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Agency

Better Assessment Science Integrating point and Nonpoint Sources

BASINS

Version 4.5

User's Manual

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Disclaimer

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Contents

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Version 4.5 Core of the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) system is a maintenance release that builds on Version 4.1 and earlier versions of the system. See the User's Manuals for the earlier versions for the team involved in the production of those versions of the system.

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The BASINS 3.1 system, upon which version 4.0 is based, was developed for EPA by AQUA TERRA Consultants under EPA contract number 68-C-01-037. USDA-ARS Southwest Watershed Research Center and the US-EPA National Research Exposure Lab in Las Vegas, NV are acknowledged for their contribution of the Automated Geospatial Watershed Assessment (AGWA) tool as an extension for BASINS 3.1.

The BASINS 3.0 system, upon which version 3.1 is based, was developed for EPA by AQUA TERRA Consultants under EPA contract number 68-C-98-010. This system was developed by AQUA TERRA in cooperation with the following three groups outside of EPA:

Tetra Tech, Inc., Fairfax, Virginia, provided conceptual design, core system implementation, extension implementation, database update, documentation, testing, and production services as a subcontractor under EPA contract number 68-C-98-010. Henry Manguerra, Dan Sandhaus, Matt Meyers, Haihong Yang, Qin Li, Ansu John, Jian Ouyang, Mustafa Faizullabhoy, Jim Callahan and Alex Trounov made up the Tetra Tech team.

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CH2M HILL, Herndon, Virginia provided the *PLOAD* extension to BASINS 3.0 under EPA contract number OW1435NTLX. Sayedul Choudhury, John Tully and Tim Hare made up the CH2M HILL team which made the enhancements which integrated *PLOAD* into BASINS 3.0. CH2M HILL also supported the development of the BMP and REPORT modules in the *HSPF* model. Avinash Patwardhan is recognized for his efforts on that effort.

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The development of the HSPFParm database was made possible by the support of a number of individuals and organizations. At EPA's Office of Science and Technology Russell Kinerson was the Work

Assignment Manager for the original development effort. In this capacity he provided focus and guidance that assured a successful product.

Equally important to the successful development of the HSPFParm database were the contributions of parameter data sets by modelers across the nation. Contributors to this first version of the database included David Chen (Chinese University of Hong Kong), James Sams (USGS, Pittsburgh), Larry Moore (University of Memphis), Thomas Fontaine (South Dakota School of Mines & Technology) and Scott Wells (Portland State University).

For the original HSPFParm development effort, AQUA TERRA Consultants was responsible for the collection of parameter values for HSPF applications, assimilation of the data into a unified database, and development of a user interface. For AQUA TERRA, Tony Donigian, Jr. was the Project Manager. In addition he developed the coarse characterization data for many of AQUA TERRA's HSPF applications that were included in the database. He provided guidance throughout the planning and development of the database and the database interface. John Imhoff was the Project Engineer and was responsible for establishing database and interface requirements, acquiring data from modelers, and coordinating documentation of the final product. John Kittle, Jr. was responsible for designing the data model for the parameter database, designing the user interface, and automating the extraction of parameter values from HSPF User Control Input files. Thomas Jobes and Paul Duda provided assistance in assembling the database; in addition Paul Duda prepared the documentation related to the data model and operational aspects of the database interface. Paul Hummel assisted in developing the initial list of requirements for the user interface, and Mark Gray provided assistance in implementing the interface.

The Minnesota Pollution Control Agency (MPCA) funded an update to HSPFParm in 2012. Under contract to the MPCA, AQUA TERRA Consultants ported the original stand-alone HSPFParm software to this BASINS plug-in. As part of that project, many recent Minnesota HSPF applications were added to the HSPFParm database. For AQUA TERRA, Paul Duda was the Project Manager. Tong Zhai of AQUA TERRA revised the documentation following the HSPFParm software's inclusion as a BASINS Plug-in. Timothy Larson and Charles Regan of MPCA are particularly acknowledged for their support.

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User Assistance and Technical Support

BASINS was developed to promote better assessment and integration of point and nonpoint sources in watershed and water quality management. It integrates several key environmental data sets with improved analysis techniques. Several types of environmental programs can benefit from the use and application of such an integrated system in various stages of environmental management planning and decision making.

EPA's Center for Exposure Assessment Modeling (CEAM) provides assistance and technical support to users of the BASINS system to facilitate its effective application. Technical support can be obtained at the BASINS Home Page: http://www2.epa.gov/exposure-assessment-models/basins-user-information-and-guidance

Introduction

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) is a multipurpose environmental analysis system for use by regional, state, and local agencies in performing watershed- and water-quality-based studies. It was developed by the U.S. Environmental Protection Agency's (EPA's) Office of Water to address three objectives:

- To facilitate examination of environmental information
- To support analysis of environmental systems
- To provide a framework for examining management alternatives

Because many states and local agencies are moving toward a watershed-based approach, the BASINS system is configured to support environmental and ecological studies in a watershed context. The system is designed to be flexible. It can support analysis at a variety of scales using tools that range from simple to sophisticated.

BASINS was also conceived as a system for supporting the development of **Total Maximum Daily Loads (TMDLs)**. Section 303(d) of the Clean Water Act requires states to develop TMDLs for water bodies that are not meeting applicable water quality standards by using technology-based controls. Developing TMDLs requires a watershed-based approach that integrates both point and nonpoint sources. BASINS can support this type of watershed-based point and nonpoint source analysis for a variety of pollutants. It also lets the user test different management options.

Traditional approaches to watershed-based assessments typically involve many separate steps preparing data, summarizing information, developing maps and tables, and applying and interpreting models. Each individual step is performed using a variety of tools and computer systems. The isolated implementation of steps can result in a lack of integration, limited coordination, and time-intensive execution. BASINS makes watershed and water quality studies easier by bringing key data and analytical components "under one roof". Using the familiar Windows environment, analysts can efficiently access national environmental information, apply assessment and planning tools, and run a variety of proven, robust nonpoint loading and water quality models. With many of the necessary components together in one system, the analysis time is significantly reduced, a greater variety of questions can be answered, and data and management needs can be more efficiently identified. BASINS takes advantage of recent developments in software, data management technologies, and computer capabilities to provide the user with a fully comprehensive watershed management tool.

A geographic information system (GIS) provides the integrating framework for BASINS. GIS organizes spatial information so it can be displayed as maps, tables, or graphics. GIS provides techniques for analyzing landscape information and displaying relationships. Through the use of GIS, BASINS has the flexibility to display and integrate a wide range of information (e.g., land use, point source discharges, water supply withdrawals) at a scale chosen by the user. For example, some users will need to examine data at a multistate scale to determine problem areas, compare watersheds, or investigate gaps in data. Others will want to work at a much smaller scale, perhaps investigating a particular river segment impaired by multiple point source discharges. This “zooming” capability of BASINS makes it a unique and powerful environmental analysis tool.

Some agencies might wish to perform analyses at a variety of scales, in a nested fashion, to meet several objectives at once. BASINS is designed to facilitate all of these scenarios because it incorporates tools that operate on both large and small watersheds. Adding locally developed, high-resolution data sources to existing data layers is an additional option that expands the local-scale evaluation capabilities.

BASINS comprises a suite of interrelated components for performing the various aspects of environmental analysis. The components include (1) nationally derived databases with tools to Build New Projects; (2) Watershed Characterization Reports that address large- and small-scale characterization needs; (3) utilities to facilitate organizing and evaluating data; (4) tools for Watershed Delineation; (5) infrastructure to include watershed loading and transport models such as Hydrological Simulation Program - Fortran (HSPF) and Soil and Water Assessment Tool (SWAT).

The watershed characterization component, working under the GIS umbrella, allows users to quickly evaluate selected areas, organize information, and display results. The model inclusion capability allows users to examine the impacts of pollutant loadings from point and nonpoint sources. Working together, these modules support several specific aspects of watershed-based analysis by

- Identifying and prioritizing water-quality-limited waters.
- Supplying data characterizing point and nonpoint sources and evaluating their magnitudes and potential significance.
- Integrating point source and nonpoint source loadings and fate and transport processes.
- Evaluating and comparing the relative value of potential control strategies.
- Visualizing and communicating environmental conditions to the public through tables, graphs, and maps.

This user’s guide provides information on the systems and procedures in BASINS Version 4.5 Core. This version provides some significant enhancements and functions beyond those provided by the earlier releases of BASINS, Versions 1.0 through 4.1. The modification and enhancement of the program reflect the extensive comments and input provided by the user community regarding earlier versions. The significant changes between BASINS versions include the following:

BASINS 4.5 Core

- Complete replacement of all the data download libraries with the D4EM version of these libraries. Data for Environmental Modeling, or D4EM, is a comprehensive set of tools that obtains and processes data to be used in mathematical environmental models. See http://www.epa.gov/athens/research/d4em.html for more information.
- Updates the HUC8 layer of the ‘Build New Project’ national map to use the March 2017 update of the Watershed Boundary Dataset (WBD).

- Provides access to both National Hydrography Dataset Plus (NHDPlus) version 1.0 and 2.1 through the data download tool.
- Updates the National Land Cover Database (NLCD) data download options to include 2011 land use and impervious area data
- Updates the North American Land Data Assimilation System (NLDAS) download to allow access to the full suite of meteorological constituents needed for watershed and in-stream models, as well as a new option to adjust time from UTC to the project time zone.
- In BASINS 4.5 Core, all model plugins are installed separately from the BASINS 4.5 Core install.

BASINS 4.1

- This release of BASINS is built upon the latest stable release of the non-proprietary, open-source GIS **MapWindow GIS** (MapWindow web site). Along with the update to the underlying GIS platform, the BASINS automatic watershed delineation tools have been updated to use TauDEM version 5 from Utah State University.
- Ensured 64-bit compatibility and compatibility with Windows 8.

BASINS 4.0

- The first version of BASINS to be primarily based on a non-proprietary, open-source GIS foundation. **MapWindow GIS** (MapWindow web site) is the lightweight open-source GIS upon which BASINS 4.0 is built. While not being dependent upon any proprietary GIS platform, the core of BASINS 4.0 is designed to complement and interoperate with enterprise and full-featured GIS systems. BASINS 4.0 can import and export projects from ArcView 3.x and ArcGIS 9.x. This interoperability allows users access to features available in these systems but not BASINS 4.0. Along with the change to the underlying GIS platform, the BASINS extensions were refactored as they were ported to the new system.
- New plug-ins were developed to support several additional models, including *SWMM*, *WASP* and *GWLF-E*. *DFLOW* was added as an analysis tool, and *NHDPlus* and *NLDAS* Precipitation were added as available download types.

BASINS 3.1

- Entirely web-based data extraction. CD sets are no longer released by EPA region, but as only one master CD for the BASINS system and tutorial data. All other data is downloaded from the web as needed.

- A new *Data Download* tool that manages the downloading of data from the web.
- A *Build New Project* tool that provides an interface for selecting the geographic area of interest from among the entire 48 contiguous United States.
- Refined BASINS web data holdings.
- 30-meter *DEMs*, from the National Elevation Dataset (NED).
- A new *Archive and Restore* tool, to assist with storage and retrieval of BASINS projects, with the ability to compare two BASINS projects.
- New extensions for the *AQUATOX* model and the *AGWA* GIS-based modeling tool.
- A new report tool based on the *Watershed Characterization System (WCS)*

BASINS 3.0

- Addition of grid data sets including USGS DEM elevations grids (1:250,000 scale).
- Additional flexibility for users to import their own data layers including elevation, landuse soils, streams and point sources layers in shapefile and/or grid file formats.
- New utility to perform automatic watershed delineations based on DEM data. The new watershed delineation tool is used to generate and define the watershed boundary, stream network, and point source discharge layers to be used for watershed modeling using *HSPF* or *SWAT*. The stream network can be generated based on the DEM or defined by an existing stream layer such as USEPA Reach File, Version 1 or National Hydrography Dataset (NHD). Point source locations can be selected from the permit compliance system layer or manually added. The tool also generates many of the watershed and stream characteristics needed for modeling including slopes, elevations, and stream widths and depths.
- A significantly enhanced *manual delineation* tool that provides users additional flexibility in editing shapes and attributes of manually delineated watersheds.
- A *grid projector* that extends the ArcView projection tool to also project grid data. This component requires Spatial Analyst.
- An *NHD download* tool that allows users to download NHD data layers from the USGS web site and import them directly into a BASINS project window using the correct projection.
- Incorporation of the *Soil and Water Assessment Tool* (SWAT) developed by the USDA Agriculture Research Service (ARS). *SWAT* is a physical based, watershed scale model that was developed to predict the impacts of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land uses and management conditions over

long periods of time. SWAT2000 is the underlying model that is run from the BASINS ArcView interface. *SWAT* requires the Spatial Analyst extension.

- A new interface to the Hydrological Simulation Program - Fortran (HSPF), called *WinHSPF*. In earlier versions of BASINS, the interface to *HSPF* was known as the Nonpoint Source Model (NPSM). *WinHSPF* builds upon the successes of NPSM, but adds enhanced graphical displays and editing capabilities such that all features of *HSPF* are available in *WinHSPF*. *WinHSPF* fully supports the MASS-LINK, SCHEMATIC and SPECIAL ACTIONS blocks of the UCI File. This interface also directly reads *HSPF* UCI file.

- A postprocessor known as *GenScn*. *GenScn* works with data in a variety of formats including Watershed Data Management (WDM) files, *SWAT* output files, and BASINS observed water quality files.

- A utility program for managing WDM files known as *WDMUtil*. WDM files are used by *HSPF* for input and output time-series data. *WDMUtil* was designed to help manage the large volumes of time-series data used with *HSPF*, as well as to add additional time series where needed.

- A pollutant loading program known as *PLOAD*. Developed by CH2M-Hill, PLOAD estimates nonpoint sources of pollution on an annual average basis, for any user-specified pollutant, using either the export coefficient or simple method approach.

BASINS 2.0

- Additions to the base data sets include USEPA Reach File Version 3 Alpha (RF3 Alpha), STATSGO soils, DEM elevation data, federal and Indian land boundaries, water quality observation data, ecoregions, fish and wildlife consumption advisories, shellfish contamination, and Clean Water Needs Survey.

- New utilities to facilitate data preparation such as *Watershed Delineation* and *Watershed Characterization Reports*.

- Expanded functionality of the nonpoint source modeling system to include in-stream transport and visualization.

- Postprocessing tools for evaluation of model output.

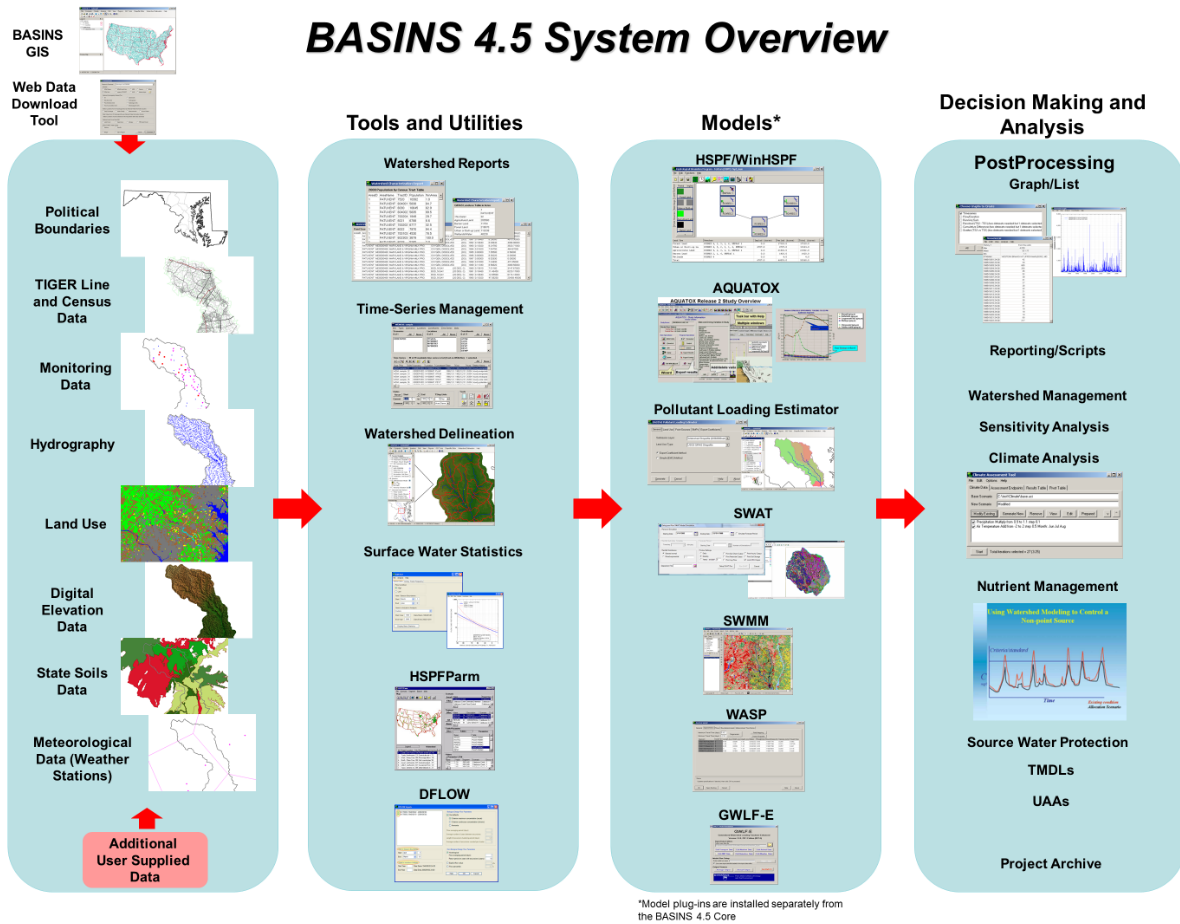
Users are encouraged to continue to provide EPA with comments and recommendations for further development. Future enhancements to the system might include adding additional types of information, using higher-resolution data, providing Internet access to data and model updates, expanding assessment and evaluation capabilities, providing enhanced data management and display tools, and adding a wider range of nonpoint source water quality and ecological modeling techniques.

System Overview and What's New

The BASINS 4.5 Core system combines several components to provide the range of tools needed for performing watershed and water quality analyses. These interrelated components can be summarized as follows:

- National environmental databases
- Watershed characterization tools
- Utilities
- Watershed and In-stream Water quality models (model plugins available and installed separately)
- Analysis tools and Postprocessors

A graphical representation of the BASINS components and their operating platform is provided in the figure below.



BASINS System Overview

The BASINS physiographic data, monitoring data, and associated assessment tools are integrated in a customized geographic information system (GIS) environment. MapWindow GIS (MapWindow web site) is the lightweight open-source GIS upon which BASINS 4.0 and subsequent versions are built. The GIS used in earlier versions is ArcView 3.x developed by Environmental Systems Research Institute, Inc. The simulation models are integrated into this GIS environment through a dynamic link in which the data required to build the input files are generated in the GIS environment and then passed directly to the models. The results of the simulation models can also be displayed visually and can be used to perform further analysis and interpretation.

BASINS 4.0 was the first version of BASINS to be primarily based on a non-proprietary, open-source GIS foundation. While not being dependent upon any proprietary GIS platform, the core of BASINS 4.0 was designed to complement and interoperate with enterprise and full-featured GIS systems. BASINS 4.0 and 4.1 can import and export projects from ArcView 3.x and ArcGIS 9.x. This interoperability allows users access to features available in these systems but not BASINS.

Previous versions of BASINS included Model Plug-ins within the BASINS installation. However, in BASINS 4.5 Core, all Model Plug-ins are packaged and installed separately. The architecture allows users to develop and include their own plug-ins in their BASINS 4.5 Core installation. A list of EPA provided Model Plug-ins, along with a short description of its function, is provided below. WinHSPF and WASP plug-ins will continue to be supported by U.S. EPA. The remaining Plug-ins in the list will be made available for installation but will not be supported by U.S. EPA.

Watershed Model plug-ins:

- *WinHSPF* is an interface to the Hydrological Simulation Program Fortran (HSPF). *HSPF* is a watershed scale model for estimating instream concentrations resulting from loadings from point and nonpoint sources.
- *SWAT* is a physical based, watershed scale model that was developed to predict the impacts of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land uses and management conditions over long periods of time. SWAT2005 is the underlying model that is run from the BASINS MapWindow interface.
- *SWMM* is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators.

Instream / Water Quality Models:

- *AQUATOX* is a simulation model for aquatic systems that predicts the fate of various pollutants, such as nutrients and organic chemicals, and their effects on the ecosystem, including fish, invertebrates, and aquatic plants.
- *WASP* is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos.

Loading models:

- *GWLF-E*, an extension of the Generalized Watershed Loading Function (GWLF) model. *GWLF-E* is a ‘mid-level’ model that estimates monthly nutrient and sediment loads within a watershed.
- *PLOAD*, a pollutant loading model. *PLOAD* estimates nonpoint sources of pollution on an annual average basis, for any user-specified pollutant, using either the export coefficient or simple method approach.

The BASINS 4.x system architecture was completely reengineered for version 3.0. Unlike its predecessor, all customized components of BASINS 3.0, such as model interfaces, data management utilities, and watershed assessment tools, are developed as BASINS extensions, thereby providing users the capability to load only the extensions needed for their BASINS project. The new architecture also allows the system to support several levels of hardware and software sophistication. For the developers, it will be easier to maintain and provide updates of the individual extensions rather than issuing a new version of the entire system. This makes it also easier for the users to upgrade their system.

The BASINS GIS provides built-in additional procedures for data query, spatial analysis, and map generation. These custom BASINS procedures allow a user to visualize, explore, query available data, and perform individualized and targeted watershed-based analyses. Some familiarity with desktop GIS systems is helpful in accessing and fully utilizing the capabilities of BASINS and the custom analytical tools. Furthermore, as users become familiar with GIS operations, environmental relationships can be further investigated using complex queries, overlays, proximity analyses, and buffer analyses.

BASINS 4.5 Core provides the following additional enhancements and features:

- Updates the HUC8 layer of the ‘Build New Project’ national map to use the March 2017 update of the Watershed Boundary Dataset (WBD).
- Provides access to both NHDPlus version 1.0 and 2.1 through the data download tool.

Databases

The BASINS system includes a variety of databases that are extracted and formatted to facilitate watershed-based analysis and modeling. The databases were compiled from a wide range of federal sources. The data were selected based on relevance to environmental analysis, national availability, and scale and resolution. As new data become available, updates may be distributed through the BASINS Internet site (see *Download*). Users are also encouraged to import locally derived data sets or higher-resolution layers into BASINS to support the most appropriate and accurate analysis. The data included within BASINS are intended to provide a starting point and data for those areas where limited site-specific information is available.

Four types of data are delivered with the BASINS analysis system:

- Base cartographic data
- Environmental background data
- Environmental monitoring data
- Point sources/loading data

Base Cartographic Data

BASINS' base cartographic data include administrative boundaries, hydrologic boundaries, and major road systems. These data are essential for defining and locating study areas and defining watershed drainage areas. The base cartographic data products included in BASINS are listed below.

Base Cartographic Data

Data Product	Source	Description
Hydrologic Unit Boundaries	U.S. Geological Survey (USGS)	Nationally consistent delineations of the hydrographic boundaries associated with major U.S. river basins
Major Roads	Federal Highway Administration	Interstate and state highway network
Populated Place Locations	USGS	Location and names of populated locations
Urbanized Areas	Bureau of the Census	Delineations of major urbanized areas used in 1990 Census

State and County Boundaries	USGS	Administrative boundaries
EPA Regions	USGS	Administrative boundaries
Census Shapefiles	Bureau of the Census	Boundary layers and associated tabular data from the 1990 and 2000 Census of Population, as well as the TIGER line files showing roads, railroads, and other linear features

Environmental Background Data

Environmental background data provide information to support watershed characterization and environmental analyses. These data include information on soil characteristics, land use layers, and the stream hydrography. This information is used in combination with modeling tools to perform more detailed assessment of watershed conditions and loading characteristics. The environmental background data included in BASINS are listed below.

Environmental Background Data

BASINS Data Product	Source	Description
Ecoregions Level III	U.S. Environmental Protection Agency (USEPA)	Ecoregions and associated delineations
National Water Quality Assessment (NAWQA) Study Unit Boundaries	USGS	Delineations of study areas
State Soil and Geographic (STATSGO) Database	U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS)	Soils information including soil component data and soils
Managed Area Database	University of California, Santa Barbara	Data layer including federal and Indian lands
Reach File Version 1 (RF1)	USEPA	Provides stream network for major rivers and supports development of stream routing for modeling purposes (1:500k)
National Hydrography Dataset1	USGS	Spatial dataset based upon the USGS DLG and the USEPA Reach File Version 3, that is more refined

		and expanded. Contains information about surface water features which are combined to form reaches (surface water drainage network), facilitating in routing for modeling purposes(1:100K)
NHDPlus 1.0/2.11	US EPA	an integrated suite of application-ready geospatial data sets that incorporates many of the best features of the National Hydrography Dataset (NHD), the USGS Watershed Boundary Dataset (WBD), and the National Elevation Dataset (NED), along with other value-added attributes.
Digital Elevation Model (DEM) 1	USGS	Topographic relief mapping; supports watershed delineations and modeling
National Elevation Dataset (NED) 1	USGS	Topographic relief mapping; supports watershed delineations and modeling
Land Use and Land Cover (GIRAS) 1	USGS	Boundaries associated with land use classifications including Anderson Level 1 and Level 2
National Land Cover Data (NLCD) 1992, 2001, 2006, and 2011 1	USGS MRLC	GIS layers from the NLCD dataset

Environmental Monitoring Data

BASINS contains several environmental data products developed from existing national water quality databases. These databases were converted into locational data layers to facilitate the assessment of water quality conditions and the prioritization and targeting of water bodies and watersheds. These data can be used to assess the current status and historical trends of a given water body and also to evaluate the results of management actions. The environmental monitoring data included in BASINS are listed below.

BASINS Environmental Monitoring Data

BASINS Data Product	Source	Description
Water Quality Monitoring Stations and Data Summaries	USEPA	Statistical summaries of water quality monitoring for physical and chemical-related parameters; parameter-specific statistics computed by station for 5-year intervals from 1970 to 1994 and 3-year interval from 1995 to 1997
Bacteria Monitoring Stations and Data Summaries	USEPA	Statistical summaries of bacteria monitoring; parameter-specific statistics computed by station for 5-year intervals from 1970 to 1994 and 3-year interval from 1995 to 1997
Water Quality Stations and Observation Data	USEPA	Observation-level water quality monitoring data for selected locations and parameters
STORET	USEPA	Observation-level water quality monitoring data from the EPA STORET database
Station Locations from NWIS1	USGS	Station locations for the selected station types, including 'Daily Discharge', 'Water Quality', 'Measurements' and 'Ground Water'
USGS Data from NWIS1	USGS	Data values collected at the selected USGS station locations
Meteorologic Stations1	National Oceanic and Atmospheric Administration (NOAA)	Location of stations in the updated BASINS Meteorological database (Version 2009)
Meteorologic Database1	NOAA	BASINS Meteorological data from the updated BASINS Meteorological database (Version 2009)
NLDAS Meteorological Data1	NASA/NOAA	Hourly meteorological data from NLDAS (North American Land Data Assimilation System) Phase 2

Point Source/Loading Data

BASINS also includes information on pollutant loading from point source discharges. The location, type of facility, and estimated loading are provided. These loadings are also used to support evaluation of watershed-based loading summaries combining point and nonpoint sources. The point source/loading data included in BASINS are listed below.

BASINS Point Source/Loading Data

BASINS Data Product	Source	Description
Permit Compliance System (PCS) Sites and Computed Annual Loadings	USEPA	NPDES permit-holding facility information; contains parameter-specific loadings to surface waters computed using the EPA Effluent Decision Support System (EDSS) for 1990-1999

1Data Layers that are added into the BASINS project using the Data Download.

Environmental Assessment Tools

Watershed characterization is key to understanding water quality issues and pollution sources in the watershed. In addition to evaluation of the watershed condition, it provides the necessary information to assess monitoring programs, identify data gaps, and develop watershed-water quality modeling strategies.

The BASINS system includes tools designed to assist in summarizing key watershed information in a format suitable for preparing Watershed Characterization Reports. These tools produce tables that inventory and characterize both point and nonpoint sources at the watershed and subwatershed scales.

Watershed Characterization Reports

BASINS provides users the capability to generate eight different types of Watershed Characterization Reports, each in tabular form:

- 1990 Population and Sewerage by Census Tract
- 2000 Population and Census Tract Table
- Landuse Distribution Table
- Permitted Point Source Facilities Table
- Point Source Discharge Concentration and Loading Table
- Water Quality Observations Stations Table

Watershed Characterization System

The BASINS Watershed Characterization System can be used to select and generate several standard reports designed to describe the physical characteristics of watersheds (subbasins) you have defined. This feature is more customized version of the Watershed Characterization Reports. The following reports are available:

- Water Bodies
- Population Estimates
- Housing and Sewage
- Soil Characteristics

- Landuse Characterization
- Permitted Point Sources
- Data Summary

Utilities

Manual Delineation Tool

The BASINS Manual Watershed Delineation tool allows the user to delineate subwatersheds manually. It allows the user to subdivide a watershed into several smaller hydrologically connected watersheds based on the user's knowledge of that watershed's drainage topography. The tool also provides users the flexibility to edit shapes and attributes of manually delineated watersheds, outlets and generating stream networks.

Automatic Delineation Tool

The BASINS Automatic Watershed Delineation tool allows the user to delineate subwatersheds based on an automatic procedure using Digital Elevation Model (DEM) data. User specified parameters provide limits that influence the size and number of subwatersheds created.

Land Use Reclassification

The Land Use Reclassification tool assists the user in grouping or renaming land use categories as needed to support modeling and analysis. Land uses can be reclassified in one of two ways: reclassification of the entire layer (all land uses) or reclassification of selected layers (single or multiple land uses from within an entire layer).

Lookup Tables

The Lookup Tables provide users quick access to relevant reference information on data products included within BASINS. Information is provided for products such as the map projection, definition of agency codes for monitoring data, Standard Industrial Classification (SIC) codes, and the water quality criteria and threshold values of selected pollutants.

Analysis Tools and Postprocessors

Climate Assessment Tool (**CAT**)

The BASINS Climate Assessment Tool (CAT) provides a flexible set of capabilities for representing and exploring climate change and its relationship to watershed science. Tools have been integrated into the BASINS system allowing users to create climate change scenarios by modifying historical weather data, and to and use these data as the meteorological input to several BASINS watershed models (HSPF, SWAT, and SWMM). A capability is also provided to calculate specific hydrologic and water quality endpoints important to watershed management based on model output (e.g. the 100-year flood or 7Q10 low flow event). Finally, the CAT can be used to assess the outcomes of a single climate change scenario, or to automate multiple model runs to determine the sensitivity or general pattern of watershed response to different types and amounts of climate change. In BASINS 4.5, CAT is included within the *WinHSPF* model plugin installation package.

Time Series Functions

BASINS contains utilities to manage and analyze available project time-series data. Project time-series data are managed through the Time-Series Management Utilities. The Graph menu item is used to produce graphs of the selected time series. When the 'Graph' menu item is selected, a form is produced for choosing from among a set of possible graph types. Among the implemented graph types include Timeseries, Flow/Duration, Running Sum, Residual, Cumulative Difference, and Scatter. The List menu item produces a listing of dates and associated values for the selected time series.

Hardware and Software Requirements

BASINS Version 4.5 Core is a customized MapWindow GIS application that integrates environmental data, analysis tools, and modeling systems. BASINS' hardware requirements are, at a minimum, similar to those of the PC-based MapWindow system. There are no additional software requirements for BASINS because all software components integrated into the program are open source.

Users must have administrator privileges to install BASINS.

BASINS can be installed and operated on machines with the Microsoft Windows operating system equipped with the software, random access memory (RAM), virtual memory, and hard disk space presented in the table below.

Because the performance (response time) under the minimum requirements option might be too slow for some users especially when dealing with large data sets, a preferred set of requirements is also included.

BASINS Hardware/Software Requirements

Hardware/Software	Minimum Requirements	Preferred Requirements
Processor	1GHz processor	2GHz processor or higher
Available hard disk space	2.0 Gb	10.0 Gb
Random access memory (RAM)	512 Mb of RAM plus 2 Gb of page space	1 Gb of RAM plus 2 Gb of page space
Color monitor	16 bit color, Resolution 1024x768	32 bit color, Resolution 1600x1200
DVD/Compact disc reader/writer	Optional	Optional
Internet Connection	WiFi	DSL or better
Operating system	Windows 7, Windows 8, or later	Same

Internet Explorer 9.0 or newer is required to view help files.

Installation

Installation Instructions for BASINS 4.5 Core

BASINS 4.5 Core is available at http://www2.epa.gov/exposure-assessment-models/basins-user-information-and-guidance.

BASINS 4.5 Core is distributed as a single installation program. The setup program provides a software wizard which guides the user through the setup process.

Installation Requirements

It is assumed that BASINS users already have some familiarity with Microsoft Windows, as well as GIS concepts, and that they have a basic understanding of water quality analysis techniques and modeling.

The user must have administrator privileges before starting the installation. Since some new system files are included in this release, the user may need to restart Windows after some files have been updated before continuing with the installation.

Installing BASINS 4.5 Core

The BASINS installation program copies BASINS system files and tools, and it also sets up BASINS icons automatically.

The BASINS installation program allows the user to install the BASINS system. The BASINS system installation program installs all of these components to your local hard drive in a fixed directory structure. It also sets up a Windows BASINS program group that includes icons for the BASINS components.

When running the installation program, follow the instructions on the screen.

Tip: The BASINS installation program does not copy any BASINS data (except the optional tutorial) to your hard drive.

Tip: If you have multiple hard drives or partitioned drives, you may have only one BASINS directory in each partitioned or physical drive.

General Notes

It is recommended that the BASINS system be installed at the root of a drive. The user must have write access to the folder in which BASINS is installed.

Be sure you have administrator privileges before starting the installation. Since some new system files are included in this release, you may need to restart Windows after some files have been updated before continuing with the installation.

