water down the pipe.

NOTE: Any evidence of physical and biological fouling that could have affected the monitoring data must be recorded for further analysis.

7.4 TELEMETRY EQUIPMENT MAINTENANCE

Proper maintenance of the Telemetry equipment is essential to obtain accurate data. Equipment must be in good operating conditions, routine and schedule maintenance and inspection must be peformed..

must include at least the following activities

to ensure that your telemetry equipment is mounted far enough above sea level to be clear of wave action and storm surges due to hurricanes. Take out equipment
(EPA 2002)

Battery: Campbell Scientific

Cyclic service life of rechargeable batteries

The industry definition of the “cyclic service life” of a battery is the period until it dorps to 60% of its rated capacity. For a 7 Ahr battery, this is when after repeated recharging, the battery can only deliver 4.2 Ahrs. When choosing a battery, you should also consider the number of recharge cycles you can expect from the battery until it reaches the end of tis cyclic life.

Several factors affect the cyclic service life, including ambient temp during charging and storage, number of discharge cycles, depth of discharge cycles and charging voltage. Clearly these are complex relationships.

The following may help you assess your batteries’ service life:

1) temperature: warmer temperatures decrease life because heat hastens chemicals reaction that cause corrosion of the internal electroedes. The temperature effects are graphed and described on the following page.

Depth of discharge

Determine minimum and maximum battery voltages in your daily data. Analyze the data using tool to count the number of times the voltage dropped below certain values.

Check for more info http://www.mpoweruk.com/life.htm

7.5 MEASURE THE DISTANCE FROM THE SONDE's HOLDING BOLTS TO THE BOTTOM SEDIMENTS

Water depth is one of the parameters measured by a monitoring sonde. A differential strain gauge transducer is generally employed to measure the pressure of the water column plus the atmospheric pressure above the water. To have an accurate water depth measurement, a program must be utilized to eliminate the errors produced by atmospheric pressure variations.

Water depth is the distance from the water surface to bottom sediments. The sonde measures water depth as the distance from the transducer to water surface; therefore to have an accurate water depth, the distance from the transducer to the bottom sediments must be added.

In a fixed structure monitoring platforms, the distance from the transducer to bottom sediments can be divided into two segments: the distance between the transducer and the bolts (where the monitoring sonde sits inside the guard-pipe) and the distance between the bolts and the bottoms sediments. The distance from the transducer to the bolts is fixed and known. The distance between the bolts and the bottom may vary; given the bottom can change over time.

> There are some environments that are more conducive to have bottom movements (*i.e.* deposition of sediments) than others; therefore the distance between the transducer to the bottom must be measured frequently.

In addition, verification measurements must be taken around the guard-pipe to check if physical fouling or different bottoms movements occurred under the guard-pipe that would cause an inaccurate water depth measurement.

To determine the distance between the bolts and the bottom, a special tool is utilized (made with an aluminum telescoping extension pole and a disk with two opposite openings). Three measurements are taken, one inside the pipe and two outside the pipe. These three measurements are utilized to calculate the distance between the bolts and the bottom.

The procedure to determine the distance between the bolts and the bottom is shown in the following page.

1 Build the measuring pole

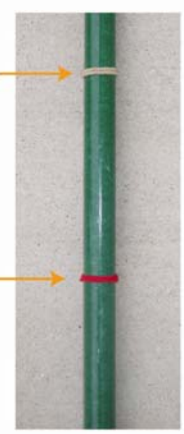
- Cut a 3-3/4 inch diameter disk.
  - Materials: fiber glass, plastic, wood or any other convenient material.
  - The circular piece is made for a 4 inch PVC pipe; adjust diameter for other types of pipes.

- Cut two openings at opposite sides of the disk.
  - Make the openings big enough so the disk goes through the bolts easily.
- Secure the disk to a telescopic pole.
  - The disk can be attached to the telescopic pole permanently or by a coupling so it can be easily removed.
  - Telescopic poles come in a variety of length, with 24 ft the longest length that can be easily purchased in any home improvement retailer. If longer poles are needed, a good option is to create your own extension to be attached at the end of the pole.

2 Measure distance "bolts-bottom" inside the guard-pipe

- Lower the pole inside the guard-pipe until the disk hits the bolts.
- Set a ruler on top of the guard-pipe and mark the point where the ruler touches the pole with a rubber band.
  - This point is called **TOP-BOLTS distance (TB)**

- Rotate the pole so the openings match the bolts and the disk goes through the bolts.
- Lower the pole until the round piece hits the bottom.
- Mark this point with a second rubber band.
  - This point is called **TOP-BOTTOM INSIDE distance (TB Inside)**
- Remove the pole from the guard-pipe.



