

# ***UMCES***

***UNIVERSITY OF MARYLAND CENTER for ENVIRONMENTAL SCIENCE***

***CHESAPEAKE BAY:  
WATER QUALITY MONITORING PROGRAM  
ECOSYSTEMS PROCESSES COMPONENT (EPC)***

***QUALITY ASSURANCE PROJECT PLAN  
FY2009***

***JULY 2008 - JUNE 2009***

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# Maryland Chesapeake Bay Water Quality Monitoring Program

## **Ecosystem Processes Component (EPC)**

Quality Assurance Project Plan for Water Quality  
Monitoring in Chesapeake Bay for FY 2008

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## ACRONYMS AND ABBREVIATIONS

AA autoanalyzer  
C carbon  
CBP EPA's Chesapeake Bay Program  
CBL University of Maryland's Chesapeake Biological Laboratory  
CBL Chesapeake Biological Laboratory  
cm centimeter  
DGPS Differential Global Positioning System  
DHMH Maryland Department of Health and Mental Hygiene  
DNR Maryland Department of Natural Resources  
DI de-ionized  
DIP (or  $\text{PO}_4^{-3}$ ) Dissolved inorganic phosphorus  
DO Dissolved Oxygen  
DOC Dissolved organic carbon  
EPA U.S. Environmental Protection Agency  
EPC Ecosystem Processes Component  
g gram  
ICES International Council for the Exploration of the Sea  
KCl Potassium chloride  
Kd Water column light attenuation  
L liter  
m meters  
MDE Maryland Department of the Environment, Annapolis, MD  
min. minute  
mg milligram  
ml milliliter  
mm millimeter  
 $\mu\text{g}$  micrograms  
N nitrogen  
NASL Nutrient Analytical Services Laboratory  
 $\text{NH}_4^+$  Ammonium  
NIST National Institute of Science and Technology  
 $\text{NO}_2^-$  Nitrite  
 $\text{NO}_2^- + \text{NO}_3^-$  Nitrite plus nitrate

nm nanometer  
no number  
NTU nephelometric turbidity unit  
OD optical density  
ODU Old Dominion University  
P phosphorus  
PAR Photosynthetically Active Radiation  
PC Particulate carbon  
PI Principal Investigator  
PN Particulate nitrogen  
PP Particulate phosphorus  
 $\text{PO}_4^{-3}$  Dissolved inorganic phosphorus  
QA Quality assurance  
QAPP Quality Assurance Project Plan  
QC Quality control  
RFO Research Fleet Operations  
R/V research vessel  
SAS Statistical Analysis System  
Si silica  
SAV Submerged aquatic vegetation  
SONE Sediment Oxygen and Nutrient Exchanges  
TDN total dissolved nitrogen  
TDP total dissolved phosphorus  
TSS seston (total suspended solids)  
USDI U.S. Department of the Interior  
USGS U.S. Geological Survey  
VIMS Virginia Institute of Marine Science  
YSI Yellow Springs Instrument  
VFX Vertical Flux Array  
VSS Volatile suspended solids  
°C degrees Celsius

# 1. INTRODUCTION

## 1.1 Project Description and Background

During the middle decades of the twentieth century a considerable number of environmental measurements were made at a number of locations in Chesapeake Bay and its tributary rivers. Measurements included physical, chemical and limited biological variables and from these early measurements a considerable increase in understanding of estuarine physics, chemistry and biology was achieved. However, these measurements were not made in a consistent fashion and, as a result, were of limited utility in some applications. For example, dissolved nutrient measurements were made at a series of sites in the Patuxent River for a year or more and then efforts were relocated to a few sites in the mainstem bay. At some later time nutrient measurements were again made in the Patuxent but at different stations and at different times of the year using different sampling and analytical methodologies. A review of water quality measurements made in the Patuxent from the late 1930's until 1978 identified 44 separate studies, most of which were of too short a duration or at so limited a number of stations that detection of trends was not possible (Mihursky and Boynton, 1978). Similar problems were evident in other areas of the Bay and tributaries. Following completion of the first EPA Chesapeake Bay Program this serious limitation was clearly identified and a strong recommendation emerged to develop a long-term water quality monitoring program that would be capable of accurately assessing the current status of the Bay and be useful in detecting trends resulting from human activities. It was recognized that long-term measurements were needed to overcome the expected year-to-year variability due to climate variability and to ultimately assess changes due to both deleterious human activities and restoration efforts by management.

This Quality Assurance Project Plan (QAPP) describes the implementation of one component of the Maryland portion of the EPA Chesapeake Bay monitoring program described in *Chesapeake Bay: A Framework for Action* (EPA, 1983). This portion of the program is known as the "Ecosystem Processes Component (EPC)." The EPC has focused monitoring efforts in three areas including: (1) measurements of sediment influences on water column water quality; (2) description of water quality in shallow water zones of tributary rivers using emerging technologies; and (3) monitoring epiphytic growth on seagrass leaves. Details concerning objectives and methodologies used in the EPC are contained in this report. While early work of the EPC focused primarily on the importance of fluxes across the sediment-water interface and the dynamics of these interactions, the program has diversified since that time. It continues to diversify its research to better meet the changing goals of the monitoring program (Boynton *et al.*, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006). This has involved expansion of some program elements and the discontinuation of others as well as the development of tools that improve monitoring capabilities. EPC developed techniques to spatially evaluate sediment water fluxes in a more cost effective manner. More recently, evaluation of near-shore water quality conditions relative to submerged vegetation (SAV) and SAV epiphytic growth has become an important portion of the program. Five years

ago, EPC developed continuous surface water quality mapping techniques for the program. The design of this equipment has recently been updated.

## 1.2 Objectives

The Chesapeake Bay Water Quality Monitoring Program was initiated to provide guidelines for restoration, protection and future use of the mainstem estuary and its tributaries and to provide evaluations of implemented management actions directed towards alleviating some critical pollution problems. In addition to the EPC program portion, the monitoring program also has components that measure:

- Freshwater, nutrient and other pollutant input rates,
- chemical and physical properties of the water column,
- toxicant levels in sediments and organisms,
- phytoplankton community characteristics (abundances, biomass and primary production rates), and
- benthic community characteristics (abundances and biomass).

The current program is composed of the following complimentary study elements:

- **DATAFLOW mapping** of surface waters in the Potomac River.  
High resolution mapping of surface waters will be conducted monthly in the Potomac River from July through October 2008.
- Information collected in this program is integrated with other elements of the monitoring program to gain a better understanding of the processes affecting water quality of the Chesapeake Bay and its tributaries and the maintenance and restoration of living resources.

## 1.3 Sampling Design and Data Quality Objectives

### 1.3.1 Spatially Intensive Water Quality Mapping: DATAFLOW VI Mapping System

DATAFLOW mapping of surface waters will be conducted in at least two distinct geographic regions in the Potomac River in FY2009.

**Potomac River:** DATAFLOW mapping in the Potomac River will be conducted monthly from July through October, 2008. Cruise tracks have been established in the lower segment of the Potomac (estuary mouth to St. Georges Island) and in the very upper portion of the estuary (Marshall Hall to Washington, DC).

The purpose of DATAFLOW is to assess the spatial variability in water quality. The

spatial resolution of the data collected depends on the speed and cruise track of the vessel. However, both are constrained by time and funds available to perform a practical assessment. It has been shown (EPC Interpretive #19, Boynton *et al.*, 2002) that spatially intensive sampling can uncover patterns in water quality that are missed by single fixed station monitoring. The purpose of the calibration stations is to correlate DATAFLOW sensor output to universally measured parameters (Kd, secchi) and laboratory derived results (TSS, Chlorophyll-*a*) collected simultaneously. Correlation to laboratory values or universally measured parameters would still be required.

### 1.3.2 DATAFLOW Calibration Stations

In addition to the high-resolution data collected by DATAFLOW VI, calibration data will be collected at a total of 48 locations within the tributary. Several calibration stations within the tributary will also coincide with locations of DNR high-frequency continuous monitoring data collection. The remaining sites will be selected to represent a large signal range needed for sensor calibration. At these locations, water samples will be collected for the full-suite analysis of dissolved nutrient concentrations, chlorophyll-*a* (active and total), phaeophytin, total suspended solids and volatile suspended solids (Table 1-1). Measurements of PAR will be made to calculate water column light attenuation (Kd). Secchi depth measurements will be taken. EPC will collect a sub-set (11) of the 48 samples referred to above.

**Table 1-1. Description of sampling schedule and water quality variables measured as part of the DATAFLOW High-resolution surface water mapping in 2007 and 2008. These data are in addition to logged variables. Variable abbreviations shown below are as follows: DIN = dissolved inorganic nitrogen, DIP = dissolved inorganic phosphorus, siliceous acid = si, Chla = chlorophyll-a, TSS = total suspended solids, VSS = volatile suspended solids, DOC=dissolved organic carbon, TDN, TDP= total dissolved nitrogen and phosphorus, PC/PN/PP = particulate carbon, nitrogen, phosphorus, PIP=particulate inorganic phosphorus, PAR=photosynthetically active radiation.**

Tributary	Calibration Stations	Sampling Frequency (Approximate Schedule)	Variables Measured	
			Nutrient Analysis	Physical Parameters
Potomac	Total of 11 stations, 6 stations in upper Potomac and 5 stations in Lower Potomac	Monthly; July - October, 2008.	DIN, DIP, Si, Chla (DHMH), TSS/VSS(CBL), DOC(CBL), TDN(CBL), TDP (CBL), PC/PN/PP(CBL), PIP (CBL)	Water column PAR, Secchi depth, weather, sea state condition

## 2. MEASURED PARAMETERS



Some parameters —conductivity, salinity, temperature, dissolved oxygen, Secchi depth— are measured *in situ*. The other measured parameters — including nitrogen, phosphorus, carbon, total suspended solids and chlorophyll-*a* are determined in the laboratory. Tables 2-1 and 2-2 list the parameters measured, the detection limits and method references. Details of sample collection, sample processing and storage, and analytical procedures are described in Appendix A.

**Table 2-1. A Summary of Field Parameters, Method Reference and Performance Criteria.**

Matrix	Parameter (Units)	Method Reference - Field	Minimum Detection Limit	Holding Time and Condition
Water	Temperature (C)	Probe p. A-xxxiv	-5.0 C	<i>In situ</i>
Water	Depth - Station (m)	Depth sensor p. A-ix Garmin GPS/Sounder 185 p. A-ix	0.0m  0.5m	<i>In situ</i>
Water	Dissolved Oxygen (mg L <sup>-1</sup> )	Probe p. A-xiv	0.0 mg L <sup>-1</sup>	<i>In situ</i>
Water	Specific Conductance (mS cm <sup>-1</sup> )*	Probe p. A-viii	0.1 mS cm <sup>-1</sup>	<i>In situ</i>
Water	Salinity (psu)	Probe p. A-xxxi	0 psu	<i>In situ</i>
Water	Secchi depth (m)	Disk 25.5 cm diameter p. A-xxxii	0.1 m	<i>In situ</i>
Water	pH	Probe p. A-xxxiv	0.0 (su)	<i>In situ</i>
Water	Photosynthetically Active Radiation (μM m <sup>-2</sup> sec <sup>-1</sup> )	<i>Li-cor</i> Li-192SA, Li-190SA on board sensor p. A-xxx	0.0 μM m <sup>-2</sup> sec <sup>-1</sup>	<i>In situ</i>
Water	Chlorophyll- <i>a</i> (%FS)	6025 Chlorophyll Probe p. A-xvi	0.0 %	<i>In situ</i>
Water	Turbidity (NTU)	Probe p. A-xli	0.0 NTU	<i>In situ</i>

\* mS cm<sup>-1</sup> (European measurement) = 1 mmho cm<sup>-1</sup> (European and USA equivalent)

**Table 2-2. Shallow Water Monitoring Program Grab Sample Water Column Parameters, Methods References, Detection Limits, and Holding Times and Conditions.**

<b>Matrix</b>	<b>Parameter (Units)</b>	<b>Method Reference - Analytical</b>	<b>Detection Limits</b>	<b>Holding Time and Condition</b>
Water	Ammonium (mg L <sup>-1</sup> as N)	EPA Method 350.1 (EPA 1979) AquaKem 250 p. A-i	0.003 mg L <sup>-1</sup>	Freezing-28 days
Water	Active Chlorophyll-a (µg L <sup>-1</sup> )	APHA (1981) p. A-iii	0.1 µg l <sup>-1</sup>	Freezing-28 days
Water	Total Chlorophyll-a (µg L <sup>-1</sup> )	APHA (1981) p. A-v	0.1 µg l <sup>-1</sup>	Freezing-28 days
Water	Dissolved Organic Carbon (mg L <sup>-1</sup> as C)	Sugimura and Suzuki (1988) p. A-x	0.24 mg L <sup>-1</sup>	Freezing-28 days
Water	Dissolved Inorganic Phosphorus (mg L <sup>-1</sup> as P)	EPA method 365.1 (EPA 1979) AquaKem 250 p. A-xii	0.0006 mg L <sup>-1</sup>	Freezing-28 days
Water	Nitrite (mg L <sup>-1</sup> as N)	EPA method 353.2 (EPA 1979) AquaKem 250 p. A-xii	0.0006 mg L <sup>-1</sup>	Freezing-28 days
Water	Nitrite + Nitrate (mg L <sup>-1</sup> as N)	EPA method 353.2 (EPA 1979) and enzymatic nitrate method. AquaKem 250 p. A-xix	0.0007 mg L <sup>-1</sup>	Freezing-28 days
Water	Particulate carbon (mg L <sup>-1</sup> as C)	EPA method 440.0 (EPA 1997) p. A-xxii	0.0633 mg L <sup>-1</sup>	Freezing-28 days
Water	Particulate nitrogen (mg L <sup>-1</sup> as N)	EPA method 440.0 (EPA 1997) p. A-xxiii	0.0105 mg L <sup>-1</sup>	Freezing-28 days
Water	Particulate phosphorus (mg L <sup>-1</sup> as P)	Aspila et. al. (1976) p. A-xxv	0.0054 mg L <sup>-1</sup>	Freezing-28 days
Water	Particulate inorganic phosphorus (mg L <sup>-1</sup> as P)	Aspila et al. (1976) p. A-xxvii	0.0024 mg L <sup>-1</sup>	Freezing-28 days
Water	Silicate (mg L <sup>-1</sup> as Si)	EPA method 370.1 (EPA 1971) AquaKem 250 p. A-xxxiii	0.08 mg L <sup>-1</sup>	4° C - 28 days
Water	Total Suspended Solids (mg L <sup>-1</sup> )	EPA method 160.2 (with slight modification) (EPA 1979; APHA 1975). p: xxxix	2.4 mg L <sup>-1</sup>	Freezing-28 days
Water	Total Dissolved Nitrogen (mg L <sup>-1</sup> as N)	D'Elia et al. 1977; Valderrama 1981 p. A-xxxv	0.02 mg L <sup>-1</sup>	Freezing-28 days
Water	Total Dissolved Phosphorus (mg L <sup>-1</sup> as P)	Valderrama 1981 p. A-xxxvii	0.0015 mg L <sup>-1</sup>	Freezing-28 days
Water	Volatile Suspended Solids (mg L <sup>-1</sup> )	APHA (1975) p. A-xlii	0.90 mg L <sup>-1</sup>	Freezing-28 days

\* Detection Limits as of January/February 2007

## REFERENCES for Table 2-2:

**American Public Health Association (APHA).** 1981. Method 1002 G, chlorophyll (trichromatic), in *Standard Methods for the Examination of Water and Wastewater*, 17th ed.

