Quality Assurance Project Plan
for the
Maryland Department of Natural Resources
Chesapeake Bay Tidal Monitoring Programs
Trends Analysis Methods for the period
July 1, 2021 - June 30, 2022

May 2021

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Quality Assurance Project Plan
for the
Maryland Department of Natural Resources
Chesapeake Bay
Tidal Monitoring Programs
Data Management and Analysis
for the period July 1, 2021 - June 30, 2022

May 2021

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Thomas Parham, Principal Investigator
Director, Tidewater Ecosystem Assessment Division
Maryland Department of Natural Resources

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Richard Ortt
Acting Director, Resource Assessment Services
Maryland Department of Natural Resources

____

Christine Conn, Ph.D., Quality Assurance Officer
Director, Integrated Planning and Review Program
Maryland Department of Natural Resources

____

James Hargett, Project Officer
Chesapeake Bay Program Office
U.S. Environmental Protection Agency

____

Lee McDonnell, Quality Assurance Officer
Chesapeake Bay Program Office
U.S. Environmental Protection Agency

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PREFACE

This document describes and references other documents describing data management and analysis for the Maryland Department of Natural Resources Chesapeake Bay Tidal Monitoring Program. Included are data analysis methods for long-term tidal water quality data. This program is funded through the Maryland Department of Natural Resources and the U.S. Environmental Protection Agency.

Editor:
Renee J. Karrh, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, C-2, Annapolis, Maryland 21401.

1 *INTRODUCTION*

1.1 Project description and rationale

At the completion of the U. S. Environmental Protection Agency's (EPAs) $27 million study of Chesapeake Bay, the Agency published a document entitled *Chesapeake Bay: A Framework for Action* (EPA 1983). This report strongly recommended a long-term monitoring program to serve the Bay's management community by accurately describing the current state of the Bay mainstem and tidal tributaries (baseline or ‘status’) and detecting long-term changes (trends) resulting from human activities. Management strategies at that time were hindered by the lack of precise information about the Bay and its response to increasing or decreasing pollution.

Managers, scientists, and statisticians recognized that to establish baseline conditions and then begin to identify trends would require a multi-year effort on the order of a decade or more. Long-term data was needed to overcome the natural year-to-year variability that can obscure changes due to human activities. As the EPA study drew to a close, scientists and managers convened in workshops to formulate plans on several topics, including water quality monitoring. The monitoring workshop recommendations for chemical and physical measurements were published in the appendices of *Chesapeake Bay: A Framework for Action* (EPA 1983).

Under the 117e grant to DNR from EPA, tidal water quality trends will be calculated for the parameters listed in Section 3. Additional analyses may be completed as per the needs of the Bay Program and/or DNR. This Quality Assurance Project Plan (QAPP) describes Maryland's data analysis and quality assurance/ quality control methods used when determining long-term trends in water quality parameters. Datasets used in these analyses are from the Maryland Long-term Water Quality Monitoring Program databases, 1985 to present (DNR databases).

1.2 Data analysis objectives and acceptance criteria objectives

The Maryland Department of Natural Resources (DNR) analyzes long-term monitoring program data to address water quality monitoring objectives of the Chesapeake Bay Water Quality Monitoring Program. Long-term water quality datasets are analyzed to determine if trends are present; trends, either increasing or decreasing, are used to evaluate effectiveness and track progress of management actions to reduce nutrient and sediment pollution. Tidal water quality information is linked with other monitoring information (shallow-water monitoring, benthic monitoring, SAV monitoring, non-tidal monitoring) and examined in the context of the whole to gain a more comprehensive understanding of water quality processes and the relationship between water quality and living resources. Results will be used in the development of reporting products for management and the public.

The quality assurance objective for data analysis is to estimate the trends of tidal water quality parameters at individual stations and Bay Program segments, with a minimum 95% confidence as per Chesapeake Bay Program presentation guidelines.

Acceptance Criteria for data usability are:

1. Annual (calendar year) and seasonal water quality trends will be determined for stations with continuous sampling throughout the time period. Using the recommendations from Helsel and Hirsch (2002, pg. 351) with regard to trend analysis, data completeness is evaluated by:
    a. dividing the study period into thirds (three periods of equal length);
    b. determining the coverage in each period (e.g. if the record is generally monthly, count the months for which there are data); and
    c. if any of the thirds has less than 20 percent of the total coverage then the trend will not be reported.

2. Due to sampling protocols, Eastern and Western Mainstem stations are not sampled in January, February, November or December. Annual trends will not be calculated for these stations.

3. Water quality data used in this project must meet the specifications described in the approved EPA-approved Quality Assurance Project Plan. Data that fail to meet QA/QC criteria for sampling and laboratory analysis are excluded from databases and not available to data analysts.

4. “Preliminary” data may not be used for preparing final data analysis products and interpretations.

1.3 Key project personnel

Diana Domotor, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, D-2, Annapolis, Maryland 21401.

Andrew Keppel, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, C-2, Annapolis, Maryland 21401.

Renee Karrh, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, C-2, Annapolis, Maryland 21401.

Mark Trice, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, D-2, Annapolis, Maryland 21401.

Elgin Perry, Statistics Consultant, 377 Resolutions Rd., Colonial Beach, Va. 22443.

2 DATA MANAGEMENT, VERIFICATION (ACCEPTANCE CRITERIA) AND DOCUMENTATION

2.1 Input (raw) data

Data management and verification (acceptance criteria) procedures for input (raw) to the databases used in this project are described in the Quality Assurance Project Plan (QAPP) documents:

Maryland Department of Natural Resources (MDNR). 2021. Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program Chemical and Physical Properties Component for the Period July 1, 2021 - June 30, 2022.

Maryland Department of Natural Resources (MDNR). 2021. Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Shallow Water Quality Monitoring Program for the period July 1, 2021 - June 30, 2022.

These documents are reviewed annually and updated as needed.

2.2 Analysis datasets

2.2.1 Data extraction of current year data

Data extraction programs have been developed by DNR that extract the needed data from the input datasets. DNR currently works with SAS software for this purpose, and acquires the data from ACCESS database storage files. The data are not extracted for the analyses until the entire dataset for the 'current' calendar year is available in the input datasets, generally by April of the following year.

Analysis datasets are created with the primary analysis parameters (or those needed to calculate the primary analysis parameters, see Table 2). These include:

- total dissolved nitrogen (TDN)
- total dissolved phosphorus (TDP)
- particulate nitrogen (PN)
- particulate phosphorus (PP)
- total phosphorus (TP) if directly measured
- total keldjahl nitrogen (TKNW)
- nitrate-nitrate (NO23)
- ammonium (NH4)
- dissolved inorganic phosphorus (PO4)
- total suspended solids (TSS)
- active chlorophyll a (CHLA)
- Secchi depth (SECCHI)
- dissolved oxygen (DO)
- salinity (SALINITY)
- water temperature (WTEMP)

The data extraction program extracts the following descriptive information from the input databases: Program Code, Project Code, Station Name, Sample Date, Sample Depth, Layer Code, Replicate Number. The program also extracts parameter value, parameter APC code, and parameter flag into individual temporary datasets for each of the parameters. Parameter value, Parameter APC code and Parameter flag are renamed to include the parameter's name to allow the program to then combine individual parameters into a single line of data for a given Station Name, Sample Date, Sample Depth, Layer Code, Replicate Number combination. For example, for NO23 data, Parameter Value is renamed NO23, Parameter APC code is renamed NO23_A and Parameter Flag is renamed NO23_G.

The individual parameter temporary datasets are merged together into a single dataset using the descriptive parameters Station Name, Sample Date, Layer Code, Sample Depth, and Replicate Number. The resulting dataset file is named 'RAWtype***year***', where 'type' is either *TRIB* for tributary data or *MAIN* for Mainstem data and ***year*** is the four-digit numeric year for the data. The resulting dataset is stored on the analyst's personal computer hard drive under a directory set up specifically for the analysis project under a subdirectory named 'Datasets'. All programs are saved under a subdirectory named 'Programs'. These directories are backed up to the DNR network drives periodically and can be available to other analysts as needed. The network directories are backed up to a separate location each evening and can be used in the event of a loss of the files from the network. The analyst's personal computer hard drive is backed up periodically to external data storage (thumb drive) that can be used in the event of a loss of files from the personal computer.

2.2.2 Datasets from previous years

2.2.2.1 Mainstem datasets

The historic Mainstem datasets are fairly straightforward. The same laboratory has analyzed the nutrient data for almost the entire data period for all stations in this subcategory of DNR's analysis. This greatly simplifies the steps following combination with the historic datasets. The exceptions are Mainstem station CB5.1W, which is collected under the Patuxent River Tributary program and data is stored in Tributary datasets, and the Potomac River station LE2.3, which is collected and processed as a Mainstem station and treated as a Mainstem station until later in the analysis process.

Historic Mainstem datasets were created and saved by individual analysts and retained as permanent rawdata datasets. These historic rawdata datasets are named a variety of things depending on what years of data are included. Historic rawdata datasets are used instead of re-extracting all of the data each year for the primary reason that any and all knowledge needed to handle the historic databases is already incorporated into the creation of these datasets and may not be available to the current analyst to recreate the same dataset. Also, any data corrections identified in previous years of analysis are already made in these datasets but may or may not have been made in the historic input (raw) databases.

The current year's RAWMAIN***year*** dataset is appended to the historic dataset. The entire dataset then passes through a series of checks to remove nutrient parameter data that has specific Analytical Problem Codes (APC) which disqualify the data for analysis. Definitions of these APCs are included in Table 1. It was previously determined that these were the only problematic APC codes present in the historic datasets. The combined dataset is next merged with a list of the stations assigned to each CBP segment. Next, any parameter that is coded as 'greater than the upper detection limit' (*parameter*_G = 'G') is then deleted. The final dataset is saved to the hard drive as BA85***yr***rw where ***yr*** is the two-digit numeric year for the data.

DNR completed an extensive quality assurance check of all of the historic data (from 1985 to present) in 2012 and 2013 and developed a list of additional edits that are made to the raw data. Subsequent years' data was also reviewed in the same manner and any new edits are added to this quality assurance step for succeeding years on an annual basis. These edits are saved to a new dataset named BA85***yr***qa.

Graphs of the BA85***yr***qa dataset are reviewed to ensure that all data for all years and all analyzed parameters is in the saved dataset. If any data is not present, the analyst returns to the previous steps to determine what errors in the input database or the program have prevented the data from being extracted, or to verify that the data does not exist.

2.2.2.2 Tributary datasets

The historic Tributary datasets are not straightforward due to differences in the sampling of Potomac and Patuxent rivers in previous sampling programs and differences between those and the rest of the Tributary monitoring stations. As the result of these differences, separate subgroups of Tributary data are maintained in the early steps of dataset preparation.

The Patuxent stations are selected from the current year's RAWTRIB***year*** dataset; this subset is appended to the combined historic Patuxent dataset. The dataset then passes through a series of checks to remove nutrient parameter data that has specific Analytical Problem Codes (APC) which disqualify the data for analysis. Definitions of these APCs are included in Table 1. It was previously determined that these were the only problematic APC codes present in the historic datasets. Next, any parameter that is coded as 'greater than the upper detection limit' (*parameter*_G = 'G') is then deleted. The dataset is then merged with a list of the stations assigned to each CBP segment. The final dataset is saved to the hard drive as PX85***yr***rw.

For Potomac stations (except LE2.3, see above) and the other Tributary stations, current subsetted datasets are appended to historic datasets. The entire dataset then passes through a series of checks to remove data that has specific Analytical Problem Codes (APC) which disqualify the data for analysis (see above). Next, any parameter that is coded as 'greater than the upper detection limit' (*parameter*_G = 'G') is then deleted. The dataset is then merged with a list of the stations assigned to each CBP segment. The final dataset is saved to the hard drive as TB85***yr***rw.

DNR completed an extensive quality assurance check of all of the historic data (from 1985 to present) in 2012 and 2013 and developed a list of additional edits that are made to the raw data. These edits are saved to a new dataset named PX85***yr***qa or TB85***yr***qa. Subsequent years' data was also reviewed in the same manner and any new edits are added to this quality assurance step for succeeding years on an annual basis.

Graphs of the PX85***yr***qa and TB85***yr***qa datasets are reviewed to ensure that all data for all years and all analyzed parameters is in the saved dataset. If any data is not present, the analyst returns to the previous steps to determine what errors in the input database or the program have prevented the data from being extracted, or to verify that the data does not exist.

Table 1. Analytical Problem Codes (APC)- data not used for analysis

TEA: Maryland Department of Natural Resources Tidal Ecosystem Assessment
CBP: Environmental Protection Agency Chesapeake Bay Program Office
CBL: University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Nutrient Analytical Services Laboratory

TEA Code	CBP Code	CBL Code	Description
A	A	1	Laboratory accident
B	B		Chemical matrix interference
BB	TP	19	Torn filter pad
C	C	12	Instrument failure
D	D	2	Insufficient sample
F	F		Unknown
J	J		Incorrect sample fraction for analysis
M	X	5	Sample received warm
NN	NN	21	Particulates found in filtered sample
P	A	7	Lost results
R	R	8	Sample contaminated
RR	RR	18	No sample received
S	A		Sample container broken during analysis
TS	SS		Sample rejected due to high suspended sediment concentration
TT			If NH4 is greater than dissolved Kjeldahl N by 0.1 mg N/L
U	U		Inconsistent relationship between variables
UU	V		Analysis discontinued
V	V	9	Sample results rejected due to quality control criteria
VV			Station name not sampled due to bad field conditions
X	X	10	Sample not preserved properly
XX	NQ		Dissolved organic carbon > total organic carbon

2.2.3 Check and correct method detection limits

In the past, method detection limits (MDLs) were changed at uneven time intervals, when analysis methods or equipment changed. Since 2006, these MDLs are determined each year. The process is described in the *University of Maryland, Chesapeake Biological Laboratory Nutrient Analytical Services Laboratory Standard Operating Procedures and Methods* which is Appendix VII of the Quality Assurance Project Plan for the Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program- Chemical and Physical Properties Component for the period July 1, 2021 – June 30, 2022. The current year's MDLs are applied to the raw data as part of the data processing procedures as detailed in the same document.

As a secondary check, all detection limits, historic and current year’s, are verified in the BA85***yr***qa, PX85***yr***qa and TB85***yr***qa datasets. The program checks to ensure that any measured value at or below the MDL at the time of sample collection for a given parameter is coded as below detection limit (*parameter*_G = ‘<’). If the value is below MDL, the parameter value is corrected to the value of the MDL at the time of sample collection and the *paramete*r_G code is coded as below detection limit. The program also checks to ensure that no data values that are greater than the MDL at the time of sample collection are incorrectly coded as less than the detection limit; if so, the *parameter*_G code is removed. Once all of the data is checked for correct MDLs, calculated parameters are determined as appropriate (different parameters are calculated at different time periods, see Table 2). Parameter method codes are added as needed (*parameter*_M).

Table 2. **Time periods and calculation methods for the calculated parameters.**
If both constituents _G = ‘<’ then calculated parameter _G = ‘<’.

Calculated parameter	Station group	Time period	Calculation	Method code
DIN	All	All	DIN = NH4 + NO23	DIN_M = 'D01'
TN	Tributary/Potomac	Prior to 4/30/1998	TN = TKNW + NO23	TN_M = 'D01'
		After 5/1/1998	TN = PN + TDN	TN_M = 'D01'
	Patuxent/CB5.1W	Prior to 6/30/1990	TN = TKNW + NO23	TN_M = 'D01'
		After 7/1/1990	TN = PN + TDN	TN_M = 'D01'
	Main/LE2.3	1/1/1985 -5/15/1985 10/1/1986- 9/30/1987	TN = TKNW + NO23	TN_M = 'D01'
		5/16/1985-9/30/1986 After 10/1/1987	TN = PN + TDN	TN_M = 'D01'
TP	Tributary/Potomac	Prior to 4/30/1998	Directly measured	TP_M = 'L01'
		After 5/1/1998	TP = PP + TDP	TP_M = 'D01'
	Patuxent/CB5.1W	Prior to 6/30/1990	Directly measured	TP_M = 'L01'
		After 7/1/1990	TP = PP + TDP	TP_M = 'D01'
	Main/LE2.3	1/1/1985 -5/15/1985 10/1/1986- 9/30/1987	Directly measured	TP_M = 'L01'
		5/16/1985-9/30/1986 After 10/1/1987	TP = PP + TDP	TP_M = 'D01'

2.2.4 **Below detection limit datasets**

Starting in 1996, the laboratories provide actual readings data values for parameters even when those values are below the current MDL. These readings are stored separately in the ACCESS databases. Separate analysis datasets are created for 1996-current containing the readings data values (below detection limit data) to remove the impact of censored data on trends analysis. Datasets are handled in the same manner as described in Sections 2.2.1 and 2.2.2, with the exception that Tributary and Patuxent datasets are no longer separate but combined (so there are no separate PX datasets).

