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STANDARD OPERATING PROCEDURES FOR MANAGING LIVING RESOURCE MONITORING DATA AT THE CHESAPEAKE BAY PROGRAM

Chesapeake Bay Program
A Watershed Partnership

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A. Project Management

Section A4: Project Staff and Organization

The project participants are responsible for the creation, QA/QC, data verification and maintenance of living resource (biological) monitoring databases and participation in data analysis projects involving these databases. Management and interpretation of living resource data is a cross-disciplinary effort and involves coordination with a number of different teams within the Bay Program. The intended users of the biomonitoring databases and analysis products of this project are numerous. The chief clients are the CBP Goal Implementation teams, the environmental management agencies in the Chesapeake Bay watershed (local, state and federal) and the regions academic community and the public at large.

Project Staff

Jacqueline Johnson, Living Resources Data Manager/Analyst, Interstate Commission on the Potomac River Basin

Claire Buchanan, Associate Director Aquatic Habitat, Interstate Commission on the Potomac River Basin (Project Coordinator)

Grant Officer

Richard Batiuk, Associate Director for Science, Chesapeake Bay Program Office, US EPA

Chesapeake Bay Program Team leaders are not part of the direct organizational scheme for this effort but are noted below for their coordination roles.

Brian Burch, Chesapeake Bay Program Data Center Manager, US EPA

Peter Tango, Chesapeake Bay Program Monitoring and Assessment Coordinator, USGS

Mary-Ellen Ley, Chesapeake Bay Program Quality Assurance Coordinator, USGS

Section A5: Project Objective/Background

The Chesapeake Bay Program Office (CBPO) facilitates effective interaction among national, regional, state, and private programs to develop and implement comprehensive plans, programs and activities to restore and protect the nation's largest, most significant and complex estuary. The CBPO provides support to the Chesapeake Executive Council, advisory committees, the Management Board and its Goal Implementation Teams, and enables them to execute their responsibilities under the 1987 Chesapeake Bay Agreement and coordinate programs necessary to restore and protect the Bay's living resources and their supporting habitats. The CBPO encourages continual information exchange among all participating and interested parties, and facilitates coordination among state, federal, regional and local agencies whose programs affect the Chesapeake Bay and its surrounding watershed, airshed, and coastal ocean.

A critical, long term role of the CBPO has been to provide data management support to the Chesapeake Bay Program partners in order to make monitoring data more accessible to managers, modelers, and researchers through uniform database structures and documentation, and to encourage the use of monitoring data through better availability, interpretation, and reporting. All activities conducted as part of this project are being conducted in support of the Chesapeake Bay Program goals as identified in the 1983, 1987 and 2000 Chesapeake Bay Agreements , the 1988 Living Resources Monitoring Plan, the 1993 Chesapeake Bay Strategy for the Restoration and Protection of Ecologically Valuable Species, the 1996 Strategy for Increasing Basin-wide Public Access to Chesapeake Bay Information, and the 2008 Chesapeake Action Plan-Strategic Framework for Restoring and Conserving the Chesapeake Watershed.

The **Living Resources and Water Quality Data Management and Analysis Project** (Project) has traditionally focused on incorporating biological and water quality monitoring data and data analysis products into readily accessible relational databases, and performing analysis of the monitoring data for interpretation and reporting purposes. The project has also promoted development of data exchanges and distributed data archives of high value data among program partners.

Major areas of emphasis with respect to biological monitoring data have been the acquisition, processing, quality assurance, and development of the following data types:

Primary data: Primary (raw) data sets are submitted to the CBP Data Center by monitoring programs operating in the Chesapeake Bay basin (data providers). These data sets vary in their level of refinement. Data may be original laboratory or experimental data, real time monitoring data directly from the field, or quality assured data sets. Many data sets are currently available from the Data Center in "as is" condition with their existing documentation. A long-term goal of the CBP Data Center is to work with the data providers to produce primary data sets that meet or come close to CIMS standards and specifications and to de-emphasize use of primary data in favor of "CIMS compliant data."

CBP Data: All CBP data has been processed into CBP monitoring databases or CIMS compliant databases by Data Center staff or CIMS partners. All CIMS-compliant databases follow common data dictionaries and data reporting standards. Biological and living resources point data become CIMS data after they are placed in uniform, relational databases. Prior to loading data into the databases, data are rigorously checked for duplicate fields, outliers, erroneous data and other errors, and problems in the data are resolved with the data providers. Biological and living resources point data in CIMS database structures are currently stored in relational databases and as comma or pipe delimited ASCII flat files on CBP Data Center servers and the CBP-CIMS Internet home page.

Ecosystem Indicator data: Databases of technical indicators calculated from monitoring data are now becoming available. The indicators are calculated from water quality, biological and living resources CBP databases using accepted algorithms and/or GIS methods. These forms of the data are expected to be most useful to CBP participants and resource managers.

The Project has had a major influence on the establishment of CIMS and continues to be a major contributor to the CIMS effort. The Project has helped establish CIMS standards for data dictionaries, data documentation and uniform relational database designs. This document is part of the CIMS data management documentation. The Project has helped to improve the ability of data providers to produce quality data and establish a number of data providers as distributed CIMS data sites. The Project will continue placing an emphasis on development of more data analysis tools, creating indicators and document level information.

Section A6: Project Description and Schedule

A detailed description of data managed by the Project is available in the 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00). This document may also be obtained from the Chesapeake Bay Program Website at ftp.chesapeakebay.net/Pub/Living_Resources/guide2000.pdf. The document includes descriptions of the databases containing data from current (tidal and non-tidal benthos, Virginia only-phytoplankton and Fluorescence) and historic (phytoplankton, primary production, fluorescence, microzooplankton, mesozooplankton, gelatinous zooplankton) monitoring programs. Data from the tidal and non-tidal benthic monitoring programs are the primary data management focus of the Project.

Non-Tidal Benthic Monitoring Data

The non-tidal benthic database contains voluntarily reported in-stream macro-invertebrate survey data. The data were collected by natural resource agencies in Delaware, Maryland, New York, Pennsylvania, Virginia and West Virginia; Fairfax County, Virginia; Montgomery and Prince Georges counties in Maryland; the U.S. Forest Service, U.S. EPA, Virginia Commonwealth University, Maryland Stream Waders Program, and Susquehanna River Basin Commission. The benthic data derived from these sampling programs consists of sample enumerations for benthic species composition and abundances, ambient measurements of water quality parameters, and rapid assessments of habitat quality. The minimum requirement for inclusion of data sets into CBP database is that sampling procedures are modifications of the Environmental Protection Agency's Rapid Bioassessment Protocols for Use in Stream and Wadeable Rivers (Plafkin et al. 1989) and that the data be collected under an EPA approved quality assurance plans.

Data providers of non-tidal benthic data are responsible for the collection, processing, data compilation, and data quality assurance of biological monitoring data. The Living Resources Data Manger/Analyst is responsible for tracking receipt of data deliverables, final data QA checks, inclusion of data into long-term databases, and maintaining data user documentation. Non-tidal benthic data sets are received in varying increments in response to annual data calls in spring. Once data are received at the Data Center, they are inspected and undergo final processing and assurance checks before they are loaded into the long-term monitoring database. These data are currently available to the data providers and will shortly be available for dissemination to the public.

Tidal Benthic Monitoring Data

The tidal benthic monitoring program has a two-tiered sampling design consisting of monitoring at fixed and randomly selected stations. Data is currently collected by the states of Maryland and Virginia at 48 fixed sites and 250 randomly selected sites in the Chesapeake Bay and its major tidal tributaries annually. The benthic data derived from each sampling station consists of sample enumerations for benthic species composition and abundances, biomass measurements, ambient measurement of water quality parameters, and analysis of sediment quality (Table 1).

Each jurisdiction has contractors responsible for sample collection, processing, data compilation, and data quality assurance (Table 3). These same contractors are responsible for delivery of quality assured data to CBP-Data Center. The Living Resources Data Manger/Analyst is responsible for tracking receipt of data deliverables, final data QA checks, inclusion of data into long-term databases, and maintaining data user documentation. Tidal benthic data is delivered in 12 month increments on an annual basis (May). Once data is received at the Data Center, they are inspected, undergo final processing and assurance checks, and are loaded into the long-term monitoring database for dissemination to the public. Once data have been accepted for public release, sign off notifications are sent to biological monitoring project officer. Ideally this data processing cycle is completed within 14 working days of receipt of a data deliverable unless the data are rejected for quality assurance failure/s and sent back to the data providers.

Tidal Plankton Monitoring Data

The current plankton-monitoring program consists of Phytoplankton and fluorescence surveys in the Commonwealth of Virginia. Data for phytoplankton are collected at 14 fixed site locations in the lower Chesapeake Bay and major Virginia tidal tributaries. The phytoplankton data consists of sample enumerations for species composition and abundances (Table 1). Picoplankton abundance measurements are also made at selected stations. The fluorescence data consists of *insitu* fluorescence measurement of chlorophyll taken over vertical profiles are taken at 24 fixed stations and horizontal transects measuring taken underway transiting between vertical stations.

The commonweath has a contractor are responsible for sample collection, processing, data compilation, and data quality assurance (Table 3). These same contractors are responsible for delivery of quality assured data to CBP-Data Center. The Living Resources Data Manger/Analyst is responsible for tracking receipt of data deliverables, final data QA checks, inclusion of data into long-term databases, and maintaining data user documentation. Tidal plankton data is delivered in three installments annually.

(January-June in October, July-September in December, October-December in April of the following year) Once data is received at the Data Center, they are inspected, undergo final processing and assurance checks, and are loaded into the long-term monitoring database for dissemination to the public. Once data have been accepted for public release, sign off notifications are sent to biological monitoring project officer. Ideally this data processing cycle is completed within 14 working days of receipt of a data deliverable unless the data are rejected for quality assurance failure/s and sent back to the data providers.

Section A7: Database Quality Objectives

Accuracy of Database

Much of the data managed by the Project contains taxonomic names and numbers of organisms found in samples. The naming of organisms is sometime problematic due to the subjective nature of taxonomic identification. The data providers are responsible for assuring the accuracy of organism identifications. The Project is responsible for assuring that data reported to the CBP Data Center are accurately placed in the database systems for dissemination to the public. Monitoring programs with mandatory data reporting requirements are subject to periodic data audits in order to maintain data accuracy. These audits are conducted by CBP and the laboratory. Random months of data are pulled from the CBP databases and compared to those in the data provider's databases.

Completeness

Data records for each data provider are routinely checked to assure that all sample results are being reported for each reporting period. The data provider must document missing data. A program of periodic data audits assures that all data reported to the CBP Data Center are maintained in the CBP databases.

Comparability

Comparability of data from multiple data providers is critical for making basin-wide assessments of ecosystem health. All data providers with mandatory data reporting requirements have designated parameters, reporting units, and CIMS standard data formats that apply to all data delivered to the Living Resources Data Manager/Analyst, as described in The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00) or the Chesapeake Bay Guidance for Data Management (October 2003).

Living resource monitoring programs are multi-state, multi-investigator, and multi-laboratory efforts and the original program objectives are not always identical. This has led to significant differences among participants in sampling design and sample enumeration techniques. The Data Manager/Analyst needs to understand the level of comparability inherent in the samples collected and processed by the different laboratories. As part of the data management effort, these differences—when known—have been documented in the data user documentation for each individual data set and in comprehensive data user guides.

Precision

Determination of the precision of taxonomic identifications is sometime problematic due to the subjective nature of taxonomic identification. Species presence/absence and abundance range checks against previous years sampling for a given month and station are performed. Additionally each data provider is required to recount 10% if all samples to assure reproducibility of counts. Recount data stored with the raw data deliveable and available to data users upon request. Accessory parameters such as sediment chemical assessment or ambient water quality parameters have routine range checks performed on the data prior to loading into the master CBP databases.

Data Resubmission

For mandatory data submitters, the data providers are required to certify the validity of their data. As part of this requirement, data providers are contractually required to correct all problems found in any data within 2 years of initial EPA sign off. However most data providers have made every attempt to correct data problems found after the two-year contractual obligation.

B. Data Acquisition and Management

Data acquisition involves receiving tidal benthic data from monitoring programs funded through CBP match programs and non-tidal benthic monitoring data funded by a variety of sources. Data from these monitoring efforts have approved quality assurance plans and are delivered to the CBP Data Center by the data providers. Once received, data sets undergo final data quality assurance checks (see individual data types for details), are compiled into CBP master databases with updated documentation updated, and released for dissemination to the public through the Chesapeake Information Management System (CIMS).

Section B9: Non-Direct Measurement (Data Acquisition Requirements)

Lower trophic level monitoring data are managed in a series related databases. Data from the now reduced or discontinued phytoplankton, primary production, microzooplankton, mesozooplankton, and gelatinous zooplankton monitoring programs are housed in the CBP Plankton Database. Data and derived indicator metrics for the tidal and non-tidal benthic monitoring programs reside in two separate benthic databases. All horizontal and vertical fluorescence data from the Chesapeake Bay Tidal Water Quality Monitoring Program and the historic Maryland Special Potomac River Surveys reside in the Chesapeake Bay Program Fluorescence Data Base. The protocols for processing each type of data into its final database are very similar. Data providers of non-tidal benthic data are responsible for the collection, processing, data compilation, and data quality assurance of biological monitoring data. The Living Resources Data Manger/Analyst is responsible for tracking receipt of data deliverables, final data QA checks, inclusion of data into long-term databases, and maintaining data user documentation. Non-tidal benthic data are received in varying increments in response to annual data calls in spring. Once data are received at the Data Center, they are inspected and undergo final processing and assurance checks before they are loaded into the long-term monitoring database. These data are currently available to the data providers and will shortly be available for dissemination to the public.

1: System and Processing Procedures

All tidal biological monitoring data are currently processed by the Living Resources Data Manager/Analyst and stored in Microsoft access or SQL Server databases residing on CBP Data Center servers. Raw data products are delivered to the CBP Data Center by the data providers. All data are placed on the CBP computer systems by the data provider at ftp://ftp.chesapeakebay.net/lr/. Upon receipt, one copy of the original unprocessed data set is archived at NAS: G:\LR\MONITOR, in directories as specified in Figures 1, 2, and 3. All data are stored in directories by data type (BENTHIC, PHYTOPLANKTON, MESOZOOPLANKTON, MICROZOOPLANKTON, NON_TIDAL_BENTHIC, PICOPLANKTON, PRODUCTION AND FLUORESCENCE) and by jurisdiction where data was collected. For data collected under CBP monitoring grants, data and information about the data are housed in the subdirectories RAW, SAS_CONVERSION, QA_DATA, and REPORTS. Note that some jurisdictions have subdirectories for separation by data provider if more than one laboratory has been used by a state. The RAW directory will contain original deliverable monitoring data from a provider. Some RAW directories will have data deliverables in subdirectories by year. The SAS_CONVERSION directory contains any SAS code generated by the data provider or the Project for the conversion of historic SAS data files into a format for inclusion into the current data deliverable formats. (Prior to 1995, SAS datasets were the standard CBP data deliverable format.) The QA_DATA directory contains quality assurance recounts of 10% of samples for count monitoring deliverable or regression of chlorophyll to fluorescence as required under monitoring contract. The REPORTS subdirectory contains any summary data reports or reports of data analysis generated by a data provider and/or provider. There are other subdirectories within LR\MONITOR for data provider quality assurance plans, miscellaneous data set, and split sample data. Note that the deliverables under discussion here include: raw data and calibration regressions, which are stored in the directories RAW and QA_DATA.