**American Public Health Association (APHA).** 1975. Method 208D, total nonfilterable residue dried at 103-105EC (total suspended matter), in *Standard Methods for the Examination of Water and Wastewater*, 14<sup>th</sup> Edition. APHA: Washington, D.C. 1193 p.

**Aspila, I., H. Agemian and A. S. Y. Chau.** 1976. A semi-automated method for the determination of inorganic, organic and total phosphate in sediments. *Analyst* 101:187-197.

**D'Elia, C. F., P. A. Steudler and N. Corwin.** 1977. Determination of total nitrogen in aqueous samples using persulfate digestion. *Limnol. Oceanogr.* 22:760-764.

**Hydrolab System Water Quality Instrumentation Manual (HSWQIM).** 1984-1998 (multiple editions). Published by Hydrolab Corporation, P.O. Box 50116, Austin, Texas.

**Parsons, T.R., Takahashi, M. and B. Hargrave.** 1977. *Biological Oceanographic Processes*. Pergammon Press. Oxford. 332 p. (pages 71-85).

**Patton, C.J., A.E. Fischer, W.H. Campbell and E.R. Campbell.** 2002. Corn leaf nitrate reductase- A nontoxic alternative to cadmium for photometric nitrate determinations in water samples by air-segmented continuous-flow analysis. *Env Sci. and Technology* 36(4):729-735.

**Smith, R. C.** 1969. An underwater spectral irradiance collector. *J. Mar. Res.* Vol. 27: 341-351.

**Sugimura, Y. and Y. Suzuki.** 1988. A high temperature catalytic oxidation method for the determination of non-volatile dissolved organic carbon in seawater by direct injection of a liquid sample. *Mar. Chem.* 24:105 - 131.

**Technicon Industrial Systems.** 1977. Industrial Method No. 186-72W/B, in *Silicates in Water and Seawater*. Technicon Industrial Systems: Tarrytown, NY.

**US Environmental Protection Agency (EPA).** 1997. *US EP A Method 440.0. Determination of Carbon and Nitrogen in Sediments and Particulates of Estuarine/Coastal Waters Using Elemental Analysis*. Revision 1.4. National Exposure Research Laboratory, Office of Research and Development, US Environmental Protection Agency: Cincinnati, OH.

**US Environmental Protection Agency (EPA).** 1979. *Methods for Chemical Analysis of Water and Wastes*. EPA-600/4-79-020. 460 p.

**Valderrama, J. C.** 1981. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. *Mar. Chem.* 10:109-122.

**Welch, P.S.** 1948. Chapter 11 in *Limnological Methods*. Blakiston: Philadelphia, PA. pp. 159-167.

### **3. FIELD MEASUREMENTS AND SAMPLING**

#### **3.1 Spatially Intensive Water Quality Mapping: DATAFLOW VI Mapping System**

DATAFLOW VI is a compact, self-contained surface water quality mapping system, suitable for use in a small boat operating at speeds of approximately 20 knots. The system collects water through a pipe ("ram") deployed on the transom of the vessel, pumps it through an array of water quality sensors, and discharges the water overboard.

##### **3.1.1 Water Quality Instrumentation**

DATAFLOW VI (Figure 3-1) has a YSI 6600 Sonde equipped with a flow through chamber. The sensors include a Clark-type YSI 6562 DO probe, a YSI 6560 conductivity/temperature probe, a 6026 turbidity probe, and a 6025 chlorophyll probe. The sonde transmits data collected from the sensors to a portable computer running a LabView software routine that logs the sensor data. On each dataflow cruise water samples are collected at a number of fixed stations and analyzed at the Nutrient and Analytical Services Laboratory at Chesapeake Biological Laboratory for total dissolved nitrogen, particulate nitrogen, nitrite, nitrite + nitrate, ammonium, total dissolved phosphorus, particulate phosphorus, orthophosphate, dissolved organic carbon, particulate carbon, silica, total suspended solids, and volatile suspended solids using the same methods described in Section 4. Chlorophyll *a* (*total and active*) is analyzed by DHMH. Water column vertical profiles are also performed at each calibration station using a second YSI Sonde which provide temperature, specific conductance, dissolved oxygen concentration and percent saturation, and pH at discrete depths. This procedure follows Maryland DNR fixed-station and shallow water monitoring methodology (*see* Michael et al., 2006). For details of procedures at each calibration station see Appendix B.

##### **3.1.2 Positioning and Depth Information**

DATAFLOW VI is equipped with a Garmin 178C WAAS (Wide Area Augmentation System) enabled Global Positioning System receiver with a built in depth sounder. The Garmin 178C GPS transmits NMEA data to a portable computer running a LabView software routine that concatenates the strings of data from both the YSI 6600 and the GPS/Depthsounder.

##### **3.1.3 Flow Meter**

DATAFLOW VI is equipped with an inline flow meter. Although the flow rate does not affect any of the sensor readings, decreased flow is an indication of either a partial blockage or an interruption of water flow to the instrument. Thus, the flow data is used

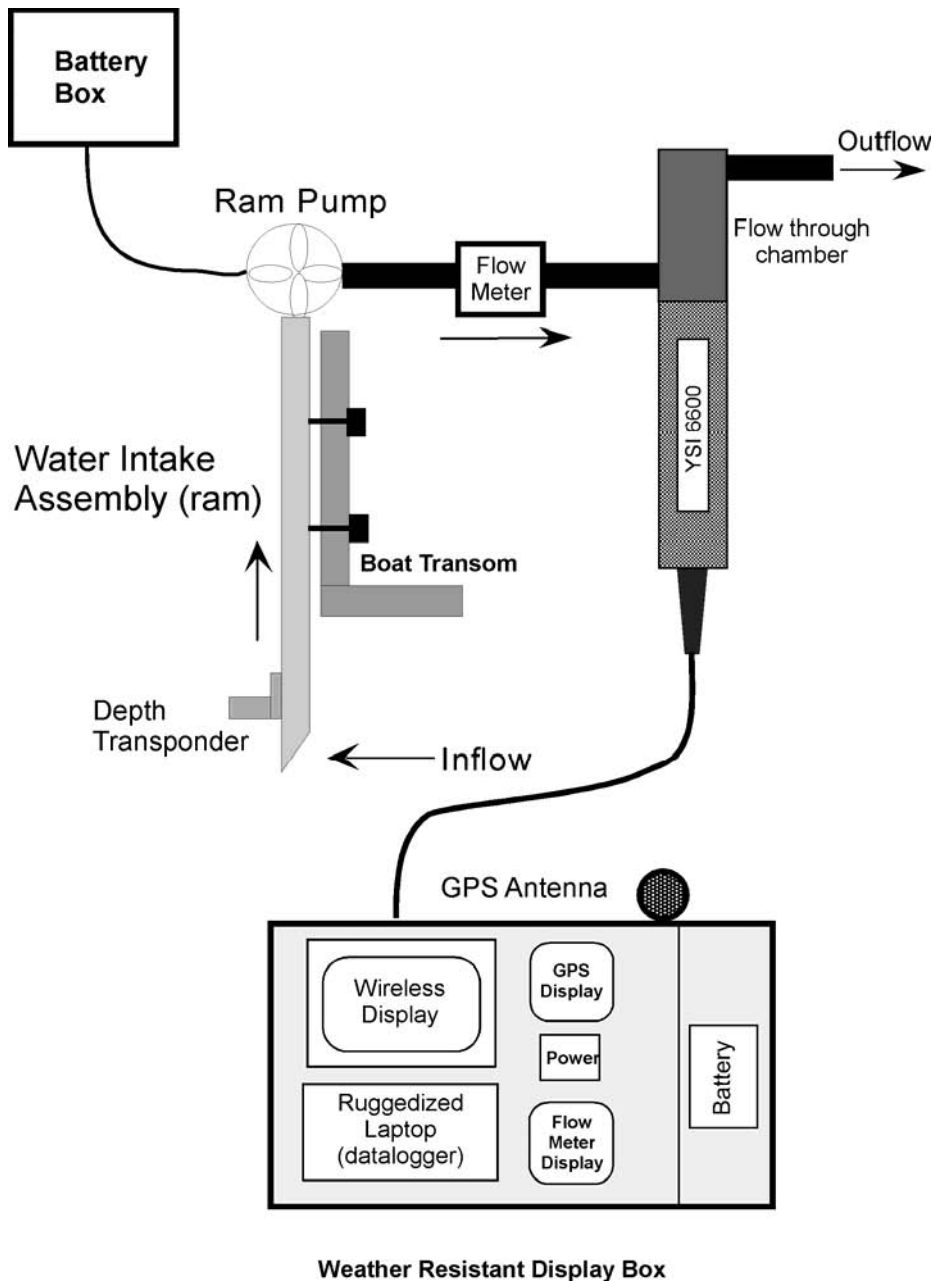
in the field as a diagnostic tool to ensure that the instrument is working properly and later as a quality assurance tool, to verify that water flow was uninterrupted. A boat horn is wired to the flow meter. If the flow is interrupted and the flow rate falls below  $3.0 \text{ l m}^{-1}$ , the horn sounds and warns the operators that a problem must be corrected.

### **3.1.4 Physical Parameters**

Temperature, salinity, conductivity, and dissolved oxygen measurements were collected with a Yellow Springs International (YSI) 6600 multi-parameter water quality monitor. Water column turbidity was estimated with a secchi disk, while water column light flux in the photosynthetically active frequency range (PAR) was measured with a *Li-Cor* LI-192SA underwater quantum sensor and *Li-Cor* LI-190SA quantum sensor. Light flux measurements were collected on deck (out of the water) and up to five discrete water depths in order to calculate water column light attenuation ( $K_d$ ). Weather and sea-state conditions such as air temperature, percent cloud cover, wind speed and direction, total water depth, and wave height were also recorded.

### **3.1.5 Water Column Nutrients**

Whole water samples were collected in polyethylene jugs from the DATAFLOW outlet hose. The whole water samples were placed in coolers for transport back to the laboratory for further processing. Whole water portions were filtered in the laboratory using 47 mm  $0.7 \mu\text{m}$  (GF/F) glass fiber filters and were analyzed by NASL for the following particulate nutrients: ammonium ( $\text{NH}_4^+$ ), nitrate ( $\text{NO}_2^-$ ), nitrite plus nitrate ( $\text{NO}_2^- + \text{NO}_3^-$ ), phosphate ( $\text{PO}_4^{3-}$ ), Total Dissolved Phosphorus, Total Dissolved Nitrogen, Particulate Phosphorus, Particulate Inorganic Phosphorus, Particulate Nitrogen, Particulate Carbon, Silicate, Dissolved Organic Carbon, and Volatile Suspended Solids (VSS). Total and Active chlorophyll-*a* (where Total chlorophyll-*a* includes chlorophyll-*a* plus breakdown products) concentrations will be analyzed by the Maryland Department of Health and Mental Hygiene (DHMH). On each dataflow cruise water samples are collected at a number of stations and analyzed for the same full suite of nutrients as listed above using the same methods described in Section 4.



**Figure 3-1. Schematic diagram of DATAFLOW VI illustrating the path of water through the instrument.** Seawater is picked up behind the transom of the research vessel through the "ram." A centrifugal pump mounted on the ram ("ram pump") pulls up the seawater. The water runs through a flow meter that is wired to a horn that sounds if the flow rate falls below  $3 \text{ l m}^{-1}$ . If flow is interrupted during sampling, the horn sounds informing operators that a problem exists. The water exits the flow meter and enters the YSI flow-through chamber. The water runs across the sensor probes and exits the flow-through chamber before being discharged overboard. The displays for the Ruggedized Laptop, Garmin 178C GPS, and flow meter display are located on the instrument platform.

#### 4. LABORATORY ANALYSIS

Methods for the determination of dissolved and particulate nutrients are as follows: ammonium ( $\text{NH}_4^+$ ), nitrite ( $\text{NO}_2^-$ ), nitrite plus nitrate ( $\text{NO}_2^- + \text{NO}_3^-$ ), and dissolved inorganic phosphorus (DIP or  $\text{PO}_4^-$ ) are measured using the automated method of EPA (1979); particulate carbon (PC) and particulate nitrogen (PN) samples are analyzed using an Elemental Analyzer; particulate phosphorus (PP) concentration is obtained by acid digestion of muffled-dry samples (Aspila *et al.*, 1976); methods of Strickland and Parsons (1972) and Parsons *et al.* (1984) are followed for chlorophyll-*a* analysis, silicate (Si), total dissolved nitrogen (TDN), total dissolved phosphorus (TDP), dissolved organic carbon (DOC) and particulate inorganic phosphorus (PIP).

All analytical (laboratory) parameters, except Chlorophyll, are analyzed at the University of Maryland's Chesapeake Biological Laboratory (CBL), Nutrient Analytical Services Laboratory.



## **5. DATA MANAGEMENT, VERIFICATION AND DOCUMENTATION**

The objectives of QA/QC standards are to provide accurate measurement of water quality parameters in Potomac River. Over the years that the EPC has been making measurements consistent protocols have been developed in the field. Together with laboratory procedures already in place and used by NASL and data management procedures, the data obtained can be analyzed and interpreted so that the final report submitted will meet the objectives stated for this study. Information derived from the report will be useful to managers making decisions concerning Potomac River.

### **5.1 QA/QC Field Checks**

Cruises are scheduled well ahead of time with Research Fleet Operations (RFO). A schedule for activities for each day of the individual cruises is submitted to the PI and other members of staff. Cruises that are canceled due to weather or mechanical problems with the research vessel are rescheduled when possible.

Upon return from the field, data from DATAFLOW instrument will be downloaded to a PC to verify that data has been collected properly. Water samples will be processed and transferred to NASL for further analysis. Within two weeks of field sampling, raw data will be screened for compliance to QA/QC standards and an electronic copy will be sent to Maryland DNR in Microsoft "Excel" or "csv" format. Field data will be transcribed to Maryland DNR field sheets and sent to DNR for electronic data entry.