Datasets are named using the same conventions as above, with the addition of ‘_bdl’ at the end of the name to distinguish them as actual readings datasets (e.g. TB96***yr***rw_bdl for raw data).

2.2.5 Create input datasets for analysis programs

Trends will be run using one of three time periods: start of sampling to present (for most stations this is either 1985-present of 1986-present), 1999 to present and the most recent 10-year period. Several reference tables are required for the GAMs programming and are all included in an Excel file called 'MDDNRLookupTables(*layer param*Final).xlsx'. The *layer* is dependent on the station (either S for surface or SAP for surface-above pycnocline and B for bottom and BBP for bottom-below pycnocline); the *parameter* is the analysis parameter. A separate Excel file is needed for each layer-parameter pairing because the best flow model for a given station and parameter is independently determined for each layer-parameter pair for a station and is not required to be the same across all parameters or between layers. The trends programming reads in these lookup tables from '\mySettings\' These individual tables are:

1) tidalStations: list of the station names and related information

2) parameterList: list of parameters and related information

3) layerLukup: list of possible layer code combinations that can be tested

4) usgsGages: list USGS gage locations for matching flow data to trend datasets for analysis

5) methodsList: detailed list of time periods for changes in methods, detection limits and other potential interventions needed for running GAM3 and GAM5 models. Details are for each 'stationMethodGroup' defined for Maryland's tidal datasets and is linked to the trend dataset through this variable. This table was developed in 2017 and is updated annually as needed.

6) StationMethodList: information specific to each individual station including station information (name, location type, coordinates, relevant USGS gage, station group, stationMethodGroup (links to MethodList), flow correction averaging window (if applicable), parameters that are flow corrected in GAMs 3 (flwParms) and 5, and parameters that are salinity corrected in GAMs 3 and 5 (salParms). Because each station has a best flow model determined for each parameter and each layer, and these are not forced to be the same across parameters, separate tables are maintained for each parameter and layer.

An example of these tables is provided in Appendix II.

Interval censoring is used for Baytrends, as described in Harcum (2016) technical memo (in Appendix III). This requires the creation of a dataset 'detlimsub8595' from the tb85*yr*qa, ba85*yr*qa and px85*yr*qa datasets (see Section 2.2.3): 'detlimsub8595' has any data that is below the detection limit replaced with the method detection limit at the time of sampling. A second dataset 'nosub96*yr*' is created from the tb85*yr*qa_BDL and ba85*yr*qa_BDL datasets (see Section 2.2.4): 'nosub96*yr*' has the data as reported by the laboratory even if it is below the method detection limit (including in some cases negative values).

These two datasets are combined and parameters that potentially have censored data (i.e. TN, TP, TSS, CHLA, DIN, PO4) are converted to a two parameter format. If a specific datapoint is below detection limit (prior to 1996) and coded with a '<' in the *parameter*_G field, then that datapoint is translated to two columns, *parameter*_lo value = zero (as the lowest part of the censoring interval) and the *parameter*_hi value being set the value in the original dataset (the highest part of the censoring interval, which was set to the detection limit at the time of sampling in previous steps of dataset preparation). If a specific datapoint is not below detection limit (all years) or the below detection limit data is available (after 1996) both *parameter*_lo and *parameter*_hi are set to the value of the datapoint. This reformatted dataset is then saved as MD85***yr*** where ***yr*** is the most recent year in the dataset. This final analysis dataset is imported into R using the **loaddata** and **makeSurvDF** procedures in R, named R85***yr***_Surv.rda and saved to the root directory for analysis (specified by the analyst in the R code).

2.3 Data Analysis

2.3.1 Data analysis programs output datasets

The R statistical package programming 'Baytrends' version 2.0.5 was written by Chesapeake Bay Program staff and consultants and made available on the Comprehensive R Archive Network (CRAN) (https://CRAN.R-project.org/package=baytrends) in May 2021. The input dataset is R85***yr***_Surv.rda. Output includes comma-delimited (*.csv) results summary tables and individual summary tables and graphics file by ***parameter*** (*.docx) of summary results and graphics. Naming of the files includes the ***version*** of the Baytrends software. Output file names include:

MD ***yr version*** stat *parameter layer*.csv
MD ***yr version*** chng *parameter layer*.csv
MD ***yr version*_*parameter layer type gam*_all**.**docx (*type* and *gam* varies depending on parameter)

2.3.2 Analysis parameters

The primary parameters for which trend analyses are conducted each year are listed below:

Four nutrient parameters:

- total nitrogen (TN)
- dissolved inorganic nitrogen (DIN)
- total phosphorus (TP)
- dissolved inorganic phosphorus (PO4)

Seven additional parameters:

- total suspended solids (TSS)
- active chlorophyll a (CHLA), as a response indicator of nutrient enrichment and habitat quality
- Secchi depth (SECCHI), as a measure of water clarity
- summer bottom dissolved oxygen (DO), as a response indicator of nutrient enrichment and habitat quality
- salinity
- water temperature

Water samples for laboratory analysis of nutrients, chlorophyll *a* and total suspended solids are collected at surface and bottom layers. For some stations, additional samples are taken at 1.5 m above and 1.5 m below the pycnocline, if a pycnocline exists, or at defined depths in the water column. For trend analyses, where both surface and above-pycnocline samples are collected, measurements are averaged, resulting in one value for the surface-mixed layer. Likewise, where both bottom and below-pycnocline samples are collected, measurements are averaged, resulting in one value for the bottom-mixed layer. Trend analyses are done for surface-mixed and bottom-mixed layers for TN, TP, DIN, PO4, CHLA and TSS.

Secchi depth is measured at most stations and recorded as a surface layer measurement and analyzed for trends.

Dissolved oxygen, salinity and water temperature are measured *in-situ* at 1- to 2-m intervals through the water column and at the same depths where nutrient samples are collected (see above). For dissolved oxygen, only the data corresponding to the bottom nutrient sample collection depth (bottom layer) is analyzed for trends. For salinity and water temperature, readings from the depths that correspond to the depths where the nutrient parameters were collected are averaged, resulting in one value for the surface-mixed layer and bottom-mixed layers and are analyzed for trends.

2.3.3 General Additive Models (GAMs) for linear and nonlinear trends

Trend tests are conducted using an R statistical package developed by the Chesapeake Bay Program and partners. Trend tests are completed using a Generalized Additive Models (GAMs) approach. The methods used in are described in the following documents available on the Bay Program website at https://www.chesapeakebay.net/who/group/integrated_trends_analysis_team:

Murphy, R.R., E. Perry, J. Harcum, J. Keisman. 2019. A Generalized Additive Model approach to evaluating water quality: Chesapeake Bay case study. Environmental Modeling and Software 118:1-13. https://doi.org/10.1016/j.envsoft.2019.03.027

Murphy, R.R. and E. Perry. 2018 (Draft) Methods for Application of Generalized Additive Models (GAMs) for Water Quality Trends in Tidal Waters of Chesapeake Bay

A listing of the applicable GAMs models available for use is given in Table 3.

The R package for tidal trends, called 'Baytrends', was developed through coordinated efforts at the Chesapeake Bay Program; version 2.0.5 was written by Chesapeake Bay Program staff and consultants and made available on the Comprehensive R Archive Network (CRAN) (https://CRAN.R-project.org/package=baytrends) in May 2021. This Baytrends package is loaded into the R statistical program using RStudio software and calls on many other pre-written and specialty written packages and programs.

Previous trends analysis testing determined that the GAM2 model is the chosen model, based on Akaike information criterion (AIC) score, in almost all cases for all parameters when interventions are not required and flow correction is not used. Intervention testing (GAM3 model), flow or salinity correction testing (GAM4 models) and combined flow/intervention testing (GAM5 models) to determine what as the best model (based on AIC score and test p-value) was completed in 2018 and 2019 for parameters TN, TP, DIN, PO4, TSS, and CHLA, Secchi, dissolved oxygen, water temperature and pH. Best flow models and if intervention models were required was determined for each individual Maryland tidal station. Once the individual stations were tested, in 2019 and 2020 those results were used to determine an overall best model (by layer and parameter) for flow or salinity correction and for intervention by looking at results for stations within an geographic region or that were in the same subgroup of data historically (i.e. Patuxent data or Tributary data). In most instances, this best overall model was still within the top three chosen models for the individual stations, but when necessary the best model for the overall group was used for consistency among stations even if it was not the best model for a given station. This best flow information is stored in the StationMasterList table (Section 2.2.5) and accessed by the R programming for each individual station.

Table 3. Temporal GAM structures in Baytrends (Murphy and Perry, 2018)

Model name	**Description**	**Structure of right hand side of equation**
gam2	Nonlinear trend with seasonality (plus interaction)	cyear + s(cyear, k=gamK1) + s(doy,bs='cc') + ti(cyear,doy,bs=c('tp','cc')), knots = list(doy = c(1,366)), select=TRUE *where: gamK1=c(10,2/3) means that the maximum of 10 or 2/3*number of years is selected*
gam3	Nonlinear trend with seasonality (plus interaction) and intervention	intervention + cyear + s(cyear, k=gamK1) + s(doy,bs='cc') + ti(cyear,doy,bs=c('tp','cc')), knots = list(doy = c(1,366)), select=TRUE *where: gamK1=c(10,2/3) means that the maximum of 10 or (2/3*number of years) is selected*
gam4	Nonlinear trend with seasonality (plus interaction) and hydrology effect	cyear + s(cyear, k=gamK1) + s(doy,bs='cc') + ti(cyear,doy,bs=c('tp','cc')) + s(flw_sal,k=gamK2) + ti(flw_sal,doy,bs=c('tp','cc')) + ti(flw_sal, cyear,bs=c('tp' ,'tp')) + ti(flw_sal,doy,cyear, bs=c('tp','cc','tp')), knots = list(doy = c(1,366)), select=TRUE *where: gamK1=c(10,1/3) means that the maximum of 10 or (1/3*number of years) is selected, and gamK2=c(10,2/3) means that the maximum of 10 or (2/3*number of years) is selected*
gam5	Nonlinear trend with seasonality (plus interaction), hydrology effect, and intervention	intervention + cyear + s(cyear, k=gamK1) + s(doy,bs='cc') + ti(cyear,doy,bs=c('tp','cc')) + s(flw_sal,k=gamK2) + ti(flw_sal,doy,bs=c('tp','cc')) + ti(flw_sal, cyear,bs=c('tp' ,'tp')) + ti(flw_sal,doy,cyear, bs=c('tp','cc','tp')), knots = list(doy = c(1,366)), select=TRUE *where: gamK1=c(10,1/3) means that the maximum of 10 or (1/3*num years) is selected, and gamK2=c(10,2/3) means that the maximum of 10 or (2/3*num years) is selected*

2.4 References

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http://www.potomacriver.org/publications/?type=0&publication_year=2009&publication_author=126&search=&post_type=publications

Murphy, R. and E. Perry. 2018. Draft: Methods for Application of Generalized Additive Models (GAMs) for Water Quality Trends in Tidal Waters of Chesapeake Bay. Online at:
http://www.chesapeakebay.net/groups/group/integrated_trends_analysis_team

Murphy, R.R., E. Perry, J. Harcum, J. Keisman. 2019. A Generalized Additive Model approach to evaluating water quality: Chesapeake Bay case study. Environmental Modeling and Software 118:1-13. https://doi.org/10.1016/j.envsoft.2019.03.027

3 *VALIDATION OF STATISTICAL ANALYSES*

As described in Section 2, numerous quality assurance checks of dataset compilation and the statistical analyses are performed:

1. The entire raw data dataset passes through a series of checks to remove data that has specific Analytical Problem Codes (APC) which disqualify the data for analysis. Definitions of these APCs are included in Table 1. It was determined previously that these were the only problematic APC codes that were actually present in the historic datasets.

2. Raw datasets are graphically reviewed to ensure that all data for all years and all analyzed parameters is in the saved dataset. If any data is not present, the analyst returns to the previous steps to determine what errors in the input database or the program have prevented the data from being extracted, or to verify that the data does not exist.

3. All detection limits are verified in the raw datasets to ensure that any measured value at or below the MDL at the time of sample collection for a given parameter is coded as below detection limit and to ensure that no data values that are greater than the MDL at the time of sample collection are incorrectly coded as less than the detection limit.

4. Graphs of the trends datasets are reviewed to ensure that all data for all years and all analyzed parameters is in the saved dataset. If any data is not present, the analyst returns to the previous steps

to determine what errors have prevented the data from being included in these datasets.

Further QA checks are performed once the trends results have been calculated:

1. Output files (*.csv) are reviewed to ensure the correct data has been analyzed and that the results are complete.

2. Results from the previous year's trends analysis are compared to the results of the current analysis to determine if any major changes occurred. If major changes occurred, the analyst returns to the above files to ensure that the results are correct.

3. Data is analyzed to ensure that the required number of months and years of data are present in the analyzed dataset to meet the Acceptance Criteria.

4 *REPORTS TO MANAGEMENT*

Data tables output as comma-delimited (*.csv) tables and summary results and graphics output as (*.html) files are provided to the Chesapeake Bay Program to fulfill the data deliverable requirement under the grant. This data deliverable is due June 30 of each year. Generally, trends analysis runs are completed by the end of May each year, and final QA of the results is completed by mid-June. In most previous years, the summary tables have been delivered to the Bay Program by mid-June. The electronic summary tables are sent by email to the Project Officer or uploaded to a Google Drive and shared with the Project Officer and other Bay Program analysts.

Various other summary tables are compiled for DNR's needs. One of these is a table of Annual trends results that is used on the DNR website for creating on demand maps. These maps are available to the user by the end of June-early July each year.

As time allows or need requires, static maps are created using ArcMap software to display the Annual surface mixed layer trends for Total Nitrogen, Total Phosphorus, Total Suspended Solids, Chlorophyll *a* and Secchi Depth and the Summer Bottom Dissolved Oxygen results. These maps are made at a Maryland Baywide scale and are used in many DNR presentations. These maps are not funded under the 117e grant and are not a deliverable.

Semi-annual progress reports are prepared and submitted to the Project Officer in July and January each project year.

APPENDIX I: Chronological List of Tidal Water Quality Trend Analysis Methods

Date	Methods used
1985	First full year of monitoring at most tidal monitoring locations Additional tidal tributary stations started in 1986 and 2003
1990-present	Seasonal Kendall Test Sen’s slope estimator Van Belle and Hughes procedure for segment trends
1999-2014	Non-linear trend analysis Replaced with new method in 2015
1996-1999	Flow adjusted trend analysis
1995-present	Calendar year trend analysis
2007-2014	Water year trend analysis
2012-present	Initiated trends with data as reported below detection limits by the labs (censoring not performed) for 1999-current trend period.
2012-2013, annual review current year data	Extensive quality assurance checks of all historic data; developed additional edits to the datasets from the results
December 2015	Initiated use of new statistical programming in R software (version 1) as developed by Chesapeake Bay Program. Using only the below detection limited datasets for the 1999-current trend period and the most recent ten year trend period. 1985-present trends were not completed due to continuing development of new statistical models by Chesapeake Bay Program. No longer doing segment trends.
April 2017	No longer doing Seasonal Kendall trends. Version 2.6 of the R package for GAMs used. 1985-present trends were completed for parameters not impacted by laboratory changes (DO, SALINITY, SECCHI, WTEMP) 1999-2016 trends were completed for parameters potentially impacted by lab changes and or change to below method detection limit data (TN, TP, DIN, PO4, TSS, CHLA) Percent change for most recent 10 years was also determined from the full time period model.
June 2018	Version 4 of the Baytrends R package for GAMs used. Flow or salinity corrections and significant interventions (lab changes, methods changes, changes to below detection limited data) were determined through extensive testing and applied on a station-by-station basis for each parameter as determined using the GAM3 (intervention), GAM4 (flow or salinity correction) or GAM5 (flow correction and interventions) models for surface-mixed layer trends for TN, TP, TSS, CHLA, Secchi depth and dissolved oxygen. Flow/salinity adjusted (GAM4) trends were completed for water temperature. Un-adjusted trends (GAM2) were completed for all parameters.