Figure 1. Data Directory Structure for the Storage of Fluorescence Monitoring Program Data

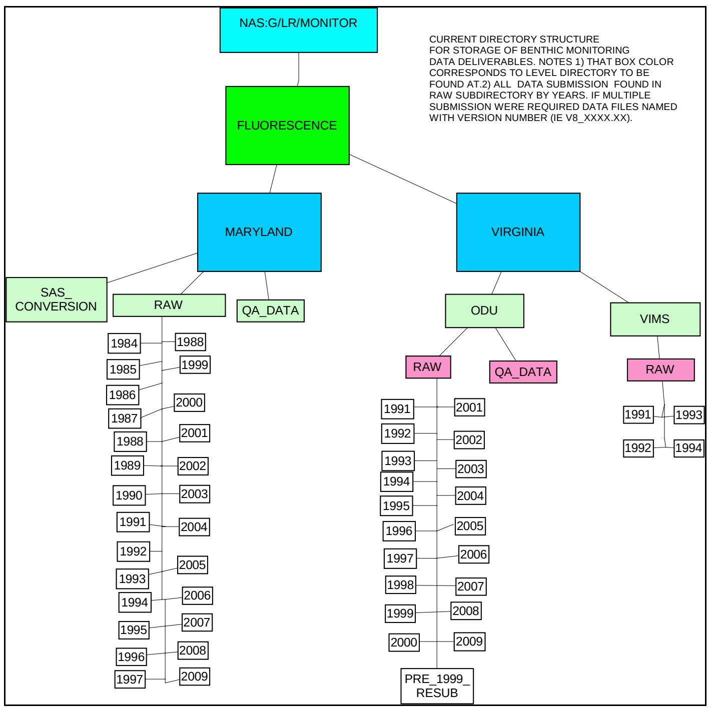


Figure 2. Data Directory Structure for the Storage of Plankton Monitoring Program Data

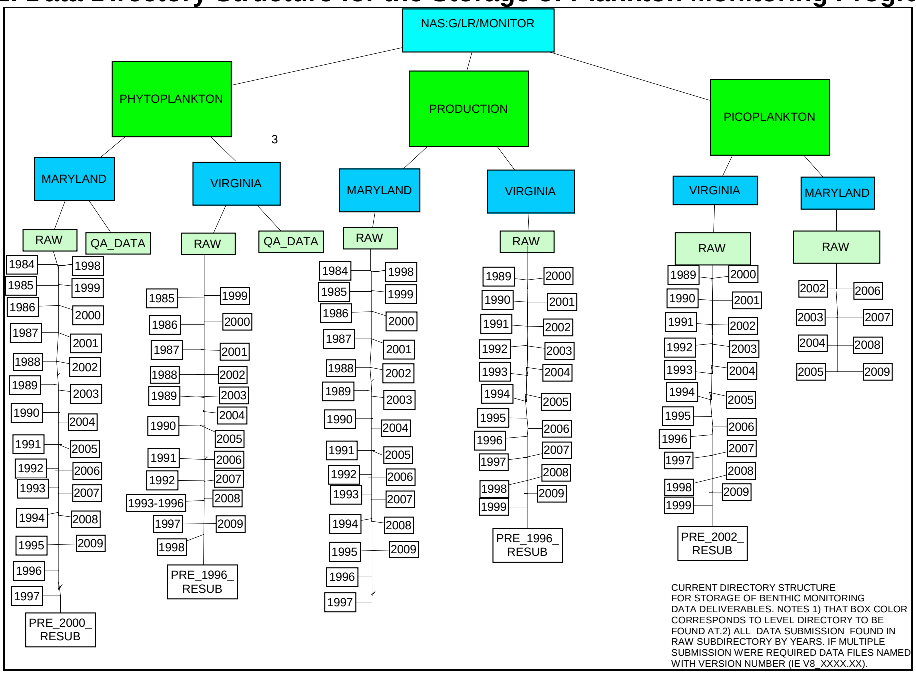


Figure 3. Data Directory Structure for the Storage of Tidal Benthic Monitoring Program Data

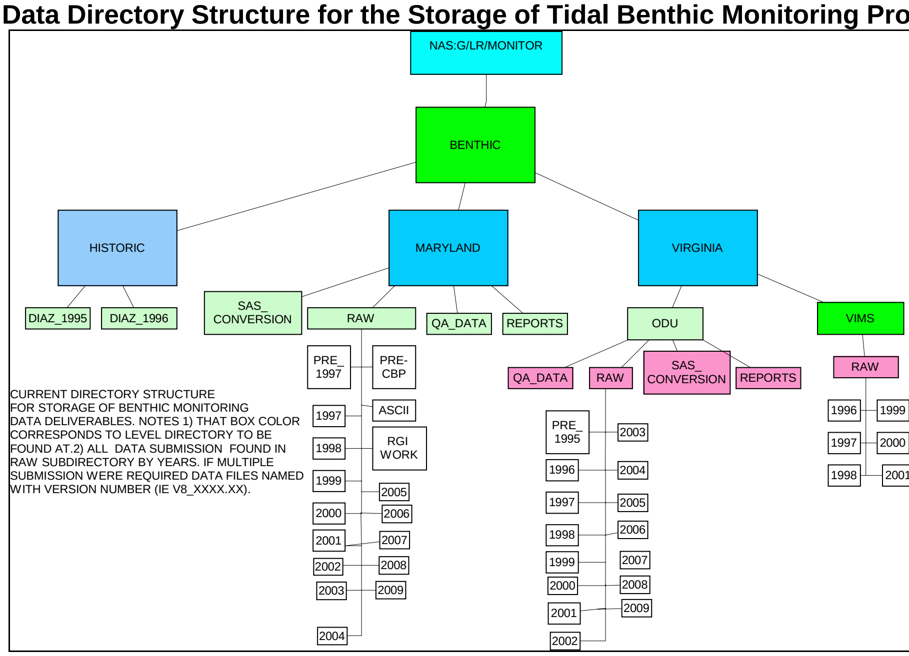
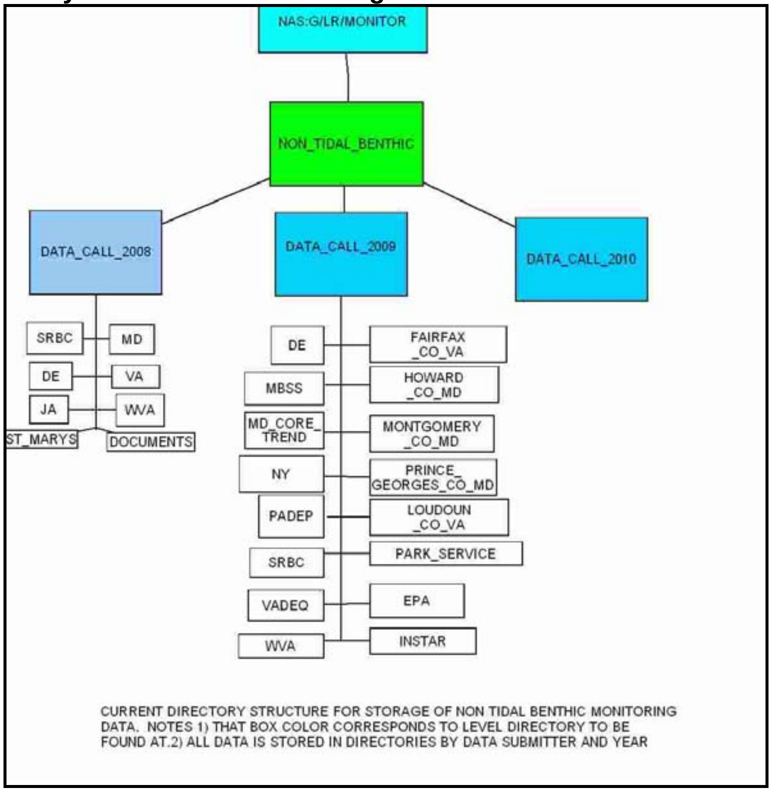


Figure 4. Data Directory Structure for the Storage of Non-Tidal Benthic Monitoring Program Data



The voluntarily reported non-tidal benthic monitoring data are handled in a manner similar to the tidal counterpart with slight differences in the structure of the archive directories (Figure 4). All data are stored in directories by data call year and submitter. Any summary data reports, data documentation, or QA plans generated by a data provider are also stored in the directory with the data.

Second copies of all data deliverables are placed on F:/jjohnson/working_data. This second copy is the working copy of a data deliverable, and these data sets are the ones processed for inclusion in the CBP databases. These raw data files are processed through working databases and used to compile the final data sets. They are located on the Data Manager's PC with CD backups found in the Data Manager's office. The final compiled data sets are loaded into their respective databases located on the CBP Servers at Gar/databases/. Once data have been successfully uploaded to the relational databases any working copies of data deliverables on F:/jjohnson/working_data are deleted.

1.1 Parameters

Parameters found in all living resources databases are listed in Table 1. Databases, parameter name and reporting units list parameters. Note extension MDB denotes Microsoft access data base, the extension MDF denotes a SQL Server data base.

Table 1. Parameters Included in Living Resource Databases.

DATABASE	PARAMETER	UNITS	NOTES
BENTHIC.MDB	AFDW	GRAMS/SAMPLE	BENTHIC BIOTA MEASURE
BENTHIC.MDB	BURROWS	COUNT	NUMBER OF BURROWS-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	CLAY	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	COUNT	NUMBER/SAMPLE	BENTHIC BIOTA MEASURE
BENTHIC.MDB	DO	MG/L	AMBIENT WATER QUALITY MEASURE
BENTHIC.MDB	DO_PSAT	PCT SATURATION	AMBIENT WATER QUALITY MEASURE
BENTHIC.MDB	GAS VOID DEPTH	CENTIMETERS	DEPTH OF GAS VOIDS-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	GAS VOIDS	COUNT	NUMBER OF GAS FILLED VOIDS-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	GRAND_SCORE	UNITLESS	CALCULATED BIBI PARAMETER
BENTHIC.MDB	INFAUNA	COUNT	NUMBER OF INFAUNA ORGANISMS OBSERVED-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	INFAUNA DEPTH	CENTIMETERS	DEPTH OF INFAUNA OBSERVED-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	INTSAL	PPT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	KURTOSIS	FOLK METHOD	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	MEANDIAM	PHI	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	MEDDIAM	PHI	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	MOIST	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	ORP	MV/CM	AMBIENT WATER QUALITY MEASURE
BENTHIC.MDB	PCT_BIO_DP05	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_CARN_OMN	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_DEPO	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PI_ABUND	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PI_BIO	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PI_F_ABUND	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PI_F_BIO	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PI_O_ABUND	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PI_O_BIO	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PS_ABUND	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PS_BIO	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PS_O_ABUND	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_PS_O_BIO	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PCT_TANYPODINI	PERCENT	CALCULATED BIBI PARAMETER
BENTHIC.MDB	PENETRATION	CENTIMETERS	GEAR PENETRATION DEPTH-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	PH	pH	AMBIENT WATER QUALITY MEASURE
BENTHIC.MDB	QUARTDEV	UNITLESS	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	RPD	CENTIMETERS	REDOX POTENTIAL DISCONTINUITY LAYER DEPTH-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	SALINITY	PSU	AMBIENT WATER QUALITY MEASURE
BENTHIC.MDB	SAND	PERCENT	BENTHIC SEDIMENT MEASURE

DATABASE	PARAMETER	UNITS	NOTES
BENTHIC.MDB	SILT	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	SILTCLAY	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	SKEWNESS	FOLK METHOD	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	SORT	FOLK METHOD	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	SORT	PHI	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	SPCOND	UMHO/CM	AMBIENT WATER QUALITY MEASURE
BENTHIC.MDB	SURFACE RELIEF	CENTIMETERS	SURFACE RELIEF-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	SW	UNITLESS	CALCULATED BIBI PARAMETER
BENTHIC.MDB	TC	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	TIC	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	TN	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	TOC	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	TOLARANCE	UNITLESS	CALCULATED BIBI PARAMETER
BENTHIC.MDB	TOT_ABUND	NUMBER/METER SQUARED	CALCULATED BIBI PARAMETER
BENTHIC.MDB	TOT_BIOMASS	GRAMS/METER SQUARED	CALCULATED BIBI PARAMETER
BENTHIC.MDB	TOT_TXA_DP05	NUMBER/METER SQUARED	CALCULATED BIBI PARAMETER
BENTHIC.MDB	TOTAL_SCORE	UNITLESS	CALCULATED BIBI PARAMETER
BENTHIC.MDB	VOLORG	PERCENT	BENTHIC SEDIMENT MEASURE
BENTHIC.MDB	WATER VOID DEPTH	CENTIMETERS	DEPTH OF WATER VOIDS-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	WATER VOIDS	COUNT	NUMBER OF WATER FILLED VOIDS-APPLIES TO HISTORIC SEDIMENT IMAGING PROGRAM
BENTHIC.MDB	WTEMP	DEGC	AMBIENT WATER QUALITY MEASURE
FLU.MDF	CHL_F	UG/L	CALCULATED FLUORESCENCE CHLOROPHYLL VALUE
FLU.MDF	VOLTS	MV	FLUOROMETER FLUORESCENCE VOLTAGE
PLANKTON.MDF	ASH_FRWT	MG/METER CUBED	APPLIES TO MEASUREMENT OF MESOOZOOPLANKTON (HISTORIC)
PLANKTON.MDF	ASH_WT	MG/METER CUBED	APPLIES TO MEASUREMENT OF MESOOZOOPLANKTON (HISTORIC)
PLANKTON.MDF	ASHFREWT	GRAMS/SAMPLE	APPLIES TO MEASUREMENT OF MESOOZOOPLANKTON (HISTORIC)
PLANKTON.MDF	ASHWT	GRAMS/SAMPLE	APPLIES TO MEASUREMENT OF MESOOZOOPLANKTON (HISTORIC)
PLANKTON.MDF	BIOVOLUME	ML/SAMPLE	APPLIES TO MEASUREMENT OF GELATINOUS ZOOPLANKTON (HISTORIC)
PLANKTON.MDF	CARBFIX	UG/L/HOUR	APPLIES TO MEASUREMENT OF PRIMARY PRODUCTION
PLANKTON.MDF	CHLA	UG/L	APPLIES TO MEASUREMENT OF CHLOPHYLL MADE WITH PRIMARY PRODUCTION
PLANKTON.MDF	COUNT	NUMBER/LITER	APPLIES TO MEASUREMENT OF PHYTOPLANKTON, PICOPLANKTON, AND MICROZOOPLANKTON (HISTORIC)
PLANKTON.MDF	COUNT	NUMBER/METER CUBED	APPLIES TO MEASUREMENT OF MESOOZOOPLANKTON (HISTORIC)

DATABASE	PARAMETER	UNITS	NOTES
PLANKTON.MDF	COUNT	NUMBER PER SAMPLE	APPLIES TO MEASUREMENT OF GELATINOUS ZOOPLANKTON (HISTORIC)
PLANKTON.MDF	COUNT	ML/ SAMPLE	APPLIES TO MEASUREMENT OF GELATINOUS ZOOPLANKTON (HISTORIC)
PLANKTON.MDF	DRY_WT	MG/METER CUBED	APPLIES TO MEASUREMENT OF MESOOZOOPLANKTON (HISTORIC)
PLANKTON.MDF	DRYWT	GRAMS/SAMPLE	APPLIES TO MEASUREMENT OF MESOOZOOPLANKTON (HISTORIC)
PLANKTON.MDF	SET_VOL	ML/METER CUBED	APPLIES TO MEASUREMENT OF GELATINOUS ZOOPLANKTON (HISTORIC)
PLANKTON.MDF	SET_VOLZ	ML/METER CUBED	APPLIES TO MEASUREMENT OF GELATINOUS ZOOPLANKTON (HISTORIC)
PLANKTON.MDF	SETVOL	ML/SAMPLE	APPLIES TO MEASUREMENT OF GELATINOUS ZOOPLANKTON (HISTORIC)
PLANKTON.MDF	SETVOLZ	ML/SAMPLE	APPLIES TO MEASUREMENT OF GELATINOUS ZOOPLANKTON (HISTORIC)
NON_TIDAL_BENTHIC.MDF	AESTH	UNITLESS	HABITAT REPORTING PARMETER-AESTHETICS
NON_TIDAL_BENTHIC.MDF	BANKS	UNITLESS	HABITAT REPORTING PARMETER-BANK STABILITY
NON_TIDAL_BENTHIC.MDF	BANKV	UNITLESS	HABITAT REPORTING PARMETER-BANK VEGETATION
NON_TIDAL_BENTHIC.MDF	CH_ALT	UNITLESS	HABITAT REPORTING PARMETER-CHANNEL ALTERATION
NON_TIDAL_BENTHIC.MDF	COVER	UNITLESS	HABITAT REPORTING PARMETER-BOTTOM SUBSTRATE & AVAILABLE COVER
NON_TIDAL_BENTHIC.MDF	EMBED	UNITLESS	HABITAT REPORTING PARMETER-EMBEDDEDNESS
NON_TIDAL_BENTHIC.MDF	EPI_SUB	UNITLESS	HABITAT REPORTING PARMETER-EPIFAUNAL SUBSTRATE
NON_TIDAL_BENTHIC.MDF	FLOW	UNITLESS	HABITAT REPORTING PARMETER-FLOW
NON_TIDAL_BENTHIC.MDF	GRAZE	UNITLESS	HABITAT REPORTING PARMETER-GRAZING
NON_TIDAL_BENTHIC.MDF	INSTR	UNITLESS	HABITAT REPORTING PARMETER-INSTREAM HABITAT
NON_TIDAL_BENTHIC.MDF	P_SUB	UNITLESS	HABITAT REPORTING PARMETER-POOL SUBSTRATE
NON_TIDAL_BENTHIC.MDF	POOL	UNITLESS	HABITAT REPORTING PARMETER-POOL/GLIDE QUALITY
NON_TIDAL_BENTHIC.MDF	REMOT	UNITLESS	HABITAT REPORTING PARMETER-REMOTENESS
NON_TIDAL_BENTHIC.MDF	RIFF	UNITLESS	HABITAT REPORTING PARMETER-RIFFLE/RUN/POOL RATIO
NON_TIDAL_BENTHIC.MDF	RIP_SC	UNITLESS	HABITAT REPORTING PARMETER-RIPARIAN VEGETATION SCORE
NON_TIDAL_BENTHIC.MDF	RIP_W	UNITLESS	HABITAT REPORTING PARMETER-RIPARIAN VEGETATION ZONE WIDTH
NON_TIDAL_BENTHIC.MDF	ROOT	UNITLESS	HABITAT REPORTING PARMETER-NUMBER OF ROOTWADS
NON_TIDAL_BENTHIC.MDF	SED	UNITLESS	HABITAT REPORTING PARMETER-SEDIMENTATION
NON_TIDAL_BENTHIC.MDF	SHAD	UNITLESS	HABITAT REPORTING PARMETER-SHADING
NON_TIDAL_BENTHIC.MDF	SINU	UNITLESS	HABITAT REPORTING PARMETER-SINUOSITY