Notes for Users Upgrading to BASINS 4.5 Core

If you have an earlier version of BASINS installed already, uninstall it before installing BASINS 4.5. Earlier BASINS project files and data will not be deleted during the uninstall process. Earlier BASINS projects (MapWindow .mwprj files) may not open correctly in BASINS 4.5 Core, but the map layers may be loaded into new BASINS 4.5 Core projects.

Finding Functionality from Earlier Versions

Users of earlier versions of BASINS (3.1 and prior) might need a few minutes to become familiar with the new features and structure of BASINS 4.0 and subsequent versions. Not all of the earlier BASINS components have a directly corresponding component in later versions of BASINS. This section is included to help users of BASINS 3.1 find the functions of BASINS 4.0 and subsequent versions that fulfill the same functional requirements as BASINS 3.1. Unless otherwise noted, a directly corresponding component of the current version of BASINS exists for each component of BASINS 3.1.

As stated previously, BASINS 4.0 and subsequent versions are built upon a lightweight open-source GIS known as MapWindow GIS (MapWindow web site, Introduction to MapWindow). BASINS 4.0 was the first version of BASINS to be primarily based on a non-proprietary, open-source GIS foundation.

Environmental Assessment Tools

The Assessment Tools from BASINS 3.1, *TARGET*, *ASSESS*, and *Data Mining*, have been superseded in version 4.0 and subsequent versions by the new Watershed Characterization Reports tool. The Watershed Characterization Reports are more powerful than ever before, with a full scripting capability and the ability to summarize within any set of user-specified polygons.

Utilities

The *Theme Manager* component from BASINS 3.1 has been discontinued for version 4.0 and subsequent versions. All of the auxiliary map layers from BASINS 3.1 are loaded onto the map as the project is created. The legend grouping capability of MapWindow is used to group the layers logically.

The BASINS *Import* Tool from BASINS 3.1 is not available in BASINS 4.0 and subsequent versions because each of the BASINS components has been re-engineered to accommodate user-supplied GIS layers. It is anticipated that users will want to import locally developed data, which might be more accurate, at a higher resolution, or more reflective of current conditions. Such layers can be added to the map and then used by the BASINS tools directly.

The functionality of the *Grid Projector* from BASINS 3.1 is now built into the core GIS. In BASINS 4.0 and subsequent versions a grid may be downloaded, projected, and loaded into the project seamlessly, and in one step. Since the core GIS handles grid data, no special extensions are needed to accommodate grids.

The *Predefined Delineation Tool* of BASINS 3.1 has been discontinued for BASINS 4.0 and subsequent versions. Any user-supplied layers can be brought into BASINS through the core GIS functionality. Advanced functionality of each of the BASINS components has been developed to accommodate user-supplied GIS layers. User-supplied subbasins and streams layers can be used as inputs to the Manual Watershed Delineator to produce output streams and subbasins layers with the required attributes for modeling.

The functionality of the *Water Quality Observation Data Management* utility is part of the core GIS functionality. With MapWindow GIS, users can manipulate water quality observation locations and data.

DEM Reclassification is part of the standard MapWindow GIS legend editor features.

GenScn facilitates the display and interpretation of output data derived from model applications. *GenScn* is not a model itself. It serves as a postprocessor for both the *HSPF* and *SWAT* models, as well as a tool for visualizing observed water quality data and other time-series data. Beginning with BASINS 4.1, *GenScn* is available as a separate download at http://www.aquaterra.com/basins4. Most of the functionality of GenScn is now included in the core BASINS user interface.

WDMUtil is a utility program for managing Watershed Data Management (WDM) files, which contain input and output time-series data for *HSPF*. Beginning with BASINS 4.1, WDMUtil is available as a separate download at http://www.aquaterra.com/basins4. The import functionality of WDMUtil has migrated to the BASINS 4.x feature Read Data with Script.

Performing 'WDMUtil' Functions in BASINS 4.5 Core

Much of the WDM Time-series management functionality of WDMUtil is available through the 'File' menu option in BASINS, especially through the 'File:Manage Data' menu option. This functionality is documented in the user's manual under Time-Series Management.

To create a new WDM file in BASINS: Use 'File:New Data'. Select 'WDM Time Series' as the file type, and specify the file name using the open file dialog.

To import local weather data using scripts: Use 'File:OpenData'. Select 'Read Data with Script' as the file type, navigate to the text file of timeseries data using the file dialog, and then a script selection form appears. Click 'Find' to select the script to use, or click 'Edit' to create a new one, and then click 'Run' to import the data.

To save the newly added timeseries to WDM: Use 'File:Save Data In'. Select the name of the WDM file from those available in the current BASINS project, select the timeseries from the list of those available, and click 'OK'. The timeseries will be written to the WDM file.

To view the contents of a WDM file: Use 'File:Manage Data'. Then choose the 'Analysis:List' menu item. Select 'no' to see a full list of data sets available. A data selection window will appear which summarizes the contents of the WDM file.

To edit attribute values: Use 'Analysis:List' to list the data. In the Timeseries List window, use 'File:Select Attributes' to select which attributes will be visible. Edit attributes as desired. Close the list, then use 'File:Save Data In' to save the revised timeseries to the selected WDM file.

To edit timeseries values: Use 'Analysis:List' to list the data. Edit the values as desired. Close the list, then use 'File:Save Data In' to save the revised timeseries to the selected WDM file.

To delete a WDM timeseries: Use ‘File:Manage Data’. Select the file name in the Data Sources window, and then choose the ‘File:Remove Data from File’ menu item. Choose the timeseries to be deleted.

Functions for computing meteorological timeseries and performing time step disaggregation for meteorological data are available within the ‘Compute:Meteorologic Generation’ menu option. These functions are documented in the user’s manual under Compute.

To perform meteorological computations: Use ‘Compute:Meteorologic Generation’, then choose the particular function desired. Once the new timeseries is computed, save the new timeseries to WDM.

To disaggregate a meteorological timeseries: Use ‘Compute:Meteorologic Generation’, then choose the particular disaggregation function desired. Once the new timeseries is computed, save the new timeseries to WDM.

BASINS Details

This section of the manual provides information on the utilities available in BASINS and detailed instruction on how to construct and manage a project within BASINS. BASINS has a wide range of implicit utilities as well as links and plug-ins that avail the utility of other software programs via the BASINS interface. This section begins with a discussion of the BASINS interface, available plug-ins and the utilities they provide, then moves on to the procedures necessary to build and manage a BASINS project, and concludes with instruction on how to use information from the BASINS project to set up separate independent, yet linked, watershed models.

User Interface

The BASINS user interface is based on a customized MapWindow interface. Within the system, all forms consist of menus, toolbars, text boxes, buttons, lists, tables, check boxes, and radio buttons. Both the left and right mouse buttons are used for mouse interaction.

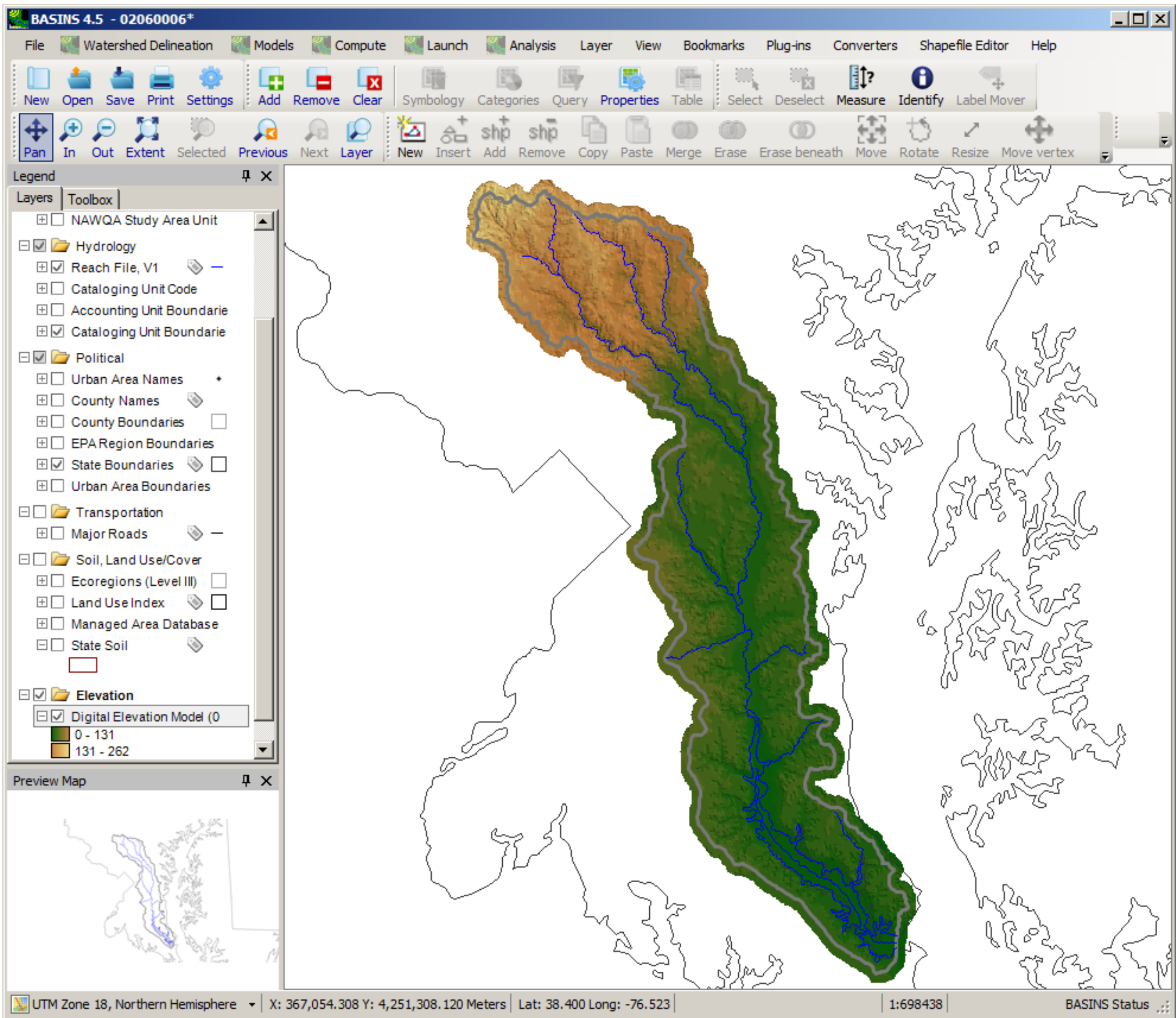
The BASINS windows are organized logically, with access to the most basic and relevant information available easily, and more detailed information available through additional menus or buttons. Similarly, some windows organize data by stacked tabs, with the most frequently used tabs at the top of the stack.

The BASINS user interface was designed to ensure that the user knows where they are within the system. Each window is labeled with a title that indicates its function and confirms to the user that the menu item or button they used took them to the expected place. The name on the main window is updated each time a project is opened to reflect the project's file name. An asterisk appears after the project's file name when the project has unsaved changes.

BASINS Customized MapWindow Interface

The BASINS customized MapWindow interface contains all of the menu, button, and toolbar items that are present in the standard MapWindow interface. This provides access to MapWindow's full array of utilities, including raster and vector operations and managing their associated attribute tables. These tools and menus are activated through the **Plug-ins** menu item on the main form, which is also used to access a number of additional menus and tool bar items that execute watershed delineation, BASINS utilities, data management and analysis tools, watershed characterization reports, and watershed models. The BASINS customized MapWindow interface is shown below.

Note: Depending on which plug-ins are installed and activated, the user's main BASINS menus may look different than the menu depicted in screenshots throughout this documentation.



Menu Missing

When the main BASINS window is not at full width, items on the right-hand side of the menu will be cut off. To access these menu items, including the Help menu, simply maximize the BASINS window.

Standard MapWindow Toolbar Items

The following MapWindow toolbar items are available in the BASINS customized MapWindow interface. They are used throughout this manual. Use this section as a reference during execution of BASINS functions.

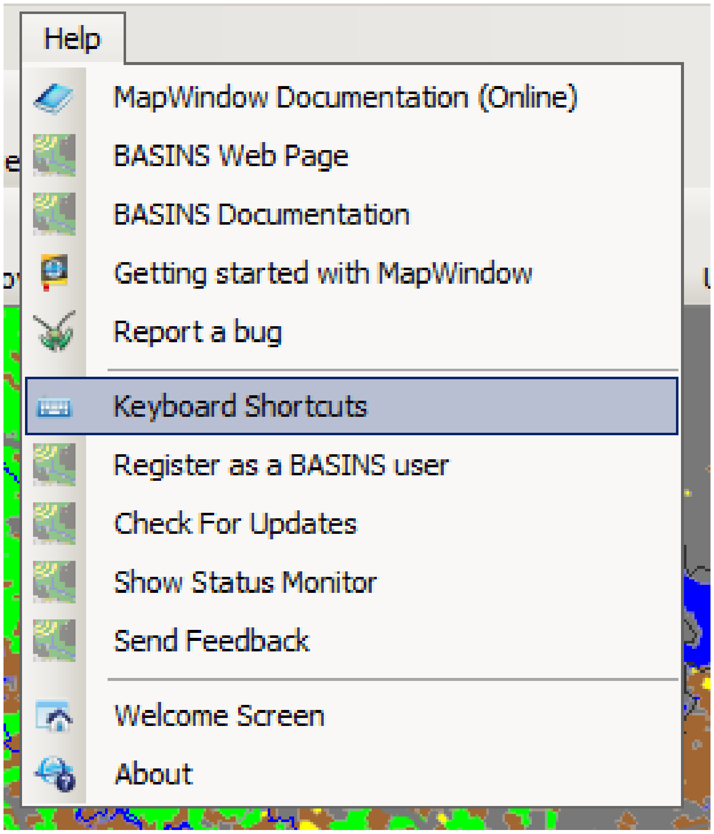
	Open New Project		Open Existing Project		Save Current Project
	Print Map Display		Add Layer		Remove Layer
	Remove All Layers		Pan		Select
	Measure Distance or Area		Zoom In	.	.
	Zoom Out		Zoom to Extent		Feature Identifier
	Move Vertex		Table Editor		Add New Shape to Current Shapefile
	Remove Shape from Current Shapefile		Create New Shapefile		Add Vertex to Existing Shapefile
	Remove Vertex from Existing Shapefile	.	.	.	.

Visit the MapWindow web site for complete documentation on that program.

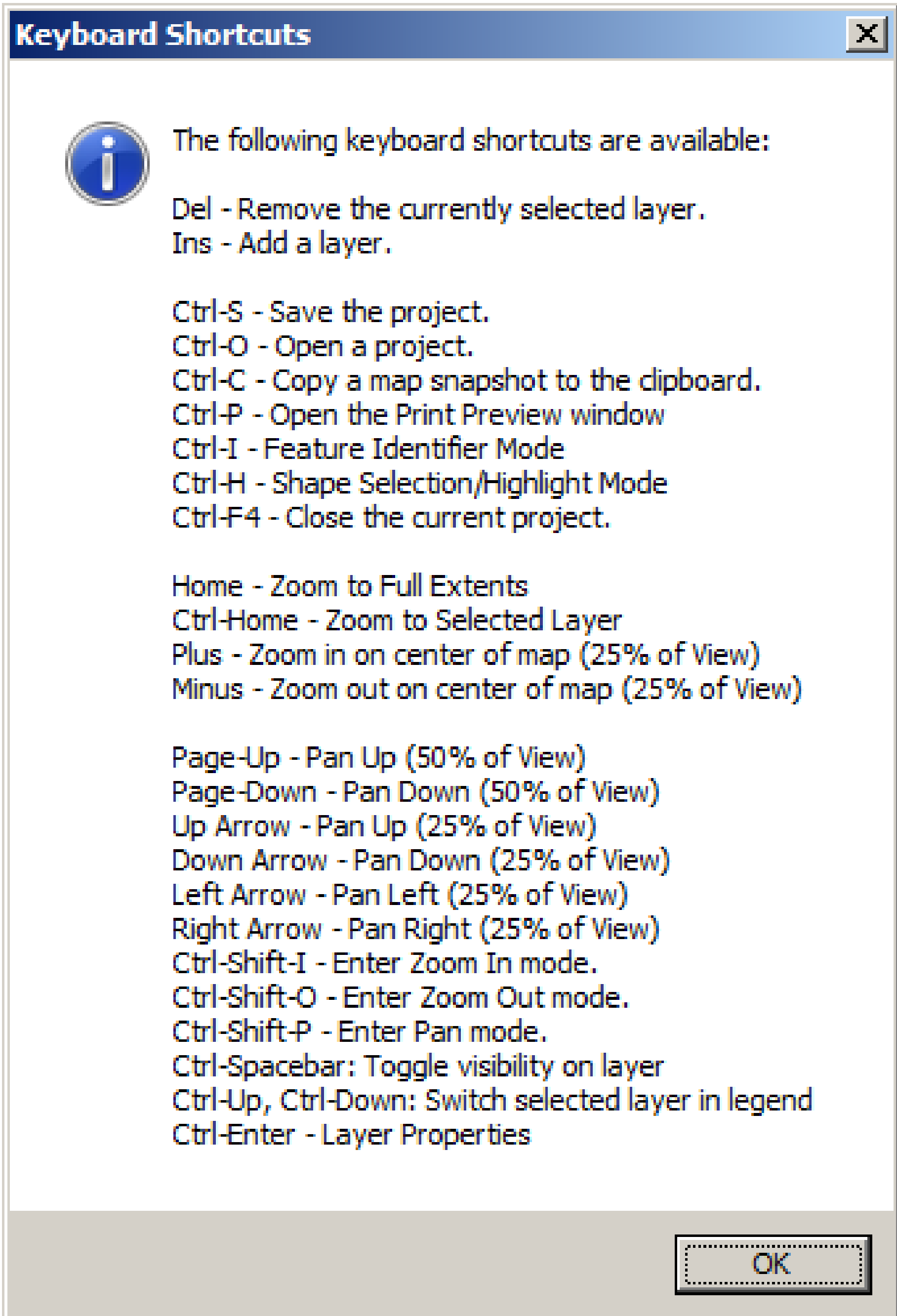
For further instructions and videos about using MapWindow, consult MapWindow Tutorials (*Note*: .pdf documents must be opened in a separate window). Keyboard Shortcuts To provide users flexibility, use of a mouse is not necessary in BASINS.

MapWindow Shortcuts

There are several keyboard shortcuts that facilitate MapWindow-related functions, such as zooming and panning within the main BASINS screen. These shortcuts are listed in the **Help: Keyboard Shortcuts** menu option:



This opens the following screen:



"F1" Keyboard Shortcuts

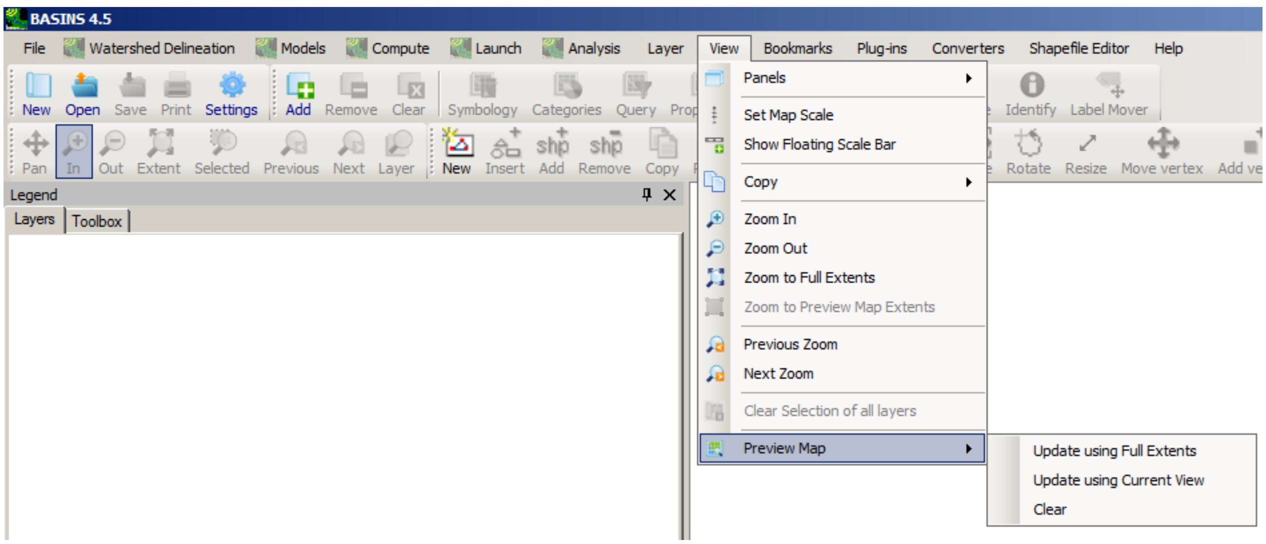
As an added help feature in BASINS, the user can press the **F1** key on many screens to access corresponding Help information from the BASINS documentation. For example, pressing F1 from the main BASIN window will open the BASINS documentation.

Also, pressing F1 from the **Climate Assessment Tool** will open the BASINS documentation to the page about **CAT**.

Another type of keyboard shortcut using F1 is tooltips. By pressing F1 from the **Save As** dialog box, tooltips appear describing the text boxes (depending on where the cursor is): Legend and Preview Map

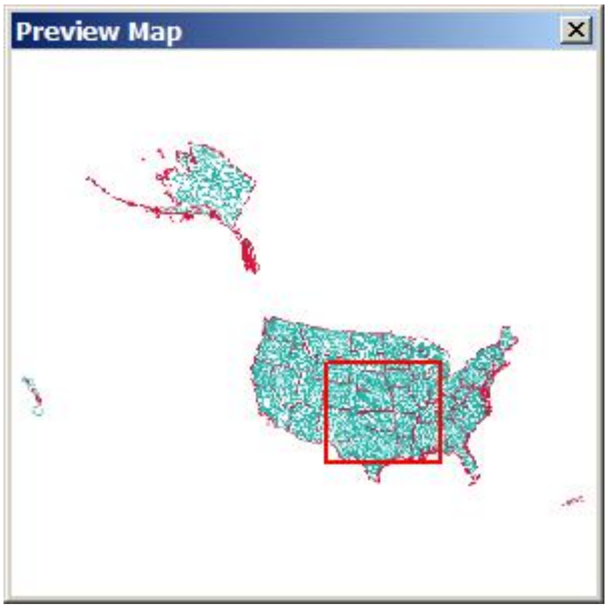
Preview Map

The Preview Map may be updated at any time by choosing the **View** menu option on the main BASINS screen, then **Preview Map**.

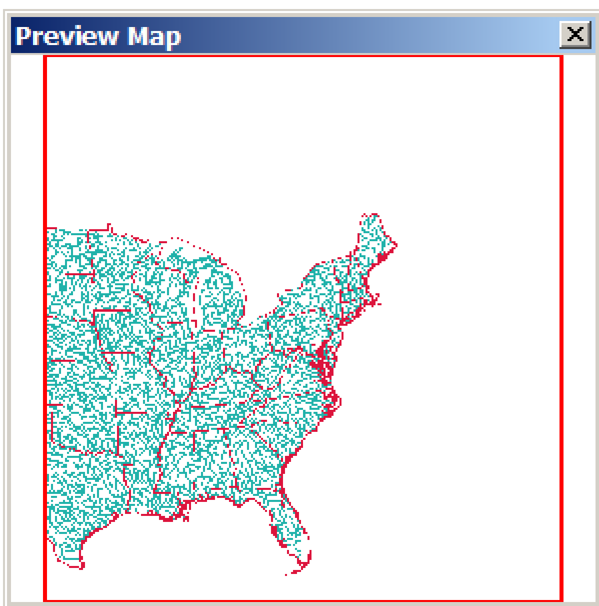


When the user updates the map, the image in the locator window will be built using the layers and symbology currently displayed in the main map. Be sure to turn off any layers which are extremely detailed, leaving only those layers important for orienting the user. There are three options:

- Update Using Full Extents: Updates or refreshes the Preview Map panel, showing the current map in a red box within the full extent of all the selected layers.



- Update Using Current View: Updates or refreshes the Preview Map panel, showing the current map in a red box with only its immediate surroundings.

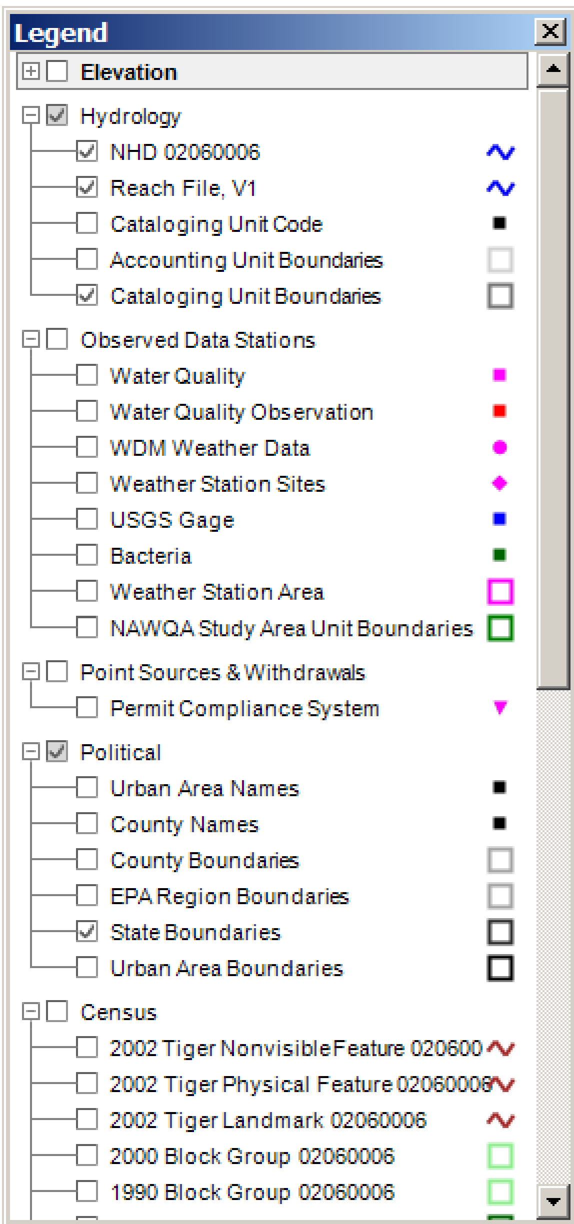


- Clear: Clears the Preview Map Pane

Within the Preview Map frame, the user can drag the map to adjust the current view.

Legend

The legend is a graphical representation of all the map layers in the current project. The position of the legend is the left hand side of the screen. The legend offers layer manipulation functionality including but not limited to changing a layer's symbology or the order of display for the layers.



Legend Information:

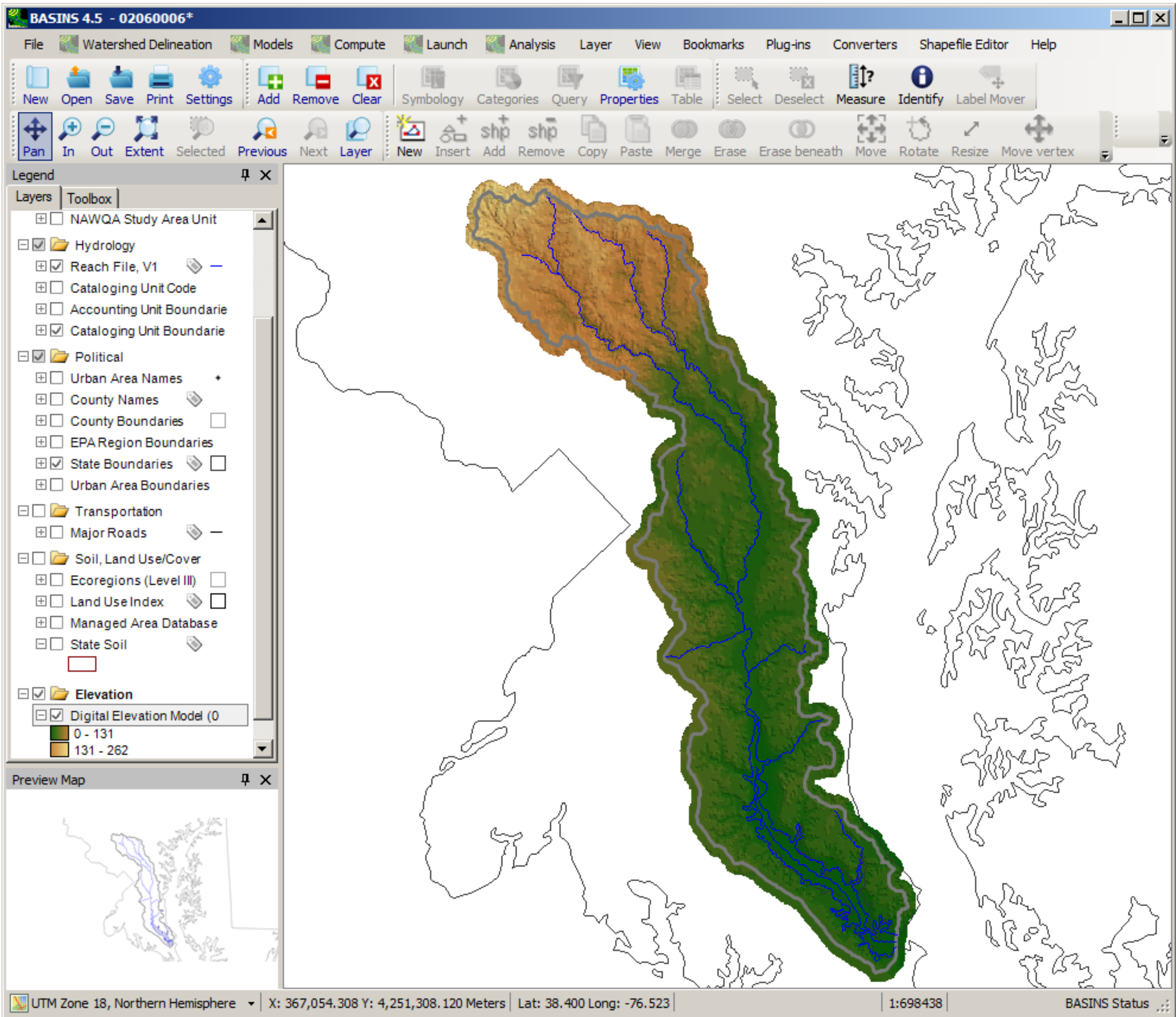
- Visibility Checkbox: This indicates whether a layer is always visible (checked), always hidden (blank).
- Text: This is the name of the layer.
- Each line represents a layer of data that’s in the main view. The image to the right of the legend is an indicator to help identify the data layer. If, for example, the user had a polygon Shapefile that was filled, the color in this image would be the same as the fill color. For a line Shapefile, the color here will match the color the line is drawn with. Some layers have a plus or minus next to them. This indicates that they are collapsible or expandable. For example, a grid may have a coloring scheme indicating terrain height which may be displayed by expanding the layer, and hidden by collapsing it.

Changing the name of a layer does not affect the underlying data. The layer name is project dependent and will not modify any information stored against the map source.

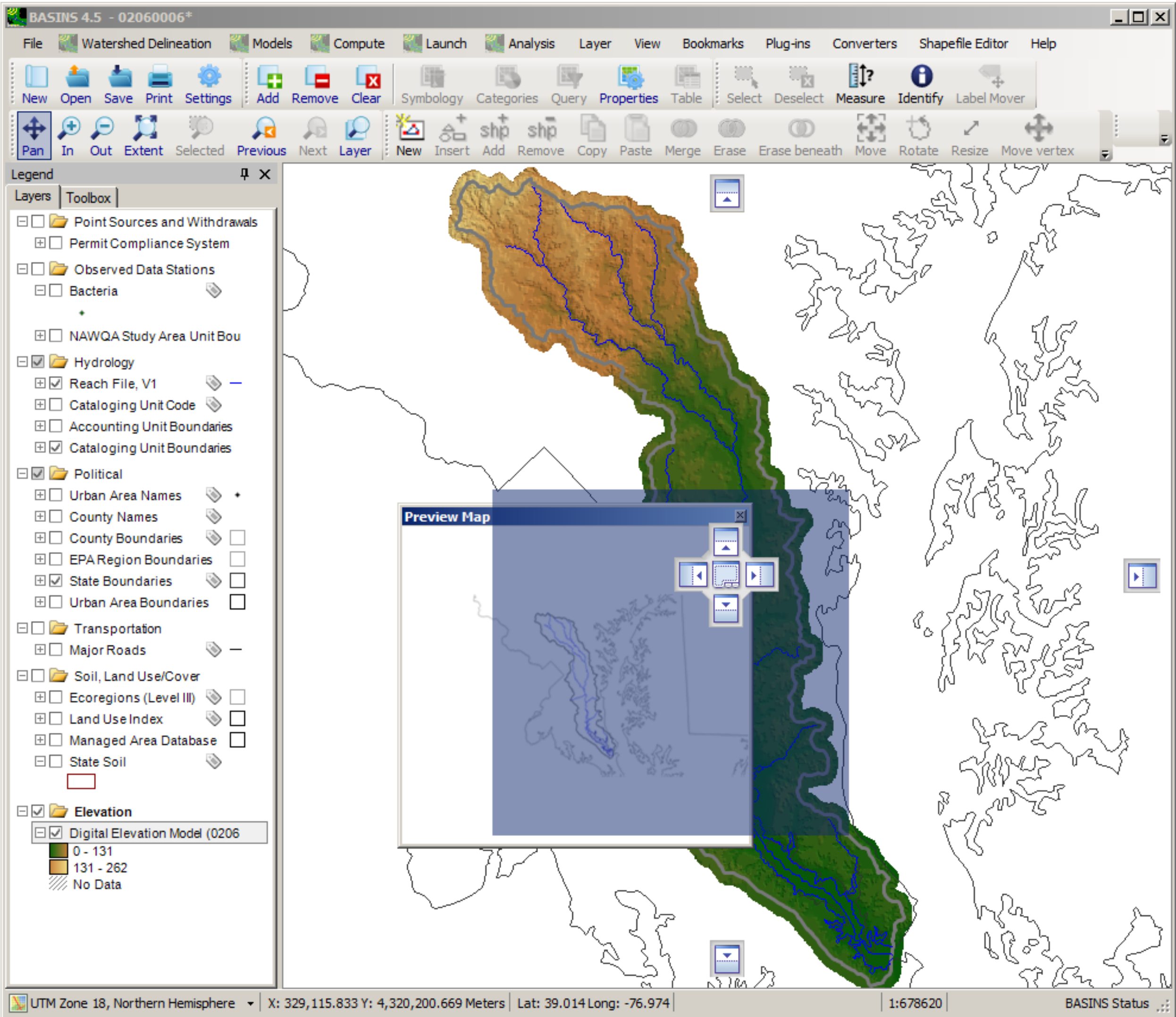
For more information about changing layer names and symbolization, see Legend Editor.