Date	Methods used
May 2019	Version 1.1.0 of the Baytrends R package for GAMs used. Flow or salinity corrections and significant interventions (lab changes or methods changes) were determined through extensive testing and applied on a station-by-station basis for each parameter as determined using the GAM3 (intervention), GAM4 (flow or salinity correction) or GAM5 (flow correction and interventions, where applicable) models for TN, TP, DIN, PO4, TSS, CHLA, Secchi depth, dissolved oxygen, water temperature and pH. Un-adjusted trends (GAM2) were also completed for these parameters.
May 2020	Version 1.2.1 of the Baytrends R package for GAMs used. Extensive review was completed to determine the best flow models to use for groups of stations to made trends analysis models more consistent within geographic regions, monitoring programs, parameters, etc.
May 2021	Version 2.0.5 of the Baytrends R package for GAMs was used; switch to the Surv data format (previously Baytrends had used a QW data format)

APPENDIX II: Reference Tables required for GAMs procedure

1) tidalStations: list of the station names and related information

station	state	locationType	waterbody	latitude	longitude	cbSeg92	usgsGageName	usgsGageID	usgsGageMatch	stationRO1	stationRO2	stationGrpName	stationMethodGroup
CB1.1	MD	main	Chesapeake Bay	39.54794	-76.0848	CB1TF	Susquehanna River at Conowingo, MD	"01578310"	Direct	1	1	Chesapeake Bay Mainstem (CB1TF)	MD-Mainstem
CB2.1	MD	main	Chesapeake Bay	39.44149	-76.026	CB1TF	Susquehanna River at Conowingo, MD	"01578310"	Direct	1	2	Chesapeake Bay Mainstem (CB1TF)	MD-Mainstem
CB2.2	MD	main	Chesapeake Bay	39.34873	-76.1758	CB2OH	Susquehanna River at Conowingo, MD	"01578310"	Direct	2	1	Chesapeake Bay Mainstem (CB2OH)	MD-Mainstem
CB3.1	MD	main	Chesapeake Bay	39.2495	-76.2405	CB2OH	Susquehanna River at Conowingo, MD	"01578310"	Direct	2	2	Chesapeake Bay Mainstem (CB2OH)	MD-Mainstem
CB3.2	MD	main	Chesapeake Bay	39.16369	-76.3063	CB3MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	3	1	Chesapeake Bay Mainstem (CB3MH)	MD-Mainstem
CB3.3C	MD	main	Chesapeake Bay	38.99596	-76.3597	CB3MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	3	2	Chesapeake Bay Mainstem (CB3MH)	MD-Mainstem
CB3.3E	MD	main	Chesapeake Bay	39.00412	-76.3452	CB3MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	3	3	Chesapeake Bay Mainstem (CB3MH)	MD-Mainstem
CB3.3W	MD	main	Chesapeake Bay	39.00462	-76.3881	CB3MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	3	4	Chesapeake Bay Mainstem (CB3MH)	MD-Mainstem
CB4.1C	MD	main	Chesapeake Bay	38.82593	-76.3995	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	1	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.1E	MD	main	Eastern Bay	38.81809	-76.3714	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	2	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.1W	MD	main	Chesapeake Bay	38.81498	-76.4627	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	3	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.2C	MD	main	Chesapeake Bay	38.64618	-76.4213	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	4	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.2E	MD	main	Chesapeake Bay	38.64499	-76.4013	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	5	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.2W	MD	main	Chesapeake Bay	38.64354	-76.5022	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	6	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.3C	MD	main	Chesapeake Bay	38.55505	-76.4279	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	7	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.3E	MD	main	Chesapeake Bay	38.55624	-76.3912	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	8	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.3W	MD	main	Chesapeake Bay	38.55728	-76.494	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	9	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB4.4	MD	main	Chesapeake Bay	38.41457	-76.3457	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	10	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem
CB5.1	MD	main	Chesapeake Bay	38.3187	-76.2921	CB5MH_M	Susquehanna River at Conowingo, MD	"01578310"	Direct	5	1	Chesapeake Bay Mainstem (CB5MHMD)	MD-Mainstem
CB5.1W	MD	main	Chesapeake Bay	38.32522	-76.3757	CB5MH_M	Patuxent River near Bowie, MD	"01594440"	Indirect	5	2	Chesapeake Bay Mainstem (CB5MHMD)	MD-CB51W
CB5.2	MD	main	Chesapeake Bay	38.13705	-76.2279	CB5MH_M	Susquehanna River at Conowingo, MD	"01578310"	Direct	5	3	Chesapeake Bay Mainstem (CB5MHMD)	MD-Mainstem
CB5.3	MD	main	Chesapeake Bay	37.91011	-76.1714	CB5MH_M	Susquehanna River at Conowingo, MD	"01578310"	Direct	5	4	Chesapeake Bay Mainstem (CB5MHMD)	MD-Mainstem
WT1.1	MD	trib	Bush River	39.43511	-76.2421	BSHOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	1	Upper Western Shore	MD-Tributary
WT2.1	MD	trib	Gunpowder River	39.37747	-76.3347	GUNOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	2	Upper Western Shore	MD-Tributary
WT3.1	MD	trib	Middle River	39.30538	-76.4095	MIDOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	3	Upper Western Shore	MD-Tributary
WT4.1	MD	trib	Back River (Md)	39.27755	-76.4437	BACOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	4	Back_Patapsco	MD-Tributary
WT5.1	MD	trib	Patapsco River	39.21309	-76.5225	PATMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	5	Back_Patapsco	MD-Tributary
WT6.1	MD	trib	Magothy River	39.07851	-76.5101	MAGMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	6	Lower Western Shore	MD-Tributary
WT7.1	MD	trib	Severn River	39.00764	-76.5035	SEVMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	7	Lower Western Shore	MD-Tributary
WT8.1	MD	trib	South River	38.9496	-76.5461	SOUMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	8	Lower Western Shore	MD-Tributary
WT8.2	MD	trib	Rhode River	38.88696	-76.5349	RHDMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	9	Lower Western Shore	MD-Tributary
WT8.3	MD	trib	West River	38.8425	-76.5341	WSTMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	10	Lower Western Shore	MD-Tributary
TF1.0P	MD	trib	Patuxent River	38.95557	-76.6941	PAXTF	Patuxent River near Bowie, MD	"01594440"	Direct	15	1	Patuxent River	MD-Patuxent
TF1.3	MD	trib	Patuxent River	38.81092	-76.7123	PAXTF	Patuxent River near Bowie, MD	"01594440"	Direct	15	2	Patuxent River	MD-Patuxent
TF1.2	MD	trib	Western Branch	38.81428	-76.7508	WBRTF	Patuxent River near Bowie, MD	"01594440"	Indirect	15	3	Patuxent River	MD-Patuxent
WXT0001	MD	trib	Western Branch	38.78539	-76.7134	WBRTF	Patuxent River near Bowie, MD	"01594440"	Indirect	15	4	Patuxent River	MD-Patuxent
TF1.4	MD	trib	Patuxent River	38.77302	-76.7093	PAXTF	Patuxent River near Bowie, MD	"01594440"	Direct	15	5	Patuxent River	MD-Patuxent
TF1.5	MD	trib	Patuxent River	38.71012	-76.7015	PAXTF	Patuxent River near Bowie, MD	"01594440"	Direct	15	6	Patuxent River	MD-Patuxent
TF1.6	MD	trib	Patuxent River	38.65845	-76.6838	PAXOH	Patuxent River near Bowie, MD	"01594440"	Direct	15	7	Patuxent River	MD-Patuxent
TF1.7	MD	trib	Patuxent River	38.58211	-76.681	PAXOH	Patuxent River near Bowie, MD	"01594440"	Direct	15	8	Patuxent River	MD-Patuxent
RET1.1	MD	trib	Patuxent River	38.4909	-76.6643	PAXMH	Patuxent River near Bowie, MD	"01594440"	Direct	15	9	Patuxent River	MD-Patuxent
LE1.1	MD	trib	Patuxent River	38.42535	-76.6018	PAXMH	Patuxent River near Bowie, MD	"01594440"	Direct	15	10	Patuxent River	MD-Patuxent
LE1.2	MD	trib	Patuxent River	38.37887	-76.5113	PAXMH	Patuxent River near Bowie, MD	"01594440"	Direct	15	11	Patuxent River	MD-Patuxent
LE1.3	MD	trib	Patuxent River	38.3398	-76.4849	PAXMH	Patuxent River near Bowie, MD	"01594440"	Direct	15	12	Patuxent River	MD-Patuxent
LE1.4	MD	trib	Patuxent River	38.312	-76.4215	PAXMH	Patuxent River near Bowie, MD	"01594440"	Direct	15	13	Patuxent River	MD-Patuxent

1) tidalStations: list of the station names and related information

station	state	locationType	waterbody	latitude	longitude	cbSeg92	usgsGageName	usgsGageID	usgsGageMatch	stationRO1	stationRO2	stationGrpName	stationMethodGroup
PIS0033	MD	trib	Piscataway Creek	38.69842	-76.9867	PISTF	Potomac River at Chain Bridge, Washington,	"01646500"	Indirect	16	1	Potomac River	MD-Potomac
XFB1986	MD	trib	Piscataway Creek	38.69786	-77.0232	PISTF	Potomac River at Chain Bridge, Washington,	"01646500"	Indirect	16	2	Potomac River	MD-Potomac
TF2.1	MD	trib	Potomac River	38.70664	-77.0488	POTTF_MI	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	3	Potomac River	MD-Potomac
TF2.2	MD	trib	Potomac River	38.69067	-77.1111	POTTF_MI	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	4	Potomac River	MD-Potomac
TF2.3	MD	trib	Potomac River	38.6082	-77.1739	POTTF_MI	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	5	Potomac River	MD-Potomac
MAT0078	MD	trib	Mattawoman Creek	38.58852	-77.1186	MATTF	Potomac River at Chain Bridge, Washington,	"01646500"	Indirect	16	6	Potomac River	MD-Potomac
MAT0016	MD	trib	Mattawoman Creek	38.56508	-77.1935	MATTF	Potomac River at Chain Bridge, Washington,	"01646500"	Indirect	16	7	Potomac River	MD-Potomac
TF2.4	MD	trib	Potomac River	38.5301	-77.2654	POTTF_MI	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	8	Potomac River	MD-Potomac
RET2.1	MD	trib	Potomac River	38.4035	-77.2691	POTOH1_I	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	9	Potomac River	MD-Potomac
RET2.2	MD	trib	Potomac River	38.3525	-77.2051	POTOH1_I	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	10	Potomac River	MD-Potomac
RET2.4	MD	trib	Potomac River	38.3626	-76.9906	POTMH_N	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	11	Potomac River	MD-Potomac
LE2.2	MD	trib	Potomac River	38.1576	-76.598	POTMH_N	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	12	Potomac River	MD-Potomac
LE2.3	MD	trib	Potomac River	38.0215	-76.3477	POTMH_N	Potomac River at Chain Bridge, Washington,	"01646500"	Direct	16	13	Potomac River	MD-LE23
ET1.1	MD	trib	Northeast River	39.56976	-75.9678	NORTF	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	1	Upper Eastern Shore	MD-Tributary
ET2.1	MD	trib	Back Creek	39.5293	-75.8114	C&DOH_N	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	2	Upper Eastern Shore	MD-Tributary
ET2.3	MD	trib	Elk River	39.50873	-75.8978	ELKOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	3	Upper Eastern Shore	MD-Tributary
ET2.2	MD	trib	Bohemia River	39.46704	-75.8737	BOHOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	4	Upper Eastern Shore	MD-Tributary
ET3.1	MD	trib	Sassafras River	39.36415	-75.882	SASOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	5	Upper Eastern Shore	MD-Tributary
ET4.1	MD	trib	Chester River	39.2437	-75.9249	CHSTF	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	6	Upper Eastern Shore	MD-Tributary
XHH4742	MD	trib	Corsica River	39.07807	-76.0972	CSHMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	7	Upper Eastern Shore	MD-Tributary
ET4.2	MD	trib	Chester River	38.99233	-76.2151	CHSMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	8	Upper Eastern Shore	MD-Tributary
EE1.1	MD	trib	Eastern Bay	38.88	-76.2515	EASMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	9	Upper Eastern Shore	MD-Tributary
ET5.1	MD	trib	Choptank River	38.80645	-75.9097	CHOOH	Choptank River near Greensboro, MD	"01491000"	Direct	18	10	Choptank	MD-Tributary
ET5.2	MD	trib	Choptank River	38.5807	-76.0587	CHOMH2	Choptank River near Greensboro, MD	"01491000"	Direct	18	11	Choptank	MD-Tributary
EE2.1	MD	trib	Choptank River	38.6549	-76.2643	CHOMH1	Choptank River near Greensboro, MD	"01491000"	Direct	18	12	Choptank	MD-Tributary
EE2.2	MD	trib	Little Choptank River	38.52609	-76.3041	LCHMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	13	Choptank	MD-Tributary
ET6.1	MD	trib	Nanticoke River	38.54833	-75.7031	NANTF_M	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	14	Lower Eastern Shore	MD-Tributary
ET6.2	MD	trib	Nanticoke River	38.34133	-75.8883	NANMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	15	Lower Eastern Shore	MD-Tributary
WIW0141	MD	trib	Wicomico River	38.34153	-75.6957	WICMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	16	Lower Eastern Shore	MD-Tributary
ET7.1	MD	trib	Wicomico River	38.26783	-75.7879	WICMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	17	Lower Eastern Shore	MD-Tributary
ET8.1	MD	trib	Manokin River	38.13794	-75.8141	MANMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	18	Lower Eastern Shore	MD-Tributary
ET9.1	MD	trib	Big Annemessex River	38.055	-75.8017	BIGMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	19	Lower Eastern Shore	MD-Tributary
ET10.1	MD	trib	Pocomoke River	38.07615	-75.5713	POCTF	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	20	Lower Eastern Shore	MD-Tributary
EE3.0	MD	trib	Fishing Bay	38.28093	-76.0103	FSBMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	21	Lower Eastern Shore	MD-Tributary
EE3.1	MD	trib	Tangier Sound	38.19685	-75.9732	TANMH_N	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	22	Lower Eastern Shore	MD-Tributary
EE3.2	MD	trib	Tangier Sound	37.98139	-75.9242	TANMH_N	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	23	Lower Eastern Shore	MD-Tributary
EE3.3	MD	trib	Pocomoke Sound	37.91455	-75.8015	POCMH_N	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	24	Lower Eastern Shore	MD-Tributary

2) \parameterList: list of parameters and related information

parm	parmSource	parmCat	parmName	parmCalc	parmNamelc	parmUnits	parmRecenso	parmRO1	parmRO2	parmTrend	logTrans	trendIncrease
secchi	SECCHI	Primary	Secchi Depth	No	Secchi depth	m		1	1	TRUE	FALSE	Improving
chla	CHLA	Primary	Chlorophyll a (Corrected)	No	chlorophyll a (corrected)	ug/L	0.1	1	2	TRUE	TRUE	Degrading
do	DO	Primary	Dissolved Oxygen	No	dissolved oxygen	mg/L	0.1	1	3	TRUE	FALSE	Improving
tn	TN	Primary	Total Nitrogen	Yes	total nitrogen	mg/L	0.1	1	4	TRUE	TRUE	Degrading
tp	TP	Primary	Total Phosphorus	Both	total phosphorus	mg/L	0.01	1	5	TRUE	TRUE	Degrading
po4	po4	Primary	Orthophosphorus	xx	orthophosphorus	mg/L	0.001	1	8	TRUE	TRUE	Degrading
din	DIN	Primary	Dissolved Inorganic Nitrogen	Yes	dissolved inorganic nitrogen	mg/L		1	7	TRUE	TRUE	Degrading
salinity	SALINITY	Primary	Salinity	No	salinity	ppt		1	9	TRUE	FALSE	Increasing
tss	TSS	Primary	Total Suspended Solids	No	total suspended solids	mg/L	0.1	1	6	TRUE	TRUE	Degrading
wtemp	WTEMP	Primary	Water Temperature	No	water temperature	deg C		1	10	FALSE	FALSE	Increasing

