WASP Hands-On Example

Objective

The objective of this hands-on example is to provide you with the steps you would need to take to create a real-world WASP input file. We will be using a simple WASP network which will allow us to complete all our objectives in the time we have for this workshop. While this network is simple the process for developing a WASP network is the same whether you have 20 segments or 500 segments.

This example will take you step by step in setting up our example WASP input file. We will be accessing data from an Excel spreadsheet which was used to help organize data prior to pasting/importing into our model setup. While the WASP interface has capabilities of processing input data (units' conversion, scaling and plotting) it is better to organize your data in a spreadsheet or database. We will be using several components of the Water Resources Database (WRDB):

1. Database management application will be used to manage all the time series data that will be used by WASP for the simulation period. This includes boundary concentration time series, meteorological data, and monitoring data used for calibration.
2. WRDBGraph application will be used for plotting WASP output and comparing to measured data. WRDBGraph has several tools to aid in the calibration of WASP and providing publication quality graphics that can be used in reports.

We will also expose the user to several R-Scripts that can be automated to process WASP output to aid in calibration. The R-scripts provide comprehensive visual graphics as well as statistical analysis.

Model Network Overview

Throughout this exercise we will build an example WASP input file for the network depicted in Figure 1. The model network consists of a mainstem river that terminates in a lake. The mainstem will have one tributary that has a wastewater treatment plant.

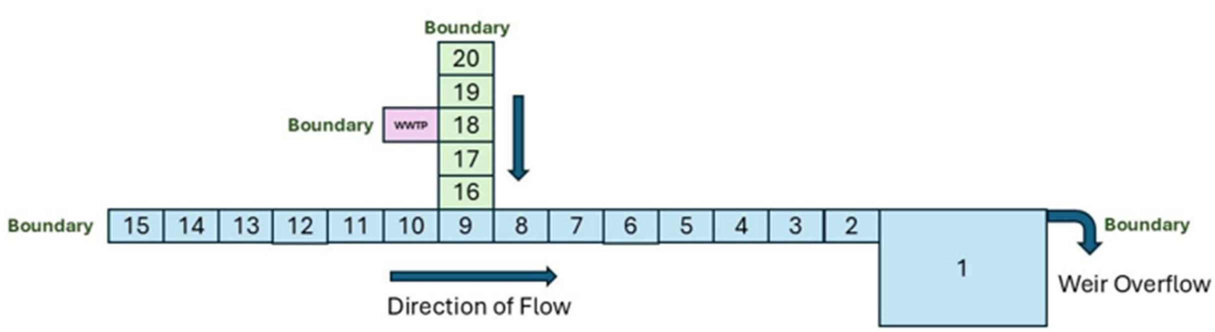


Figure 1 Model Network Schematic

Your course materials contains an Excel spreadsheet where model network was preprocessed and put into a form which is easily brought into the WASP interface.

Initial Model Setup

When creating a new WASP input file, the first data form that needs to be completed prior to moving to other data entry screens is the Dataset Parameterization screen (Figure 2). You must select which model you would like to develop an input file (Eutrophication or Toxicant). Followed by setting the time domain for the simulation period.

Parameterization

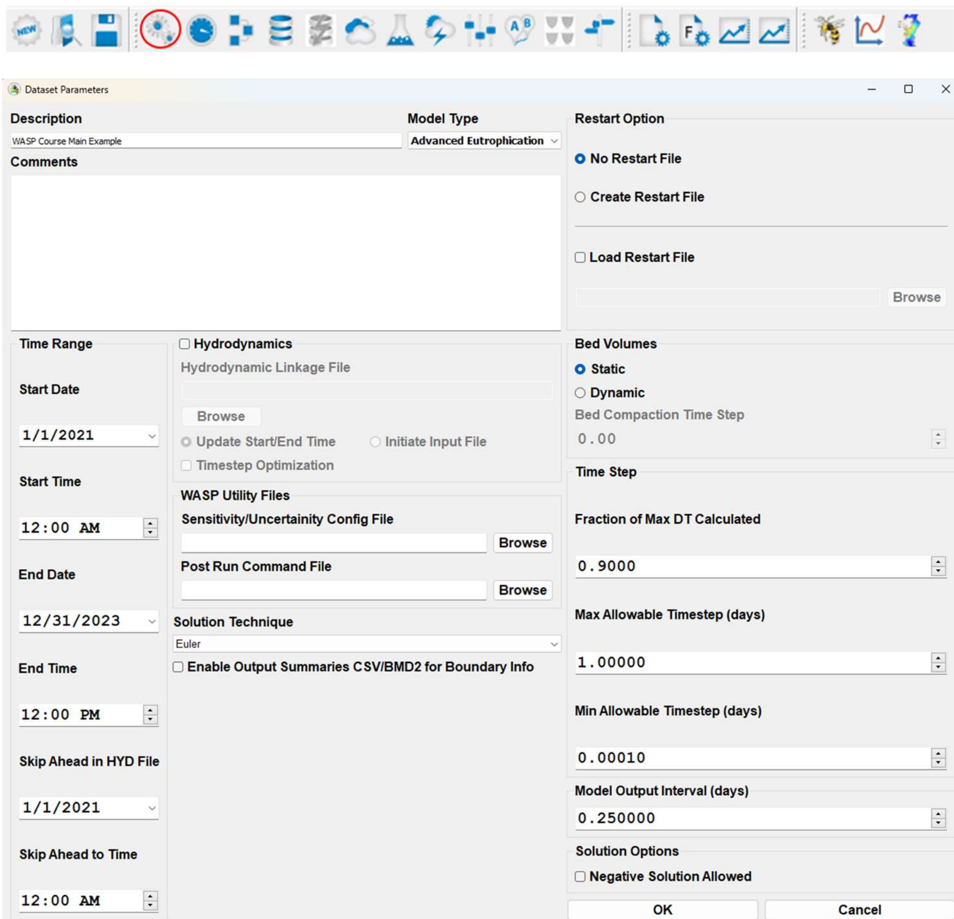


Figure 2 Dataset Parameterization

- **Description** – this text field allows the user to enter a brief description of the model input. This description will appear on the title bar of the WASP interface once the input file is loaded.
- **Model Type** – this drop down allows the user to select which of the water quality models they would like to create an input file. WASP has two models available to the user: eutrophication and toxicant model. Once the user selects a model type the WASP interface will configure itself specifically for that selected model type.
- **Time Range** – WASP Is a time variable model that requires the user to set the time domain for the simulation. ***It should be noted that the user must specify a time range for the simulation period before being allowed to advance in other parts of the WASP interface***.

- Start Date – this field allows the user to specify the Gregorian date for the start of the simulation. Users can either enter the month day and year by typing in the box or click on the down caret to use a calendar interface.
- Start Time – this field allows the user to specify the time for the start of the simulation. User has the option clicking in the dialogue box typing the time or use the spinners to the right.
- End Date – this field allows the user to specify the Gregorian date for the end of the simulation. Users can either enter the month day and year by typing in the box or click on the down caret to use a calendar interface.
- End Time – this field allows the user to specify the time for the end of the simulation. User has the option clicking in the dialogue box typing the time or use the spinners to the right.
- Skip Ahead Date in HYD File & Skip Ahead Time in HYD File -- these dialog boxes are only used when the user has selected a hydrodynamic linkage option. By changing the date and time from something other than the start time of the simulation will cause WASP to read ahead in the hydrodynamic until the new specified start time.

* **Hydrodynamics Check Box** -- checking this box will allow the user to establish a link to a previously created hydrodynamic linkage file. This file is typically created by running EFDC.
    - Browse for Hydrodynamic Interface File -- the browse button brings up a traditional file dialog box in which the user can browse and locate the desired hydrodynamic linkage file.
    - Update Start/End Time -- the user will select this item if they re-executed the hydrodynamic model where the only thing changed in the hydrodynamic simulation is that date range.
    - Initialize WASP Input with Hydrodynamic Interface File -- this option is automatically selected when the user selects a hydrodynamic linkage file. Once the user clicks OK at the bottom of the screen, WASP will open the selected hydrodynamic linkage file and read in information such as: start date and time, end date and time, number of segments, segment names, transport mode, and flow paths.
    - Timestep Optimization –
* **Sensitivity/Uncertainty Config File** – The ability to read script files that allows the user to conduct sensitivity and uncertainty analysis. Use the browse button to select the script file.
* **Post Run Command File** – this option allows the user to create the command file that will be executed upon the completion of the model simulation. This option can be useful: executing calibration scripts, move/arrange model files and any other desired function.
* **Solution Technique** -- WASP has 3 solution techniques available for simulation. For most simulations the user should be selecting Euler. The cosmic solution technique is automatically enabled when linking to an EFDC hydrodynamic linkage file. The Runge-Kutta solution technique should be enabled when you have very dynamic changes in such states variables as pH.
* **Enable Output Summaries CSV/BMD2 Boundary Information** - checking this box will enable WASP to create a CSV file that will summarize all the boundary time series data for each state variable.

- **Restart Options** -- the restart option allows the user to chain multiple model runs in series. This option is typically used for simulations that take a long time to complete.
  - No Restart File -- by default when executing the WASP model no restart file is created.
  - Create Restart File -- Checking restart file will enable WASP to create an external file (filename will be the same as the input file, but with the extension *.rst) which will contain the final segment volumes and concentrations at the end of the simulation.
  - Load Restart File – this button will open a traditional file dialog box which will allow the user to browse for a file with the extension *.rst. Once the user selects the appropriate restart file, the interface will read the final volumes and concentrations from the previous simulation replacing the values in the initial condition and segment volumes for the loaded input file.
- **Bed Volumes**
  - Static -- this option keeps WASP from recalculating sediment segment dynamics as a function of resuspension and settling. This means sediment segment volumes will not be recalculated and will remain unchanged.
  - Dynamic --
    - Bed Compaction or Sediment Diagenesis Module Timestep -- this specifies time step (days) that WASP will use to recalculate sediment bed dynamics (typically toxicant model). When using the sediment diagenesis module this time step controls when the module, we'll calculate sediment oxygen demand and nutrient fluxes.
- **Time Step** -- WASP automatically calculates the appropriate time step based upon flow conditions, loads and kinetic transformations. Wasp makes this calculation at the end of each timestep to be used for the next timestep.
  - Fraction of Maximum DT -- this user specified fraction is used to attenuate the wasp calculated time step. The default is 0.9 which is multiplied against the calculated maximum time step.
  - Maximum Allowable Time Step -- this value will constrain that time step calculation so that it is no larger than this value. Typically, it is used to ensure a simulated value for every simulation day.
  - Minimum Allowable Time Step – this sets a minimum timestep that can be calculated.
  - Model Output Interval -- the model output interval defines how often simulation results are saved to the model output file. The unit of this interval is days. Example if you wanted simulation results written four times a day the value would be 0.25.
- **Negative Solution Checkbox** -- checking this box will allow wasp to calculate a negative concentration. By default, whenever WASP calculates a negative concentration, the value gets reset to zero. A suggested use would be to allow a negative concentration calculated for dissolved oxygen which would represent dissolved oxygen deficit.

Modeled State Variables

The WASP Eutrophication model is a start-of-the-art water quality model. Figure 3 below is a schematic that illustrates all the state variables in WASP and how they react. One of the largest strengths of WASP is the user gets to select which state variables to consider in their study.

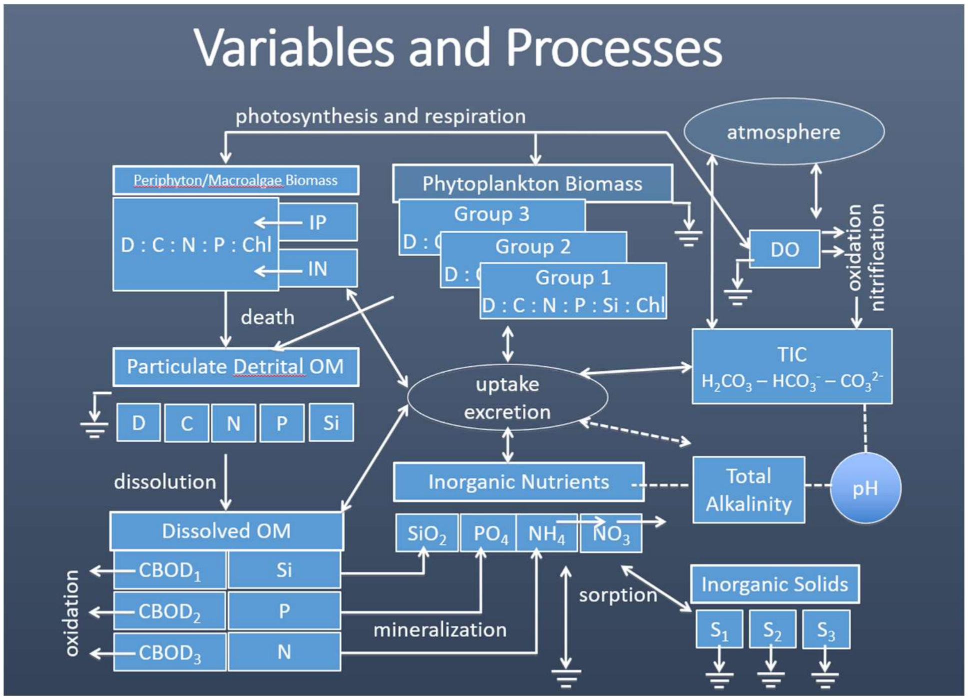
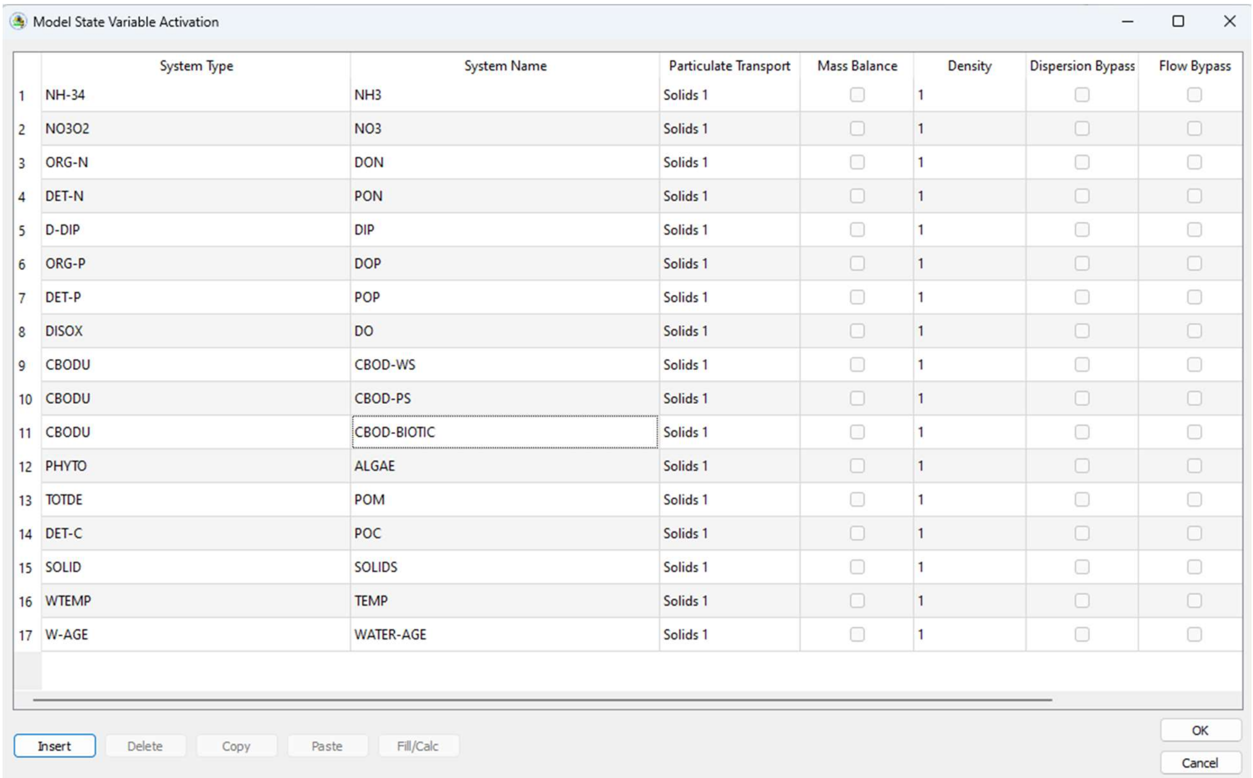


Figure 3 WASP State Variable Relationships

For our modeling example we will use the following state variables:

- Ammonia
- Nitrate
- Dissolved Organic Nitrogen
- Particulate Organic Nitrogen
- Dissolved Inorganic Phosphorus
- Dissolved Organic Phosphorus
- Particulate Organic Phosphorus
- Dissolved Oxygen
- Three CBOD State Variables (Watershed, Point Source and Biotic)
- Phytoplankton
- Particulate Organic Matter
- Particulate Organic Carbon
- Inorganic Solids
- Water Temperature
- Water Age

Figure 4 shows the system selection data form for our modeling example. There will be a total of 17 state variables simulated.



Model State Variable Activation

	System Type	System Name	Particulate Transport	Mass Balance	Density	Dispersion Bypass	Flow Bypass
1	NH-34	NH3	Solids 1	☐	1	☐	☐
2	NO3O2	NO3	Solids 1	☐	1	☐	☐
3	ORG-N	DON	Solids 1	☐	1	☐	☐
4	DET-N	PON	Solids 1	☐	1	☐	☐
5	D-DIP	DIP	Solids 1	☐	1	☐	☐
6	ORG-P	DOP	Solids 1	☐	1	☐	☐
7	DET-P	POP	Solids 1	☐	1	☐	☐
8	DISOX	DO	Solids 1	☐	1	☐	☐
9	CBODU	CBOD-WS	Solids 1	☐	1	☐	☐
10	CBODU	CBOD-PS	Solids 1	☐	1	☐	☐
11	CBODU	CBOD-BIOTIC	Solids 1	☐	1	☐	☐
12	PHYTO	ALGAE	Solids 1	☐	1	☐	☐
13	TOTDE	POM	Solids 1	☐	1	☐	☐
14	DET-C	POC	Solids 1	☐	1	☐	☐
15	SOLID	SOLIDS	Solids 1	☐	1	☐	☐
16	WTEMP	TEMP	Solids 1	☐	1	☐	☐
17	W-AGE	WATER-AGE	Solids 1	☐	1	☐	☐

Insert Delete Copy Paste Fill/Calc OK Cancel

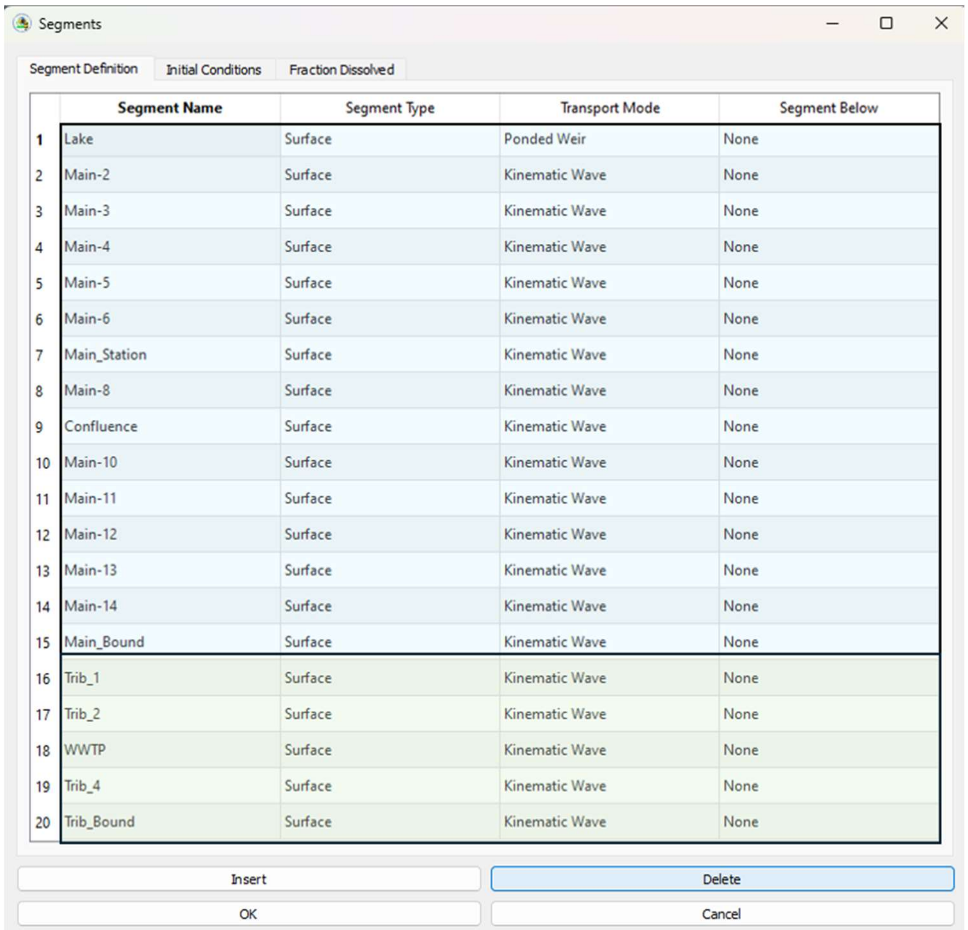
Figure 4 WASP State Variable Selection

Definition of input columns are:

- System Type – this is a drop-down selection of the available state variables that are available. For several of the state variables you can have more than one, such as Phytoplankton and CBOD you can have up to 5.
- System Name – this is an editable field that allows you to give the state variable a descriptive name that will be persistent throughout the interface data entry screens
- Particulate Transport – this input has been deprecated and would only be used for very old previously created input files.
- Mass Balance – while the mass balance is calculated for all state variables in the model, you can check 1 of the state variables to create an ASCII output file that will provide details on the mass balance.
- Density – the current version of WASP will calculate the density of water as a function of temperature and salinity/total dissolved solids.
- Dispersion Bypass – selecting this by-pass option would keep the model from transporting the selected state variable by dispersion.
- Advection Bypass -- selecting this by-pass option would keep the model from transporting the selected state variable by advection.