3 Measure distance "top-bottom" around the guard-pipe

- Cut two small pieces of duck tape and draw a line on them with a permanent marker. Mark one of these lines as "1" and the other as "2".
- Set the ruler on top of the guard-pipe to be used as a reference mark.

Select one random point at a distance of approx. 20 cm from the guard-pipe and lower the pole until the disk hits the bottom.

Move the pole around that point to verify that the depth remains constant and the pole is not sitting on top of a physical object (*e.g.* stone). If this is the case, choose another random point.

If the depth is different than the top-bottom inside distance, mark this point with the duck tape "1".

This point is called

TOP-BOTTOM OUTSIDE 1 distance (TB Outside 1)

Repeat this process - select a second point.

If the depth is different than the top-bottom inside distance, or TB Outside-1; mark this point with the duck tape "2".

This point is called

TOP-BOTTOM OUTSIDE 2 distance (TB Outside 2)

4

Calculate Bolts-Bottom Distance

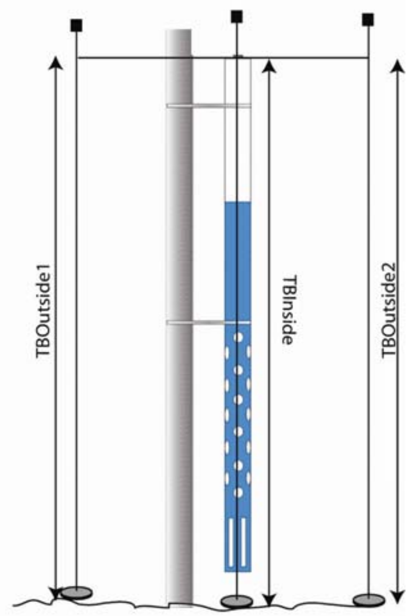
Two things that must be taken into account :

- Changes of the bottom topography under the guard pipe due to currents.
- Physical fouling under the guard-pipe.

Following, four different scenarios are presented.

The three distances are similar

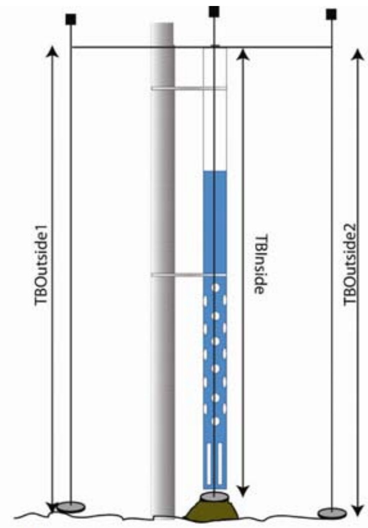
TB Inside ≅ TB Outside 1 ≅ TB Outside 2



The bottom under and around the guard-pipe is uniformly distributed in a horizontal plane. There are no physical objects below the guard pipe.

Bolts-Bottom Distance = 1/3 ([TB Inside + TB Outside 1 + TB Outside 2] - 3 TB)

TB Inside < TB Outside 1 or 2



The distance TB Inside is much smaller than the two TB Outside distances.

Possible physical fouling or sediment build up occurred under the guard-pipe.

→ Try to remove the physical fouling or built up sediment

- Removal is successful

  Bolts-Bottom Distance =

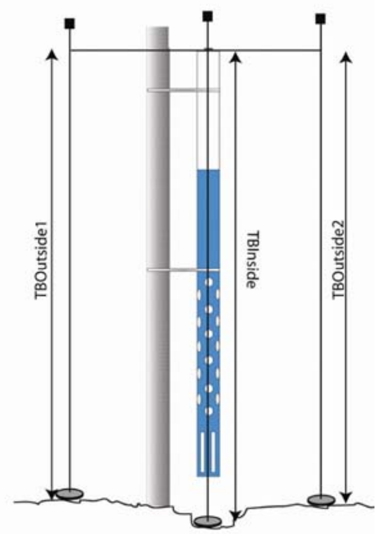
  1/3 ([TB Inside + TB Outside 1 + TB Outside 2] - 3 TB)

- Removal is not successful

  Bolts-Bottom Distance =

  1/2 ([TB Outside 1 + TB Outside 2] - 2 TB)

TB Inside > TB Outside 1 or 2

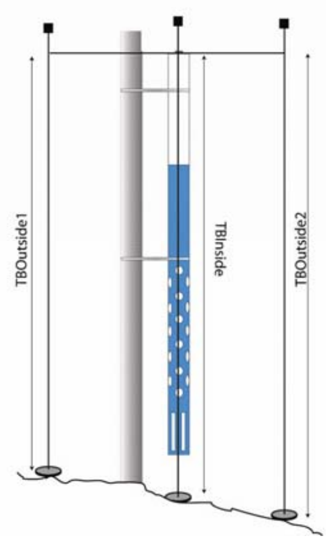


The distance TB Inside is much bigger than the two TB Outside distances.