3) \ layerLukup: list of layer codes

layers	name
S	Surface
B	Bottom
SAP	Surface & Above Pycnocline
BBP	Below and Below Pycnocline

4) \ usgsGages: list USGS gage locations for matching flow data to trend datasets for analysis

siteNumber	siteName
"01491000"	Choptank River near Greensboro, MD
"01578310"	Susquehanna River at Conowingo, MD
"01594440"	Patuxent River near Bowie, MD
"01646500"	Potomac River at Chain Bridge, Washington, DC

5) methodsList: detailed list of time periods for changes in methods or a lab change needed for running GAM3 and GAM5 models. Details are for each 'stationMethodGroup' defined for Maryland's tidal datasets and is linked to the trend dataset through this variable. This table was developed in 2018-2020 and will be updated as additional parameters are added.

stationMethodGroup	intervention	parameter	beginDate	label	endDate	laboratory	Calc	Component1	Component2	MDL1	MDL2	EQ	CalcMDL
MD-Patuxent	TRUE	chla	1/1/2009	lab_change	12/31/2030	CBL	TRUE			0.62			
MD-Tributary	TRUE	chla	1/1/2009	lab_change	12/31/2030	CBL	TRUE			0.62			
MD-CB51W	TRUE	din	7/1/1990	lab_change	12/31/1995	CBL	TRUE	nh4	no23	0.003	0.0002	ADD	0.0032
MD-Patuxent	TRUE	din	7/1/1990	lab_change	12/31/1995	CBL	TRUE	nh4	no23	0.003	0.0002	ADD	0.0032
MD-Potomac	TRUE	din	5/1/1998	lab_change	6/30/1998	CBL	TRUE	nh4	no23	0.003	0.0002	ADD	0.0032
MD-Tributary	TRUE	din	5/1/1998	lab_change	12/31/1999	CBL	TRUE	nh4	no23	0.003	0.0002	ADD	0.0032
MD-CB51W	TRUE	po4	7/1/1990	lab_change	12/31/1995	CBL	FALSE			0.0006			
MD-Patuxent	TRUE	po4	7/1/1990	lab_change	12/31/1995	CBL	FALSE			0.0006			
MD-Potomac	TRUE	po4	5/1/1998	lab_change	12/31/2030	CBL	FALSE			0.0006			
MD-Tributary	TRUE	po4	5/1/1998	lab_change	12/31/2030	CBL	FALSE			0.0006			
MD-CB51W	TRUE	tn	7/1/1990	lab_change	12/31/1995	CBL	TRUE	pn	tdn	0.0105	0.02	ADD	0.0305
MD-Patuxent	TRUE	tn	7/1/1990	lab_change	12/31/1995	CBL	TRUE	pn	tdn	0.0105	0.02	ADD	0.0305
MD-Potomac	TRUE	tn	5/1/1998	lab_change	12/31/2007	CBL	TRUE	pn	tdn	0.0105	0.02	ADD	0.0305
MD-Tributary	TRUE	tn	5/1/1998	lab_change	12/31/2007	CBL	TRUE	pn	tdn	0.0105	0.02	ADD	0.0305
MD-CB51W	TRUE	tp	7/1/1990	lab_change	12/31/1995	CBL	TRUE	pp	tdp	0.0012	0.001	ADD	0.0022
MD-Patuxent	TRUE	tp	7/1/1990	lab_change	12/31/1995	CBL	TRUE	pp	tdp	0.0012	0.001	ADD	0.0022
MD-Potomac	TRUE	tp	5/1/1998	lab_change	12/31/1999	CBL	TRUE	pp	tdp	0.0012	0.001	ADD	
MD-Tributary	TRUE	tp	5/1/1998	lab_change	12/31/1999	CBL	TRUE	pp	tdp	0.0012	0.001	ADD	0.0022
MD-CB51W	TRUE	tss	7/1/1990	lab_change	12/31/1995	CBL	FALSE			1.5			
MD-Patuxent	TRUE	tss	7/1/1990	lab_change	12/31/1995	CBL	FALSE			1.5			
MD-Potomac	TRUE	tss	5/1/1998	lab_change	12/31/1999	CBL	FALSE			1.5			
MD-Tributary	TRUE	tss	5/1/1998	lab_change	12/31/1999	CBL	FALSE			1.5			

6) StationMethodList: information specific to each individual station including station information (name, location type, coordinates, relevant USGS gage, station group, stationMethodGroup (links to MethodList), flow correction averaging windows (if applicable), parameters that are flow corrected in GAMs 3 (flwParms) and 5, and parameters that are salinity corrected in GAMs 3 and 5 (salParms). Separate tables are maintained for each parameter and by layer (either Surface and Surface/Above Pycnocline or Bottom and Below Pycnocline/Bottom). Below is an example using the TN Surface trends. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Table 7 shows the flowAvgWin of the tables for other parameters and layers.

station	state	location Type	waterbody	latitude	longitude	cbSeg92	usgsGageName	usgsGageID	usgsGageMatch	station RO1	station RO2	stationGrpName	stationMethod Group	hydroTerm	flwAvg Win	flwParms	salParms	notes	RMs_ QorSal	start
CB1.1	MD	main	Chesapeake Bay	39.54794	-76.08481	CB1TF	Susquehanna River at Conowingo, MD	"01578310"	Direct	1	1	Chesapeake Bay Mainstem (CB1TF)	MD-Mainstem	flow	30	tn		2020 change to d30 to match B flow: based on top3 AIC through 2018 for S layers added 15 because of 2018	Q	1985
CB2.1	MD	main	Chesapeake Bay	39.44149	-76.02599	CB1TF	Susquehanna River at Conowingo, MD	"01578310"	Direct	1	2	Chesapeake Bay Mainstem (CB1TF)	MD-Mainstem	flow	30	tn		2020 change to d30 to match B flow: based on top3 AIC through 2018 for S	Q	1985
CB3.3E	MD	main	Chesapeake Bay	39.00412	-76.34517	CB3MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	3	3	Chesapeake Bay Mainstem (CB3MH)	MD-Mainstem	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
CB3.3W	MD	main	Chesapeake Bay	39.00462	-76.3881	CB3MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	3	4	Chesapeake Bay Mainstem (CB3MH)	MD-Mainstem	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
CB4.1W	MD	main	Chesapeake Bay	38.81498	-76.46272	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	3	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
CB4.2E	MD	main	Chesapeake Bay	38.64499	-76.40131	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	5	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
CB4.2W	MD	main	Chesapeake Bay	38.64354	-76.50217	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	6	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
CB4.3W	MD	main	Chesapeake Bay	38.55728	-76.49402	CB4MH	Susquehanna River at Conowingo, MD	"01578310"	Direct	4	9	Chesapeake Bay Mainstem (CB4MH)	MD-Mainstem	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
WT1.1	MD	trib	Bush River	39.43511	-76.24205	BSHOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	1	Upper Western Shore	MD-Tributary	flow	120	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
WT2.1	MD	trib	Gunpowder River	39.37747	-76.33465	GUNOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	2	Upper Western Shore	MD-Tributary	salinity	1		tn	flow:based on top3 AIC through 2018 for S layers	S	1986
WT3.1	MD	trib	Middle River	39.30538	-76.40954	MIDOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	3	Upper Western Shore	MD-Tributary	salinity	1		tn	flow:based on top3 AIC through 2018 for S layers add d180 to be consistent	S	1986
WT4.1	MD	trib	Back River (Md)	39.27755	-76.44368	BACOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	4	Back_Patapsco	MD-Tributary	salinity	1		tn	both: based on top3 AIC through 2018 for S layers	S	1985
WT6.1	MD	trib	Magothy River	39.07851	-76.51005	MAGMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	6	Lower Western Shore	MD-Tributary	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
WT7.1	MD	trib	Severn River	39.00764	-76.5035	SEVMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	7	Lower Western Shore	MD-Tributary	salinity	1		tn	both: added in sal because of 2018 results; based on top3 AIC through	S	1986
WT8.1	MD	trib	South River	38.9496	-76.5461	SOUMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	8	Lower Western Shore	MD-Tributary	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
WT8.2	MD	trib	Rhode River	38.88696	-76.5349	RHDMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	9	Lower Western Shore	MD-Tributary	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1985
WT8.3	MD	trib	West River	38.8425	-76.5341	WSTMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	14	10	Lower Western Shore	MD-Tributary	salinity	1		tn	both:based on top3 AIC through 2018 for S layers add sal to be consistent	S	1985
TF1.3	MD	pax	Patuxent River	38.81092	-76.71227	PAXTF	Patuxent River near Bowie, MD	"01594440"	Direct	15	2	Patuxent River	MD-Patuxent	flow	5	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
TF1.2	MD	pax	Western Branch	38.81428	-76.7508	WBRTF	Patuxent River near Bowie, MD	"01594440"	Indirect	15	3	Patuxent River	MD-Patuxent	flow	1	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
WXT0001	MD	pax	Western Branch	38.78539	-76.71343	WBRTF	Patuxent River near Bowie, MD	"01594440"	Indirect	15	4	Patuxent River	MD-Patuxent	flow	1	tn		flow:based on top3 AIC through 2018 for S layers	Q	1991

6) StationMethodList: information specific to each individual station including station information (name, location type, coordinates, relevant USGS gage, station group, stationMethodGroup (links to MethodList), flow correction averaging windows (if applicable), parameters that are flow corrected in GAMs 3 (flwParms) and 5, and parameters that are salinity corrected in GAMs 3 and 5 (salParms). Separate tables are maintained for each parameter and by layer (either Surface and Surface/Above Pycnocline or Bottom and Below Pycnocline/Bottom). Below is an example using the TN Surface trends. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Table 7 shows the flowAvgWin of the tables for other parameters and layers.

station	state	location Type	waterbody	latitude	longitude	cbSeg92	usgsGageName	usgsGageID	usgsGageMatch	station RO1	station RO2	stationGrpName	stationMethod Group	hydroTerm	flwAvg Win	flwParms	salParms	notes	RMs_ QorSal	start
TF1.4	MD	pax	Patuxent River	38.77302	-76.70927	PAXTF	Patuxent River near Bowie, MD	"01594440"	Direct	15	5	Patuxent River	MD-Patuxent	flow	5	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
TF1.7	MD	pax	Patuxent River	38.58211	-76.68101	PAXOH	Patuxent River near Bowie, MD	"01594440"	Direct	15	8	Patuxent River	MD-Patuxent	flow	5	tn		sal: based on top3 AIC through 2018 for S layers	Q	1985
PIS0033	MD	pot	Piscataway Creek	38.69842	-76.98673	PISTF	Potomac River at Chain Bridge,	"01646500"	Indirect	16	1	Potomac River	MD-Potomac	flow	1	tn		flow:based on top3 AIC through 2018 for S layers	Q	1986
XFB1986	MD	pot	Piscataway Creek	38.69786	-77.02317	PISTF	Potomac River at Chain Bridge,	"01646500"	Indirect	16	2	Potomac River	MD-Potomac	flow	5	tn		flow:based on top3 AIC through 2018 for S layers	Q	1986
TF2.1	MD	pot	Potomac River	38.70664	-77.04876	POTTF_MD	Potomac River at Chain Bridge,	"01646500"	Direct	16	3	Potomac River	MD-Potomac	flow	5	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
TF2.2	MD	pot	Potomac River	38.69067	-77.11111	POTTF_MD	Potomac River at Chain Bridge,	"01646500"	Direct	16	4	Potomac River	MD-Potomac	flow	5	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
TF2.3	MD	pot	Potomac River	38.6082	-77.1739	POTTF_MD	Potomac River at Chain Bridge,	"01646500"	Direct	16	5	Potomac River	MD-Potomac	flow	10	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
MAT0078	MD	pot	Mattawoman Creek	38.58852	-77.11864	MATTF	Potomac River at Chain Bridge,	"01646500"	Indirect	16	6	Potomac River	MD-Potomac	flow	1	tn		flow: based on top3 AIC through 2018 for S layers; added in 90 because of	Q	1986
MAT0016	MD	pot	Mattawoman Creek	38.56508	-77.19345	MATTF	Potomac River at Chain Bridge,	"01646500"	Indirect	16	7	Potomac River	MD-Potomac	flow	10	tn		flow:based on top3 AIC through 2018 for S layers	Q	1986
TF2.4	MD	pot	Potomac River	38.5301	-77.2654	POTTF_MD	Potomac River at Chain Bridge,	"01646500"	Direct	16	8	Potomac River	MD-Potomac	flow	10	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
RET2.1	MD	pot	Potomac River	38.4035	-77.2691	POTOH1_MD	Potomac River at Chain Bridge,	"01646500"	Direct	16	9	Potomac River	MD-Potomac	salinity	1		tn	change in 2020 to match B and RET2.2	S	1985
RET2.2	MD	pot	Potomac River	38.3525	-77.2051	POTOH1_MD	Potomac River at Chain Bridge,	"01646500"	Direct	16	10	Potomac River	MD-Potomac	salinity	1		tn	both: based on top3 AIC through 2018 for S layers	S	1985
ET1.1	MD	trib	Northeast River	39.56976	-75.96782	NORTF	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	1	Upper Eastern Shore	MD-Tributary	flow	60	tn		flow:based on top3 AIC through 2018 for S layers	Q	1986
ET2.1	MD	trib	Back Creek	39.5293	-75.81135	C&DOH_MD	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	2	Upper Eastern Shore	MD-Tributary	flow	40	tn		flow:based on top3 AIC through 2018 for S layers	Q	1986
ET2.3	MD	trib	Elk River	39.50873	-75.89783	ELKOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	3	Upper Eastern Shore	MD-Tributary	flow	1	tn		change 2020 to d1 is second best fit for both S and B so matches	Q	1986
ET2.2	MD	trib	Bohemia River	39.46704	-75.87368	BOHOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	4	Upper Eastern Shore	MD-Tributary	flow	150	tn		sal: based on top3 AIC through 2018 for S layers	Q	1986
ET3.1	MD	trib	Sassafras River	39.36415	-75.88203	SASOH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	5	Upper Eastern Shore	MD-Tributary	flow	180	tn		both: based on top3 AIC through 2018 for S layers; added in 180	Q	1986
ET4.1	MD	trib	Chester River	39.2437	-75.9249	CHSTF	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	6	Upper Eastern Shore	MD-Tributary	flow	5	tn		flow:based on top3 AIC through 2018 for S layers	Q	1985
ET5.1	MD	trib	Choptank River	38.80645	-75.90971	CHOOH	Choptank River near Greensboro, MD	"01491000"	Direct	18	10	Choptank	MD-Tributary	salinity	1		tn	flow:based on top3 AIC through 2018 for S layers	S	1985
EE2.2	MD	trib	Little Choptank River	38.52609	-76.30408	LCHMH	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	13	Choptank	MD-Tributary	salinity	1		tn	both: based on top3 AIC through 2018 for S layers	S	1986

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station	state	location Type	waterbody	latitude	longitude	cbSeg92	usgsGageName	usgsGageID	usgsGageMatch	station RO1	station RO2	stationGrpName	stationMethod Group	hydroTerm	flwAvg Win	flwParms	salParms	notes	RMs_ QorSal	start
ET6.1	MD	trib	Nanticoke River	38.54833	-75.70306	NANTF_MD	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	14	Lower Eastern Shore	MD-Tributary	flow	30	tn		flow:based on top3 AIC through 2018 for S layers	Q	1986
ET6.2	MD	trib	Nanticoke River	38.34133	-75.88834	NANMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	15	Lower Eastern Shore	MD-Tributary	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1986
ET7.1	MD	trib	Wicomico River	38.26783	-75.78793	WICMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	17	Lower Eastern Shore	MD-Tributary	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1986
ET8.1	MD	trib	Manokin River	38.13794	-75.81411	MANMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	18	Lower Eastern Shore	MD-Tributary	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1986
ET9.1	MD	trib	Big Annemessex River	38.055	-75.80167	BIGMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	19	Lower Eastern Shore	MD-Tributary	flow	150	tn		change in 2020 to d150 for S 'd150 is the best match for S and B	Q	1986
ET10.1	MD	trib	Pocomoke River	38.07615	-75.57125	POCTF	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	20	Lower Eastern Shore	MD-Tributary	flow	15	tn		flow:based on top3 AIC through 2018 for S layers	Q	1986
EE3.0	MD	trib	Fishing Bay	38.28093	-76.01033	FSBMH	Choptank River near Greensboro, MD	"01491000"	ChopDefault	18	21	Lower Eastern Shore	MD-Tributary	salinity	1		tn	sal: based on top3 AIC through 2018 for S layers	S	1986
EE3.3	MD	trib	Pocomoke Sound	37.91455	-75.80148	POCMH_MD	Susquehanna River at Conowingo, MD	"01578310"	SusDefault	18	24	Lower Eastern Shore	MD-Tributary	flow	150	tn		change in 2020 S to d150 to match leave as d150 because better AIC and	Q	1986

7) StationMethodList (partial): The hydroTerm and flowAvgWin for other parameters (see top row for which parameter is shown) by both layers- Surface, Surface/Above Pycnocline, Bottom, Below Pycnocline/Bottom. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Grey fill indicates parameter is not measured for that station/layer.