At the end of the monitoring season, additional data QA/QC procedures are conducted by DNR office personnel at the Tawes Office. Staff plot all the data and then thoroughly research any outliers or other odd values. For example, we compare unusual values to historic values and values elsewhere in the Bay, consider weather events, and consult with field staff regarding possible legitimate causes for those values. In cases where values are not legitimate, they are deleted from the dataset with the approval of the field staff and the Quality Assurance Officer.

### **5.2 Preparation of Collection Gear**

During the last few days prior to initiating a research cruise all the necessary equipment involved in the collection of water and collection of physical water quality data are inventoried according to "checklists". All equipment is checked to insure that it is fully operational and has been properly cleaned. The equipment is packed into containers that provide for easy transport and subsequently loaded aboard the research vessel. The "checklist" is then re-examined to verify the presence of all necessary gear.

Standards and reagents involved in the calibration of instrumentation are made according to a schedule of shelf life (*i.e.* daily, weekly or seasonally) or if the supply is exhausted. All chemicals are handled, prepared and stored in accordance with standard laboratory practices. Lost samples are a rarity and in those instances a code is inserted into the data

to record the problems encountered (See Section 5.3.1.2). Details of sample collection are found in Appendix A.

### **5.2.1 Potential Contamination**

During the course of a research cruise different steps are taken to insure that the chances for contamination are minimized. These practices involve almost constant washing of equipment during the course of a cruise. All containers used to collect bulk raw water are rinsed with copious amounts of sample (station) water before they are filled and are thoroughly acid washed and then rinsed with deionized water at the end of the cruise. Containers from which samples will be taken for chemical analysis are rinsed additionally with deionized water. All containers into which are placed water and sediment samples for chemical analysis (after being fully processed) are single use/disposable plastic vials and centrifuge tubes that require no cleaning. All syringes and other laboratory equipment used in processing these samples are washed with deionized water between each use. All glassware associated with the preparation of standards and reagents is cleaned with copious amounts deionized water and acid washed when appropriate.

### **5.2.2 Calibration Procedures and Frequency**

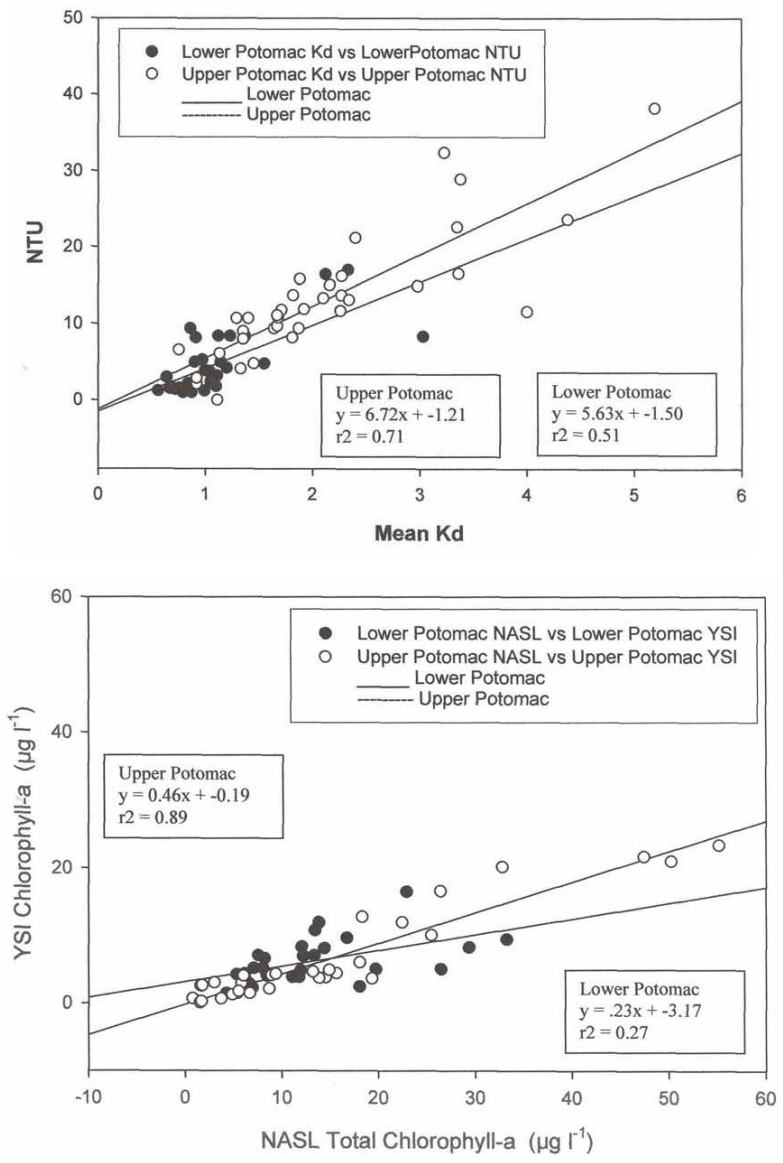
All instruments (YSI 6920/600/6600) involved in the collection of physical water quality data (temperature, conductivity, salinity and dissolved oxygen) are calibrated weekly, with the exception of dissolved oxygen calibration, which occurs prior to each cruise and incorporates a standard air calibration based on air temperature and barometric pressure. Conductivity/salinity is calibrated with a 0.10 molar standard of potassium chloride. Temperature is calibrated by the manufacturer only when the instrument is returned for service.

All instruments are maintained in accordance with manufacturers' specifications. Standards and reagents involved in the calibration of instrumentation are made according to a schedule of shelf life (*i.e.* daily, weekly or seasonally) or if the supply is exhausted. All chemicals are handled, prepared and stored in accordance with standard laboratory practices. If any apparent problems arise the instrument is removed from use until the malfunction can be diagnosed and remedied.

All of the sensors for the continuous surface water quality mapping system must be calibrated. The conductivity sensor, dissolved oxygen sensor, transmissometer, fluorometer, and pH are calibrated in the laboratory with known standards. These standards are as follows:

<b>Parameter</b>	<b>Calibration Method</b>
Specific Conductance	0.10 M KCl
Dissolved Oxygen	Air Calibration
Transmissometer	Turbidity Standards
Fluorometer	Laboratory Standard
pH	Laboratory Standard

Laboratory calibrations are performed daily for dissolved oxygen and conductivity and occasionally for transmittance and fluorescence. Although laboratory air calibrations are performed for the dissolved oxygen sensor, several Winkler titrations are performed regularly to ensure proper calibration. For transmittance and fluorescence, the manufacturer recommends that the instrument be calibrated against *in-situ* properties measured in the field. A variable number of water samples are collected in a field deployment that are analyzed for total and active chlorophyll-*a* and total suspended solids concentrations. These field standards are related to sensor readings via regression procedures. An example of the calibration curves derived for chlorophyll-*a* and water column light attenuation are shown in Figure 5-1.



**Figure 5-1.** Examples of Calibration Curves used during Spatially Inensive Water Quality Mapping (DATAFLOW) from April to October, 2006. Data Analysis: (top) Light Attenuation and (bottom) Total Chlorophyll Concentration.

### **5.3 Field Data Recording**

All field data is recorded on specially prepared field data sheets that are included as Appendix A. The initials of the person recording the data are recorded on each data sheet. The raw data sheets are reviewed for possible missing data values due to sample collection problems prior to data entry. These sheets are filed in the laboratory. A cruise log book is also kept.

#### **5.3.1 General Information Related to Data Sets**

##### **5.3.1.1 Naming Conventions**

Data files are given unique names, consistent with Maryland DNR naming conventions reflecting the name of the data set.

##### **5.3.1.2 Incorporation of Error Codes in Data Tables**

In order to keep a record of problems experienced while collecting data, a one or two letter alpha code (Appendix D) is entered in the data table that describes the problems associated with questionable parameter values.

##### **5.3.1.3 Data Tables QA/QC Control**

Data recorded by instruments in the field are entered directly onto specially prepared data sheets. Data are checked against any field notes and then transferred manually from these field sheets to Maryland DNR Field Sheets for keypunch data entry by State personnel. Data from samples analyzed by NASL are transmitted directly to DNR. Blank data sheets for both SAV and Water Quality Mapping data are included in Appendix B.

##### **5.3.1.4 Spatially Intensive Water Quality Mapping - Raw Data Sets**

The data are electronically transferred from the instrument computer to a laboratory desktop at the end of each day of sampling. The data are stored as an ASCII text file. This file is retained indefinitely as the original record of the data collection. Due to the enormous quantity of data no hard copy will be submitted.

#### **5.3.2 Submission of Data Files**

Files are submitted as comma delimited text files. Wherever possible, the EPC abbreviations for variables are used. Additional information regarding the format of the data and details of variable labels, file structure and data and sampling anomalies are to be submitted as a metadata file to fulfill the requirements of the EPA Chesapeake Bay Liaison Office (EPA/CBLO).

### 5.3.2.1 Spatially Intensive Water Quality Mapping - Processing of Data

Very little post-processing is required before the data can be used. However, there are two kinds of problems that occur occasionally: misread positioning information and erroneous values caused by electronic noise. Both problems can usually be detected easily by visually scanning the data, by calculating summary statistics, or by calculating the difference between successive observations. A Microsoft Excel macro is used to initiate QA/QC on Spatially Intensive Water Quality Mapping Data before the datasets are transmitted to Maryland DNR.

## 5.4 Description of Individual Data Sets

### 5.4.1 Spatially Intensive Water Quality Mapping Data Sets

Two data sets contain the water quality measurements; however **please note** that due to the large quantity of data no hard copy of the data is submitted. A single parameter sheet is found in Appendix B. QA/QC checks identify missing data that are documented in these data sets using the appropriate code.

Filename **AAAmddyyyyR/Q** (where AAA = sample site designation, e.g. POT = Potomac River; mm = month; dd = day; yyyy = year), the screened data set contains: date, time, latitude, longitude for each record of water temperature, salinity (ppt), dissolved oxygen ( $\mu\text{g l}^{-1}$ ), total chlorophyll-a ( $\mu\text{g l}^{-1}$ ), fluorescence ( $\mu\text{g l}^{-1}$ ) and transmissometer values (NTU). An 'R' indicates a raw dataset consisting of data output directly from the instrument, whereas a 'Q' indicates that the dataset has been subjected to QA/QC as per Maryland DNR protocol.

## 6. PROJECT QUALITY ASSURANCE/QUALITY CONTROL

For information related to parameter accuracy and precision please refer to Table 2-2.

### 6.1 Audit

The NASL at the Chesapeake Biological Laboratory provides nutrient analyses to University, State and Federal agencies. As part of the laboratory's QA/QC program, NASL participates in cross calibration exercises with other institutions and agencies whenever possible. Refer to D'Elia *et al.* (1997) for specific details but some examples include:

- Particulate carbon and nitrogen cross calibration with Woods Hole Oceanographic Institution and Horn Point Environmental Laboratory.
- International Council for the Exploration of the Sea (ICES) inorganic nutrient round-robin communication. The fourth international inter-comparison report was published in 1991 (Kirkwood, Aminot and Perttilä, 1991).
- Comparisons of dissolved nutrient analyses conducted at Horn Point Environmental Laboratory, Bigelow Laboratory, the University of Delaware and the University of New Hampshire.
- Quarterly cross calibration exercises with Virginia Institute of Marine Science (VIMS) and Old Dominion University (ODU). The most recent inter-comparison confirmed all parameters routinely analyzed by these laboratories as part of the Chesapeake Bay Monitoring Program. Samples from various saltness and nutrient regimes were analyzed under this exercise.
- Environmental Protection Agency (EPA) unknown audits for various nutrients have been conducted.
- EPA audits of known nutrients were analyzed using samples in different salinity water while looking for possible matrix effects.

NASL has analyzed National Institute of Standards and Technology (NIST) and National Research Board of Canada reference materials, primarily estuarine sediment, as a check for their particulate and sediment carbon, nitrogen and phosphorus methods.

As part of the Chesapeake Bay Monitoring Program, the laboratory analyzes approximately ten percent of the total sample load for QA/QC checks. These samples include laboratory duplicates and spike analyses. Two audits are completed each year.

Specific EPC procedures include inorganic nitrogen (ammonium  $[\text{NH}_4^+]$ , nitrite  $[\text{NO}_2^-]$ , nitrite plus nitrate  $[\text{NO}_2^- + \text{NO}_3^-]$  and dissolved inorganic phosphorus [DIP or  $\text{PO}_4^{3-}$ ] for which a standard curve usually comprising five concentrations encompassing the expected range for that particular sample set, are analyzed at the beginning of each new run. A standard, which is treated as a sample, is analyzed at least every 20 samples. Baseline corrections are determined either manually or automatically, depending on the instrument providing the analysis. Data needed to calculate concentrations are recorded along with the sample concentration in laboratory notebooks, a carbon copy of which is provided to the EPC group. This procedure is also carried out for other parameters performed by the laboratory in support for the EPC effort. Precision and limits of detection for the variables are included in D'Elia *et al.* (1997) and included as part of the sampling procedure in Appendix A.

## **6.2 Sample Custody**

Upon arrival at NASL, samples are counted, observed for potential problems (melting, broken containers, *etc.*) and placed in a freezer until analysis. Sample information and date of arrival are recorded on a log sheet.

## **6.3 Instrument Maintenance**

Analytical instruments are maintained on a regular basis and records are kept of hours of operation, scheduled maintenance, pump tube changes, *etc.* A critical spare parts inventory is maintained for each instrument. Instrument down-time is minimized by troubleshooting instrument problems telephonically with manufacturers and service representatives. Spare parts can be received within 24 hours via next-day air service.



## 7. DATA ANALYSIS AND REPORTING

### 7.1 Analysis of existing data

The PI has analyzed and reported water quality information of the Chesapeake Bay and related tributaries including the Potomac, Patuxent, Choptank and Susquehanna Rivers since 1985. Two data sets, the Vertical Flux Array (VFX) data set and the Sediment Oxygen and Nutrient Exchanges (SONE) data set are now complete. Yearly technical reports have been submitted continuously since 1984, published results and numerous presentations have been made at various program review and professional meetings. Various smaller studies with particular reference to distinct ecologically important aspects of the EPC program have been completed, data collected, analyzed and the results included in the final report. The PI has also suggested new areas where additional data could improve the quality of the EPC study.

### 7.2 Reports

- The *Level I: Data and Progress Report* will be replaced by a letter report summarizing the delivery of data in electronic format to DNR personnel during FY2009.