Docking

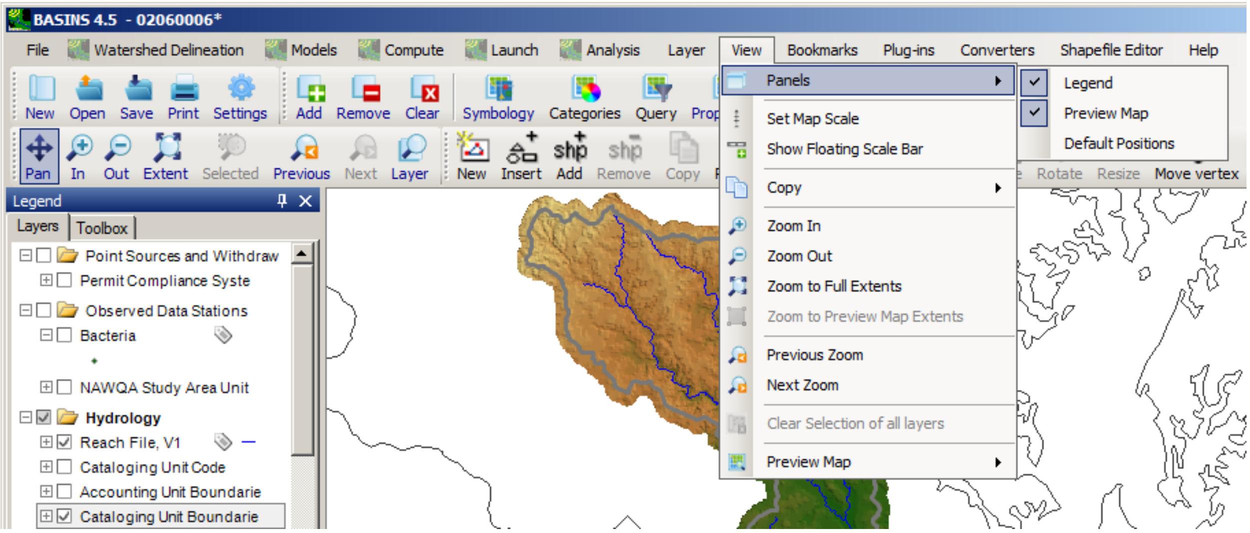
Window docking is a new and useful way to customize the user’s information windows in **MapWindow**. Docking is available for the **Legend** and the **Preview Map**, both originally located on the far left of the BASINS screen.



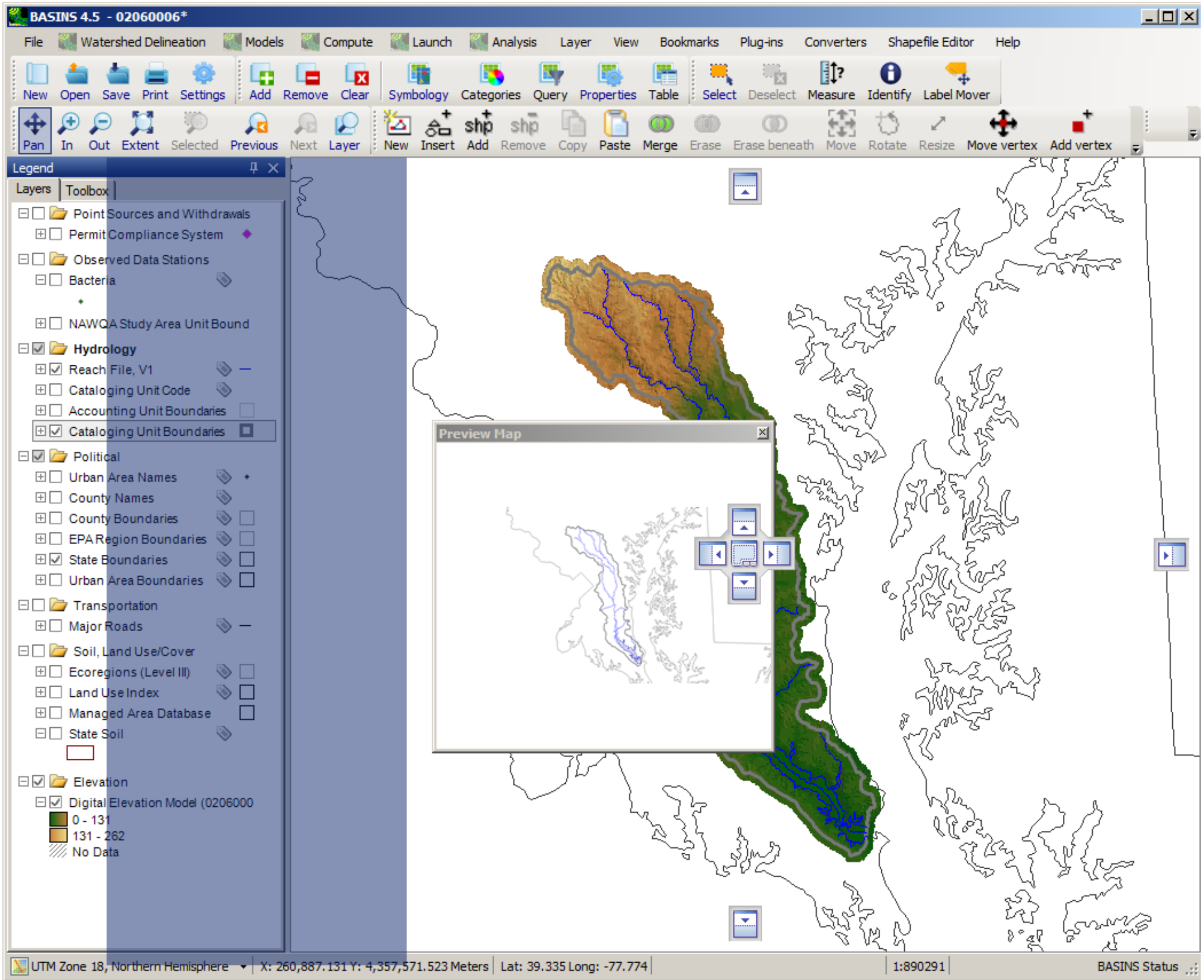
Docking and tabbing windows in **MapWindow** is easy to do by clicking and pulling on the top of the window. Hold down the left mouse key and drag the window to desired location.



In the event the windows are undocked in a bad location, you may use the view menu to check or uncheck the **Show legend** and **Show preview map** options to turn them on or off.



When dragging either the Legend or Preview Map, there are several possible locations to “snap” to a set position. These are represented by 5 floating windows with arrows that appear as either the Legend or Preview Map is dragged.



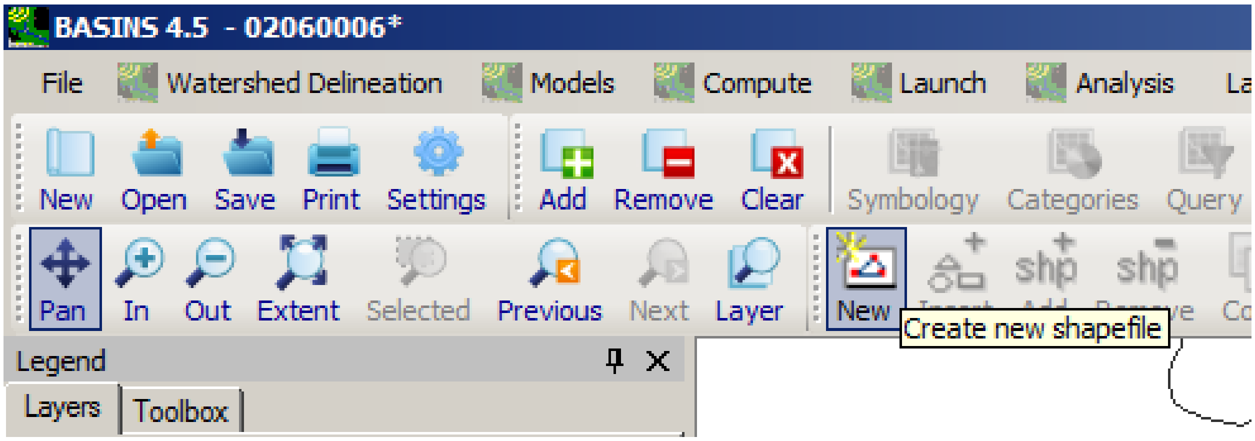
Although the frames can be docked anywhere on the screen, the locations where they “snap” into position include: vertical left, horizontal left, top, bottom, and stacked tabs. To enter one of these formats, while dragging the frame, place the cursor over one of the floating windows with arrows.

To separate the Preview Map and Legend from the tabbed view, hold down ALT while dragging one of them.

Toolbars

Toolbars in BASINS provide a shortcut to commonly used controls or functions. The benefit of the toolbar button is that it requires only a single click to perform a function, rather than selecting several menu options. Each toolbar item has a graphical image suggestive of its function to guide the user.

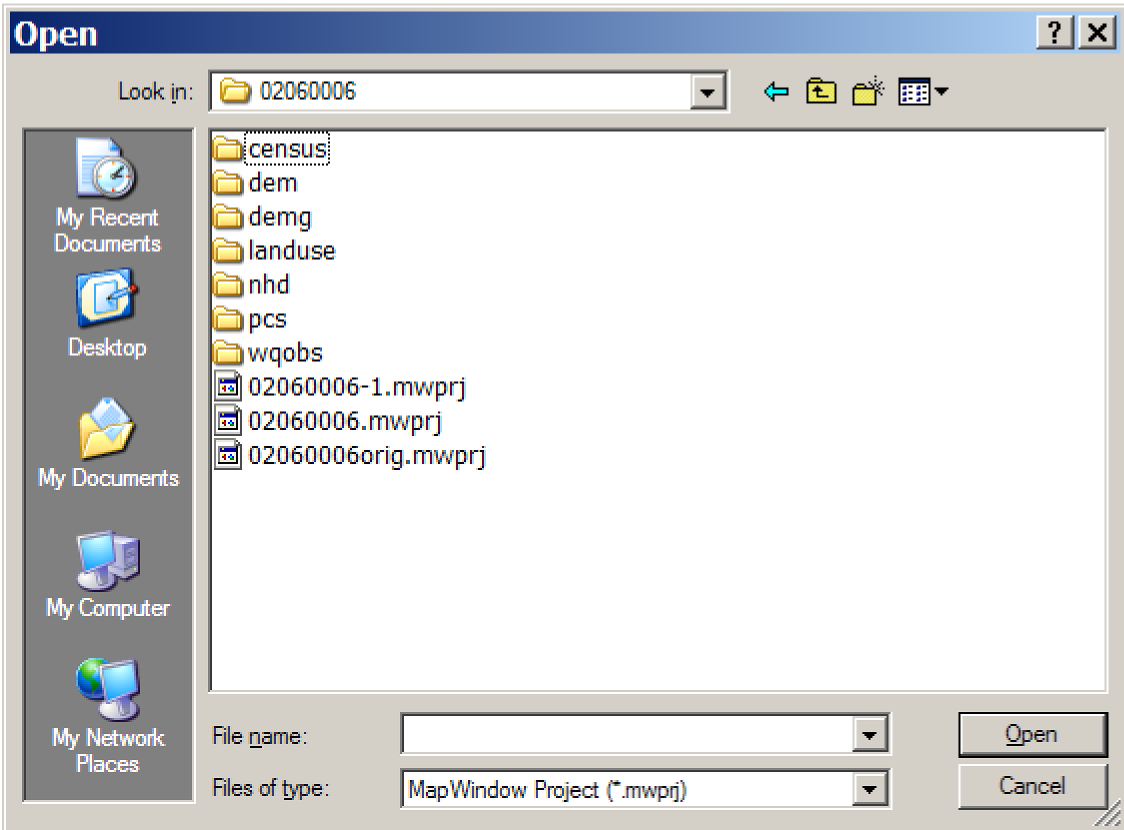
In BASINS, toolbar buttons also contain **tooltips**, which are accessible when the cursor is held over the button briefly. A text description of the button’s function will appear, as shown in the picture below.



Dialogs Many interactions within BASINS involve dialog windows. The consistent interfaces on these forms are used for many common tasks including opening a file, saving a file, and printing.

File Dialog

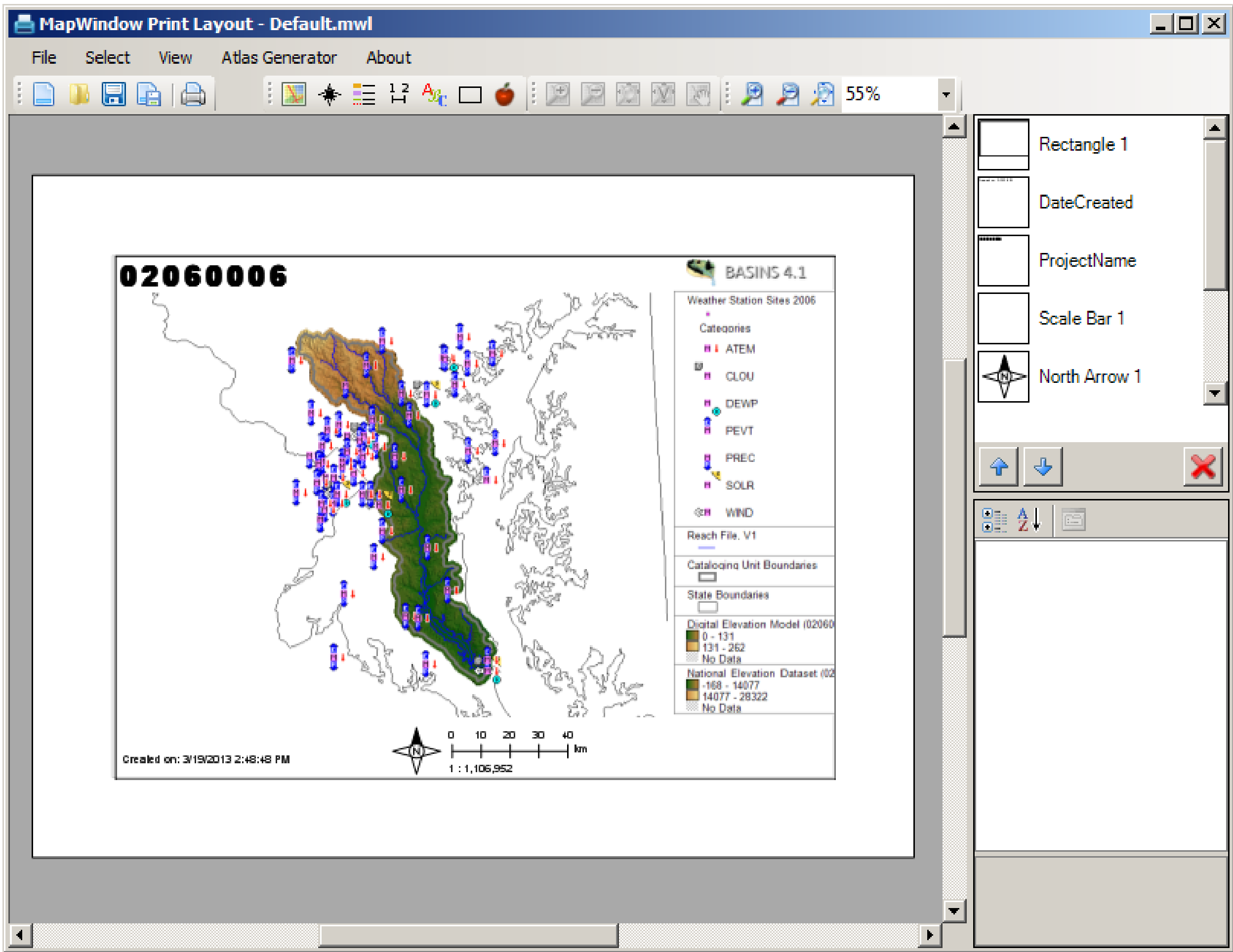
Throughout BASINS, the user will frequently desire to open or save an existing data file, which utilizes a file dialog window. The typical file dialog box consists of a dropdown list at the top which displays the directory path. The middle box displays all files of the type specified within the current directory. To change the file specification type, use the dropdown labeled ‘Files of type’ at the bottom of the window.



Print Dialog

The print dialog in BASINS is a specialized form written for MapWindow. From the main BASINS 4 menu, selecting **File:Print** opens a print layout window. This gives the user the opportunity to select which aspects of the MapWindow document to print.

Within the **File** menu of the Print Layout window are found typical printing functions such as options to set the printer specifications, page setup, and **Print**.


MapWindow Print Layout - Default.mwl
File
Select
View
Atlas Generator
About
55%
02060006
BASINS 4.1
Weather Station Sites 2006
Categories
ATEM
CLOU
DEWP
PEVT
PREC
SOLR
WIND
Reach File, V1
Cataloging Unit Boundaries
State Boundaries
Created on: 3/19/2013 2:48:48 PM
0 10 20 30 40
km
1 : 1,106,952
Rectangle 1
DateCreated
ProjectName
Scale Bar 1
North Arrow 1

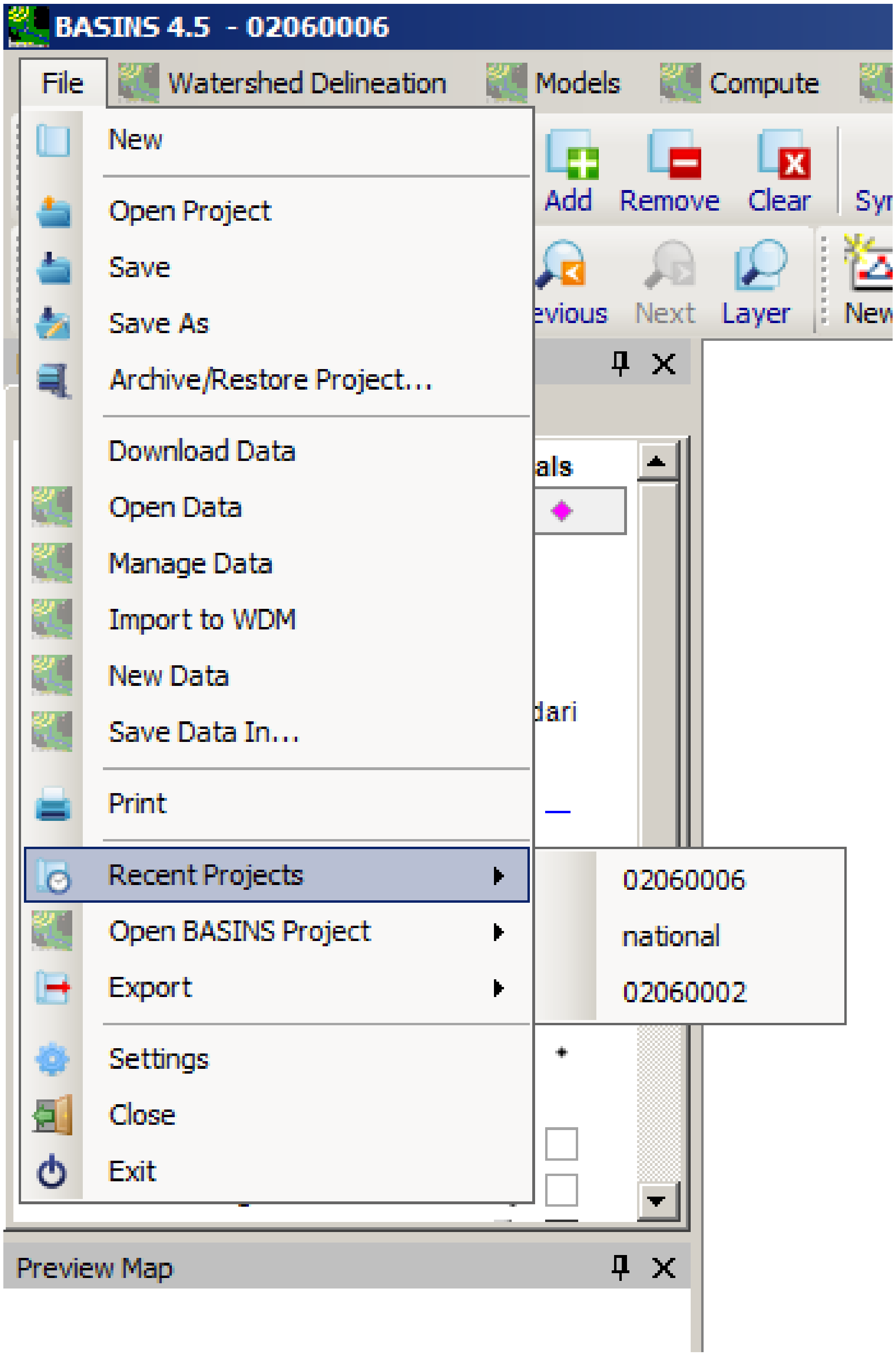
Project Creation and Management

Once the BASINS program is instantiated, the user has two options for accessing a BASINS project:

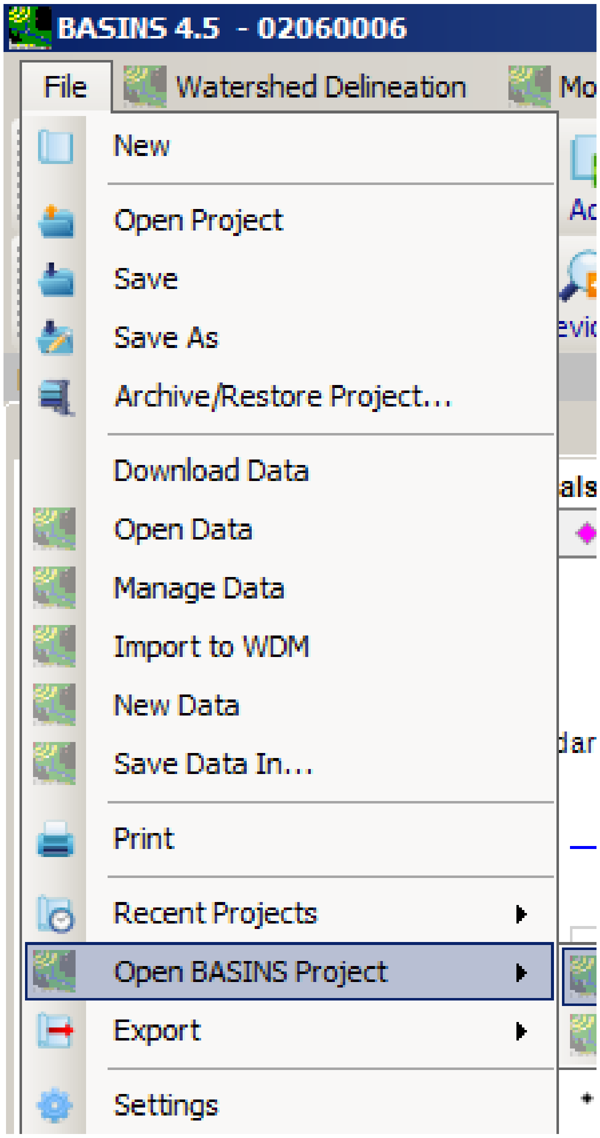
- Build a new BASINS project
- Open an existing BASINS 4 project

If the BASINS plug-in is active, then the **Welcome to BASINS 4.5 Window** avails these options when BASINS is opened. Otherwise, the user can always create a new project or open an existing project through the **File:New** menu item (or button) and **File:Open** menu item (or button), respectively, on the main BASINS form.

The **File:Recent Projects** menu item displays for selection a submenu of the most recent projects that have been opened since the last BASINS 4 installation.



The **File:Open BASINS Project** menu item displays for selection a submenu of the subdirectories under the '/BASINS/Data/' directory. If selected, the program will search that subdirectory for a BASINS project file (extension .MWPRJ).



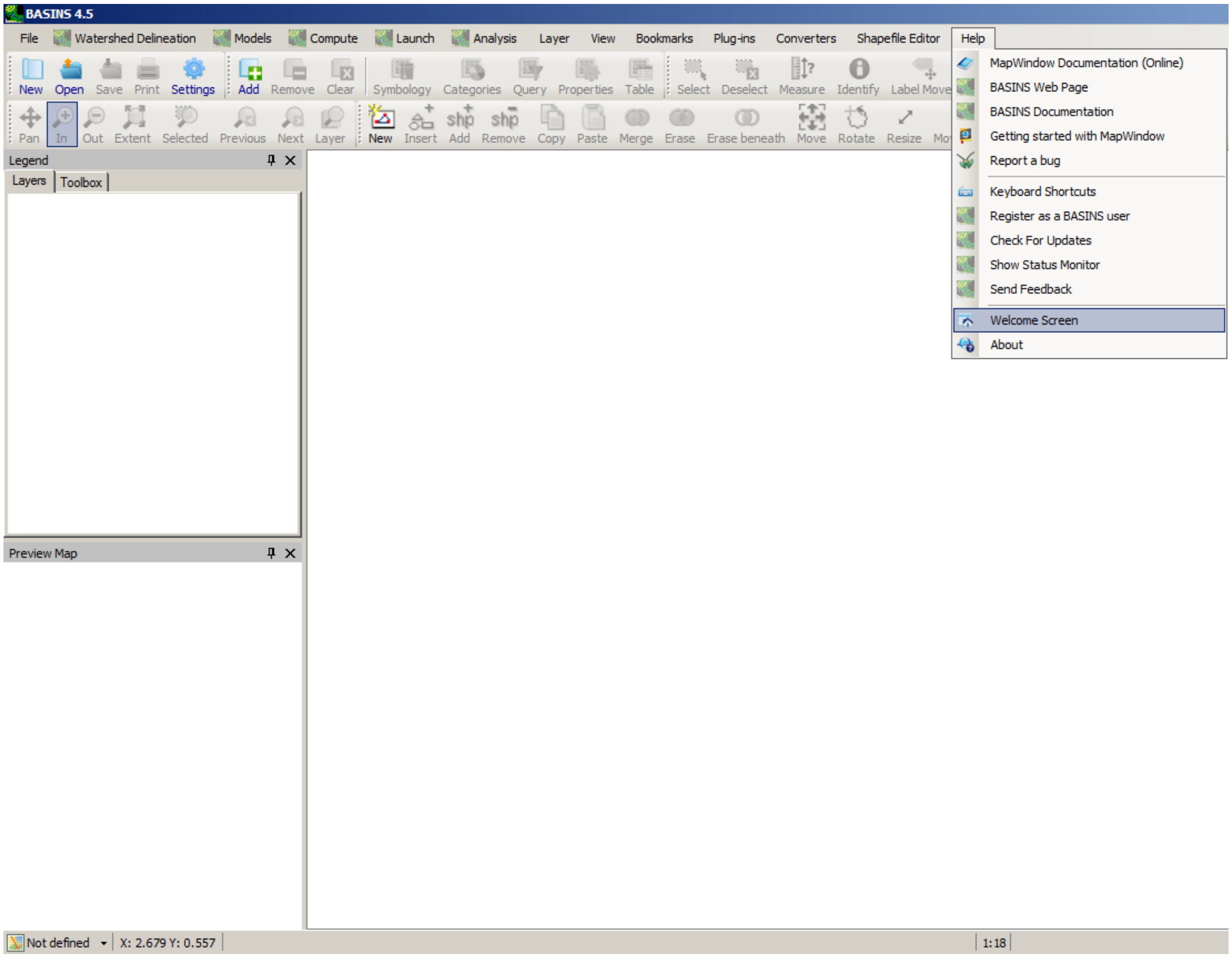
The **File:Settings** menu item opens a pop-up window with various fields that control aspects of MapWindow. Visit the MapWindow web site for complete documentation on that program.

For further instructions and videos about using MapWindow, consult MapWindow Tutorials (*Note*: .pdf documents must be opened in a separate window).

Once a project is open, the user should add the desired GIS and time-series data. Welcome to BASINS 4.5 Window

The opening window offers options for getting a BASINS project up and running (Build or Open). It also provides a link to this BASINS 4.5 User Manual that can help to get the user started.

To re-open the **Welcome to BASINS 4.5** window, go to **Help: Welcome Screen** on the main BASINS menu.



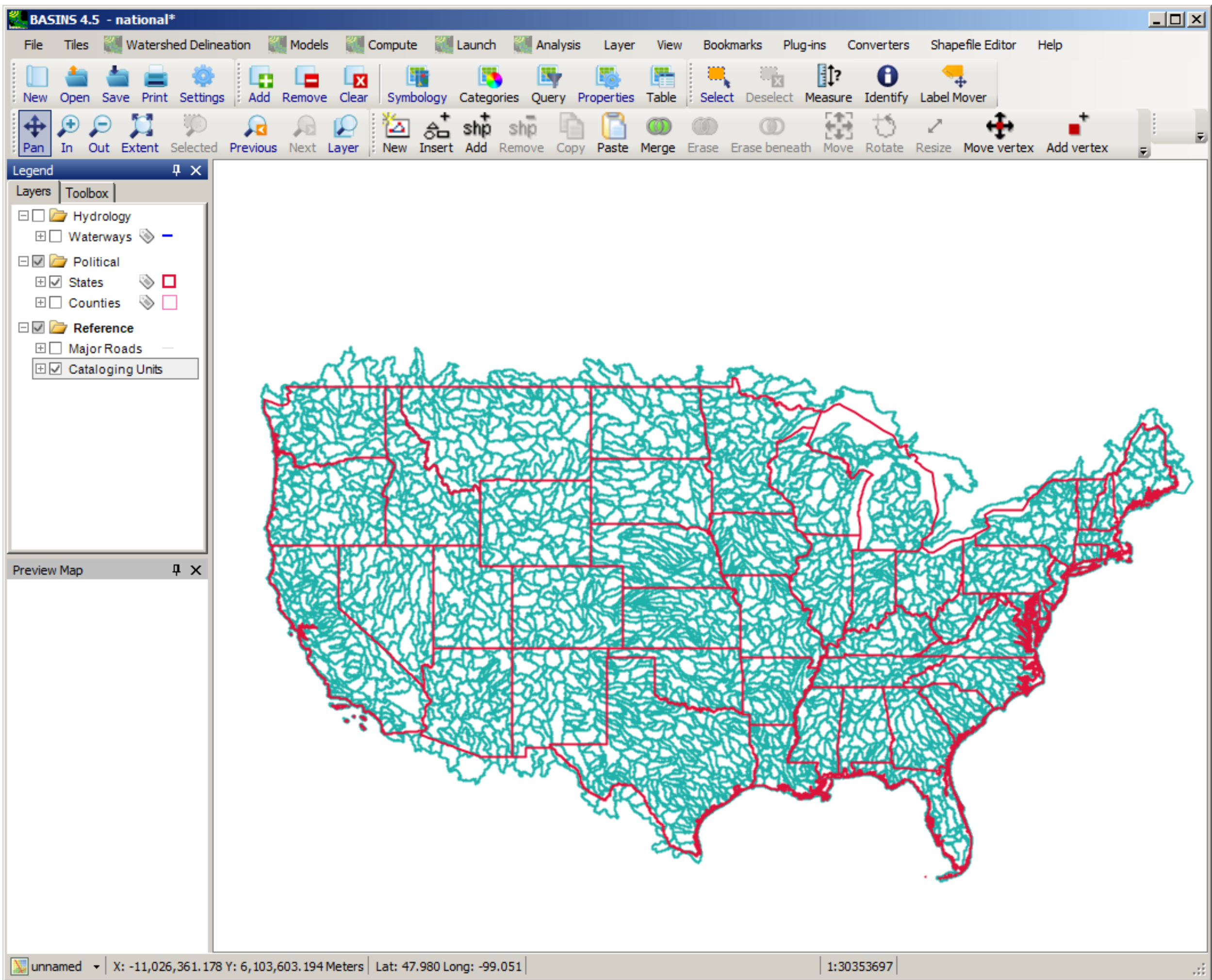
Build BASINS Project The **Build BASINS Project** option allows the user to extract environmental data for a specific geographic area from archive files stored on the BASINS web site. This tool is also used to define the desired map projections for the geographic data, as well as to build the initial BASINS project.