Surface							TN		TP		TSS		DIN		PO4	
station	start	layer	usgsGageID	station RO1	station RO2	stationMethod Group	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win
CB1.1	1985	S	"01578310"	1	1	MD-Mainstem	flow	30	flow	1	flow	1	flow	150	flow	5
CB2.1	1985	S	"01578310"	1	2	MD-Mainstem	flow	30	flow	5	flow	5	flow	15	flow	10
CB3.3E	1985	S	"01578310"	3	3	MD-Mainstem	salinity	1	flow	10	salinity	1	salinity	1	flow	30
CB3.3W	1985	S	"01578310"	3	4	MD-Mainstem	salinity	1	flow	10	salinity	1	salinity	1	salinity	1
CB4.1W	1985	S	"01578310"	4	3	MD-Mainstem	salinity	1	flow	10	flow	60	salinity	1	salinity	1
CB4.2E	1985	S	"01578310"	4	5	MD-Mainstem	salinity	1	flow	30	flow	90	salinity	1	flow	30
CB4.2W	1985	S	"01578310"	4	6	MD-Mainstem	salinity	1	flow	30	flow	90	salinity	1	flow	30
CB4.3W	1985	S	"01578310"	4	9	MD-Mainstem	salinity	1	flow	40	flow	120	salinity	1	flow	40
WT1.1	1985	S	"01578310"	14	1	MD-Tributary	flow	120	flow	180	flow	150	flow	10	flow	10
WT2.1	1986	S	"01578310"	14	2	MD-Tributary	salinity	1	flow	180	flow	180	flow	10	flow	30
WT3.1	1986	S	"01578310"	14	3	MD-Tributary	salinity	1	flow	180	flow	5	flow	40	flow	30
WT4.1	1985	S	"01578310"	14	4	MD-Tributary	salinity	1	flow	40	flow	120	flow	90	salinity	1
WT6.1	1985	S	"01578310"	14	6	MD-Tributary	salinity	1	salinity	1	flow	120	flow	210	salinity	1
WT7.1	1986	S	"01578310"	14	7	MD-Tributary	salinity	1	salinity	1	salinity	1	salinity	1	flow	15
WT8.1	1985	S	"01578310"	14	8	MD-Tributary	salinity	1	salinity	1	salinity	1	salinity	1	flow	90
WT8.2	1985	S	"01578310"	14	9	MD-Tributary	salinity	1	salinity	1	salinity	1	salinity	1	flow	90
WT8.3	1985	S	"01578310"	14	10	MD-Tributary	salinity	1	salinity	1	salinity	1	salinity	1	flow	90
TF1.3	1985	S	"01594440"	15	2	MD-Patuxent	flow	5	flow	1	flow	1	flow	5	flow	5
TF1.2	1985	S	"01594440"	15	3	MD-Patuxent	flow	1	flow	1	flow	1	flow	1	flow	1
WXT0001	1991	S	"01594440"	15	4	MD-Patuxent	flow	1	flow	1	flow	1	flow	1	flow	1
TF1.4	1985	S	"01594440"	15	5	MD-Patuxent	flow	5	flow	1	flow	1	flow	5	flow	5
TF1.7	1985	S	"01594440"	15	8	MD-Patuxent	flow	5	salinity	1	salinity	1	salinity	1	flow	90
PIS0033	1986	S	"01646500"	16	1	MD-Potomac	flow	1	flow	15	flow	1	flow	1	flow	5
XFB1986	1986	S	"01646500"	16	2	MD-Potomac	flow	5	flow	5	flow	1	flow	15	flow	5
TF2.1	1985	S	"01646500"	16	3	MD-Potomac	flow	5	flow	1	flow	1	flow	5	flow	5
TF2.2	1985	S	"01646500"	16	4	MD-Potomac	flow	5	flow	1	flow	1	flow	5	flow	5
TF2.3	1985	S	"01646500"	16	5	MD-Potomac	flow	10	flow	5	flow	5	flow	15	flow	10
MAT0078	1986	S	"01646500"	16	6	MD-Potomac	flow	1	flow	210	flow	1	flow	10	flow	10
MAT0016	1986	S	"01646500"	16	7	MD-Potomac	flow	10	flow	10	flow	5	flow	15	flow	10
TF2.4	1985	S	"01646500"	16	8	MD-Potomac	flow	10	flow	5	flow	5	flow	30	flow	10
RET2.1	1985	S	"01646500"	16	9	MD-Potomac	salinity	1	flow	5	salinity	1	salinity	1	flow	30
RET2.2	1985	S	"01646500"	16	10	MD-Potomac	salinity	1	flow	5	salinity	1	salinity	1	salinity	1
ET1.1	1986	S	"01578310"	18	1	MD-Tributary	flow	60	flow	20	flow	5	flow	5	flow	20
ET2.1	1986	S	"01578310"	18	2	MD-Tributary	flow	40	flow	50	flow	40	flow	90	flow	50
ET2.3	1986	S	"01578310"	18	3	MD-Tributary	flow	1	flow	50	flow	40	flow	120	flow	50
ET2.2	1986	S	"01578310"	18	4	MD-Tributary	flow	150	flow	50	flow	40	flow	210	flow	30
ET3.1	1986	S	"01578310"	18	5	MD-Tributary	flow	180	flow	1	flow	1	flow	210	flow	150
ET4.1	1985	S	"01491000"	18	6	MD-Tributary	flow	5	flow	1	flow	120	flow	5	flow	5
ET5.1	1985	S	"01491000"	18	10	MD-Tributary	salinity	1	flow	20	flow	150	flow	20	flow	20
EE2.2	1986	S	"01578310"	18	13	MD-Tributary	salinity	1	salinity	1	flow	120	flow	120	flow	10
ET6.1	1986	S	"01491000"	18	14	MD-Tributary	flow	30	flow	5	flow	150	flow	30	flow	5
ET6.2	1986	S	"01491000"	18	15	MD-Tributary	salinity	1	salinity	1	salinity	1	flow	50	salinity	1
ET7.1	1986	S	"01491000"	18	17	MD-Tributary	salinity	1	salinity	1	flow	210	salinity	1	salinity	1
ET8.1	1986	S	"01491000"	18	18	MD-Tributary	salinity	1	salinity	1	flow	90	flow	150	flow	150
ET9.1	1986	S	"01491000"	18	19	MD-Tributary	flow	150	salinity	1	flow	180	flow	150	flow	60
ET10.1	1986	S	"01491000"	18	20	MD-Tributary	flow	15	flow	180	flow	10	flow	15	flow	5
EE3.0	1986	S	"01491000"	18	21	MD-Tributary	salinity	1	salinity	1	salinity	1	flow	120	flow	1
EE3.3	1986	S	"01578310"	18	24	MD-Tributary	flow	150	flow	210	flow	120	flow	210	salinity	1

7) StationMethodList (partial): The hydroTerm and flowAvgWin for other parameters (see top row for which parameter is shown) by both layers- Surface, Surface/Above Pycnocline, Bottom, Below Pycnocline/Bottom. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Grey fill indicates parameter is not measured for that station/layer.

Surface							CHLA		DO		WTEMP		SECCHI	
station	start	layer	usgsGageID	station RO1	station RO2	stationMethod Group	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win
CB1.1	1985	S	"01578310"	1	1	MD-Mainstem	flow	10	flow	10	flow	5	flow	5
CB2.1	1985	S	"01578310"	1	2	MD-Mainstem	flow	10	flow	10	flow	5	flow	5
CB3.3E	1985	S	"01578310"	3	3	MD-Mainstem	salinity	1	salinity	1	flow	210	salinity	1
CB3.3W	1985	S	"01578310"	3	4	MD-Mainstem	salinity	1	salinity	1	flow	210	salinity	1
CB4.1W	1985	S	"01578310"	4	3	MD-Mainstem	salinity	1	salinity	1	salinity	1	salinity	1
CB4.2E	1985	S	"01578310"	4	5	MD-Mainstem	salinity	1	salinity	1	salinity	1	salinity	1
CB4.2W	1985	S	"01578310"	4	6	MD-Mainstem	salinity	1	salinity	1	salinity	1	salinity	1
CB4.3W	1985	S	"01578310"	4	9	MD-Mainstem	flow	60	salinity	1	flow	210	salinity	1
WT1.1	1985	S	"01578310"	14	1	MD-Tributary	flow	90	flow	1	flow	1	flow	50
WT2.1	1986	S	"01578310"	14	2	MD-Tributary	flow	150	flow	40	flow	1	salinity	1
WT3.1	1986	S	"01578310"	14	3	MD-Tributary	flow	150	flow	40	flow	1	flow	90
WT4.1	1985	S	"01578310"	14	4	MD-Tributary	flow	10	flow	40	flow	1	flow	210
WT6.1	1985	S	"01578310"	14	6	MD-Tributary	flow	40	flow	10	flow	210	salinity	1
WT7.1	1986	S	"01578310"	14	7	MD-Tributary	flow	60	flow	10	flow	210	salinity	1
WT8.1	1985	S	"01578310"	14	8	MD-Tributary	flow	210	flow	15	flow	210	salinity	1
WT8.2	1985	S	"01578310"	14	9	MD-Tributary	salinity	1	flow	15	flow	210	salinity	1
WT8.3	1985	S	"01578310"	14	10	MD-Tributary	salinity	1	flow	15	flow	210	salinity	1
TF1.3	1985	S	"01594440"	15	2	MD-Patuxent	flow	5	flow	1	flow	5		
TF1.2	1985	S	"01594440"	15	3	MD-Patuxent	flow	1	flow	1	flow	1		
WXT0001	1991	S	"01594440"	15	4	MD-Patuxent	flow	5	flow	1	flow	5	flow	1
TF1.4	1985	S	"01594440"	15	5	MD-Patuxent	flow	5	flow	1	flow	5	flow	1
TF1.7	1985	S	"01594440"	15	8	MD-Patuxent	salinity	1	flow	180	flow	5	salinity	1
PIS0033	1986	S	"01646500"	16	1	MD-Potomac	flow	5	flow	1	flow	1		
XFB1986	1986	S	"01646500"	16	2	MD-Potomac	flow	5	flow	1	flow	1	flow	1
TF2.1	1985	S	"01646500"	16	3	MD-Potomac	flow	10	flow	10	flow	5	flow	1
TF2.2	1985	S	"01646500"	16	4	MD-Potomac	flow	10	flow	10	flow	5	flow	5
TF2.3	1985	S	"01646500"	16	5	MD-Potomac	flow	10	flow	10	flow	5	flow	5
MAT0078	1986	S	"01646500"	16	6	MD-Potomac	flow	5	flow	1	flow	1		
MAT0016	1986	S	"01646500"	16	7	MD-Potomac	flow	20	flow	1	flow	1	flow	10
TF2.4	1985	S	"01646500"	16	8	MD-Potomac	flow	10	flow	10	flow	5	flow	10
RET2.1	1985	S	"01646500"	16	9	MD-Potomac	flow	20	salinity	1	flow	5	flow	10
RET2.2	1985	S	"01646500"	16	10	MD-Potomac	flow	20	salinity	1	flow	5	flow	10
ET1.1	1986	S	"01578310"	18	1	MD-Tributary	flow	150	flow	210	flow	210	flow	5
ET2.1	1986	S	"01578310"	18	2	MD-Tributary	flow	30	flow	210	flow	210	flow	40
ET2.3	1986	S	"01578310"	18	3	MD-Tributary	flow	30	flow	210	flow	210	flow	30
ET2.2	1986	S	"01578310"	18	4	MD-Tributary	flow	30	flow	210	flow	210	salinity	1
ET3.1	1986	S	"01578310"	18	5	MD-Tributary	flow	150	flow	210	flow	1	flow	5
ET4.1	1985	S	"01491000"	18	6	MD-Tributary	flow	15	flow	5	flow	1	flow	5
ET5.1	1985	S	"01491000"	18	10	MD-Tributary	flow	20	flow	10	flow	1	flow	60
EE2.2	1986	S	"01578310"	18	13	MD-Tributary	salinity	1	salinity	1	flow	1	salinity	1
ET6.1	1986	S	"01491000"	18	14	MD-Tributary	flow	40	flow	1	flow	1	flow	180
ET6.2	1986	S	"01491000"	18	15	MD-Tributary	salinity	1	salinity	1	flow	5	salinity	1
ET7.1	1986	S	"01491000"	18	17	MD-Tributary	flow	150	salinity	1	flow	5	salinity	1
ET8.1	1986	S	"01491000"	18	18	MD-Tributary	salinity	1	salinity	1	flow	5	salinity	1
ET9.1	1986	S	"01491000"	18	19	MD-Tributary	salinity	1	salinity	1	flow	5	flow	40
ET10.1	1986	S	"01491000"	18	20	MD-Tributary	flow	5	flow	10	flow	5	flow	120
EE3.0	1986	S	"01491000"	18	21	MD-Tributary	salinity	1	salinity	1	flow	5	salinity	1
EE3.3	1986	S	"01578310"	18	24	MD-Tributary	salinity	1	salinity	1	flow	5	salinity	1

7) StationMethodList (partial): The hydroTerm and flowAvgWin for other parameters (see top row for which parameter is shown) by both layers- Surface, Surface/Above Pycnocline, Bottom, Below Pycnocline/Bottom. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Grey fill indicates parameter is not measured for that station/layer.