**\*\*NOTE: Water column nutrient concentration data collected by EPC as part of the spatially intensive monitoring program in FY2009 will be sent directly to Maryland DNR from Nutrient and Analytical Services Laboratory (NASL) as part of the standard monitoring protocols and will not be the responsibility of the Ecosystems Processes Component (EPC).**

- The second report is the comprehensive *Level I: Interpretive Report* that will be delivered as a draft, and will then be updated to reflect comments made by the contracting officer. The report will include graphical and statistical analyses of data with particular emphasis on the three major objectives of the DNR monitoring program. Comparisons will be made with the relevant scientific literature, historical data, other data collected in the Chesapeake Bay and the Chesapeake Bay Monitoring Program. Twenty hard copies of this report, in addition to a read-only PDF version of the report will be supplied to Maryland DNR. Individual data or graphics files used to construct graphics will not be supplied.

Additional deliverables:

- An updated QAPP document for fiscal year 2010 will be submitted in May 2009.
- Monthly reports documenting progress made with field-work and in data management will be submitted.

All reports are submitted by Dr. Walter R. Boynton, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, P.O. Box 38, Solomons, MD 20688-0038 to Mr. Bruce Michael, Maryland Department of Natural Resources,

Resource Assessment Administration, Tidewater Ecosystems Assessment Division,  
Tawes State Office Building, D-2, 580 Taylor Avenue, Annapolis, MD 20401.

## **8. PROJECT ORGANIZATION AND RESPONSIBILITIES**

This section lists the individuals responsible for the major aspects of the EPC of Maryland's Chesapeake Bay Water Quality Monitoring Program.

The collection and preparation of samples, plus data entry and management will be completed at Chesapeake Biological Laboratory under the direction of Professor Walter Raymond Boynton (PI). All correspondence regarding this project should be addressed to: Dr. Walter R. Boynton, Chesapeake Biological Laboratory, University of Maryland, Center for Environmental Science, P.O. Box 38, Solomons, MD 20688-0038. All sediment and water quality analyses are performed by Nutrient Analytical Services Laboratory (NASL) at the Chesapeake Biological Laboratory except Chlorophyll which is performed by DHMH.

### **Principal Investigator: Professor Walter Boynton**

**RESPONSIBILITIES:** The principal investigator (PI), Dr. Walter Boynton, will supervise all activities associated with this project. This includes field work, data management and report writing. He will be responsible for all stages of the analysis of samples, resolving problems that may arise, and assure the satisfactory completion of the study. He is responsible for data review and oversight and submission of data. The PI will review the results of the analyses and approve the quality assurance/quality control protocols to insure the validity of the results. The PI will administer the financial and technical requirements of the project and be responsible for preparing the data and progress report and the final report to be submitted at the end of the project. He will also meet, at regular time intervals, with the other members of staff to discuss and review their responsibilities in relation to the project. The PI will respond to questions by the contracting agencies regarding the completion of different stages of the project and the reports that have to be submitted as part of the deliverables outlined in the project contract.

### **Field Program Supervisor: Eva M. Bailey** **Advanced Senior Faculty Research Assistant (2002-Present)**

**RESPONSIBILITIES:** Ms. Eva M. Bailey supervises and manages research programs, field and laboratory projects, reports and execution, and is responsible for data analysis, report preparation and presentation. Ms. Bailey also supervises personnel.

### **Spatial Mapping Field Program Manager: Janet M. Barnes** **Advanced Faculty Research Assistant (2007 - Present)**

**RESPONSIBILITIES:** Ms. Janet Barnes manages the spatial mapping field program, data collection, data QA/QC, data submission and instrument maintenance. Ms. Barnes also trains and supervises junior personnel in the field and as needed in the laboratory.

**Field Program Assitant: Maria Ceballos**  
**Laboratory Assistant (2002 - Present)**

RESPONSIBILITIES: Ms. Maria Ceballos assists in field program management and execution, data collection, data analysis, report preparation and presentation, and instrument maintenance.

## 9. REFERENCES

- Aspila, I., H. Agemian, and A.S.Y. Chau.** 1976. A semi-automated method for the determination of inorganic, organic and total phosphate in sediments. *Analyst* 101:187-197.
- Boynton, W. R. and F. M. Rohland.** 1990. Ecosystems Processes Component (EPC) Data Dictionary. Chesapeake Biological Laboratory (CBL), University of Maryland System, Solomons, MD 20688-0038. Ref. No. [UMCES] CBL 90-029.
- Boynton, W.R. and W.M. Kemp.** 1985. Nutrient regeneration and oxygen consumption by sediments along an estuarine salinity gradient. *Mar. Ecol. Prog. Ser.* 23:45-55.
- Boynton, W.R., W.M. Kemp and C.W. Keefe.** 1982. A comparative analysis of nutrients and other factors influencing estuarine phytoplankton production, p. 69-90. In: V.S. Kennedy, [Ed.], *Estuarine Comparisons*, Academic Press, NY.
- Boynton, W. R., W. M. Kemp, J. M. Barnes, L. L. Matteson, J. L. Watts, S. Stammerjohn, D. A. Jasinski and F. M. Rohland.** 1991. Ecosystem Processes Component Level 1 Interpretive 8. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref. No. [UMCES] CBL 91-110a.
- Boynton, W. R., J. H. Garber, R. Summers and W. M. Kemp.** 1995. Inputs, Transformations, and Transport of Nitrogen and Phosphorus in Chesapeake Bay and Selected Tributaries. *Estuaries* 18(1B): 285-314.
- Boynton, W.R., W.M. Kemp, J.M. Barnes, F.M. Rohland, L.L. Matteson, L.L. Magdeburger, J.D. Hagy III, J.M. Frank, B.F. Sweeney, M.M. Weir and R.M. Stankelis.** 1997. Ecosystem Processes Component Level 1 Interpretive Report No. 14. Chesapeake Biological Laboratory (CBL), University of Maryland System Center for Environmental and Estuarine Studies, Solomons, MD 20688-0038. Ref No. [UMCEES]CBL 97-009a.
- Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H. Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.** 1998. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 98-073a.
- Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, J.D. Hagy, and J.M. Frank.** 1999. Ecosystem Processes Component Level 1 Interpretive Report No. 16. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 99-0070a.

- Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, J.D. Hagy, and J.M. Frank.** 2000. Ecosystem Processes Component Level 1 Interpretive Report No. 17. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 00-0174.
- Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, J.M. Frank and J.M. Lawrence.** 2001. Ecosystem Processes Component Level 1 Interpretive Report No. 18. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 01-0088.
- Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, J.M. Frank and J.M. Lawrence.** 2002. Ecosystem Processes Component Level 1 Interpretive Report No. 19. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 02-0152a.
- Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, E.M. Bailey and P.W. Smail.** 2003. Ecosystem Processes Component Level 1 Interpretive Report No. 20. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 03-303a.
- Boynton, W.R. and R.M. Stankelis (editors); P.W. Smail and E.M. Bailey.** 2004. Ecosystem Processes Component Level 1 Interpretive Report No. 21. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 04-086.
- Boynton, W.R., R.M. Stankelis and P.W. Smail (editors); E.M. Bailey and H.L. Soulen.** 2004. Ecosystem Processes Component Level 1 Interpretive Report No. 21. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 05-067.
- D'Elia, C.F., E.E. Connor, N.L. Kaumeyer, C.W. Keefe, K. V. Wood and C.F. Zimmerman.** 1997. Nutrient Analytical Services Laboratory Standard Operating Procedures. Technical Report Series No. 158-97. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688-0038.
- Environmental Protection Agency (EPA).** 1979. Methods for Chemical Analysis of Water and Wastes. USEPA-6000/4-79-020. Environmental Monitoring and Support Laboratory, Cincinnati, OH.

- Environmental Protection Agency (EPA).** 1983. Chesapeake Bay: A Framework for Action. Chesapeake Bay Program: Annapolis, MD. 186 p.
- Environmental Protection Agency (EPA).** 1989. Sediment data management plan. Chesapeake Bay Program. CBP/TRS 29/89.
- Frank, J. M., F. M. Rohland, R. M. Stankelis, J. M. Lawrence, B. Bean, H. Pine and W. R. Boynton.** 2003. Monitoring of Sediment Oxygen and Nutrient Exchanges in the Chester River Estuary in Support of TMDL Development. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref. No.[UMCES] CBL 03-131.
- Kana, T. M., M. B. Sullivan, J. C. Cornwell and K. M. Groszkowski.** 1998. Denitrification in estuarine sediments determined by membrane inlet mass spectrometry. *Limnology and Oceanography* 43(2): 334-339.
- Kemp, W.M. and W.R. Boynton.** 1980. Influence of biological and physical factors on dissolved oxygen dynamics in an estuarine system: implications for measurement of community metabolism. *Estuar. Coast. Mar. Sci.* 11:407-431.
- Kemp, W.M. and W.R. Boynton.** 1981. External and internal factors regulating metabolic rates of an estuarine benthic community. *Oecologia* 51:19-27.
- Kemp, W. M., P. A. Sampou, J. Garber, J. Tuttle and W. R. Boynton.** 1992. Seasonal depletion of oxygen from bottom waters of Chesapeake Bay: Roles of benthic and planktonic respiration and physical exchange processes. *Marine Ecology Progress Series* 85: 137-152.
- Kemp, W. M. and W. R. Boynton.** 1992. Benthic-Pelagic Interactions: Nutrient and Oxygen Dynamics. *In:* D.E. Smith, M. Leffler and G. Mackiernan [Eds.], *Oxygen Dynamics in the Chesapeake Bay: A synthesis of Recent Research*. Maryland Sea Grant Book, College Park, MD, pp. 149-221.
- Kirkwood, D., A. Aminot and M. Perttilä.** 1991. International Council for the Exploration of the Sea (ICES) Report on the Results of the 4<sup>th</sup> Intercomparison Exercise for Nutrients in Sea Water. No 174. ISSN 1017-6195.
- Magnien R.E. et al.** 1987. Monitoring for management actions. First Biennial Report. The Maryland Office of Environmental Programs, Chesapeake Bay, Water Quality Monitoring Program, Baltimore, MD.
- Michael, B., M. Trice and C. Trumbauer.** 2006. Quality Assurance Project for the Maryland Department of Natural Resources Chesapeake Bay Shallow Water Quality Monitoring Program. Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, Annapolis, MD.

- Mihursky, J.A. and W.R. Boynton.** 1978. A review of the Patuxent Estuary Data Base. Final Report to Maryland Department of Natural Resources Power Plant Siting Program. Ref. No. [UMCES] CBL 78-157.
- Nutrient Analytical Services Laboratory (NASL) Standard Operating Procedures.** 2004. Chesapeake Biological Laboratory, Solomons, MD 20688. February 2004.
- Parsons, T.R., Y. Maita and C.M. Lalli.** 1984. Determination of chlorophylls and total carotenoids: Spectrophotometric method. pp. 101 - 112 *in* Parsons, T.R., Y. Maita and C.M. Lalli. A manual of chemical and biological methods for seawater analysis. Pergamon Press, Oxford.
- Rohland, F. M., W. R. Boynton, R. M. Stankelis and J. M. Frank.** 1998. Work Quality Assurance Project Plan for Water Quality Monitoring in the Chesapeake Bay. Chesapeake Biological Laboratory, University of Maryland System, Solomons, MD 20688-0038. Ref. No. [UMCES] CBL 98-115.
- Rohland, F.M., W.R. Boynton, R.M. Stankelis, B.W. Bean, and H.J. Pine.** 2002. Maryland Chesapeake Bay Water Quality Monitoring Program, Ecosystem Processes Component (EPC), Quality Assurance Project Plan for Water Quality Monitoring in Chesapeake bay for FY 2003, July 2002-June2003, Revision 7. Prepared for the Maryland Department of Natural Resources, September 2002. University of Maryland Center for Environmental Sciences, Chesapeake Biological Laboratory, P.O. Box 38, Solomons, MD. Technical Report Series No. TS-343-01-CBL. Ref. No. [UMCES]CBL 01-0306b.
- Shoaf, W. T. and B. W. Lium.** 1976. Improved extraction of chlorophyll a and b from algae using dimethyl sulfoxide. *Limnology and Oceanography* 21(6): 926-928.
- Strickland, J.D.H. and T.R. Parsons.** 1972. A practical handbook of seawater analysis. Fish. Res. Bd. Can. Bull. 167 (second edition).
- Weiss, R.F.** 1970. The solubility of nitrogen, oxygen and argon in water and seawater. *Deep Sea Research* 17:721- 735.



# **APPENDIX A: EPC PARAMETERS**

## APPENDIX A: EPC PARAMETERS

### ***APPENDIX A: NOTE:***

Note that "DNR/EPC ABBREVIATION; ANALYTICAL METHOD NO. AND FIELD METHOD NO." in each of the descriptions of parameters in this section were originally coded following the guidelines outlined in:

**Environmental Protection Agency (EPA).** 1989. The Sediment Data Management Plan, Chesapeake Bay Program. United States Environmental Protection Agency, CBP/TRS 29/89.

This plan was made available to us when the first data dictionary for the EPC program was compiled in 1990.

At this time we have reviewed and wherever possible we have standardized and used water quality parameter abbreviations, "NEW\_METHOD" codes from the CBP Water Quality Database (1984 - present) Data Dictionary (<http://www.chesapeakebay.net/data/index.html>) the online data dictionary at the Chesapeake Information Management System (CIMS) Data Hub (<http://www.chesapeakebay.net/cims/index.htm>), incorporating them into our document. We have not changed sediment or SAV parameters.

**A-1. EPC Parameter: Ammonium**

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: The ammonium in a filtered water sample is by the Berthelot Reaction in which a blue-colored compound similar to indophenol forms when a solution of ammonium salt is added to sodium phenoxide, followed by the addition of sodium hypochlorite. The addition of a potassium sodium tartrate and sodium citrate solution prevents precipitation of hydroxides of calcium and magnesium.

INSTRUMENTATION: Technicon TrAAcs-800 Nutrient Analyzer

REFERENCES:

- (1) **Technicon Industrial Systems.** 1986. Technicon Industrial Method No 804-86T. Technicon Industrial Systems, Tarrytown, NY 10591.  
and: United States Environmental Protection Agency. 1979. Methods of chemical analysis of water and wastes. Off. Res. Devel. Cincinnati, OH. EPA-600/4-79-020.  
as modified by: **D'Elia, C.F., E.E. Connor, N.L. Kaumeyer, C.W. Keefe, K. V. Wood and C.F. Zimmerman.** 1997. Nutrient Analytical Services Laboratory Standard Operating Procedures. Technical Report Series No. 158-97. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688-0038. p.11.
- (2) **Clesceri, L.S., A.E. Greenberg and R.R. Trussell (Editors).** 1989. Standard methods for the examination of water and waste water. Am. Public Health Assoc., Am. Water Works Assoc. and Water Pollution Control Federation. Washington, DC. (Section: 4500-NH3 H. Automated Phenate Method).