DATABASE	PARAMETER	UNITS	NOTES
NON_TIDAL_BENTHIC.MDF	THAL	UNITLESS	HABITAT REPORTING PARMETER-THALWEG DEPTH
NON_TIDAL_BENTHIC.MDF	VEL_D	UNITLESS	HABITAT REPORTING PARMETER-VELOCITY/DEPTH RATIO
NON_TIDAL_BENTHIC.MDF	WWID	UNITLESS	HABITAT REPORTING PARMETER-WETTED WIDTH
NON_TIDAL_BENTHIC.MDF	COUNT	NUMBER PER SAMPLE	BENTHIC BIOTA MEASURE
NON_TIDAL_BENTHIC.MDF	ACIDITY	MG/L	ACIDITY
NON_TIDAL_BENTHIC.MDF	AL	MG/L	TOTAL ALUMINUM
NON_TIDAL_BENTHIC.MDF	ANC	MEQ/L	ACID NEUTRALIZING CAPACITY
NON_TIDAL_BENTHIC.MDF	AS	UG/L	TOTAL ARSENIC
NON_TIDAL_BENTHIC.MDF	BOD5W	MG/L	WHOLE 5-DAY BIOCHEMICAL OXYGEN DEMAND
NON_TIDAL_BENTHIC.MDF	CA	MG/ML	CALCIUM, TOTA;
NON_TIDAL_BENTHIC.MDF	CD	UG/L	TOTAL CADMIUM
NON_TIDAL_BENTHIC.MDF	CHLA	UG/L	ACTIVE CHLOROPHYLL-A
NON_TIDAL_BENTHIC.MDF	CLF	MG/L	TOTAL CHLORIDE
NON_TIDAL_BENTHIC.MDF	CLW	MG/L	TOTAL CHLORIDE
NON_TIDAL_BENTHIC.MDF	COD	MG/L	CHEMICAL OXYGEN DEMAND
NON_TIDAL_BENTHIC.MDF	COLOR	SU	TRUE WATER COLOR
NON_TIDAL_BENTHIC.MDF	CR	UG/L	TOTAL CHROMIUM
NON_TIDAL_BENTHIC.MDF	CU	UG/L	TOTAL COPPER
NON_TIDAL_BENTHIC.MDF	DCU	MG/L	DISSOLVED COPPER
NON_TIDAL_BENTHIC.MDF	DIC	MG/L	CARBON, INORGANIC, TOTAL
NON_TIDAL_BENTHIC.MDF	DO	MG/L	DISSOLVED OXYGEN IN MG/L
NON_TIDAL_BENTHIC.MDF	DO_SAT_P	PCT	DO SATURATION USING PROBE UNITS IN PERCENT
NON_TIDAL_BENTHIC.MDF	DOC	MG/L	DISSOLVED ORGANIC CARBON
NON_TIDAL_BENTHIC.MDF	DZN	MG/L	DISSOLVED ZINC
NON_TIDAL_BENTHIC.MDF	FCOLI_C	COL/100 ML	FECAL COLIFORMS (COLONIES)
NON_TIDAL_BENTHIC.MDF	FE_M	MG/L	TOTAL IRON
NON_TIDAL_BENTHIC.MDF	FE_U	UG/L	TOTAL IRON
NON_TIDAL_BENTHIC.MDF	FLOW_INS	CFS	STREAM FLOW; INSTANTANEOUS
NON_TIDAL_BENTHIC.MDF	HARDNESS	MG/L	HARDNESS AS CACO3
NON_TIDAL_BENTHIC.MDF	HG	UG/L	TOTAL MERCURY
NON_TIDAL_BENTHIC.MDF	K	MEQ/L	POTASSIUM, TOTAL
NON_TIDAL_BENTHIC.MDF	MGF	MG/L	DISSOLVED MAGNESIUM AS MG
NON_TIDAL_BENTHIC.MDF	MN	UG/L	TOTAL MANGANESE
NON_TIDAL_BENTHIC.MDF	NAF	MG/L	DISSOLVED SODIUM AS NA
NON_TIDAL_BENTHIC.MDF	NH4F	MG/L	AMMONIUM NITROGEN AS N (FILTERED SAMPLE)
NON_TIDAL_BENTHIC.MDF	NH4W	MG/L	AMMONIUM NITROGEN AS N (WHOLE SAMPLE)
NON_TIDAL_BENTHIC.MDF	NI	UG/L	TOTAL NICKEL
NON_TIDAL_BENTHIC.MDF	NO23F	MG/L	NITRITE+NITRATE NITROGEN AS N (FILTERED SAMPLE)
NON_TIDAL_BENTHIC.MDF	NO23W	MG/L	NITRITE+NITRATE NITROGEN AS N (WHOLE SAMPLE)
NON_TIDAL_BENTHIC.MDF	NO2F	MG/L	NITRITE NITROGEN AS N (FILTERED SAMPLE)
NON_TIDAL_BENTHIC.MDF	NO2W	MG/L	NITRITE NITROGEN AS N (WHOLE SAMPLE)

DATABASE	PARAMETER	UNITS	NOTES
NON_TIDAL_BENTHIC.MDF	NO3F	MG/L	NITRATE NITROGEN AS N (FILTERED SAMPLE)
NON_TIDAL_BENTHIC.MDF	NO3W	MG/L	NITRATE NITROGEN AS N (WHOLE SAMPLE)
NON_TIDAL_BENTHIC.MDF	PB	UG/L	TOTAL LEAD
NON_TIDAL_BENTHIC.MDF	PH	SU	PH CORRECTED FOR TEMPERATURE (25 DEG C)
NON_TIDAL_BENTHIC.MDF	PHEO	UG/L	PHEOPHYTIN
NON_TIDAL_BENTHIC.MDF	PO4F	MG/L	ORTHOPHOSPHATE PHOSPHORUS AS P (FILTERED SAMPLE)
NON_TIDAL_BENTHIC.MDF	PO4W	MG/L	ORTHOPHOSPHATE PHOSPHORUS AS P (WHOLE SAMPLE)
NON_TIDAL_BENTHIC.MDF	SALINITY	PPT	SALINITY UNITS ARE PARTS PER THOUSAND (PPT) AND ARE EQUAL TO PRACTICAL SALNITY UNITS (PSU).
NON_TIDAL_BENTHIC.MDF	SE	UG/L	TOTAL SELENIUM
NON_TIDAL_BENTHIC.MDF	SECCHI	M	SECCHI DEPTH
NON_TIDAL_BENTHIC.MDF	SIF	MG/L	SILICA AS SI (FILTERED SAMPLE)
NON_TIDAL_BENTHIC.MDF	SIW	MG/L	SILICA AS SI (WHOLE SAMPLE)
NON_TIDAL_BENTHIC.MDF	SO4F	MG/L	SULFATE
NON_TIDAL_BENTHIC.MDF	SO4W	MG/L	TOTAL SULFATE AS SO4
NON_TIDAL_BENTHIC.MDF	SPCOND	UMHOS/CM	CONDUCTIVITY CORRECTED FOR TEMPERATURE (25 DEG C) AND SALINITY
NON_TIDAL_BENTHIC.MDF	SSC_%FINE	PCT	CALCULATED PERCENT FINE SAND
NON_TIDAL_BENTHIC.MDF	SSC_TOTAL	MG/L	TOTAL SUSPENDED SEDIMENT CONCENTRATION
NON_TIDAL_BENTHIC.MDF	TALK	MG/L	TOTAL ALKALINITY AS CACO3
NON_TIDAL_BENTHIC.MDF	TDN	MG/L	TOTAL DISSOLVED NITROGEN
NON_TIDAL_BENTHIC.MDF	TDP	MG/L	TOTAL DISSOLVED PHOSPHORUS
NON_TIDAL_BENTHIC.MDF	TDS	MG/L	TOTAL DISSOLVED SOLIDS;GRAVIMETRIC;DRIED AT 180 C
NON_TIDAL_BENTHIC.MDF	TKNW	MG/L	TOTAL KJELDAHL NITROGEN (WHOLE SAMPLE)
NON_TIDAL_BENTHIC.MDF	TN	MG/L	TOTAL NITROGEN
NON_TIDAL_BENTHIC.MDF	TOC	MG/L	TOTAL ORGANIC CARBON
NON_TIDAL_BENTHIC.MDF	TOTAL_DEPTH	M	TOTAL STATION DEPTH
NON_TIDAL_BENTHIC.MDF	TP	MG/L	TOTAL PHOSPHORUS
NON_TIDAL_BENTHIC.MDF	TSS	MG/L	TOTAL SUSPENDED SOLIDS
NON_TIDAL_BENTHIC.MDF	TURB_FTU	FTU	TURBIDITY; TURBIDIMETER (FORMAZIN UNITS)
NON_TIDAL_BENTHIC.MDF	TURB_NTU	NTU	TURBIDITY; NEPHELOMETRIC METHOD
NON_TIDAL_BENTHIC.MDF	VELOCITY	M/S	CURRENT VELOCITY
NON_TIDAL_BENTHIC.MDF	WIDTH	M	TOAL STREAM CHANNEL WIDTH
NON_TIDAL_BENTHIC.MDF	WTEMP	DEG C	WATER TEMPERATURE
NON_TIDAL_BENTHIC.MDF	ZN	UG/L	TOTAL ZINC
NON_TIDAL_BENTHIC.MDF	ZNF	UG/L	DISSOLVED ZINC

1.2 Sampling Station Profile

The tidal benthic monitoring program is geographically focused on the mainstem and tidal tributaries of Chesapeake Bay. The program initially sampled at 70-fixed site in tidal waters to assess trends. The program has evolved to include both fixed site monitoring and a probability-based sampling effort. Currently, 48 fixed sites and 250 random sites are sampled annually in the mainstem and tidal tributaries of the Bay. Sampling occurs twice annually. Fixed sites are sampled in spring and summer and random strata sites are sampled in summer only. Note that in Maryland the fixed sampling sites were based on sites originally sampled as part of the historic Maryland Power Plant Siting Program and do not correspond to regular CBP monitoring stations.

The non-tidal benthic monitoring data is geographically focused on the wadeable non-tidal tributaries in the Chesapeake Bay watershed. The strategy for selection of sampling sites varies by jurisdiction and individual study. In general, there are three general types of sites: long term fixed, targeted short term, and random strata (Table 2).

The Phytoplankton and Fluorescence monitoring program have a geographic focus in the Virginia mainstem and tidal tributaries of the bay. Plankton monitoring has been performed concurrently with water quality monitoring at as many as 14 fixed site stations 12 times a year. Fluorescence measurements to approximate chlorophyll in the water column are taken both over the vertical at fixed station and horizontally while the boat is underway between fixed monitoring sites. The current *insitu* fluorescence-monitoring program has 24 fixed sites, primarily in the bays mainstem. There is currently no fluorescence monitoring in Virginia tidal tributaries associated with this Living Resource monitoring program.

Table 2. Descriptions of Non-Tidal Benthic Monitoring Site Selection Protocol.

AGENCY	PROGRAM_NAME	SAMPLING DETAILS
Delaware Department of Natural Resources and Environmental Control	Delaware Biological Monitoring Program	Sampling in the fall, ~50 sites/year, presently targeted sampling driven by TMDL investigations, some targeted sites some random sites
Fairfax County Department of Public Works and Environmental Services	Stream Quality Assessment Program	Random stratified sampling design. Probabilistic sampling of 40 randomly selected sites per year. Thirteen Reference sites are sampled each year, eleven piedmont sites and 2 coastal plain sites. Several trend sites are sampled on a rotating basis.
Howard County Department of Public Works	Biological Monitoring and Assessment Program	Random stratified sampling on a five-year rotating basis. Strata based on 10 Digit HUCS, 10 sites sampled in each.
Loudoun County Department Of Building And Development	Stream Quality Assessment Program	Both probability-based (177 sites) and target (23) sites, one time assessment
Maryland Department of Natural Resources	Maryland Biological Stream Survey	Random stratified sampling design. Probabilistic sampling via 8 digit HUC sampling unit, 250 sites
Maryland Department of Natural Resources	Maryland Core/Trend Monitoring Network	Long term fixed sites sampled between July and August on an annual basis.
Montgomery County Department of Environmental Protection	Dept. of Environmental Protection	Both targeted and probability-based sampling, depending on management need. Sites selected in one of three ways using geographic and stream order stratification: 1) Reaches are randomly selected and sites are randomly chosen on the reach. 2) Reaches are targeted and sites are randomly chosen on the reach, or 3) both reaches and sites are targeted. Baseline sites are revisited on a 5-year watershed rotational basis.
New York Department Of Environmental Conservation	Routine Statewide Monitoring Program	RIBS (Rotating Intensive Basin Studies) network monitoring is conducted in 2-4 watersheds/yr, 5 yr sampling rotation
Pennsylvania Department of Environmental Protection	Division of Water Quality Assessment and Standards	Probabilistic is rotating watersheds. Targeted for TMDLs and threatened areas.
Prince George's County Department of Environmental Resources	Programs and Planning Division	Random stratified sampling design. Probabilistic sampling via the County's 41 designated watersheds. 5-year cycle (1999-2004), approximately 255 sites. Also some targeted sites each year and special studies.

AGENCY	PROGRAM_NAME	SAMPLING DETAILS
Susquehanna River Basin Commission	Watershed Assessment and Protection	Project-dependent: rotating basin surveys every 6 years; yearly sampling at selected sites; most sampling during base flow conditions (summer/early fall)
United States Environmental Protection Agency	Wadeable Stream Assessment Program	Systematic randomized section of sites
United States Forest Service	National Forest stream assessment	Project-dependent. Reference, inventory and/or target sampling 1 time a year
Virginia Commonwealth University	INSTAR	Probabilistic site selection based on 14 digit HUC sampling unit
Virginia Department of Environmental Quality	Chesapeake Bay Monitoring Program	Reference and target sampling 2 times/year
West Virginia Department of Environmental Protection	Div of Water and Waste Management	Random and targeted sampling on a 5 yr sampling rotation

1.3 Data Sources

All tidal benthic data currently managed by the Project are collected as part of the Chesapeake Bay Water Quality Monitoring Program (WQMP). Living resource components of this program may be directly funded by EPA or funded by the states as a matching funds program. Due to ongoing monitoring program priority shifts, a number of lower trophic monitoring programs have been added and terminated over the 20 year history of the Chesapeake Bay Program. Data from both active and defunct programs reside in the CBP databases.

1.3.1 Data Sources for Active Monitoring Programs

The sources of data for the active monitoring programs are listed below. The tidal programs are described in detail in the *2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00).

Table 3. Data Sources for Active Lower Trophic Monitoring Programs

Data Type	State Agency	Geographic Area	Data Provider	Time Frame	Current Principal Investigator
Tidal Benthos	Maryland Department of Natural Resources	Mainstem and tidal tributaries in Maryland	Versar Incorporated	1984-Present	Roberto Llanso
Tidal Benthos	Virginia Department of Environmental Quality	Mainstem and tidal tributaries in Virginia	Old Dominion University	1985-Present	Dan Dauer
Non-Tidal Benthos	Delaware Department of Natural Resources and Environmental Control	Non-tidal streams in State of Delaware	Agency Staff	March 2000-Present	Ellen Dickey
Non-Tidal Benthos	Fairfax County Department of Public Works and Environmental Services	Non-tidal streams in Fairfax County Virginia	Agency Staff	April 1999-Present	Shannon Curtis
Non-Tidal Benthos	Howard County Department of Public Works	Non-tidal streams in Howard County Maryland	Multiple Contractors	March 2001-Present	Angela Morales
Non-Tidal Benthos	Loudoun County Department Of Building And Development	Non-tidal streams in Loudoun County Virginia	Versar Incorporated	One year-2009	David Ward
Non-Tidal Benthos	Maryland Department of Natural Resources	Non-tidal streams in State of Maryland	Agency Staff	May 2004-Present	Dan Boward
Non-Tidal Benthos	Montgomery County Department of Environmental Protection	Non-tidal streams in Montgomery County Maryland	Agency Staff	September 1989-Present	Keith Van Ness
Non-Tidal Benthos	New York Department Of Environmental Conservation	Non-tidal streams in State of New York	Agency Staff	July 2002-Present	Alexander J. Smith

Data Type	State Agency	Geographic Area	Data Provider	Time Frame	Current Principal Investigator
Non-Tidal Benthos	Pennsylvania Department of Environmental Protection	Non-tidal streams in State of Pennsylvania	Staff & Multiple Contractors	March 1999-Present	Brian Chalfant
Non-Tidal Benthos	Prince George's County Department of Environmental Resources	Non-tidal streams in Prince George's County Maryland	Multiple Contractors	June 1994-Present	Erik Leppo
Non-Tidal Benthos	Susquehanna River Basin Commission	Non-tidal streams in Susquehanna River Basin in New York and Pennsylvania	Agency Staff	April 1986-Present	A. Gavin
Non-Tidal Benthos	United States Environmental Protection Agency	Nation-Wide	Agency Staff	One Year-2004	Susan Holdsworth
Non-Tidal Benthos	United States Forest Service	Nation-Wide	Agency Staff	May 2000-May 2003	Dawn Kirk
Non-Tidal Benthos	INteractive STream Assessment Resource Program	Non-tidal streams in Commonwealth of Virginia	Agency Staff	January 1999-Present	Greg Garman
Non-Tidal Benthos	Virginia Department of Environmental Quality	Non-tidal streams in Commonwealth of Virginia	Agency Staff	May 1992-Present	Aimee J. Budd
Non-Tidal Benthos	West Virginia Deparment of Environmental Protection	Non-tidal streams in State of West Virgina	Agency Staff	August 1996-Present	John Wirts
Phytoplankton and Picoplankton	Virginia Department of Environmental Quality	Mainstem and tidal tributaries in Virginia	Old Dominion University	1985-Present	Harold Marshall
Fluorescence	Virginia Department of Environmental Quality	Mainstem and tidal tributaries in Virginia	Old Dominion University	1991-Present	Suzanne Dougton

1.3.2 Data Sources for Discontinued Monitoring Programs

The sources of data for the discontinued monitoring programs are listed below and described in detail in the *2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00).