Surface/ Above Pycnocline							TN		TP		TSS		DIN		PO4	
station	start	layer	usgsGageID	station RO1	station RO2	stationMethod Group	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win
CB2.2	1985	SAP	"01578310"	2	1	MD-Mainstem	flow	30	flow	5	flow	10	flow	30	salinity	1
CB3.1	1985	SAP	"01578310"	2	2	MD-Mainstem	salinity	1	flow	5	salinity	1	salinity	1	salinity	1
CB3.2	1985	SAP	"01578310"	3	1	MD-Mainstem	salinity	1	flow	5	salinity	1	salinity	1	salinity	1
CB3.3C	1985	SAP	"01578310"	3	2	MD-Mainstem	salinity	1	flow	10	salinity	1	salinity	1	flow	30
CB4.1C	1985	SAP	"01578310"	4	1	MD-Mainstem	salinity	1	flow	10	salinity	1	salinity	1	salinity	1
CB4.1E	1985	SAP	"01578310"	4	2	MD-Mainstem	salinity	1	flow	10	flow	60	salinity	1	salinity	1
CB4.2C	1985	SAP	"01578310"	4	4	MD-Mainstem	salinity	1	flow	30	salinity	1	salinity	1	salinity	1
CB4.3C	1985	SAP	"01578310"	4	7	MD-Mainstem	salinity	1	salinity	1	flow	120	salinity	1	salinity	1
CB4.3E	1985	SAP	"01578310"	4	8	MD-Mainstem	salinity	1	flow	40	flow	120	salinity	1	salinity	1
CB4.4	1985	SAP	"01578310"	4	10	MD-Mainstem	salinity	1	salinity	1	flow	120	salinity	1	salinity	1
CB5.1	1985	SAP	"01578310"	5	1	MD-Mainstem	salinity	1	salinity	1	flow	120	salinity	1	salinity	1
CB5.1W	1985	SAP	"01594440"	5	2	MD-CB51W	salinity	1	flow	90	flow	180	salinity	1	salinity	1
CB5.2	1985	SAP	"01578310"	5	3	MD-Mainstem	salinity	1	salinity	1	flow	120	salinity	1	salinity	1
CB5.3	1985	SAP	"01578310"	5	4	MD-Mainstem	salinity	1	salinity	1	salinity	1	salinity	1	salinity	1
WT5.1	1985	SAP	"01578310"	14	5	MD-Tributary	salinity	1	flow	15	flow	210	flow	150	flow	90
TF1.5	1985	SAP	"01594440"	15	6	MD-Patuxent	flow	5	flow	60	flow	50	flow	5	flow	5
TF1.6	1985	SAP	"01594440"	15	7	MD-Patuxent	flow	5	salinity	1	flow	180	salinity	1	flow	5
RET1.1	1985	SAP	"01594440"	15	9	MD-Patuxent	flow	30	salinity	1	salinity	1	salinity	1	flow	120
LE1.1	1985	SAP	"01594440"	15	10	MD-Patuxent	flow	90	flow	60	flow	120	flow	120	flow	150
LE1.2	1985	SAP	"01594440"	15	11	MD-Patuxent	salinity	1	flow	60	flow	120	flow	120	flow	150
LE1.3	1985	SAP	"01594440"	15	12	MD-Patuxent	salinity	1	flow	90	flow	180	flow	150	flow	150
LE1.4	1985	SAP	"01594440"	15	13	MD-Patuxent	salinity	1	flow	120	flow	180	salinity	1	flow	150
RET2.4	1985	SAP	"01646500"	16	11	MD-Potomac	salinity	1	flow	50	salinity	1	salinity	1	salinity	1
LE2.2	1985	SAP	"01646500"	16	12	MD-Potomac	salinity	1	flow	60	salinity	1	salinity	1	salinity	1
LE2.3	1985	SAP	"01646500"	16	13	MD-LE23	salinity	1	salinity	1	flow	210	salinity	1	salinity	1
ET4.2	1985	SAP	"01491000"	18	8	MD-Tributary	salinity	1	flow	180	flow	120	flow	30	salinity	1
EE1.1	1985	SAP	"01578310"	18	9	MD-Tributary	salinity	1	salinity	1	flow	210	flow	120	salinity	1
ET5.2	1985	SAP	"01491000"	18	11	MD-Tributary	flow	60	flow	40	flow	150	flow	90	flow	150
EE2.1	1985	SAP	"01491000"	18	12	MD-Tributary	flow	90	flow	210	flow	150	flow	60	flow	20
EE3.1	1985	SAP	"01578310"	18	22	MD-Tributary	flow	150	salinity	1	flow	120	flow	150	flow	150
EE3.2	1986	SAP	"01578310"	18	23	MD-Tributary	flow	150	salinity	1	flow	120	flow	210	flow	150

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Surface/ Above Pycnocline							CHLA		DO		WTEMP		SECCHI	
station	start	layer	usgsGageID	station RO1	station RO2	stationMethod Group	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win
CB2.2	1985	SAP	"01578310"	2	1	MD-Mainstem	salinity	1	flow	10	flow	10	salinity	1
CB3.1	1985	SAP	"01578310"	2	2	MD-Mainstem	salinity	1	flow	15	salinity	1	salinity	1
CB3.2	1985	SAP	"01578310"	3	1	MD-Mainstem	salinity	1	flow	20	salinity	1	salinity	1
CB3.3C	1985	SAP	"01578310"	3	2	MD-Mainstem	salinity	1	salinity	1	flow	210	salinity	1
CB4.1C	1985	SAP	"01578310"	4	1	MD-Mainstem	salinity	1	salinity	1	salinity	1	salinity	1
CB4.1E	1985	SAP	"01578310"	4	2	MD-Mainstem	salinity	1	salinity	1	salinity	1	salinity	1
CB4.2C	1985	SAP	"01578310"	4	4	MD-Mainstem	salinity	1	salinity	1	salinity	1	salinity	1
CB4.3C	1985	SAP	"01578310"	4	7	MD-Mainstem	flow	60	salinity	1	flow	210	salinity	1
CB4.3E	1985	SAP	"01578310"	4	8	MD-Mainstem	flow	60	salinity	1	flow	210	salinity	1
CB4.4	1985	SAP	"01578310"	4	10	MD-Mainstem	flow	60	salinity	1	flow	150	flow	50
CB5.1	1985	SAP	"01578310"	5	1	MD-Mainstem	flow	60	salinity	1	flow	150	flow	50
CB5.1W	1985	SAP	"01594440"	5	2	MD-CB51W	flow	210	salinity	1	flow	40	salinity	1
CB5.2	1985	SAP	"01578310"	5	3	MD-Mainstem	salinity	1	salinity	1	flow	150	flow	60
CB5.3	1985	SAP	"01578310"	5	4	MD-Mainstem	salinity	1	salinity	1	flow	150	flow	60
WT5.1	1985	SAP	"01578310"	14	5	MD-Tributary	flow	40	flow	10	salinity	1	flow	20
TF1.5	1985	SAP	"01594440"	15	6	MD-Patuxent	flow	5	flow	5	flow	5	flow	60
TF1.6	1985	SAP	"01594440"	15	7	MD-Patuxent	flow	5	flow	60	flow	5	salinity	1
RET1.1	1985	SAP	"01594440"	15	9	MD-Patuxent	salinity	1	flow	180	flow	5	salinity	1
LE1.1	1985	SAP	"01594440"	15	10	MD-Patuxent	salinity	1	flow	180	flow	5	salinity	1
LE1.2	1985	SAP	"01594440"	15	11	MD-Patuxent	salinity	1	flow	180	flow	40	salinity	1
LE1.3	1985	SAP	"01594440"	15	12	MD-Patuxent	flow	150	salinity	1	flow	40	salinity	1
LE1.4	1985	SAP	"01594440"	15	13	MD-Patuxent	flow	150	salinity	1	flow	40	salinity	1
RET2.4	1985	SAP	"01646500"	16	11	MD-Potomac	flow	20	salinity	1	flow	210	salinity	1
LE2.2	1985	SAP	"01646500"	16	12	MD-Potomac	flow	150	salinity	1	flow	210	salinity	1
LE2.3	1985	SAP	"01646500"	16	13	MD-LE23	flow	180	salinity	1	flow	180	flow	60
ET4.2	1985	SAP	"01491000"	18	8	MD-Tributary	salinity	1	salinity	1	salinity	1	salinity	1
EE1.1	1985	SAP	"01578310"	18	9	MD-Tributary	salinity	1	salinity	1	salinity	1	salinity	1
ET5.2	1985	SAP	"01491000"	18	11	MD-Tributary	flow	210	flow	210	flow	5	flow	120
EE2.1	1985	SAP	"01491000"	18	12	MD-Tributary	flow	210	salinity	1	salinity	1	salinity	1
EE3.1	1985	SAP	"01578310"	18	22	MD-Tributary	salinity	1	salinity	1	flow	5	salinity	1
EE3.2	1986	SAP	"01578310"	18	23	MD-Tributary	salinity	1	salinity	1	flow	5	salinity	1

7) StationMethodList (partial): The hydroTerm and flowAvgWin for other parameters (see top row for which parameter is shown) by both layers- Surface, Surface/Above Pycnocline, Bottom, Below Pycnocline/Bottom. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Grey fill indicates parameter is not measured for that station/layer.

Bottom							TN		TP		TSS		DIN		PO4	
station	start	layer	usgsGageID	station RO1	station RO2	stationMethod Group	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win
CB1.1	1985	B	"01578310"	1	1	MD-Mainstem	flow	30	flow	1	flow	1	flow	150	flow	5
CB2.1	1985	B	"01578310"	1	2	MD-Mainstem	flow	30	flow	5	flow	5	flow	15	flow	10
CB3.3E	1985	B	"01578310"	3	3	MD-Mainstem	flow	90	flow	90	salinity	1	flow	40	flow	30
CB3.3W	1985	B	"01578310"	3	4	MD-Mainstem	flow	90	flow	90	flow	120	flow	40	salinity	1
CB4.1W	1985	B	"01578310"	4	3	MD-Mainstem	flow	150	flow	90	flow	150	flow	40	salinity	1
CB4.2E	1985	B	"01578310"	4	5	MD-Mainstem	flow	150	flow	30	flow	180	flow	40	salinity	1
CB4.2W	1985	B	"01578310"	4	6	MD-Mainstem	flow	150	flow	30	flow	150	flow	40	salinity	1
CB4.3W	1985	B	"01578310"	4	9	MD-Mainstem	salinity	1	salinity	1	flow	210	flow	60	salinity	1
WT1.1	1985	B	"01578310"	14	1	MD-Tributary	flow	120	flow	180	flow	150	flow	10	flow	10
WT2.1	1986	B	"01578310"	14	2	MD-Tributary	salinity	1	flow	180	flow	180	flow	10	flow	30
WT3.1	1986	B	"01578310"	14	3	MD-Tributary	salinity	1	flow	180	flow	5	flow	40	flow	30
WT4.1	1985	B	"01578310"	14	4	MD-Tributary	salinity	1	flow	180	flow	120	flow	90	salinity	1
WT6.1	1985	B	"01578310"	14	6	MD-Tributary	salinity	1	salinity	1	flow	120	flow	210	salinity	1
WT7.1	1986	B	"01578310"	14	7	MD-Tributary	flow	180	salinity	1	salinity	1	flow	180	flow	15
WT8.1	1985	B	"01578310"	14	8	MD-Tributary	flow	180	flow	210	salinity	1	flow	180	flow	90
WT8.2	1985	B	"01578310"	14	9	MD-Tributary	salinity	1	flow	20	salinity	1	salinity	1	flow	90
WT8.3	1985	B	"01578310"	14	10	MD-Tributary	salinity	1	flow	10	salinity	1	salinity	1	flow	90
TF1.7	1985	B	"01594440"	15	8	MD-Patuxent	flow	5	salinity	1	salinity	1	salinity	1	flow	90
TF2.1	1985	B	"01646500"	16	3	MD-Potomac	flow	5	flow	1	flow	1	flow	5	flow	5
TF2.2	1985	B	"01646500"	16	4	MD-Potomac	flow	5	flow	1	flow	1	flow	5	flow	5
TF2.3	1985	B	"01646500"	16	5	MD-Potomac	flow	10	flow	5	flow	5	flow	15	flow	10
TF2.4	1985	B	"01646500"	16	8	MD-Potomac	flow	10	flow	5	flow	5	flow	30	flow	10
RET2.1	1985	B	"01646500"	16	9	MD-Potomac	salinity	1	flow	5	salinity	1	salinity	1	flow	30
RET2.2	1985	B	"01646500"	16	10	MD-Potomac	salinity	1	salinity	1	salinity	1	salinity	1	salinity	1
ET1.1	1986	B	"01578310"	18	1	MD-Tributary	flow	60	flow	20	flow	5	flow	5	flow	20
ET2.1	1986	B	"01578310"	18	2	MD-Tributary	flow	40	flow	50	flow	40	flow	90	flow	50
ET2.3	1986	B	"01578310"	18	3	MD-Tributary	flow	1	flow	50	flow	40	flow	120	flow	50
ET2.2	1986	B	"01578310"	18	4	MD-Tributary	flow	150	flow	50	flow	40	flow	210	flow	30
ET3.1	1986	B	"01578310"	18	5	MD-Tributary	flow	180	flow	1	flow	1	flow	210	flow	150
ET4.1	1985	B	"01491000"	18	6	MD-Tributary	flow	5	flow	1	flow	120	flow	5	flow	5
ET5.1	1985	B	"01491000"	18	10	MD-Tributary	salinity	1	flow	20	flow	150	flow	20	flow	20
EE2.2	1986	B	"01578310"	18	13	MD-Tributary	flow	150	salinity	1	flow	120	flow	120	flow	10
ET6.1	1986	B	"01491000"	18	14	MD-Tributary	flow	30	flow	5	flow	150	flow	30	flow	5
ET6.2	1986	B	"01491000"	18	15	MD-Tributary	salinity	1	salinity	1	salinity	1	flow	50	salinity	1
ET7.1	1986	B	"01491000"	18	17	MD-Tributary	salinity	1	salinity	1	flow	210	salinity	1	salinity	1
ET8.1	1986	B	"01491000"	18	18	MD-Tributary	salinity	1	salinity	1	flow	90	flow	150	flow	150
ET9.1	1986	B	"01491000"	18	19	MD-Tributary	flow	150	flow	150	flow	180	flow	150	flow	60
ET10.1	1986	B	"01491000"	18	20	MD-Tributary	flow	15	flow	180	flow	10	flow	15	flow	5
EE3.0	1986	B	"01491000"	18	21	MD-Tributary	salinity	1	salinity	1	salinity	1	flow	120	flow	1
EE3.3	1986	B	"01578310"	18	24	MD-Tributary	flow	150	flow	210	flow	120	flow	210	salinity	1

7) StationMethodList (partial): The hydroTerm and flowAvgWin for other parameters (see top row for which parameter is shown) by both layers- Surface, Surface/Above Pycnocline, Bottom, Below Pycnocline/Bottom. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Grey fill indicates parameter is not measured for that station/layer.

Bottom							CHLA		DO		WTEMP	
station	start	layer	usgsGageID	station RO1	station RO2	stationMethod Group	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win
CB1.1	1985	B	"01578310"	1	1	MD-Mainstem	flow	10	flow	10	flow	5
CB2.1	1985	B	"01578310"	1	2	MD-Mainstem	flow	10	flow	10	flow	5
CB3.3E	1985	B	"01578310"	3	3	MD-Mainstem	salinity	1	salinity	1	flow	210
CB3.3W	1985	B	"01578310"	3	4	MD-Mainstem	salinity	1	salinity	1	flow	210
CB4.1W	1985	B	"01578310"	4	3	MD-Mainstem	salinity	1	salinity	1	salinity	1
CB4.2E	1985	B	"01578310"	4	5	MD-Mainstem	salinity	1	salinity	1	salinity	1
CB4.2W	1985	B	"01578310"	4	6	MD-Mainstem	salinity	1	salinity	1	salinity	1
CB4.3W	1985	B	"01578310"	4	9	MD-Mainstem	salinity	1	salinity	1	flow	210
WT1.1	1985	B	"01578310"	14	1	MD-Tributary	flow	90	flow	1	flow	1
WT2.1	1986	B	"01578310"	14	2	MD-Tributary	flow	150	flow	40	flow	1
WT3.1	1986	B	"01578310"	14	3	MD-Tributary	flow	90	flow	40	flow	1
WT4.1	1985	B	"01578310"	14	4	MD-Tributary	flow	10	flow	40	flow	1
WT6.1	1985	B	"01578310"	14	6	MD-Tributary	flow	60	flow	10	flow	210
WT7.1	1986	B	"01578310"	14	7	MD-Tributary	flow	60	flow	10	flow	210
WT8.1	1985	B	"01578310"	14	8	MD-Tributary	flow	210	flow	15	flow	210
WT8.2	1985	B	"01578310"	14	9	MD-Tributary	salinity	1	flow	15	flow	210
WT8.3	1985	B	"01578310"	14	10	MD-Tributary	salinity	1	flow	15	flow	210
TF1.7	1985	B	"01594440"	15	8	MD-Patuxent	salinity	1	flow	180	flow	5
TF2.1	1985	B	"01646500"	16	3	MD-Potomac	flow	10	flow	10	flow	5
TF2.2	1985	B	"01646500"	16	4	MD-Potomac	flow	10	flow	10	flow	5
TF2.3	1985	B	"01646500"	16	5	MD-Potomac	flow	10	flow	10	flow	5
TF2.4	1985	B	"01646500"	16	8	MD-Potomac	flow	10	flow	10	flow	5
RET2.1	1985	B	"01646500"	16	9	MD-Potomac	flow	20	salinity	1	flow	5
RET2.2	1985	B	"01646500"	16	10	MD-Potomac	flow	20	salinity	1	flow	5
ET1.1	1986	B	"01578310"	18	1	MD-Tributary	flow	150	flow	210	flow	210
ET2.1	1986	B	"01578310"	18	2	MD-Tributary	flow	30	flow	210	flow	210
ET2.3	1986	B	"01578310"	18	3	MD-Tributary	flow	30	flow	210	flow	210
ET2.2	1986	B	"01578310"	18	4	MD-Tributary	flow	30	flow	210	flow	210
ET3.1	1986	B	"01578310"	18	5	MD-Tributary	flow	150	flow	210	flow	1
ET4.1	1985	B	"01491000"	18	6	MD-Tributary	flow	15	flow	5	flow	1
ET5.1	1985	B	"01491000"	18	10	MD-Tributary	flow	20	flow	10	flow	1
EE2.2	1986	B	"01578310"	18	13	MD-Tributary	salinity	1	salinity	1	flow	1
ET6.1	1986	B	"01491000"	18	14	MD-Tributary	flow	40	flow	1	flow	1
ET6.2	1986	B	"01491000"	18	15	MD-Tributary	salinity	1	salinity	1	flow	5
ET7.1	1986	B	"01491000"	18	17	MD-Tributary	flow	150	salinity	1	flow	5
ET8.1	1986	B	"01491000"	18	18	MD-Tributary	salinity	1	salinity	1	flow	5
ET9.1	1986	B	"01491000"	18	19	MD-Tributary	salinity	1	salinity	1	flow	5
ET10.1	1986	B	"01491000"	18	20	MD-Tributary	flow	5	flow	10	flow	5
EE3.0	1986	B	"01491000"	18	21	MD-Tributary	salinity	1	salinity	1	flow	5
EE3.3	1986	B	"01578310"	18	24	MD-Tributary	salinity	1	salinity	1	flow	5

7) StationMethodList (partial): The hydroTerm and flowAvgWin for other parameters (see top row for which parameter is shown) by both layers- Surface, Surface/Above Pycnocline, Bottom, Below Pycnocline/Bottom. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Grey fill indicates parameter is not measured for that station/layer.