BASINS projects can also be built from existing MapWindow projects, or as subsets of existing BASINS projects. See the following sections for details on those features:

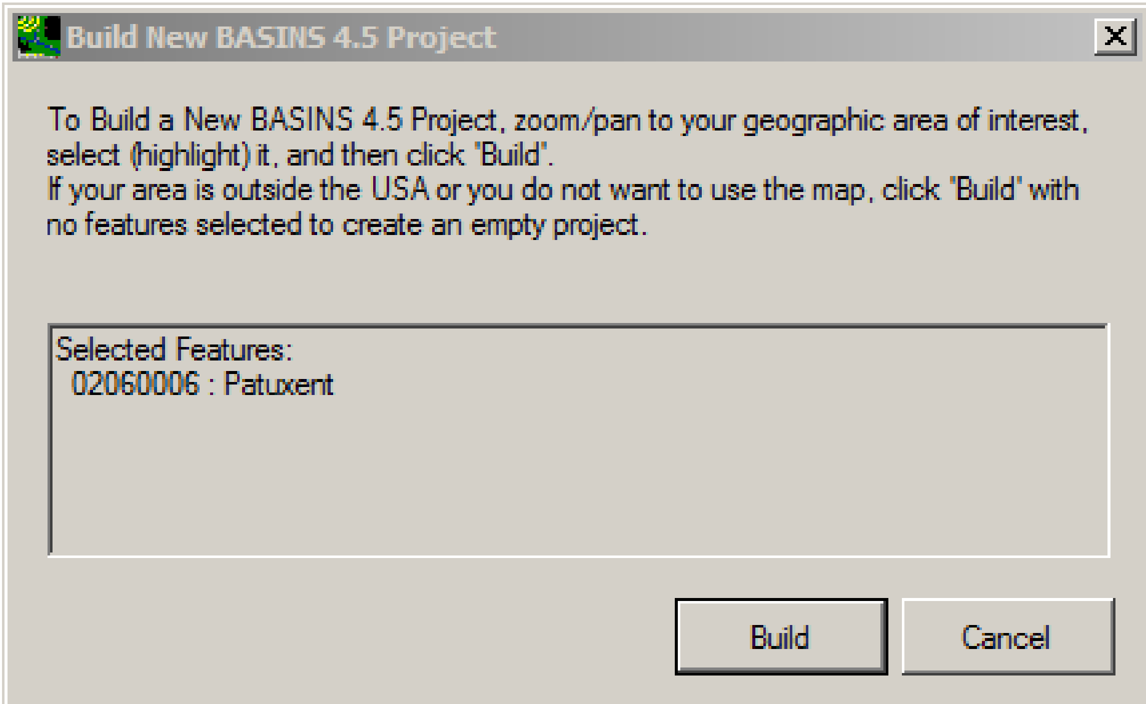
- Building a BASINS Project from an Existing MapWindow Project
- Building a BASINS Project as a Subset of an Existing BASINS Project

BASINS data on the Internet are already processed by specific geographic areas (e.g., cataloging units) and compressed into self-extracting zip files (archive files). The **Build BASINS Project** tool is used select the geographic areas of interest, download the core BASINS data for that area, decompress the data, and project the geographic data into the user-specified map projection. This process places the retrieved data into the BASINS data directory on the user hard drive.

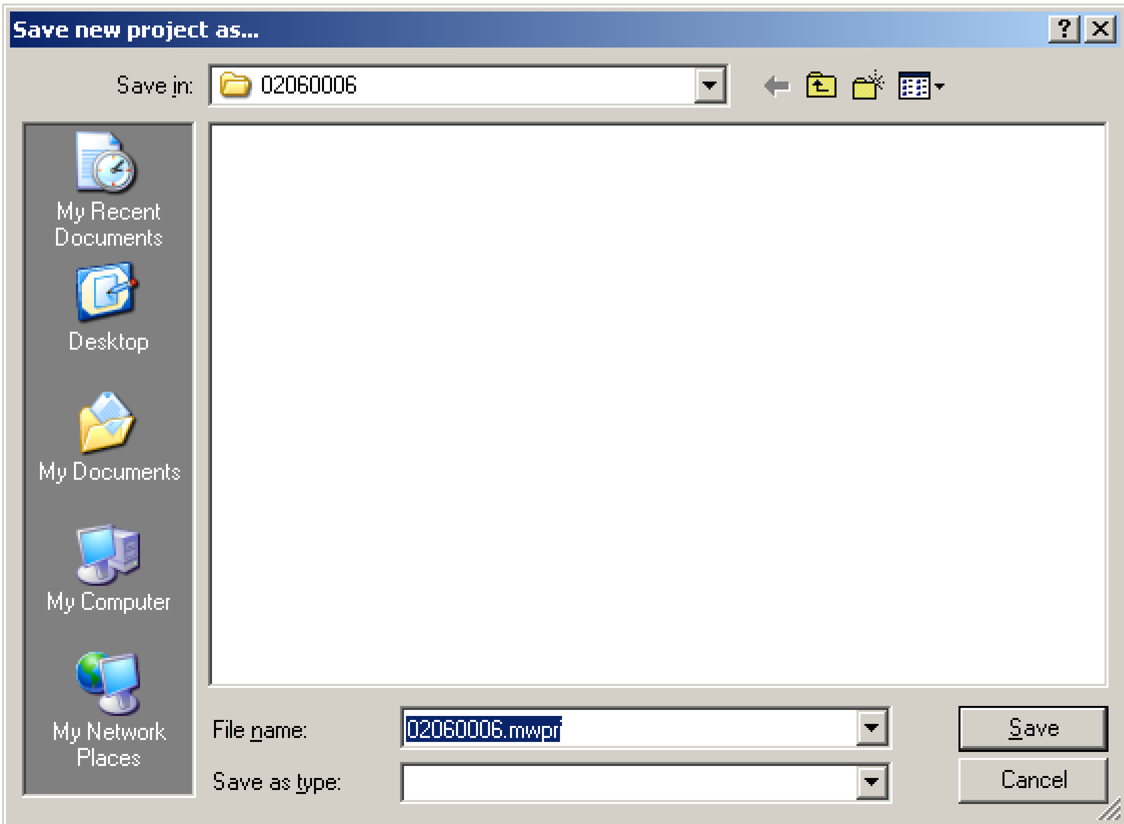
Using this tool a user selects one or more states, counties, or HUC-8 hydrologic cataloging units anywhere in the United States. Standard GIS controls can be used to zoom  in on and pan  to the subject area of interest from the initial MapWindow display of the United States.



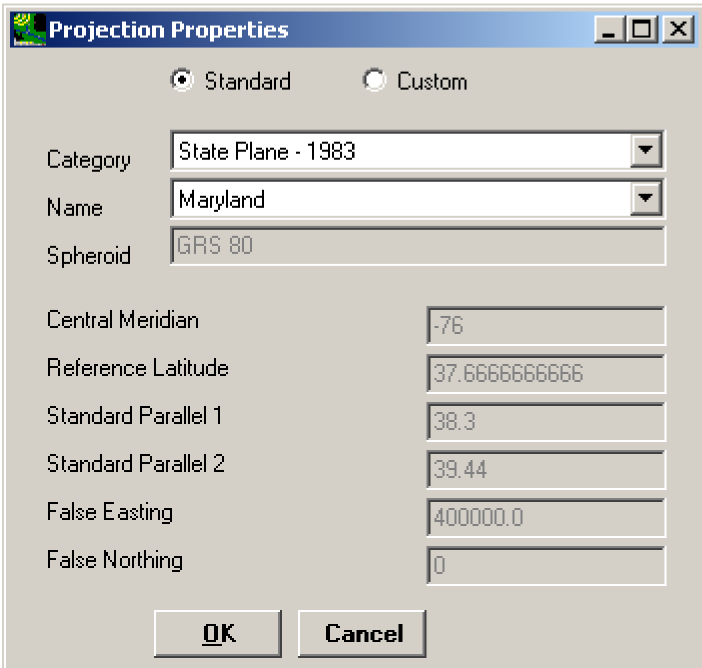
The following window pops up upon selecting the **Build BASINS Project** option, and the user should click the **Build** button AFTER the area of interest has been selected  and highlighted yellow. In this case one Cataloging Unit has been selected. Had a county or state been selected, the data for all Cataloging Units in that county or state would be downloaded and extracted. Data can be extracted for more than one Cataloging Unit, county, or state.



The user will then be prompted to select a directory name and location to house the BASINS project. The default name for the directory is the HUC-8 code, and the default location is in '\BASINS\data\'.



Once the directory is selected, the user is prompted to select the desired projection for the GIS files with the following window. Generally, the user will simply select the desired **Category** and the appropriate **Name** for that category based on the location of the selected HUC-8. However, a custom projection can be defined by the user if the required input data is known. The selected directory will then automatically be populated with the appropriate GIS files.



Note: The Map Units property for all GIS layers automatically defaults to meters.

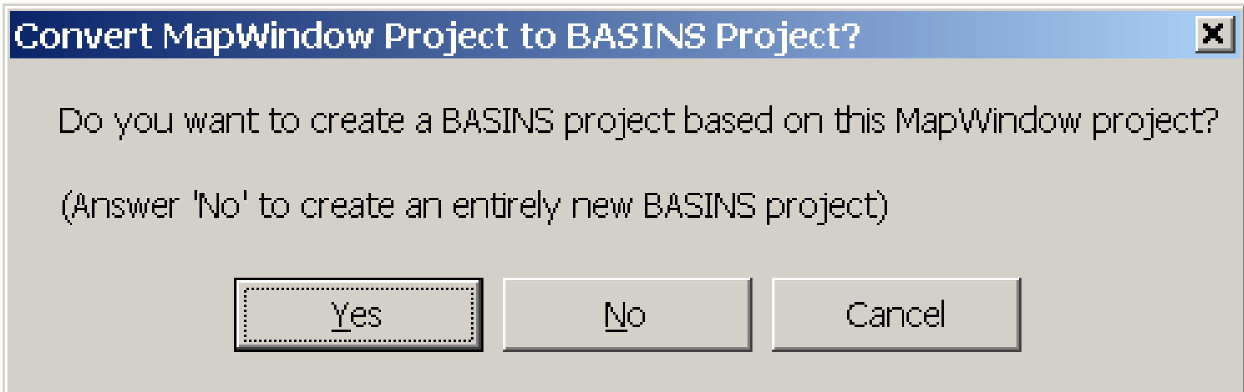
The project is now established and can be further developed with utilities available through the main menu of the interface.

For further information about building a BASINS project, see the Build a BASINS Project Tutorial.

Note: If the user knows the name of the area of interest but not the specific location on the map, the MapWindow **Table Editor** can be useful. The **Table Editor** allows the user to view all of the attributes of the current map layer. From the attributes the user can select the name of the area of interest and view its location on the map. Building a BASINS Project from an Existing MapWindow Project

With the BASINS plug-in active, the user can build a BASINS project from any existing MapWindow project. This feature allows a MapWindow user to transform a MapWindow project into a BASINS project, setting up the project as necessary to enable BASINS features such as the automatic download and projection of new map layers.

From an existing MapWindow project, choose the **File:New** menu item on the main BASINS form. The following dialog will appear:



Click **No** to build an entirely new BASINS project, as documented in the section Build BASINS Project. Click **Yes** to convert the existing MapWindow Project into a new BASINS project.

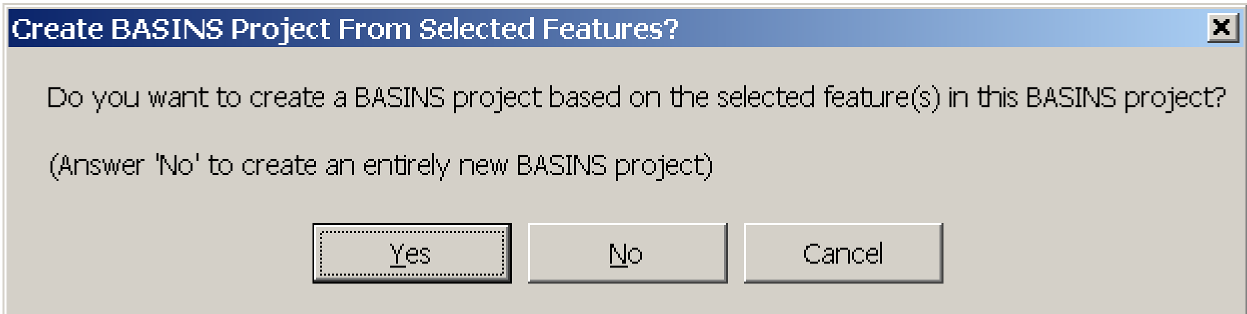
If the user clicks **Yes**, the procedure is very similar to the one outlined in the Build BASINS Project section, with a few exceptions. The national project will be opened with the State, County, and Cataloging Unit Boundaries, plus the dotted outline of the project area from the existing MapWindow project. This dotted outline gives a reference that the user may find useful for identifying which Cataloging Units to include in the new BASINS project.

The user must choose one or more State, County, or Cataloging Units, and then click **Build**. The user will be required to specify a project folder and project name. If the map projection can be determined from the existing MapWindow project, that projection will be used for the new BASINS project, otherwise the user will be prompted to specify the projection.

When the new BASINS project has been built, it will load in MapWindow with the standard BASINS map layers plus those layers contained in the original MapWindow project. Building a BASINS Project as a Subset of an Existing BASINS Project

With the BASINS plug-in active, the user can build a BASINS project as a subset of any existing BASINS project. This feature allows a BASINS user to narrow the geographic scope of a BASINS project, as might be desired when the user is setting up a model for only a portion of a Cataloging Unit.

From an existing BASINS project, select the feature(s) from an active shapefile layer to be used as the extents of the new BASINS project. Then choose the **File:New** menu item on the main BASINS form. The following dialog will appear:

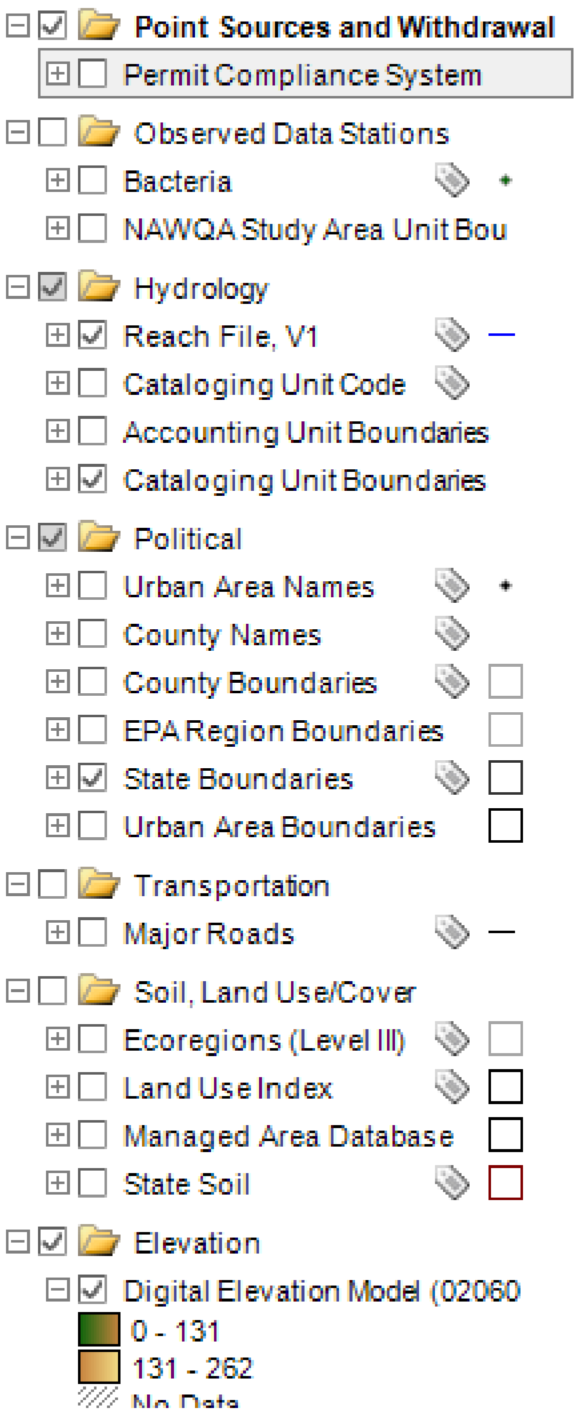


Click **No** to build an entirely new BASINS project, as documented in the section Build BASINS Project. Click **Yes** to build a project containing a subset of the current BASINS project.

If the user clicks **Yes**, the user will be required to specify a project folder and project name. Once those are specified, BASINS will build a new project containing the same layers as the original project, but the extent of the map layers will be reduced. Any shapefile feature that is contained (wholly or partially) within the specified extents will be retained, and any grid will be reduced to the specified extents. Layers that do not overlap the specified extents will be retained in the project in their entirety.

Once the new BASINS project has been built, it will be opened in MapWindow as the current active BASINS project. Open Existing BASINS Project This utility opens an existing BASINS project. Underneath the **Open Existing BASINS Project** entry is a list of previously opened projects available for immediate selection (no projects will be listed when BASINS is first instantiated). Otherwise, the user is prompted to browse for an existing BASINS project.

GIS and Time-Series Data When a BASINS project is created, a large cache of GIS layers is downloaded and stored in the project directory. These layers are immediately made available on the left section of the main BASINS form. Click on the associated checkbox to have a layer appear on the MapWindow interface.



The user may download an additional wide range of data via the **File:Download Data** menu item. The available data can be divided into two general categories, GIS layers and time series.

GIS

- Digital Elevation Model (DEM) Shapefile
- DEM Grid (DEMG) (100m resolution)
- Geographic Information Retrieval and Analysis System (GIRAS) Landuse Shapefile
- National Elevation Dataset (NED) Grid (30m resolution)
- National Hydrography Dataset (NHD) PolyLine layer
- Census Shapefiles
- Meteorologic Data Locations
- NHDPlus (including grids and shapefiles, v1.0 and v2.0)
- USGS Station Locations from the National Water Information System (NWIS)
- North American Land Data Assimilation System (NLDAS) Grid
- National Land Cover Database (NLCD) (1992)
- National Land Cover Database (NLCD) (2001, 2006, 2011)
- EPA STORET Water Quality Stations

Notes: The Map Units property for all GIS layers automatically defaults to meters. When choosing whether to use the 30m resolution NED grid or the 100m resolution DEMG grid as the basis for delineating and physically characterizing subbasins within the subject watershed, it is important to consider the scale of the watershed area. If an entire HUC-8 is being modeled, the DEMG is probably a better choice due to performance considerations, while the NED would provide enhanced detail for significantly smaller watersheds. The same consideration should be given to stream layers when burning them in. The NLCD GIS layers are in Albers Equal-Area Conic projection, with Spheroid GRS 80 and Reference Latitude 23.0.

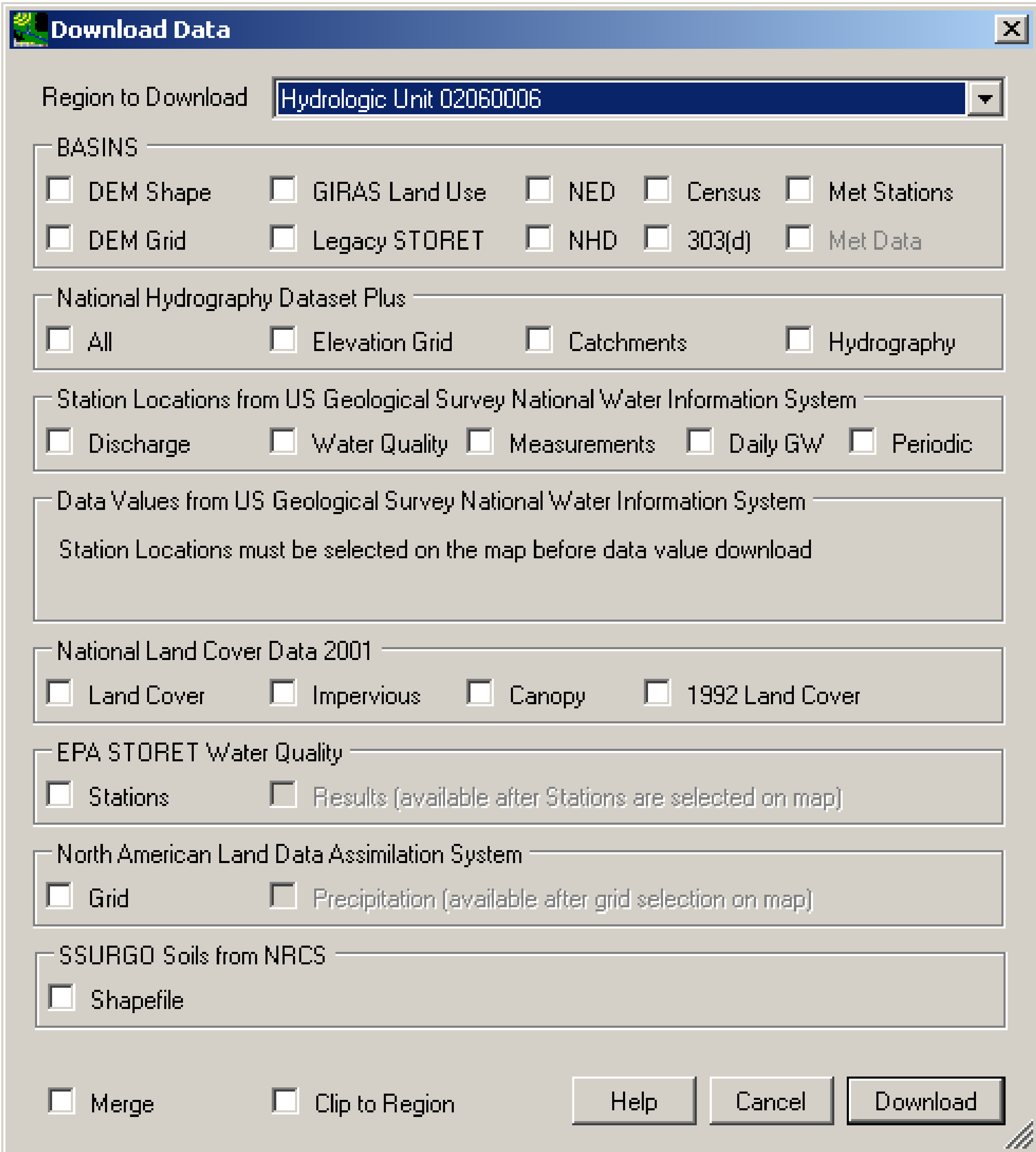
Time Series	
	• Meteorological Datasets in WDM format • USGS (NWIS) Daily Streamflow • USGS (NWIS) Water Quality • USGS (NWIS) Streamflow Measurements • USGS (NWIS) Instantaneous Data Archive (IDA) Discharge • NLDAS Hourly Meteorological Data
Note:	The BASINS system can read time-series data stored in a variety of file formats, which are detailed in the Time-Series Types section of this documentation. All time-series data must be converted into one of these formats before it can be brought into a BASINS project.

Once downloaded, data may be managed using an array of GIS Utilities and Time-Series Management Utilities. Download Data

The user may download a wide range of GIS and time-series data in several easy steps via the **File:Download Data** menu item.

Key Procedures

Select **File:Download Data** from the main menu, and the **Download Data** form appears.



- Choose the Region to Download. Region options include the project's Hydrologic Units, the View Rectangle, and the Extent of the Selected Layer.
- Select the checkboxes of the data types you wish to download, then click the **Download** button.

- There will be a pause while the requested data files are downloaded from the internet and projected, merged, and clipped as needed. When the process is complete, the **Download Data** form will disappear and user control will return to the main BASINS GIS interface.
- Once GIS data has been downloaded, it becomes available in the table of contents on the left side of the main BASINS form. Time-series data becomes available for use via the Time-Series Management Utilities. A log file containing details of the download and processing is written to the BASINS cache log folder.

  Note: The **Merge** and **Clip to Region** check boxes, rather than specifying data types, specify particular options for how downloaded data is added into the project. Merge can be useful for GIS data types that are available for download as individual regions. Selecting Merge will create one GIS layer from individually downloaded regions. Thus if a BASINS project includes multiple HUCs, using this option when the data is downloaded it will be merged into a single data layer. Merge is currently implemented only for NHD Plus data.

  The 'Clip to Region' option can be useful for download types where a larger area than is selected must be retrieved. If Clip is not selected, the layer will be added to the project as it was downloaded. Selecting Clip will remove parts of the downloaded layer outside the region of interest before adding the layer to the project. Clip implemented for NHD Plus and BASINS data types. Other data types are downloaded by rectangle and are not affected by Clip and Merge.

  Data types are grouped within a series of frames on this Download Data form:

  BASINS

  The types within the BASINS group include datasets that have been pre-processed for BASINS and are stored on an EPA server for download. See BASINS Data Types for more details on the data types available through the BASINS group.

  NHD Plus

  Within the National Hydrography Dataset (NHD) Plus group are options to download the elevation grid, catchments shapefiles, hydrography shapefiles, plus an option to download all NHDPlus layers (NHDPlus v1.0 and v2.1). The grids are large files and take some time to reproject. Value Added Attributes (VAAs) are added to the shapefile attribute tables. Once downloaded, these data will be projected and made available in the BASINS GIS interface.

  USGS Stations from NWIS

  The 'Station Locations from US Geological Survey National Water Information System' options download station locations for the selected station types. Station locations are available for 'Daily Discharge', 'Water Quality', 'Measurements' and 'Ground Water'. The downloaded station locations are made available on the BASINS map as shapefiles by data type.

USGS Data from NWIS

The 'Data Values from US Geological Survey National Water Information System' options download data values collected at the selected USGS station locations. Station locations to retrieve data from must first be downloaded and then individual stations must be selected on the map before downloading data values. Choose the station location type where the data of interest is collected

- Click Download to get the station layer
- Select the station layer in the legend
- Use the Select Tool from the toolbar (looks like a small arrow and a dashed box) to select which stations to get data from
- Open the Download Data form again. The type of data will be automatically selected based on the stations that are selected on the map.
- Click Download again to get the data.
- After downloading, data values are stored in the NWIS folder within the BASINS project. These timeseries become part of the BASINS project.

National Land Cover Data (NLCD)

The 'National Land Cover Data' group is used to download GIS layers from the NLCD dataset. Layers from the 2001, 2006 and 2011 dataset available for download include the land cover, impervious, and canopy grids. The 1992 Land Cover grid from NLCD is also available for download. Once downloaded, the grids will be projected and loaded onto the BASINS map.

North American Land Data Assimilation System

Hourly Meteorological Data from NLDAS (North American Land Data Assimilation System) Phase 2 can be added to the BASINS project using these options. The 'Grid' option should be used first to download and display the NLDAS station locations. When this option is used, 2 shapefiles will be added to the map in the Observed Data Stations group: "NLDAS Grid Center" is a layer of points at the center of each grid cell, and "NLDAS Grid" is a layer of outlines of each grid cell.

The 'Hourly Data' option is available after one or more NLDAS grid locations are selected on the map. When either NLDAS Grid layer is selected in the legend, and one or more grid cells are selected using the Select tool, the 'Hourly Data' option downloads the NLDAS time series and either reads the data in the downloaded format or imports it into a WDM file. To use the data in HSPF, adding to a WDM file is needed. On this screen, the user has the option to change the time zone from UTC to a project specific time zone.

BASINS Data Types **DEM Shape** provides a shapefile layer of elevations useful for performing watershed delineation. Once downloaded, the data will be projected and automatically added to the

BASINS project. It will then be available as a map layer to display in the BASINS GIS interface.

DEM Grid (DEMG) and National Elevation Dataset (NED) provide grid data that can be used for various BASINS functions including automatic watershed delineation.

GIRAS Landuse data provide land use tiles from the USGS GIRAS Landuse database covering the selected HUC. Once downloaded, these data will be projected and made available to add to the BASINS View in the BASINS GIS interface.

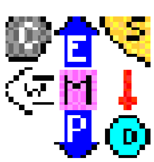
National Hydrography Dataset (NHD) provides a shapefile layer of stream channel data. This BASINS shapefile is a combination of the route feature class and flow relationships table from the NHDinARC version of the NHD. Once downloaded, the layer will be projected and made available within the BASINS GIS interface.

Census provides boundary layers and associated tabular data from the 1990 and 2000 Census of Population, as well as the TIGER line files showing roads, railroads, and other linear features. Once downloaded, these data will be projected and made available in the BASINS GIS interface.

Meteorologic downloads BASINS Meteorological data from the updated BASINS Meteorological database (Version 2009) and creates a shapefile of the locations of that data. The updated database contains data at over 16,000 stations, though not all stations are still active and most of them contain only a subset of all the meteorological constituents used in BASINS. For those stations that are current, data have been updated through the year 2009.

After downloading is complete, a new GIS layer (�Weather Station Sites 2009�) is added showing the location of the stations. This layer is stored as a shape file (met.shp) in the BASINS project directory. All stations within the current view are downloaded and merged into a single project WDM file. The resulting WDM file is by default stored in the BASINS project directory (e.g. \BASINS\Data\Project Name\met\met.wdm). This default location can be changed using the folder button next to the Meteorologic checkbox in the Download Data form. The new WDM file is automatically added to the current project.

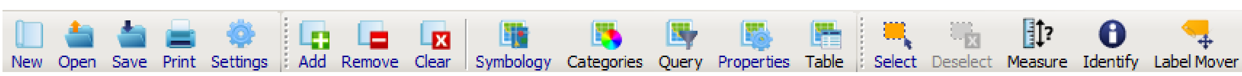
The BASINS GIS interface has been updated to display a suite of distinct icons to graphically represent which constituents are available at each meteorological station.



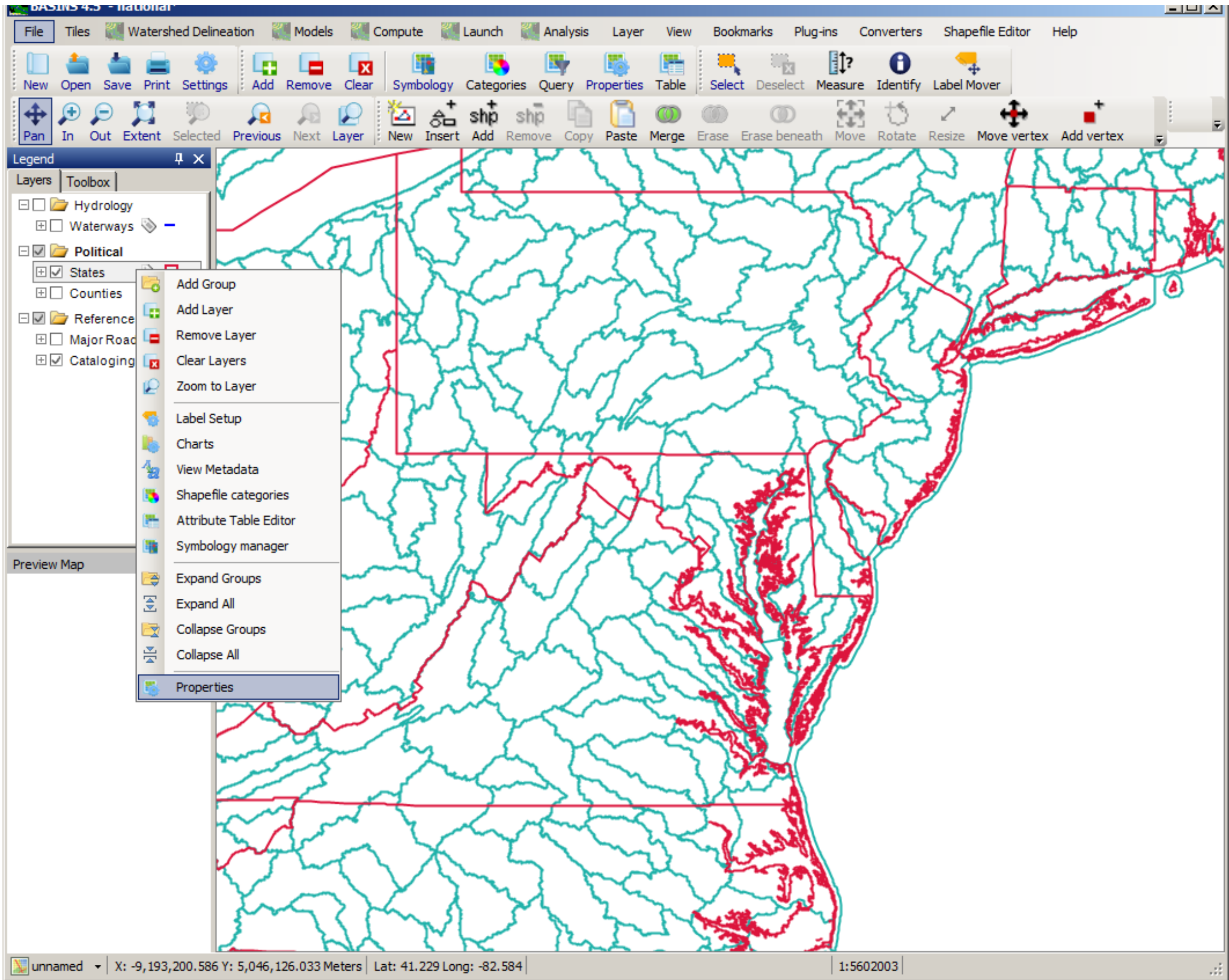
With each station marked by the letter M, the seven available constituents are represented at the following positions in relation to the station center:

- Precipitation (PREC) - due South
- Wind speed (WIND) - due West
- Cloud Cover (CLOU) - North West
- Potential Evapotranspiration (PEVT) - due North
- Solar Radiation (SOLR) - North East
- Air Temperature (ATEM) - due East
- Dewpoint Temperature (DEWP) - South East

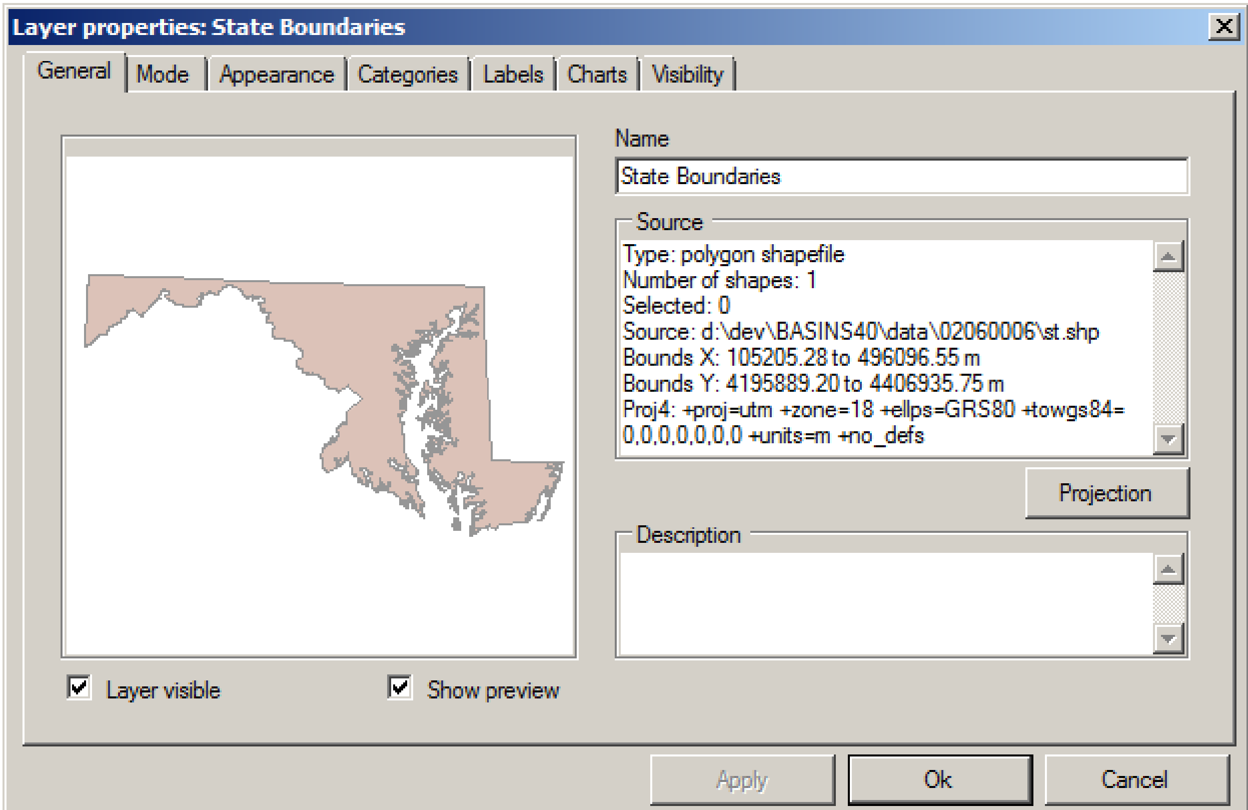
An enhancement for BASINS 4.5 allows direct download and/or calculation of this full suite from the North American Land Data Assimilation System (NLDAS) gridded data set. Published by NASA, NLDAS runs in near real-time on a 1/8th-degree grid over central North America, with retrospective NLDAS datasets extending back to January 1979. This enhancement not only allows direct download of this data for a specified region but also facilitate creation of HSPF models driven by this gridded data.
GIS Utilities The main BASINS form contains a MapWindow toolbar that allows the user to manage GIS layers. The standard toolbar consists of icons that allow the user to: open, save, or start a new project; print the current map display; add or remove layers; and pan, zoom, select, and measure distance on the map display. The standard toolbar appears as follows.