Segment Definition/Transport Mode

The user is responsible for defining the number of segments, segment type, transport model and the segment located below the one being defined (Figure 5). The WASP model network is an unstructured grid, which allows the user to define segmentation in 1-dimension, 2-dimension, 3-dimension or a mixture of all dimensions.



Segments

Segment Definition | Initial Conditions | Fraction Dissolved

	Segment Name	Segment Type	Transport Mode	Segment Below
1	Lake	Surface	Ponded Weir	None
2	Main-2	Surface	Kinematic Wave	None
3	Main-3	Surface	Kinematic Wave	None
4	Main-4	Surface	Kinematic Wave	None
5	Main-5	Surface	Kinematic Wave	None
6	Main-6	Surface	Kinematic Wave	None
7	Main_Station	Surface	Kinematic Wave	None
8	Main-8	Surface	Kinematic Wave	None
9	Confluence	Surface	Kinematic Wave	None
10	Main-10	Surface	Kinematic Wave	None
11	Main-11	Surface	Kinematic Wave	None
12	Main-12	Surface	Kinematic Wave	None
13	Main-13	Surface	Kinematic Wave	None
14	Main-14	Surface	Kinematic Wave	None
15	Main_Bound	Surface	Kinematic Wave	None
16	Trib_1	Surface	Kinematic Wave	None
17	Trib_2	Surface	Kinematic Wave	None
18	WWTP	Surface	Kinematic Wave	None
19	Trib_4	Surface	Kinematic Wave	None
20	Trib_Bound	Surface	Kinematic Wave	None

Insert | Delete

OK | Cancel

Figure 5 Network Segment and Transport Definition

- **Segment Name** – user can provide segment names that will be propagated throughout the interface wherever segment information is needed. Segment names ***must be unique***. If you are going pasting information into this column there cannot be a space between words, unless they are incapsulated by "Main Bound".
- **Segment Type** –
    - Surface – is a water segment that has an interface with the atmosphere.
    - Sub-Surface – is a water segment that has a surface segment or sub-surface type above it.

- Surface Benthic (Sediment) – is sediment segment that has surface or sub-surface segment above it.
- Sub-Surface Benthic (Sediment) -- is sediment segment that has surface benthic segment above it.
- Discharge Pipe – is a segment that does not have an atmospheric interface (no light penetration, no reaeration, no atmospheric deposition).

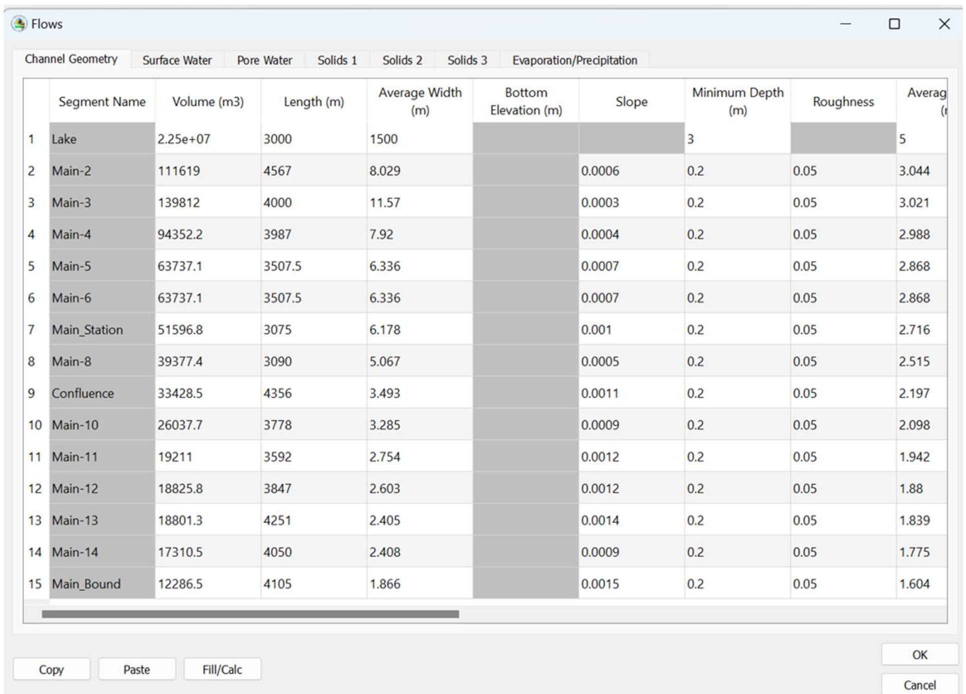
- **Transport Mode** –
  - Flow Routing -- steady specified flow reaches
  - Stream Routing -- unsteady specified flow reaches
  - Kinematic Wave – free flowing reaches
  - Ponded Weir -- weir overflow reaches
  - Lake (1D-Vertical) – stratified lake/pond reach
  - Dynamic Flow -- backwater/tidal impacted reaches
  - Hydrodynamic Linkage – reach volumes, depths, velocity and flows provided via external linkage file.
  - Sediment – mechanistic sediment transport
- **Segment Below** – indicates to WASP what segment is directly below the one being defined. This to provide a pathway for light propagation through the water column

Flows & Flow Paths

This section of the WASP interface is where you define flow conductivity between your segments, segment geometry and provide time series of flows at the boundary for each the defined flow paths. This is probably the most tedious input that must be entered for your data set.

- **Channel Geometry** -- this data entry screen is where you define your segment geometry for the transport mode.
- **Surface Water** -- this flow field is used to define surface water flow paths for all of your boundary flows coming into your model network.
- **Pore Water** -- this flow field is used to define pore water flow through sediment segments into the overlying water column. This field can be used for accounting for groundwater influences. While pore water moves through the sediment pore spaces it will only transport dissolved concentrations of the state variable.
- **Solids 1 – 3** – The entering of solids transport has been deprecated in this version of WASP. These transport fields were used in the past to define settling and resuspension of inorganic solids. This input requirement has been removed since the introduction of mechanistic sediment transport.
- **Evaporation/Precipitation** – this flow field is used to provide rainfall and evaporation time series for your model network. If you are simulating water temperature evaporation is part of the calculation for predicting water temperature.

Figure 6 depicts channel geometry data input that is required for the selected transport modes. The wasp interface will Gray out columns where data is not required for the defined transport mode of the segment. The segment names cannot be changed on this screen, they are defined on the segment definition screen. When the defining geometry for kinematic wave or dynamic flow you should be entering the average width, depth and velocity for the segment. This information can be obtained from USGS studies and National Hydrography Dataset (NHDPlus).



	Segment Name	Volume (m3)	Length (m)	Average Width (m)	Bottom Elevation (m)	Slope	Minimum Depth (m)	Roughness	Averag
1	Lake	2.25e+07	3000	1500			3		5
2	Main-2	111619	4567	8.029		0.0006	0.2	0.05	3.044
3	Main-3	139812	4000	11.57		0.0003	0.2	0.05	3.021
4	Main-4	94352.2	3987	7.92		0.0004	0.2	0.05	2.988
5	Main-5	63737.1	3507.5	6.336		0.0007	0.2	0.05	2.868
6	Main-6	63737.1	3507.5	6.336		0.0007	0.2	0.05	2.868
7	Main_Station	51596.8	3075	6.178		0.001	0.2	0.05	2.716
8	Main-8	39377.4	3090	5.067		0.0005	0.2	0.05	2.515
9	Confluence	33428.5	4356	3.493		0.0011	0.2	0.05	2.197
10	Main-10	26037.7	3778	3.285		0.0009	0.2	0.05	2.098
11	Main-11	19211	3592	2.754		0.0012	0.2	0.05	1.942
12	Main-12	18825.8	3847	2.603		0.0012	0.2	0.05	1.88
13	Main-13	18801.3	4251	2.405		0.0014	0.2	0.05	1.839
14	Main-14	17310.5	4050	2.408		0.0009	0.2	0.05	1.775
15	Main_Bound	12286.5	4105	1.866		0.0015	0.2	0.05	1.604

Figure 6 Define Segment Geometry for Transport Options

- **Segment Name** – segment name appears here for convenience. To edit a segment name, you must go back to the segment definition screen.
- **Volume (m3)** – this column is used to define segment volumes. If you do not enter a volume WASP will calculate the initial volume: Length * Average Width * Average Depth.
- **Length (m)** -- this column is used to define the length of the segments.
- **Average Width (m)** – this column is used to define the average width of the segment under average flow conditions.
- **Bottom Elevation** (**m**) -- this column is used to define the bottom elevation of the segment that is used in the dynamic flow option. The bottom elevation column and the initial surface elevation column are used to determine the initial surface water slope.
- **Slope** -- this column defines the average bottom slope of the segment reach. The segment defined slopes are used in the kinematic wave transport mode.
- **Minimum Depth (m)** -- this column defines a minimum depth that will be retained when flows become low or zero. This always ensures that there is volume of water for each segment.

- **Roughness** --this column represents the roughness coefficient (Manning's n) for each of the segments. This value is used in the calculation of flow with the kinematic wave transport option.
- **Initial Surface Elevation (m)** -- this column represents the initial surface elevation of a segment when the model first starts to run. This column is used with the dynamic flow transport option.
- **Depth Multiplier/Depth Exponent/Velocity Exponent** -- these columns work in conjunction with one another (hydraulic coefficients) to calculate varying segment widths, depths and velocities as function of changing flows.
- **Average Velocity** – this column is used to provide the average velocity under average flow conditions or in the case flow routing, represents the water velocity at that condition.
- **Side Slope** – not implemented
- **Weir Height (m)** – this column defines the height of the weir above the downstream receiving water body.
- **Weir Type** -- This column defines the weir type. Currently WASP one weir type.

Figure 7 illustrates the Flow Field Parameter section at the top of the Surface Water tab. You will that the WASP interface allows the user to apply scale and conversion factors to the inputs. This is a convenient way to convert user input data to the correct WASP internal units. These values are used for all defined flow functions. An example of this if a user gets flow data from the USGS it will most likely be reported a cubic feet per second, WASP requires the flows to be in cubic meters per second, user will have to enter the appropriate conversion factor (0.02831) to convert to cubic meters per second. The scale factor can be used for sensitivity analysis and/or testing management options regarding flow. Be unchecking the Used box will keep the interface from passing the flow information into the model at execution.

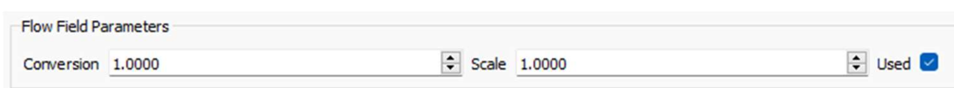


Figure 7 Scale & Conversion for Flow Fields

We are now going to define the flow paths and flow time series for our model example. In Figure 8 you will see 3 colored arrows (green, pink, blue), for each of these arrows we will have to define a flow function. A flow function is a path of where the water comes into our model network and where it exits. For each of these flow functions we will have to provide a flow time series. This input takes the same form if you are defining pore water flows.

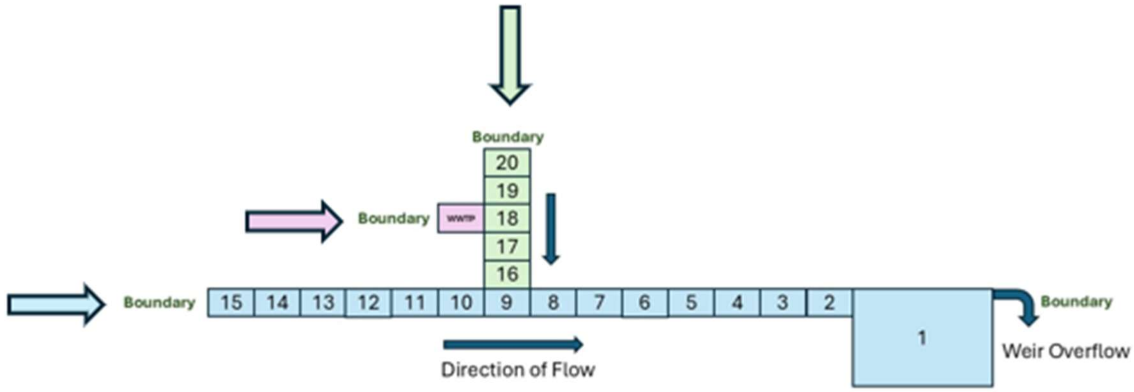


Figure 8 Model Network for Flow Paths

Figure 9 illustrates the various input components for defining flows for your model network. 1 defines individual flow functions and their options. For each flow function entered there will be an associated segment pair (2) and moment value pairs (3) which will generate the time series plot (4). To change to a flow function definition, click on the row in Flow Function table (1).

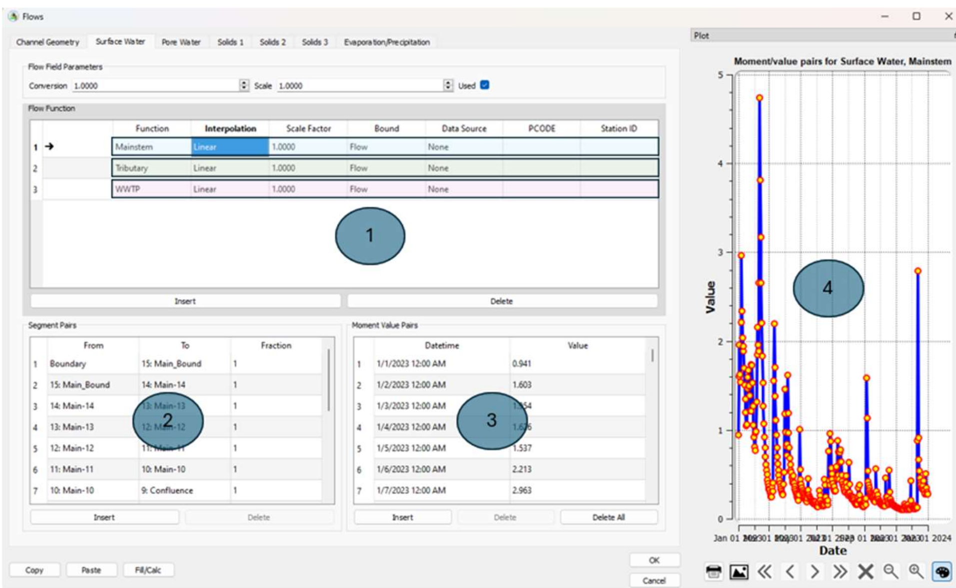


Figure 9 Flow Paths and Flow Timeseries

Figure 10 illustrates the required fields to define the options for a particular flow function.

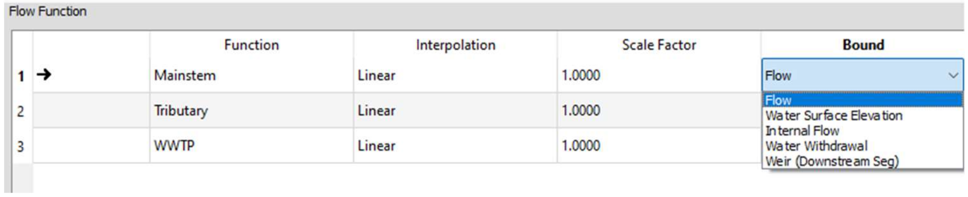


Figure 10 Flow Function Definition

- **Function** –user can provide descriptive name for the flow function
- **Interpolation** – this drop down allows the user to define the interpolation option for the flow time series data. The interpolation option determines how WASP will determine the inflow as it iterates through time. Options are linear and step function.
- **Scale Factor** – this scale factor is specific to the individual flow function. When WASP interpolates flows from the time series, the flows will be multiplied by this scale factor.
- **Bound** – because of the various transport modes and other ways to move water there are several options for defining water movement. These boundary types expect the data entered in the moment value pairs to be in the appropriate units.
  - Flow (cms) – the most prevalent is flow. You will enter a time series of flow.
  - Water Surface Elevation (m) – is used for the dynamic wave transport mode. For example, if you have a tide at a downstream boundary, you will enter a time series of water surface elevations.
  - Internal Flow (cms) – this bound type allows you to transfer water from any segment to another in the model network regardless of connectivity. You will enter a time series of flow.
  - Water Withdrawal (cms) – this bound type allows you to define a water withdrawal from a segment. This bound type differs in that WASP will not withdraw water if there is not significant volume. This bound type was implemented because of uncertainty in reported withdrawal flows.
  - Weir/Dam Discharge (cms) – this bound type allows you to define a weir or dam discharge. Typically used for dam releases for power generation where the water is not going over the top of the dam.

2 – Segment Pair Definition – this table defines the flow path of water from a boundary through your model network. Here we are defining the flow path from the mainstem river in our model network). A flow from outside the model network or from inside the model network to outside are called boundaries. The important distinction here is wherever there is a boundary you will have to provide time series of concentrations for each of the state variables being simulated. If you have a downstream boundary (in this case segment 1 – Lake) does not reverse flow you do not need to provide a boundary condition.

The **From** and **To** segments should be entered in the direction of positive flow. In our direction of flow is from Segment 15 to Segment 1.

The fraction is used to divert flow around things such as islands (see transport PowerPoint).

Inflow Calculation at Segment 15 would be:

Flow In (Boundary to Segment 15) = Flow Time Series Value * Fraction

3 & 4 – Moment Value Pairs – this is a time series of flows (or whatever is required for the bound type) that will enter the model network for the specific flow function. Once time series information is entered a time series plot (4) will be populated.

Segment Pairs

	From	To	Fraction
1	Boundary	15: Main_Bound	1
2	15: Main_Bound	14: Main-14	1
3	14: Main-14	13: Main-13	1
4	13: Main-13	12: Main-12	1
5	12: Main-12	11: Main-11	1
6	11: Main-11	10: Main-10	1
7	10: Main-10	9: Confluence	1
8	9: Confluence	8: Main-8	1
9	8: Main-8	7: Main_Station	1
10	7: Main_Station	6: Main-6	1
11	6: Main-6	5: Main-5	1
12	5: Main-5	4: Main-4	1
13	4: Main-4	3: Main-3	1
14	3: Main-3	2: Main-2	1
15	2: Main-2	1: Lake	1
16	1: Lake	Boundary	1

Insert Delete

Figure 11 Segment Pairs - Flow Continuity

Segment Parameter

The segment parameters allow the user to define environmental conditions that can vary both in space and time that are not directly simulated by the model. For segment parameters that do not link with environmental time functions you would assign a value to individual segments. These values stay constant. Some segment parameters consist of two items in the case of the example below for air temperature (Figure 12) there is Row 2 Air Temperature of Segment (°C or Multiplier) and Row 3 Pointer for Air Temperature Time Function, if you want the segment to have a steady air temperature of 20 °C you would enter 20 for the Lake segment on Row 2 and do not enter any information for Row 3 time function.