Bottom/ Below Pycnocline							TN		TP		TSS		DIN		PO4	
station	start	layer	usgsGageID	station RO1	station RO2	stationMethod Group	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win
CB2.2	1985	BBP	"01578310"	2	1	MD-Mainstem	flow	30	flow	5	flow	10	salinity	1	flow	30
CB3.1	1985	BBP	"01578310"	2	2	MD-Mainstem	flow	60	flow	60	salinity	1	flow	40	salinity	1
CB3.2	1985	BBP	"01578310"	3	1	MD-Mainstem	flow	90	flow	90	salinity	1	flow	40	salinity	1
CB3.3C	1985	BBP	"01578310"	3	2	MD-Mainstem	salinity	1	flow	90	flow	180	flow	40	flow	30
CB4.1C	1985	BBP	"01578310"	4	1	MD-Mainstem	salinity	1	flow	90	flow	180	flow	120	flow	60
CB4.1E	1985	BBP	"01578310"	4	2	MD-Mainstem	flow	150	flow	90	flow	180	flow	120	salinity	1
CB4.2C	1985	BBP	"01578310"	4	4	MD-Mainstem	salinity	1	flow	120	flow	180	flow	150	salinity	1
CB4.3C	1985	BBP	"01578310"	4	7	MD-Mainstem	salinity	1	salinity	1	flow	180	flow	150	salinity	1
CB4.3E	1985	BBP	"01578310"	4	8	MD-Mainstem	salinity	1	flow	120	flow	180	flow	150	salinity	1
CB4.4	1985	BBP	"01578310"	4	10	MD-Mainstem	salinity	1	salinity	1	flow	210	flow	150	salinity	1
CB5.1	1985	BBP	"01578310"	5	1	MD-Mainstem	salinity	1	flow	150	flow	210	flow	150	salinity	1
CB5.1W	1985	BBP	"01594440"	5	2	MD-CB51W	salinity	1	flow	90	flow	180	salinity	1	salinity	1
CB5.2	1985	BBP	"01578310"	5	3	MD-Mainstem	salinity	1	flow	150	flow	210	flow	150	salinity	1
CB5.3	1985	BBP	"01578310"	5	4	MD-Mainstem	flow	180	flow	150	flow	210	flow	180	salinity	1
WT5.1	1985	BBP	"01578310"	14	5	MD-Tributary	salinity	1	flow	15	salinity	1	flow	150	flow	90
TF1.5	1985	BBP	"01594440"	15	6	MD-Patuxent	flow	5	flow	60	flow	50	flow	5	flow	5
TF1.6	1985	BBP	"01594440"	15	7	MD-Patuxent	flow	5	salinity	1	flow	180	salinity	1	flow	5
RET1.1	1985	BBP	"01594440"	15	9	MD-Patuxent	flow	90	salinity	1	salinity	1	salinity	1	flow	120
LE1.1	1985	BBP	"01594440"	15	10	MD-Patuxent	flow	90	flow	60	flow	120	flow	120	flow	150
LE1.2	1985	BBP	"01594440"	15	11	MD-Patuxent	flow	90	flow	60	flow	120	flow	120	flow	150
LE1.3	1985	BBP	"01594440"	15	12	MD-Patuxent	flow	90	flow	90	flow	180	flow	150	flow	150
LE1.4	1985	BBP	"01594440"	15	13	MD-Patuxent	flow	90	flow	120	flow	180	salinity	1	flow	150
RET2.4	1985	BBP	"01646500"	16	11	MD-Potomac	salinity	1	salinity	1	salinity	1	flow	50	salinity	1
LE2.2	1985	BBP	"01646500"	16	12	MD-Potomac	flow	120	salinity	1	salinity	1	flow	120	salinity	1
LE2.3	1985	BBP	"01646500"	16	13	MD-LE23	flow	150	salinity	1	salinity	1	flow	120	salinity	1
ET4.2	1985	BBP	"01491000"	18	8	MD-Tributary	flow	120	flow	180	flow	120	flow	30	salinity	1
EE1.1	1985	BBP	"01578310"	18	9	MD-Tributary	flow	150	salinity	1	flow	210	flow	120	salinity	1
ET5.2	1985	BBP	"01491000"	18	11	MD-Tributary	flow	60	flow	210	flow	150	flow	90	flow	150
EE2.1	1985	BBP	"01491000"	18	12	MD-Tributary	flow	90	flow	210	flow	150	flow	60	flow	20
EE3.1	1985	BBP	"01578310"	18	22	MD-Tributary	flow	150	salinity	1	flow	120	flow	150	flow	150
EE3.2	1986	BBP	"01578310"	18	23	MD-Tributary	flow	150	salinity	1	flow	120	flow	210	flow	150

7) StationMethodList (partial): The hydroTerm and flowAvgWin for other parameters (see top row for which parameter is shown) by both layers- Surface, Surface/Above Pycnocline, Bottom, Below Pycnocline/Bottom. flowAvgWin is the selected flow or salinity (flow is set to 1 by default but not used) for each station for each parameter and layer. Grey fill indicates parameter is not measured for that station/layer.

Bottom/ Below Pycnocline							CHLA		DO		WTEMP	
station	start	layer	usgsGageID	station RO1	station RO2	stationMethod Group	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win	hydroTerm	flwAvg Win
CB2.2	1985	BBP	"01578310"	2	1	MD-Mainstem	flow	40	flow	10	flow	10
CB3.1	1985	BBP	"01578310"	2	2	MD-Mainstem	flow	40	flow	15	salinity	1
CB3.2	1985	BBP	"01578310"	3	1	MD-Mainstem	flow	40	flow	20	salinity	1
CB3.3C	1985	BBP	"01578310"	3	2	MD-Mainstem	flow	180	flow	210	flow	210
CB4.1C	1985	BBP	"01578310"	4	1	MD-Mainstem	flow	180	flow	210	salinity	1
CB4.1E	1985	BBP	"01578310"	4	2	MD-Mainstem	salinity	1	salinity	1	salinity	1
CB4.2C	1985	BBP	"01578310"	4	4	MD-Mainstem	flow	180	flow	210	salinity	1
CB4.3C	1985	BBP	"01578310"	4	7	MD-Mainstem	flow	180	flow	210	flow	210
CB4.3E	1985	BBP	"01578310"	4	8	MD-Mainstem	salinity	1	salinity	1	flow	210
CB4.4	1985	BBP	"01578310"	4	10	MD-Mainstem	flow	210	flow	210	flow	150
CB5.1	1985	BBP	"01578310"	5	1	MD-Mainstem	flow	210	flow	210	flow	150
CB5.1W	1985	BBP	"01594440"	5	2	MD-CB51W	flow	210	salinity	1	flow	40
CB5.2	1985	BBP	"01578310"	5	3	MD-Mainstem	flow	210	flow	210	flow	150
CB5.3	1985	BBP	"01578310"	5	4	MD-Mainstem	flow	210	flow	210	flow	150
WT5.1	1985	BBP	"01578310"	14	5	MD-Tributary	flow	40	flow	10	salinity	1
TF1.5	1985	BBP	"01594440"	15	6	MD-Patuxent	flow	5	flow	5	flow	5
TF1.6	1985	BBP	"01594440"	15	7	MD-Patuxent	flow	5	flow	60	flow	5
RET1.1	1985	BBP	"01594440"	15	9	MD-Patuxent	salinity	1	flow	180	flow	5
LE1.1	1985	BBP	"01594440"	15	10	MD-Patuxent	salinity	1	flow	180	flow	5
LE1.2	1985	BBP	"01594440"	15	11	MD-Patuxent	salinity	1	flow	180	flow	40
LE1.3	1985	BBP	"01594440"	15	12	MD-Patuxent	flow	150	salinity	1	flow	40
LE1.4	1985	BBP	"01594440"	15	13	MD-Patuxent	flow	150	salinity	1	flow	40
RET2.4	1985	BBP	"01646500"	16	11	MD-Potomac	flow	20	salinity	1	flow	210
LE2.2	1985	BBP	"01646500"	16	12	MD-Potomac	salinity	1	salinity	1	flow	210
LE2.3	1985	BBP	"01646500"	16	13	MD-LE23	salinity	1	salinity	1	flow	180
ET4.2	1985	BBP	"01491000"	18	8	MD-Tributary	salinity	1	salinity	1	salinity	1
EE1.1	1985	BBP	"01578310"	18	9	MD-Tributary	salinity	1	salinity	1	salinity	1
ET5.2	1985	BBP	"01491000"	18	11	MD-Tributary	flow	210	flow	210	flow	5
EE2.1	1985	BBP	"01491000"	18	12	MD-Tributary	flow	210	salinity	1	salinity	1
EE3.1	1985	BBP	"01578310"	18	22	MD-Tributary	salinity	1	salinity	1	flow	5
EE3.2	1986	BBP	"01578310"	18	23	MD-Tributary	salinity	1	salinity	1	flow	5

APPENDIX III: Interval Censoring for Trends datasets

TETRA TECH

To:	Jeni Keisman
Cc:	Rebecca Murphy, Elgin Perry
From:	Jon Harcum
Date:	November 2, 2016
Subject:	CBP GAM Technical Support: create data sets for baytrends

This technical memorandum documents an approach to create data sets that include censored data for baytrends. This memorandum accompanies three csv files and a prototype R script for this process. It is expected that the R script would need to be customized to accommodate the particular format of the files that can be created by the stakeholders. It may also be necessary to add some additional error checking.

As depicted in Figure 1, the three csv formatted files are read into R objects and then combined. The first two files mddnrZeroSub1.csv and mddnrDetLimSub1.csv are earlier data which include censored data. The file mddnrZeroSub1.csv would be data that are created assuming zero is substituted for detection limit values--all water quality variables use a .lo suffix naming convention. This will often result in zero values in the table but might also result in non-zero values where the water quality variable such as total nitrogen is computed as a sum of various nitrogen species. The file mddnrDetLimSub1.csv is a companion to previous file, but instead uses detection limit substitution—water quality variables that used detection limit substitution have a .hi suffix naming convention. Field observed values that didn't have censoring can be stored in mddnrDetLimSub1.csv as well. The third csv file, mddnrNoSub1.csv, are data where the BMDL value is included. A screen capture of each file is shown in Figure 2. The included R script would result in a data set that can be viewed in R Studio (Figure 3).

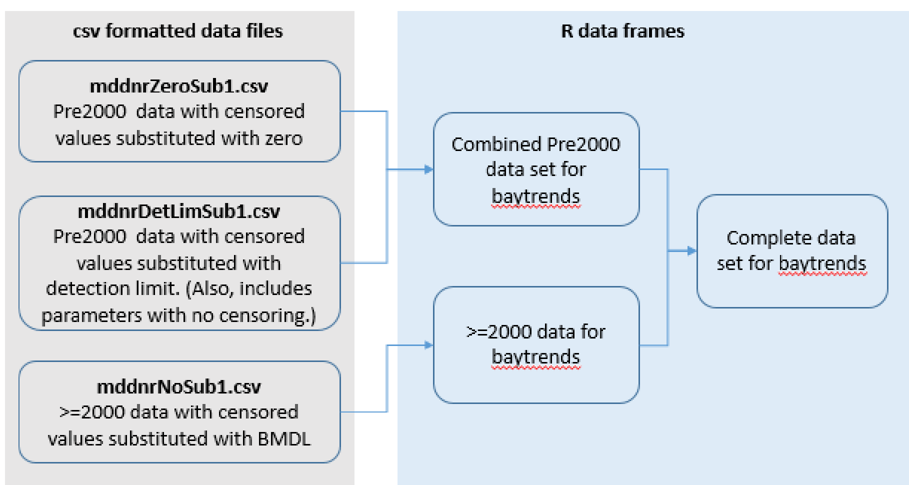

Figure 1. Conceptual approach of creating censored data sets for baytrends.

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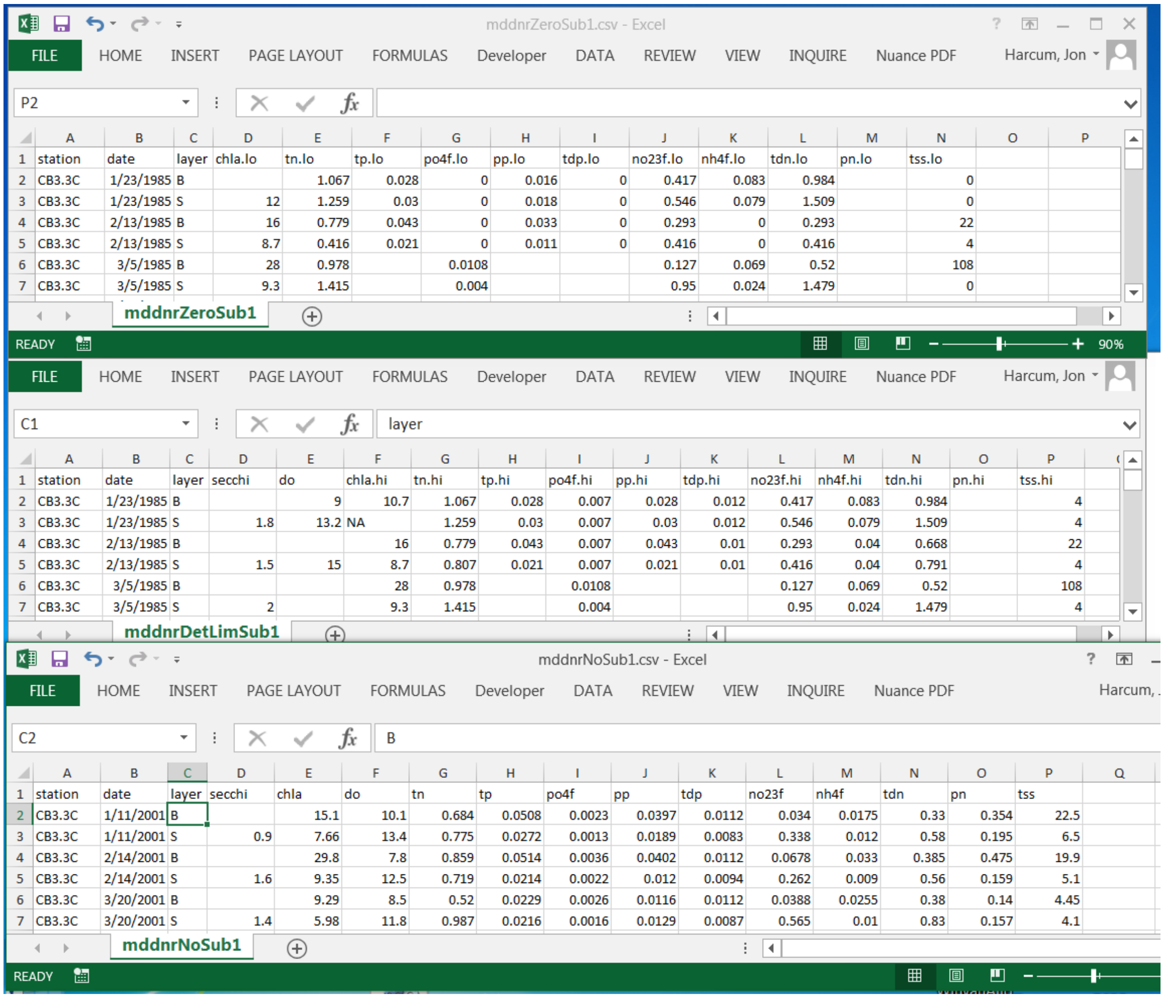
Direct 864-650-5815 tetratech.com



mddnrZeroSub1.csv - Excel

	station	date	layer	chla.lo	tn.lo	tp.lo	po4f.lo	pp.lo	tdp.lo	no23f.lo	nh4f.lo	tdn.lo	pn.lo	tss.lo
2	CB3.3C	1/23/1985	B		1.067	0.028	0	0.016	0	0.417	0.083	0.984		0
3	CB3.3C	1/23/1985	S	12	1.259	0.03	0	0.018	0	0.546	0.079	1.509		0
4	CB3.3C	2/13/1985	B	16	0.779	0.043	0	0.033	0	0.293	0	0.293		22
5	CB3.3C	2/13/1985	S	8.7	0.416	0.021	0	0.011	0	0.416	0	0.416		4
6	CB3.3C	3/5/1985	B	28	0.978		0.0108			0.127	0.069	0.52		108
7	CB3.3C	3/5/1985	S	9.3	1.415		0.004			0.95	0.024	1.479		0