Table 4. Data Sources for Terminated Lower Trophic Monitoring Programs.

Data Type	State Agency	Geographic Area	Data Provider	Time Frame	Principal Investigator
Benthic sediment Characterizations	Virginia Department of Environmental Quality	Mainstem and tidal tributaries in Virginia	Virginia Institute of Marine Sciences	1996-2001	Robert Diaz
Fluorescence	Virginia Department of Environmental Quality	Upper Mainstem in Virginia	Virginia Institute of Marine Sciences	1991-1996	Kevin Curling
Fluorescence	Maryland Department of Natural Resources	Special Potomac River Survey	Morgan State University Estuarine Research Center	1991-2002	Richard Lacouture
Mesozooplankton	Maryland Department of Natural Resources	Mainstem and tidal tributaries in Maryland	Versar Incorporated	1984-2002	William Burton
Mesozooplankton	Virginia Department of Environmental Quality	Mainstem and tidal tributaries in Virginia	Old Dominion University	1985-2002	Kent Carpenter
Microzooplankton	Maryland Department of Natural Resources	Mainstem and tidal tributaries in Maryland	Morgan State University Estuarine Research Center	1984-2002	Stella Sellner
Microzooplankton	Virginia Department of Environmental Quality	Mainstem and tidal tributaries in Virginia	Old Dominion University	1994-2002	Kent Carpenter
Phytoplankton and Picoplankton	Maryland Department of Natural Resources	Mainstem and tidal tributaries in Maryland	Morgan State University Estuarine Research Center	1984-2009	Richard Lacouture

Data Type	State Agency	Geographic Area	Data Provider	Time Frame	Principal Investigator
Primary Production	Virginia Department of Environmental Quality	Mainstem and tidal tributaries in Virginia	Old Dominion University	1994-2009	Kneeland Neisius
Fluorescence	Maryland Department of Natural Resources	Mainstem and tidal tributaries in Maryland	Morgan State University Estuarine Research Center	1991-2009	Richard Lacouture

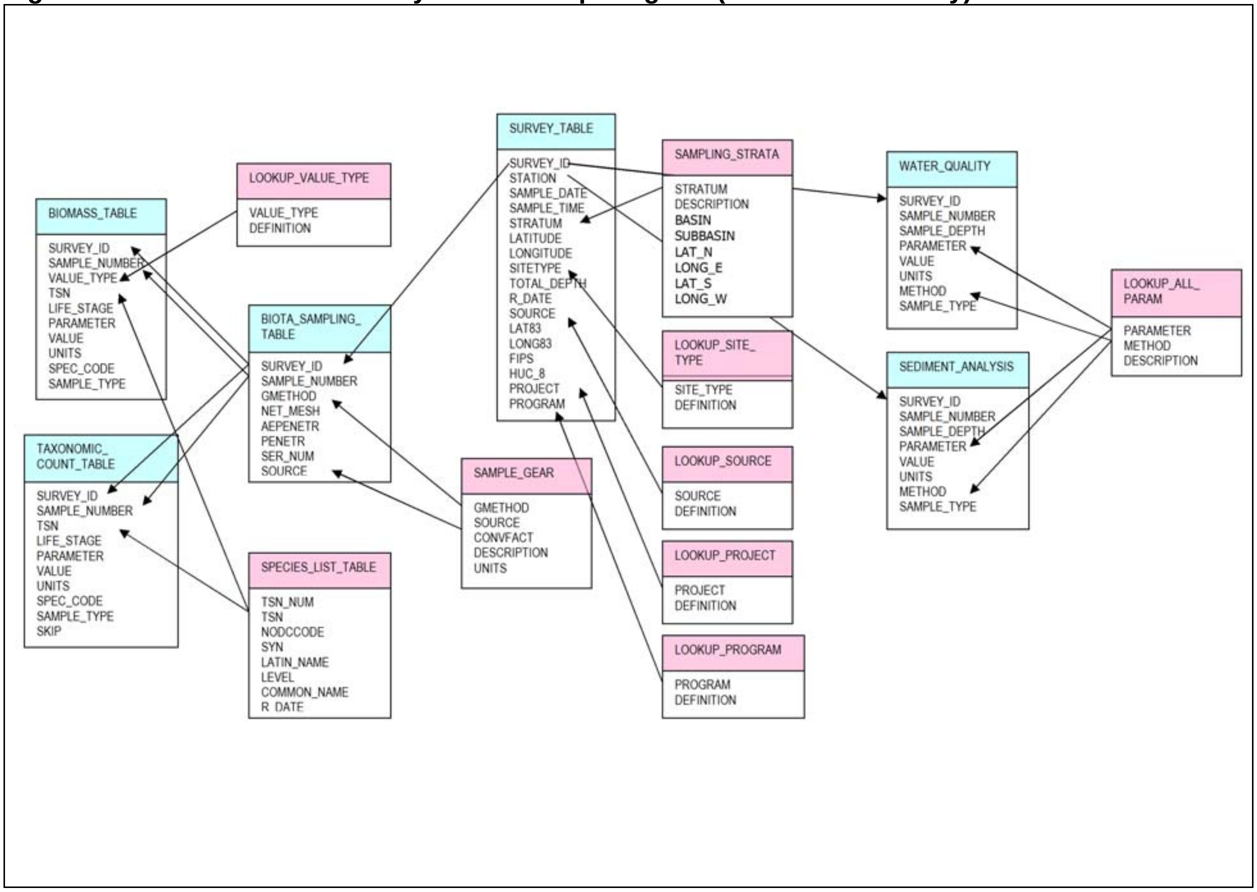
1.4 Living Resource Database Summaries

A major objective of the Project has been the development and upkeep of relational databases for the maintenance of biological monitoring data. Due to the diverse sampling protocols used in biological monitoring it was decided that data was best managed in a series of four databases with one each for fluorescence, plankton, non-tidal benthic and tidal benthic monitoring data.

1.4.1 Tidal Benthic Database Summary

The Chesapeake Bay program Benthic database contains data from soft bottom benthic macroinvertebrate samples collected in the mainstem and tidal tributaries of Chesapeake Bay, the Benthic Sediment imaging program, assorted historic soft bottom benthic surveys, and summary Benthic Index of Biotic Integrity data. Only data from the regular soft bottom benthic monitoring is currently being added to the database. This database is composed nine primary data table (SURVEY_TABLE, BIOMASS_TABLE, BIOTA_EVENT_TABLE, TAXONOMIC_TABLE, WATER_QUALITY_TABLE, SEDIMENT_ANALYSIS, IBI_METRICS, PHOTO_EVENT_TABLE AND PHOTO_ANALYSIS_TABLE) and twenty-nine other “look up” and data processing tables, which are linked to the primary tables. The relationships between these tables are shown in Figure 6. Extensive technical detail explaining the data fields, tables, rules of referential integrity and other data quality controls can be found in the document *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* available online at ftp://ftp.chesapeakebay.net/Pub/Living_Resources/benth/ RDBMS.PDF.

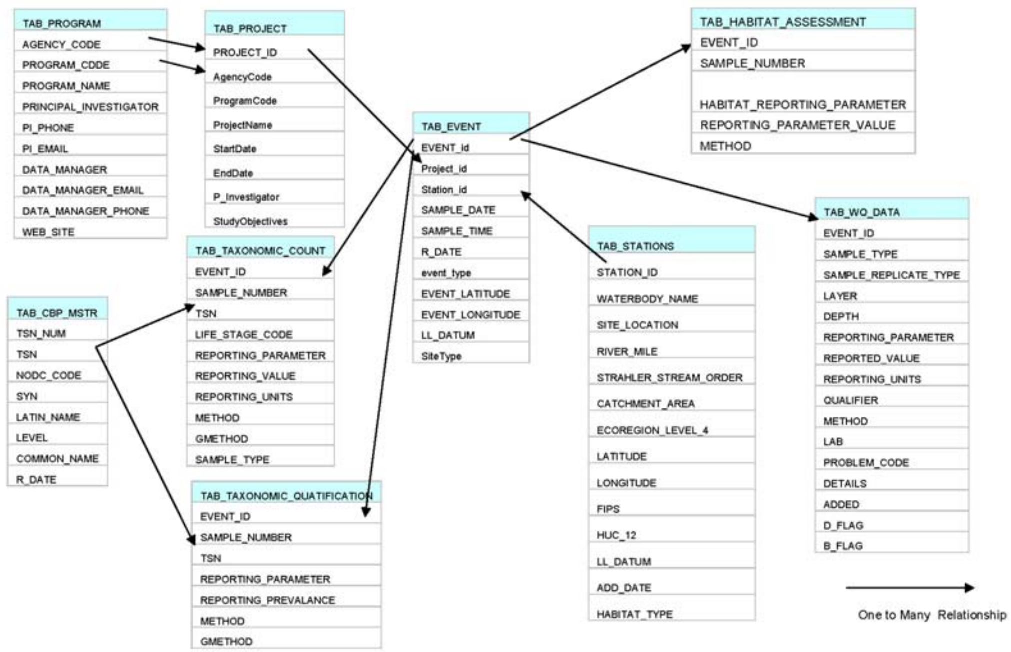
Figure 5. Benthic Database Entity Relationship Diagram (Active Tables Only)



1.4.2 Non-Tidal Benthic Database Summary

The CBP Non-Tidal Benthic database contains data from the soft bottom benthic macroinvertebrate samples collected in wadeable streams and rivers in the non-tidal tributaries to Chesapeake Bay, habitat parameter scores, some water quality parameters, and summary Benthic Index of Biotic Integrity data. This database is composed nine primary data table (TAB_PROGRAM, TAB_PROJECT, TAB_EVENT, TAB_STATION, TAB_HABITAT_ASSESSMENT, TAB_WQ_DATA, TAB_CBP_MSTR, TAB_TAXONOMIC_COUNT AND TAB_TAXONOMIC_QUANTIFICATION) and twenty-nine other "look up" and data processing tables linked to the primary tables. The relationships between the major tables are shown in figure 6. Extensive technical detail explaining the data fields, tables, rules of referential integrity and other data quality controls are available on request.

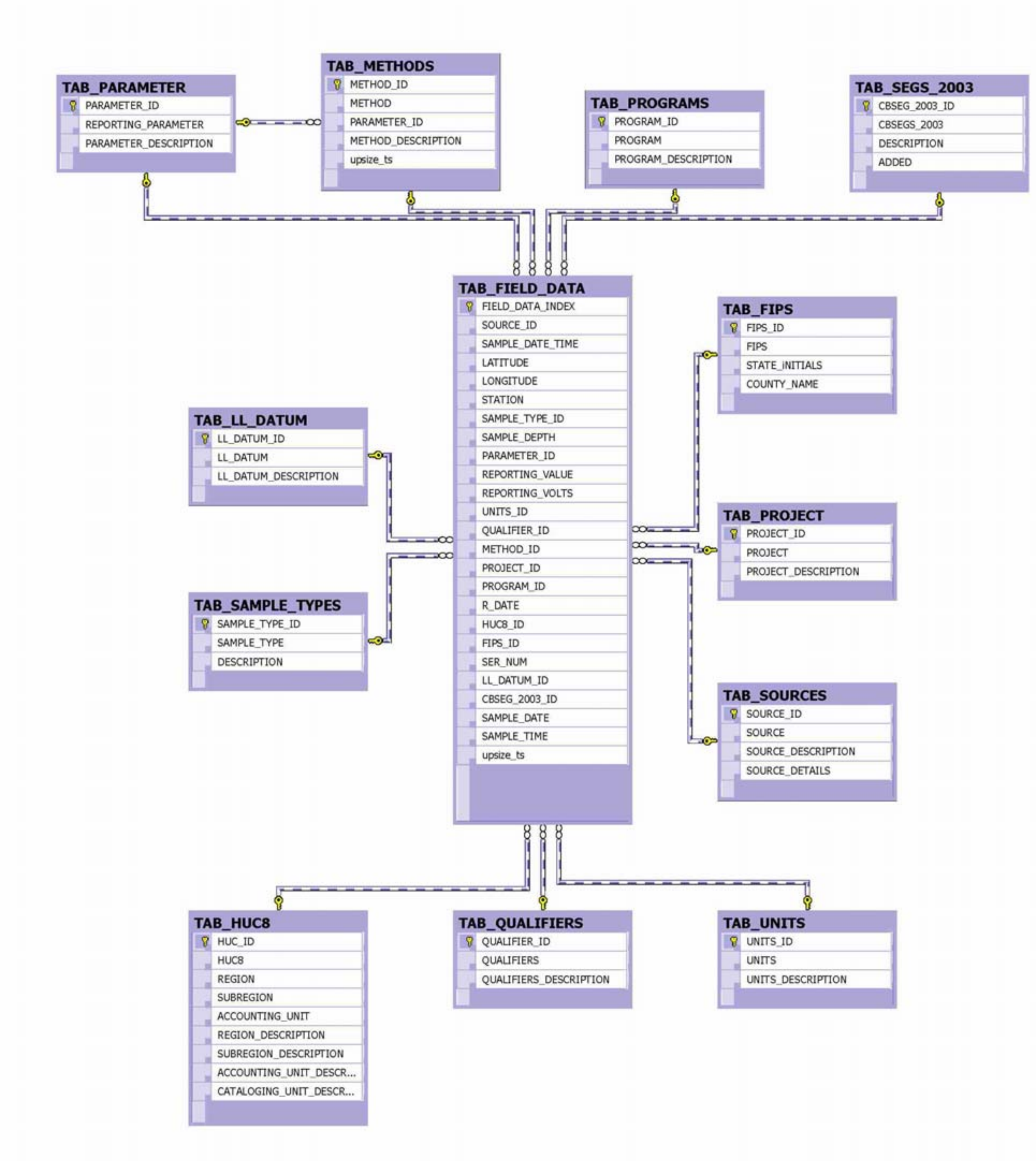
Figure 6. Non-Tidal Benthic Database Entity Relationship Diagram (Active Tables Only)



1.4.3 Fluorescence Database Summary

The Chesapeake Bay program fluorescence database contains data derived from the horizontal and vertical fluoresce surveys done in the mainstem and tidal tributaries of Maryland including the historic special Potomac surveys. This database is composed one primary data table (FIELD_DATA TABLE) and nine other “look up” tables, which are linked to the primary table. The relationships between tables are shown in figure 7. Extensive technical detail explaining the data fields, tables, rules of referential integrity and other data quality controls can be found in the document *Fluorescence Monitoring Database, Version 2.0, A Database Design and Data Dictionary,* which can be found at ftp://ftp.chesapeakebay.net/Pub/Living_Resources/fluor/Flurdbms.pdf.