To use a segment parameter and time function together you typically enter a multiplier (row 2) of 1.0 and then point to 1 of the 4 air temperature time functions that are available.

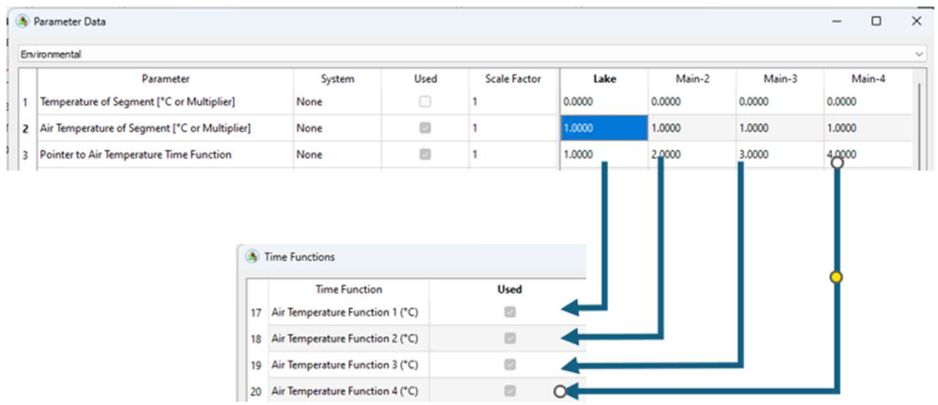
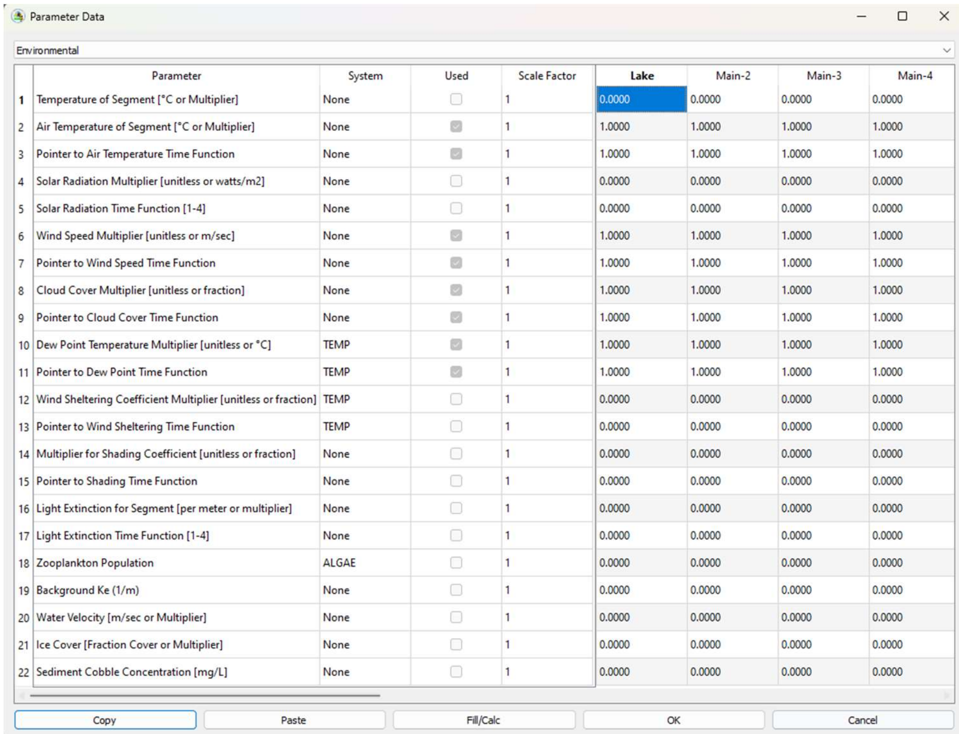


Figure 12 Segment Parameters Working with Time Functions

The calculated Air Temperature over the downstream Lake segment would be calculated as follows:

Air Temperature for Segment 1 = Air Temperature Multiplier (row 2) * Air Temperature value interpolated from the Air Temperature time series 1.

Figure 13 illustrates the main segment parameter input form, note there is a dropdown that breaks the parameters down by functional groups. While there are many segment parameters you need to enter information for the ones of concern in your model.



	Parameter	System	Used	Scale Factor	Lake	Main-2	Main-3	Main-4
1	Temperature of Segment [°C or Multiplier]	None	☐	1	0.0000	0.0000	0.0000	0.0000
2	Air Temperature of Segment [°C or Multiplier]	None	☑	1	1.0000	1.0000	1.0000	1.0000
3	Pointer to Air Temperature Time Function	None	☑	1	1.0000	1.0000	1.0000	1.0000
4	Solar Radiation Multiplier [unitless or watts/m2]	None	☐	1	0.0000	0.0000	0.0000	0.0000
5	Solar Radiation Time Function [1-4]	None	☐	1	0.0000	0.0000	0.0000	0.0000
6	Wind Speed Multiplier [unitless or m/sec]	None	☑	1	1.0000	1.0000	1.0000	1.0000
7	Pointer to Wind Speed Time Function	None	☑	1	1.0000	1.0000	1.0000	1.0000
8	Cloud Cover Multiplier [unitless or fraction]	None	☑	1	1.0000	1.0000	1.0000	1.0000
9	Pointer to Cloud Cover Time Function	None	☑	1	1.0000	1.0000	1.0000	1.0000
10	Dew Point Temperature Multiplier [unitless or °C]	TEMP	☑	1	1.0000	1.0000	1.0000	1.0000
11	Pointer to Dew Point Time Function	TEMP	☑	1	1.0000	1.0000	1.0000	1.0000
12	Wind Sheltering Coefficient Multiplier [unitless or fraction]	TEMP	☐	1	0.0000	0.0000	0.0000	0.0000
13	Pointer to Wind Sheltering Time Function	TEMP	☐	1	0.0000	0.0000	0.0000	0.0000
14	Multiplier for Shading Coefficient [unitless or fraction]	None	☐	1	0.0000	0.0000	0.0000	0.0000
15	Pointer to Shading Time Function	None	☐	1	0.0000	0.0000	0.0000	0.0000
16	Light Extinction for Segment [per meter or multiplier]	None	☐	1	0.0000	0.0000	0.0000	0.0000
17	Light Extinction Time Function [1-4]	None	☐	1	0.0000	0.0000	0.0000	0.0000
18	Zooplankton Population	ALGAE	☐	1	0.0000	0.0000	0.0000	0.0000
19	Background Ke (1/m)	None	☐	1	0.0000	0.0000	0.0000	0.0000
20	Water Velocity [m/sec or Multiplier]	None	☐	1	0.0000	0.0000	0.0000	0.0000
21	Ice Cover [Fraction Cover or Multiplier]	None	☐	1	0.0000	0.0000	0.0000	0.0000
22	Sediment Cobble Concentration [mg/L]	None	☐	1	0.0000	0.0000	0.0000	0.0000

Figure 13 WASP Environmental Segment Parameters

Available segment parameters that are available in the eutrophication model or defined below.

- **Temperature of Segment** [°C or Multiplier] – this parameter specifies either a constant water temperature for the segment or a value that is multiplied by the Water Temperature time function. While most environmental time functions have more than 1 time series available, water temperature has only 1 time function. If you have spatial and temporal variations in water temperature, you need to simulate water temperature as a state variable.
- **Air Temperature of Segment** [°C or Multiplier] -- this parameter specifies either a constant air temperature for the segment or a value that is multiplied by the Air Temperature time function that is selected.
- **Pointer to Air Temperature Time Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in air temperature.
- **Solar Radiation Multiplier** [watts/m2 or multiplier] -- this parameter specifies either a constant solar radiation for the segment or a value that is multiplied by the Solar Radiation time function that is selected.
- **Solar Radiation Time Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in solar radiation.
- **Wind Speed Multiplier** [m/sec or multiplier] -- this parameter specifies either a constant wind speed for the segment or a value that is multiplied by the Wind Speed time function that is selected.
- **Pointer to Wind Speed Time Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in wind speed.

- **Cloud Cover Multiplier** [fraction or multiplier] -- this parameter specifies either a constant cloud cover for the segment or a value that is multiplied by the Cloud Cover time function that is selected. Note: Cloud Cover fraction is 0 for clear sky & 1 for complete cloud cover.
- **Pointer to Cloud Cover Time Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in cloud cover.
- **Dew Point Temperature Multiplier** [°C or multiplier] -- this parameter specifies either a constant dew point for the segment or a value that is multiplied by the Dew Point time function that is selected.
- **Pointer to Dew Point Time Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in dew point temperature.
- **Wind Sheltering Coefficient Multiplier** [unitless or fraction] -- this parameter specifies either a constant wind sheltering coefficient for the segment or a value that is multiplied by the Wind Sheltering Coefficient function that is selected. Note: Wind Sheltering Coefficient fraction is 0 for no shelter & 1 for completely sheltered.
- **Pointer to Wind Sheltering Time Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in wind sheltering.
- **Multiplier for Shading Coefficient** [unitless or fraction or multiplier] -- this parameter specifies either a constant wind shading coefficient for the segment or a value that is multiplied by the Shading Coefficient function that is selected. Note: Shading Coefficient fraction is 0 for no shading & 1 for completely shaded.
- **Pointer to Shading Time Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in light shading.
- **Light Extinction for Segment** [per meter or multiplier] -- this parameter specifies either a constant light extinction for the segment or a value that is multiplied by the Light Extinction time function that is selected.
- **Light Extinction Time Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in light extinction.
- **Background Ke** (1/m) – this parameter allows the user to specify a segment specific background light extinction
- **Zooplankton Population** -- this parameter allows the user to specify a segment specific zooplankton population that will graze on phytoplankton.
- **Water Velocity** [m/sec or Multiplier] -- this parameter specifies either a constant water velocity for the segment or a value that is multiplied by the Water Velocity time function. While most environmental time functions have more than 1 time series available, water velocity has only 1 time function. If you have spatial and temporal variations in water velocity, you need to use a transport mode that will calculate water velocity as a function of flow.
- **Ice Cover** [Fraction Cover or Multiplier] -- this parameter specifies either a constant ice cover for the segment or a value that is multiplied by the Ice Cover time function. Note: if you are simulating water temperature, ice formation can be simulated based upon environmental conditions.

- **Sediment Cobble Concentration** [mg/L] -- this parameter allows the user to specify a segment specific Sediment Cobble Concentration used in the mechanistic sediment transport algorithms.
- **Solid Settling Velocity in Segment** [m/day] -- this parameter allows the user to specify a segment specific Solid Settling Velocity.
- **Phytoplankton Settling Velocity in Segment** [m/day] -- this parameter allows the user to specify a segment specific Phytoplankton Settling Velocity.
- **Settling Velocity of Segment Particulate Organic Matter** [m/day] -- this parameter allows the user to specify a segment specific Settling Velocity of POM (detritus).
- **Solid Resuspension Velocity in Segment** [m/day] -- this parameter allows the user to specify a segment specific Solid Resuspension Velocity.
- **Pathogen Settling Velocity in Segment** [m/day] -- this parameter allows the user to specify a segment specific Pathogen Settling Velocity.
- **Measured Segment Reaeration Rate** [per day] -- this parameter allows the user to specify a segment specific measure Reaeration Rate that will not change.
- **Segment elevation above sea level** [m] -- this parameter allows the user to specify a segment specific Elevation used in the Dissolved Oxygen Saturation calculation.
- **Dam Elevation** [meters] -- this parameter allows the user to specify a segment specific Dam Elevation (if one exists). Defined as the height of the dam. This is used to add dissolved oxygen to the segment below caused by the falling water and mixing.
- **Dam Pool WQ** Coefficient -- this parameter allows the user to specify a segment specific that is needed for the oxygen addition due to the dam.
- **Dam Type Coefficient** -- this parameter allows the user to specify a segment specific Dam Type Coefficient used in calculating the oxygen due to the dam.
- **Tsvigolo Escape Coefficient** -- this parameter allows the user to specify a segment specific Tsvigolo Escape Coefficient that is used for calculating a segment specific reaeration rate using the Tsvigolo formulation.
- **Minimum Reaeration Velocity for Segment** [m/day] -- this parameter allows the user to specify a segment specific
- **Fraction of Bottom of Segment Covered by Macro Algae** – this parameter defines how much the sediment area is suitable for the establishment of attached algae (periphyton/macro algae). A fraction of 0 means there is no suitable area, 1 means the entire bottom area is suitable for attachment.
- **Benthic Ammonia Flux** [mg/m2-day] -- this parameter specifies either a constant benthic ammonia flux for the segment or a value that is multiplied by the Benthic Ammonia time function. While most environmental time functions have more than 1 time series available, Benthic Ammonia Flux has only 1 time function. If you have spatial and temporal variations in benthic ammonia flux, you should consider using the mechanistic sediment diagenesis module which will predict this flux temporally and spatially as a function of water quality conditions and what settles to the bottom.
- **Benthic Phosphate Flux** [mg/m2-day] -- this parameter specifies either a constant benthic phosphate flux for the segment or a value that is multiplied by the Benthic Phosphate time function. While most environmental time functions have more than 1 time series available,

Benthic Phosphate Flux has only 1 time function. If you have spatial and temporal variations in benthic phosphate flux, you should consider using the mechanistic sediment diagenesis module which will predict this flux temporally and spatially as a function of water quality conditions and what settles to the bottom.

- **Benthic NO3 Flux** [mg/m2-day] -- this parameter specifies either a constant benthic nitrate flux for the segment or a value that is multiplied by the Benthic Ammonia time function. While most environmental time functions have more than 1 time series available, Benthic Nitrate Flux has only 1 time function. If you have spatial and temporal variations in benthic nitrate flux, you should consider using the mechanistic sediment diagenesis module which will predict this flux temporally and spatially as a function of water quality conditions and what settles to the bottom.
- **Sediment Oxygen Demand** [g/m2-day] -- this parameter specifies either a constant sediment oxygen demand for the segment or a value that is multiplied by the Sediment Oxygen Demand time function. While most environmental time functions have more than 1 time series available, Sediment Oxygen Demand has only 1 time function. If you have spatial and temporal variations in sediment oxygen demand, you should consider using the mechanistic sediment diagenesis module which will predict this flux temporally and spatially as a function of water quality conditions and what settles to the bottom.
- **Sediment Diagenesis Segment Attached to this Segment** – this parameter specifies which sediment diagenesis module computational segment that settled materials and overly water column conditions apply. The sediment diagenesis module allows the user to assign multiple WASP segments to sediment diagenesis computational segments.
- **PON Initial Condition for Sediment Diagenesis Segment** (mg/L) – specifies the initial condition of particulate organic nitrogen for the sediment diagenesis module.
- **POP Initial Condition for Sediment Diagenesis Segment** (mg/L) – specifies the initial condition of particulate organic phosphorus for the sediment diagenesis module.
- **POC Initial Condition for Sediment Diagenesis Segment** (mg/L) -- specifies the initial condition of particulate organic carbon for the sediment diagenesis module.
- **POSi Initial Condition for Sediment Diagenesis Segment** (mg/L) -- specifies the initial condition of particulate organic silica for the sediment diagenesis module.
- **Fraction of [PO-N/P/C] in Class 1** (0 to 1) – fraction of settled particulate material to G Class 1 of sediment diagenesis module.
- **Fraction of [PO-N/P/C] in Class 2** (0 to 1) -- fraction of settled particulate material to G Class 2 of sediment diagenesis module.
- **Fraction of [PO-N/P/C] in Class 3** (0 to 1) – fraction of settled particulate material to G Class 3 of sediment diagenesis module.
- **Atm Deposition of Nitrate** (mg/m2-day or Multiplier) – this parameter specifies either a constant atmospheric deposition rate for nitrate for the segment or a value that is multiplied by the Atmospheric Deposition Nitrate time function that is selected.
- **Atm Deposition of Nitrate Function** [1-4] -- this parameter specifies which of the available environmental time functions to use to provide temporal variation in atmospheric deposition rates.

- **Atm Deposition of Ammonia** (mg/m2-day or Multiplier) -- this parameter specifies either a constant atmospheric deposition rate for ammonia for the segment or a value that is multiplied by the Atmospheric Deposition Ammonia time function that is selected.
- **Atm Deposition of Ammonia** Function [1-4] – this parameter specifies which of the available environmental time functions to use to provide temporal variation in atmospheric deposition rates.
- **Atm Deposition of Orthophosphate** (mg/m2-day or Multiplier) -- this parameter specifies either a constant atmospheric deposition rate for orthophosphate for the segment or a value that is multiplied by the Atmospheric Deposition Orthophosphate time function that is selected.
- **Atm Deposition of Orthophosphate** Function [1-4] – this parameter specifies which of the available environmental time functions to use to provide temporal variation in atmospheric deposition rates.
- **Atm Deposition of Org Nitrogen** (mg/m2-day or Multiplier) -- this parameter specifies either a constant atmospheric deposition rate for organic nitrogen for the segment or a value that is multiplied by the Atmospheric Deposition Organic Nitrogen time function that is selected.
- **Atm Deposition of Org Nitrogen Function** [1-4] – this parameter specifies which of the available environmental time functions to use to provide temporal variation in atmospheric deposition rates.
- **Atm Deposition of Org Phosphorus** (mg/m2-day or Multiplier) -- this parameter specifies either a constant atmospheric deposition rate for organic phosphorus for the segment or a value that is multiplied by the Atmospheric Deposition Organic Phosphorus time function that is selected.
- **Atm Deposition of Org Phosphorus Function** [1-4] – this parameter specifies which of the available environmental time functions to use to provide temporal variation in atmospheric deposition rates.
- **Atm Deposition of CBOD** (mg/m2-day or Multiplier) -- this parameter specifies either a constant atmospheric deposition rate for CBOD for the segment or a value that is multiplied by the Atmospheric Deposition CBOD time function that is selected.
- **Atm Deposition of CBOD Function** [1-4] – this parameter specifies which of the available environmental time functions to use to provide temporal variation in atmospheric deposition rates.
- **Atm Deposition of POC** (mg/m2-day or Multiplier) – this parameter specifies either a constant atmospheric deposition rate for POC for the segment or a value that is multiplied by the Atmospheric Deposition POC time function that is selected.
- **Atm Deposition of POC Function** [1-4] – this parameter specifies which of the available environmental time functions to use to provide temporal variation in atmospheric deposition rates.

Environmental Time Functions

Figure 14 depicts the environmental time functions that are available in the eutrophication model. Like flow path definitions the user can shut off a particular time functions by un-checking used. Like flows there are two methods for interpolation: linear and step function. Time series data is entered for each individual time function that is highlighted in the top table with the time function names.