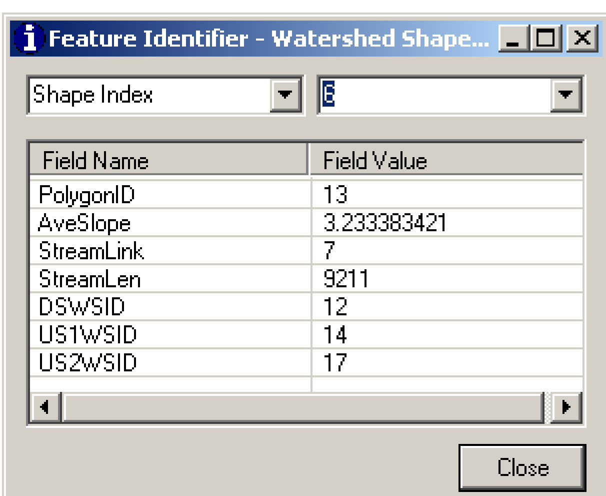
- **Legend Editor** allows the user to change the appearance of individual map layers, such as which layers will be labeled on the MapWindow display, which attribute will be assigned as the label, as well as font settings and extent relative to the display. The **Legend Editor** is accessible by highlighting the name of a layer on the main BASINS screen to make it active, right-clicking on the layer, and selecting **Properties**.



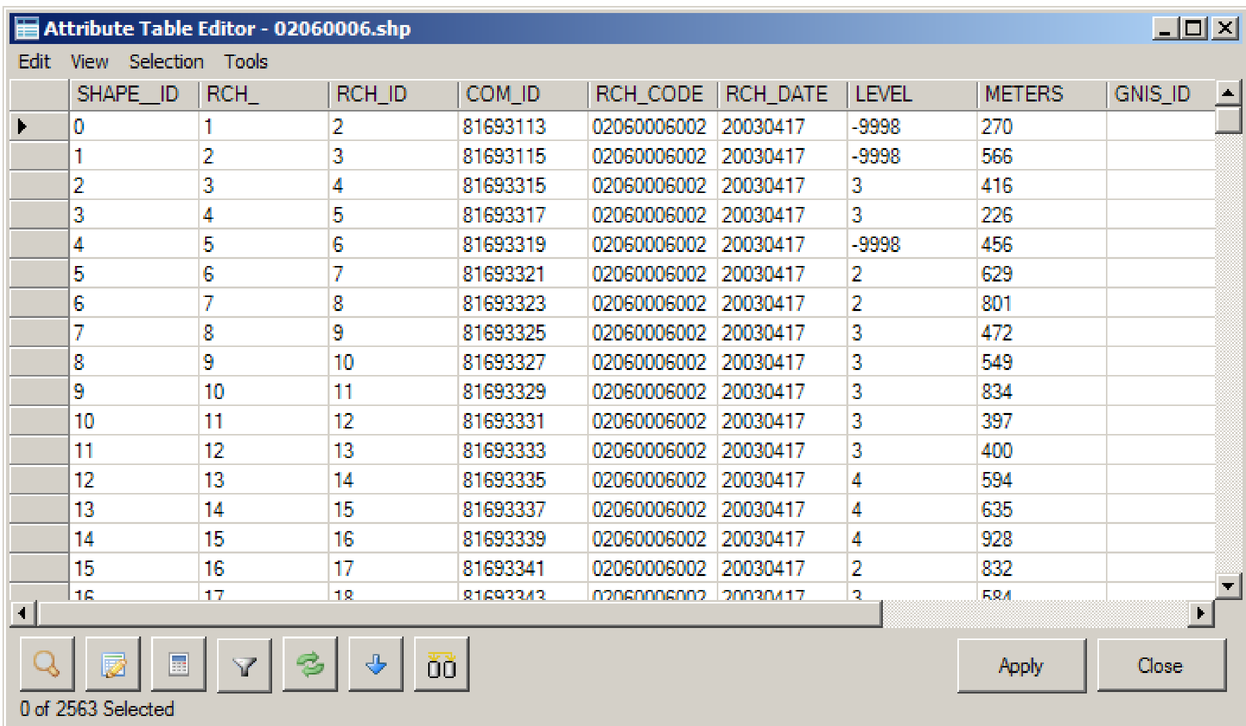
From the **Legend Editor**, the user can alter **Layer Properties, Legend Properties, and Symbology**.



- **Identifier** uses the  icon on the main form. Highlight the layer of interest (click on the layer name to make it active). Then, when the icon is clicked and an area of the active layer selected, the **Feature Identifier** window will pop up displaying a list of attributes for that area.



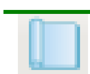
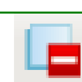
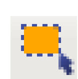
- **Table Editor** uses the  icon on the main form. When clicked, the DBF table associated with the active layer is displayed on the **Attribute Table Editor** form where attribute values can be modified.

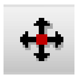


SHAPE__ID	RCH_	RCH_ID	COM_ID	RCH_CODE	RCH_DATE	LEVEL	METERS	GNIS_ID
0	1	2	81693113	02060006002	20030417	-9998	270	
1	2	3	81693115	02060006002	20030417	-9998	566	
2	3	4	81693315	02060006002	20030417	3	416	
3	4	5	81693317	02060006002	20030417	3	226	
4	5	6	81693319	02060006002	20030417	-9998	456	
5	6	7	81693321	02060006002	20030417	2	629	
6	7	8	81693323	02060006002	20030417	2	801	
7	8	9	81693325	02060006002	20030417	3	472	
8	9	10	81693327	02060006002	20030417	3	549	
9	10	11	81693329	02060006002	20030417	3	834	
10	11	12	81693331	02060006002	20030417	3	397	
11	12	13	81693333	02060006002	20030417	3	400	
12	13	14	81693335	02060006002	20030417	4	594	
13	14	15	81693337	02060006002	20030417	4	635	
14	15	16	81693339	02060006002	20030417	4	928	
15	16	17	81693341	02060006002	20030417	2	832	
16	17	18	81693343	02060006002	20030417	3	584	

An array of additional GIS utilities is available via the **Plug-in** menu.

The following table details all of the MapWindow tool bar items that are available in the BASINS Customized MapWindow Interface.

	Open New Project		Open Existing Project		Save Current Project
	Print Map Display		Add Layer		Remove Layer
	Remove All Layers		Pan		Select

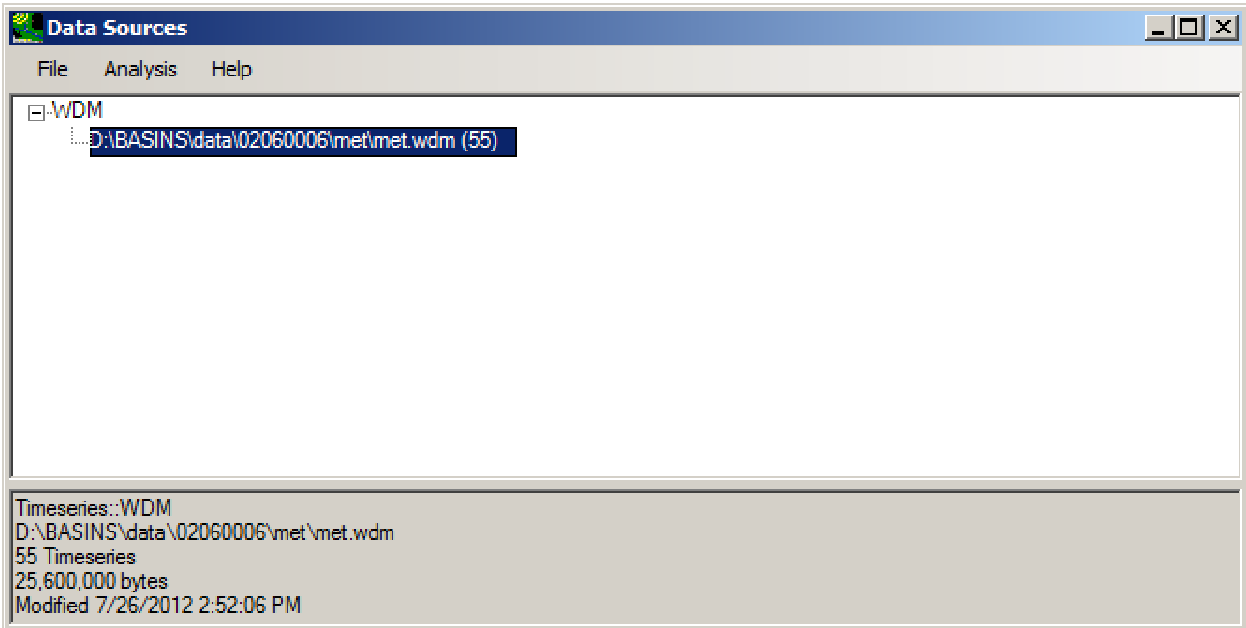
	Measure Distance or Area		Zoom In	.	.
	Zoom Out		Zoom to Extent		Feature Identifier
	Move Vertex		Table Editor		Add New Shape to Current Shapefile
	Remove Shape from Current Shapefile		Create New Shapefile		Add Vertex to Existing Shapefile
	Remove Vertex from Existing Shapefile	.	.	.	.

Visit the MapWindow web site for complete documentation on that program.

For further instructions and videos about using MapWindow, consult MapWindow Tutorials (*Note*: .pdf documents must be opened in a separate window). Time-Series Management Data files and their time series can be managed via the **File** menu on the main form. There are five items on that menu that execute various data management utilities. Simply make the desired selection(s) from the pop-up form associated with each menu item.

Menu Item	Utility
New Data	Creates a new WDM file for data storage. Time series can later be saved to this file with the **Save Data In** menu item.
Open Data	Opens a data file for inclusion in the current BASINS project. The data file type can be one of the available depending upon the plug-ins loaded. See Time-Series Types for more details.
Download Data	Download additional GIS or timeseries data from the internet.
Save Data In	Browse for time series in the current BASINS project and save that data to a selected WDM file.
Manage Data	Open or close any of the available data file types to include/exclude that data file in/from the current BASINS project. See below for more details.

The **Manage Data** menu item produces the ‘Data Sources’ form for managing the time series data sources available in the project. The top pane of the 'Data Sources' form shows each time-series data source in the project. Clicking on one of the file names produces a summary of the timeseries in that file in the bottom pane.



From the **File** menu, additional data sources may be opened, and data sources that are currently opened may be closed.

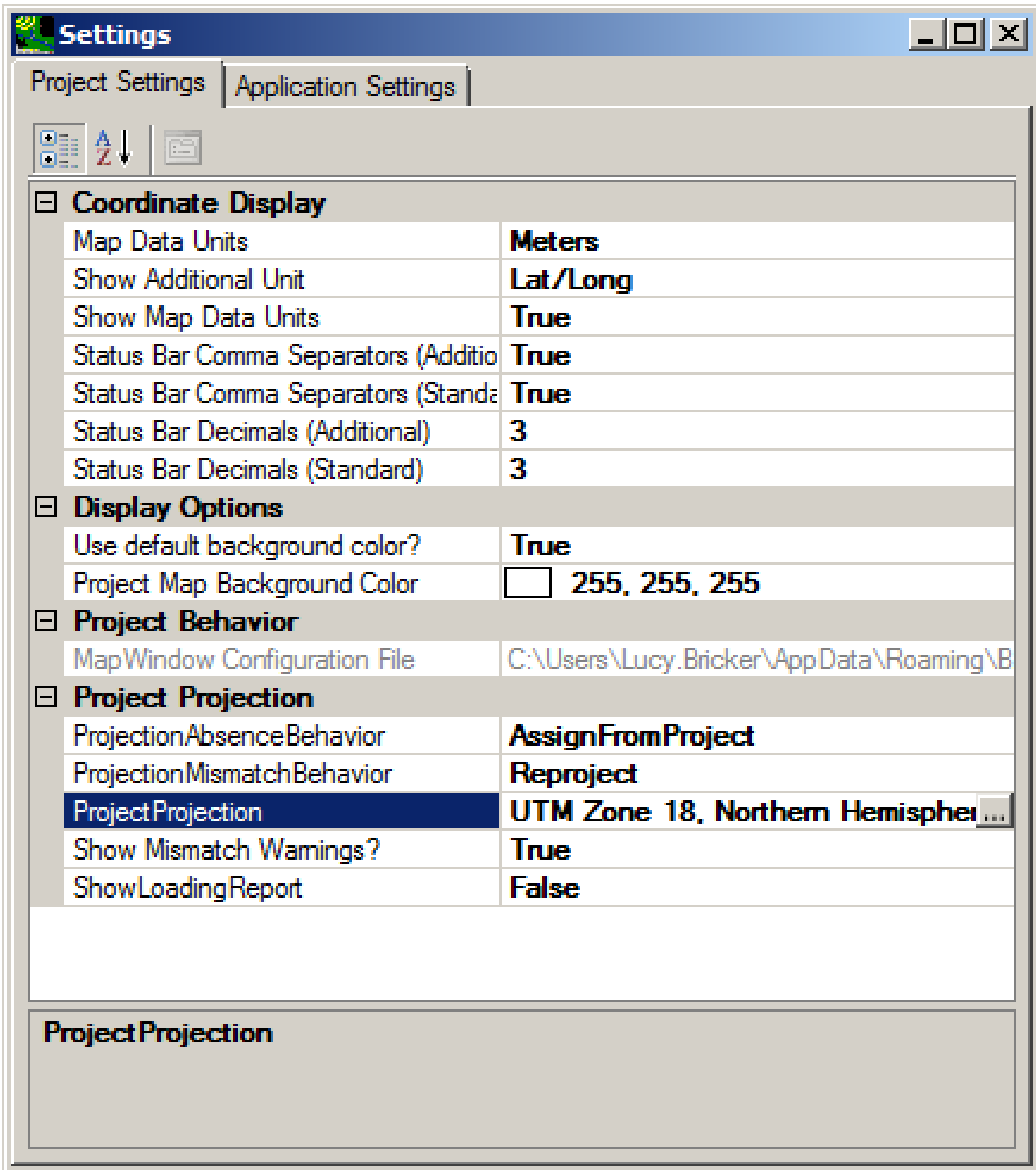
The **Analysis** menu provides access to the BASINS Analysis tools. Choosing a menu item in the Analysis menu will perform that analysis on all timeseries in the selected data source.   Map Projections A map projection is a mathematical expression used to transform the earth's curved terrain to a flat surface. When a user creates a GIS project, the projection must be specified so that the software knows how to represent the three-dimensional surface of the earth on a flat, two-dimensional map. Any map projection causes some degree of distortion to one or more map properties, such as area, distance, scale, or shape. Within MapWindow GIS and BASINS, hundreds of map projections are available. It is up to the user to choose one of these projections for the BASINS project.

Within BASINS the user is asked to choose a projection during the Build BASINS Project process. This projection will be used throughout the BASINS project. When data is added to the project through the BASINS Data Download tool, BASINS will automatically re-project the data into the specified projection.

MapWindow also has projection capabilities. The following section describes MapWindow's capabilities with regard to map projections.

The first layer that the user adds to a new MapWindow project will be checked for projection data (an ESRI-style ".prj" file containing Well-Known Text (WKT) projection information). If a .prj file is found, the

MapWindow project will adopt that projection. This information can be viewed under the file/settings menu.

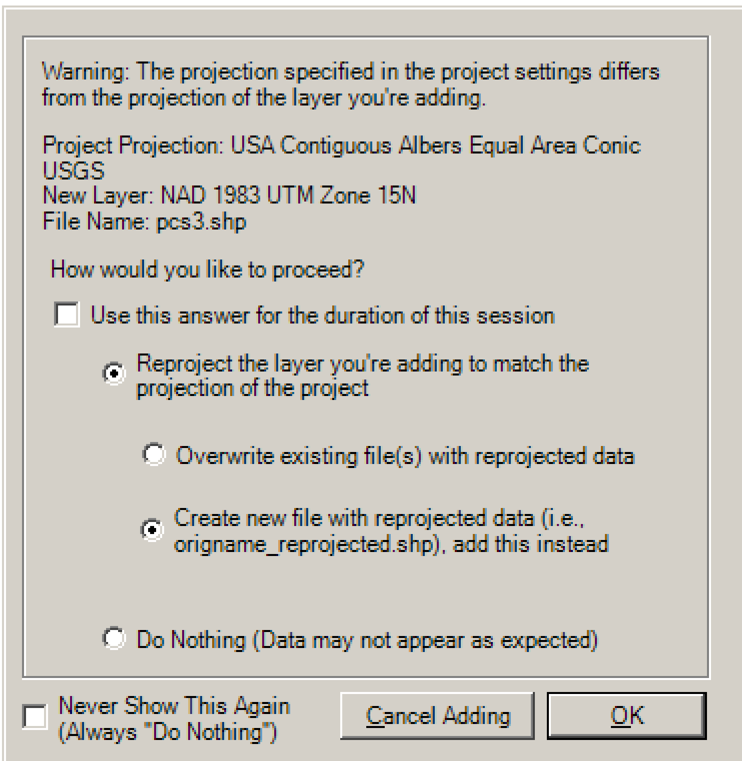


Projection Mismatch

When additional layers are added, if they are in the same projection, they simply load.

If they are in a different projection, then the user is asked how they would like to handle the situation. The default is to reproject the new layer to the projection of the originally added layer (the “project projection”).

The user can also set up BASINS to automatically reproject into project projection for the rest of the session.

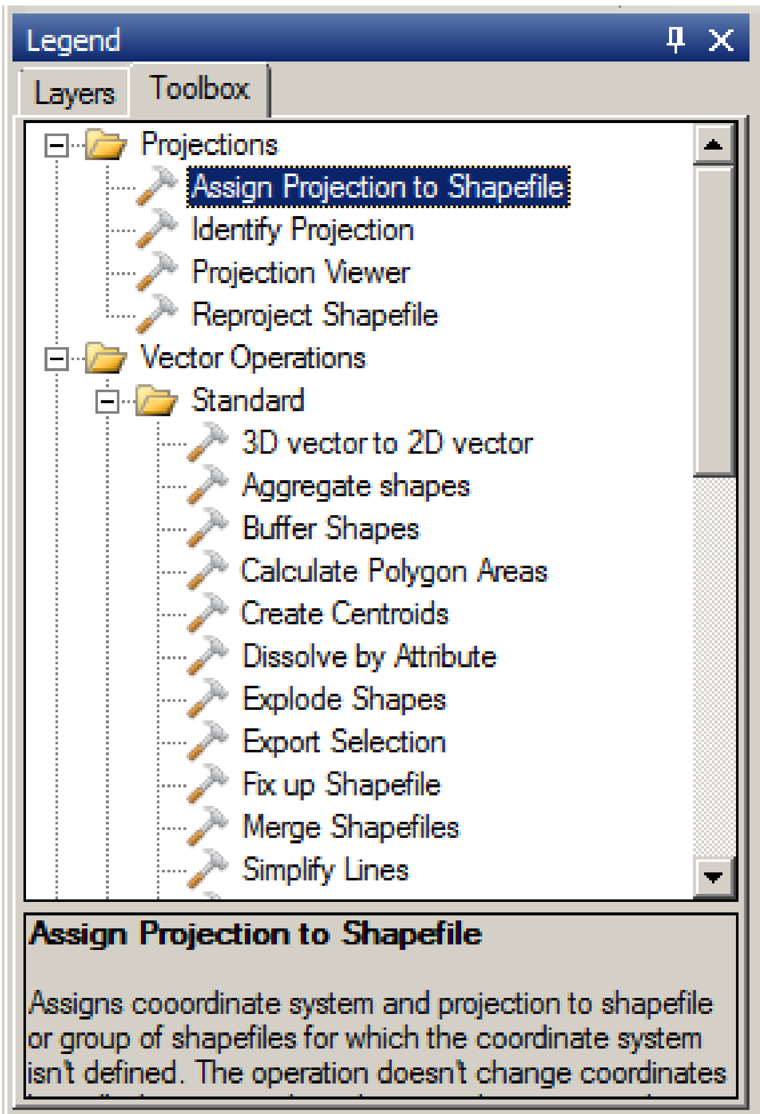


Note: MapWindow does not support on-the-fly projection because it gives the user a false sense of the data being in a projection which it is not in. This is a situation that is suitable for viewing, but problematic for modeling. Instead, MapWindow provides a facility to warn the user when data with mismatched projections are added to the same project. The user is then prompted to optionally reproject the data such that all data is in the same projection, or proceed with the disclaimer that data may not appear as expected.

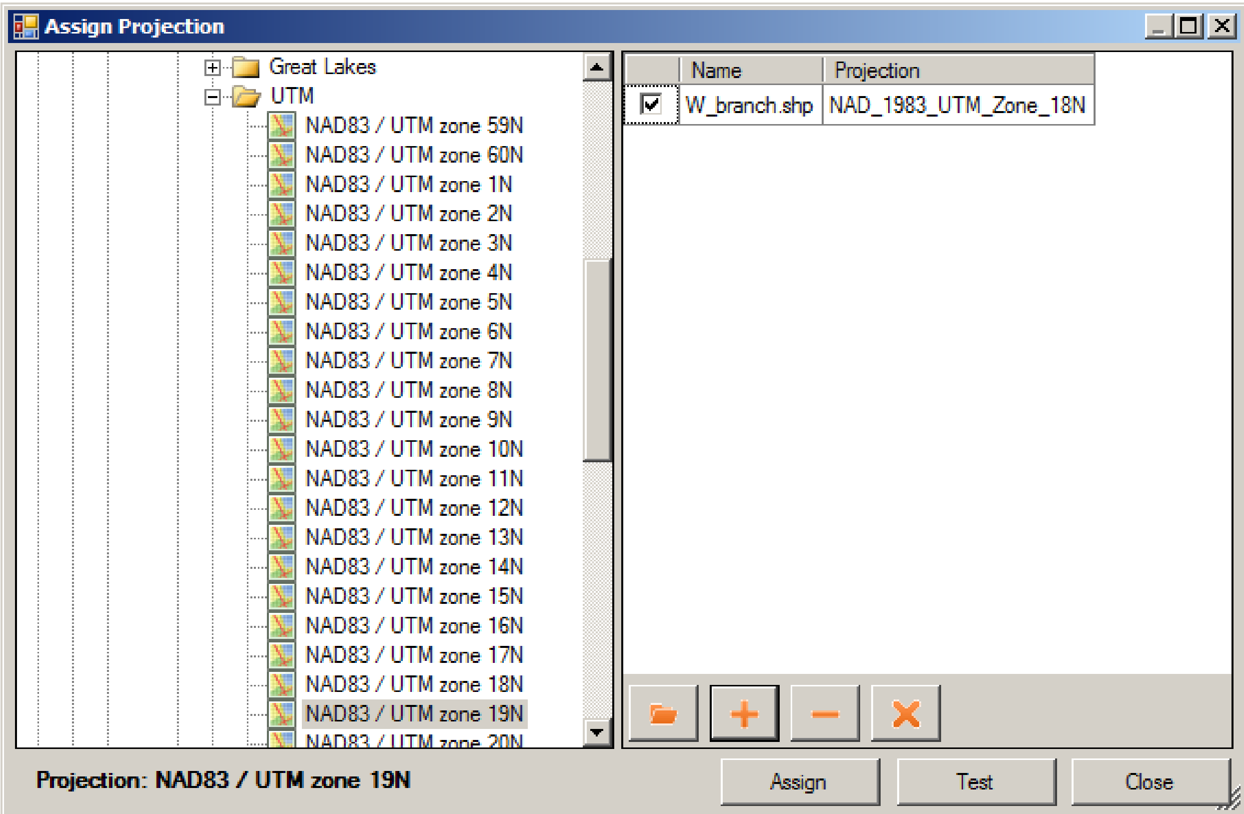
Assigning Projections

In the main BASINS window, in the Legend pane, click on the ‘Toolbox’ tab.

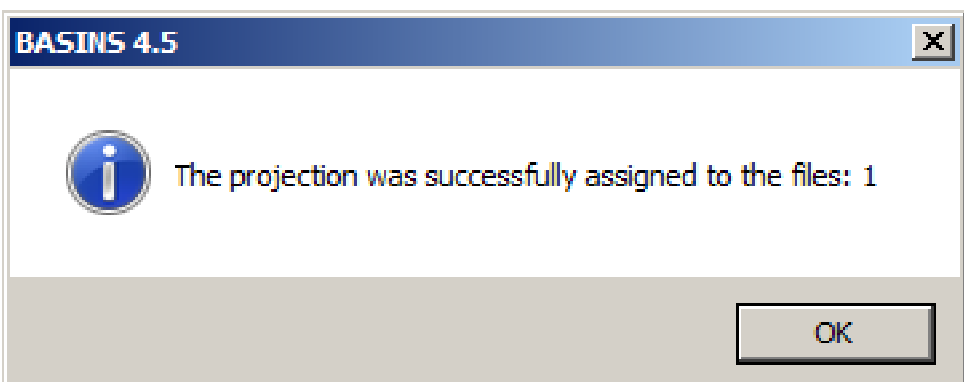
- Select **Assign Projection to Shapefile**.



- A dialog will open where the user can specify the desired projection and the layer(s) to which to assign the projection. Click **Assign** when ready.



- Click **Ok** on the following screen:



-

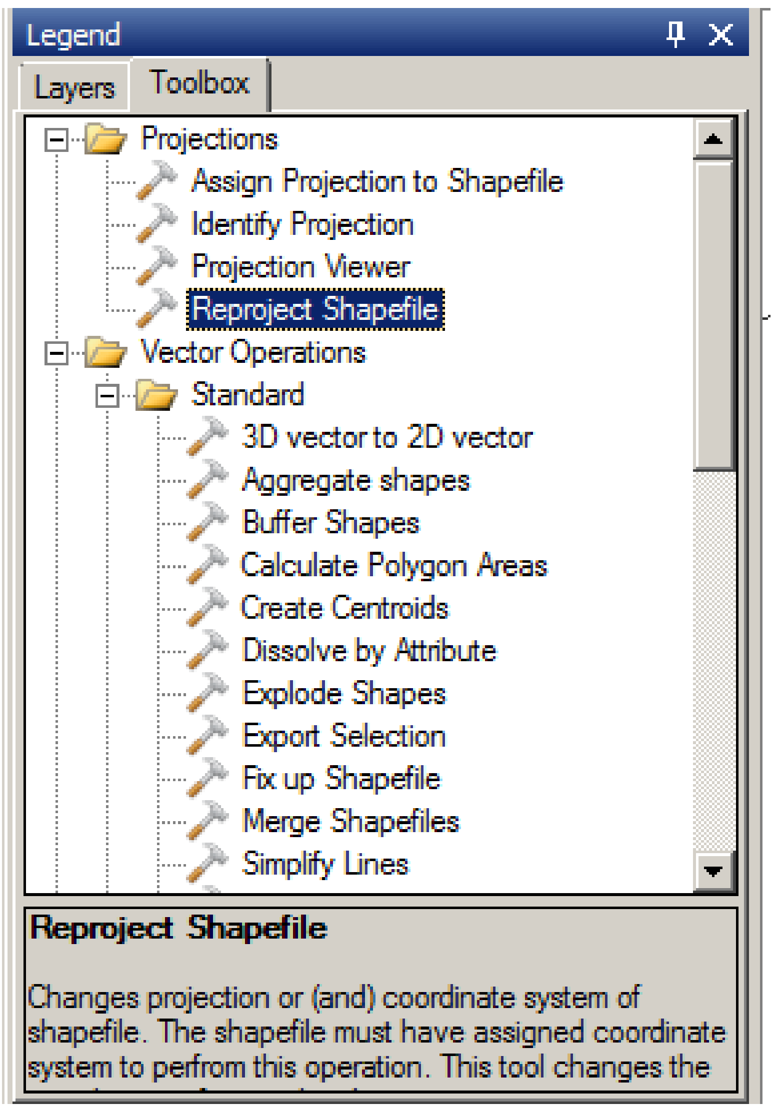
Reprojections

MapWindow allows the user to reproject files, or place them in a new spatial reference system from the currently used reference system, for modeling and mapping. All data for modeling is typically kept in the same projection.

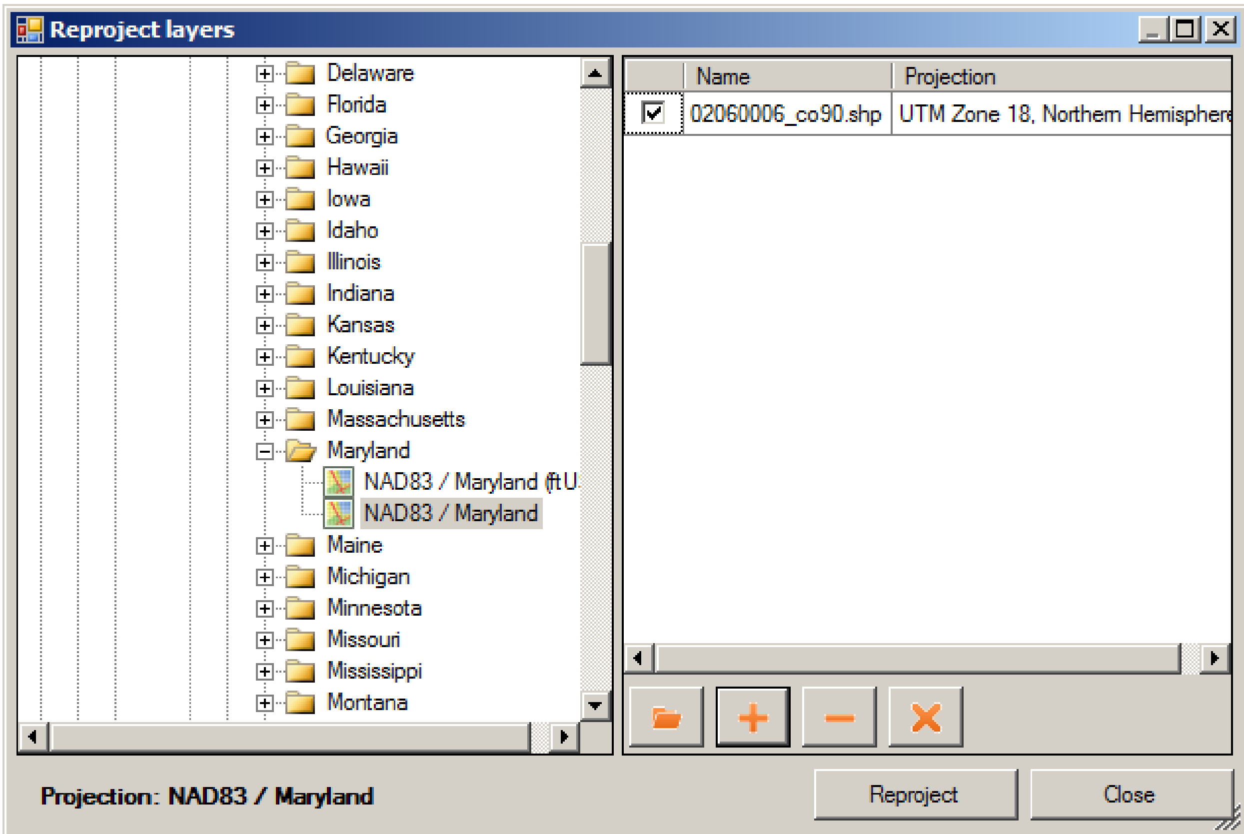
To reproject a shapefile:

In the main BASINS window, in the Legend pane, click on the ‘Toolbox’ tab.

- Select **Reproject Shapefile**.