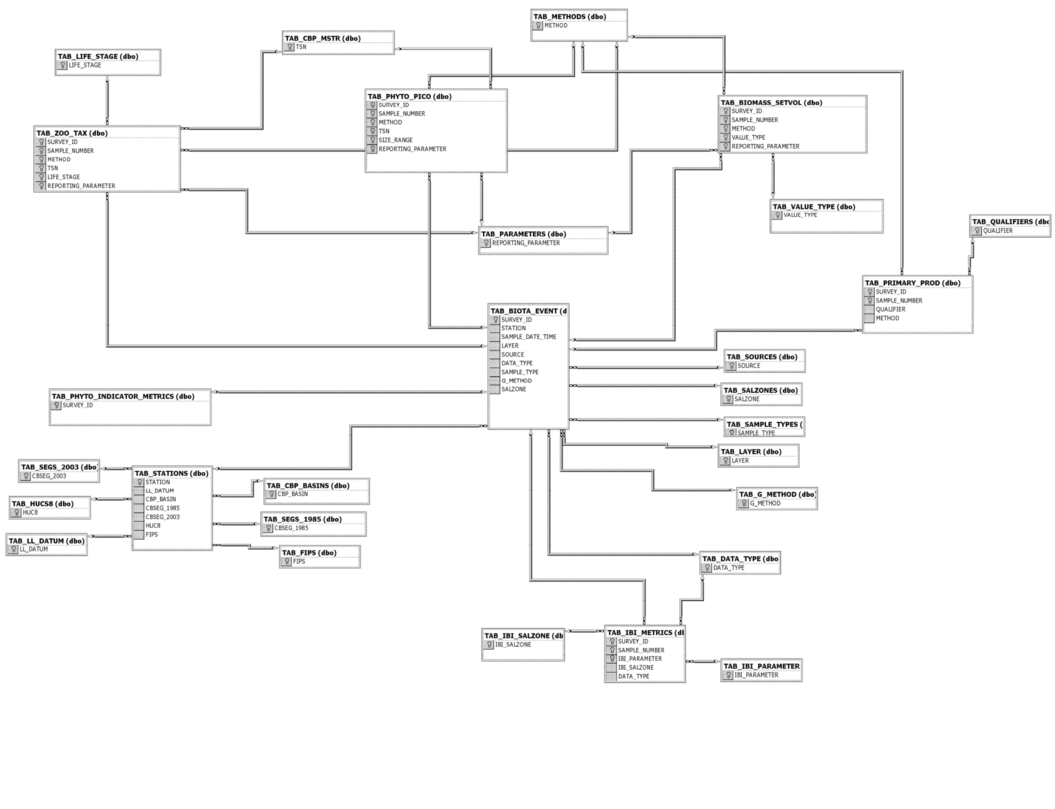
Figure 7. Fluorescence Database Entity Relationship Diagram



1.4.4 Plankton Database Summary

The Chesapeake Bay Program Plankton database contains data derived from the phytoplankton, picoplankton, primary production microzooplankton, mesozooplankton and gelatinous zooplankton monitoring efforts. Currently only phytoplankton, data are being added regularly. This database is composed five primary data tables (BIOTA_EVENT_TABLE, PHYTO_PICO_TABLE, ZOO_TAX_TABLE, BIOMASS_SETVOL_TABLE, and PRIMARY_PROD_TABLE) and twenty-two other "look up" and data processing tables, which are linked to the primary table. The relationships between these tables are shown in figure 6. Extensive technical detail explaining the data fields, tables, rules of referential integrity and other data quality controls can be found in the document *Phytoplankton And Zooplankton Monitoring Database: Version 3.0, Database Design And Data Dictionary* which can be found at ftp://ftp.chesapeakebay.net/Pub/Living_Resources/plank/phytzoo.pdf.

Figure 8 Plankton Database Entity Relationship Diagram



2: Data Processing Procedures

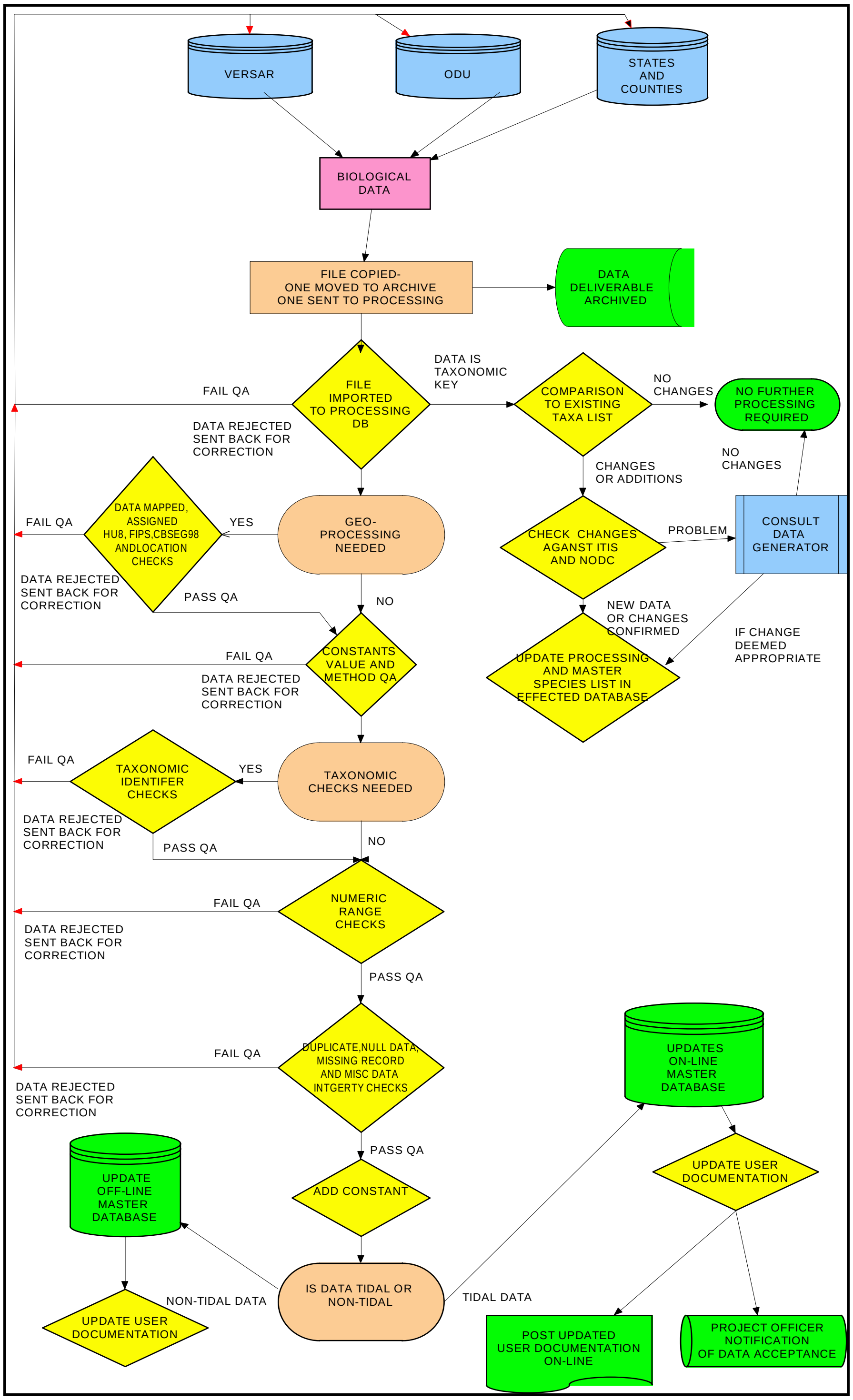
Data received by the LRDMP from the original data generators arrived as the CBP data center on a regular but staggered schedule to allow for prompt processing and release of data to the public. Data from the Fluorescence and Phytoplankton programs are delivered three times a year. Data from January-June of the current calendar year is delivered in October of the same calendar year. Data collected from July-September is delivered in December of the same calendar year. Data collected from October-December of the previous calendar year is delivered in April of the following calendar year. Tidal benthic data is a grant deliverable and is received in 12-month increments in May of the following calendar year of collection. Benthic Index of Biotic Integrity Data for the previous year arrives one month after the corresponding monitoring data (June). Grant deliverable data is processed with in fourteen working days of data delivery. All data received at the Data Center are processed through final QAQC checks and loaded into CBP databases or sent back to the data provider/provider for revisions. The QAQC procedures vary somewhat by data type and will be discussed in detail in the following sections. On successful inclusion of data into a CBP data base, an email notification is sent to the EPA Project Officer and CC'ed to the data provider noting the data's acceptance. General procedures for processing data managed by the Project are outlined in Figure 7.

Non-tidal benthic data received by the Project from data providers arrives at the CBP Data Center in response to periodic data calls. Data are accepted and processed on a rolling basis. Sharing and reporting of the data is done on a voluntary basis. A process to make the data available to the general public is being developed.

2.1 Tidal Benthic Data Processing

The processing steps for entering data components into the tidal benthic database are similar to those of the plankton database. All data deliverables have six basic files: SAMPLING_EVENT_TABLE, BIOTA_SAMPLING_EVENT_TABLE, WATER_QUALITY_TABLE, SEDIMENT_ANALYSIS_TABLE, TAXONOMIC_DATA_TABLE, and BIOMASS_TABLE. The benthic taxonomic and biomass data are accompanied by a data provider taxonomic key (PI_TAXON_LISTS). Loading procedures assume that data to be added into the database are available in a comma delimited ASCII format in a predetermined format. All monitoring programs have been provided with PC SAS programs or CIMS Guidance to create the necessary files for loading of data into the database (Appendix E – Submitters Guidelines For Living Resources Monitoring Data Submissions in *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00)). The loading of tables must be performed in a predetermined order due to the referential integrity requirements of the relational database. The loading order of tables is as follows: the Benthic Event table followed by the Biota Event table. The PI_TAXON_LISTS updated and any additions that need to be made to the SPECIES_LIST_TABLE should be done before any taxonomic or biomass data is loaded to the database. The remaining data tables may be then loaded in any order.

Figure 9. CBPO Living Resource Benthic Data Flow Diagram



2.1.1 Processing Tidal Benthic Event Data

Event data are processed in the following sequence:

1) All data are delivered by the data providers as comma delimited ASCII file ready for data loading. All files must contain a header row followed by rows of data in the format and order as shown in Table 5.

Table 5. CIMS Data Deliverable Format for Benthic Event Data

VARIABLE	TYPE	LENGTH
STATION	TEXT	15
SAMPLE_DATE	DATE	10
STRATUM	TEXT	4
LATITUDE	NUMERIC	8.5
LONGITUDE	NUMERIC	8.5
SITE_TYPE	TEXT	2
SAMPLE_TIME	DATE/TIME	5
SOURCE	TEXT	8
TOTAL_DEPTH	NUMERIC	8.1
YEARCODE	TEXT	8
CRUISENO	TEXT	8
STAEQ85	TEXT	8
SITE	TEXT	8
SAMPTYPE	TEXT	8

2) All data are imported into the data processing database C:\access\benthic\process_Benthos_2k.mdb using the import template specific for the data provider laboratory (VERSAR or ODU) and data type (event). As part of the import procedure, all data records are assigned an auto-index number. The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data provider for correction.

3) The latitudes and longitudes for each sampling event are exported out by auto-index number and plotted using the CBPO GEOTAGGER TOOL. Sampling positions are plotted and receive assignments of USGS HUC8, FIPS, and CBP 1998 Segment codes. Sites are visually checked to confirm that all positions are on the water, in the correct jurisdiction, and approximately the correct body of water (i.e. mainstem, Potomac River). If errors are found, data is returned to the data provider for correction. The resulting geographic attribute file is exported from GEOTAGGER and imported into C:\access\benthic\process_Benthos_2k.mdb.

4) A series of code or acceptable value checks are performed on the following fields: SOURCE, STRATUM, and SITE_TYPE. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00)*. If errors are found or undocumented changes in the sampling events are found, data is returned to the data provider for correction or for adequate documentation.

5) A series of data range checks are performed on the fields found in Table 6. If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, data are returned to the data provider for correction or minimally written explanation of problem.

Table 6. Data Quality Assurance Guidelines for Benthic Event Records

SAMPLE_DATE	Are sample dates within range of sampling period?
LATITUDE	Do values fall within bounding ranges for Chesapeake Bay? (36.0000 TO 40.0000) All positions reported in NAD83 geographic datum.
LONGITUDE	Do values fall within bounding ranges for Chesapeake Bay? (-75.0000 TO -78.0000). All positions reported in NAD83 geographic datum.
SAMPLE_TIME	Are sample times within range of generally accepted daylight hours? (0600-1730 24 hour time)
TOTAL_DEPTH	For Fixed stations, is value less than the reported historic max station depth from the water quality data? For Random stations, is range between 0.2 and 40 meters?

6) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Fixed stations sampling events: Were scheduled stations to be sampled during the reporting period sampled? Are there the appropriate numbers of random stations?

If errors are found, data is returned to the data provider for correction or documentation.

7) A series of default constant CBP codes are added to the data set for PROJECT, PROGRAM, and R_DATE. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00).

8) The new monitoring data are then held until their accompanying biota event taxonomic, biomass, water quality and sediment data tables have completed pre-processing. The event file is compared against the data tables to assure that every data record has an event record. The data file is then compared against the event table to assure that every event record has at least one event record. If errors are found, data is returned to the data provider for correction. Note that there will be sampling events where only sediment analysis and water quality data was taken and there will be no biota event, biomass or taxonomic records.

9) The event records are added to SURVEY_TABLE of the Chesapeake Bay Benthic Database. Event ID numbers are assigned to each event record. These ID numbers are then assigned to corresponding records of all other data types. The biota sampling event data are then added to the BIOTA_SAMPLING_TABLE. After which all other data types are appended to their appropriate table as specified in *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary.*

10) Any relevant comments from the data provider documentation file and other necessary data updates are added to the end user and FGDC Metadata documentation files and updated files are put on the CBP web site.

11) A notification email is sent to the EPA Project Officer noting acceptance of data deliverable (Figure 8). If data is sent back to the data provider and data correction will take more than 7 working dates a data rejection notice is sent to the project officer.

Figure 9. Sample Project Officer Data Deliverable Notification Email

The following grant deliverables have been received under Virginia Monitoring grant #CB983825-01-0. (117e grant)

Data Set	Date Range	Due Date	Submitted	Accepted
Primary Production Monitoring Data	Jan-June 2004	10/15/2004	10/06/2004	10/19/2004
Fluorescence Monitoring Data	Jan-June 2004	10/15/2004	09/28/2004	10/20/2004

2.1.2 Processing Benthic Biota Event Data

1) Data providers deliver all data as comma delimited ASCII files ready for data loading. All files must contain a header row followed by rows of data in the format and order shown in Table 7.

2) All data are imported into the data processing database C:\access\benthic\process_Benthos_2k.mdb using the import template specific for the data provider laboratory (VERSAR or ODU) and data type (biota). As part of the import procedure all data records are assigned an auto-index number. The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data provider for correction.

Table 7. CIMS Data Deliverable Format for Benthic Biota Sampling Event Data.

FIELD	TYPE	LENGTH
STATION	TEXT	15
SAMPLE_DATE	DATE/TIME	10
SAMPLE_TIME	DATE/TIME	5
SAMPLE_NUMBER	NUMERIC	8.0
GMETHOD	TEXT	5
NET_MESH	NUMERIC	8.1
PENETR	NUMERIC	8.2
AEPENETR	TEXT	2
SER_NUM	TEXT	12
SOURCE	TEXT	8
YEARCODE	TEXT	8
CRUISENO	TEXT	6
STAEQ85	TEXT	8
STAEQ89	TEXT	8
SITE	TEXT	8

3) A series of code or acceptable value check are performed on the following fields: SOURCE, GMETHOD, and AEPENETR. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00)*. If errors are found or undocumented changes in the sampling events are found, data is returned to the data provider for correction or for adequate documentation.

4) A series of data range checks are performed on the fields found in Table 8. If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, data are returned to the data provider for correction or minimally written explanation of problem.

Table 8. Data Quality Assurance Guidelines for Benthic Biota Sampling Event Records.

SAMPLE_DATE	Are sample dates within range of sampling period?
SAMPLE_TIME	Are sample times within range of generally accepted daylight hours? (0600-1730 24 hour time)
SAMPLE_NUMBER	Are values present and between 1-4 for fixed stations and 1 for random stations?
NET_MESH	Are values present and usually 0.5mm? (Other values acceptable if documented.)
PENETR	Is sampling gear penetration depth present and within acceptable range? (6-25 cm for box cores currently in use)

5) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Check of Fixed stations sampling events: Were scheduled stations sampled during the reporting period sampled? Are there the appropriate numbers of random stations?
- Check to confirm that every record in the BIOTA EVENT table must have a record in the SURVEY EVENT table.

If errors are found, data is returned to the data provider for correction or documentation.

6) A series of default constant CBP codes are added to the data set for GMETHOD and other field. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00).

7) Processing then follows steps 8-11 as described in Section 2.1.1 Processing Sampling Event Data.

2.1.3 Processing Benthic Water Quality Data

1) All data are delivered by the data providers as comma delimited ASCII files ready for loading. All files must contain a header row followed by rows of data in the format and order shown in Table 9.

Table 9. CIMS Data Deliverable Format for Benthic Water Quality Data.

FIELD	TYPE	LENGTH
STATION	TEXT	15
SAMPLE_DATE	DATE/TIME	10
SAMPLE_TIME	DATE/TIME	5
SAMPLE_NUMBER	NUMERIC	8.0
SAMPLE_DEPTH	NUMERIC	8.1
PARAMETER	TEXT	20
VALUE	NUMERIC	12.4
UNITS	TEXT	12
INS_CODE	TEXT	8
SOURCE	TEXT	8
LABEL	TEXT	50
YEARCODE	TEXT	8
CRUISENO	TEXT	6
STAEQ85	TEXT	8
STAEQ89	TEXT	8
SITE	TEXT	8
SAMPLE_TYPE	TEXT	2

2) All data is imported in to the data processing database C:\access\benthic\process_Benthos_2k.mdb using the import template specific for the data provider laboratory (VERSAR or ODU) and data type (WQ). As part of the import procedure all data records are assigned an auto-index number. The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data provider for correction.

3) A series of code or acceptable value check are performed on the following fields: SOURCE, PARAMETER, SAMPLE_TYPE and UNITS. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00)*. If errors are found or undocumented changes in the sampling events are found, data are returned to the data provider for correction or for adequate documentation.

4) A series of data range checks are performed on the field found in Table 10. If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, data are returned to the data provider for correction or minimally written explanation of problem.

Table 10. Data Quality Assurance Guidelines for Benthic Water Quality Records.

PARAMETER	MAXIMUM VALUE	MINIMUM VALUE	REPORTING UNITS
DO	15	0	MG/L
DO_PSAT	125	0	PERCENT
PH	14	0	SU

PARAMETER	MAXIMUM VALUE	MINIMUM VALUE	REPORTING UNITS
SALINITY	32	0	PPT
SPCOND	50000	0	UMHO/CM
WTEMP	40	-4	DEGC

5) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Fixed stations sampling events: Were stations scheduled to be sampled during the reporting period sampled? Are there the appropriate numbers of random stations?
- Confirmation that every record in WQ has a corresponding record in the survey.