REPORTED UNITS: micromolar ( $\mu\text{M}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.003 mg L <sup>-1</sup>	January 2007

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COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION:

Samples are filtered through a 2.5 cm diameter GF/F filter pad. Approximately 15 ml is collected in 3 Auto-Analyzer (AA) vials, which are triple rinsed with sample water prior to filling with sample and immediately frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, 0.7µm glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland, Solomons, MD. [UMCEES]CBL Ref. No. 89-050. p.25.
- (2) **Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H. Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.** 1998. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 98-073a.

**A-2.1. EPC Parameter: Chlorophyll-*a* - Active**

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: The total chlorophyll-*a* sample is acidified and measured fluorometrically. Active chlorophyll-*a* is then determined by subtracting the value obtained following acidification from the total chlorophyll-*a* value.

LABORATORY INSTRUMENTATION: Turner Designs Model TD 700

REFERENCES:

- (1) **Strickland, J.D.H. and T.R. Parsons.** 1972. A practical handbook of seawater analysis. Bull. 167 (Second Edition), Fisheries Research Board of Canada, Ottawa, Canada.
- (2) **D'Elia, C.F., E.E. Connor, N.L. Kaumeyer, C.W. Keefe, K. V. Wood and C.F. Zimmerman.** 1997. Nutrient Analytical Services Laboratory Standard Operating Procedures. Technical Report Series No. 158-97. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688-0038. p.64

REPORTED UNITS:

**Water:** micrograms per liter ( $\mu\text{g l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	$0.1 \mu\text{g l}^{-1}$	January 2007

PRECISION:	N/A	Not available
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COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION:

Water samples are filtered through an untreated 4.7 cm diameter GF/F filter pad. The filter pad is folded in half inward, wrapped in aluminum foil and frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 4.7 cm diameter, 0.7 $\mu\text{m}$  glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland, Solomons, MD. [UMCEES]CBL Ref. No. 89-050. p.25.
- (2) **Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H. Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.** 1998. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 98-073a.
- (3) **Boynton, W. R., R. M. Stankelis, F. M. Rohland, J. D. Hagy III, and J. M. Frank.** 1999. Ecosystem Processes Component Level 1 Interpretive Report #16. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science. Solomons, MD. Technical Report Series No. TS-190-99.

**A-2.2. EPC Parameter: Chlorophyll-a - Total**

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

ANALYTICAL METHOD NO.: SDCHTA18 (NEW\_METHOD: CHLAL03)

METHOD SUMMARY: Prior to analysis, the sample is thawed and chlorophyll-a extracted overnight in 40 ml of 90% acetone. The sample is read fluorometrically.

LABORATORY INSTRUMENTATION: Turner Designs Model TD 700

FIELD INSTRUMENTATION: Yellow Springs Instrument (YSI) 6025 Chlorophyll probe

REFERENCES:

- (1) **Strickland, J.D.H. and T.R. Parsons.** 1972. A practical handbook of seawater analysis. Bull. 167 (Second Edition), Fisheries Research Board of Canada, Ottawa, Canada.
- (2) **D'Elia, C.F., E.E. Connor, N.L. Kaumeyer, C.W. Keefe, K. V. Wood and C.F. Zimmerman.** 1997. Nutrient Analytical Services Laboratory Standard Operating Procedures. Technical Report Series No. 158-97. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688-0038. p.64

REPORTED UNITS:

**Water:** micrograms per liter ( $\mu\text{g l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	$0.1 \mu\text{g l}^{-1}$	January 2007

PRECISION:	N/A	Not available
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COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION:

Water samples are filtered through an untreated 4.7 cm diameter GF/F filter pad. The filter pad is folded in half inward, wrapped in aluminum foil and frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 4.7 cm diameter, 0.7µm glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

Samples are placed in an ice-filled cooler onboard the research vessel and frozen upon reaching shore.

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland, Solomons, MD. [UMCEES]CBL Ref. No. 89-050. p.25.
- (2) **Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H. Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.** 1998. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 98-073a.
- (3) **Boynton, W. R., R. M. Stankelis, F. M. Rohland, J. D. Hagy III, and J. M. Frank.** 1999. Ecosystem Processes Component Level 1 Interpretive Report #16. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science. Solomons, MD. Technical Report Series No. TS-190-99.



**A-2.3. EPC Parameter: Chlorophyll (*in situ*)**

STUDY ELEMENTS: Spatially Intensive Water Quality Mapping (AAAmdddy)

COLLECTION DEVICE:

Yellow Springs Instrument (YSI) 6025 Chlorophyll probe

SAMPLE COLLECTION:

Chlorophyll measurements are made *in-situ* with a probe.

REPORTED UNITS: micrograms per liter ( $\mu\text{g l}^{-1}$ )

DETECTION LIMITS: Upper Limit	Lower Limit	Dates Valid
$400 \mu\text{g l}^{-1}$	$0 \mu\text{g l}^{-1}$	October 2003 - present

REFERENCES:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

SAMPLE COLLECTION: **Spatially Intensive Water Quality Mapping:**

Water is pumped from approximately 50 cm depth at the stern of the research vessel and passes directly through a series of in-line sensors at a nominal flow rate of at least 20 - 25 l m<sup>-1</sup>. The conductivity probes are located in-line and are directly exposed to a continuous flow of ambient water. Conductivity value is transmitted directly to YSI 650 data logger.

REPORTED UNITS: micrograms per liter ( $\mu\text{g l}^{-1}$ )

DETECTION LIMITS: Upper Limit	Lower Limit	Dates Valid
$400 \mu\text{g l}^{-1}$	$0 \mu\text{g l}^{-1}$	October 2003 - present

REFERENCES:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

### A-3. EPC Parameter: Specific Conductance

STUDY ELEMENTS: Water Column Profile  
Spatially Intensive Water Quality Mapping (AAAmddyyyy)

FIELD METHOD NO.: CONDF01

COLLECTION DEVICE:

**Water Column Profile:** Yellow Springs Instrument (YSI) 6560  
Temperature/Conductivity probe

SAMPLE COLLECTION:

Specific conductance measurements are made *in-situ* with a probe.

REPORTED UNITS: millisiemens per centimeter ( $\text{mS cm}^{-1}$ )

DETECTION LIMITS: Upper Limit Lower Limit Dates Valid  
 $100 \text{ mS cm}^{-1}$   $0.1 \text{ mS cm}^{-1}$  October 2003 - present

REFERENCES:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

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SAMPLE COLLECTION: **Spatially Intensive Water Quality Mapping:**

Water is pumped from approximately 50 cm depth at the stern of the research vessel and passes directly through a series of in-line sensors at a nominal flow rate of at least 20 - 25  $\text{l m}^{-1}$ . The conductivity probes are located in-line and are directly exposed to a continuous flow of ambient water. Specific conductance value is transmitted directly to a data logger.

REPORTED UNITS: millisiemens per centimeter ( $\text{mS cm}^{-1}$ )

DETECTION LIMITS: Upper Limit Lower Limit Dates Valid  
 $100 \text{ mS cm}^{-1}$   $0.1 \text{ mS cm}^{-1}$  October 2003 - present

REFERENCE:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

#### A-4. EPC Parameter: Depth - Station

STUDY ELEMENT: Water Column Profile  
Spatially Intensive Water Quality Mapping (AAAmddyyyy)

COLLECTION DEVICE:

**Water Column Profile:** Yellow Springs Instrument (YSI) 6600  
Depth Sensor

SAMPLE COLLECTION: The calibrated depth sensor uses a differential strain gauge transducer to calculate depth from the pressure of the water column and the atmospheric pressure above the water column. The 6600 is lowered over board and the depths are measured at one meter or half meter intervals depending on the total depth of the station.

REPORTED UNITS: meters (m)

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	61 m	0 m	October 2003 - present

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COLLECTION DEVICE:

**Spatially Intensive Water Quality Mapping:** Research vessel fathometer  
(GARMIN GPS/Sounder 185)

SAMPLE COLLECTION: The electronic signal of the Fathometer is directed to the bottom and the echo from that signal is recorded and reported in units of either feet or meters.

**Spatially Intensive Water Quality Mapping:** The electronic signal of the fathometer is directed to the bottom and the echo from the signal is recorded. The depth data is transmitted as an ASCII string via the NMEA 0183 v1.5 data bus to a digital port on the datalogger, which records the depth data continuously.

REPORTED UNITS: meters (m)

DETECTION LIMITS: **Spatially Intensive Water Quality Mapping:**

Upper Limit	Lower Limit	Dates Valid
600m	0.5 m	January 2007

REFERENCES:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.
- (2) Operations Manual, Garmin GPS/Sounder 185.

## A-5. EPC Parameter: Dissolved Organic Carbon

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: A filtered water sample is treated with hydrochloric acid and sparged with ultra pure carrier grade air to driver off inorganic carbon. High temperature combustion (680°C) on a catalyst bed of platinum-coated alumina balls breaks down organic carbon into carbon dioxide (CO<sub>2</sub>). The CO<sub>2</sub> is carried by ultra pure air to non-dispersive infrared detector (NDIR) where CO<sub>2</sub> is detected.

INSTRUMENTATION: Shimadzu TOC-500 total organic carbon analyzer.

### REFERENCES:

- (1) **Sugimura, T. and Y. Suzuki.** 1988. A high temperature catalytic oxidation method for the determination of non-volatile dissolved organic carbon in seawater by direct injection of a liquid sample. Mar. Chem. 24:105-131.

REPORTED UNITS: milligrams per liter (mg l<sup>-1</sup>)

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.24 mg L <sup>-1</sup>	January 2007

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### COLLECTION DEVICE:

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

### SAMPLE COLLECTION:

Samples are filtered through a 2.5 cm diameter GF/F filter pad.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, 0.7µm glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

### REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland, Solomons, MD. [UMCEES]CBL Ref. No. 89-050. p.25.
- (2) **Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H. Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.**

1998. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 98-073a.

## A-6. EPC Parameter: Dissolved Inorganic Phosphorus\*

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: A filtered water sample is reacted with ammonium molybdate and antimony potassium tartrate in an acid medium to form an antimony phosphomolybdate complex which is reduced to an intensely blue colored complex by ascorbic acid. The sample is measured colorimetrically at 880 nm using the Auto-Analyzer II.

INSTRUMENTATION: Technicon Auto-Analyzer II

### REFERENCES:

- (1) **Technicon Industrial Systems.** 1973. Ortho phosphate in water and seawater. Technicon Industrial Method No. 155-71W/Tentative. Technicon Industrial Systems, Tarrytown, NY 10591. p.6. and: United States Environmental Protection Agency. 1979. Methods for chemical analysis of water and wastes. Method #365.1. Off. Res. Devel. Cincinnati, OH. EPA-600/4-79-020.  
as modified by: **D'Elia, C.F., E.E. Connor, N.L. Kaumeyer, C.W. Keefe, K. V. Wood and C.F. Zimmerman.** 1997. Nutrient Analytical Services Laboratory Standard Operating Procedures. Technical Report Series No. 158-97. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688. p.29.
- (2) **D'Elia, C.F., P.A. Steudler and N. Corwin.** 1977. Determination of total nitrogen in aqueous samples using persulfate digestion. *Limnol. Oceanogr.* 22: 760-764.
- (3) **Valderrama, J.C.** 1981. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. *Mar. Chem.* 10:109-122.

REPORTED UNITS: micromolar ( $\mu\text{M}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Date Valid
	N/A	0.0006 mg L <sup>-1</sup>	January 2007

**\*NOTE: Water column dissolved inorganic phosphorus values are adjusted using a small correction value:**

(Dissolved Inorganic Phosphorus - (salinity x 0.000816))

### REFERENCE:

- (1) **Froelich, P.N. and M.E.Q. Pilson.** 1978. Systematic absorbance errors with Technicon Auto Analyzer II Colorimeters. *Water Research* 12:599-603.

COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION:

Samples are filtered through a 2.5 cm diameter GF/F filter pad. Approximately 15 ml is collected in 3 Auto-Analyzer (AA) vials, which are triple rinsed with sample water prior to filling with sample and immediately frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, 0.7 $\mu$ m glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland, Solomons, MD. [UMCEES]CBL Ref. No. 89-050. p.25.
- (2) **Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H. Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.** 1998. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 98-073a.

**A-7. EPC Parameter: Dissolved Oxygen**

STUDY ELEMENTS: Water Column Profile  
Spatially Intensive Water Quality Mapping (AAAmmdyyy)

COLLECTION DEVICE:  
**Water Column Profile:** Rapid Pulse - Clarke type, polarographic, Yellow Springs Instrument (YSI) 6562 DO Probe

SAMPLE COLLECTION:  
DO measurements are made *in-situ*.

An electrical current, proportional to the partial pressure of dissolved oxygen in the sample, is recorded and converted to units of milligrams per liter.

REPORTED UNITS: milligrams per liter ( $\text{mg l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	$50 \text{ mg l}^{-1}$	$0 \text{ mg l}^{-1}$	October 2003 - present

REFERENCE:  
(1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

COLLECTION DEVICE:  
**Spatially Intensive Water Quality Mapping and Continuous Water Quality Monitoring:** Rapid Pulse - Clarke type, polarographic, Yellow Springs Instrument (YSI) 6562 DO Probe

SAMPLE COLLECTION: An electrical current, proportional to the partial pressure of dissolved oxygen in the water, is recorded and converted internally to units of milligrams per liter. The water sample is pumped from approximately 50 cm depth at the stern of the research vessel and passes directly through a series of in-line sensors at a nominal flow rate of at least  $20\text{-}25 \text{ l m}^{-1}$ . The dissolved oxygen probe is located in-line and is directly exposed to a continuous flow of ambient water. Dissolved oxygen information is transmitted directly to data logger.

REPORTED UNITS: milligrams per liter ( $\text{mg l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	$50 \text{ mg l}^{-1}$	$0 \text{ mg l}^{-1}$	October 2003 - present



REFERENCE:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

## A-8. EPC Parameter: Fluorescence

STUDY ELEMENT: Spatially Intensive Water Quality Mapping (AAAmdddyyy)

COLLECTION DEVICE: Yellow Springs Instrument (YSI) 6025 Chlorophyll Probe

### SAMPLE COLLECTION:

Blue excitation light (wavelength=455 nm) is directed onto a continuous flow of water. This excitation energy source is adsorbed by chlorophyll-a and re-emitted as red light (wavelength=685 nm). This red light is detected by a photodiode and the signal is transmitted directly to the data logger. The water sample is pumped from approximately 50 cm depth at the stern of the research vessel and passes directly through a series of in-line sensors at a nominal flow rate of at least 20- 25 l m<sup>-1</sup>.