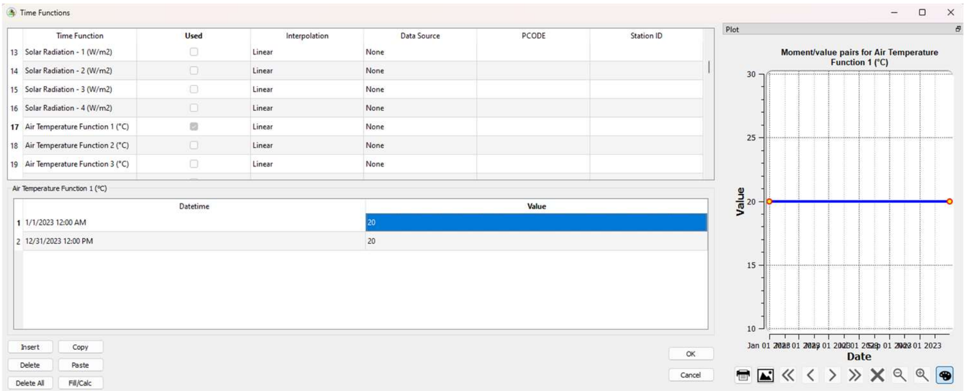


Figure 14 WASP User Defined Time Functions

Time Function Definition

- **Water Temperature Function** (°C) – provides a time series to provide temporal changes in water temperature assigned to segments.
- **Velocity Function** (m/sec) – provides a time series to provide temporal changes in water velocity assigned to segments.
- **Zooplankton Population** (count) – provides a time series to provide temporal changes in zooplankton population assigned to segments.
- **Atmospheric Pressure** – provides a time series to provide temporal changes in atmospheric pressure.
- **CO2 Atmospheric Partial Pressure** (Atmospheres) – provides a time series to provide temporal changes in CO_2 atmospheric partial pressure.
- **Reaeration Function** (per day) – provides a time series to provide temporal changes in reaeration function assigned to segments.
- **Ice Cover Function** 1 (fraction covered) – provides a time series to provide temporal changes in ice cover assigned to segments.
- **Fraction Daily Light** (fraction) – provides a time series to provide fraction of the day that is light.
- **Algal Settling Rate** (m/day) – provides a time series to provide temporal changes in algal settling rate assigned to segments.
- **Light Extinction Coefficient Functions** - 4 (1/m)
- **Solar Radiation** (W/m2) – provides 4 time series to provide temporal changes in solar radiation.
- **Air Temperature Function** (°C) – provides 4 time series to provide temporal changes in air temperature.
- **Wind Speed Function** (m/sec) – provides 4 time series to provide temporal changes in wind speed.

- **Cloud Cover Function** (fraction) – provides 4 time series to provide temporal changes in cloud cover.
- **Dew Point Function** (°C) – provides 4 time series to provide temporal changes in dew point.
- **Canopy Shading Function** (fraction) – provides 4 time series to provide temporal changes in canopy shading.
- **Phosphorus Benthic Flux** (mg/m2-day) – provides a time series of description (user provided) sediment phosphorus flux. To have WASP calculate a sediment flux based upon environmental conditions the user should invoke the sediment diagenesis module.
- **Sediment Oxygen Demand Flux** (mg/m2-day) – provides a time series of description (user provided) sediment oxygen demand flux. To have WASP calculate a sediment oxygen demand flux based upon environmental conditions the user should invoke the sediment diagenesis module.
- **Ammonia Benthic Flux** (mg/m2-day) – provides a time series of description (user provided) sediment ammonia flux. To have WASP calculate an ammonia sediment flux based upon environmental conditions the user should invoke the sediment diagenesis module.
- **Nitrate Benthic Flux** (mg/m2-day) – provides a time series of description (user provided) sediment nitrate flux. To have WASP calculate a nitrate flux based upon environmental conditions the user should invoke the sediment diagenesis module.
- **Atm. Dep. of Nitrate Function** (mg/m2-day) – provides 4 time series to provide temporal changes in atmospheric nitrate deposition.
- **Atm. Dep. of Ammonia Function** (mg/m2-day) – provides 4 time series to provide temporal changes in atmospheric ammonia deposition.
- **Atm. Dep. of Orthophosphate Function** (mg/m2-day) – provides 4 time series to provide temporal changes in atmospheric orthophosphate deposition.
- **Atm. Dep. of Org Nitrogen Function** (mg/m2-day) – provides 4 time series to provide temporal changes in atmospheric organic nitrogen deposition.
- **Atm. Dep. of Org Phosphorus Function** (mg/m2-day) – provides 4 time series to provide temporal changes in atmospheric organic phosphorus deposition.
- **Atm. Dep. of CBOD Function** (mg/m2-day) – provides 4 time series to provide temporal changes in atmospheric CBOD deposition.
- **Atm. Dep. of POC Function** 4 (mg/m2-day) – provides 4 time series to provide temporal changes in atmospheric particulate organic carbon deposition.

Boundary Conditions

Determining and defining model boundaries and providing time series of concentrations associated with the defined flows (Flow Function definitions) can be a critical step. In the case of our example there are a total of 4 boundaries (Figure 15). There is an inflow boundary at segment 15 (mainstem), segment 20 (tributary), segment 18 (wastewater treatment plant) and a downstream boundary at segment 1 (lake).

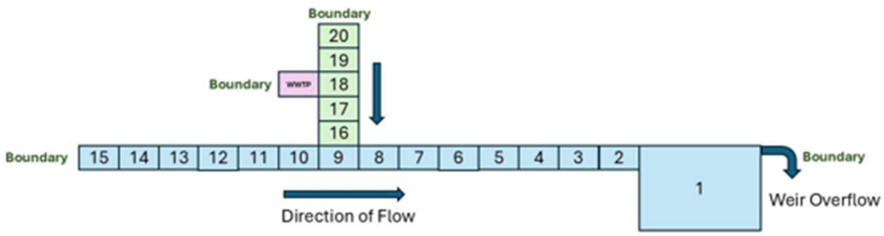


Figure 15 Model Network Boundaries

Figure 16 shows the boundary data entry screen. The upper table (1) displays all the boundaries, which is a row for each of the segments in the WASP network that has a flow coming in from outside the model network or where a flow leaves the model network. In the case of the Lake segment if we had a reversing flow here, we would need to provide a concentration associated with that flow. The columns across the top of the table represent the state variables being simulated. Selecting a row and column will allow the user to enter/edit or review the time series of concentrations entered in table (2). A time series graph will be displayed (3) for the data entered in table 2.

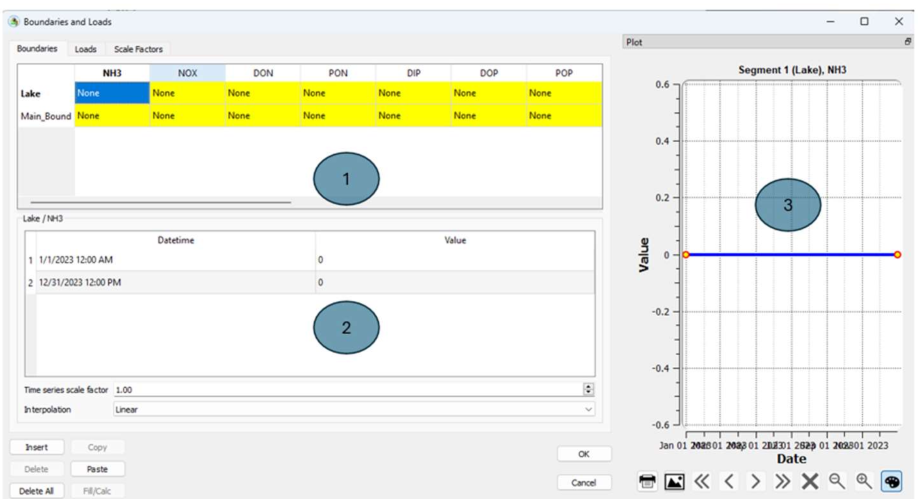


Figure 16 Entering a Boundary Concentration for State Variable and Boundary Segment

Figure 17 illustrates the boundary concentration definition screen. On inspection we can see we have three boundary locations as defined in our model network. If you see an extra boundary or a missing one, you need to revisit the Flow Definition screen to see if they were entered correctly.

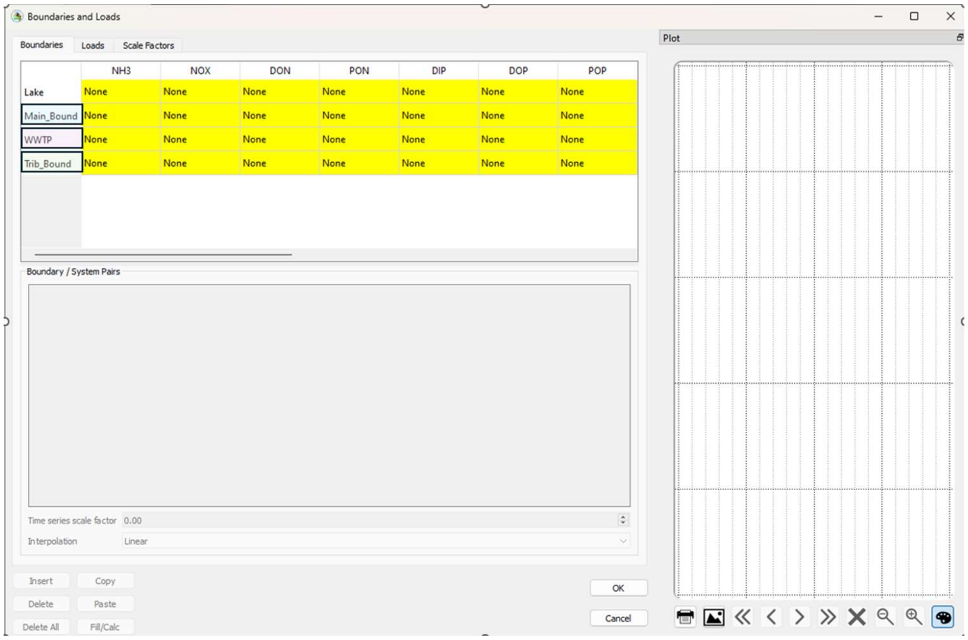
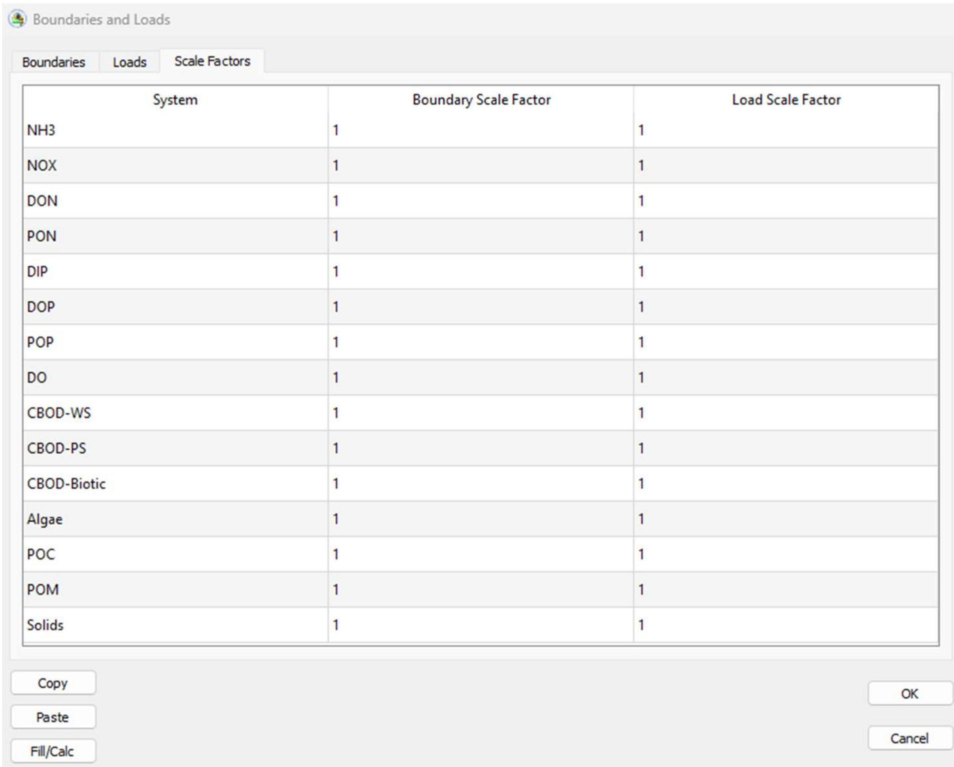


Figure 17 Boundary Concentration Definition for State Variables

Figure 18 illustrates the boundary and load scale factoring input screen. You can specify a scale factor to attenuate all boundary concentration time series. The scale factor defined here will be multiplied by the specific boundary time series defined above.



Boundaries and Loads

Boundaries | Loads | Scale Factors

System	Boundary Scale Factor	Load Scale Factor
NH3	1	1
NOX	1	1
DON	1	1
PON	1	1
DIP	1	1
DOP	1	1
POP	1	1
DO	1	1
CBOD-WS	1	1
CBOD-PS	1	1
CBOD-Biotic	1	1
Algae	1	1
POC	1	1
POM	1	1
Solids	1	1

Copy
Paste
Fill/Calc
OK
Cancel

Figure 18 Global Boundary Scale Factors by State Variable

Water Resources Database

To help us get organized we will be using the Water Resources Database (WRDB) to manage all our time series data that we will be using to develop our WASP input file. WRDB was specifically developed for managing time series water resource data as well as model inputs and outputs. WRDB is not specific to wasp or to modeling in general, it can be used for retrieving, processing and visualizing time series data. In our example here we will be creating a new WRDB project where we will be importing all the data that we have collected and processed into a spreadsheet. WRDB has a very sophisticated import routine which makes it easy to get time series data into the database from many different forms.

Step 1:

Our first step is to create a WRDB project. We need to execute the main WRDB application, from the start menu start typing Water Resources Database, you should see 

and select. Next, we will go to the file menu and select New Project (Figure 19).

Figure 19 WRDB - Creating a Project

After you have selected create New Project you will be presented with the form where you can provide information about the project you're about to create. WRDB allows the user to store metadata for virtually every step that you take and adding data to the database. Figure 20 illustrates the form where you specify a project name, this is what is displayed when you select Open Project.

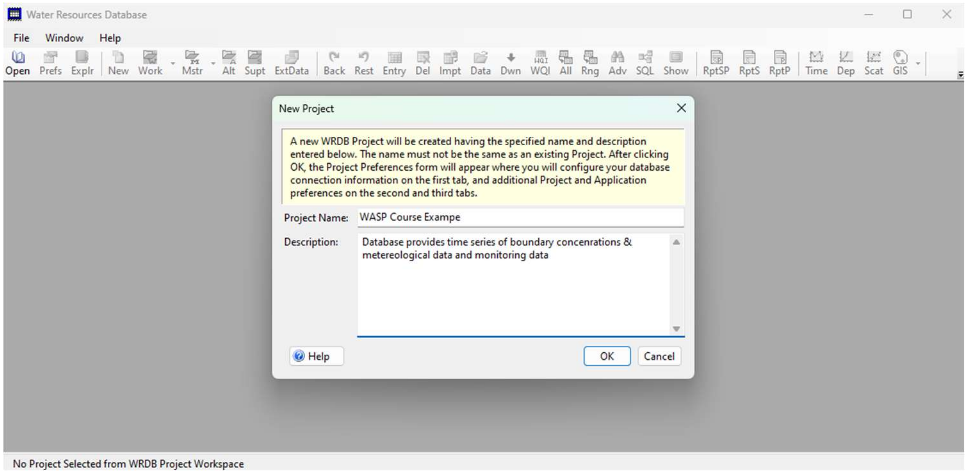


Figure 20 WRDB - New Project Description

Figure 21 shows the project preference configuration form. For our project we will be setting the Database Type to **SQLite.** We will set the database name and location to the WASP course materials location:

***your_desktop*\WASP_Course\Examples\Main_Example\WRDB\wasp_course.sdb**

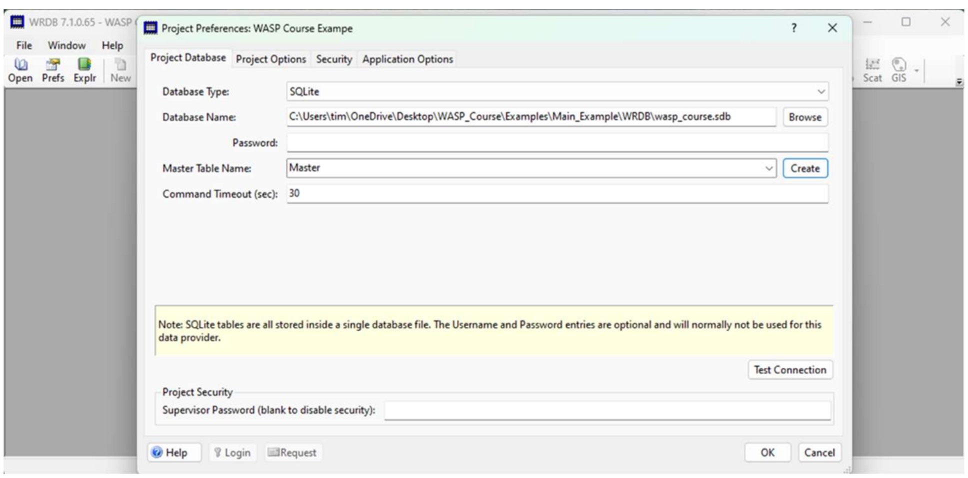


Figure 21 WRDB - New Project Preferences

Database formats supported by WRDB:

- Microsoft Access – this option will be depreciated in future versions.
- SQL Server – this is a client/server database that can be cloud based or server configured locally on your computer.
- Oracle – this is a client/server database that can be cloud based
- MySQL – this is a client/server database that can be cloud based or server configured locally on your computer.
- PostgreSQL– this is a client/server database that can be cloud based or server configured locally on your computer.

- SQLite – this is a lightweight database system that resides on your local computer
- Database Name -- provides the location and filename for the WRDB project file that you are creating. If you are using one of the cloud-based database management systems you will need to provide server name, username and password to connect.
- Password – we are leaving this field blank, but if a password is specified it would have to be provided to access the project.
- Master Table Name: we will not be using a Master Table but will be required to create one. To do this click the Create button, it will offer up the default name Master, click okay.

Once you click okay WRDB will initialize the database file. The file structure and database scheme are controlled by WRDB. We will be creating 2 working tables, first one will contain our time series of boundary flows and concentrations, second table will contain the meteorological data. Depending upon your WRDB configuration you can create and access tables by clicking on Open Working table (Figure 22).

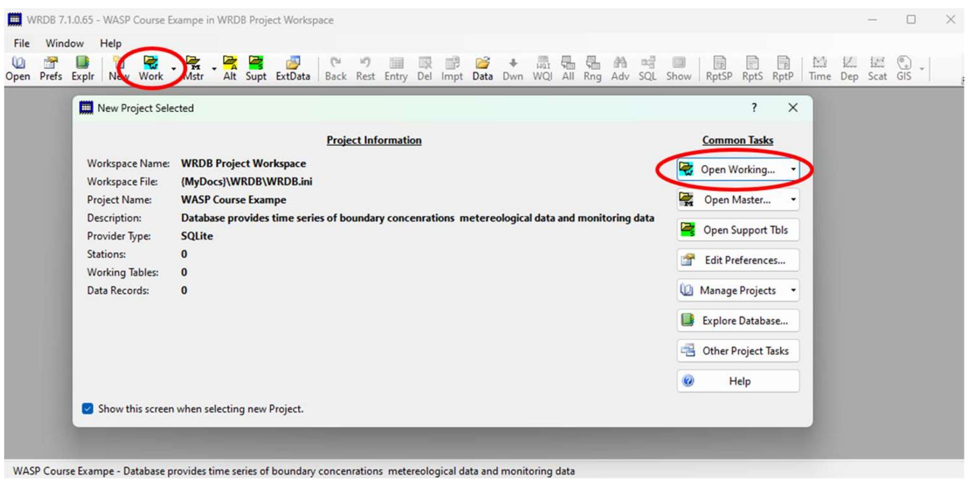


Figure 22 WRDB - New Project Created Working Tables

Once in the Working Table dialog use the Create New (Figure 23) to create 2 working tables:

- Boundary_Data – Boundary time series data for flows and concentrations.
- Met_Data – Meteorological data for water temperature computation.
- Monitoring_Data – Measured water quality data that will be used during the calibration process.