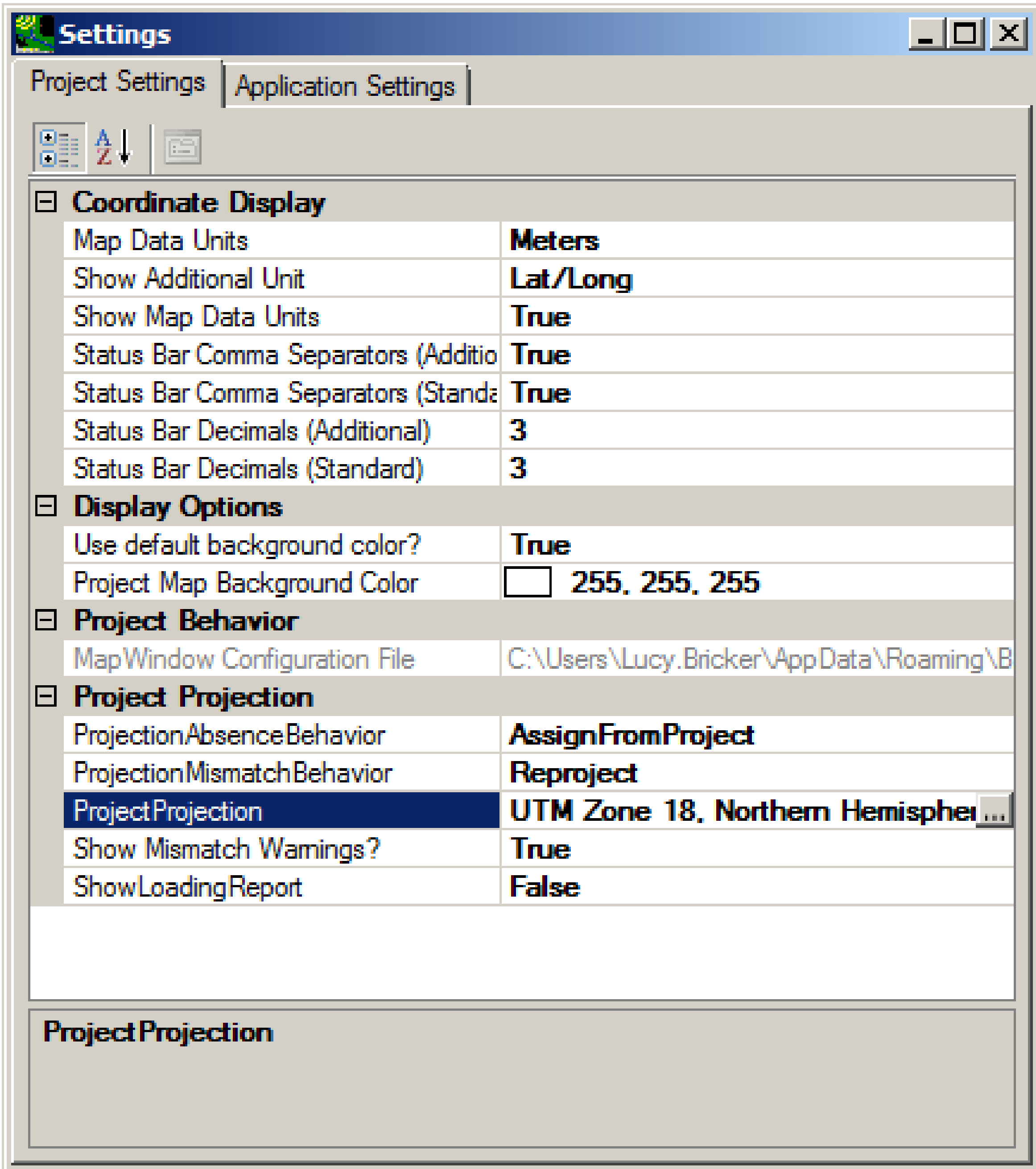


- A dialog will open where the user can specify the desired projection and the layer(s) to reproject. Click **Reproject** when ready.

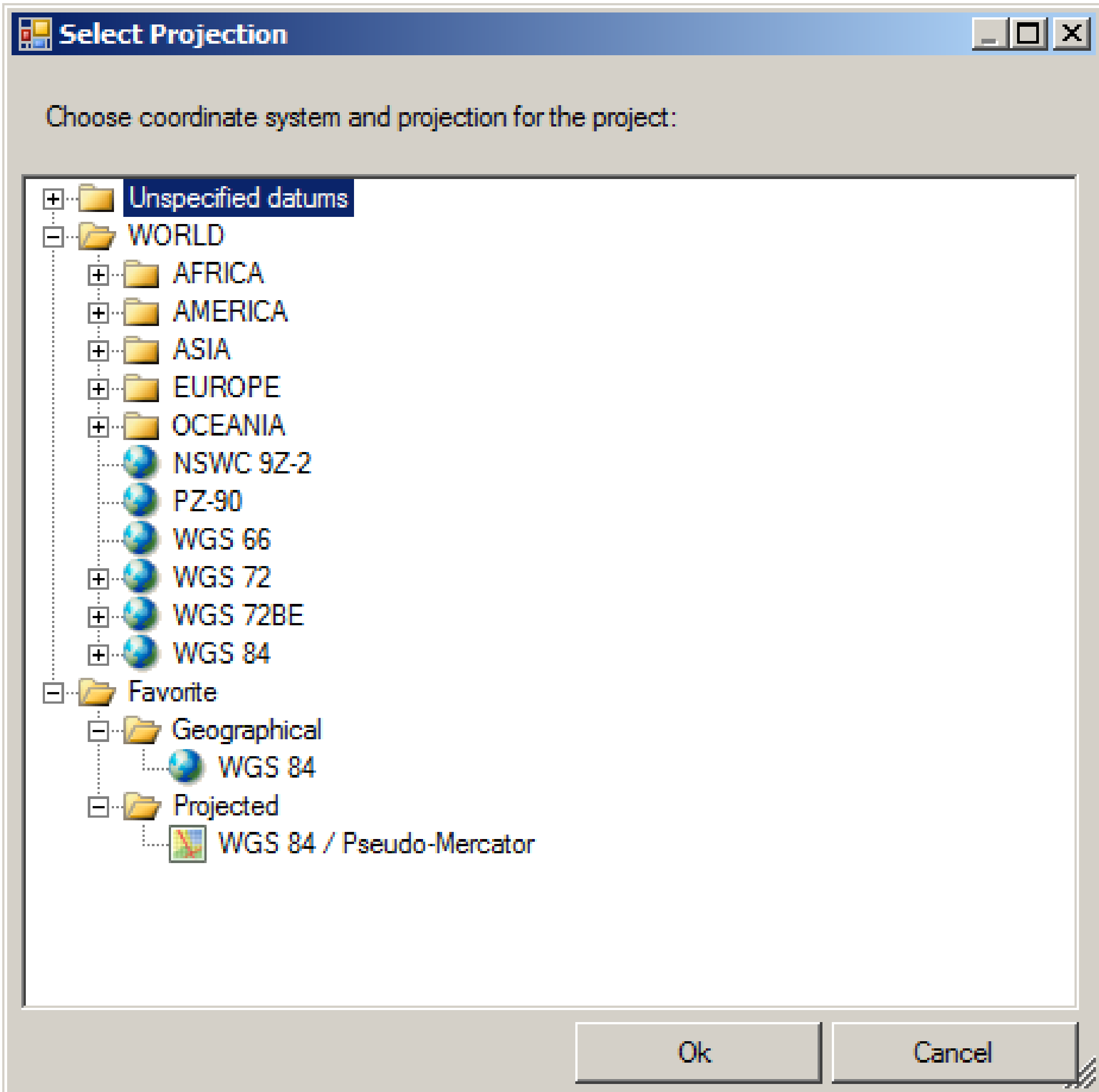


- *Projection Name Correction*

  In order to change the name of the projection, go to **File:Settings** on the main BASINS window.

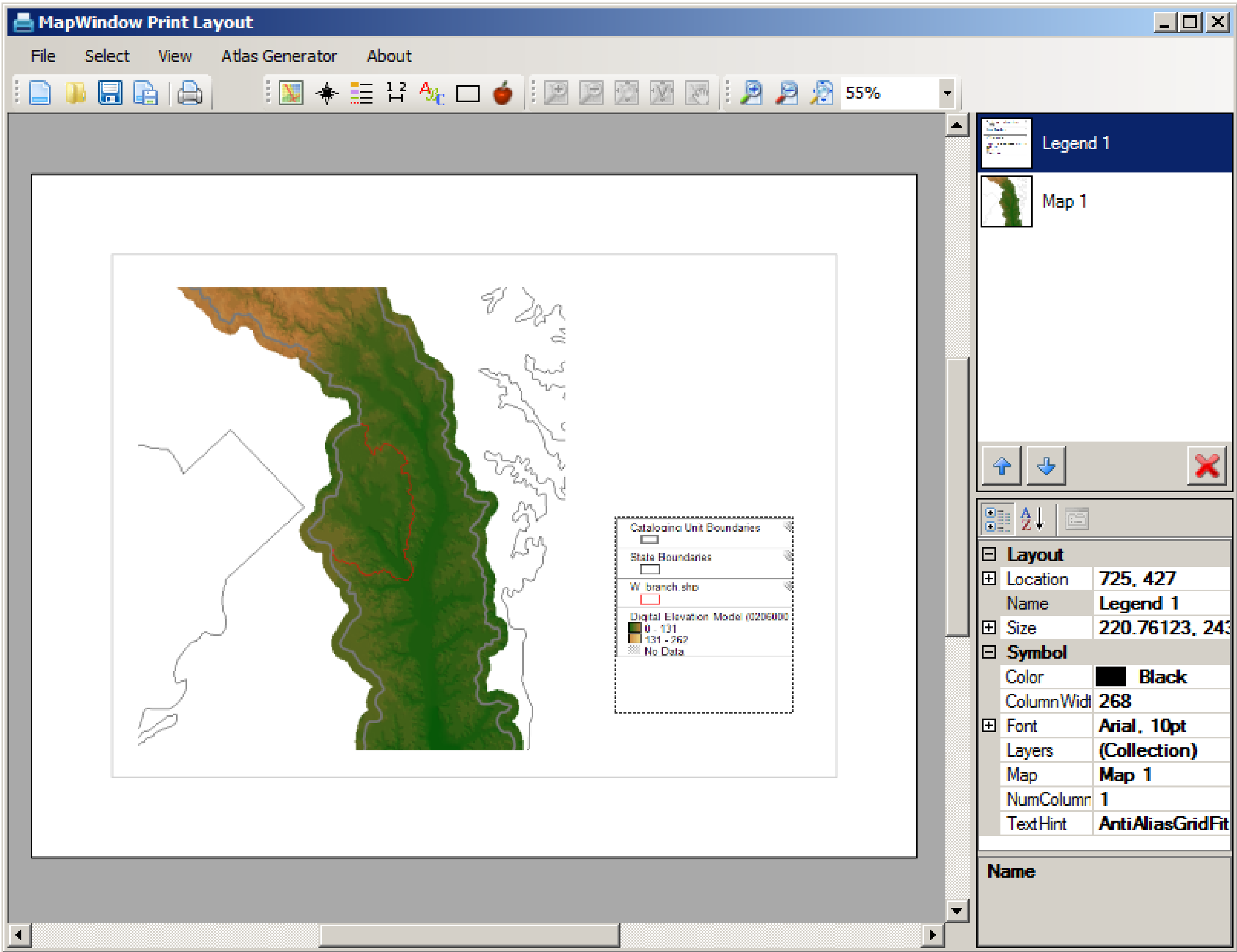


The name of the current project projection can be adjusted by clicking on the "..." button and then specifying the desired projection on the form that follows.

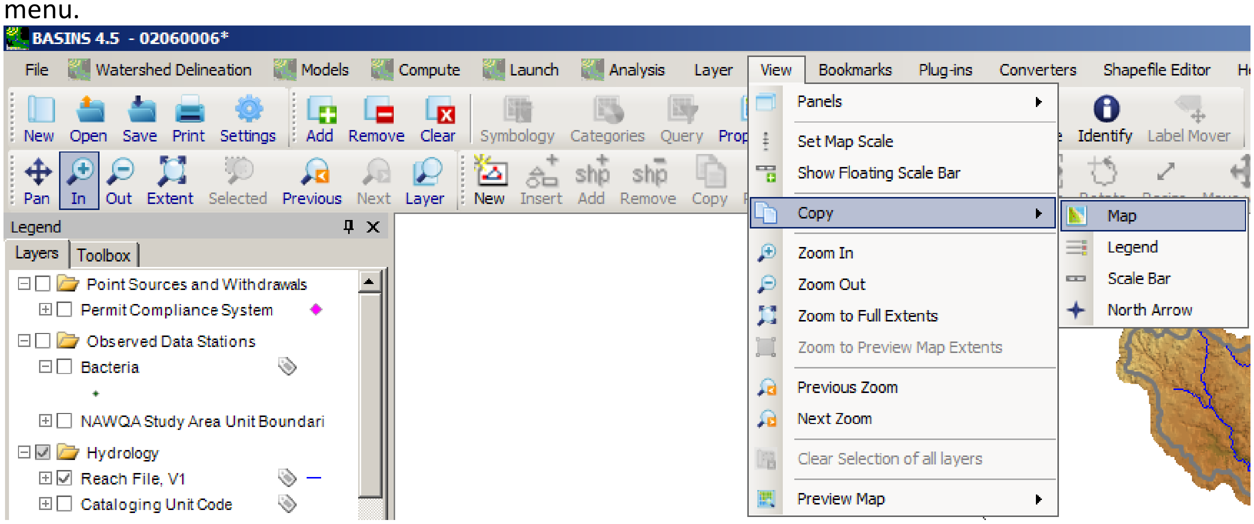


(For more information about the **Projection Parameters** utility, see Projection Parameters)

- Hard Copy and Exporting *Hard Copy* In order to print the current map view, select **File:Print** from the main BASINS toolbar. The MapWindow Print Layout form will pop up, which allows the user to select what map elements to display, create the layout of those elements, and then send that image to a printer.



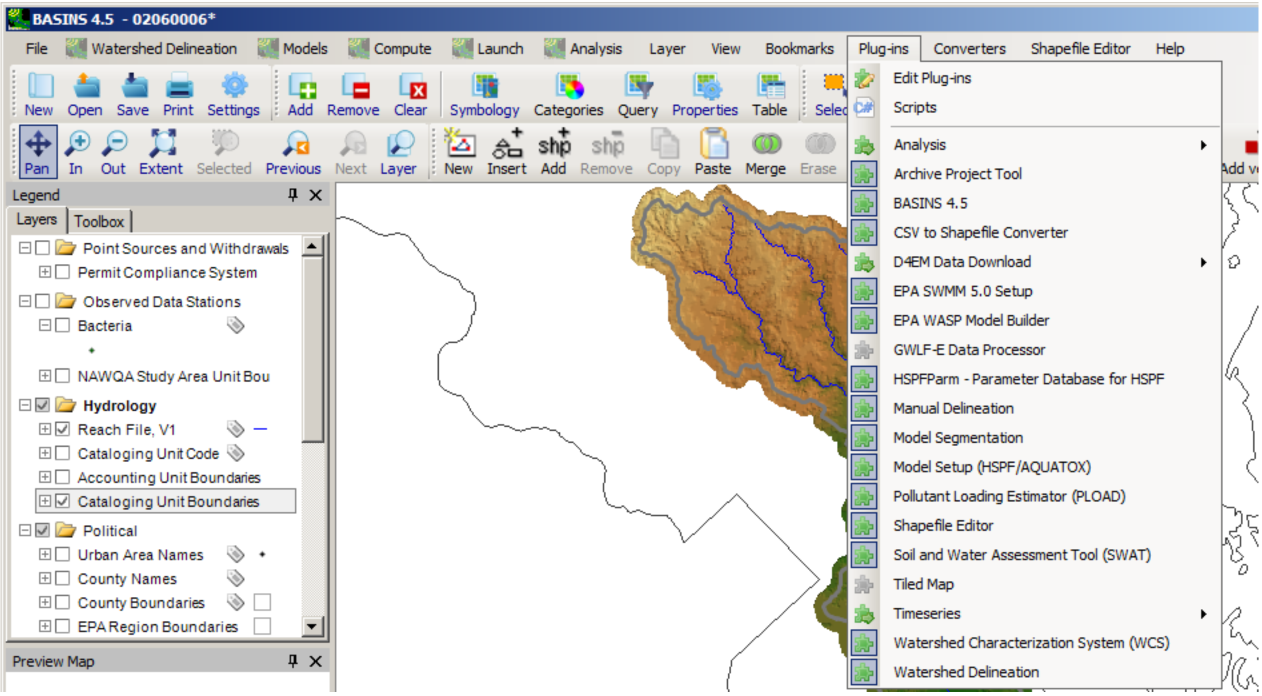
Exporting The user may export a map image as a bitmap (.BMP) or graphic interchange file (.GIF), for instance to include within a word processing document. Select **View:Copy** from the main BASINS menu.



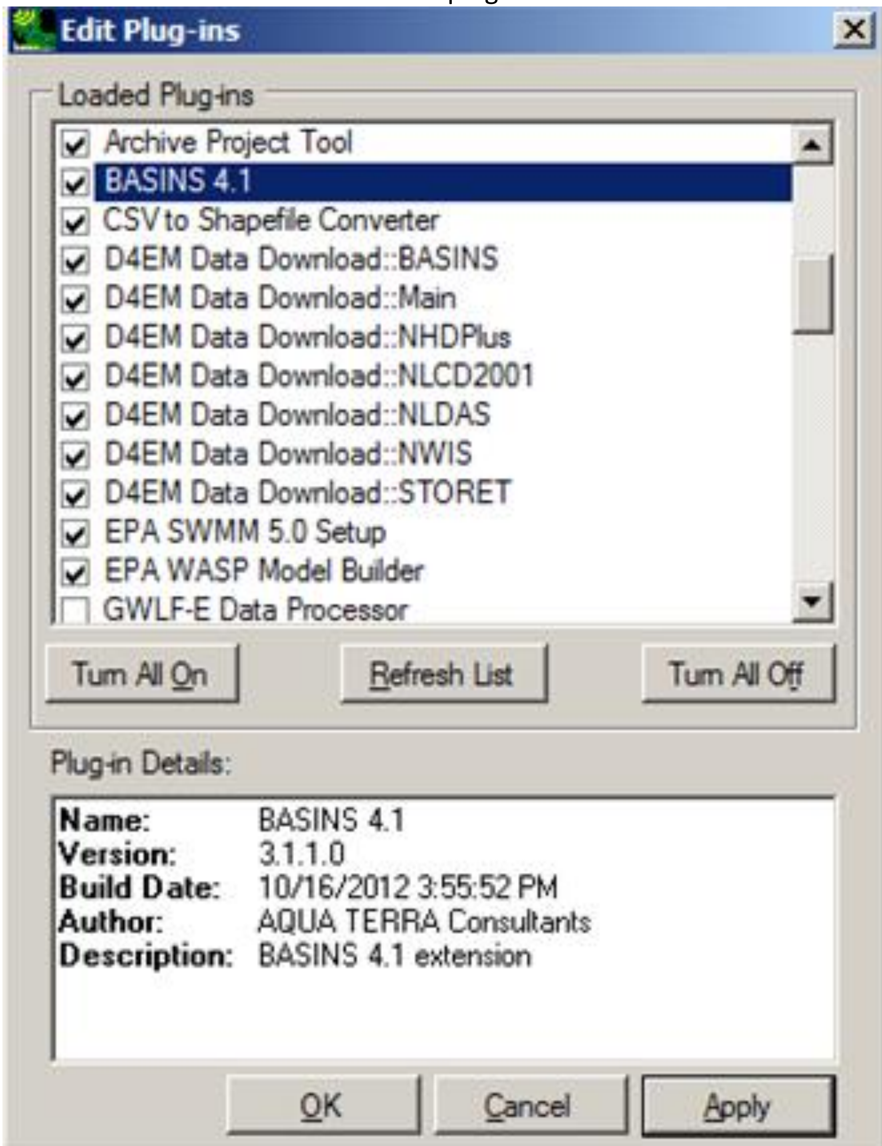
The user will then be presented with a dialog asking where to save the file. The user may export a scale bar by selecting the View menu, then Copy, then Scale Bar. This will prompt the user for a location to save the resulting image file. This file could then be used in word processing or publishing software. Lastly, the user may export a north arrow by choosing the View menu, then Copy, then North Arrow. This also will prompt the user for a location to save the image.

Plug-ins

Plug-ins are modular and extensible software programs that interact with the host program to provide additional functions via the host program's user interface. The functionality of plug-ins is as varied as the software programs which they support. There are hosts of plug-ins available for BASINS, and they can be accessed via the **Plug-ins** item on the main menu.



To edit the selection of plug-ins currently available, select the **Edit Plug-ins** option on the **Plug-ins** menu. This sets the default of which plug-ins are activated.



The BASINS plug-in provides essential and additional functionality for BASINS 4.5. The D4EM Data Download plug-ins provide the functionality for downloading spatial and timeseries data (See Download Data for more details). The other plug-ins provide additional GIS, time series, model setup, and analysis, and computation utilities.

Type	Name
GIS	GIS Utilities GIS-Related Plug-ins Identifier Legend Editor Shapefile Editor Table Editor Watershed Delineation Plug-ins
Time Series	Time Series Types Time Series Operations

Model Plug-ins	HSPFSWATWASPSWMMAQUATOXPLOAD GWLF-E (Plug-ins are separately for installation)
Analysis Plug-ins	Cligen Climate Assessment Tool (installed with HSPF plug-in) Data Tree DFLOW Graph List Lookup Tables Reclassify Land Use Seasonal Attributes Synoptic USGS Surface Water Statistics Watershed Characterization Reports Watershed Characterization System
Compute Plug-ins	Statistics Generate Timeseries Seasons Meteorologic Generation Events
Other	Archive Project

Note: Data for Environmental Modeling, or D4EM, is a comprehensive set of tools that obtains and processes data to be used in computational environmental models. The software enables users to download data from various websites, and then processes the data to create model inputs.

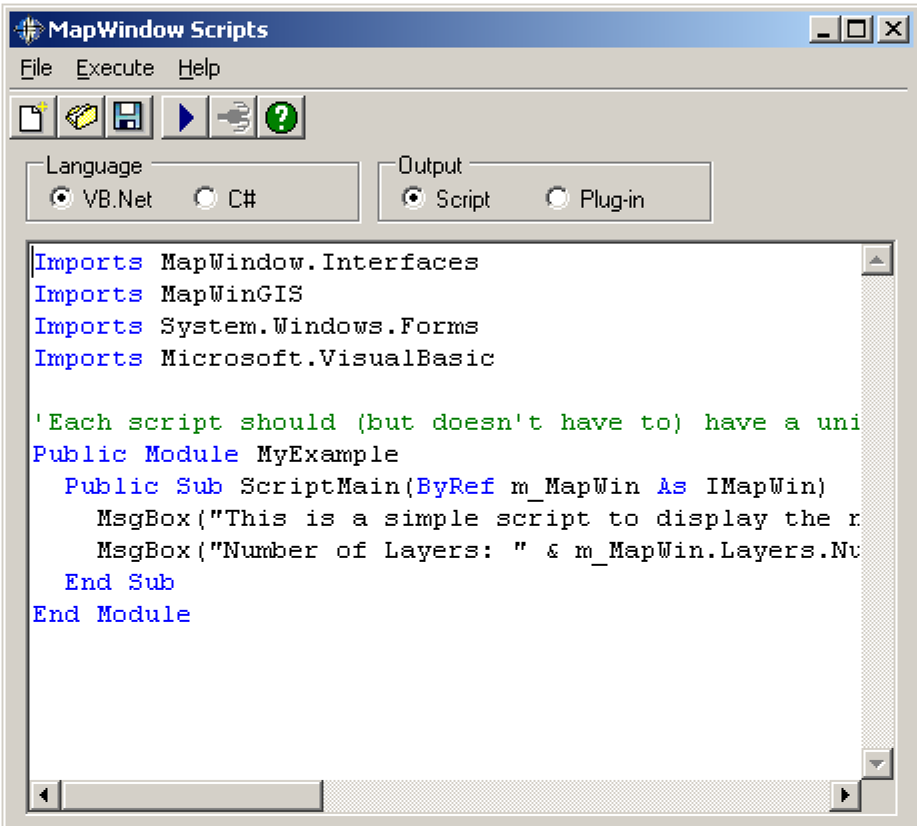
BASINS Main Plug-in

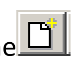
The BASINS plug-in adds two items: b> Analysis and **Compute**, to the main menu on the interface. These utilities provide additional time series management and model setup capabilities, links to external web sites that serve as information resources, and links to external software packages that manage GIS and time-series data. It also invokes the **Welcome to BASINS 4.5** window upon instantiation of the program, which expedites setting up or opening a project.

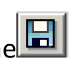
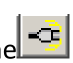
Scripts

A script consists of programming code stored in an ASCII file that is compiled at runtime, allowing the user an easy, dynamic method to assemble customized utilities. The user has a choice of writing code in one of two languages, VB.Net or C#. It follows that a user must have basic programming skills in the selected language if they are to assemble a successful script. The product of the scripting operation can be either a script, which can be loaded and run at a later time, or a plug-in, which will be compiled and added to the **Plug-ins** menu. Complete documentation about MapWindow scripting is available via the  button or the **Help** menu item on the **MapWindow Scripts** window.

The **MapWindow Scripts** window pops up when the user selects **Plug-ins:Scripts**.

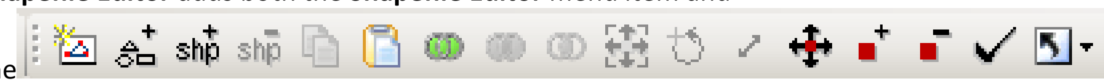


To start a new script, click the  button. To open an existing script, click the  button. Once the programming code has been selected from the **Language** frame and the desired code has been written, the user has several options.

- To save the module as a script, select **Script** from the **Output** frame then click the  button
- To run the script, select **Script** from the Output frame then click the  button
- To compile the code as a plug-in, select **Plug-in** from the **Output** frame then click the  button. The name of the new plug-in, which will appear on the **Plug-ins** menu, is assigned in the code as the Name property.

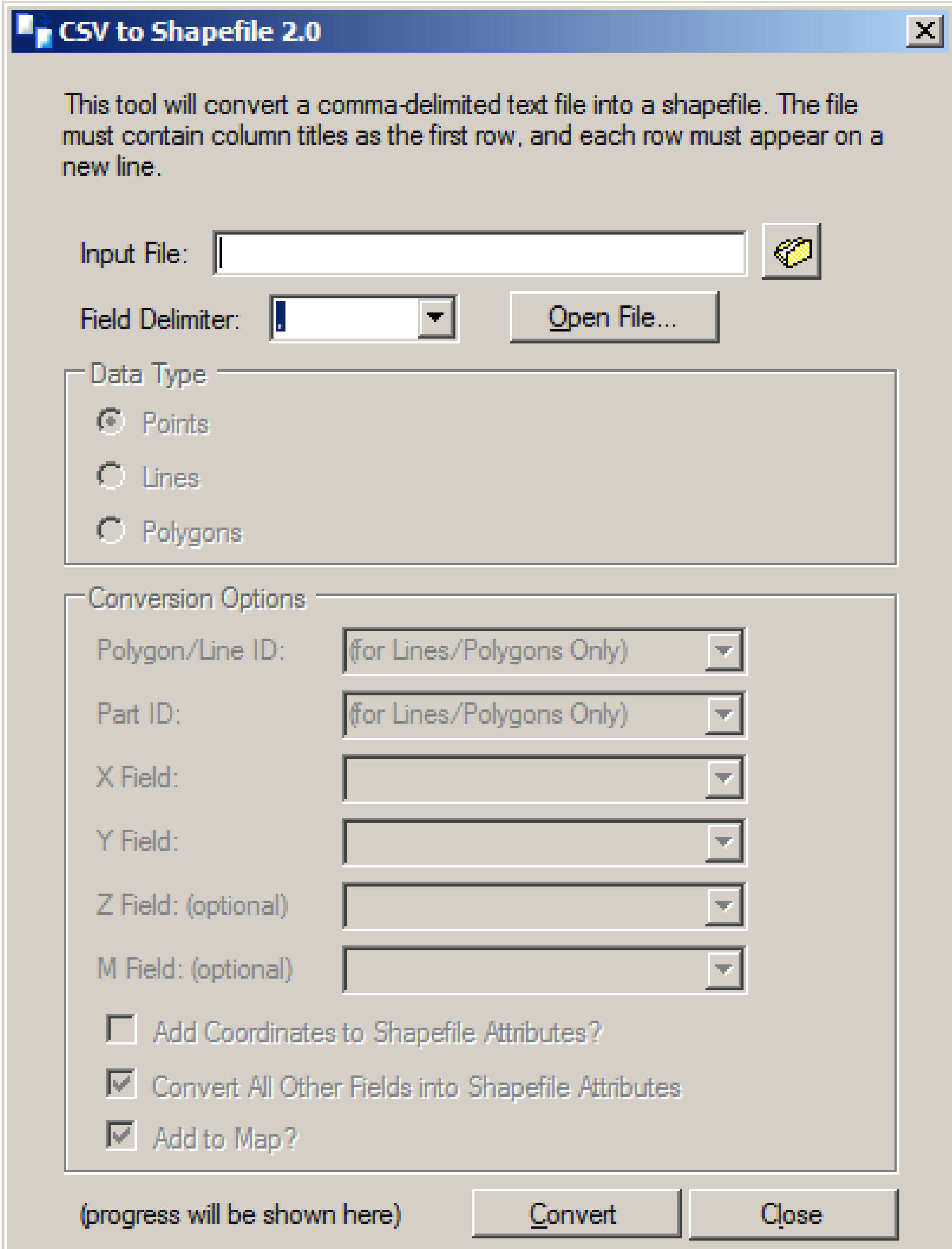
GIS-Related Plug-ins

There are a series of GIS-related plug-ins available as part of the MapWindow installation package, each providing a particular range of utility. This section will cover plug-ins available on the plug-in menu; for an explanation of other GIS functions, see GIS Utilities.

- **Shapefile Editor** adds both the **Shapefile Editor** menu item and the 

buttons to the main toolbar.

- **CSV to Shapefile Converter** adds the **Converters** menu item to the main toolbar.

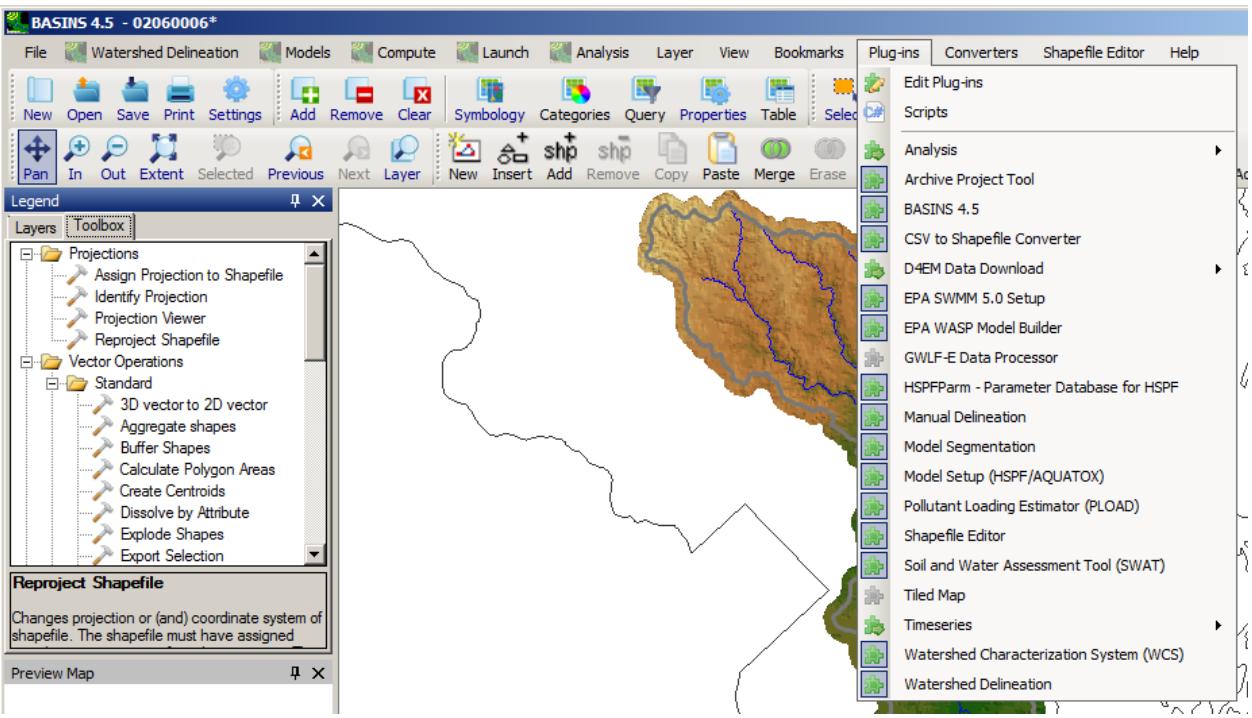


This plug-in allows the user to convert at comma-delimited text file into a point shapefile.

Visit the MapWindow web site for complete documentation on that program. For further instructions and videos about using MapWindow, consult MapWindow Tutorials (*Note*: .pdf documents must be opened in a separate window).

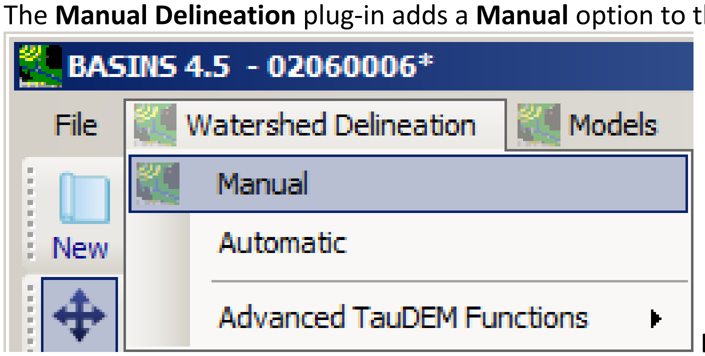
Delineation Plug-ins

There are two methods of watershed delineation available in BASINS: Manual Watershed Delineation and Automatic Watershed Delineation. Both are available on the **Plug-ins** menu option on the main BASINS window.



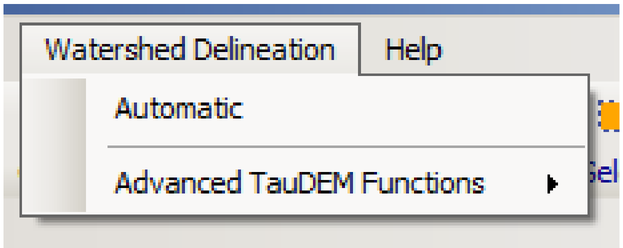
If either **Manual Delineation** or **Watershed Delineation** is selected from the **Plug-ins** list, a new menu option titled **Watershed Delineation** will appear on the main BASINS menu.