REPORTED UNITS: %FS (Full scale)

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	100%	0%	October 2003 - present

RESOLUTION: 0.1%

### REFERENCE:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

**A-9. EPC Parameter: Nitrite**

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: Nitrite in a filtered water sample is determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a reddish purple azo dye which is then measured colorimetrically at 520 nm using the Auto-Analyzer II.

INSTRUMENTATION: Technicon TrAAcs-800 Nutrient Analyzer

REFERENCES:

- (1) **Technicon Industrial System.** 1987. Technicon Industrial Method No. 818-87T. Technicon Industrial Systems, Tarrytown, NY 10591. p.4. as modified by: **D'Elia, C.F., E.E. Connor, N.L. Kaumeyer, C.W. Keefe, K. V. Wood and C.F. Zimmerman.** 1997. Nutrient Analytical Services Laboratory Standard Operating Procedures. Technical Report Series No. 158-97. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688-0038. p.14.

REPORTED UNITS: micromolar ( $\mu\text{M}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.0006 mg L <sup>-1</sup>	January 2007

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COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION:

Samples are filtered through a 2.5 cm diameter GF/F filter pad. Approximately 15 ml is collected in 3 Auto-Analyzer (AA) vials, which are triple rinsed with sample water prior to filling with sample and immediately frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, 0.7 $\mu\text{m}$  glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland, Solomons, MD. [UMCEES]CBL Ref. No. 89-050. p.25.
- (2) **Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H. Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.** 1998. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 98-073a.

## A-10. EPC Parameter: Nitrite+Nitrate

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: Filtered samples are passed through a granulated copper cadmium column to reduce nitrate to nitrite. The nitrite (originally present plus reduced nitrate) is then determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a reddish purple azo dye which is then measured colorimetrically using the Auto-Analyzer II. Nitrate concentration is obtained by subtracting the corresponding nitrite value from NO<sub>2</sub> + NO<sub>3</sub> concentration.

INSTRUMENTATION: Technicon Auto Analyzer II

### REFERENCES:

- (1) **Technicon Industrial System.** 1977. Nitrate and nitrite in water and seawater. Technicon Industrial Method No. 158-71W/A Tentative. Technicon Industrial Systems, Tarrytown, NY 10591. p.4. and: United States Environmental Protection Agency. 1979. Method No. 353.2 *in* Methods of chemical analysis of water and wastes. United States Environmental Protection Agency, Office of Research and Development. Cincinnati, Ohio. Report No. EPA-600/4-79-020. March 1979. 460pp. as modified by: **D'Elia, C.F., E.E. Connor, N.L. Kaumeyer, C.W. Keefe, K. V. Wood and C.F. Zimmerman.** 1997. Nutrient Analytical Services Laboratory Standard Operating Procedures. Technical Report Series No. 158-97. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688-0038. p.17.

REPORTED UNITS: micromolar ( $\mu\text{M}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.0007 mg L <sup>-1</sup>	January 2007

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### COLLECTION DEVICE :

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle..

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

### SAMPLE COLLECTION:

Both samples are filtered through a 2.5 cm diameter GF/F filter pad. Approximately 15

ml is collected in 3 Auto-Analyzer (AA) vials, which are triple rinsed with sample water prior to filling with sample and immediately frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, 0.7mm glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland, Solomons, MD. [UMCEES]CBL Ref. No. 89-050. p.25.
- (2) **Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H. Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.** 1998. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Ref No. [UMCES] CBL 98-073a.

## A-11. EPC Parameter: Particulate Carbon

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: Prior to analysis the pads in the aluminum foil are placed in a drying oven and dried overnight at 45C. Combustion of the sample occurs in pure oxygen under static conditions in excess of oxygen at about 950C. Detection of carbon is by thermal conductivity using a Perkin-Elmer 240-XA Elemental Analyzer.

INSTRUMENTATION: Technicon Auto Analyzer II

### REFERENCES:

- (1) **Control Equipment Corporaion.** 1986. Operating Manual for Model 240-XA Elemental Analyzer. Lowell, MA.
- (2) **D'Elia, C.F., N.L. Kaumeyer, C.W. Keefe, K.V. Wood and C.F. Zimmerman.** 1988. Nutrient Analytical Services Laboratory Standard Operating Procedures. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688. p.49.

REPORTED UNITS: micrograms per liter ( $\mu\text{g l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.0633 $\text{mg L}^{-1}$	January 2007

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### COLLECTION DEVICE:

**SAV Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION: A water sample is collected either from the DATAFLOW discharge or a Niskin bottle as outlined above. A known volume of water is filtered using a Gelman filter and a precombusted (Muffled) 2.5 cm diameter GF/F filter pad. The filter pad is folded in half inward, wrapped in aluminum foil and frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, precombusted (550 C for one hour), 0.7 $\mu\text{m}$  glass fiber filter pad.

SAMPLE PRESERVATION: Frozen < -20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory, University of Maryland, Solomons, MD. [UMCES]CBL Ref. No. 89-050. p.49.



## A-12. EPC Parameter: Particulate Nitrogen

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: Prior to analysis the pads in the aluminum foil are placed in a drying oven and dried overnight at 45C. Combustion of the sample occurs in pure oxygen under static conditions in excess of oxygen at about 950C. Detection of carbon is by thermal conductivity using a Perkin-Elmer 240-XA Elemental Analyzer.

INSTRUMENTATION: Technicon Auto Analyzer II

### REFERENCES:

- (1) **Control Equipment Corporation.** 1986. Operating Manual for Model 240-XA Elemental Analyzer. Lowell, MA.
- (2) **D'Elia, C.F., N.L. Kaumeyer, C.W. Keefe, K.V. Wood and C.F. Zimmerman.** 1988. Nutrient Analytical Services Laboratory Standard Operating Procedures. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688. p.49.

REPORTED UNITS: micrograms per liter ( $\mu\text{g l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.0105 mg L <sup>-1</sup>	January 2007

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### COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle..

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION: A water sample is collected either from the DATAFLOW discharge or a Niskin bottle as outlined above. A known volume of water is filtered using a Gelman filter and a precombusted (Muffled) 2.5 cm diameter GF/F filter pad. The filter pad is folded in half inward, wrapped in aluminum foil and frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, precombusted (550 C for one hour), 0.7 $\mu\text{m}$  glass fiber filter pad.

SAMPLE PRESERVATION: Frozen < -20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory, University of Maryland, Solomons, MD. [UMCES]CBL Ref. No. 89-050. p.49.

### A-13. EPC Parameter: Particulate Phosphorus

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: The sample is dried at 50 overnight, muffled at 550 C for 1.5 hours and cooled. Phosphorus is extracted using 1N HCl and the “phosphomolybdenum blue” complex read colorimetrically at 880 nm using the Auto-Analyzer II.

INSTRUMENTATION: Technicon Auto Analyzer II

#### REFERENCES:

- (1) **Aspila, I., H. Agemian and A.S.Y. Chau.** 1976. A semi-automated method for the determination of inorganic, organic and total phosphate in sediments. *Analyst.* 101:187-197.
- (2) **D’Elia, C.F., N.L. Kaumeyer, C.W. Keefe, K.V. Wood and C.F. Zimmerman.** 1988. Nutrient Analytical Services Laboratory Standard Operating Procedures. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688. p.49.

REPORTED UNITS: micrograms per liter ( $\mu\text{g l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.0054 $\text{mg L}^{-1}$	January 2007

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#### COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION: A water sample is collected either from the DATAFLOW discharge or a Niskin bottle as outlined above. A known volume of water is filtered using a Gelman filter and a precombusted (Muffled) 2.5 cm diameter GF/F filter pad. The filter pad is folded in half inward, wrapped in aluminum foil and frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, precombusted (550 C for one hour), 0.7 $\mu\text{m}$  glass fiber filter pad.

SAMPLE PRESERVATION: Frozen < -20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory, University of Maryland, Solomons, MD. [UMCES]CBL Ref. No. 89-050. p.49.

#### A-14. EPC Parameter: Particulate Inorganic Phosphorus

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: The sample is dried at 50 overnight. Phosphorus is extracted using 1N HCl and the “phosphomolybdenum blue” complex read colorimetrically at 880 nm using the Auto-Analyzer II.

INSTRUMENTATION: Technicon Auto Analyzer II

#### REFERENCES:

- (1) **Aspila, I., H. Agemian and A.S.Y. Chau.** 1976. A semi-automated method for the determination of inorganic, organic and total phosphate in sediments. *Analyst*. 101:187-197.
- (2) **D’Elia, C.F., N.L. Kaumeyer, C.W. Keefe, K.V. Wood and C.F. Zimmerman.** 1988. Nutrient Analytical Services Laboratory Standard Operating Procedures. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688. p.49.

REPORTED UNITS: micrograms per liter ( $\mu\text{g l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.0024 $\text{mg L}^{-1}$	January 2007

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#### COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

#### SAMPLE COLLECTION:

A known volume of water is filtered using a Gelman filter and a precombusted (Muffled) 2.5 cm diameter GF/F filter pad. The filter pad is folded in half inward, wrapped in aluminum foil and frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, precombusted (550 C for one hour), 0.7 $\mu\text{m}$  glass fiber filter pad.

SAMPLE PRESERVATION: Frozen < -20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory, University of Maryland, Solomons, MD. [UMCES]CBL Ref. No. 89-050. p.49.

**A-15. EPC Parameter: pH**

STUDY ELEMENTS: Water Column Profile  
Spatially Intensive Water Quality Mapping (AAAmmdyyy)

COLLECTION DEVICE:  
**Water Column Profile:** Yellow Springs Instrument (YSI) 6566 pH probe

SAMPLE COLLECTION:  
pH measurements are made *in-situ* with a probe.

REPORTED UNITS: Standard Units (SU)

DETECTION LIMITS: Upper Limit Lower Limit Dates Valid  
14 0 October 2003 - present

REFERENCES:  
(1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

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SAMPLE COLLECTION:  
**Spatially Intensive Water Quality Mapping:**  
Water is pumped from approximately 50 cm depth at the stern of the research vessel and passes directly through a series of in-line sensors at a nominal flow rate of at least 20 - 25 l m<sup>-1</sup>. The pH probe is located in-line and is directly exposed to a continuous flow of ambient water. pH value is transmitted directly to the datalogger. The YSI 6561 pH probe on multi-parameter water quality instrument's value is logged by the instrument.

REPORTED UNITS:

DETECTION LIMITS: Upper Limit Lower Limit Dates Valid  
14 0 October 2003 - present

REFERENCE:  
(1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

**A-16. EPC Parameter: Photosynthetically Active Radiation**

STUDY ELEMENTS: Water Column Light Attenuation Measurements  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY:

**Water Column Light Attenuation Measurements:** The LI-192SA sensor is lowered over board and measurements taken *in-situ* at several discrete water depths. Simultaneous light flux readings are measured with the LI-190SA deck sensor.

COLLECTION DEVICE: Li-Cor Li-192SA underwater quantum sensor, LI-190SA deck reference quantum sensor, LI-1400 data logger.

SAMPLE COLLECTION:

**Water Column Light Attenuation Measurements:** The Li-192SA is lowered over board and measurements taken *in-situ* at several discrete water depths. Simultaneous light flux readings are measured with the LI-190SA deck sensor to be used as a correction factor

REPORTED UNITS:  $\mu\text{M m}^{-2} \text{ sec}^{-1}$

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	$0.0 \mu\text{M m}^{-2} \text{ sec}^{-1}$	March 2003

REFERENCES:

- (1) **LI-COR Inc.** 1990. LI-COR Underwater Radiation Sensors, Type SA Instruction Manual, Publication No. 8609-57. LI-COR, Inc., 4421 Superior Street, P.O. Box 4425, Lincoln, NE 68504.



**A-17. EPC Parameter: Salinity**

STUDY ELEMENTS: Water Column Profile  
Spatially Intensive Water Quality Mapping (AAAmddyyyy)

COLLECTION DEVICE: Yellow Springs Instrument (YSI) Model probe 6560  
Temperature/Conductivity probe.

SAMPLE COLLECTION: Salinity is determined automatically by the probe, from instrument conductivity and temperature readings according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (1989).

REPORTED UNITS: parts per thousand (ppt)

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	70 ppt	0 ppt	October 2003 - present

REFERENCES:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

## A-18. EPC Parameter: Secchi Depth

STUDY ELEMENTS: Water Column Profile  
Spatially Intensive Water Quality Mapping

COLLECTION DEVICE: Secchi Disk

SAMPLE COLLECTION: A secchi disk measuring 25.5 cm\* diameter is used. The upper surface is divided into four equal quadrants and are colored so that the two quadrants opposite each other are black and the intervening ones are white.

Readings with the secchi disk are made *in-situ* without the aid of sunglasses. The secchi disk is lowered into the water and the depth at which it is no longer visible is recorded.

For use in spatially intensive water quality measurements, the secchi depth reading is taken near the stern of the vessel and the time at which the reading is taken is noted (to the second) from the Global Positioning System. This facilitates later matching of secchi depth readings with transmissometer data.

REPORTED UNITS: meters (m)

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.1 m	January 2007

REFERENCES:

- (1) **Tyler, John.** 1968. The secchi disk. *Limnol. Oceanogr.* 13(1): 1-6.

\* **Note:** *VIMS, ODU and DNR use a 20 cm Secchi disk.*

**A-19. EPC Parameter: Silicate**

STUDY ELEMENTS: Spatially Intensive Water Quality Mapping

METHOD SUMMARY: This reaction is based on the reduction of silicomolybdate in acidic solution to “molybdenum blue” by ascorbic acid. Oxalic acid is added to eliminate interference from phosphates. The silicomolybdate complex is measured colorimetrically at 660nm using the Auto-Analyzer II.

REFERENCES:

- (1) **Technicon Industrial Systems.** 1977. Silicates in water and seawater. Technicon Industrial Method No. 186-72W/B. Technicon Industrial Systems, Terrytown, NY. 10591. p2. *as modified by:* D’Elia, C.F., N.L. Kaumeyer, C.W. Keefe, K.V. Wood and C.F. Zimmerman. 1988. Nutrient Analytical Services Laboratory Standard Operating Procedures. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688. p.21.

REPORTED UNITS: micromolar ( $\mu\text{M}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.08 mg L <sup>-1</sup>	January 2007

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COLLECTION DEVICE:

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION:

The water sample is filtered using a Gelman filter and a 2.5 cm diameter GF/F filter pad. Approximately 15 ml is collected.

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.32 $\mu\text{M}$	May 1985-Present

## A-20. EPC Parameter: Temperature

STUDY ELEMENTS: Water Column Profile  
Spatially Intensive Water Quality Mapping (AAAmddyyyy)

### COLLECTION DEVICE:

**Water Column Profile:** Yellow Springs Instrument (YSI) 6560  
Temperature/Conductivity probe

### SAMPLE COLLECTION:

Temperature measurements are made with a probe on an instrument.