If errors are found, data is returned to the data provider for correction or documentation.

6) A series of default constant CBP codes are added to the data set. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00).

7) Processing then follows steps 8-11 as described in Section 2.1.1 Processing Sampling Event Data.

2.1.4 Processing Benthic Sediment Data

1) All data are delivered by the data providers as comma delimited ASCII files ready for data loading. All files must contain a header row followed by rows of data in the format and order shown in Table 11.

Table 11. CIMS Data Deliverable Format for Benthic Sediment Data.

FIELD	TYPE	LENGTH
STATION	TEXT	15
SAMPLE_DATE	DATE/TIME	10
SAMPLE_TIME	DATE/TIME	5
SAMPLE_NUMBER	NUMERIC	8.0
SAMPLE_DEPTH	NUMERIC	8.1
PARAMETER	TEXT	20
VALUE	NUMERIC	12.4
UNITS	TEXT	12
SOURCE	TEXT	8
YEARCODE	TEXT	8
CRUISENO	TEXT	6
STAEQ85	TEXT	8
STAEQ89	TEXT	8
SITE	TEXT	8
SAMPLE_TYPE	TEXT	2
LABEL	TEXT	20

2) All data are imported into the data processing database C:\access\benthic\process_Benthos_2k.mdb using the import template specific for the data provider laboratory (VERSAR or ODU) and data type (WQ). As part of the import procedure all data records are assigned an auto-index number. The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data provider for correction.

3) A series of code or acceptable value checks are performed on the following fields: SOURCE, PARAMETER, SAMPLE_TYPE and UNITS Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00)*. If errors are found or undocumented changes in the sampling events are found, data is returned to the data provider for correction or for adequate documentation.

4) A series of data range checks are performed on the field found in Table 12. If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, data is returned to the data provider for correction or minimally written explanation of problem.

Table 12. Data Quality Assurance Guidelines for Benthic Sediment Data.

PARAMETER	MAXIMUM VALUE	MINIMUM VALUE	REPORTING UNITS
CLAY	100	0	PERCENT
INTSAL	32	0	PPT
KURTOSIS	10	0	FOLK METHOD
MEANDIAM	10	0	PHI
MEDDIAM	10	0	PHI
MOIST	100	0	PERCENT
QUARTDEV	0	0	FOLK METHOD
SAND	100	0	PERCENT
SILT	100	0	PERCENT
SILTCLAY	100	0	PERCENT
SKEWNESS	5	-5	FOLK METHOD
SORT	5	0	FOLK METHOD
TC	100	0	PERCENT
TIC	100	0	PERCENT
TN	100	0	PERCENT
VOLORG	100	0	PERCENT

5) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Fixed stations sampling events: Were scheduled stations sampled during the reporting period sampled? Are there the appropriate numbers of random stations?
- Confirmation that every record in the Sediment Record must have a corresponding record in the SURVEY data.

If errors are found, data is returned to the data provider for correction or documentation.

6) A series of default constant CBP codes are added to the data set. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00).

7) Processing then follows steps 8-11 as described in Section 2.1.1 Processing Sampling Event Data.

2.1.5 Processing Benthic Investigator Taxonomic Keys

The CBP Data Center recognizes that access to consistent, scientifically credible taxonomic information is essential to many Program activities. The CIMS Technical Information Team recognizes that the National Integrated Taxonomic Information System (ITIS) program is best equipped to provide this kind of taxonomic standardization and support. ITIS is a partnership of federal agencies formed to satisfy their mutual needs for scientifically credible taxonomic information. ITIS provides taxonomic data and a directory of taxonomic expertise that will organize and provide access to, standardized nomenclature support a national taxonomic inventory system. Therefore, in order to facilitate the need for uniform quality taxonomic information exchange within the Chesapeake Bay Program and other national programs, the ITIS Standards have been adopted. Therefore the CBP requires that data submitters and CIMS partners serving data on the Internet should utilize the ITIS Taxonomic Serial Numbers (TSNs) for taxa identification. Detailed information about ITIS and access to its taxonomic database can be found at URL: http://www.itis.usda.gov/plantproj/itis/index.html.

The following steps are taken in processing taxonomic data:

1) All data providers who provide data containing taxonomic information are required to submit their current species lists as comma delimited ASCII file ready for data loading. All files must contain a header row followed by rows of data in the format and order shown in Table 13.

Table 13. CIMS Data Deliverable Format for Taxonomic Keys.

VARIABLE	TYPE	LENGTH
SPECCODE	Text	14
SOURCE	Text	8
DATA_TYPE	Text	2
SOURCE_LBL	Text	45
NODCCODE	Text	12
TSN	Text	7

2) All data is imported in to the data processing database C:\access\plankton\process_plankton_2k.mdb using the import template specific for the data provider (ANS or ODU) and data type (taxon_key). The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data provider for correction.

3) All taxonomic keys are queried to find additions to the list. If new species are found, the Latin Name is submitted to the online IT IS database (Integrated Taxonomic Information System on-line database, http://www.itis.usda.gov) to confirm the TSN. The confirmed TSN is also checked against the NOAA-NODC species code list (Hardy, 1996) to obtain or confirm the provided NODCCODE. Once all these checks are confirmed, the new species are added to the PI_SPECIES_LIST_TABLE and to the CBP_MSTR_TABLE if need be.

3) All taxonomic keys are compared to the current records on the PI_SPECIES_LIST to find changes in nomenclature. If species name changes are found, the Latin Name is submitted to the online IT IS database (Integrated Taxonomic Information System on-line database, http://www.itis.usda.gov) to confirm the TSN. The confirmed TSN is also checked against the NOAA-NODC species code list (Hardy, 1996) to obtain or confirm the provided NODCCODE. Once all these checks are confirmed, the new species are added to the PI_SPECIES_LIST_TABLE and to the CBP_MSTR_TABLE if need be.
The PI is contacted in regards to propagating the name change through the entire CBP database if the change has not already been requested.

2.1.6 Processing Benthic Taxonomic And Biomass Data

1) The same procedure is used for both taxonomic and biomass data. The data providers deliver all data as comma delimited ASCII file ready for data loading. All files should contain a header row followed by rows of data in the format and order shown in Tables 14 and 15.

2) All data are imported into the data processing database C:\access\benthic\process_benthic_2k.mdb using the import template specific for the data provider laboratory (VERSAR or ODU) and data type (taxon or biomass). The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data provider for correction.

Table 14. CIMS Data Deliverable Format for Benthic Taxonomic Data.

FIELD	TYPE	LENGTH
STATION	TEXT	15
SAMPLE_DATE	DATE	10
SAMPLE_NUMBER	NUMERIC	8.0
TAXON	TEXT	15
PARAMETER	TEXT	20
VALUE	NUMERIC	8.0
UNITS	TEXT	12
SER_NUM	TEXT	12
SOURCE	TEXT	8
YEARCODE	TEXT	8
CRUISENO	TEXT	6
STAEQ85	TEXT	8
STAEQ89	TEXT	8
SITE	TEXT	8
GEARCODE	TEXT	5
NETMESH	NUMERIC	8.1
SKIP	TEXT	1

Table 15. CIMS Data Deliverable Format for Benthic Biomass Data

FIELD	TYPE	LENGTH
STATION	TEXT	15
SAMPLE_DATE	DATE/TIME	10
SAMPLE_NUMBER	NUMERIC	8.0
VALUE_TYPE	TEXT	1
TAXON	TEXT	15
PARAMETER	TEXT	20
VALUE	NUMERIC	8.5
UNITS	TEXT	12
SER_NUM	TEXT	12
SOURCE	TEXT	8
SAMPLE_TYPE	TEXT	2
GEARCODE	TEXT	5
NETMESH	NUMERIC	8.1
YEARCODE	TEXT	8
CRUISENO	TEXT	6
STAEQ85	TEXT	8
STAEQ89	TEXT	8
SITE	TEXT	8

3) A series of code or acceptable value check are performed on the following fields: SOURCE, VALUE_TYPE, SAMPLE_TYPE, and STATION. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00)*. Always read all accompanying documentation that comes with the data submission; there may have been changes in sampling instruments or other protocol, which require the assignment of new method codes. If errors are found or new method codes need to be assigned, data are returned to the data provider for correction.

4) An UPDATE_TSN TAXON query is run. This query updates any ITIS taxon serial number changes made while processing PI_SPECIES list and adds CBP size designations which are based on the data providers' in-house species codes. It is critical that all species lists are up-to-date before performing this query. Remember, species identification is by TSN Numbers in CIMS databases. Data records will not load if TSN numbers are missing.

5) A series of data range checks are performed on the fields found in Table 16.

Table 16. Data Quality Assurance Guidelines for Benthic Taxonomic or Biomass Data.

VALUE	Are abundance values or biomass values for a given taxa within a previously observed range for a fixed station for given month? (1984-1998, mean plus/minus 2 standard deviations). If highly frequent taxa are missing, event is noted.
SAMPLE_DATE	Are sample dates within range of sampling period?
SAMPLE_TIME	Are sample times within range of generally accepted daylight hours? (0600-1730 24 hour time)

If data values are found that do not meet accepted data ranges and there is no explanatory documentation from the laboratory, data are returned to the data provider for correction or minimally written explanation of problem.

6) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Detection of a minimum number of records for a sampling event (1 record minimum).
- Check of stations sampling events: Were scheduled stations sampled during the reporting period sampled?

If errors are found, data is returned to the data provider for correction.

7) Processing then follows steps 8-11 as described in Section 2.1.1 Processing Sampling Event Data.

2.1.7 Processing Benthic Indicator Data

The following processing steps are taken:

1) Beginning in January 2005, the data providers submitted calculated Benthic Index of Biotic Integrity indices. IBI Metrics (developed by Weisberg et.al. (1997), modified by Alden et.al. (2002)) are calculated using the protocol described in the document *Methods for Calculating the Chesapeake Bay Benthic Index of Biotic Integrity* (http://www.baybenthos.versar.com). The data providers deliver all BIBI data as comma delimited ASCII file ready for data loading. All files must contain a header row followed by rows of data in the format and order shown in Table 17.

Table 17. CIMS Data Deliverable Format for Benthic IBI Data.

NAME	TYPE	SIZE
STATION	TEXT	15
SAMPLE_DATE	DATE/TIME	8
SAMPLE_NUMBER	NUMERIC	4
IBI_PARAMETER	TEXT	15
VALUE	NUMERIC	8
SCORE	NUMERIC	4
IBI_SALZONE	TEXT	2
IBI_BOTTOM_TYPE	TEXT	1
R_DATE	DATE/TIME	8

2) All data are imported into the data processing database C:\access\benthic\process_Benthos_2k.mdb using the import template specific for the data provider laboratory (VERSAR or ODU) and data type (biota). As part of the import procedure, all data records are assigned an auto-index number. The import screen also confirms that data type values in all fields are correct. If errors are found, data are returned to the data provider for correction.

3) A series of code or acceptable value check are performed on the following fields: SOURCE, IBI_SALZONE, and IBI_BOTTOM_TYPE. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary*. If errors are found or undocumented changes in the sampling events are found, data is returned to the data provider for correction or for adequate documentation.

4) A series of data range checks are performed on the fields found in table 17. If data values are found to not meet accepted data ranges shown in table 18 and do not have explanatory documentation from the laboratory, data are returned to the data provider for correction or minimally written explanation of problem.

Table 18. Data Quality Assurance Guidelines for Benthic IBI Data

IBI_PARAMETER	DESCRIPTION	MAXIMUM VALUE	MINIMUM VALUE
GRAND_SCORE	FIXED STATION REPLICATE AVERAGED TOTAL BENTHIC RESTORATION GOAL SCORE	5	1
PCT_CARN_OMN	PERCENT CARNIVORES AND OMNIVORES	100	0
PCT_DEPO	PERCENT DEEP DEPOSIT FEEDERS	100	0
PCT_PI_ABUND	PERCENT POLLUTION INDICATIVE SPECIES ABUNDANCE	100	0
PCT_PI_BIO	PERCENT POLLUTION INDICATIVE SPECIES BIOMASS	100	0
PCT_PI_F_ABUND	PERCENT POLLUTION INDICATIVE SPECIES ABUNDANCE-FRE	100	0
PCT_PI_F_BIO	PERCENT POLLUTION INDICATIVE SPECIES BIOMASS-FRESH	100	0
PCT_PI_O_ABUND	PERCENT POLLUTION INDICATIVE SPECIES ABUNDANCE-OLI	100	0
PCT_PI_O_BIO	PERCENT POLLUTION INDICATIVE SPECIES BIOMASS-OLIGO	100	0
PCT_PS_ABUND	PERCENT POLLUTION SENSITIVE SPECIES ABUNDANCE	100	0
PCT_PS_BIO	PERCENT POLLUTION SENSITIVE SPECIES BIOMASS	100	0
PCT_PS_O_ABUND	PERCENT POLLUTION SENSITIVE SPECIES ABUNDANCE-OLIG	100	0
PCT_PS_O_BIO	PERCENT POLLUTION SENSITIVE SPECIES BIOMASS-OLIGOH	100	0
PCT_TANYPODINI	PERCENT TANYPODINAE TO CHIRONOMIDAE	100	0
SCORE	IBI SCORE FOR ANY METRIC (1, 3, OR 5)	5	1
SW	SHANNON-WEINER SPECIES DIVERSITY INDEX	0	5
TOLARANCE	POLLUTION TOLARACE INDEX	0	10
TOT_ABUND	TOTAL SPECIES ABUNDANCE (NUMBER PER METER SQUARED)	0	500000
TOT_BIOMASS	TOTAL SPECIES BIOMASS IN (GRAMS PER METER SQUARED)	0	2000
TOTAL_SCORE	TOTAL BENTHIC RESTORATION GOAL SCORE FOR SAMPLE	5	1

5) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- If a station had biological data sampled and enumerated during a reporting period, were IBI data calculated for each sample replicate?

If errors are found, data is returned to the data provider for correction or documentation.

6) A series of default constant CBP codes are added to the data set. Acceptable code values for all of these fields can be found in the *Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00).

7) The IBI data are then held until its accompanying biota event taxonomic, biomass, water quality and sediment data tables have completed pre-processing. The event file is compared against the data tables to assure that every data record has an event record. The data file is then compared against the event table to assure that every event record has at least one event record. If errors are found, data is returned to the data provider for correction.

8) The IBI records are added to IBI_METRIC_TABLE of the Chesapeake Bay Benthic Database. Event ID numbers are assigned to each event record. These ID numbers are then assigned to corresponding records of all other data types. IBI data are added to the database only after all other benthic monitoring data for the given reporting period have been loaded.

9) Any relevant comments from the data provider documentation file and other necessary data updates are added to the end user and FGDC Metadata documentation files, and the updated files are put on the CBP web site www.chesapeakebay.net.

10) A notification email is sent to the EPA Project Officer noting acceptance of data deliverable (Figure 8). If data are sent back to the data provider and data correction is expected to take more than 7 working dates, a data rejection notice is sent to the Project Officer.

2.2 Non-Tidal Benthic Data Processing

The processing steps for entering data components into the non-benthic database are not standardized due to the voluntary nature of the data sharing and reporting. While a number of jurisdictions use the EPA supported Environmental Data Analysis System (EDAS) tool for data management, other programs have opted to design their own relational databases (FoxPro, MS-Access, MS-SQL Server) or use Statistical Analysis System (SAS) software for data management. The result is that data from each submitter come in different file structures and file formats with varying levels of documentation and quality assurance. In general, a data submitter will send four tables/files: a stations table, a taxonomic count table, water quality table and a habitat assessment table. From the submitted files, five load tables are created (LOAD_TAB_STATION, LOAD_TAB_EVENT, LOAD_TAB_HABITAT, LOAD_TAB_WQ AND LOAD_TAXA_COUNT). The load tables must be added to the database in a predetermined order due to the referential integrity requirements of the relational database. The LOAD_TAB_STATION table data must be added first, followed by the LOAD_TAB_EVENT data, after which the LOAD_TAB_HABITAT, LOAD_TAB_WQ and LOAD_TAXA_COUNT data may be added in any order. However any PI_TAXON_LISTS updated and any additions that need to be made to the SPECIES_LIST_TABLE should be done before any taxonomic data is loaded to the database.

2.2.1 Processing Non-Tidal Benthic Stations Data

1) All data is delivered by the data providers. Data providers have been delivering data through a variety of methods including email, posting on web sites and cdrom. All files must contain a header row followed by rows of data. The submitted data are currently reformatted by the Data Manager into the load table format shown in Table 19.

Table 19. Load Table Format for Non-Tidal Benthic Stations Data

VARIABLE	TYPE	LENGTH
STATION_ID	TEXT	20
WATERBODY_NAME	TEXT	250
SITE_LOCATION	TEXT	255
ECOREGION_LEVEL_4	TEXT	50
LATITUDE	DOUBLE	9.5
LONGITUDE	DOUBLE	9.5
FIPS	TEXT	5
HUC_12	TEXT	12
LL_DATUM	TEXT	10
ADD_DATE	DATE/TIME	10
HABITAT_TYPE	TEXT	10

2) All station data are imported into the data processing database C:\access\NTbenthic\process_provider_name.mdb using the import template specific to the data provider and data type (Station). As part of the import procedure all data records are assigned an auto-index number.