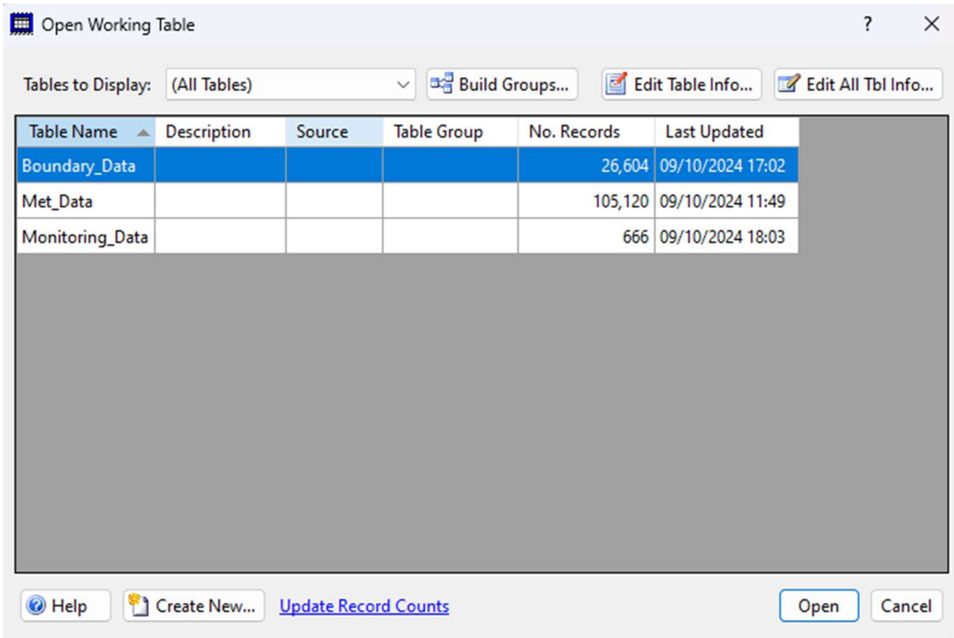


Figure 23 WRDB -- Working Table

It is recommended that you import all your support table data (station information, parameter code data) before importing any time series data. You have the option to type the support table information in by hand or import from a spreadsheet. In your example we will be importing the support table meta data by pasting from a spreadsheet. A counter intuitive step is you will need to have a Working Table open to paste any information into WRDB. In our case, click on Boundary_Data and click on the Open button at the bottom right (Figure 23).

Using the Main_Example spreadsheet we will be copying and pasting information from the WRDB tab in the spreadsheet to the WRDB working table (Figure 24).

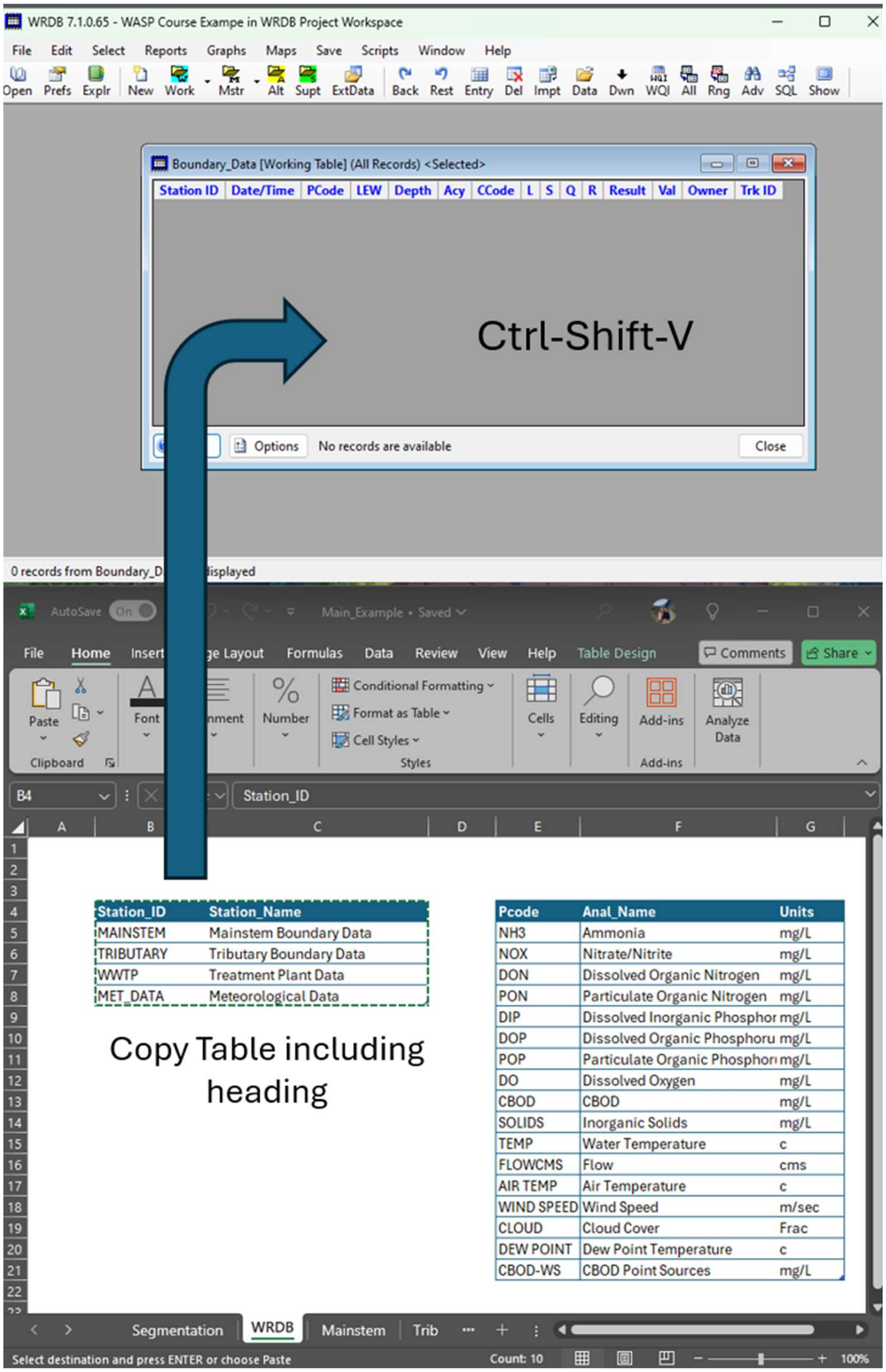


Figure 24 WRDB - Pasting Support Table Information (meta data)

Once Ctr-Shift-V is pressed on the WRDB working table, the WRDB import utility will be loaded which facilitates importing the data (Figure 25). Because the spreadsheet column headers use WRDB recognized key fields we do not need to map any of the data we will just click continue.

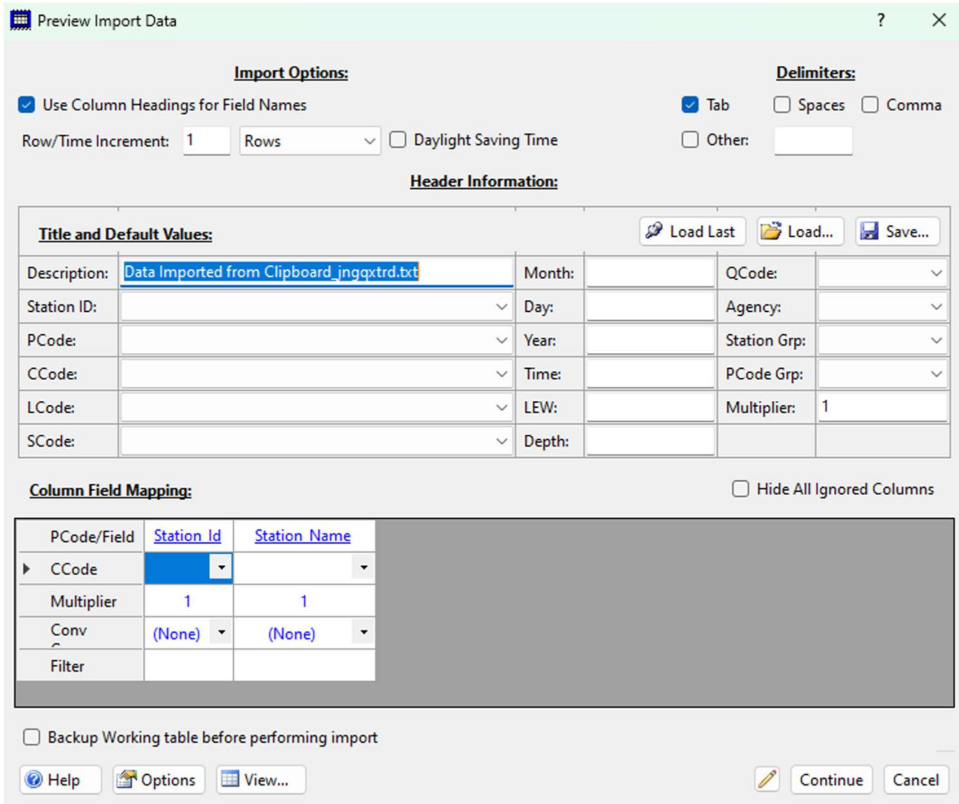


Figure 25 WRDB - Import Utility

Once you click continue, the import progress dialog window (Figure 26) will appear. You should review this window to determine everything is aligned properly and then click continue.

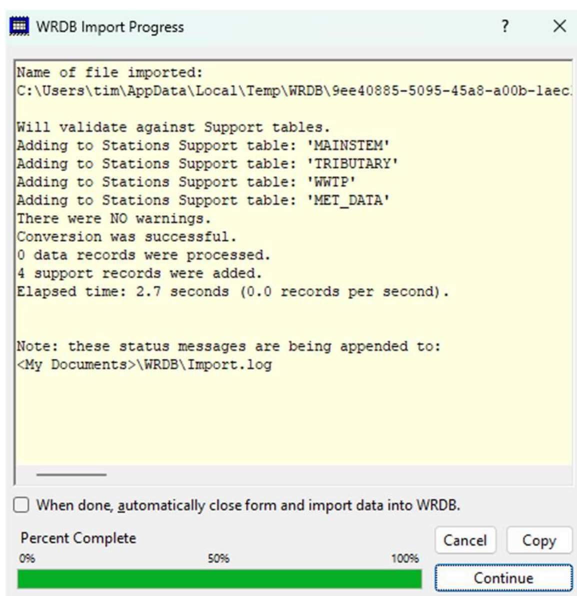


Figure 26 WRDB -- Import Status

We will use the same process to import the PCode data into the support table.

Once we have completed importing all the support data, we can now import the boundary and meteorological time series data. Figure 27 illustrates the requirements for importing time series data. Unlike the support table requirements, time series data needs information for 4 fields in the working table. The Station_ID and PCode fields are mandatory fields that relate to information in the support table. Date/Time and Results are the other 2 fields.

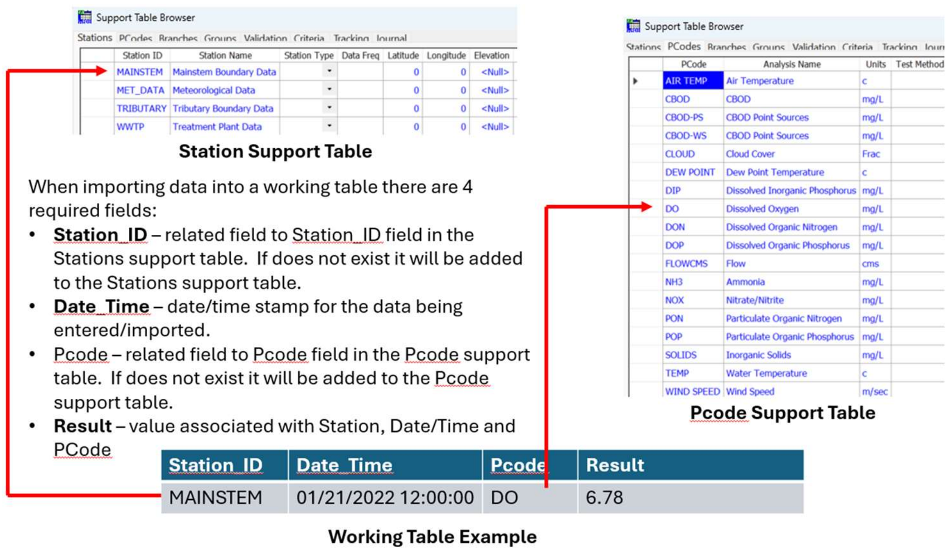


Figure 27 WRDB - Importing Data Requirements

With the Boundary_Data working table open we will import the boundary concentration time series for the Mainstem, Tributary and WWTP boundary. This will be done in 3 distinct steps. We will start by copying the table in the Mainstem tab of the spreadsheet and paste it into the Boundary_Data working table (Figure 28). Inspecting the Mainstem table in the spreadsheet, the required Date/Time field will get the information from the Date and Time column. The remaining columns contain parameter code data for the specific date and time. It should be noted that the column headers match the PCode as entered in the support table and will be matched up in the import utility.

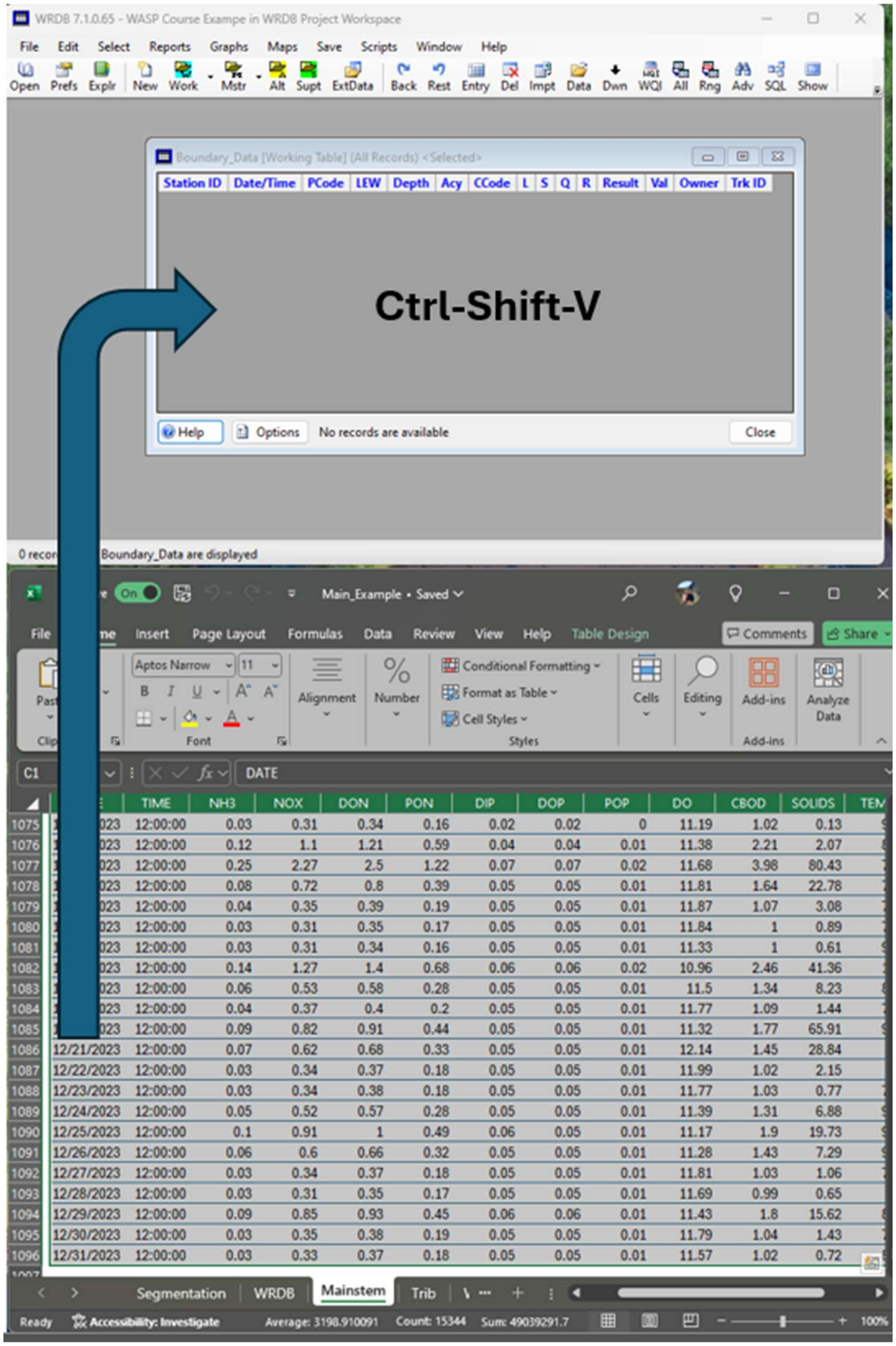


Figure 28 WRDB - Importing Boundary Time Series Data

Once the copied table is pasted into the Boundary_Data working table the WRDB import utility will be displayed. Unlike pasting the support data, we have a little more information needs to be provided prior to importing. The spreadsheet table contained 3 of the 4 mandatory fields to define a time series data point in a working table. The spreadsheet had the date/time, Pcode and Result required fields, but the Station_ID field was not defined. Using the drop-down menu (Figure 29) option for

Station_ID we will select the correct Station_ID for the boundary that is being imported. Once the Station_ID is defined, click the Continue button this will import all the data.

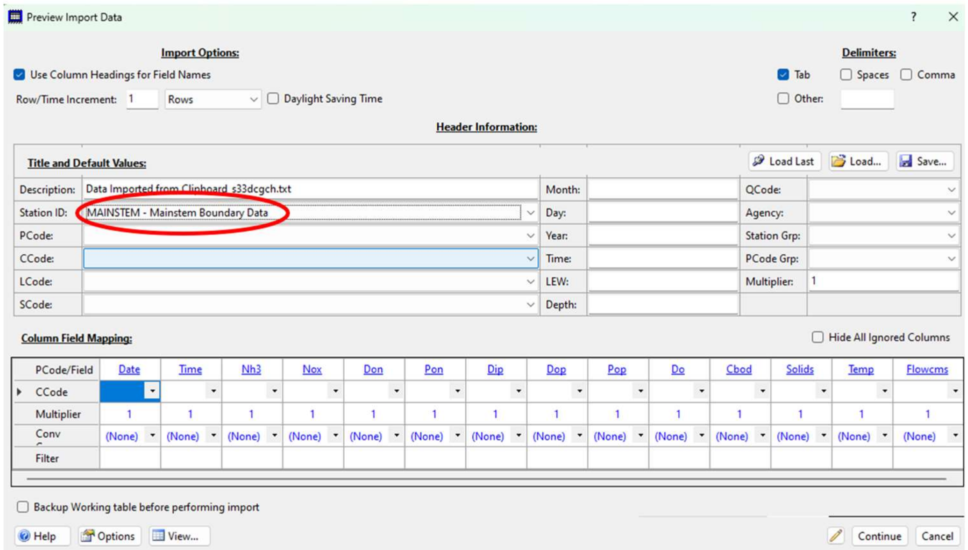


Figure 29 WRDB - Import Boundary Data

Using the same process, we will import the tributary and WWTP boundary data, copying the data from the tabs in the spreadsheet. Once all the boundary data is imported into WRDB, close the Boundary_Data working table and open the Met_Data working table. Copy and paste the Met_Data tab into the working table, remember to select MET_DATA Station_ID. Copy and paste the Monitoring_Data tab into the working table Monitoring_data, we do not have to specify the Station_ID as it is included in the table from the spreadsheet.

Linking WRDB to WASP

Now with the data processed into WRDB we are going to parameterize WASP to retrieve all the time series into the various input tables in the WASP interface. When the WASP interface was developed, it was designed to work with WRDB which allows the linking of a WRDB working table with WASP a snap. While this was part of the design it is very easy to link to other database structures.

To start the linkage process you need to click on the External Data Source icon. This will display Figure 30, click on Add to start the linkage process for a particular data source. In our example we will be creating 2 external linkages to our WRDB project working tables: Boundary_Data and Met_Data.

You would also use this dialog box to edit or delete external data connections.