REPORTED UNITS: centigrade (C)

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	70 C	-5 C	October 2003 - present

### REFERENCE:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

STUDY ELEMENT: Spatially Intensive Water Quality Mapping (AAAmddyyyy)

COLLECTION DEVICE: YSI 6560 Conductivity/Temperature Probe

SAMPLE COLLECTION: Water is pumped from approximately 50 cm depth at the stern of the research vessel and passes directly through a series of in-line sensors at a nominal flow rate of at least 20 - 25 l m<sup>-1</sup>. The temperature probe is located in-line and is directly exposed to a continuous flow of ambient water. Alternatively, the probe may be attached to an instrument used for vertical profiling.

REPORTED UNITS: degrees centigrade (C)

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	>70 C	-5 C	October 2003 - present

### REFERENCE:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

**A-21. EPC Parameter: Total Dissolved Nitrogen**

STUDY ELEMENT: Spatially Intensive Water Quality Mapping

METHOD SUMMARY: This method uses the persulfate oxidation technique for nitrogen where under alkaline conditions, nitrate is the sole N product. Filtered samples are passed through a granulated copper cadmium column to reduce nitrate to nitrite. The nitrite (originally present plus nitrate) is then determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a reddish purple azo dye which is then measured colormetrically using the Auto-Analyzer II.

REFERENCES:

- (1) **D’Elia, C.F., P.A. Steudler and N. Corwin.** 1977. Determination of total nitrogen in aqueous samples using persulfate digestion. *Limnol. Oceanogr.* 22:760-764.
- (2) **Technicon Industrial System.** 1977. Nitrate and nitrite in water and seawater. Technicon Industrial Method No. 158-71W/A Tentative. Technicon Industrial Systems, Tarrytown, NY 19591. p.4. **and:** United States Environmental Protection Agency. 1979. Methods of chemical analysis of water and wastes. Method #353.2. Off. Res. Devel. Cincinnati, OH. EPA-600/4-79-020. **as modified by: D’Elia, C.F., N.L. Kaumeyer, C.W. Keefe, K.V. Wood and C.F. Zimmerman.** 1988. Nutrient Analytical Services Laboratory Standard Operating Procedures. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688. p.29.

REPORTED UNITS: micromolar ( $\mu\text{M}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.02 mg L <sup>-1</sup>	January 2007

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COLLECTION DEVICE:

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION:

A water sample is filtered using a Gelman filter and a 2.5 cm diameter GF/F filter pad. Exactly 10ml is collected in a clean test tube, which is triple rinsed with sample and immediately frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, 0.7µm glass fiber filter pad.

SAMPLE PRESERVATION: Frozen < -20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory, University of Maryland, Solomons, MD. [UMCES]CBL Ref. No. 89-050. p.25.

## A-22. EPC Parameter: Total Dissolved Phosphorus

STUDY ELEMENT: Spatially Intensive Water Quality Mapping

METHOD SUMMARY: This method uses the persulfate oxidation technique for phosphorus where under alkaline conditions, phosphorus is the sole P product. A filtered water sample is reacted with ammonium molybdate and antimony potassium tartrate in an acid medium to form an antimony-phosphomolybdate complex which is reduced to an intensely blue colored complex by ascorbic acid. The sample is measured colorimetrically at 880 nm using the Auto-Analyzer II.

### REFERENCES:

- (1) **Menzel, D.W. and N. Corwin.** 1965. The measurement of total phosphorus in seawater based on the liberation of organically bound fractions by persulfate oxidation. *Limnol. Oceanogr.* 10:280-282.
- (2) **United States Environmental Protection Agency.** 1979. Methods for chemical analysis of water and wastes. Method #365.3. Off. Res. Devel. Cincinnati, OH. EPA-600/4-79-020. *as modified by: D'Elia, C.F., N.L. Kaumeyer, C.W. Keefe, K.V. Wood and C.F. Zimmerman.* 1988. Nutrient Analytical Services Laboratory Standard Operating Procedures. Chesapeake Biological Laboratory (CBL), Box 38, Solomons, MD 20688. p.29.

REPORTED UNITS: micromolar ( $\mu\text{M}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.0015 mg L <sup>-1</sup>	January 2007

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### COLLECTION DEVICE:

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

### SAMPLE COLLECTION:

A water sample is filtered using a Gelman filter and a 2.5 cm diameter GF/F filter pad. A water sample is filtered using a Gelman filter and a 2.5 cm diameter GF/F filter pad. Exactly 10ml is collected in a clean test tube, which is triple rinsed with sample and immediately frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 2.5 cm diameter, 0.7 $\mu\text{m}$  glass fiber filter pad.

SAMPLE PRESERVATION: Frozen < -20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory, University of Maryland, Solomons, MD. [UMCES]CBL Ref. No. 89-050. p.25.



## A-23. EPC Parameter: Total Suspended Solids

STUDY ELEMENT: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: A known volume of water or water that also contains epiphytic material is filtered through pre-weighed filter pads. Filter pads are dried for one hour at 103-105 C and weighed.

### REFERENCES:

- (1) **Clesceri, L.S., A.E. Greenberg and R.R. Trussell (Editors).** 1989. Standard methods for the examination of water and water water. Method 2540.E. Am. Public Health Assoc., Washington, DC. 1268p.

REPORTED UNITS: milligrams per liter ( $\text{mg l}^{-1}$ )

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	2.4 $\text{mg L}^{-1}$	January 2007

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### COLLECTION DEVICE:

**Water Column Nutrients:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle noting the exact time of collection (to the second) from the Global Positioning System. This facilitates later matching of total suspended solids measurements with concurrent transmissometer readings from the mapping instrument.

### SAMPLE COLLECTION:

A known volume is filtered through a preweighed 4.7 cm diameter GF/F filter pad. The filter pad is folded in half inward, wrapped in aluminum foil, frozen and stored until analyzed.

FILTER TYPE/PORE SIZE: Whatman GF/F 4.7 cm diameter, 0.7 $\mu\text{m}$  glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

REFERENCES:

- (1) **Boynton, W.R., R.M. Stankelis, F.M. Rohland, J.D. Hagy III and J.M. Frank.** 1999. Ecosystem Processes Component Level 1 Interpretive Report #16. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, Solomons, MD 20688-0038. Technical Report Series No. TS-190-99.

## A-24. EPC Parameter: Turbidity

STUDY ELEMENT: Spatially Intensive Water Quality Mapping (AAAmddyyyy)

### COLLECTION DEVICE:

Yellow Springs Instrument (YSI) 6136 Turbidity Probe

### SAMPLE COLLECTION:

**Spatially Intensive Water Quality Mapping:** A filtered, single wavelength light source is passed through a 10-cm column of continuously flowing seawater. A photodiode sensor converts returns a voltage proportional to the amount of transmitted light. This voltage is sensed and recorded by the datalogger. Voltages are converted nephelometric turbidity units (NTU) via a calibration curve established in the laboratory. The water sample is pumped from approximately 50 cm depth at the stern of the research vessel and passes directly through a series of in-line sensors at a nominal flow rate of at least 20 -25 l m<sup>-1</sup>.

REPORTED UNITS: nephelometric turbidity units (NTU).

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	1000 NTU	0 NTU	October 2003 - present

### REFERENCE:

- (1) **Environmental Monitoring Systems Operating Manual; YSI 6 series: 6600 Sonde.** 2002. YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387.

**A-25. EPC Parameter: Volatile Suspended Solids**

STUDY ELEMENTS: Water Column Nutrients  
Spatially Intensive Water Quality Mapping

METHOD SUMMARY: A known volume of water or water that also contains epiphytic material is filtered through pre-weighed filter pads. Filter pads are dried overnight at 103-105 C and weighed. Filter pads are then combusted at 550 C for 90 minutes and then re-weighed. Volatile weight is determined by subtraction.

REFERENCES:

- (1) **Clesceri, L.S., A.E. Greenberg and R.R. Trussell (Editors).** 1989. Standard methods for the examination of water and water water. Method 2540.E. Am. Public Health Assoc., Washington, DC. 1268p.

REPORTED UNITS: milligrams (mg l<sup>-1</sup>)

DETECTION LIMITS:	Upper Limit	Lower Limit	Dates Valid
	N/A	0.90 mg L <sup>-1</sup>	January 2007

PRECISION:	N/A	Not determined
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COLLECTION DEVICE:

**Spatially Intensive Water Quality Mapping:** Water discharged from a short tube located immediately after the discharge from the DATAFLOW instrument is collected in a sample bottle.

SAMPLE COLLECTION:

The water sample is filtered through an untreated 4.7 cm diameter GF/F filter pad. The filter pad is folded in half inward, wrapped in aluminum foil and frozen.

FILTER TYPE/PORE SIZE: Whatman GF/F 4.7 cm diameter, 0.7µm glass fiber filter pad.

SAMPLE PRESEVATION: Frozen <-20 C

REFERENCES:

- (1) **Garber, J.H., W.R. Boynton and W.M. Kemp.** 1987. Ecosystem processes component study plan and budget for FY-88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland, Solomons, MD. [UMCEES]CBL Ref. No. 89-050. p.25.
- (2) **Boynton, W.R. and F.M. Rohland (editors); R.M. Stankelis, N.H.**

**Burger, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir.**  
1998. Ecosystem Processes Component Level 1 Interpretive Report No.  
15. Chesapeake Biological Laboratory (CBL), University of Maryland  
Center for Environmental Science, Solomons, MD 20688-0038. Ref No.  
[UMCES] CBL 98-073a.

# **APPENDIX B: SAMPLE DATA SHEETS**

**APPENDIX B:  
SAMPLE DATA SHEETS**

## **B-1. DATAFLOW VI Typical Cruise Plan: Potomac River R/V Pisces**

**4/16/07 - 4/17/07**

**Area of Operations:** Potomac River from Point Lookout, upriver to St. Georges Island.

**Scientists:** *E. M. Bailey, S.M. Moesel, L.A. Moore*

**Objectives:** Map water quality parameters that occur along inshore-offshore transects and depth gradients throughout the study region with emphases on littoral zones where SAV communities could potentially occur.

### **Cruise Schedule:**

*Monday:*

4/16/2007

0630 Prepare for departure.

0700 Depart CBL in Solomons, MD trailing boat, to Point Lookout.

0800 Deploy boat at Point Lookout boat ramp. Begin mapping in lower Potomac River (5 calibration stations) between South, West of Point Lookout and Jutland Creek. Fifteen minutes spent at each calibration station.

1400 Return to Point Lookout boat ramp, trailer back to Solomons, MD.

1500 Return to Solomons, refuel R/V Pisces and return to CBL boat basin.

1500-1700 Transfer water samples to Nutrient Analytical Services Laboratory and download data from logger.

*Tuesday:*

4/17/2007

0630 Prepare for departure.

0700 Depart CBL, trailing boat, to Marshall Hall .

0930 Deploy boat at Marshall Hall boat ramp. Begin mapping in upper Potomac River (6 calibration stations) between Smallwood State Park and Blue Planes Sewage Treatment Plant. Fifteen minutes spent at each calibration station.

1500 Return to Smallwood State Park boat ramp, trailer back to Solomons, MD.

1730 Return to Solomons, refuel R/V Pisces and return to CBL boat basin.

1730-1930 Transfer water samples to Nutrient Analytical Services Laboratory  
and download data from logger



## **B-2. Spatially Intensive Water Quality Mapping: Calibration Stations.**

Approximately 11 stop stations are planned to obtain measurements for field calibrations of the fluorometer and transmissometer. At each stop station we will:

- (1) Record time of arrival from GPS.
- (2) Record approximate wind speed and direction.
- (3) Take Secchi Depth reading, noting exact time of reading from GPS.
- (4) Take series of PAR measurements (0.1, 0.25, 0.5, 0.75 1.0 m).
- (5) Take dissolved oxygen, salinity, temperature, pH, chlorophyll, and turbidity profile of the water column.
- (6) Collect water to filter full-suite nutrient analysis in the laboratory.

### Water column profile using second sonde:

Collect the 0.5 m readings first. Record the exact minute that the 0.5 m readings are collected as the start time. You must also simultaneously collect the whole water sample for Chlorophyll and Nutrient analysis at this time. Then lower the sonde to the bottom and take readings 0.3 m above the bottom and every 0.5 m or 1.0 m intervals to the surface depending on the total depth (see below).

### If total depth is < 3 m.:

Instrument readings will be collected at 0.5 m from the surface and at 0.5 m intervals, and 0.3 m above the bottom.

### If total depth is 3 m. or > than 3 m.:

Instrument readings will be collected at 0.5 m from the surface and at 1.0 m intervals, and 0.3 m above the bottom.

### Light Measurements:

#### **Equipment Needed:**

1. Secchi Disk with Cable.
2. Li-Cor Light Meter System:
  - LI-192SA, flat cosine Underwater Quantum Sensor
  - LI-190SA air (deck) reference sensor
  - Data Logger (LI-1400)

Procedure (Michael, et al., 2004.)

### Shallow Water Monitoring (Data Flow)

Light attenuation profiles are performed in shallow waters for SAV habitat assessment. The following procedure is prescribed for correlating with in-vivo turbidity data (i.e., from water quality mapping and fixed continuous monitors). Record PAR at a depth of 0.1, 0.25, 0.5, 0.75, and 1.0 meter.

PAR is determined from the sunny (or unshaded) side of a vessel or pier during daylight

hours. Both deck and submersed probes must be away from the shadow of the vessel.

Check the sensor operation by connecting the deck sensor and underwater sensor to the corresponding ports of the Li- Cor data logger, and turn the power on. Check battery level. Cover the sensor and check to see if the output is very near zero. Place the sensor under a light source to assure that it has a positive reading. A negative reading indicates that the polarity of the sensor is reversed (i.e. the sensor is plugged into the cable backwards.) A very positive or negative reading in the dark indicates a possible short in the cable or some other electrical short.

In the field, mount the deck sensor in a location which is level and unobstructed by shadows. Ensure that sensors are positioned properly on the deck sensor mounting and the lowering frame. Connect deck sensor and underwater sensor to corresponding ports of the data logger, and turn the power on.

Set instrument averaging constant to display results from previous 10 or 15 seconds.

Lower the frame until the sensor is just below the surface of the water. At a depth of 0.1 meter (~4 inches), simultaneously record the deck sensor and the underwater readings for the "surface" measurement. If wave action prevents this, take the initial reading at 0.5 meters. Depth of the underwater sensor diffuser below the surface of the water is determined with a calibrated pole or non-stretching rope.