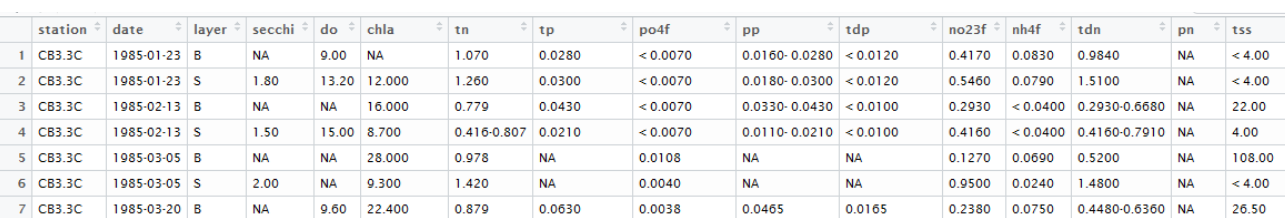
mddnrDetLimSub1

	station	date	layer	secchi	do	chla.hi	tn.hi	tp.hi	po4f.hi	pp.hi	tdp.hi	no23f.hi	nh4f.hi	tdn.hi	pn.hi	tss.hi
2	CB3.3C	1/23/1985	B		9	10.7	1.067	0.028	0.007	0.028	0.012	0.417	0.083	0.984		4
3	CB3.3C	1/23/1985	S	1.8	13.2	NA	1.259	0.03	0.007	0.03	0.012	0.546	0.079	1.509		4
4	CB3.3C	2/13/1985	B			16	0.779	0.043	0.007	0.043	0.01	0.293	0.04	0.668		22
5	CB3.3C	2/13/1985	S	1.5	15	8.7	0.807	0.021	0.007	0.021	0.01	0.416	0.04	0.791		4
6	CB3.3C	3/5/1985	B			28	0.978		0.0108			0.127	0.069	0.52		108
7	CB3.3C	3/5/1985	S	2		9.3	1.415		0.004			0.95	0.024	1.479		4

mddnrNoSub1.csv - Excel

	station	date	layer	secchi	chla	do	tn	tp	po4f	pp	tdp	no23f	nh4f	tdn	pn	tss
2	CB3.3C	1/11/2001	B		15.1	10.1	0.684	0.0508	0.0023	0.0397	0.0112	0.034	0.0175	0.33	0.354	22.5
3	CB3.3C	1/11/2001	S	0.9	7.66	13.4	0.775	0.0272	0.0013	0.0189	0.0083	0.338	0.012	0.58	0.195	6.5
4	CB3.3C	2/14/2001	B		29.8	7.8	0.859	0.0514	0.0036	0.0402	0.0112	0.0678	0.033	0.385	0.475	19.9
5	CB3.3C	2/14/2001	S	1.6	9.35	12.5	0.719	0.0214	0.0022	0.012	0.0094	0.262	0.009	0.56	0.159	5.1
6	CB3.3C	3/20/2001	B		9.29	8.5	0.52	0.0229	0.0026	0.0116	0.0112	0.0388	0.0255	0.38	0.14	4.45
7	CB3.3C	3/20/2001	S	1.4	5.98	11.8	0.987	0.0216	0.0016	0.0129	0.0087	0.565	0.01	0.83	0.157	4.1

Figure 2. Screen capture of csv file layout.



	station	date	layer	secchi	do	chla	tn	tp	po4f	pp	tdp	no23f	nh4f	tdn	pn	tss
1	CB3.3C	1985-01-23	B	NA	9.00	NA	1.070	0.0280	< 0.0070	0.0160- 0.0280	< 0.0120	0.4170	0.0830	0.9840	NA	< 4.00
2	CB3.3C	1985-01-23	S	1.80	13.20	12.000	1.260	0.0300	< 0.0070	0.0180- 0.0300	< 0.0120	0.5460	0.0790	1.5100	NA	< 4.00
3	CB3.3C	1985-02-13	B	NA	NA	16.000	0.779	0.0430	< 0.0070	0.0330- 0.0430	< 0.0100	0.2930	< 0.0400	0.2930-0.6680	NA	22.00
4	CB3.3C	1985-02-13	S	1.50	15.00	8.700	0.416-0.807	0.0210	< 0.0070	0.0110- 0.0210	< 0.0100	0.4160	< 0.0400	0.4160-0.7910	NA	4.00
5	CB3.3C	1985-03-05	B	NA	NA	28.000	0.978	NA	0.0108	NA	NA	0.1270	0.0690	0.5200	NA	108.00
6	CB3.3C	1985-03-05	S	2.00	NA	9.300	1.420	NA	0.0040	NA	NA	0.9500	0.0240	1.4800	NA	< 4.00
7	CB3.3C	1985-03-20	B	NA	9.60	22.400	0.879	0.0630	0.0038	0.0465	0.0165	0.2380	0.0750	0.4480-0.6360	NA	26.50

Figure 3. View of combined data set in R Studio.

Some additional notes to consider:

1) There are many equivalent approaches to performing this task. The most important aspect is that baytrends expects that 1) station + date + layer are the primary key and 2) each water quality variable is stored as a qw data type. More information on qw data types can be found at ??smwrQW.
2) The baytrends::loadData function (v0.2.3) has been modified to automatically seek out and convert date like fields to POSIXct format. The user can perform their own import of the data using read.csv, but would need to ensure that the date field is converted to POSIXct format and that the expected primary key is established.
3) Unfortunately, the R function, rbind, does not work properly with qw variables. The included R script has a work around this issue.

R script “combine some data.R’

```
# -----< Description >-------------------------------
# 10May2017 RJK
# 02Nov2016: combine some data
#
#RJK edits 06Mar2017
# add in code from Jon to change SAS blanks . to R blanks NA
#but turns out the no data is blanks not .
#change file names and directory locations

# Initialize #####
library(baytrends)
rm(list=ls())
cat("\014")
ProjRoot <- 'D:/data/BayTrends 2017/work30'
setwd(ProjRoot)

# user needs to know their data and how organized
pkSel <- c('station','date','layer')  #primary key
oneCol <- c("secchi",        "salinity", "do", "wtemp", "cond", "ph")
twoCol <- c("chla", "tn", "tp", "tss", "din", "po4", "tdn", "tdp", "nh4", "no23")

# read in data sets -original version ####
# replace the blanks with NA in Excel before run the R script- RJK
#df1a <- loadData(folder='.', file='*zerosub8595.csv',  pk=pkSel)
#df1b <- loadData(folder='.', file='*detlimsub8595.csv', pk=pkSel)
#df2 <- loadData(folder='.', file='*nosub9616.csv',   pk=pkSel)

# read in data sets - from Jons email 03022017 and then edited to be blanks not . ####
source("loadData2.r")
df1a <- loadData2(folder='.', file='*zerosub8595.csv',  pk=pkSel, naChar = "")
df1b <- loadData2(folder='.', file='*detlimsub8595.csv', pk=pkSel, naChar = "")
df2 <- loadData2(folder='.', file='*nosub9616.csv',   pk=pkSel, naChar = "")
# check for character fields
if(length(setdiff(names(df1a)[sapply(df1a, is.character)], pkSel))>0) stop('check df1a for chr fields')
if(length(setdiff(names(df1b)[sapply(df1b, is.character)], pkSel))>0) stop('check df1b for chr fields')
if(length(setdiff(names(df2 )[sapply(df2 , is.character)], pkSel))>0) stop('check df2 for chr fields')

# process early data that has censored data ####

# merge zero substituion and detection limit substitution data into one file
df1c <- merge(df1a, df1b, by=pkSel, all=TRUE)

# convert 1-column variables to qw format
for (var in oneCol) {
 df1c[, var] <- suppressWarnings( as.qw(values      = df1c[,var],
                    value2      = df1c[,var],
                    remark.codes   = rep("",nrow(df1c)),
                    value.codes   = "",
                    reporting.level = rep(NA_real_, nrow(df1c)),
                    reporting.method = "",
                    reporting.units = "",
                    analyte.method  = "",
                    analyte.name   = "",
                    unique.code   = ""))
```

```
 df1c[,var]@rounding <- c(3,4)
}

# convert 2-column variables to qw format
for (var in twoCol) {
 # set up "<" where needed
 qualifier <- rep("",nrow(df1c))
 qualifier[df1c[,paste0(var,".lo")] == 0 & df1c[,paste0(var,".hi")] > 0] <- "<"
 df1c[, var] <- suppressWarnings( as.qw(values      = df1c[,paste0(var,".lo")],
                   value2      = df1c[,paste0(var,".hi")],
                   remark.codes   = qualifier,
                   value.codes   = "",
                   reporting.level = rep(NA_real_, nrow(df1c)),
                   reporting.method = "",
                   reporting.units = "",
                   analyte.method  = "",
                   analyte.name   = "",
                   unique.code   = ""))
 df1c[,var]@rounding <- c(3,4)
}

# keep only qw format variables
df1Finished <- df1c[,c(pkSel,oneCol,twoCol)]

# process later data that does not have censoring ####
for (var in c(oneCol,twoCol)) {
 df2[, var] <- suppressWarnings( as.qw(values      = df2[,var],
                   value2      = df2[,var],
                   remark.codes   = rep("",nrow(df2)),
                   value.codes   = "",
                   reporting.level = rep(NA_real_, nrow(df2)),
                   reporting.method = "",
                   reporting.units = "",
                   analyte.method  = "",
                   analyte.name   = "",
                   unique.code   = ""))
 df2[,var]@rounding <- c(3,4)
}

df2Finished <- df2[,c(pkSel,oneCol,twoCol)]
remove(df1a,df1b,df1c,df2)

# combine the data - unfortuately rbind is not clean for qw type variables. ####

df3 <- rbind(df1Finished,df2Finished)

for (var in c(oneCol,twoCol)) {
 qualifier <- rep("",nrow(df3))
 qualifier[df3[,var][,1] == 0 & df3[,var][,2] > 0] <- "<"
 df3[, var] <- suppressWarnings( as.qw(values      = df3[,var][,1],
                   value2      = df3[,var][,2],
                   remark.codes   = qualifier,
                   value.codes   = "",
                   reporting.level = rep(NA_real_, nrow(df3)),
                   reporting.method = "",
                   reporting.units = "",
```

```
                analyte.method  = "",
                analyte.name   = "",
                unique.code   = ""))
 df3[,var]@rounding <- c(3,4)
}

MD8516_QW <- df3[,c(pkSel,oneCol,twoCol)]
remove(df3)

save(MD8516_QW, file='MD8516_QW.rda')
```

NOTE: through further development of Baytrends package during 2017-2018, the structure of the input data was changed to the following:

Column headings:

station
date
layer
secchi_lo
secchi_hi
secchi_symbol
salinity_lo
salinity_hi
salinity_symbol
do_lo
do_hi
do_symbol
wtemp_lo
wtemp_hi
wtemp_symbol
cond_lo
cond_hi
cond_symbol
ph_lo
ph_hi
ph_symbol
chla_lo
chla_hi
chla_symbol
tn_lo
tn_hi
tn_symbol
tp_lo
tp_hi
tp_symbol

tss_lo
tss_hi
tss_symbol
din_lo
din_hi
din_symbol
po4_lo
po4_hi
po4_symbol
tdn_lo
tdn_hi
tdn_symbol
tdp_lo
tdp_hi
tdp_symbol
nh4_lo
nh4_hi
nh4_symbol
no23_lo
no23_hi
no23_symbol

For inputting the most recent year data (2017) the following R script was used:

```
# Project Folder (not the flipping of the '\' for '/')
ProjRoot <- 'D:/data/BayTrends 2018/myData'
setwd(ProjRoot)

library(baytrends)


##############  Export #############
#Use the function qw.export to export "qw" formatted data.

## load the included data frame, dataCensored, into the global environment
load('D:/data/BayTrends 2018/Baytrends_datasets/MD8516_QW_baytrends.rda')
#
oldDF <- MD8516_QW
## Check for qw class
str(oldDF)

## identify the current working directory as the location to save
## the outputted data set
dir.save <- getwd()

## identify the name of the comma delimited (csv) file for the
## outputted data set
fn.output <- "MD8516_QW.csv"

## run function
qw.export(oldDF, dir.save, fn.output)
```

```
#############   Import ##########################
##Use the function qw.import to import "qw" formatted data.
##The above exported file,  is used for demonstration.

##To create a data frame that includes qw objects, the data needs to be in the format that was generated by qw.export. That is, one file with each qw parameter having three columns (x_lo, x_hi, and x_symbol where x is the name of the parameter). The list of parameter codes that will be as column names of the qw-formatted variables are specifed in the argument qw.names.
##The output of the qw.import function must be directed to a variable.
#Any modification of column classes (e.g., POSIXct, numeric, or integer) will need to be performed by the user. The function str() is useful for examing the structure of the data frame.

##library(baytrends)

## Define function arguments
fn.import <- "NoSub2017.csv"
qw.names <- c("secchi", "salinity", "do", "wtemp", "cond", "ph", "chla", "tn", "tp", "tss", "din", "po4",
  "tdp", "tdn",  "nh4", "no23")

## fun function
NoSub2017<- qw.import(fn.import, qw.names)

## Check for qw class
str(NoSub2017)

## convert date field to POSIXct
NoSub2017[,"date"] <- as.POSIXct(NoSub2017[,"date"])

## recheck structure (other columns can be converted using
## as.numeric() and as.integer() if desired)
str(NoSub2017)

## save the data frame for future use
save(NoSub2017, file="NoSub2017_QW.rda")

##Combining QW Data Frames
##Use the function rbindQW to combine two data frames with "qw" formatted data.
##The below code chunk demonstrates combining the data from two data frames.

newDF <- rbindQW(MD8516_QW, NoSub2017)

# Save to data file separate use
save(newDF, file='MD8517_QW_baytrends.rda')
#head(newDF)
#str(newDF)

## identify the name of the comma delimited (csv) file for the
## outputted data set
fn.output <- "MD8517_QW_baytrends.csv"

## run function
qw.export(newDF, dir.save, fn.output)
```

NOTE: through further development of Baytrends package for version 2.0.5, the QW format is no longer used and instead data is input into R using the following (email from Jon Harcum March 3, 2021):

```
df_in   <- loadData(file = "ExampleData.csv")
df_Surv <- makeSurvDF(df_in)
```

Baytrends also include documentation in the R repository on CRAN (https://CRAN.R-project.org/package=baytrends).