There is a hole under the guard-pipe; possibly due to the interaction of nearstation current circulation with the monitoring platform.

Bolts-Bottom Distance = 1/2 ([TB Outside 1 + TB Outside 2] - 2 TS)

TB Outside 1 > TB Inside > TB Outside 2



The three distances exhibit a significant difference; showing a decline or an incremental pattern.

The bottom surface shows a slope around the monitoring station .

Bolts-Bottom Distance = TB Inside - TS

7.6 CORRECTION FACTOR FOR WATER LEVEL/DEPTH DATA REPORTING

Austin *et al.* (2004) state that multiparameter sondes equipped with non-vented pressure sensors are most commonly used for continuous water quality monitoring. Standard calibration protocols for the non-vented sensor use ambient atmospheric pressure at the time of calibration. Changes in atmospheric pressure between calibrations appear as changes in water depth. A 1.0 millibar change in atmosphere pressure corresponds to an approximate 1.0 centimeter change in water depth. Therefore, use of a non-vented pressure sensor can result in significant water depth errors for large-scale weather and storm events. This error is eliminated for level sensors because they are vented to the atmosphere throughout the data sonde deployment time interval. If proper atmospheric pressure data is available, non-vented sensor depth measurements can be post-corrected for deployments between calibrations. This correction combined with a common reference point from a survey station, results in more accurate water depth data.

Austin *et. al.* demonstrate the relative ease of adjusting non-vented depth sensor data for atmospheric pressure changes to reflect more accurate measurements.

Ambient laboratory atmospheric pressure was measured using a Varila pressure sensor with data being stored at 15 minute intervals on a Campbell 10X datalogger. Following retrieval of the instrument from the field, data can be downloaded and saved as an Excel file. Atmospheric pressure data collected at the appropriate time interval and the atmospheric pressure at the time of calibration can be added to the Excel file.

The raw depth data is adjusted by the following simplistic equation:

$$Depth_{adjusted} = Depth_{YSIraw} + \frac{(atm.\ pressure_{calibration} - atm.\ pressure_{ambient})}{100}$$

In many cases, adjustment of the raw data can correct depth levels to positive values, which can result in more accurate and less confusing information (Figure 7.8, Table 7.4).

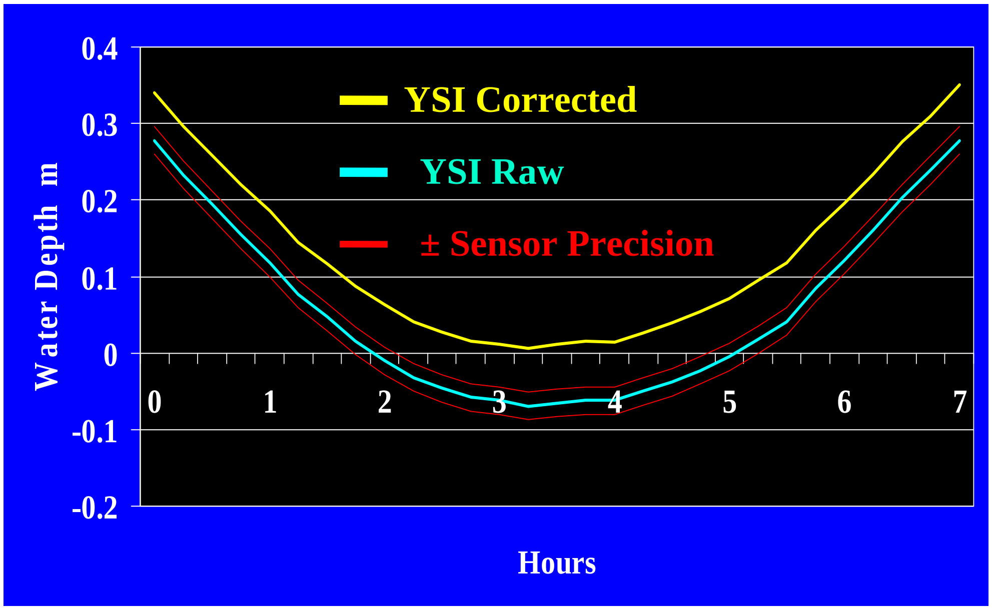


Figure 7.9 Raw vs. corrected YSI depth data from the York River over time (accuracy +/- 0.018 m)

Time	Raw Depth	Adjusted Depth	Ambient Pressure	Calibration Pressure
05:00	1.66	1.72	1014.8	1020.30
05:15	1.64	1.69	1014.8	1020.30
05:30	1.62	1.68	1014.9	1020.30
05:45	1.61	1.67	1014.4	1020.30
06:00	1.61	1.67	1013.9	1020.30
06:15	1.59	1.66	1014.0	1020.30
06:30	1.59	1.66	1013.4	1020.30
006:45	1.60	1.67	1013.1	1020.30
07:00	1.60	1.68	1013.0	1020.30

Table 7.4 Example of raw depth data using atmospheric pressure at time of calibration vs. adjusted data using ambient atmospheric pressure from weather station.