3) The latitudes and longitudes for each sampling station are rounded to 5 significant digits and are exported out by auto-index number and plotted using the ARC_MAP. All data are transformed into NAD 83 coordinate, if not provided in that format. Sampling positions are plotted and receive assignments of

USGS HUC12, HUC12 Water body name, FIPS, and EPA level 4 ecoregion. Acceptable code values for all geographic attributes can be found in the document *Non-Tidal Benthic Monitoring Database: Version 2.0, A Database Design And Data Dictionary.* Sites are visually checked to confirm that all positions in the correct jurisdiction and immediately adjacent to or in the correct body of water. If errors are found, data are returned to the data provider for correction. Stations outside of the Chesapeake Bay watershed are dropped from further processing at this point. The resulting geographic attribute file is exported back into the appropriate processing database.
.

4) The initial data submitter's site location description and all merged GIS attributes are reformatted into the load file template. Constants for LL_DATUM and HABITAT_TYPE are added. HABITAT_TYPE is provided by the data provider. Acceptable code values for all of these parameters can be found in the *Non-Tidal Benthic Monitoring Database: Version 2.0, A Database Design And Data Dictionary.*

5) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Are fixed sites the same as sites already in the database stations table? If a fixed site is already in the stations table, the site is removed from the load table.
- Checks listed in Table 20.

Table 20. Data Quality Assurance Guidelines for Non-Tidal Benthic Station Records.

LATITUDE	Do values fall within bounding ranges for Chesapeake Bay Basin? (36.0000 TO 40.0000) All positions reported in NAD83 geographic datum.
LONGITUDE	Do values fall within bounding ranges for Chesapeake Bay Basin ? (-75.0000 TO -78.0000). All positions reported in NAD83 geographic datum.

If errors are found, the data provider is contacted for correction or documentation information.

6) The new monitoring data are then held until their accompanying event taxonomic, habitat, and water quality have completed pre-processing.

7) The stations records are added to TAB_STATIONS of the Chesapeake Bay Non-Tidal Benthic Database.

2.2.2 Processing Non-Tidal Benthic Sampling Event Data

1) All data is delivered by the data providers. All files must contain a header row followed by rows of data. The submitted data are currently reformatted by the Data Manager into the load table format shown in Table 21.

Table 21. Load Table Format for Non-Tidal Benthic Sample Event Data

FIELD	TYPE	LENGTH
EVENT_ID	LONG_INTEGER	4
PROJECT_ID	LONG_INTEGER	4
STATION_ID	TEXT	40
SAMPLE_DATE	DATE/TIME	10
SAMPLE_TIME	DATE/TIME	10
R_DATE	DATE/TIME	10
EVENT_TYPE	LONG_INTEGER	4
EVENT_LATITUDE	DOUBLE	8
EVENT_LONGITUDE	DOUBLE	8
SITETYPE	TEXT	5
LL_DATUM	TEXT	10

2) All taxonomic, water quality and habitat data are imported into the data processing database C:\access\NTbenthic\process_provider_name.mdb using the import template specific for the data provider and data type (Station).

3) A series of queries are run on each the taxonomic, water quality and habitat data to determine unique sampling dates. This is done because some programs do not always collect all three types of data at site on a given day. The three lists of sampling events are merged and an EVENT_TYPE code is assigned. Acceptable code values thIs parameters can be found in the *Non-Tidal Benthic Monitoring Database: Version 2.0, A Database Design And Data Dictionary.*

4) A series of data range checks are performed on the field found in Table 22. If data values are found to not meet accepted data ranges and there is no explanatory documentation from the laboratory, data are returned to the data provider for correction or minimally written explanation of problem.

5) A series of overall QA /QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Check for misdated event.
- Data checks in Table 22.

Table 22. Data Quality Assurance Guidelines for Non-Tidal Benthic Event Records.

SAMPLE_DATE	Are sample dates within range of sampling period?
SAMPLE_TIME	Are sample times within range of generally accepted daylight hours? (0600-1730) If not or time is missing a default time (0000) is assigned

If errors are found, the data provider is contacted for correction or documentation information.

6) A series of default constant CBP codes are added to the data set for PROJECT_ID, SITE_TYPE, and R_DATE. Acceptable code values for all of these parameters can be found in the *Non-Tidal Benthic Monitoring Database: Version 2.0, A Database Design And Data Dictionary.*

7) Note that the latitude and longitude for a sample site as reported by the data provider is loaded into this table.

8) The new monitoring data is then held until its accompanying taxonomic, water quality and/ habitat data table have completed pre-processing. The LOAD_TAB_EVENT event file is compared against the data table to assure that every data record has an event record. The each data file is then compared against the event table to assure that every event record has at least one event record.

9) The event records are added to TAB_EVENT of the Chesapeake Bay Non-Tidal Benthic Database. Event_ID numbers are assigned to each event record. These ID numbers are then assigned to corresponding records in the taxonomic, water quality, or habitat data records before loading to their respective tables.

2.2.3 Processing Non- Tidal Benthic Taxonomic Keys

The processing of Non-Tidal Benthic Taxonomic key information varies by individual data provider. Many of our current data providers utilize the ITIS TSNs for species identification. For these data providers we skip directly to the final data processing step below. For all other data providers, a PI_TAXONOMIC_KEY must be generated.

1) All data providers who do not use ITIS TSN's for species identification must have taxonomic keys built for TSN assignment. The taxonomic data file is queried to generate a unique list of species identification.

Table 23. Typical Format for Non-Tidal Benthic Taxonomic Keys.

VARIABLE	TYPE	LENGTH
INHOUSE_CODE	TEXT	14
ORDER	TEXT	25
FAMILY	TEXT	25
TRIBE	TEXT	25
GENUS	TEXT	25
SPECIES	TEXT	25
FINAL_ID	TEXT	50
CBP_LBL	TEXT	50
TSN	TEXT	7

2) All species name are matched against the TAB_CPB_MASTER for assignment of TSN numbers. Ambiguous identifications are rolled back to the next higher recognized taxonomic level. For example, an identification where two genera are given is rolled up to the family level.

3) If new species are found, the latin name is submitted to the online ITIS database on-line database, http://www.itis.usda.gov) to confirm the TSN. The confirmed TSN is also checked against the NOAA-NODC species code list (Hardy, 1996) to obtain or confirm the provided NODCCODE. Once all these checks are confirmed, the new species are added to the CBP_MSTR_TABLE if need be.

2.2.4 Processing of Non-Tidal Benthic Taxonomic Count Data

1) All data is delivered by the data providers. All files must contain a header row followed by rows of data. The submitted data are currently reformatted by the Data Manager into the load table format shown in Table 24.

Table 24. Load Table Format for Non-Tidal Benthic Taxonomic Data

VARIABLE	TYPE	LENGTH
EVENT_ID	LONG_INTEGER	4
STATION_ID	TEXT	25
SAMPLE_DATE	DATE	10
SAMPLE_TIME	DATE	10
SAMPLE_NUMBER	SINGLE	8
TSN	TEXT	7
LIFE_STAGE_CODE	TEXT	3
REPORTING_PARAMETER	TEXT	15
REPORTING_VALUE	SINGLE	8
REPORTING_UNITS	TEXT	15
METHOD	TEXT	6
GMETHOD	TEXT	14
SAMPLE_TYPE	TEXT	7

2) All taxonomic, water quality and habitat data is imported in to the data processing database C:\access\NTbenthic\process_provider_name.mdb using the import template specific for the data provider and data type (Station).

3) An UPDATE_TSN *TAXON* query is run. This query assigns ITIS taxon serial numbers and any applicable LIFE_STAGE CODES to identified species, based on the data providers provided

identification. It is critical that all species lists are up-to-date before performing this query. Remember, species identification is by TSN Numbers in CIMS databases. Data records will not load if TSN numbers are missing.

4) A series of data range checks are performed on the field found in Table 25.

Table 25. Data Quality Assurance Guidelines for Non-Tidal Benthic Taxonomic Data

REPORTING_VALUE	Are abundance values 0
SAMPLE_DATE	Are sample dates within range of sampling period?
SAMPLE_TIME	Are sample times within range of generally accepted daylight hours? (0600-1730 24 hour time)

If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, the data provider is contacted for correction or clarification.

6) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Detection of a minimum number of records for a sampling event (1 record minimum).
- Check of stations sampling events: Were scheduled stations sampled during the reporting period sampled?

If errors are found, data is returned to the data provider for correction.

7) Constants for METHOD, GMETHOD and SAMPLE_TYPE are added. Enumeration method and sampling gear information must be provided by the data provider. Acceptable code values for all of these parameters can be found in the *Non-Tidal Benthic Monitoring Database: Version 2.0, A Database Design and Data Dictionary.*

8) The event records are merged on from the LOAD_TAB_EVENT. The taxonomic records are then appended to TAB_TAXONOMIC_COUNT table of the Chesapeake Bay Non-Tidal Benthic Database.

2.2.5 Processing Non-Tidal Benthic Water Quality Data

1) All data are delivered by the data providers. All files must contain a header row followed by rows of data. The submitted data are currently reformatted by the Data Manager into the load table format shown in Table 26.

Table 26. Load Table Format for Non-Tidal Benthic Water Quality Data.

VARIABLE	TYPE	LENGTH
EVENT_ID	Long_Integer	4
STATION_ID	text	25
SAMPLE_DATE	Date	10
SAMPLE_TIME	Date	10
SAMPLE_TYPE	text	4
SAMPLE_REPLICATE_TYPE	text	7
LAYER	text	2
DEPTH	Single	8
REPORTING_PARAMETER	text	15
REPORTED_VALUE	Single	8
REPORTING_UNITS	text	10
QUALIFIER	text	1
METHOD	text	4
LAB	text	10
PROBLEM_CODE	text	2
DETAILS	Memo	
ADDED	Date	10
D_FLAG	Boolean	1
B_FLAG	Boolean	1

2) All taxonomic, water quality and habitat data are imported in to the data processing database C:\access\NTbenthic\process_provider_name.mdb using the import template specific for the data provider and data type.

3) Most water quality data are provided in a non-normalized format. If this is the case, data are exported to SAS and a proc transpose procedure is used to normalize the data. Transposed data is then re-imported into the Access processing database.

3) Data parameter names and reporting units are converted to CBP standard names and units. Method codes and quality assurance flags are assigned for each parameter based on data provider provided documentation. Acceptable code values for all of these fields can be found in the *Non-Tidal Benthic Monitoring Database: Version 2.0, A Database Design and Data Dictionary*.

4) A series of data range checks are performed on the field found in Table 27. If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, data is returned to the data provider for correction or minimally written explanation of problem.

Table 27. Data Quality Assurance Guidelines for Non-Tidal Benthic Water Quality Records.

REPORTING PARAMETER	Minimum VALUE	Maximum VALUE	REPORTING UNITS
ACIDITY	0.0002	5739	MG/L
AL	0.008	422	MG/L
ANC	-39.9	2355.7	MEQ/L
AS	1.68	11	UG/L
BOD5W	0.38	240	MG/L
CA	0.86	69.04	MG/L
CD	0.2	0.85	UG/L
CHLA	0.18	470	UG/L
CLF	0.77	3726	MG/L
CLW	0.05	1570	MG/L
COD	32	46.4	MG/L
COLOR	0	100	SU
CR	12.3	12.3	UG/L
CU	0.59	84	UG/L
DCU	0.25	953	UG/L
DIC	0.72	30.11	MG/L
DO	0.2	1054	MG/L
DO_SAT_P	0	241	PCT
DOC	0.2	63.456	MG/L
DZN	0.4	363	UG/L
FCOLI_C	0	210000	COL/100 ML
FCOLI_C	10	3200	MPN/100 ML
FE_U	0.31	250000	UG/L
FLOW_INS	0.0006	175000	CFS
HARDNESS	0	918.7	MG/L
HG			UG/L
K	0.31	4.93	MG/L
MGF	0.67	40.63	MG/L
MN	0	96300	UG/L
NAF	0.44	47.26	MG/L
NH4F	0	9.5	MG/L
NH4W	0.005	9.52	MG/L
NI	4	503	UG/L
NO23W	0.002	21	MG/L
NO2F	0	4.01	MG/L

REPORTING PARAMETER	Minimum VALUE	Maximum VALUE	REPORTING UNITS
NO2W	0.004	2.15	MG/L
NO3F	-0.0064	46.466	MG/L
NO3W	0.04	16.9	MG/L
PB	0	80.3	UG/L
PH	1.7	14	SU
PHEO	1	142	UG/L
PO4F	0	1.14	MG/L
PO4W	0.002	36	MG/L
SALINITY	0	2.73	PPT
SE	0	700	UG/L
SECCHI	0.3	2.8	M
SIF	2.75	23.35	MG/L
SIW	1.812	16.713	MG/L
SO4F	0.55	797.66	MG/L
SO4W	1	4415.7	MG/L
SPCOND	0	6970	UMHOS/CM
SSC_%FINE	47.6	94.5	PCT
SSC_TOTAL	0	599	MG/L
TALK	0	3210	MG/L
TDN	0.09	12.1	MG/L
TDP	0.002	1.44	MG/L
TDS	-1.1	30796	MG/L
TKNW	0.05	599	MG/L
TN	0.0134	608	MG/L
TOC	0.3	368	MG/L
TOTAL_DEPTH	0.05	5	M
TP	0.001	218	MG/L
TSS	0	1322	MG/L
TURB_FTU	0.51	404.5	FTU
TURB_NTU	-8.5	725	NTU
VELOCITY	0.09	1.67	M/S
WIDTH	0.2	130	M
WTEMP	-0.26	45.7	DEG C
ZN	1	1360	UG/L
ZNF	0	36	UG/L

5) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Fixed stations sampling events: Were stations scheduled to be sampled during the reporting period sampled? Are there the appropriate numbers of random stations?
- Confirmation that every record meets the WQ Data Quality Assurance Guidelines for Non-Tidal Benthic Water Quality records and has a corresponding record in the biological and event tables.

If errors are found, data provider is contacted for correction information or documentation.

6) The event records are merged on from the LOAD_TAB_EVENT. The water quality records are then appended to TAB_WQ_DATA table of the Chesapeake Bay Non-Tidal Benthic Database.

2.2.6 Processing Non-Tidal Benthic Habitat Characterization Data

1) All data are delivered by the data providers. All files must contain a header row followed by rows of data. The submitted data are currently reformatted by the Data Manager into the load table format shown in Table 28.

Table 28. Load Table Format for Non-Tidal Benthic Habitat Characterization Data.

VARIABLE	TYPE	LENGTH
EVENT_ID	Long_Integer	4
SAMPLE_DATE	Date	10
SAMPLE_TIME	Date	10
STATION_ID	Text	25
SAMPLE_NUMBER	Single	8
HABITAT_REPORTING_ PARAMETER	Text	15
REPORTING_PARAMETER_ VALUE	Double	8
METHOD	Text	6

2) All taxonomic, water quality, and habitat data are imported into the data processing database C:\access\NTbenthic\process_provider_name.mdb using the import template specific for the data provider and data type.

3) Some of the habitat data are provided in a non-normalized format. If this is the case data are exported to SAS and a proc transpose procedure is used to normalize the data. Transposed data is then re-imported into the Access processing database.

3) Data parameter names and reporting units are converted to CBP standard names and units. Method codes are assigned based on data provider provided documentation. Acceptable code values for all of these fields can be found in the *Non-Tidal Benthic Monitoring Database: Version 2.0, A Database Design And Data Dictionary*.

4) A series of data range checks are performed on the field found in Table 29. If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, data is returned to the data provider for correction or minimally written explanation of problem.

Table 29. Data Quality Assurance Guidelines for Non-Tidal Benthic Habitat Assessment Records.

HABITAT_REPORTING_VALUE	Are values between 0 and 20
SAMPLE_DATE	Are sample dates within range of sampling period?
SAMPLE_TIME	Are sample times within range of generally accepted daylight hours? (0600-1730 24 hour time)

5) A series of overall QA QC routines are run over the data. These checks include:

- Queries to look for duplicate records.
- Fixed stations sampling events: Were stations scheduled to be sampled during the reporting period sampled? Are there the appropriate numbers of random stations?
- Confirmation that every record in WQ has a corresponding record in the survey.

If errors are found, data provider is contacted for correction information or documentation.

6) The event records are merged on from the LOAD_TAB_EVENT. The water quality records are then appended to TAB_WQ_DATA table of the Chesapeake Bay Non-Tidal Benthic Database.

2.3 Fluorescence Data Processing

The processing steps for the two types of fluorescence data (horizontal and vertical) do not vary significantly. Both types of fluorescence data are delivered in the same format. These loading procedures assume that data to be added into the database is available in a comma delimited ASCII format in a predetermined format. All monitoring programs have been provided with PC SAS programs or CIMS Guidance to create the necessary files for loading of data into the database (Appendix E – Submitters Guidelines For Living Resources Monitoring Data Submissions in *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00)). The processing of horizontal and vertical fluorescence data from all data providers occurs following these general steps.