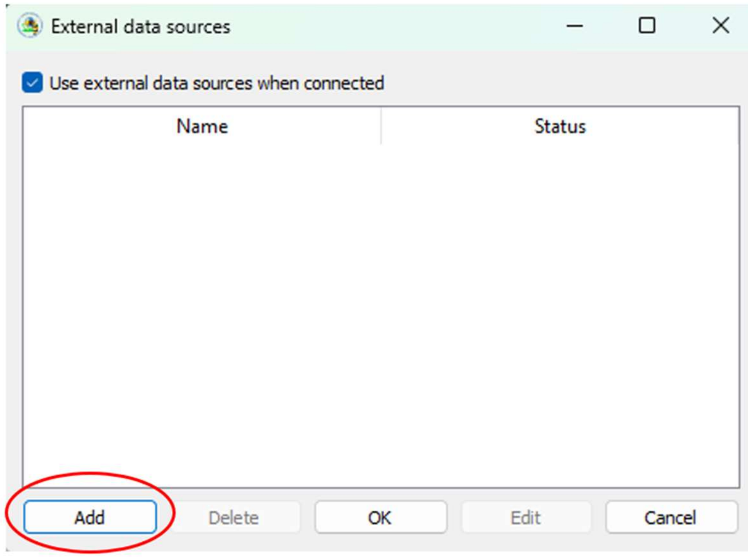


Figure 30 WASP -- Linking External Database

Once you click Add a dialog screen will appear (Figure 31). This dialog box allows you to create a connection to external data. It is important to organize your data by types for WASP, in our case we will have two types of data:

- Boundary Time Series Data for our boundary conditions (Mainstem, Tributary and WWTP)
- Meteorological Data for environmental influences (Air Temperature, Wind Speed, Dew Point, Cloud Cover)

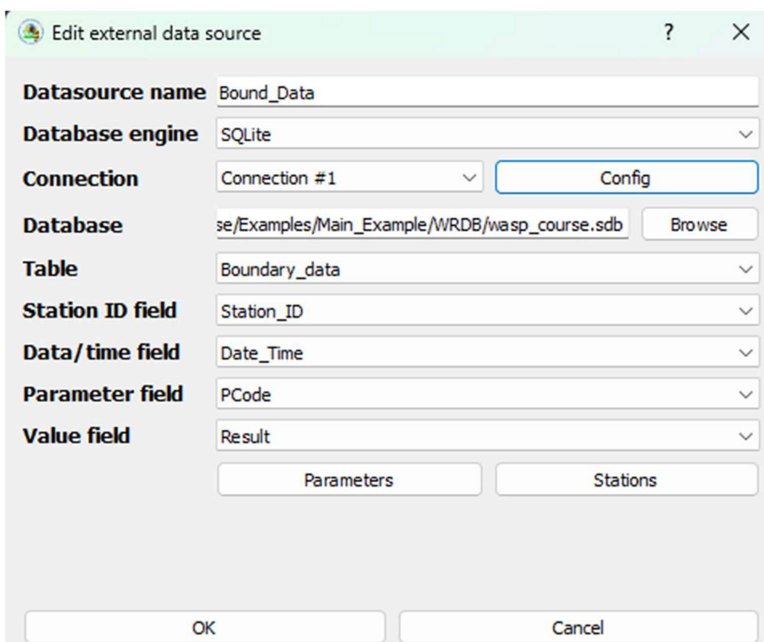


Figure 31 WASP External Database Connection

- **Data source Name**: this is the name that you define for the external connection. This name will appear in the sections of the WASP interface where you can connect to a database.
- **Database Engine**: WASP supports the following database connections:
  - **SQLite**
  - MySQL
  - Oracle
  - Access
  - Excel
  - Comma/Tab Delimited Data
- **Connection –** is used to connect to a server/cloud-based database, it will prompt for server name, username and password. For local databases you just need to create a single connection with no information.
- **Database File**: browse to the location of your WRDB project file on your computer hard drive. Should be located at: ***your_desktop*\WASP_Course\Examples\Main_Example\WRDB\wasp_course.sdb**
- **Table**: this is a table in the database. In our case our choice would be either **Boundary_Data** or **Met_Data**
- **Station ID Field**: if you are using a database structure different than WRDB, select the field name that represents the Station. The default in WASP is for WRDB connections.
- **Date/Time Field**: if you are using a database structure different than WRDB, select the field name that represents the Date/Time field. The default in WASP is for WRDB connections.
- **Parameter Field**: if you are using a database structure different than WRDB, select the field name that represents the PCode/Parameter. The default in WASP is for WRDB connections.
- **Value Field**: if you are using a database structure different than WRDB, select the field name that represents the value. The default in WASP is for WRDB connections.
- **Parameters Button**: this button will cause the interface to display the database parameter to model state variable connection (Figure 32)
- **Stations Button**: this button will cause the interface to display the database station to model segment connection (Figure 34).

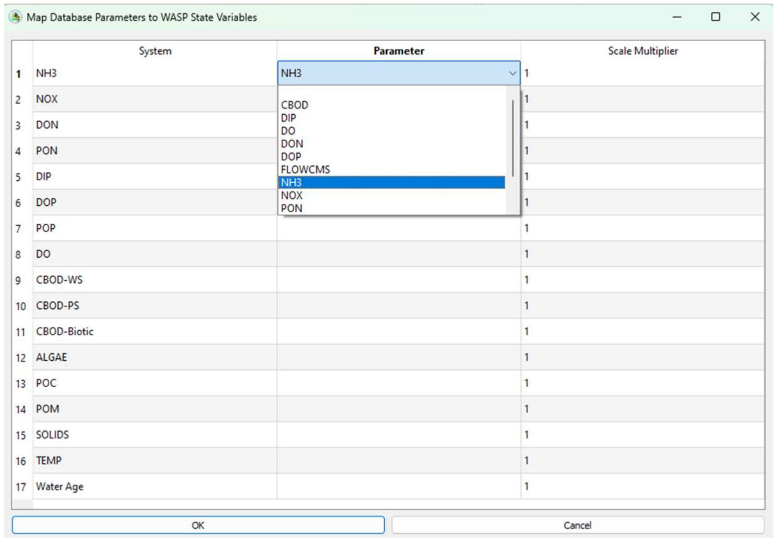


Figure 32 WASP - Database Parameter to Model State Variable Connection

- **System**: this is a non-editable field that is determined by the System/State Variable input form. Each row is a state variable where you have the option to link a database parameter.
- **Parameter**: this drop-down allows the user to select a database parameter code to be linked to a WASP state variable.
- **Scale Multiplier**: the scale multiplier allows the user to scale up or down the values from the database.

Figure 34 shows the completed Parameter Code linkage to WASP state variables.

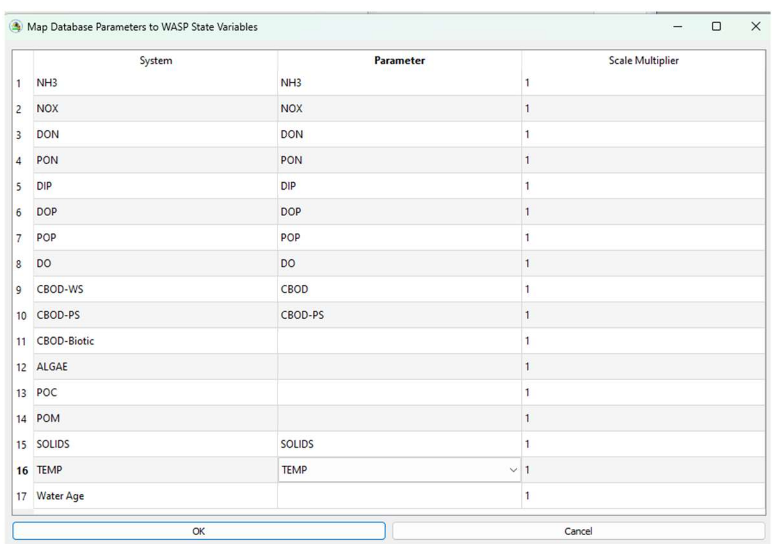


Figure 33 WASP Completed Database Parameter to Model State Variable Connection

Figure 34 illustrates the segment linkage to database Stations. The rows that are highlighted in yellow are segments that have a boundary condition. If your segment name is the same as a Station ID in the database, they are automatically linked. Otherwise, use the drop-down menu to select the database Station ID that should be linked to the segment being defined.

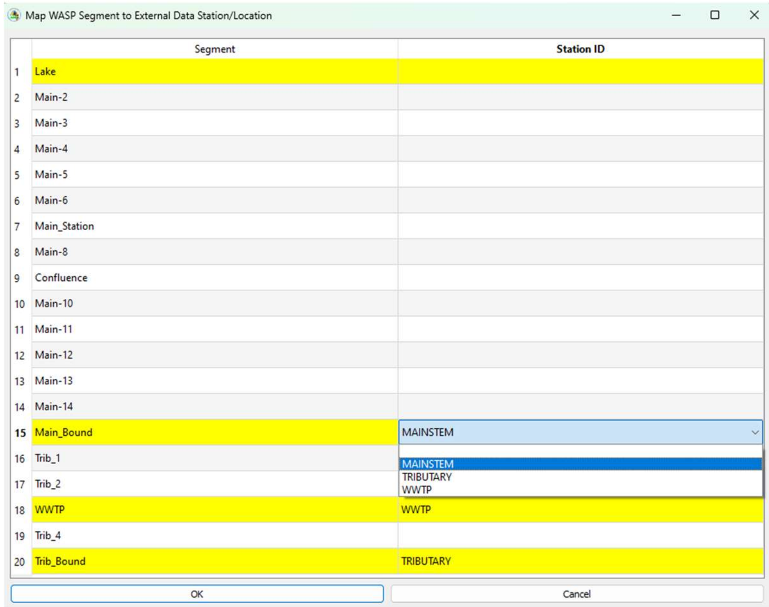


Figure 34 WASP Database Segment to Station Connection

Our next step is to create a link to the meteorological data that will be imported into the environmental time function forms of WASP. Because this is just time function data that is not directly connected to a WASP state variable or WASP segment, we just need to complete the external data connection screen. Need to add a connection as shown in Figure 30.

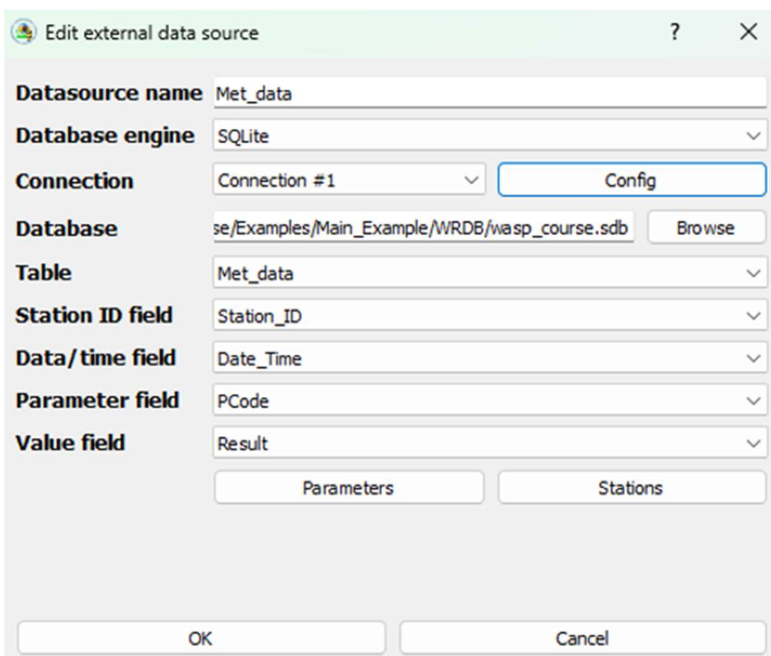


Figure 35 WASP Database Linkage for Met_Data

External Linkage for Time Function Data Time Series

Our next step is to link our various external data sources to the portion of the WASP interface in which they pertain. The figure below (Figure 36) shows the time function input screen. For air temperature, wind speed, cloud cover and dew point we will be linking to the Met_Data connection that was previously defined, which will retrieve the data from the WRDB Met_Data working table.

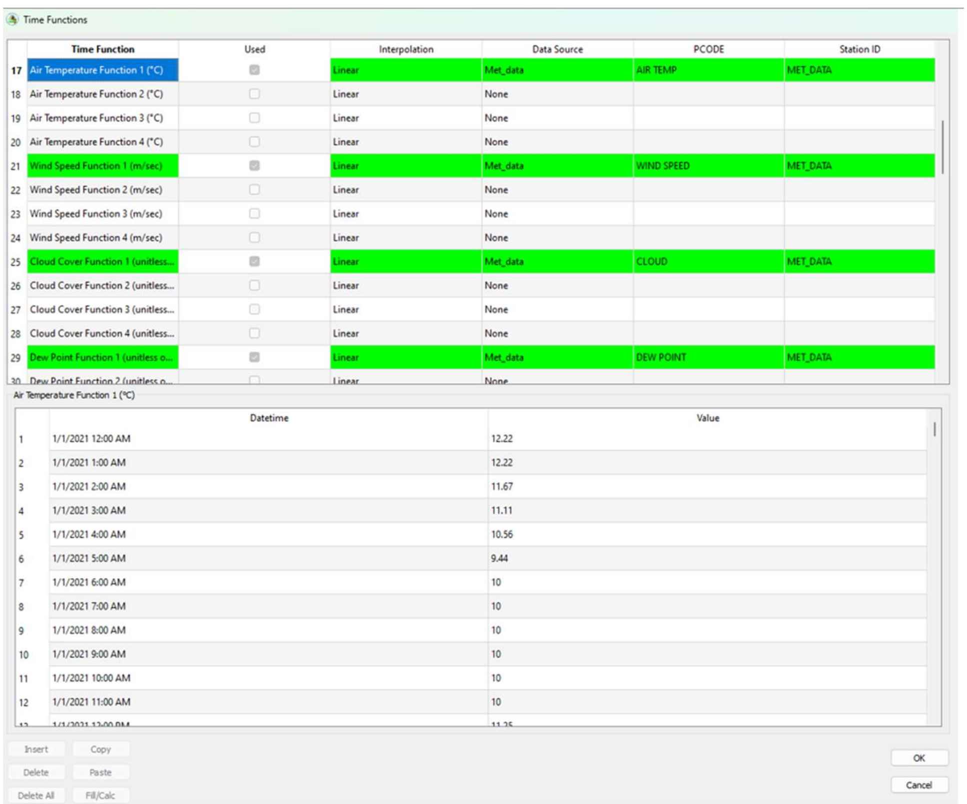


Figure 36 WASP Linking Time Functions to External Data Connections

- **Use**: Toggle to determine if the information will be used by the model at run time.
- **Interpolation**: Linear or step function for interpolation through time.
- **Data Source**: this is a drop-down selection of previously defined connections (see Figure 31)
- **PCode**: this is a drop-down selection of available parameter codes available from the Data Source.
- **Station ID:** this is a drop-down selection of available stations available from the Data Source.

External Linkage for Flow Time Series

Next step we will link inflow time series data from our external data connection (Bound_Data) to the WASP flow input screen (Figure 37). These external data connections work similarly wherever you see a column for data source. For flows we have 3 inflows (Mainstem, Tributary, WWTP) that need to be connected to the external data connection Bound_Data.

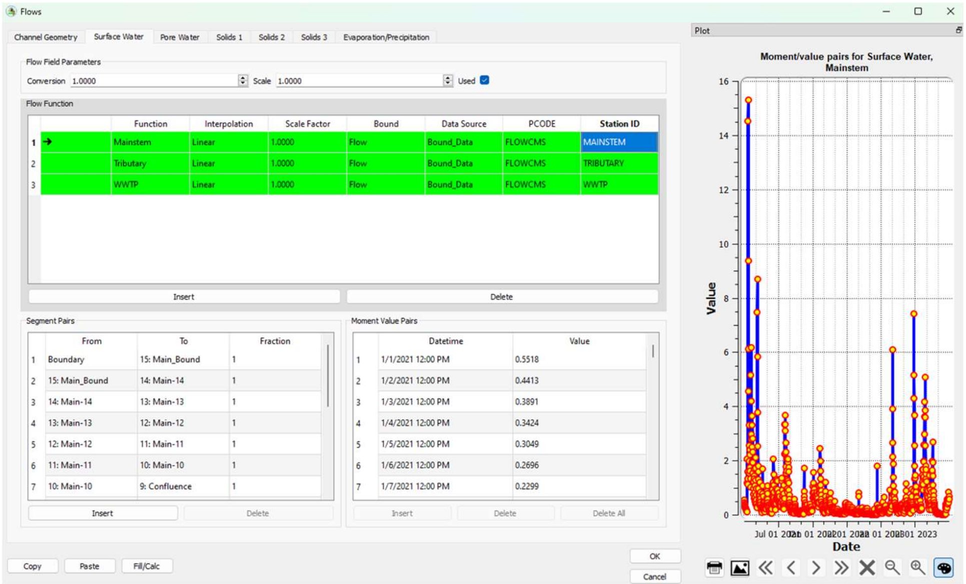


Figure 37 Linking Boundary Flow Time Series with External Data Connection

- **Data Source**: this is a drop-down selection of previously defined connections (see Figure 31)
- **PCode**: this is a drop-down selection of available parameter codes available from the Data Source.
- **Station ID:** this is a drop-down selection of available stations available from the Data Source.

External Linkage for Boundary Concentration Time Series

The external data connections for boundary concentration time series is fairly straightforward depending upon the mappings of database parameters to WASP state variables (Figure 33) and database stations to WASP segments (Figure 34).

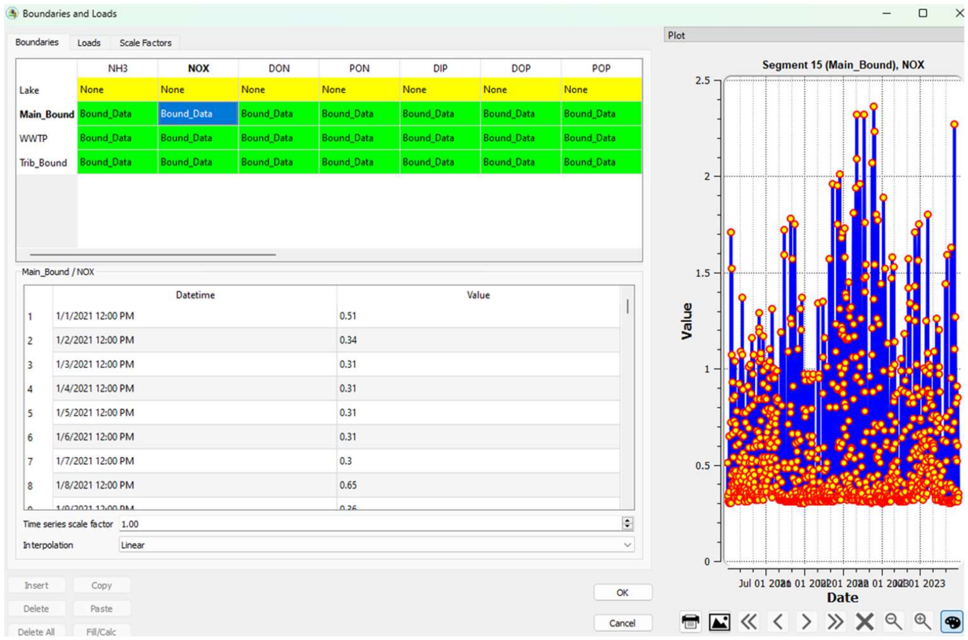


Figure 38 Linking Boundary Time Series Concentrations with Model State Variables

Light

This section defines the options and kinetic constants used to control how solar radiation is calculated or provided by the user. It also includes the option and constants for simulating light extinction in the waterbody. The user should refer to the Solar Radiation Processes PowerPoint for a detailed explanation.