Additionally, extreme storm events, such as hurricanes, are marked by large depression in atmospheric pressure during the storm's passage. For example, in the case of Hurricane Isabel, a 30 millibar drop was observed resulting in a 0.30 m error in water depth level.

Given atmospheric pressure data at the time of instrument calibration and during instrument deployment, water depths are easily corrected (Figure 7.9).

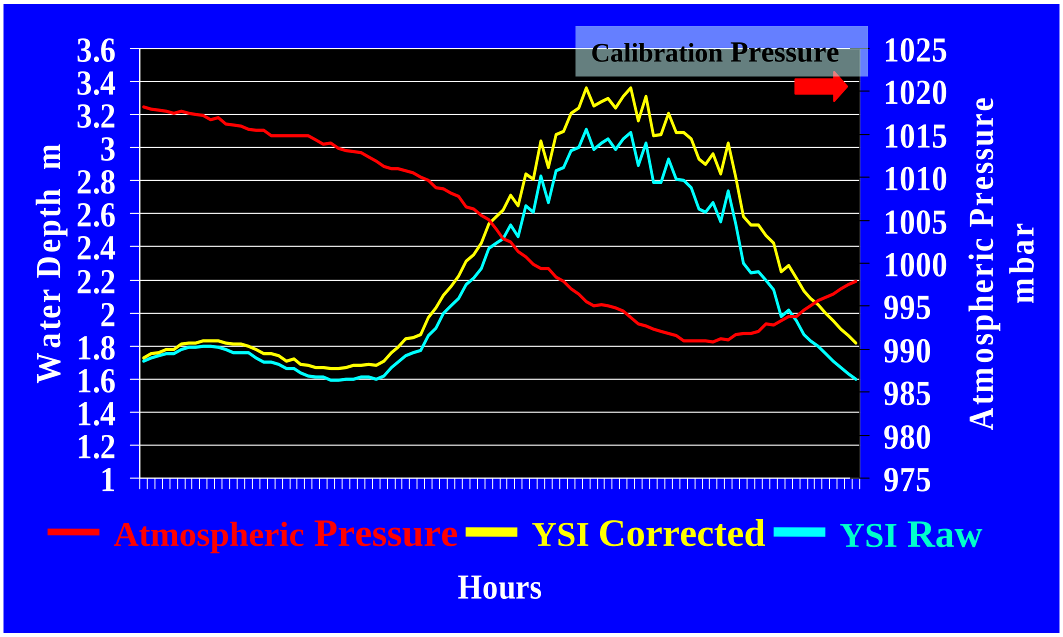


Figure 7.10 Raw vs. corrected YSI depth data using atmospheric pressure at time of Hurricane Isabel.

To further enhance the value of water level data, traditional optic or advanced GPS surveying systems can be used to reference water quality monitoring platforms in instruments to a standard vertical datum. Common local datums include mean sea level (MSL), mean lower low water (MLLW), and mean higher high water (MMHW).

Increase accuracy and value of water depth data can be realized by correcting for atmospheric pressure changes during the deployment period and reporting the data to a common vertical reference datum. Benefits of more accurate and vertically referenced water level data can facilitate AQ/QC efforts by removing erroneous negative values while providing water level information in a more user acceptable format, thereby increasing the use of water level data by a broader audience.

7.7 EQUIPMENT MAINTENANCE

As stated in ISO 9001:2600

The organization shall determine the monitoring and measurement to be undertaken and the monitoring and measuring devices needed to provide evidence of conformity of product to determined requirements.

The organization shall establish processes to ensure that monitoring and measurement can be carried out and are carried out in a manner that is consistent with the monitoring and measurement requirements.

Where necessary to ensure valid results, measuring equipment shall:

a. be calibrated or verified at specified intervals or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded;
b. be adjusted or re-adjusted as necessary;
c. be identified to enable calibration status to be determined;
d. be safeguarded from adjustments that would invalidate the measurement result;
e. be protected from damage and deterioration during handling, maintenance and storage.

All the equipment used to calibrate and post-calibrate the sensors and field verifications must be maintained, calibrated or pass some quality assurance check to ensure their accuracy and that they perform to accepted standards.

Equipment histories, records and logs must be maintained.

7.8 REFERENCE

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