Lower the frame and take subsequent measurements at depths appropriate to the monitoring location and purpose of the project (see above). Allow the instrument output to stabilize, at least for the averaging period, and record both deck and underwater readings at each depth.

The simultaneous deck and submersed readings are stored by pressing "Enter". Each record will be stored with a time stamp which will flash on the data logger readout, record this time. All readings can be subsequently retrieved at the end of the cruise.

**B-3. Location of High Resolution Surface Water Quality Mapping Calibration Stations 2007 - 2008. Other locations might be selected for the 2007 - 2008 monitoring period.**

<b>Region</b>	<b>Station</b>	<b>Latitude</b>	<b>Longitude</b>
Lower Potomac	LE2.3	38.02	-76.34
	XBF3534	38.06	-76.44
	XBG2601	38.05	-76.33
	XBF0320	38.01	-76.47
	XBF6903	37.95	-76.33
Upper Potomac	XFB0500	38.67	-77.16
	XEA6046	38.60	-77.26
	XFB8408	38.81	-77.03
	XFB0231	38.67	-77.12
	XFB2184	38.70	-77.03
	TF2.3	38.61	-77.17



## **B-5. High Resolution Surface Water Quality Mapping Measurements Data Handling**

### **FILE NAME: AAAmddyyyy:**

Excel file, the name follows a 12 part descriptor, consisting of an identification of the data set, the location of the data, the data type and date: where AAA = Tributary (POT = Potomac River) mddyyyy = date: month, day, year.

### **MEASUREMENTS:**

Date, time, latitude, longitude for each record of water temperature, salinity, dissolved oxygen, total chlorophyll-*a*, fluorescence and transmissometer values. Due to the large quantity of data not hard copy will be provided. Datafile may have fields added at the discretion of DNR personnel as shallow water quality monitoring protocols are adapted during FY 2005.

### **PARAMETERS:**

DATE	YYYYMMDD, Year, Month, Day
TIME	HHMMSS, Hours, Minutes, Seconds
LATITUDE	DD.DDDD, Degrees North Latitude
LONGITUDE	DD.DDDD, Degrees West Longitude
TOTAL DEPTH	meters (m)
BATT	voltage (V)
TEMPERATURE	degrees Celsius (C)
SPECIFIC CONDUCTANCE	millisiemens per centimeter (mS/cm)
SALINITY	parts per thousand (ppt)
DO %	percentage (%)
DO CONC	milligrams per liter (mg l <sup>-1</sup> )
TURBIDITY	nephelometric turbidity units (NTU)
TOTAL CHLOROPHYLL-A	micrograms per liter (µg l <sup>-1</sup> )
FLUORESCENCE	(%FS)

High Resolution Surface Water Quality Mapping Data Verification and Management Procedures (Michael, et al., 2004.)

- 1) Open raw .txt file created by DATAFLOW / Labview Software in Excel
- 2) Use the file naming convention of the segment three-letter designation followed by the two digit month, the two-digit day and the four-digit year and save the raw data file.
- 3) Delete all data that were taken when the boat was docked at the start and end of the cruise. Remove all data that has no associated GPS coordinate data, or data that are instrument error codes or 'garbage' characters.

4) Run the QA/QC macro by clicking the "REARRANGE DATAFLOW DATA" button on the "DNR DATAFLOW" tab of the macro dialog. When this button is clicked, the existing data columns are rearranged, new data columns are added, and error code columns are added. Error code fields are designated by the suffix "\_A". The columns are ordered as follows:

SAMPLE\_DATE  
SAMPLE\_TIME  
STATION  
WATER\_BODY  
PRI\_SEG  
SONDE  
LATITUDE  
LONGITUDE  
TOTAL\_DEPTH  
TOTAL\_DEPTH\_A  
BOAT\_SPEED  
BOAT\_SPEED\_A  
BATT  
BATT\_A  
WTEMP  
WTEMP\_A  
SPCOND  
SPCOND\_A  
SALINITY  
SALINITY\_A  
DO SAT  
DO SAT\_A  
DO  
DO\_A  
PH  
PH\_A  
TURB\_NTU  
TURB\_NTU\_A  
FLUOR  
FLUOR\_A  
TCHL\_PRE\_CAL  
TCHL\_PRE\_CAL\_A  
CHLA  
CHLA\_A  
COMMENTS

5) When clicked, the "REARRANGE DATAFLOW DATA" button also flags negative values with the GNV error code, flags missing data with the NND error code, highlights values outside of set tolerance levels in red, and returns an overview summary of exceedances (Table B5-1). Tolerance levels are purposefully large to accommodate the diversity of data collected throughout Maryland's diverse estuaries and Chesapeake Bays.

**Table B-5-1. Tolerances automatically checked by macro.**

<b>Parameter</b>	<b>Tolerance</b>
BATT	<4 and >20
WTEMP	>35
SPCOND	>50
SAL	>35
DO_SAT	>200
DO	>17.5
PH	<2 and > 10.5
TURB	>150
FLUOR	>50
TCHL_PRE_CAL	>200

Enter the Date, Station, Water Body, Primary Segment and Sonde information for the deployment being reviewed into the macro dialog box and click "ADD DATAFLOW FIELDS". This inserts these parameters into each record.

6) Flagging Values with the *QA/QC* Macro:

Sound data management practices dictate that data should never be deleted. As such, we employ a data management system in which all original data values are retained in the database, but erroneous data are masked with an error code (see Appendix 13 for list of error codes). Each parameter value field also has an error code field associated with it and is designated with the suffix "\_A" (e.g., DO\_A). Error codes should only be written to the error code fields. Comments should only be written to the COMMENTS field. Because the data file is comma separated, a comma should never be used to separate comments in the COMMENTS field; a semi-colon can be used instead. The following steps outline how the *QA/QC* Macro can be used to insert error codes and comments.

- a) Go to the "CODE ENTRY" tab of the *QA/QC* macro to access all of the tools necessary to enter error codes and comments in selected cells (Figure A14\_3).
- b) Use the "SELECT CELLS" box to select the cells of the spreadsheet in

which you want to enter error codes or comments.

c) After the cells have been selected, choose a "PREDEFINED CODE" or "CUSTOM CODE" by selecting the appropriate button.

NOTE: Custom codes should only be used for comments. They should never be used for error codes because the database only recognizes predefined error codes.

d) Select either a "PROBE SPECIFIC", "GENERAL PROBE", "NON-PROBE" or "COMMENTS" code by clicking the appropriate radio button, or if applicable, type in a custom comment.

e) Select the appropriate code and click the "ENTER CODE" button.

f) Repeat Steps b-e as necessary.

7) Using the procedures outlined above in Step 7 to flag data, identify any suspicious data by inspecting the values flagged in red and the original data graphed in EcoWatch. Common anomalies include abnormal spikes in chlorophyll and turbidity, abnormal dips in specific conductance, and abnormally high dissolved oxygen readings due to high dissolved oxygen charge. Post-calibration and in-situ field checks should also be used to identify when probes are reading incorrectly.

*NOTE: Do not be too quick to flag data. Flagging data is necessary to remove obvious outliers from the data set. Strange things can and do occur in Maryland waters, and we do not want to flag an anomaly just because it seems out of place. Anomalies should be identified, but must not be flagged unless there is proper justification. If you feel a period of data is questionable, but should not be excluded, keep it unflagged in the data set, but mention it in the comments field.*

8) Once all of the error codes and comments have been entered into the data file, close the macro and save the file as a Comma Separated Value (.CSV) file using the same naming convention as above with a "Q" added to the end (e.g., SEVO5242004Q.csv).

The resulting .CSV file can then be imported into DNR's database.

There should be two files when a data set is complete. In our example, these files would be:

PAX05172005.csv (Raw data - no editing),

PAX05172005Q.csv (Final QAIQC'd file with erroneous data masked)



# **APPENDIX C DATA ERROR CODES**

**APPENDIX C  
DATA ERROR CODES**

### Analysis Problem Codes

AGENCY CODE (see note)	ANALYSIS PROBLEM CODE	DESCRIPTION
DNR	A	Laboratory accident
DNR	B	Interference
DNR	C	Mechanical/materials failure
DNR	D	Insufficient sample
DNR	N	Sample Lost
DNR	P	Lost results
DNR	R	Sample contaminated
DNR	S	Sample container broken during analysis
DNR	V	Sample results rejected due to QA/QC criteria
DNR	W	Duplicate results for all parameters
DNR	X	Sample not preserved properly
EPC	AA	Sample thawed when received
DNR	BB	Torn filter paper
EPC	DA	Damaged epiphyte array
EPC	DS	Damaged epiphyte strip
EPC	EE	Foil pouch very wet when received from field, therefore poor replication between pads, mean reported
EPC	EN	Value corrupted by electronic noise
EPC	ES	Position or depth information interpolated due to missing GPS scan
DNR	FF	Poor replication between pads; mean reported
EPC	HD	Particulate and chlorophyll- <i>a</i> samples only taken at -1.0 cm of the Eh profile
DNR	HH	Sample not taken
DNR	JJ	Amount filtered not recorded (Calculation could not be done)
EPC	LA	Lost epiphyte array
EPC	LF	All parameters set as missing because instrument flow rate was too low
DNR	LL	Mislabeled
EPC	LS	Lost epiphyte strip
EPC	NI	Data for this variable are considered to be non-interpretable
DNR	NN	Particulates found in filtered sample
EPC	NR	No replicate analyzed for epiphyte strip chlorophyll- <i>a</i> concentration
DNR	PP	Assumed sample volume (pouch volume differs from data sheet volume; pouch volume used)
EPC	PW	Excess turbidity caused by research vessel prop wash at shallow stations

### Analysis Problem Codes (Continued)

AGENCY CODE (see note)	ANALYSIS PROBLEM CODE	DESCRIPTION
DNR	QQ	Although value exceeds a theoretically equivalent or greater value ( <i>e.g.</i> , PO4F>TDP), the excess is within precision of analytical techniques and therefore not statistically significant.
EPC	SD	All sampling at station discontinued for one or more sampling periods
***	SS	Sample contaminated in field
EPC	SW	Shallow water, light flux measured at two points only
EPC	TF	Dissolved oxygen probe failure
EPC	TL	Instrument failure in research laboratory
EPC	TS	Dissolved oxygen probe not stabilized
EPC	TT	Instrument failure on board research vessel
DNR	UU	Analysis discontinued
***	WW	Station was not sampled due to bad weather conditions, research vessel mechanical failure, VFX array lost or failure of state highway bridge to open or close
DNR	XX	Sampling for this variable was not included in the monitoring program at this time or was not monitored during a specific cruise
EPC	YB	No blank measured for MINI-SONE fluxes
EPC	YY	Data not recorded

**NOTE:**

**DNR** = Codes used in this study which were identical to those listed in Analytical Problem Codes (APC;) **Michael, B., M. Trice and C. Trumbauer.** 2006. Quality Assurance Project for the Maryland Department of Natural Resources Chesapeake Bay Shallow Water Quality Monitoring Program. Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, Annapolis, MD.

**CBL** = New codes added which are used in the EPC program.

**\*\*\*** = This code is use in both DNR and EPC program but has a different meaning, further clarification is necessary.

**Shallow Water Quality Monitoring Error Codes**  
(Michael, et al., 2006)

Category	Code	Description	Immediate Data Impacts	Suggested Uses
Specific Probe Codes	PSW	Salinity Calibrated at the Wrong Level	Data Invalid – Hide Data Value	
Specific Probe Codes	PDP	DO Poisoning (Anoxia)	Data Invalid – Hide Data Value	Membrane Degraded Due to Low DO
General Probe Codes	GBO	Blocked Optic	Data Invalid – Hide Data Value	Extreme Single-Point Turbidity and Chlorophyll Spikes
General Probe Codes	GWM	Wiper Malfunction	Data Invalid – Hide Data Value	Evident Biofouling on Optics
General Probe Codes	GWL	Wiper Lost	Data Invalid – Hide Data Value	
General Probe Codes	GSC	Seal Compromised	Data Invalid – Hide Data Value	
General Probe Codes	GPF	Probe Failure	Data Invalid – Hide Data Value	
General Probe Codes	GPC	Post Calibration Out of Range	Data Invalid – Hide Data Value	
General Probe Codes	GNV	Negative Value	Data Invalid – Hide Data Value	
Non-Probe Codes	NPF	Power Failure	Data Invalid – Hide Data Value	
Non-Probe Codes	NOW	Instrument Out of the Water	Data Invalid – Hide Data Value	
Non-Probe Codes	NNF	Ram Clogged / No Flow	Data Invalid – Hide Data Value	Water Quality Mapping Specific
Non-Probe Codes	NND		Data Invalid – Hide Data Value	Missing Data Values
Non-Probe Codes	NIS	Invalid Data Due To Incorrect YSI Setup	Data Invalid – Hide Data Value	
Non-Probe Codes	NIR	Instrument Removed	Data Invalid – Hide Data Value	Instrument Removed from Water for Short Duration (Within a Deployment)
Non-Probe Codes	NQR	Data Rejected Due To QA/QC Checks	Data Invalid – Hide Data Value	

### Shallow Water Quality Monitoring Error Codes (Continued)

Category	Code	Description	Immediate Data Impacts	Suggested Uses
Comments	CTS	Time Skip	Comment – No Impact on Data Value	Improper Time Recording By Sonde
Comments	CBF	Biofouling	Comment – No Impact on Data Value	
Comments	CWD	Instrument at Wrong Depth (Depth Value)	Comment – No Impact on Data Value	Continuous Monitoring Specific
Comments	CTF	Temperature Probe Failure	Comment – No Impact on Data Value	
Comments	CSW	Salinity Calibrated at the Wrong Level	Comment – No Impact on Data Value	
Comments	CLF	Flow Low	Comment – No Impact on Data Value	Water Quality Mapping Specific
Comments	CDB	Disturbed Bottom	Comment – No Impact on Data Value	Field Observation
Comments	CTC	Time Change	Comment – No Impact on Data Value	NA to Data Post 2003
Comments	CTW	Turbid Water	Comment – No Impact on Data Value	Field Observation
Comments	CFK	Fish Kill	Comment – No Impact on Data Value	Field Observation
Comments	CSC	Site Location Change	Comment – No Impact on Data Value	Continuous Monitoring Specific
Comments	CAS	Algal Sample Taken (Sample #)	Comment – No Impact on Data Value	Field Observation
Comments	CAB	Algal Bloom – No Sample Taken	Comment – No Impact on Data Value	Field Observation

# **APPENDIX D LOG OF SIGNIFICANT CHANGES**

**APPENDIX D  
LOG OF SIGNIFICANT CHANGES**

### Log of Significant Changes

DF = DATAFLOW

Date Initiated	Program	Description
03/07/08	DF	Station XBF0956 renamed XBF7254 by MDDNR; location not changed