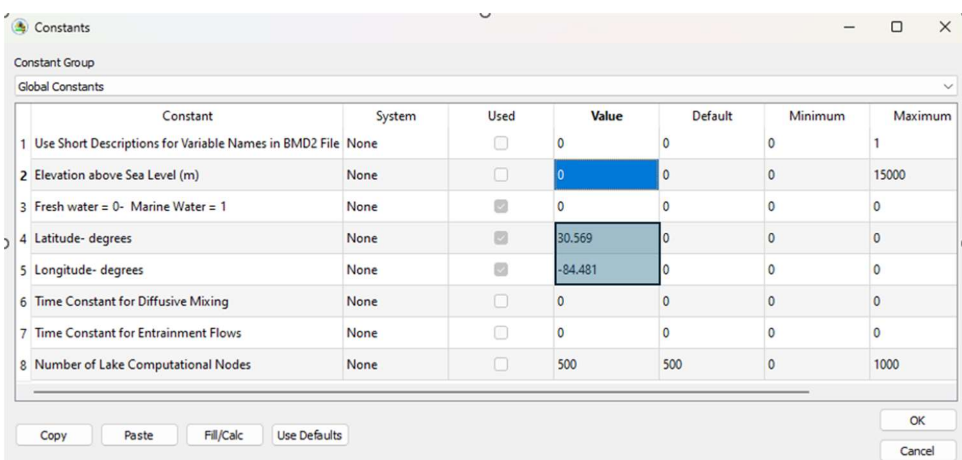
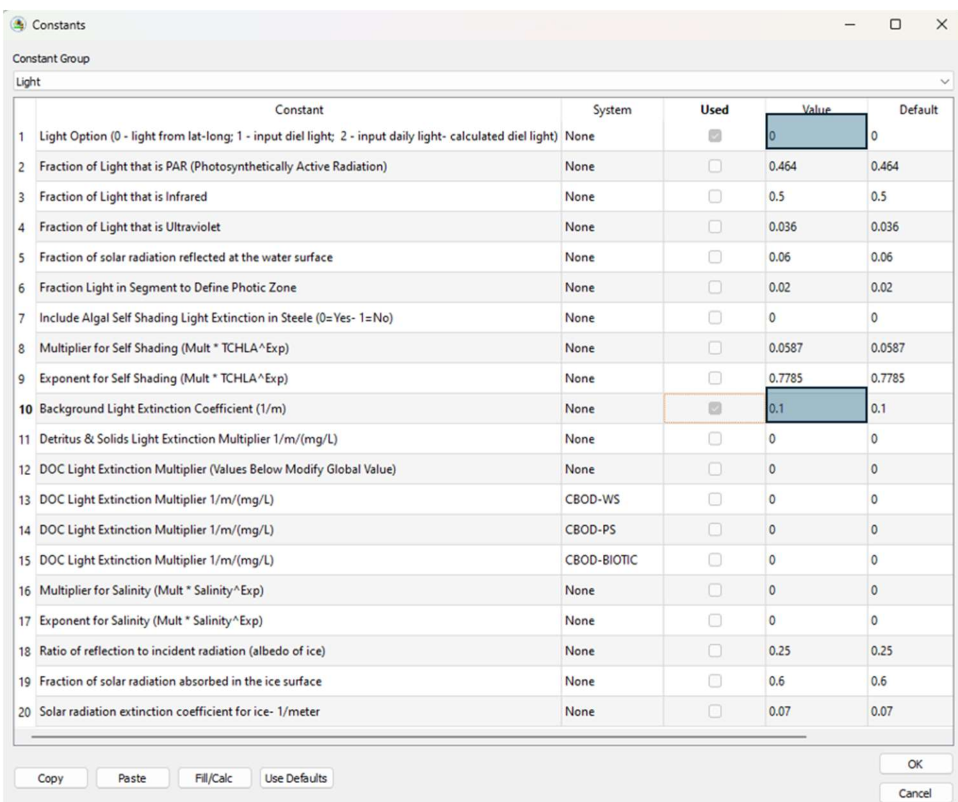


Figure 39 Global Constants Group

- **Elevation above Sea Level (m) –** specifies the elevation of the waterbody. This information is used in the dissolved saturation calculation.

- **Fresh water** = 0- Marine Water = 1 – switch to determine whether a fresh or salt water system is being modeled.
- **Latitude (degrees) –** Latitude of the location of the waterbody being simulated. Latitude and longitude are used to calculate clear sky solar radiation.
- **Longitude (degrees)** -- Longitude of the location of the waterbody being simulated. Latitude and longitude are used to calculate clear sky solar radiation.
- **CO2 Partial Pressure (atmospheres)** – CO2 partial pressure used in pH calculation.
- **Ks Option** – Option used in pH calculation, using CO2SYS marine calculation (see pH PowerPoint)
- **KSO4 Option (for pH in Seawater)** – options for pH calculation in seawater
- **pH Scale (1 to 4) for pH Output of Seawater** – output option for pH calculation.
- **Salinity Simulation Option (1 = Salinity- 2 = TDS)** – switch to calculate pH or Total Dissolved Solids/
- **Time Constant for Diffusive Mixing** – time constraint for diffusive mixing in 1-D lake transport.
- **Time Constant for Entrainment Flows** – time constraint for entrainment flows in the 1-D lake transport.
- **Number of Lake Computational Nodes** – sets the number of vertical computation nodes used in the 1-D lake transport model.
- **Use Short Descriptions for Variable Names in BMD2 File** – switch to have model use short names for output variable names



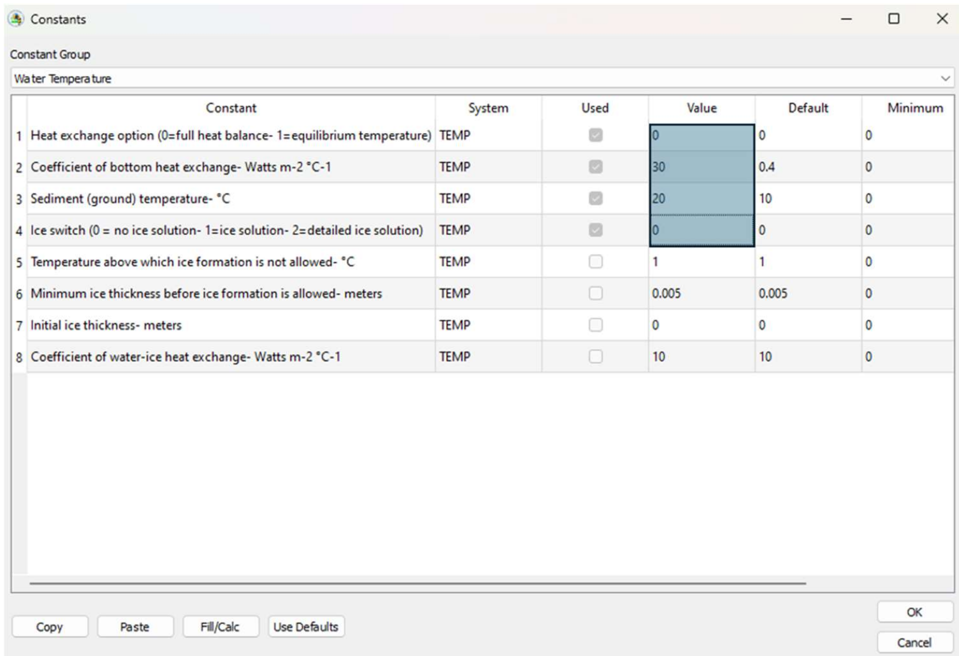
	Constant	System	Used	Value	Default
1	Light Option (0 - light from lat-long; 1 - input diel light; 2 - input daily light- calculated diel light)	None	☑	0	0
2	Fraction of Light that is PAR (Photosynthetically Active Radiation)	None	☐	0.464	0.464
3	Fraction of Light that is Infrared	None	☐	0.5	0.5
4	Fraction of Light that is Ultraviolet	None	☐	0.036	0.036
5	Fraction of solar radiation reflected at the water surface	None	☐	0.06	0.06
6	Fraction Light in Segment to Define Photic Zone	None	☐	0.02	0.02
7	Include Algal Self Shading Light Extinction in Steele (0=Yes- 1=No)	None	☐	0	0
8	Multiplier for Self Shading (Mult * TCHLA^Exp)	None	☐	0.0587	0.0587
9	Exponent for Self Shading (Mult * TCHLA^Exp)	None	☐	0.7785	0.7785
10	Background Light Extinction Coefficient (1/m)	None	☑	0.1	0.1
11	Detritus & Solids Light Extinction Multiplier 1/m/(mg/L)	None	☐	0	0
12	DOC Light Extinction Multiplier (Values Below Modify Global Value)	None	☐	0	0
13	DOC Light Extinction Multiplier 1/m/(mg/L)	CBOD-WS	☐	0	0
14	DOC Light Extinction Multiplier 1/m/(mg/L)	CBOD-PS	☐	0	0
15	DOC Light Extinction Multiplier 1/m/(mg/L)	CBOD-BIOTIC	☐	0	0
16	Multiplier for Salinity (Mult * Salinity^Exp)	None	☐	0	0
17	Exponent for Salinity (Mult * Salinity^Exp)	None	☐	0	0
18	Ratio of reflection to incident radiation (albedo of ice)	None	☐	0.25	0.25
19	Fraction of solar radiation absorbed in the ice surface	None	☐	0.6	0.6
20	Solar radiation extinction coefficient for ice- 1/meter	None	☐	0.07	0.07

Figure 40 Light Constants Group

- **Light Option** (0 - light from lat-long; 1 - input diel light; 2 - input daily light- calculated diel light) – WASP has 3 light options, the most preferable is solar radiation from latitude/longitude, this requires meteorological data. Input diel light as a time series in time functions, typically obtained from sensor data, input daily average light and the fraction of the day that is daylight.
- **Fraction of Light that is PAR** (Photosynthetically Active Radiation) – fraction of solar radiation is PAR, would need compelling reason to change from default.
- **Fraction of Light that is Infrared** -- fraction of solar radiation is infrared, would need compelling reason to change from default. Used in the organic chemical model.
- **Fraction of Light that is Ultraviolet** -- fraction of solar radiation is ultraviolet, would need compelling reason to change from default. Used in the organic chemical model.
- **Fraction of solar radiation reflected at the water surface** – fraction of incoming solar radiation that is reflected to the atmosphere.
- **Fraction Light in Segment to Define Photic Zone –** minimum fraction of light within a segment that defines the photic zone.
- **Include Algal Self Shading Light Extinction in Steele** (0=Yes- 1=No) – switch to whether include algal shading in light extinction calculations.
- **Multiplier for Self Shading** (Mult * TCHLA^Exp) – options to change default multiplier in the algal self-shading calculation.
- **Exponent for Self Shading** (Mult * TCHLA^Exp) -- options to change default exponent in the algal self-shading calculation.
- **Background Light Extinction Coefficient** (1/m) – background light extinction coefficient representing water color.
- **Detritus & Solids Light Extinction Multiplier** 1/m/(mg/L) – light extinction multiplier for the impact of detritus (POM) and inorganic solids.
- **DOC Light Extinction Multiplier** (Values Below Modify Global Value) -- light extinction multiplier for the impact of dissolved organic carbon.
- **DOC Light Extinction Multiplier** 1/m/(mg/L) – specific light extinction multiplier for sources of dissolved organic carbon (CBOD state variables)
- **Multiplier for Salinity** (Mult * Salinity^Exp) – CDOM light extinction multiplier based upon salinity regression.
- **Exponent for Salinity** (Mult * Salinity^Exp) -- CDOM light extinction exponent based upon salinity regression.
- **Ratio of reflection to incident radiation** (albedo of ice) – ratio of solar reflection when ice is present.
- **Fraction of solar radiation absorbed in the ice surface –** amount of solar radiation absorbed through the ice.
- **Solar radiation extinction coefficient for ice** (1/meter) – light extinction coefficient for solar radiation through ice.

Water Temperature

This section defines the options and kinetic constants used for the calculation of water temperature. To calculate water temperature will need to parameterize solar radiation, light extinction and provide meteorological time functions (air temperature, dew point, wind speed and cloud cover). Because temperature is a conservative substance it can aid in the calibration of the flow and dispersive exchanges. The user should refer to the Heat Module PowerPoint for a detailed explanation.



Constants

Constant Group

Water Temperature

	Constant	System	Used	Value	Default	Minimum
1	Heat exchange option (0=full heat balance- 1=equilibrium temperature)	TEMP	☑	0	0	0
2	Coefficient of bottom heat exchange- Watts m-2 °C-1	TEMP	☑	30	0.4	0
3	Sediment (ground) temperature- °C	TEMP	☑	20	10	0
4	Ice switch (0 = no ice solution- 1=ice solution- 2=detailed ice solution)	TEMP	☑	0	0	0
5	Temperature above which ice formation is not allowed- °C	TEMP	☐	1	1	0
6	Minimum ice thickness before ice formation is allowed- meters	TEMP	☐	0.005	0.005	0
7	Initial ice thickness- meters	TEMP	☐	0	0	0
8	Coefficient of water-ice heat exchange- Watts m-2 °C-1	TEMP	☐	10	10	0

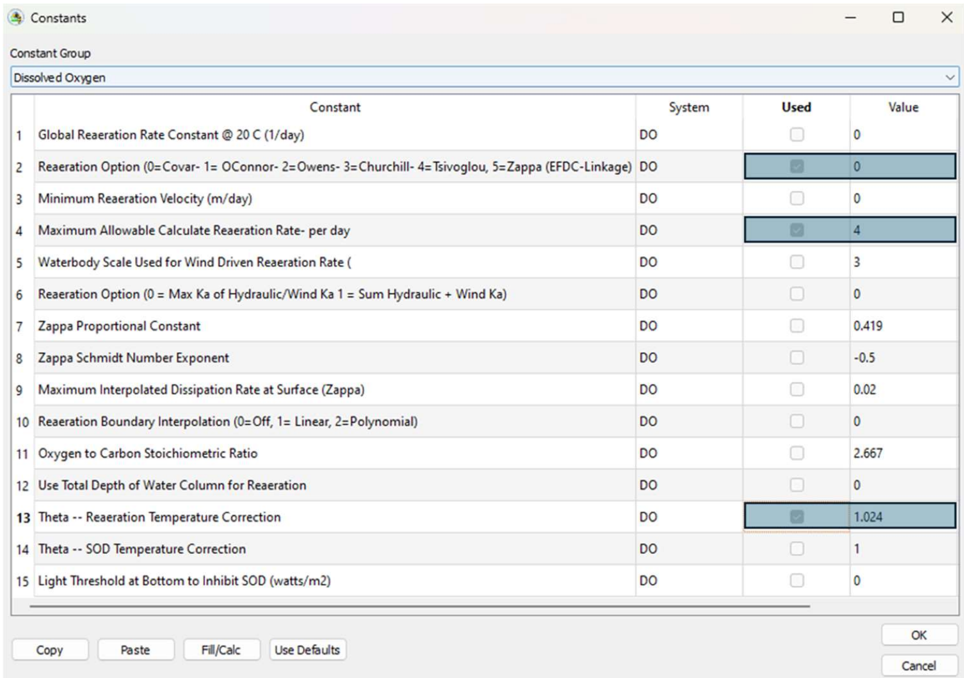
Copy Paste Fill/Calc Use Defaults OK Cancel

Figure 41 Water Temperature Constants Group

- **Heat Exchange Option** – WASP has 2 options for calculating water temperature: Full Heat Balance and Equilibrium Heat Balance. It is suggested you always use the full heat balance option.
- **Coefficient of Bottom Heat Exchange** – coefficient for heat exchange between the overlaying water column and sediments.
- **Sediment (ground) Temperature** – average sediment ground temperature
- **Ice Switch** – on/off switch for a allowing the simulation of ice formation/
- **Temperature above which Ice Formation is Not Allowed** – temperature threshold where ice would never form.
- **Minimum Uce Thickness before Ice Formation** -- threshold of simulated ice thickness, before the model will allow ice formation.
- **Initial Ice Thickness** – if simulation is start at time where there is already ice, this would be the initial condition for ice.

Dissolved Oxygen & Biochemical Oxygen Demand

This section defines the options and kinetic constants used to control dissolved oxygen and carbonaceous biochemical oxygen demand. The user should refer to the Dissolved Oxygen PowerPoints for detailed explanation.

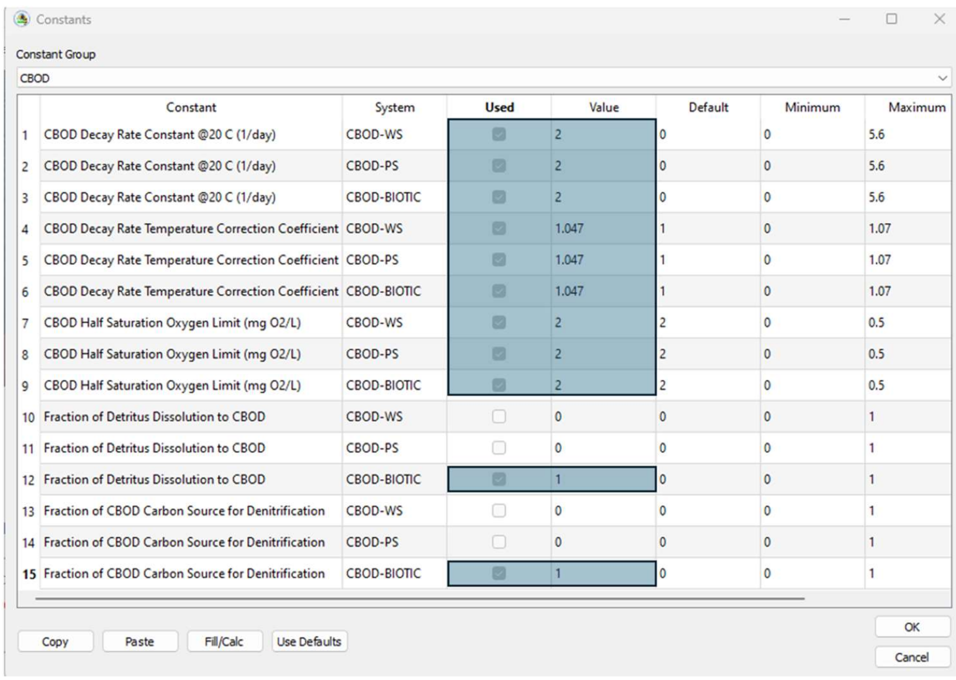


	Constant	System	Used	Value
1	Global Reaeration Rate Constant @ 20 C (1/day)	DO	☐	0
2	Reaeration Option (0=Covar- 1= OConnor- 2=Owens- 3=Churchill- 4=Tsivoglou, 5=Zappa (EFDC-Linkage)	DO	☑	0
3	Minimum Reaeration Velocity (m/day)	DO	☐	0
4	Maximum Allowable Calculate Reaeration Rate- per day	DO	☑	4
5	Waterbody Scale Used for Wind Driven Reaeration Rate (	DO	☐	3
6	Reaeration Option (0 = Max Ka of Hydraulic/Wind Ka 1 = Sum Hydraulic + Wind Ka)	DO	☐	0
7	Zappa Proportional Constant	DO	☐	0.419
8	Zappa Schmidt Number Exponent	DO	☐	-0.5
9	Maximum Interpolated Dissipation Rate at Surface (Zappa)	DO	☐	0.02
10	Reaeration Boundary Interpolation (0=Off, 1= Linear, 2=Polynomial)	DO	☐	0
11	Oxygen to Carbon Stoichiometric Ratio	DO	☐	2.667
12	Use Total Depth of Water Column for Reaeration	DO	☐	0
13	Theta -- Reaeration Temperature Correction	DO	☑	1.024
14	Theta -- SOD Temperature Correction	DO	☐	1
15	Light Threshold at Bottom to Inhibit SOD (watts/m2)	DO	☐	0

Figure 42 Dissolved Oxygen Constants Group

- **Global Reaeration Rate Constant @ 20 C** (1/day) – sets a constant reaeration rate for the model network, most suitable for a steady state condition.
- **Reaeration Option** (0=Covar- 1= OConnor- 2=Owens- 3=Churchill- 4=Tsivoglou, 5=Zappa (EFDC-Linkage) – Options for calculating reaeration (see Dissolved Oxygen PowerPoint)
- **Minimum Reaeration Velocity** (m/day) – set a minimum reaeration rate, no matter the calculated rate it will not be set lower than this value.
- **Maximum Allowable Calculate Reaeration Rate** (per day) – set a maximum reaeration rate, no matter the calculated rate it will not be set higher than this value.
- **Waterbody Scale Used for Wind Driven Reaeration Rate** – typically this should be set to 3 for large surface bodies, used in the mechanistic calculation of wind drive reaeration rate.
- **Reaeration Option** (0 = Max Ka of Hydraulic/Wind Ka 1 = Sum Hydraulic + Wind Ka) – default is WASP calculates the hydraulic reaeration rate and then the wind driven reaeration rate and uses the larger value as the effective rate. User could elect to add the rates together for the effective rate.
- **Zappa Proportional Constant –** only available when linked to EFDC
- **Zappa Schmidt Number Exponent –** only available when linked to EFDC
- **Maximum Interpolated Dissipation Rate at Surface** (Zappa) **–** only available when linked to EFDC

- **Reaeration Boundary Interpolation** (0=Off, 1= Linear, 2=Polynomial) **–** only available when linked to EFDC
- **Oxygen to Carbon Stoichiometric Ratio –** oxygen to carbon stoichiometric ratio, should use the default unless you have site specific information.
- **Use Total Depth of Water Column for Reaeration** – use total water column depth (2-D vertical) for calculating a reaeration rate.
- **Theta -- Reaeration Temperature Correction** – theta temperature correction for the calculated reaeration rate.
- **Theta -- SOD Temperature Correction** – theta temperature correction for the described sediment oxygen demand flux.
- **Light Threshold at Bottom to Inhibit SOD** (watts/m2) – specified light threshold at the sediment water interface to reduce sediment oxygen demand, promoting productivity.