1) All data is delivered as comma delimited ASCII files ready for data loading. All files should contain a header row followed by rows of data in the following format and order:

Table 30. CIMS Data Deliverable Format for Fluorescence.

VARIABLE	TYPE	LENGTH
SOURCE	TEXT	6
CHL_F	NUMERIC	8.2
SAMPLE_DATE	DATE	10
CHL_F_D	TEXT	2
CHL_F_M	TEXT	6
LATITUDE	NUMERIC	9.5
LONGITUDE	NUMERIC	9.5
STATION	TEXT	15
SAMPLE_TIME	DATE/TIME	5
SAMPLE_DEPTH	NUMERIC	8.1
SER_NUM	TEXT	12
TRIB_CODE	TEXT	3
SAMPLE_TYPE	TEXT	5
VOLTS	NUMERIC	9.5

2) All data is imported in to the data processing database C:\access\flu\process_flu_2k.mdb using the import template specific for the data provider (ANS or ODU) and data type (horizontal or vertical). As part of the import procedure all data records are assigned an auto-index number. The import screen also confirms that data type values in all fields are correct. This includes QA Regressions. If errors are found, data is returned to the data generator for correction.

3) The latitudes and longitudes for each sampling event are exported out by auto-index number and plotted using the CBPO GEOTAGGER TOOL. Sampling positions are plotted and receive assignments of USGS HUC8, FIPS, and CBP 1998 Segment codes. Sites are visually checked to confirm that all positions are on the water, in the correct jurisdiction, and approximately the correct body of water (i.e. Mainstem, Potomac River). If errors are found, data is returned to the data generator for correction. The HUCS, FIPS and Segment codes for vertical stations are checked against the standard code assignment for the fixed site station. The resulting geographic attribute file is exported from GEOTAGGER and imported into C:\access\flu\process_flu_2k.mdb.

4) A series of code check are performed on the following field SOURCE, CHL_F_D, CHL_F_M, STATION, TRIB_CODE, SAMPLE_TYPE. Acceptable code values for all of these fields can be found in the *Fluorescence Monitoring Database, Version 1.0, A Database Design and Data Dictionary or* The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00). Always read all accompanying documentation that comes with the data submission; there may have been changes in sampling instruments, position determination method or other protocol, which may require the assignment of new method codes. If errors are found or new method codes need to be assigned, data is returned to the data generator for correction.

5) A series of manual data range checks are performed on the field found in Table 31.
If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, data is returned to the data generator for correction or minimally written explanation of problem.

Table 31. Data Quality Assurance Guidelines for Fluorescence.

CHL_F	Are values with in range for method, if above or below method is method code appropriate (Method Range 0- 475 UG/L).
SAMPLE_DATE	Are sample dates within range of sampling period
LATITUDE	For vertical stations- Do they match accepted program coordinates? For Horizontal Stations-Does value fall within bounding ranges for Chesapeake Bay? (36.0000 TO 40.0000) All positions reported in NAD83 geographic datum.
LONGITUDE	For vertical stations- Do they match accepted program coordinates? For Horizontal Stations-Does value fall within bounding ranges for Chesapeake Bay? (-75.0000 TO -78.0000). All positions reported in NAD83 geographic datum.
SAMPLE_TIME	Are sample time within range of generally accepted daylight hours (6000-1730 24 hour time)
SAMPLE_DEPTH	For vertical stations- Do are they less than the reported historic max station depth from the water quality data. The default value for Horizontal data is 0.5 meters.
VOLTS	Are values within reported max –min range for instrument in use? Currently 0 to 500 MV for most labs

6) A series of overall QA /QC routines are run over the data. These checks include

- Queries to look for duplicate records.
- Number of records for a vertical sampling event (5 minimum).
- Numbers of vertical stations sampling events- were stations scheduled to be sampled actually sampled?

If errors are found, data is returned to the data generator for correction.

7) A series of default constant CBP codes are added to the data set for PROJECT, PROGRAM, R_DATE and LLDATUM. Acceptable code values for all of these fields can be found in the *Fluorescence Monitoring Database, Version 1.0, A Database Design and Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00). Similar constants are added to the QA Regressions.

8) The GEOTAGGER attribute file is merged back on to the finished data.

9) The new monitoring data is added to FIELD_DATA table of the Chesapeake Bay Fluorescence Database. The regression data are added to the REGRESSION_TABLE.

10) Any relevant comments from the data generator documentation file and other necessary data updates are added to the end user and FGDC Metadata documentation files and updated files are put on the CBP web site.

11) A notification email is sent to the EPA Project Officer noting acceptance of data deliverable. If data is sent back to the data generator and data correction will take more than 7 working dates a data rejection notice is sent to the project officer. (Figure 8)

2.4 Plankton Data Processing

The individual processing steps of the plankton data varies by monitoring component (Primary Production or Phytoplankton and Picoplankton). However all data deliverables have two basic files: a sampling Event Table and a Data Table. The phytoplankton and picoplankton data convey taxonomic information they are also accompanied by a data generator taxonomic key (PI_TAXON_LISTS). These loading procedures assume that data to be added into the database is available in a comma delimited ASCII format in a predetermined format. All monitoring programs have been provided with PC SAS programs or CIMS

Guidance to create the necessary files for loading of data into the database (Appendix E – Submitters Guidelines For Living Resources Monitoring Data Submissions in *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00)). The loading of tables must be performed in a predetermined order due to the referential integrity requirements of the relational database. The loading order of tables is as follows: the Event table followed by any Data table unless data is taxonomic and new species have been found. If new species have been identified, their names must be added to the CBP_MSTR_TABLE before any taxonomic data is loaded to the database.

2.4.1 Processing Sampling Event Data

1) All data is delivered by the data generators as comma delimited ASCII files ready for data loading. All files should contain a header row followed by rows of data in the following format and order:

Table 32. CIMS Data Deliverable Format for Plankton Event Records

VARIABLE	TYPE	LENGTH
SOURCE	TEXT	6
COLTYPE	TEXT	2
DATA_TYPE	TEXT	6
SAMPLE_DATE	DATE/TIME	10
LAYER	TEXT	2
P_DEPTH	NUMERIC	8.1
SER_NUM	TEXT	12
STATION	TEXT	15
TOTAL_DEPTH	NUMERIC	8.1
SAMPLE_TIME	DATE/TIME	8
SAMPLE_VOLUME	NUMERIC	8.3
UNITS	TEXT	10
TRIB_CODE	TEXT	3

2) All data is imported in to the data processing database C:\access\plankton\process_plankton_2k.mdb using the import template specific for the data provider (ANS or ODU) and data type (event_data). The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data generator for correction.

3) A series of code or acceptable value check are performed on the following field SOURCE, COLTYPE, DATA_TYPE, LAYER, STATION, UNITS, and TRIB_CODE. Acceptable code values for all of these fields can be found in the *Phytoplankton And Zooplankton Monitoring Database: Version 2.0, Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00)*. If errors are found or undocumented changes in the sampling events are found, data is returned to the data generator for correction or for adequate documentation.

4) A series of data range checks are performed on the field found in table 33.
If data values are found to not meet accepted data ranges without supporting documentation from the laboratory, data is returned to the data generator for correction or minimally written explanation of problem.

Table 33. Data Quality Assurance Guidelines for Plankton Event Records

SAMPLE_DATE	Are sample dates within range of sampling period
SAMPLE_VOLUME	Is Volume reported and consistent with method
SAMPLE_TIME	Are sample times within range of generally accepted daylight hours (6000-1730)
TOTAL_DEPTH	Does reported value appear to be consistent with historic total station depth from the water quality data?
P_DEPTH	Is value reported and is 1/3 total depth or less?

5) A series of overall QA /QC routines are run over the data. These checks include
- Queries to look for duplicate records.
- Check of vertical stations sampling events- were stations scheduled to be sampled actually sampled?

If errors are found, data is returned to the data generator for correction or documentation.

6) A series of default constant CBP codes are added to the data set for PROJECT, PROGRAM, METHOD, R_DATE. Acceptable code values for all of these fields can be found in the *Phytoplankton And Zooplankton Monitoring Database: Version 2.0, Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data* (EPA 903-R-00-002 CBP/TRS 235/00).

7) The new monitoring data is then held until its accompanying taxonomic or production data table has completed pre-processing. The event file is compared against the data table to assure that every data record has a corresponding event record. The data file is then compared against the event table to assure that every event record has at least one data record. If errors are found, data is returned to the data generator for correction.

8) The event records are added to SURVEY_TABLE of the Chesapeake Bay Plankton Database. Event Id numbers are assigned to each event record. These Id numbers are then assigned to corresponding records in the taxonomic or production data records. Then plankton and picoplankton data records are added to the PHYTO_PICO_TABLE. Primary Production data is appended to the PRIMARY_PROD_TABLE.

9) Any relevant comments from the data generator documentation file and other necessary data updates are added to the end user and FGDC Metadata documentation files and updated files are put on the CBP web site.

10) A notification email is sent to the EPA Project Officer noting acceptance of data deliverable (Figure 8). If data is sent back to the data generator and data correction will take more than 7 working dates a data rejection notice is sent to the project officer.

2.4.2 Processing Investigator Taxonomic Keys

1) All data generators who provide data containing species information required to submit their current species lists for each program they are reporting data as comma delimited ASCII file ready for data loading. All files should contain a header row followed by rows of data in the following format and order:

Table 34. CIMS Data Deliverable Format for Taxonomic Keys

VARIABLE	TYPE	LENGTH
SPECCODE	Text	14
SOURCE	Text	8
DATA_TYPE	Text	2
SOURCE_LBL	Text	45
NODCCODE	Text	12
TSN	Text	7

2) All data are imported into the data processing database C:\access\plankton\process_plankton_2k.mdb using the import template specific for the data provider (ANS or ODU) and data type (taxon_key). The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data generator for correction.

3) All taxonomic keys are queried to find additions to the list. If new species are found, the Latin Name is submitted to the online IT IS database (Integrated Taxonomic Information System on-line database, http://www.itis.usda.gov) to confirm the TSN. The confirmed TSN is also checked against the NOAA-NODC species code list (Hardy, 1996) to obtain or confirm the provided NODCCODE. Once all these checks are confirmed, the new species are added to the PI_SPECIES_LIST_TABLE and to the CBP_MSTR_TABLE if need be.

3) All taxonomic keys are compared to the current records on the PI_SPECIES_LIST to find changes in nomenclature. If species name changes are found, the Latin Name is submitted to the online IT IS database (Integrated Taxonomic Information System on-line database, http://www.itis.usda.gov) to confirm the TSN. The confirmed TSN is also checked against the NOAA-NODC species code list (Hardy, 1996) to obtain or confirm the provided NODCCODE. Once all these checks are confirmed, the new species are added to the PI_SPECIES_LIST_TABLE and to the CBP_MSTR_TABLE if need be.
The PI is contacted in regards to propagating the name change through the entire CBP database if the change has not already been requested.

2.4.3 Processing Taxonomic Data

1) The same procedure is used for both phytoplankton and picoplankton. The data generators deliver all data as comma delimited ASCII file ready for data loading. All files should contain a header row followed by rows of data in the following format and order:

Table 35. CIMS Data Deliverable Format for Plankton Taxonomic Data

VARIABLE	TYPE	LENGTH
SOURCE	TEXT	6
COLTYPE	TEXT	2
SAMPLE_DATE	TEXT	8
DEN_L	NUMERIC	12.3
DATA_TYPE	TEXT	3
LAYER	TEXT	2
LBL	TEXT	45
REP_NUM	NUMERIC	8
REP_TYPE	TEXT	3
SER_NUM	TEXT	12
SPECCODE	TEXT	14
STATION	TEXT	8
TRIB_CODE	TEXT	3
TSN	TEXT	7

2) All data is imported in to the data processing database C:\access\plankton\process_plankton_2k.mdb using the import template specific for the data provider (ANS or ODU) and data type (PHYT_data). The import screen also confirms that data type values in all fields are correct. If errors are found, data is returned to the data generator for correction.

3) A series of code or acceptable value check are performed on the following field SOURCE, COLTYPE, DATA_TYPE, GMETHOD, LAYER, REP_TYPE, STATION, and TRIB_CODE. Acceptable code values for all of these fields can be found in the *Phytoplankton And Zooplankton Monitoring Database: Version 2.0, Database Design And Data Dictionary* or *The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00)*. Always read all accompanying documentation that comes with the data submission; there may have been changes in sampling instruments or other protocol, which require the assignment of new method codes. If errors are found or new method codes need to be assigned, data is returned to the data generator for correction.

4) A UPDATE_TSN *TA*XON query is run. This query will update any IT IS Taxon serial numbers changes made while processing PI_SPECIES list and add CBP Size designations, based on the data generators in house species codes. It is critical that all species lists are up to date before performing this query. Remember, species identification is by TSN Numbers in CIMS databases. Data records will not load if TSN numbers are missing.

5) A series of data range checks are performed on the field found in Table 36.

Table 36. Data Quality Assurance Guidelines for Plankton Taxonomic Data

DEN_L	Are values for a given taxa within a previously observed range for a station for given month (1984-1998, mean plus/minus 2 standard deviations). If highly frequent taxa are missing, event is noted. Stations spot-checked for inappropriate taxa at station (i.e. freshwater taxa in polyhaline station).
SAMPLE_DATE	Are sample dates within range of sampling period
SAMPLE_TIME	Are sample time within range of generally accepted daylight hours (6000-1730 24 hour time)

If data values are found to to not meet accepted seasonal data ranges for dominant taxa without supporting documentation from the laboratory, data is returned to the data generator for correction or minimally written explanation of problem.

6) A series of overall QA /QC routines are run over the data. These checks include

- Checks include queries to look for duplicate records.
- Detection of a minimum number of records for a sampling event (1 record minimum).
- Check of stations sampling events- were stations scheduled to be sampled during the reporting period sampled?

If errors are found, data is returned to the data generator for correction.

7) Processing then follows steps 7-10 as described in Section 2.2.2 Processing Sampling Event Data.

References

Alden, R. W., III, D. M. Dauer, J. A. Ranasinghe, L. C. Scott, and R. J. Llansó. 2002. Statistical verification of the Chesapeake Bay Benthic Index of Biotic Integrity. Environmetrics, 13:473-498.

Chesapeake Bay Program (1983).1983 Chesapeake Bay Agreement. Annapolis: U.S. Environmental Protection Agency.

Chesapeake Bay Program (1987).1987 Chesapeake Bay Agreement. Annapolis: U.S. Environmental Protection Agency.

Chesapeake Bay Program (1988). Chesapeake Bay Living Resources Monitoring Plan, Agreement Commitment Report. Annapolis: U.S. Environmental Protection Agency. 94pp.

Chesapeake Bay Program (1993) Chesapeake Bay Strategy for the Restoration and Protection of Ecologically Valuable Species. Annapolis: U.S. Environmental Protection Agency.

Chesapeake Bay Program (1996).Strategy for Increasing Basin-wide Public Access to Chesapeake Bay Information. Annapolis: U.S. Environmental Protection Agency.

Chesapeake Bay Program (2000).Chesapeake 2000: A Watershed Partnership. Annapolis: U.S. Environmental Protection Agency.

Chesapeake Bay Program (2008). Strengthening the Management, Coordination and Accountability of the Chesapeake Bay Program. (CBP/TRS-292-08) Annapolis: U.S. Environmental Protection Agency.

Hardy, J (1996). National Oceanographic Data Center (NODC) Taxon Codes Version 8.0, U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, Silver Springs, MD.

Johnson, J.M., and Buchanan, C., (2007) The Basin- wide Species List for the Chesapeake Bay Basin, 2007. US EPA Chesapeake Bay Program. (EPA 903R-07-004 CBP/TRS 287/07)

Johnson, J,M. (2010). Non-Tidal Benthic Monitoring Database: Version 3.0, A Microsoft Access Database Design And Data Dictionary.

Johnson, J, and Legg, P. (2009). Fluorescence Monitoring Database: Version 2.0, A Microsoft Access Database Design And Data Dictionary. ftp://ftp.chesapeakebay.net/Pub/Living_Resources/ fluor/ FLURDBMS.PDF.

Johnson, J, and Legg, P. (2008). Phytoplankton and Zooplankton Monitoring Database: Version 3.0, A Microsoft Access Database Design And Data Dictionary. ftp://ftp.chesapeakebay.net/Pub/Living_Resources/ plank/SQL_PHYTZOO.pdf.

Johnson, J, and Legg, P. (2001). Benthic Monitoring Database: Version 3.0.2, A Microsoft Access Database Design And Data Dictionary. ftp://ftp.chesapeakebay.net/Pub/Living_Resources/benth/ RDBMS.PDF.

Johnson, J.M. and Buchanan, C. (2000) The 2000 User's Guide to Chesapeake Bay Program Biological and Living Resources Monitoring Data (EPA 903-R-00-002 CBP/TRS 235/00).

Integrated Taxonomic Information System on-line database, http://www.itis.usda.gov.

Llanso, R (2002) Methods for Calculating The Chesapeake Bay Benthic Index of Biotic Integrity. *http://www.baybenthos.versar.com*

Weisberg, S. B., Ranasinghe, J. A., Dauer, D. M., Schaffner, L. C., Diaz, R. J., & Frithsen, J. B. (1997). An estuarine benthic index of biotic integrity (B-IBI) for Chesapeake Bay. Estuaries, 20, 149-158.