- The **Manual Delineation** plug-in adds a **Manual** option to this menu:



Detailed information about this plug-in can be found **here**.

- The **Watershed Delineation** plug-in adds an **Automatic Delineation** and **Advanced Tau-DEM Functions** option to the **Watershed Delineation** menu:



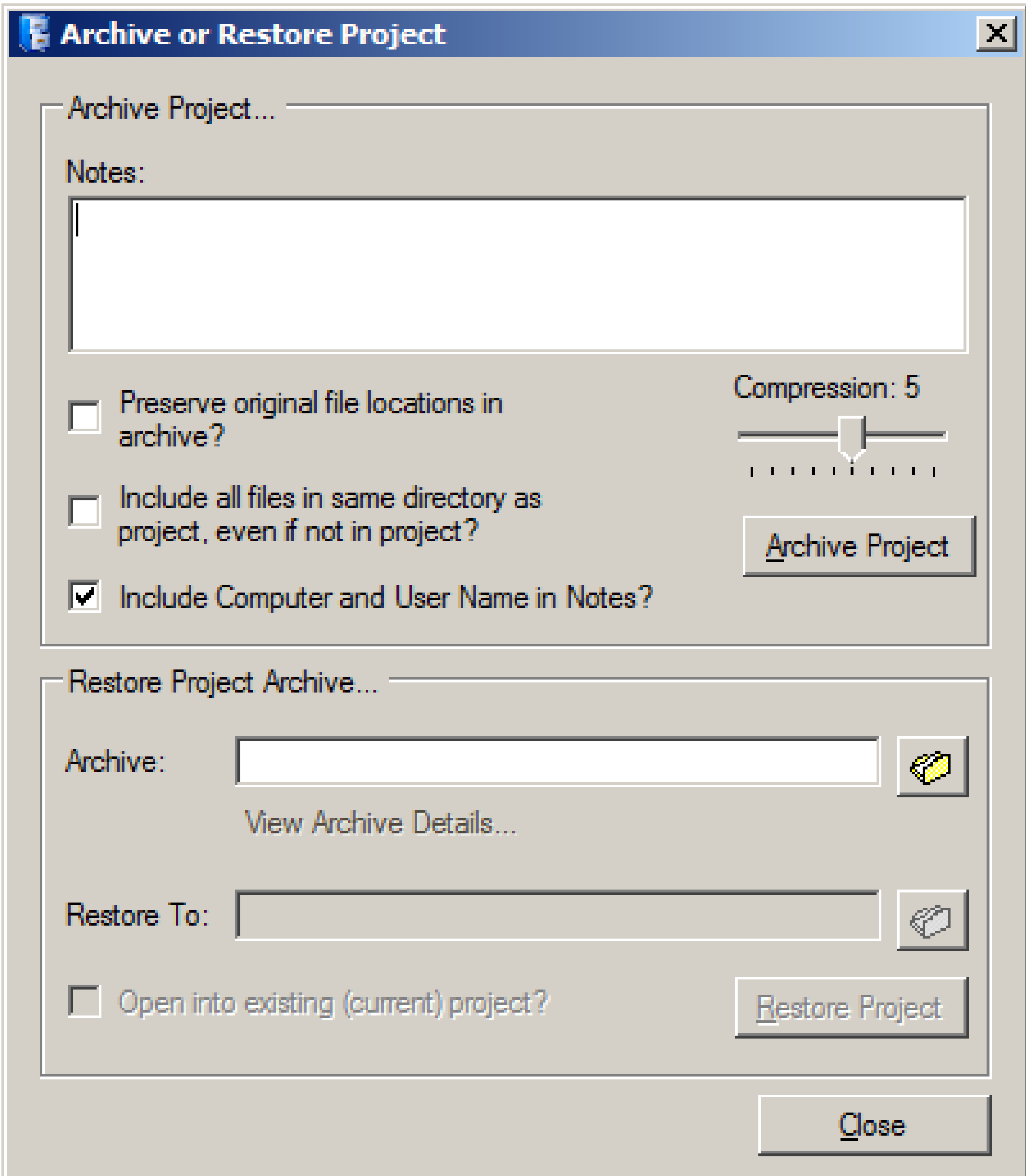
More information about this plug-in can be found **here**.

Model Plug-ins

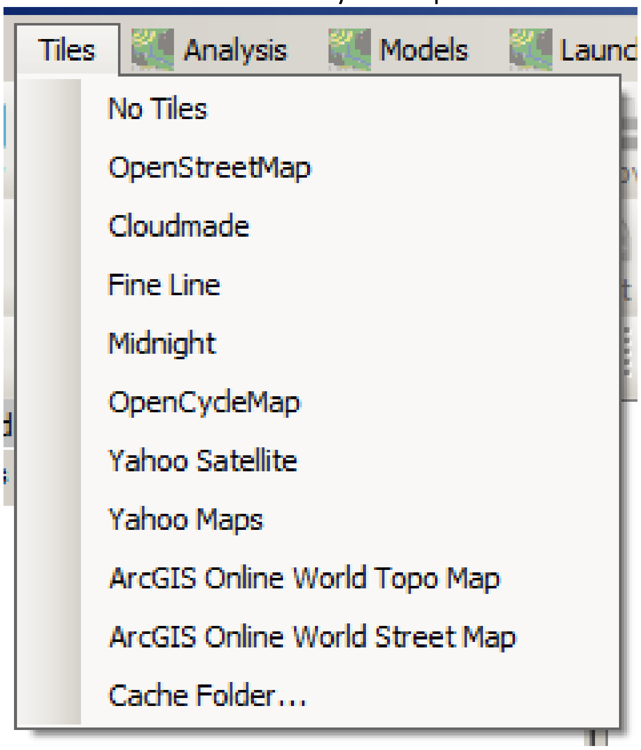
Several of the main modeling programs that can be used in BASINS are available as Plug-ins. When a particular model plugin is installed, it can be selected from the main **Plug-ins** menu. When selected, the particular model is then added to the **Models** menu options. For example, if the HSPF model plugin is installed, the Plugin-ins menu adds the menu item **Model Setup for HSPF**.

Other Plug-ins

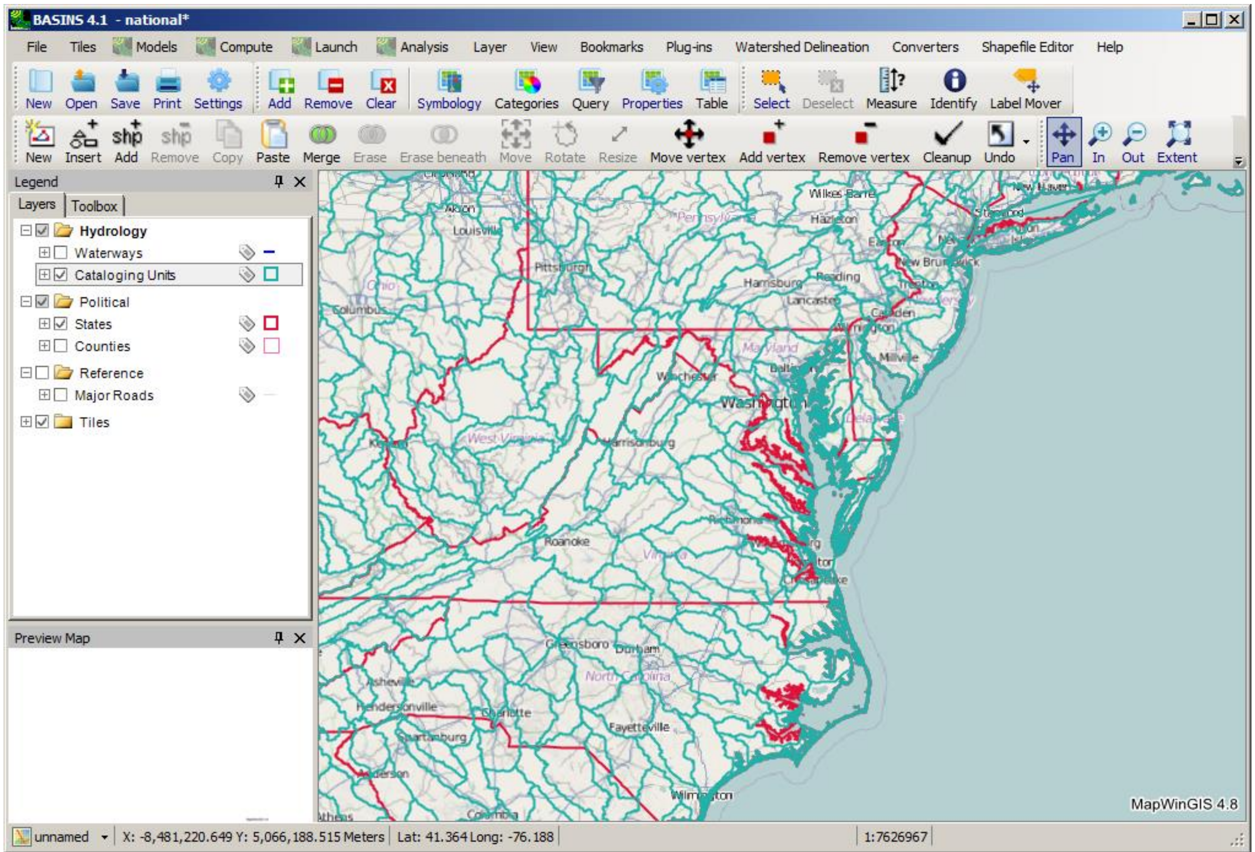
The **Archive Project Tool** plug-in allows the user to archive the many files associated with a project as one zip file. The plug-in adds the option **Archive/Restore Project** to the main **File** menu. When selected from the **File** menu, the following window pops up:



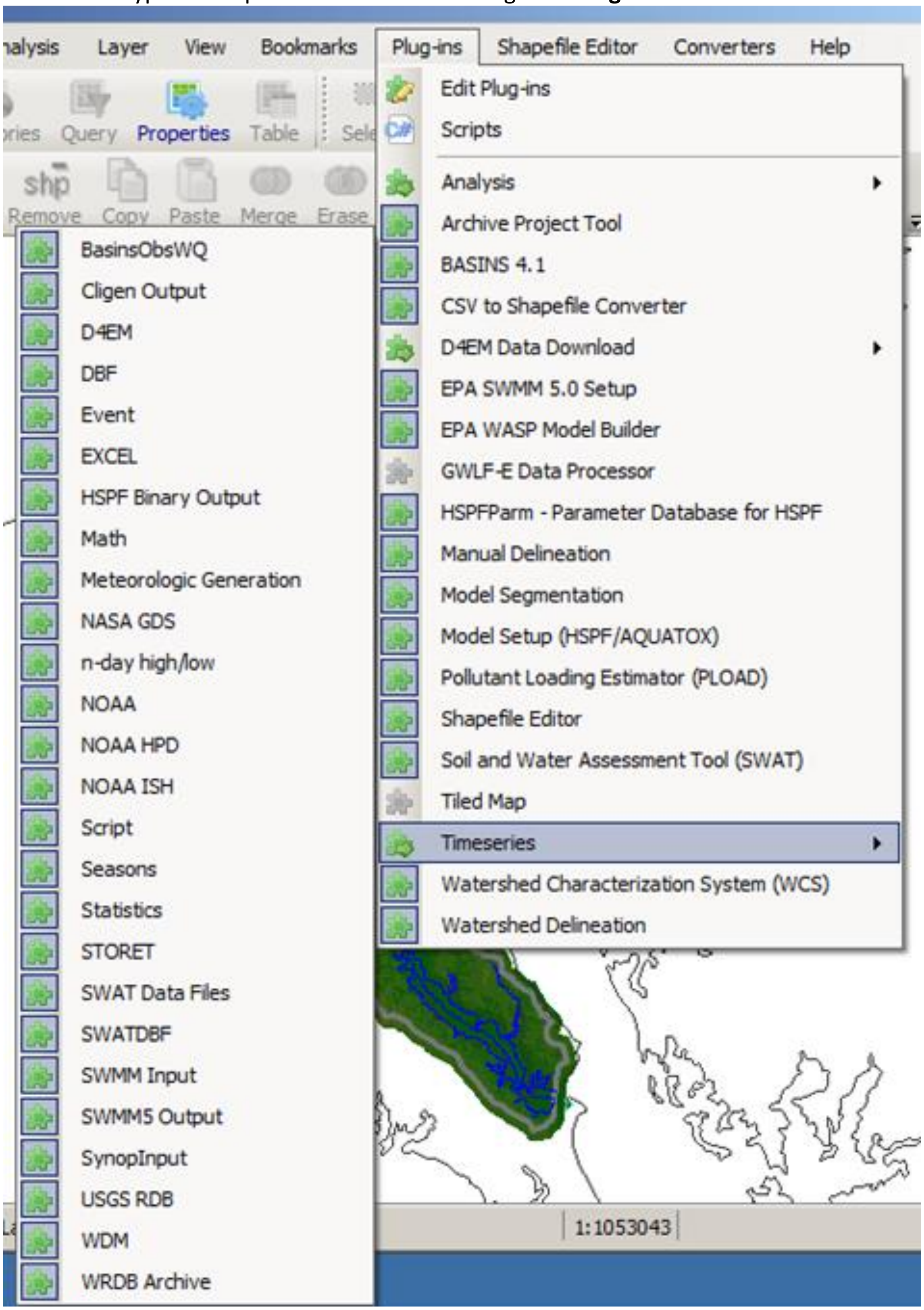
The **Tiled Map** plug-in allows the user to load a tiled base map using images from a number of different providers. This plug-in adds the 'Tiles' menu to the main MapWindow interface. Within the 'Tiles' menu a user can choose to load tiles from any of the providers shown below.



Choosing any of the tile options will result in the corresponding base map images being downloaded and added to the map, as shown below.



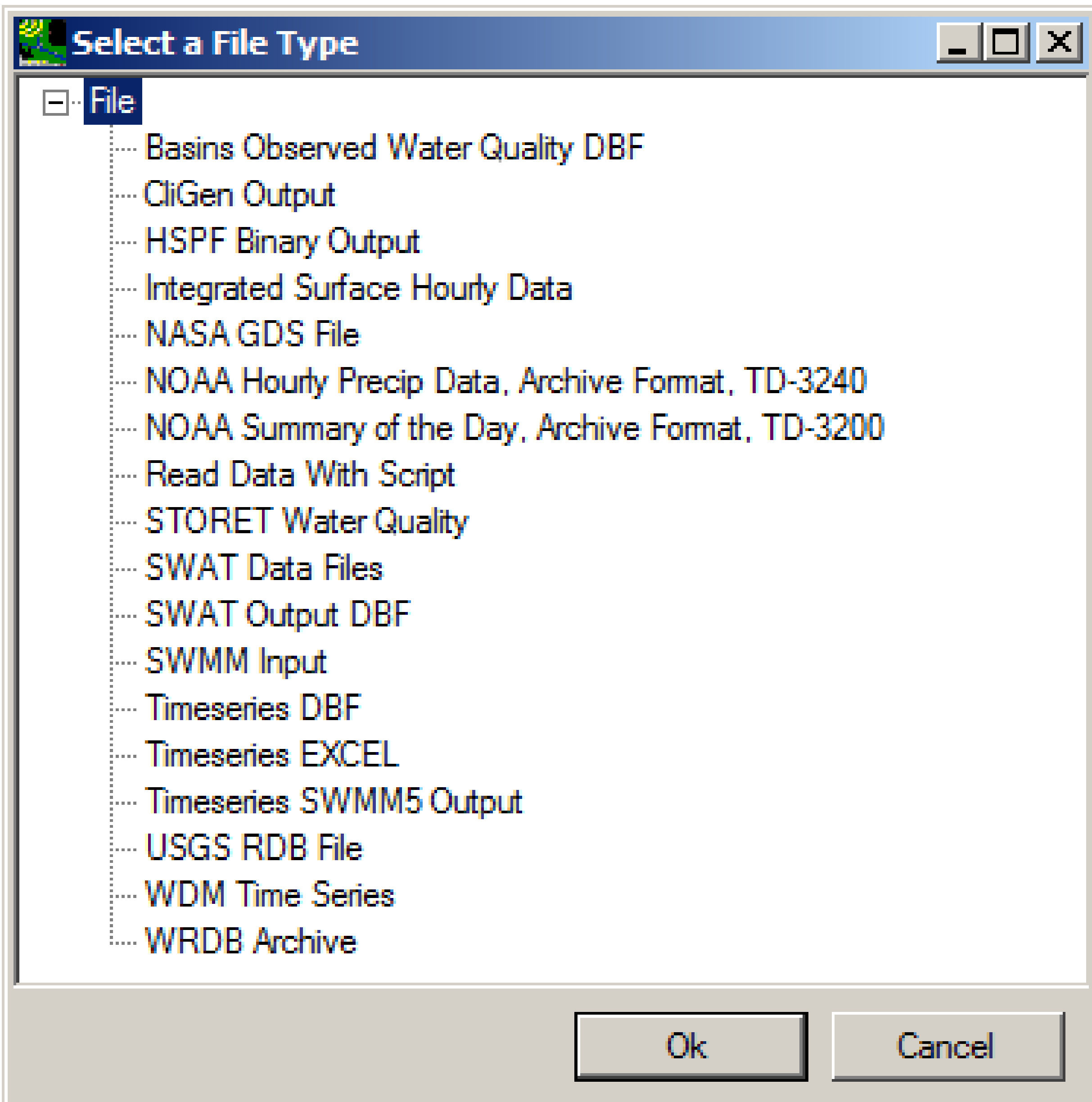
The Tiled Map feature is only available in the 'National' project when building a new BASINS project, and in any BASINS project using the 'Google Mercator' projection. Map tiles are only loaded when the provider is selected from the 'Tiles' menu; the user may wish to reselect the provider from the 'Tiles' menu after changing the zoom level or panning the map. Time-Series Plug-ins There are a variety of time-series types and operations available through the **Plug-ins:Time Series** menu.



Time-Series Types allow BASINS to recognize numeric data sets stored in different formats and to incorporate that data as part of the BASINS project. Time-Series Operations allow the user to perform a variety of mathematical procedures and analyses on data sets available within the BASINS project.

Time-Series Types

When a time-series type is selected from the **Plug-ins:Time Series** menu, that formatted data storage option becomes available for incorporation into the BASINS project via the **File:Open Data** menu item. The following **Select a File Type** window pops up when plug-ins for all available time-series types have been selected.



Time-Series Type	Description
BASINS Observed Water Quality DBF	DBF file of water quality observations downloaded with the BASINS core data
CliGen	Output from a CliGen run
HSPF Binary Output	Binary output file (.HBN) from the HSPF model
Integrated Surface Hourly Data	Meteorologic data from the named database
NASA GDS File	Timeseries format of data downloaded from the North American Land Data Assimilation System (NLDAS)
NOAA Hourly Precip Data	Meteorologic data from the named database
NOAA Summary of the Day	Meteorologic data from the named database
Read Data with Script	Utility to read a timeseries from a file into memory using a script.
STORET Water Quality	Format of data downloaded from the EPA STORET system
SWAT Data Files	SWAT Data Files (*.pcp, *.tmp, output.rch, .sub, .hru)
SWAT Output DBF	Output file from the SWAT model
SWMM Input	Timeseries from a SWMM model input file
Timeseries DBF	DBF file time series values stored with dates in one column and values in the next column
Timeseries EXCEL	Timeseries stored in Excel format with dates in one column and values in the next column
Timeseries SWMM5 Output	Output file from the SWMM model
USGS RDB	Timeseries format of data downloaded from the USGS NWIS system
WDM Time Series	Input and output time-series data that can be managed with *WDMUtil* or *GenScn*, which are available under the **Analysis** menu item. Beginning with BASINS 4.1, *GenScn* and WDMUtil are available as a separate download at http://www.aquaterra.com/basins4. Much of the WDM Time-series management functionality of WDMUtil is available through the 'File' menu option in BASINS, especially through the 'File:Manage Data' menu option. This functionality is documented in the user's manual under Time-Series Management.
WRDB Archive	Archive (.txt) format from WRDB

Time-Series Operations

When the time-series operations listed on the **Plug-ins:Time Series** menu are selected, corresponding submenu items become available under **Compute** on the main menu. The available operations, listed below, are detailed in the Compute section of this documentation.

- Event
- Math
- Meteorological Generation
- Seasons
- Statistics

Read Data with Script

The **Timeseries Script** plug-in allows a user to read a file containing a timeseries into memory based on a script that describes the format of the file.

Selection of the 'File:Open Data' menu item, followed by 'Read Data With Script', allows the user to access time series data not in a standard timeseries format recognized by BASINS and bring it into BASINS. From there the imported time series may be saved to a WDM file and/or analyzed and manipulated in the same manner as any time series known to BASINS.

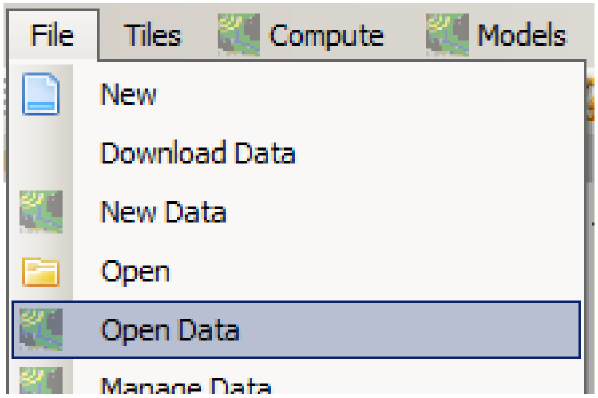
Importing of time series is performed using a scripting language. This language was developed to handle the wide variety of formats in which time series data are stored. Data Import Scripts have been developed to process many common data formats, but the system is also dynamic in that new scripts may be created and introduced through BASINS.

When 'File:Open Data', followed by 'Read Data With Script', is selected, a dialogue prompts the user for the name of the file containing the data to be imported. Once a file has been specified, the user has the option to select an existing script from the Script Selection form or to create a new script using the Script Creation Wizard. Alternatively, the user may also develop a new script by hand using a text editor and building a script from scratch or modifying an existing script. For other than simple formats, this method is preferred as the Script Creation Wizard may not be able to successfully create scripts for complex formats.

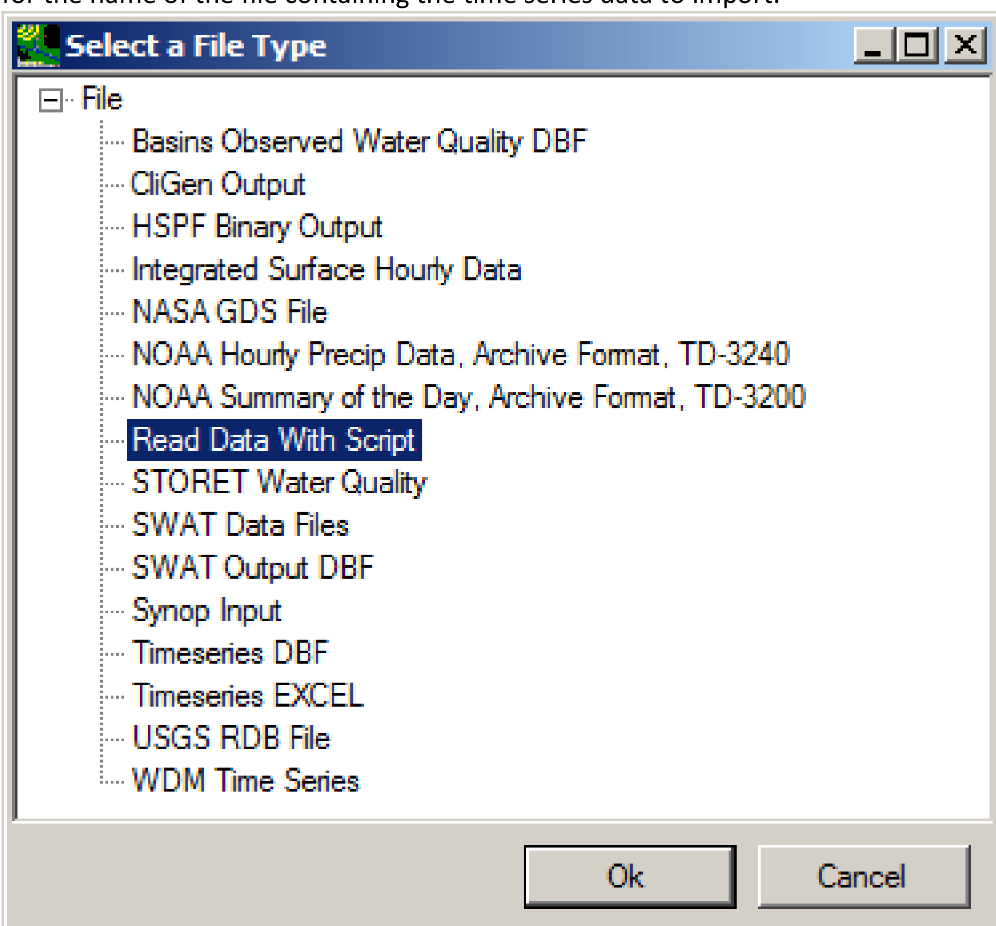
Details of the Script Selection and Script Creation Wizard forms are presented in this section. Specific Details on the scripting language are presented in the section entitled Scripting Language.

Key Procedures

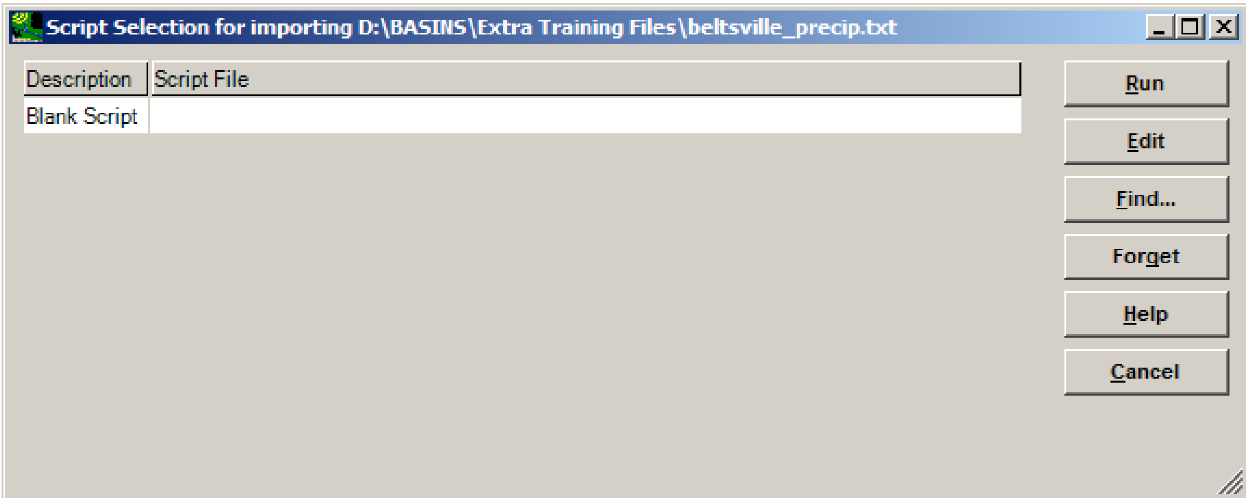
To access this plug-in, go to the 'File:Open Data' menu item.



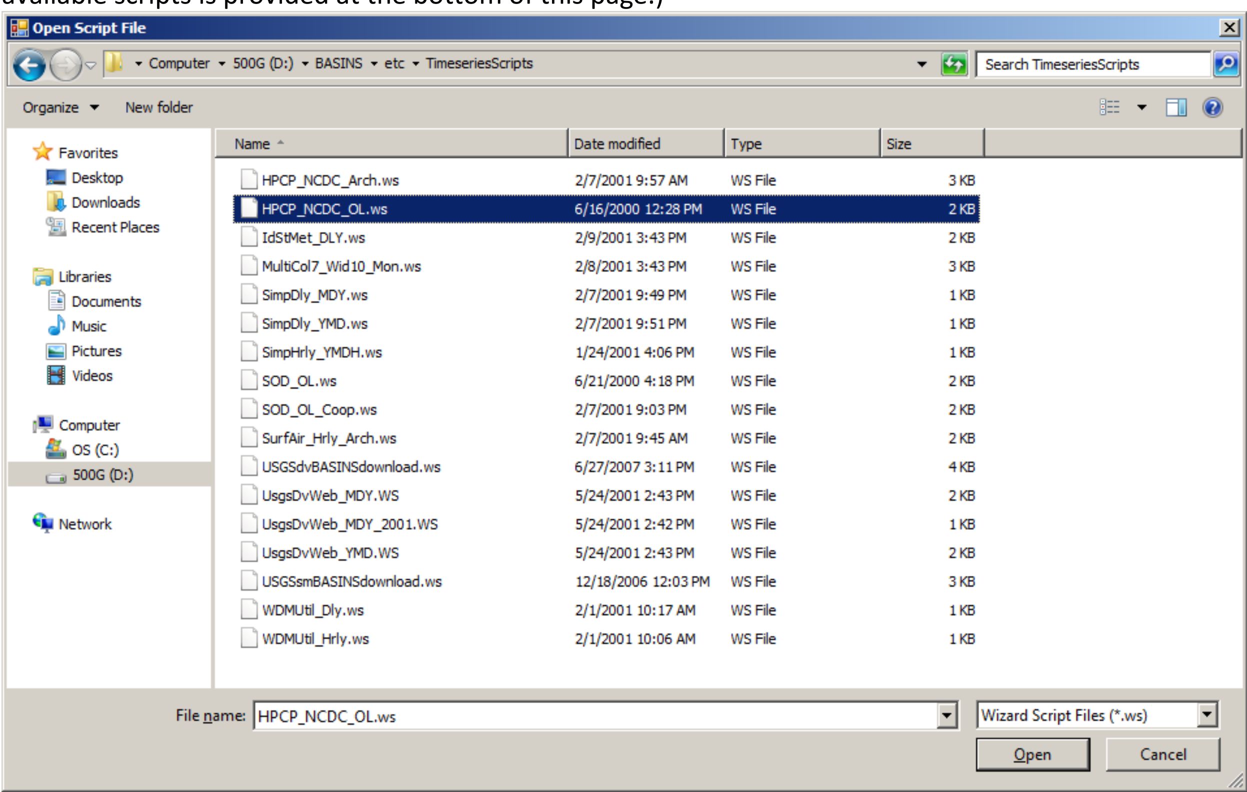
From the 'Select a File Type' window, select 'Read Data With Script'. A file dialog will prompt the user for the name of the file containing the time series data to import.



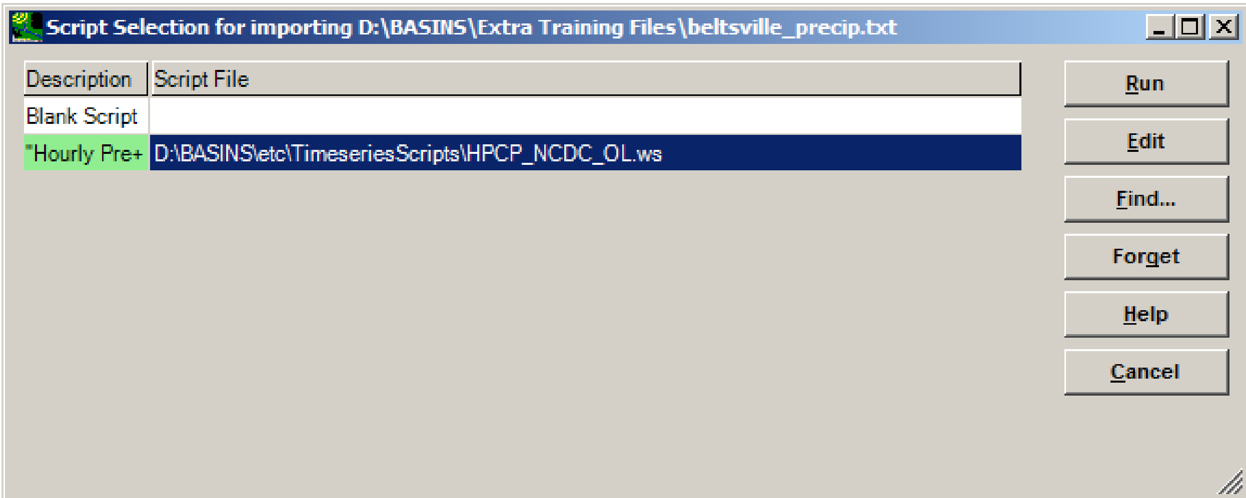
Navigate to the file, click 'Open', and the following 'Script Selection' window will appear for selecting the script to be used in reading the data.



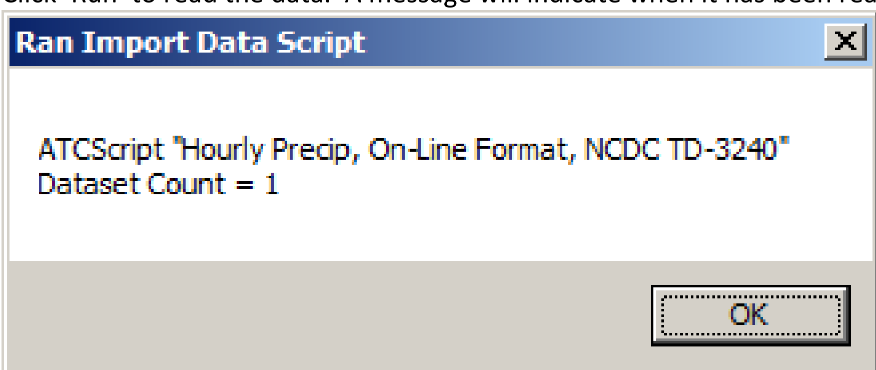
Click 'Find' to navigate to the script to be used in reading the data. (More information about the available scripts is provided at the bottom of this page.)