	Constant	System	Used	Value	Default	Minimum	Maximum
1	CBOD Decay Rate Constant @20 C (1/day)	CBOD-WS	☑	2	0	0	5.6
2	CBOD Decay Rate Constant @20 C (1/day)	CBOD-PS	☑	2	0	0	5.6
3	CBOD Decay Rate Constant @20 C (1/day)	CBOD-BIOTIC	☑	2	0	0	5.6
4	CBOD Decay Rate Temperature Correction Coefficient	CBOD-WS	☑	1.047	1	0	1.07
5	CBOD Decay Rate Temperature Correction Coefficient	CBOD-PS	☑	1.047	1	0	1.07
6	CBOD Decay Rate Temperature Correction Coefficient	CBOD-BIOTIC	☑	1.047	1	0	1.07
7	CBOD Half Saturation Oxygen Limit (mg O2/L)	CBOD-WS	☑	2	2	0	0.5
8	CBOD Half Saturation Oxygen Limit (mg O2/L)	CBOD-PS	☑	2	2	0	0.5
9	CBOD Half Saturation Oxygen Limit (mg O2/L)	CBOD-BIOTIC	☑	2	2	0	0.5
10	Fraction of Detritus Dissolution to CBOD	CBOD-WS	☐	0	0	0	1
11	Fraction of Detritus Dissolution to CBOD	CBOD-PS	☐	0	0	0	1
12	Fraction of Detritus Dissolution to CBOD	CBOD-BIOTIC	☑	1	0	0	1
13	Fraction of CBOD Carbon Source for Denitrification	CBOD-WS	☐	0	0	0	1
14	Fraction of CBOD Carbon Source for Denitrification	CBOD-PS	☐	0	0	0	1
15	Fraction of CBOD Carbon Source for Denitrification	CBOD-BIOTIC	☑	1	0	0	1

Figure 43 CBOD Constants Group

- **CBOD Decay Rate Constant** @20 C (1/day) – CBOD decay rate, the oxidation of carbonaceous. If simulating more than 1 CBOD state variable you will have to provide a rate for each CBOD group.
- **CBOD Decay Rate Temperature Correction Coefficient --** theta temperature correction for the CBOD decay rate. If simulating more than 1 CBOD state variable you will have to provide a rate for CBOD group.
- **CBOD Half Saturation Oxygen Limit** (mg O_2/L) – dissolved oxygen concentration in which the CBOD decay is halved.
- **Fraction of Detritus Dissolution to CBOD –** fraction of POC from detrital dissolution that will be converted to CBOD. If simulating more than 1 CBOD state variable you will have to provide a rate for CBOD group.

- **Fraction of CBOD Carbon Source for Denitrification –** for denitrification to occur requires a carbon source, this specifies the fraction for the source carbon among the CBOD groups.

Nutrient Cycle

Inorganic Nutrients

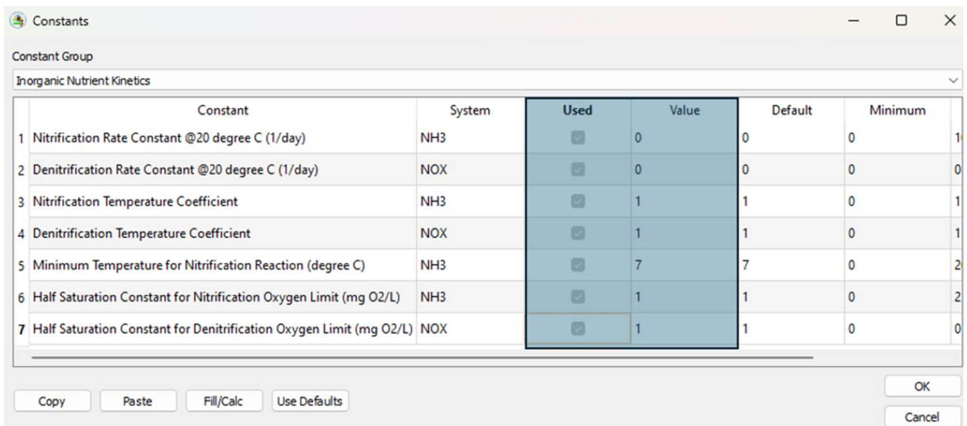
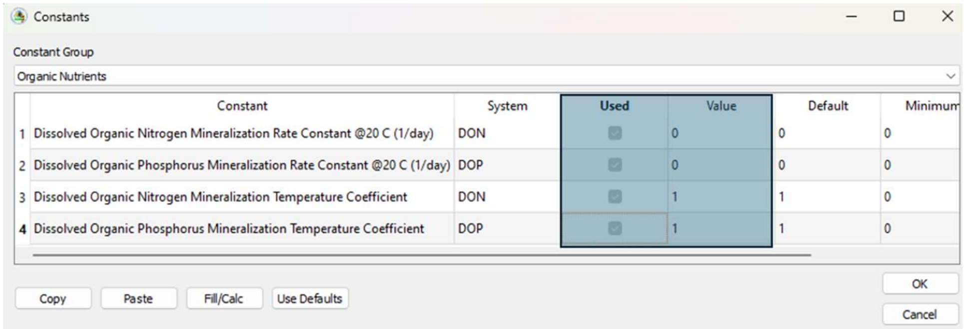


Figure 44 Inorganic Nutrient Constants Group

- **Nitrification Rate Constant @20 degree C** (1/day) – rate at which ammonia is converted to nitrate
- **Denitrification Rate Constant @20 degree C (**1/day) – rate at which nitrate is reduced to N2 gas.
- **Nitrification Temperature Coefficient --** theta temperature correction for nitrification process
- **Denitrification Temperature Coefficient --** theta temperature correction for denitrification process
- **Minimum Temperature for Nitrification Reaction** (degree C)
- **Half Saturation Constant for Nitrification Oxygen Limit** (mg O2/L) – represents the oxygen concentration where the nitrification rate is reduced by half.
- **Half Saturation Constant for Denitrification Oxygen Limit** (mg O2/L) – represents the oxygen concentration where the denitrification rate is reduced by half.

Organic Nutrients

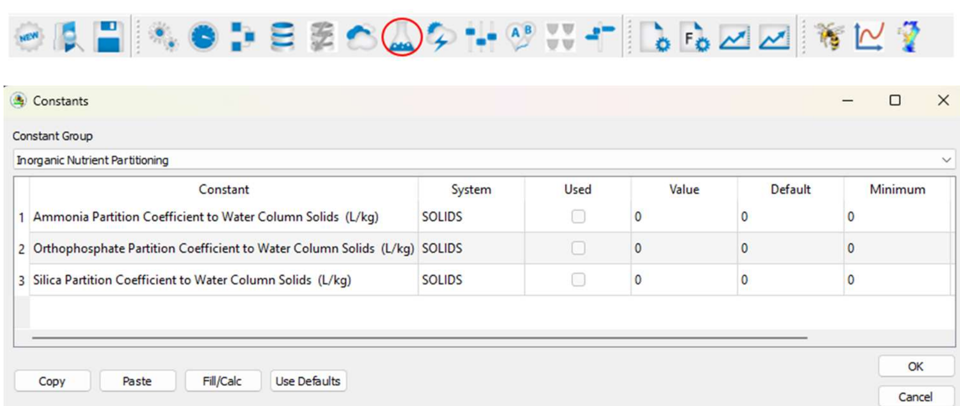


	Constant	System	Used	Value	Default	Minimum
1	Dissolved Organic Nitrogen Mineralization Rate Constant @20 C (1/day)	DON	☑	0	0	0
2	Dissolved Organic Phosphorus Mineralization Rate Constant @20 C (1/day)	DOP	☑	0	0	0
3	Dissolved Organic Nitrogen Mineralization Temperature Coefficient	DON	☑	1	1	0
4	Dissolved Organic Phosphorus Mineralization Temperature Coefficient	DOP	☑	1	1	0

Figure 45 Organic Nutrient Constants Group

- **Detritus Dissolution Rate** (1/day) – rate at which detrital material dissolves to organic nitrogen, phosphorus, silica
- **Dissolved Organic Nitrogen Mineralization Rate Constant @20 C** (1/day) – mineralization rate for the conversion of dissolved organic nitrogen to ammonia.
- **Dissolved Organic Phosphorus Mineralization Rate Constant @20 C** (1/day) – mineralization rate for the conversion of dissolved organic phosphorus to DIP.
- **Dissolved Organic Silica Mineralization Rate Constant @20 C (**1/day) – mineralization rate for the conversion of dissolved organic silica to inorganic silica.
- **Temperature Correction for detritus dissolution –** theta temperature correction for dissolution reaction
- **Dissolved Organic Nitrogen Mineralization Temperature Coefficient –** theta temperature correction for mineralization of organic nitrogen.
- **Dissolved Organic Phosphorus Mineralization Temperature Coefficient–** theta temperature correction for mineralization of organic phosphorus/.
- **Dissolved Organic Silica Mineralization Temperature Coefficient–** theta temperature correction for mineralization of organic silica

Inorganic Nutrient Partitioning



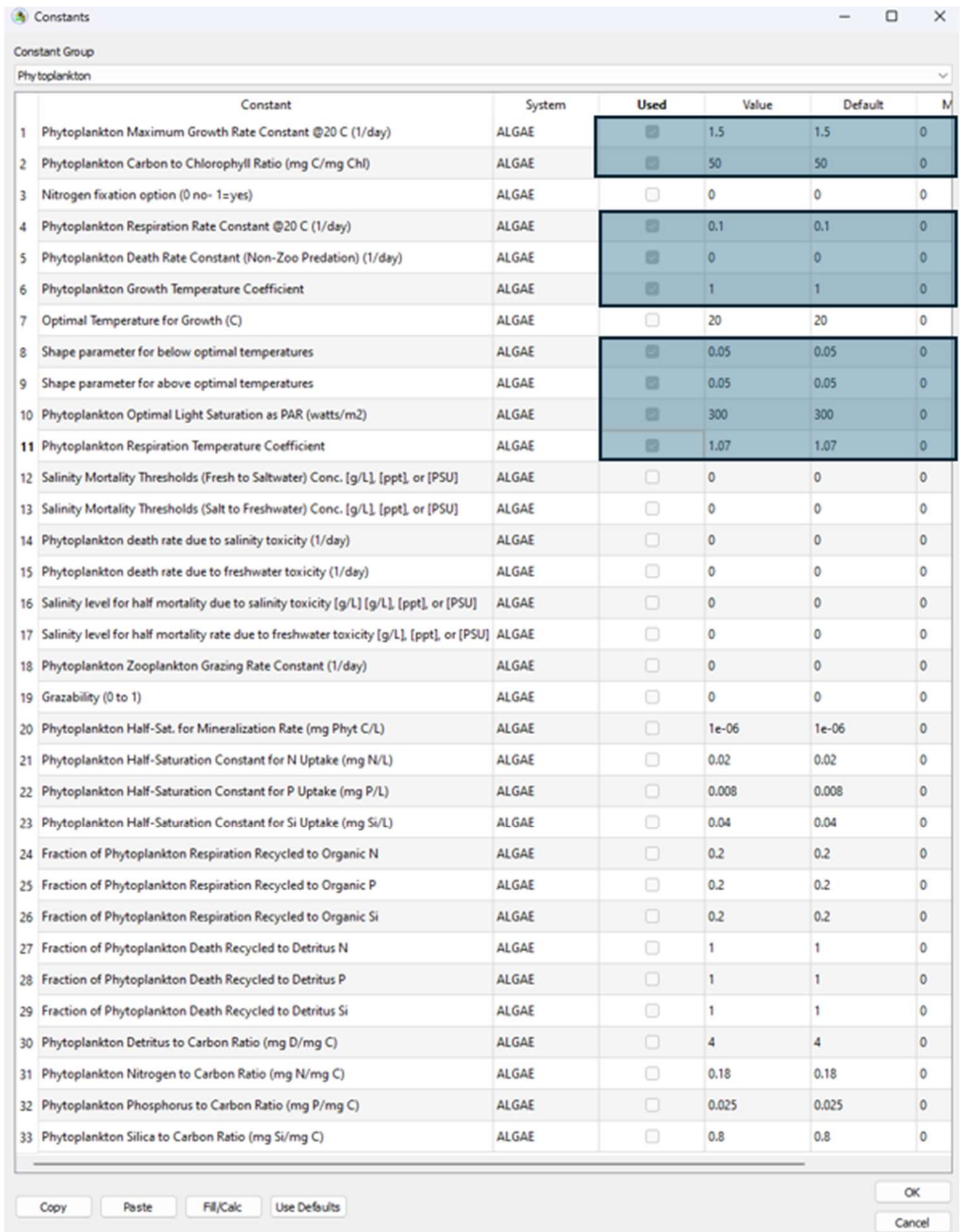
	Constant	System	Used	Value	Default	Minimum
1	Ammonia Partition Coefficient to Water Column Solids (L/kg)	SOLIDS	☐	0	0	0
2	Orthophosphate Partition Coefficient to Water Column Solids (L/kg)	SOLIDS	☐	0	0	0
3	Silica Partition Coefficient to Water Column Solids (L/kg)	SOLIDS	☐	0	0	0

Figure 46 Inorganic Nutrient Partitioning Constants Group

- **Ammonia Partition Coefficient** to **Water Column Solids** (L/kg) – equilibrium partition coefficient for sorption of ammonia to inorganic solids.

- **Dissolved Inorganic Phosphorus Partition Coefficient to Water Column Solids** (L/kg) – equilibrium partition coefficient for sorption of DIP to inorganic solids.
- S**ilica Partition Coefficient to Water Column Solids (**L/kg) – equilibrium partition coefficient for sorption of silica to inorganic solids.

Phytoplankton



Constants

Constant Group

Phytoplankton

	Constant	System	Used	Value	Default	M
1	Phytoplankton Maximum Growth Rate Constant @20 C (1/day)	ALGAE		1.5	1.5	0
2	Phytoplankton Carbon to Chlorophyll Ratio (mg C/mg Chl)	ALGAE		50	50	0
3	Nitrogen fixation option (0 no- 1=yes)	ALGAE		0	0	0
4	Phytoplankton Respiration Rate Constant @20 C (1/day)	ALGAE		0.1	0.1	0
5	Phytoplankton Death Rate Constant (Non-Zoo Predation) (1/day)	ALGAE		0	0	0
6	Phytoplankton Growth Temperature Coefficient	ALGAE		1	1	0
7	Optimal Temperature for Growth (C)	ALGAE		20	20	0
8	Shape parameter for below optimal temperatures	ALGAE		0.05	0.05	0
9	Shape parameter for above optimal temperatures	ALGAE		0.05	0.05	0
10	Phytoplankton Optimal Light Saturation as PAR (watts/m2)	ALGAE		300	300	0
11	Phytoplankton Respiration Temperature Coefficient	ALGAE		1.07	1.07	0
12	Salinity Mortality Thresholds (Fresh to Saltwater) Conc. [g/L], [ppt], or [PSU]	ALGAE		0	0	0
13	Salinity Mortality Thresholds (Salt to Freshwater) Conc. [g/L], [ppt], or [PSU]	ALGAE		0	0	0
14	Phytoplankton death rate due to salinity toxicity (1/day)	ALGAE		0	0	0
15	Phytoplankton death rate due to freshwater toxicity (1/day)	ALGAE		0	0	0
16	Salinity level for half mortality due to salinity toxicity [g/L] [g/L], [ppt], or [PSU]	ALGAE		0	0	0
17	Salinity level for half mortality rate due to freshwater toxicity [g/L], [ppt], or [PSU]	ALGAE		0	0	0
18	Phytoplankton Zooplankton Grazing Rate Constant (1/day)	ALGAE		0	0	0
19	Grazability (0 to 1)	ALGAE		0	0	0
20	Phytoplankton Half-Sat. for Mineralization Rate (mg Phyt C/L)	ALGAE		1e-06	1e-06	0
21	Phytoplankton Half-Saturation Constant for N Uptake (mg N/L)	ALGAE		0.02	0.02	0
22	Phytoplankton Half-Saturation Constant for P Uptake (mg P/L)	ALGAE		0.008	0.008	0
23	Phytoplankton Half-Saturation Constant for Si Uptake (mg Si/L)	ALGAE		0.04	0.04	0
24	Fraction of Phytoplankton Respiration Recycled to Organic N	ALGAE		0.2	0.2	0
25	Fraction of Phytoplankton Respiration Recycled to Organic P	ALGAE		0.2	0.2	0
26	Fraction of Phytoplankton Respiration Recycled to Organic Si	ALGAE		0.2	0.2	0
27	Fraction of Phytoplankton Death Recycled to Detritus N	ALGAE		1	1	0
28	Fraction of Phytoplankton Death Recycled to Detritus P	ALGAE		1	1	0
29	Fraction of Phytoplankton Death Recycled to Detritus Si	ALGAE		1	1	0
30	Phytoplankton Detritus to Carbon Ratio (mg D/mg C)	ALGAE		4	4	0
31	Phytoplankton Nitrogen to Carbon Ratio (mg N/mg C)	ALGAE		0.18	0.18	0
32	Phytoplankton Phosphorus to Carbon Ratio (mg P/mg C)	ALGAE		0.025	0.025	0
33	Phytoplankton Silica to Carbon Ratio (mg Si/mg C)	ALGAE		0.8	0.8	0

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Figure 47 Phytoplankton Constants Group

- **Phytoplankton Maximum Growth Rate Constant @20 C** (1/day) --
- **Phytoplankton Carbon to Chlorophyll Ratio** (mg C/mg Chl) --
- **Nitrogen fixation option** (0 no- 1=yes) --
- **Phytoplankton Respiration Rate Constant @20 C** (1/day) --
- **Phytoplankton Death Rate Constant (Non-Zoo Predation)** (1/day) --
- **Phytoplankton Growth Temperature Coefficient --**
- **Optimal Temperature for Growth (C) --**
- **Shape parameter for below optimal temperatures --**
- **Shape parameter for above optimal temperatures --**
- **Phytoplankton Optimal Light Saturation as PAR (watts/m2) --**
- **Phytoplankton Respiration Temperature Coefficient --**
- **Salinity Mortality Thresholds (Fresh to Saltwater) Conc. [g/L], [ppt], or [PSU] --**
- **Salinity Mortality Thresholds (Salt to Freshwater) Conc. [g/L], [ppt], or [PSU] --**
- **Phytoplankton death rate due to salinity toxicity (1/day) --**
- **Phytoplankton death rate due to freshwater toxicity (1/day) --**
- **Salinity level for half mortality due to salinity toxicity [g/L] [g/L], [ppt], or [PSU] --**
- **Salinity level for half mortality rate due to freshwater toxicity [g/L], [ppt], or [PSU] --**
- **Phytoplankton Zooplankton Grazing Rate Constant (1/day) --**
- **Grazability (0 to 1) --**
- **Phytoplankton Half-Sat. for Mineralization Rate (mg Phyt C/L) --**
- **Phytoplankton Half-Saturation Constant for N Uptake (mg N/L) --**
- **Phytoplankton Half-Saturation Constant for P Uptake (mg P/L) --**
- **Phytoplankton Half-Saturation Constant for Si Uptake (mg Si/L) --**
- **Fraction of Phytoplankton Respiration Recycled to Organic N --**
- **Fraction of Phytoplankton Respiration Recycled to Organic P --**
- **Fraction of Phytoplankton Respiration Recycled to Organic Si --**
- **Fraction of Phytoplankton Death Recycled to Detritus N --**
- **Fraction of Phytoplankton Death Recycled to Detritus P --**
- **Fraction of Phytoplankton Death Recycled to Detritus Si --**
- **Phytoplankton Detritus to Carbon Ratio (mg D/mg C) --**
- **Phytoplankton Nitrogen to Carbon Ratio (mg N/mg C) --**
- **Phytoplankton Phosphorus to Carbon Ratio (mg P/mg C) --**
- **Phytoplankton Silica to Carbon Ratio (mg Si/mg C) --**