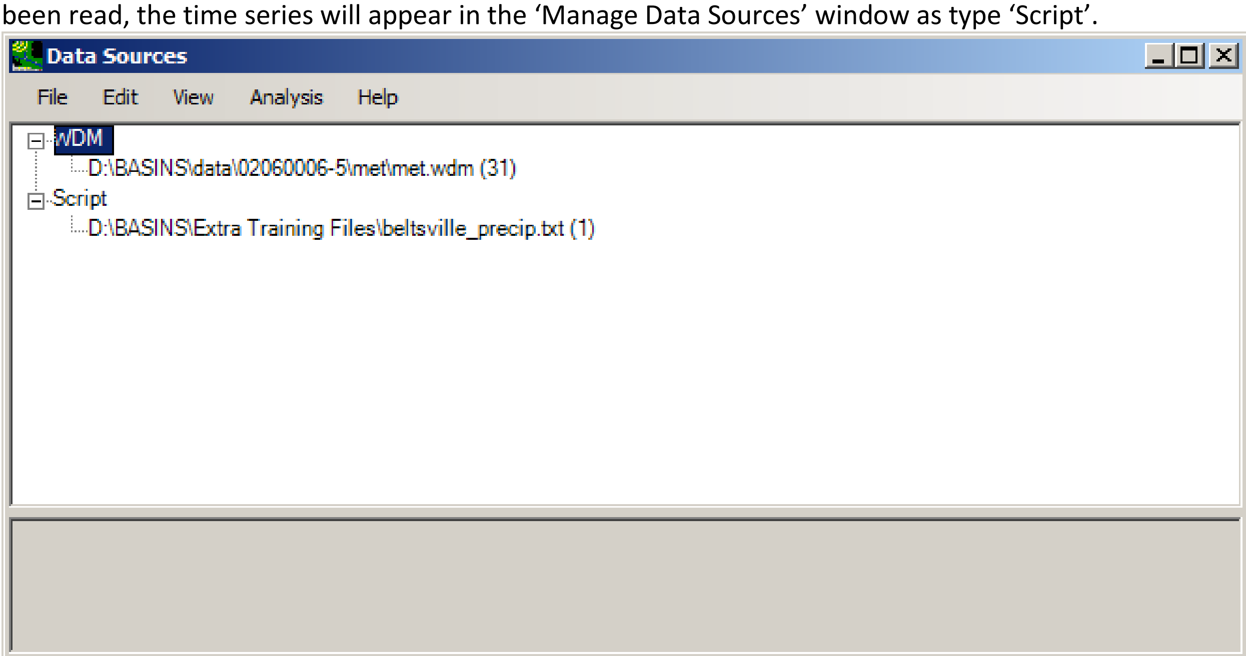
Specify the intended script file, and then click 'Open'. The 'Script Selection' window will appear highlighting the selected script to be used in reading the data.



Click 'Run' to read the data. A message will indicate when it has been read successfully.

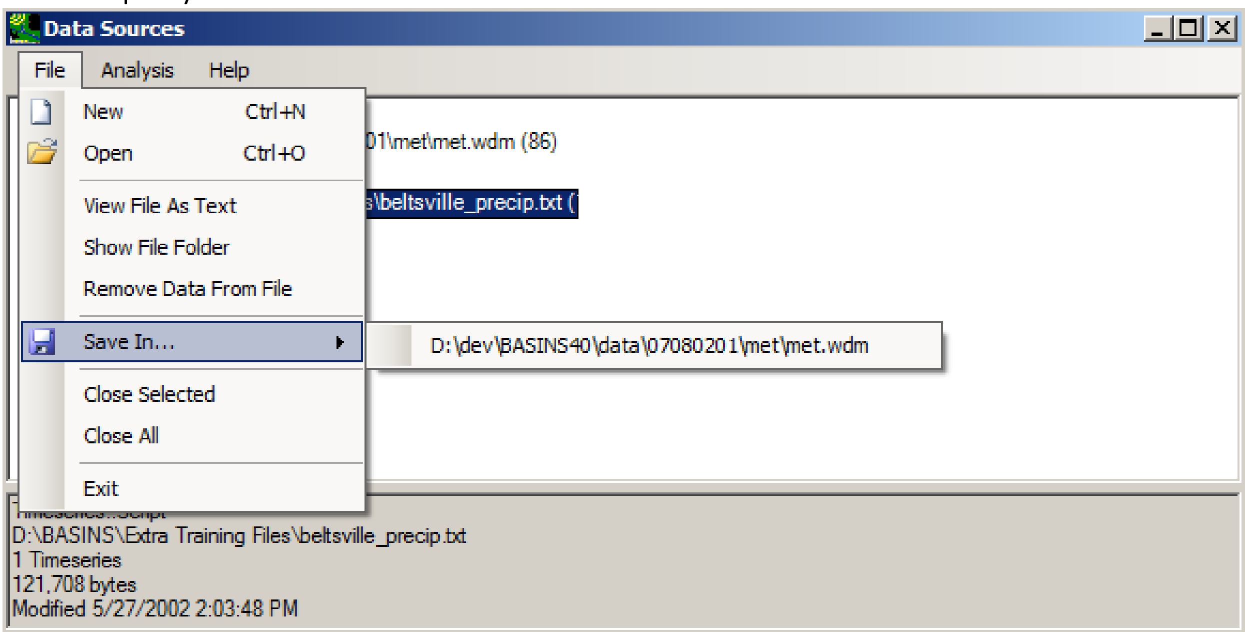


After the timeseries file has been read, the time series will appear in the 'Manage Data Sources' window as type 'Script'.

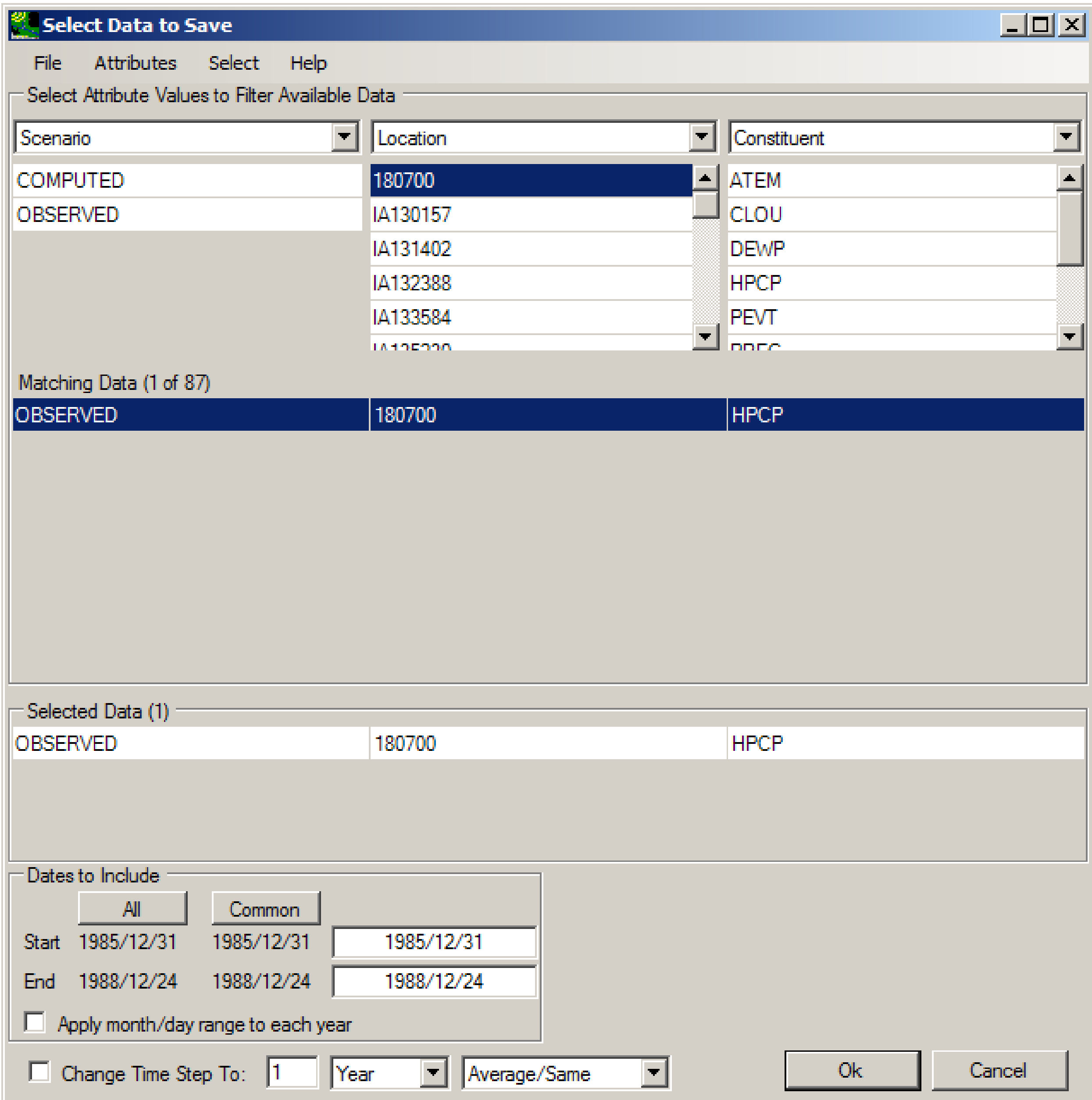


To save the imported data to WDM, from the 'Data Sources' window, use the menu option 'File:Save

In...' and specify the WDM file.



In the 'Select Data to Save' window, select the new timeseries and click 'OK'.



This new timeseries has now been written to WDM.

Script Selection

Data import scripts have been developed to process many common data formats. The Script Selection form displays all of the data import scripts of which this tool is aware. The list of scripts contains a column of short descriptions and a column of script file names. The color of the script name in the list provides a hint as to whether this script is likely to work for importing this type of data. Script names with a red background appear unlikely to work for the data file selected.

Selecting a script and then clicking the **Run** button will cause the data to be read and brought into memory.

If no appropriate script is available, the user has three options:

- Selecting a script that processes data similar to this one and then clicking the **Edit** button to bring up the Script Creation Wizard. From there the script may be modified to process the data.
- Selecting the *Blank Script* item and then clicking the **Edit** button to bring up the Script Creation Wizard. From there a new script may be built to process the data.
- Using a text editor to modify an existing script to process the data.

Note: some complex scripts use features that can not yet be edited in the graphical interface. These scripts may be edited manually as text files before pressing 'Run'.

Clicking the **Find** button browses your disk for new scripts that are not in the list. The full suite of scripts distributed with BASINS may be found in the *BASINS\etc\TimeseriesScripts* folder where BASINS was installed.

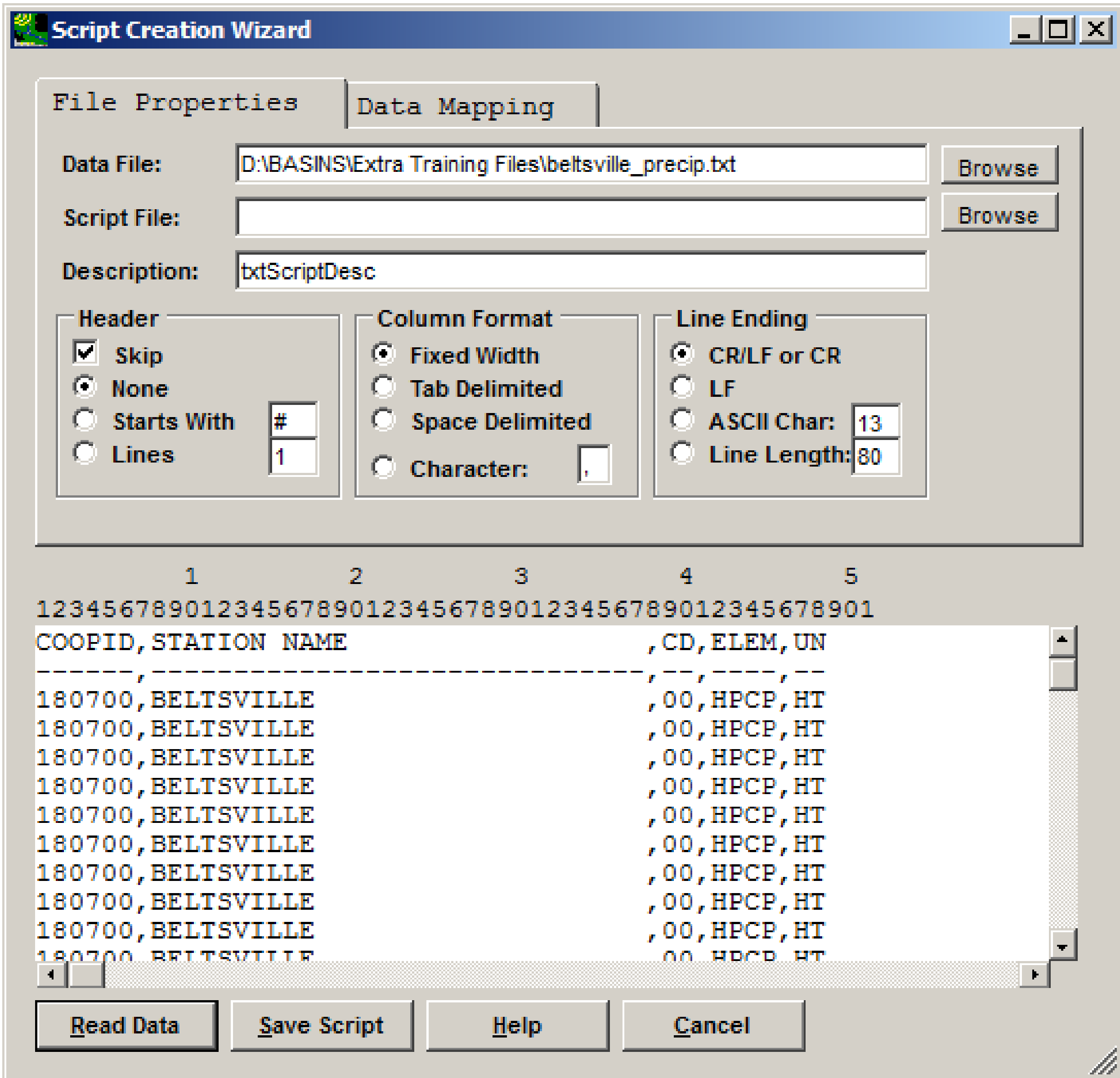
Clicking the **Forget** button removes the selected script from the list, but leaves it on disk.

Clicking the **Debug** button runs the selected script one step at a time. This is a useful tool when creating new scripts and you want to check each step of the script as it processes the data.

Clicking the **Cancel** button closes the **Script Selection** form without importing any data.

Using the Script Creation Wizard

New scripts may also be created and used in this plug-in. The Script Creation Wizard provides a feature to assist in the compilation of time series data from user-defined formats.



When the **Edit** button on the **Script Selection** form is clicked, the **Script Creation Wizard** is displayed.

The **File Properties** tab contains general specifications about the data file being imported. The name of the file being imported and the name of the script file being edited, along with its description, are displayed at the top of the form. (If building a new script, the Script File name will be blank). The Browse buttons to the right of the file names allow different files to be selected.

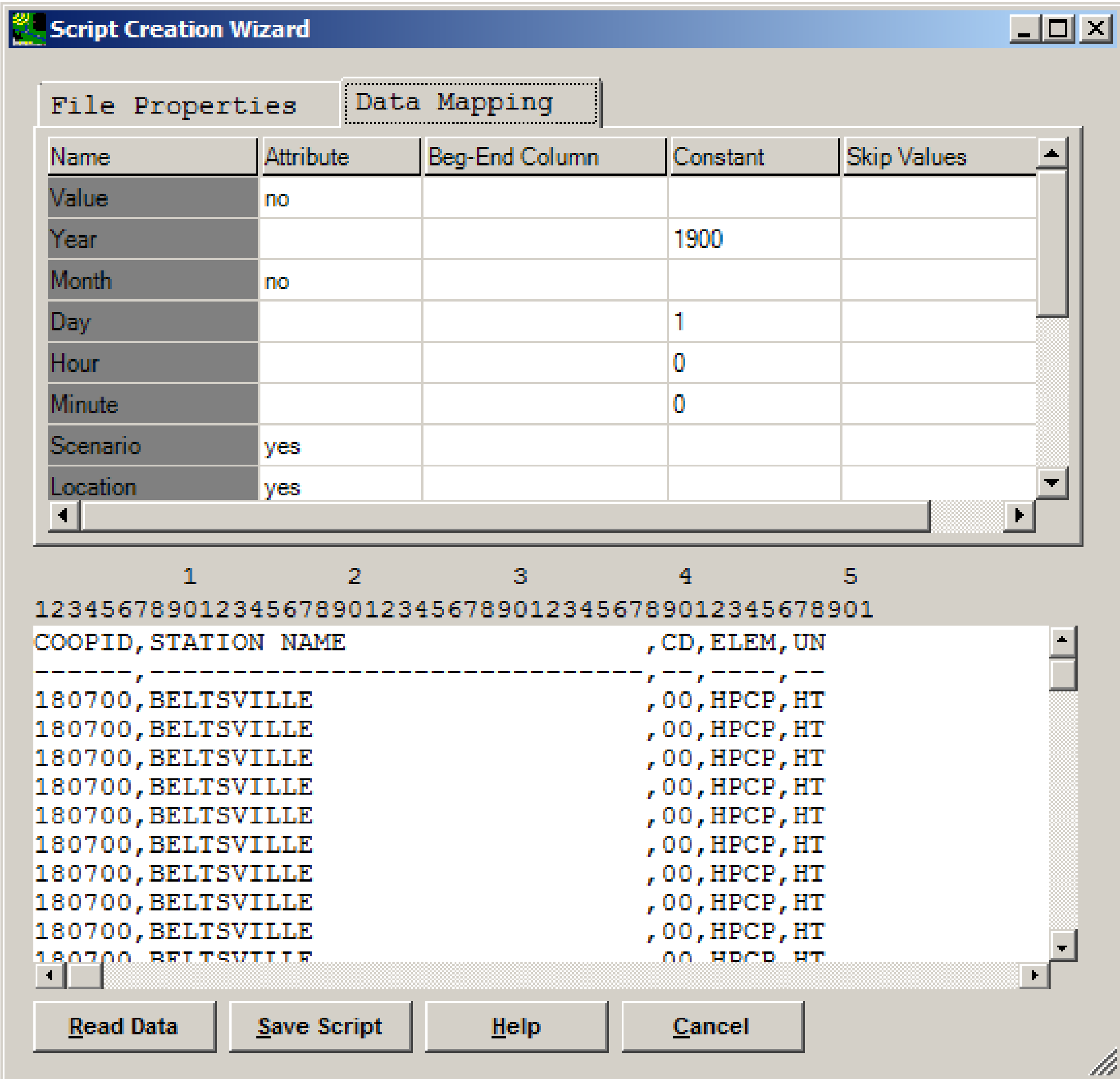
The **Header** frame contains specifications about processing any header lines in the file. If the **Skip** check box is checked, there are three options available for skipping header records: **None**, lines that **Start With** a specified character, or a specified number of **Lines**.

The **Column Format** frame contains specifications about the format of the data records. The **Fixed Width** option implies that the data elements (values, dates, etc) are in the same columns throughout the file. The **Tab** and **Space Delimited** options imply that the data elements are separated by tabs and spaces, respectively. The **Character** option allows the user to specify characters that separate the data elements.

The **Line Ending** frame contains specifications about what markers are used to indicate the end of the data records. The most common is **CR/LF** (carriage return/line feed), although some data downloaded from the internet may only contain a line feed (**LF**). Options for other **ASCII Char**acters or specific **Line Length**s are also available.

As specifications are made in these frames, the display of the data file may be adjusted to reflect them. For example, if a specific number of header lines are identified to be skipped, that many header lines will be removed from the data file display.

After making the necessary **File Properties** specifications, the **Data Mapping** tab can be used to describe the format of the data.



The list at the top of the **Data Mapping** tab contains *Name*s of various data elements used in importing data. The lower portion of the tab contains a display of the data file with column numbers across the top of it. These column numbers can be highlighted, by clicking and dragging with the mouse, to define the location of the data elements. Thus, to define the *Input Column* for a data element, click on that element and then click and drag on the column numbers in which the element is found. In some cases a data element's value will be constant (e.g. *Hour* and *Minute* for daily data). In such a case, the value for that element may be entered under the *Constant* column. The *Constant* column may also be used to apply a constant value to a data element. This is done by inserting the desired mathematical symbol in front of the constant value. For example, if the year values on a file were only the last two digits, entering *+1900* in the *Constant* column would add 1900 to the 2-digit year values when processing the data.

Some data elements are general information about the data being processed. These elements may be stored as attributes of the time series. To indicate a data element as an attribute, a *yes* is entered under the *Attribute* column for that element. The values for these attributes may then be entered under the *Constant* column. It is important to enter values for the *Scenario*, *Location*, and *Constituent* attributes as this will make the new time series more recognizable by other BASINS components.

Once the data elements have been defined as desired, the **Save Script** button may be used to write the script to a file for future use. The **Read Data** button is used to try to process the data using the script defined in the wizard. The **Cancel** button will close the Wizard and no data will be imported.

Data Import Scripts Distributed with BASINS

This table summarizes the data import scripts distributed with BASINS. Sample data files listed in the table are also distributed. These files may be found in the *BASINS\etc\TimeseriesScripts* folder where BASINS was installed.

Script File Name	Description of Data Format Script Reads	Sample Data File
HPCP_NCDC_Arch.ws	Hourly Precip, Archive Format, TD-3240	Ithaca_prec.ncd, ncdc.ncd
HPCP_NCDC_OL.ws	Hourly Precip, On-Line Format, NCDC TD-3240	aberdeen.ncd
IdStMet_DLY.ws	Idaho State Climate Services Daily Format	fennrs.log
MultiCol7_Wid10_Mon.ws	Multi-Columns (7) of Width 10, Monthly Values	acpoint.prn
SimpDly_MDY.ws	Simple Daily Value Format-mm/dd/yyyy	usgsfecal.prn
SimpDly_YMD.ws	Simple Daily Value Format-yyyy/mm/dd	
SimpHrly_YMDH.ws	txtScriptDesc	
SOD_OL.ws	Summary of the Day TD-3210	Bing_SOD.ncd
SOD_OL_Coop.ws	Summary of the Day, On-Line, Coop	Amherst.ncd
SurfAir_Hrly_Arch.ws	Surface Airways Hourly Data, Archive Format, TD-3280	surface.ncd
UsgsDvWeb_MDY.WS	USGS Daily Web Values (mm/dd/yyyy)	hist_littleyellow.cgi
UsgsDvWeb_YMD.ws	USGS Daily Web Values (yyyy/mm/dd)	tendall.rdb
WDMUtil_Exp_Dly.ws	WDMUtil Export Format - Daily Values	tmax.exp

Scripting Language

Wizard scripts use polish notation (Operator Argument Argument ...) The best way to learn how they work is to examine the sample scripts (*.ws), but this reference provides a brief summary of the various scripting language commands.

```
Command        Example

And            (And (Not EOF) (< Day 32))

ATCScript      Every scripts starts: (ATCScript "Script Description"

Attribute      (Attribute "Constituent" "PREC")

ColumnFormat   See below

Comment        (Comment "Author: Mark Gray 8 May 2000")

Dataset        (Dataset Scenario "OBSERVED"
                   Location Location
                   Constituent Constituent
                   Description "Summary of the Day")

Date           (Date Year Month Repeat Hour "0")

EOF            End of File indicator

FatalError     (FatalError "Unknown flag found")

Fill           (Fill H 1 0 -999 -998)
               This fills in any omitted, missing, or accumulated
               values to create a constant interval dataset
               First arg is first letter of time units:
                     Century, Year, Month, Hour, minute, second
               Next arg is number of time units between values
                     (default 1)
               Next arg is value to fill in for omitted values
                     (default 0)
               Next arg is value to fill in between missing values.
                     Missing values are those set to -999 by the script
                     (default -999) \
               Next arg is value to fill in between accumulated values
                     Accumulated values are those set to -998
                     (default -998)

Flag           (Flag 1) Not used by any application yet

For            (For Repeat = 1 to "31"
                    (Date Year Month Repeat)
                    (Value Value))
```

If	(If (= Value 999999) (Value -999))
In	(If (In Value 999999 000000) (Value -999))
Increment	(Increment Repeat) Sets Repeat = Repeat + 1
IsNumeric	(If (IsNumeric Value) (Increment Repeat))
LineEnd	(LineEnd CR) Defines end of line
Literal	“31” Any string enclosed in double quotes is left alone
+ / * ^ -	(Set Repeat (+ Repeat 1)) (Value (/ Value 100))
Mid	Not yet implemented
NextLine	(NextLine) Moves to the next line of the input file
Not	(While (Not EOF) ... Returns logical opposite of its argument (0, 1)
Or	(If (Or EOF (> Repeat 31)) ...
Set	(Set Constituent Col2) Assigns value of second argument to variable named by first argument.
Test	(Test (And (< Year 2100) (> Year 1800))) If the last expression within a Test returns True (True = 1) then this script will be highlighted.
Trim	(Set Constituent (Trim Col2)) Evaluates to its argument without surrounding spaces
Unset	(Unset Constituent) Opposite of Set. Remove variable definition.
Value	(Value ValRead) ValRead is the name of the column from the column definition. Assigns argument to data value in current dataset at current date.
Warn	(Warn “Uh, oh!”) A message box is opened, then the script proceeds.
While	(While (Not EOF) ...) The first argument is evaluated for truth (0 or 1). If true, the other arguments are evaluated (run)

```
                and then the loop repeats.

>               (If (> Repeats 31) ... )
>=              Comparison operators evaluate to 1 if the comparison
<               is true, 0 if it is false.
<=
<>
=
```

Fixed width ColumnFormat Example and discussion

```
  (ColumnFormat Fixed
                61-66:Value
                32-35:Year
                36-37:Month
                59-60:Hour
                9-31:Location
                55-58:Constituent
                1-8:Station
                38-42:Latitude
                43-48:Longitude
                49-54:Elevation
                59-66:Repeating)
```

For fixed width columns, the first argument is “Fixed”. All other arguments are in the format columns:name. Columns are numbered starting with 1 for the first character. Columns are either a single number indicating a single characterposition (perhaps a flag column) or a pair of numbers indicating arange of columns. 10-12 indicates a column that includes three characters on eachline: 10, 11, and 12. 10+3 indicates the same three characters and is merely analternate syntax for convenience.

The name which appears after the colon is how this column is referred to later in the script.

Repeating is a special column name. This is specified if there is more than one value on a line. The columns specified for Repeating are the first set of character positions that show the pattern. In the example above, 59-66:Repeating includes the columns for59-60:Hour and 61-66:Value so both of these columns repeat. It is important to get the boundaries of Repeating correct – The character just after the end of Repeating should correspond to the first character of Repeating. For example, if 50-59:repeating is specified, that range should include the first value on the line and 60-69 should contain the second value and so on. When reading all the values on a line, the special variable Repeat is used to determine which position we are looking at. For delimited columns, the first argument would be “Tab” or ”Space” or a string of characters which are each to be treated asa delimiter. For an Excel spreadsheet saved as comma-separated values where one column is a date in the format 6/12/99, the first argument might be ,/ so the parts of the date will be separated as well as the other columns.

Watershed Delineation

Several BASINS delineation tools are provided to assist the user with subdividing a selected HUC-8 watershed into higher-resolution subbasins. The comprehensive data products available in BASINS were developed based on nationally available information and are suited for large-scale assessments. When dealing with localized small-basin analysis, however, higher-resolution data might be necessary to effectively capture the site-specific feature variability. A watershed boundary created using the BASINS *Watershed Delineation* tool allows a user to define the entire land area contributing to flow in a stream. Watersheds can be delineated for Reach File, V1 or NHD/NHDPlus reach file stream segments depending on which data will be used for modeling. Once delineated, analyses can be performed on delineated watersheds using the BASINS *Watershed Characterization Report* tools.

The automatic and manual delineation tools and their associated functions are described below. The user does not need any additional software besides that provided with BASINS 4 to perform the delineation task.

- Automatic Delineation Tool: This tool allows the user to delineate subwatersheds based on an automatic procedure using Digital Elevation Model (DEM) data. User specified parameters provide limits that influence the size and number of subwatersheds created.

- Manual Delineation Tool: This tool allows the user to delineate subwatersheds using a mouse. Doing so allows a user to segment a watershed into several smaller hydrologically connected watersheds based on the user's knowledge of that watershed's topography.

Automatic Watershed Delineation

BASINS 4 *Automatic Watershed Delineation* tool carries out advanced GIS functions to aid the user in segmenting watersheds into several hydrologically connected sub-watersheds for use in watershed characterization and modeling. The delineation process requires a Digital Elevation Model (DEM) in grid format, and optionally a stream segment outlet point layer and/or a pre-digitized stream network (Reach File Version 1 or NHD/NHDPlus datasets) in polyline format.

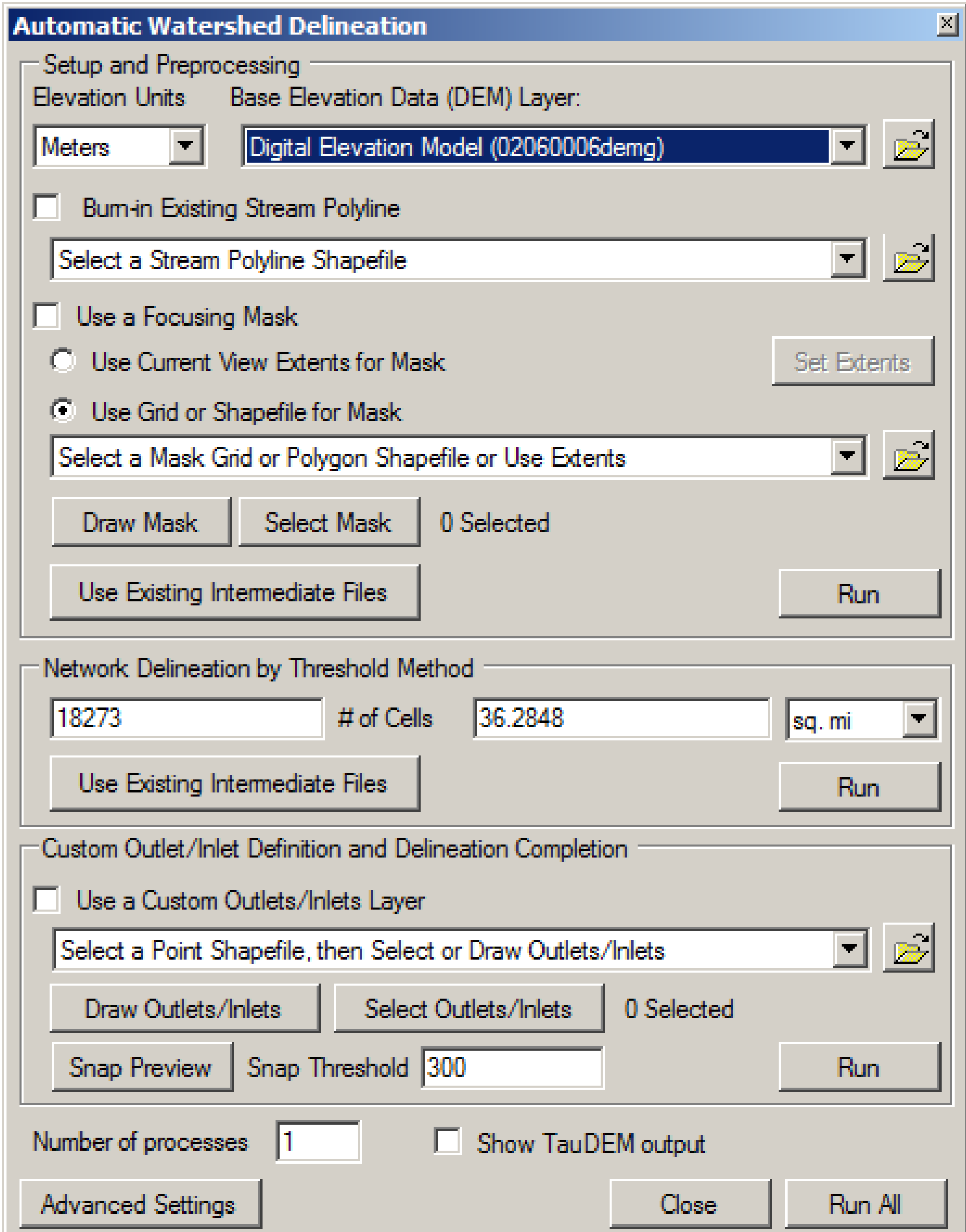
Key Procedures

- Download a DEM grid via the **File:Download Data** menu item. The BASINS DEM Grid (DEMG) has a 100 m resolution while the National Elevation Dataset (NED) has a 30 m resolution.

- Select the **Plug-ins:Watershed Delineation** menu item, which will make the automatic delineation tool available under the **Watershed Delineation:Automatic** menu item.

- (Optional) Select the **Watershed Delineation:Advanced TauDEM Funtions** menu item to avail these functions, for which full documentation is available online.

- Select the **Watershed Delineation:Automatic** menu item, and the **Automatic Watershed Delineation** form will pop up.



- Click the top button and browse for the DEM grid to provide topographic data for the delineation process.

- (Optional) Check the **Burn in Existing Stream Polyline** box, click the associated button, then browse for the stream segment polyline layer.

- (Optional) Check the **Use a Focusing Mask** box if you want to delineate subbasins in only a portion of the specified input DEM grid. When the **Use a Focusing Mask** box is checked, specify whether you wish to use the current view extents as the mask or whether you wish to use an existing grid or shapefile as the mask. The **Current View Extents** option will delineate subbasins only within the area currently shown on the map. If desired the user may click **Set Extents** to return to the map, reset the map extents, and then return to the automatic delineation dialog. If the **Use Grid or Shapefile** option is chosen, the user may click the associated button and then browse for the shapefile or grid to use. The **Draw Mask** button is used to allow the user to digitize a mask, and the **Select Mask** button is used to select particular polygons within a shapefile to be used as the mask.

- Click the **Run** button within the **Setup and Preprocessing** frame. At this point the DEM will be preprocessed for use in the following delineation options.

- Enter the minimum number of cells to be used as the threshold for delineation. For example, if the 100m resolution DEMG is being used as the basis for delineation and the threshold is set at 3000 cells, then the minimum contributing area of a delineated subbasin would be 30 million square meters (3,000 hectares). The delineation threshold can also be entered in other units of area such as square miles, using the field to the right of the number of cells.

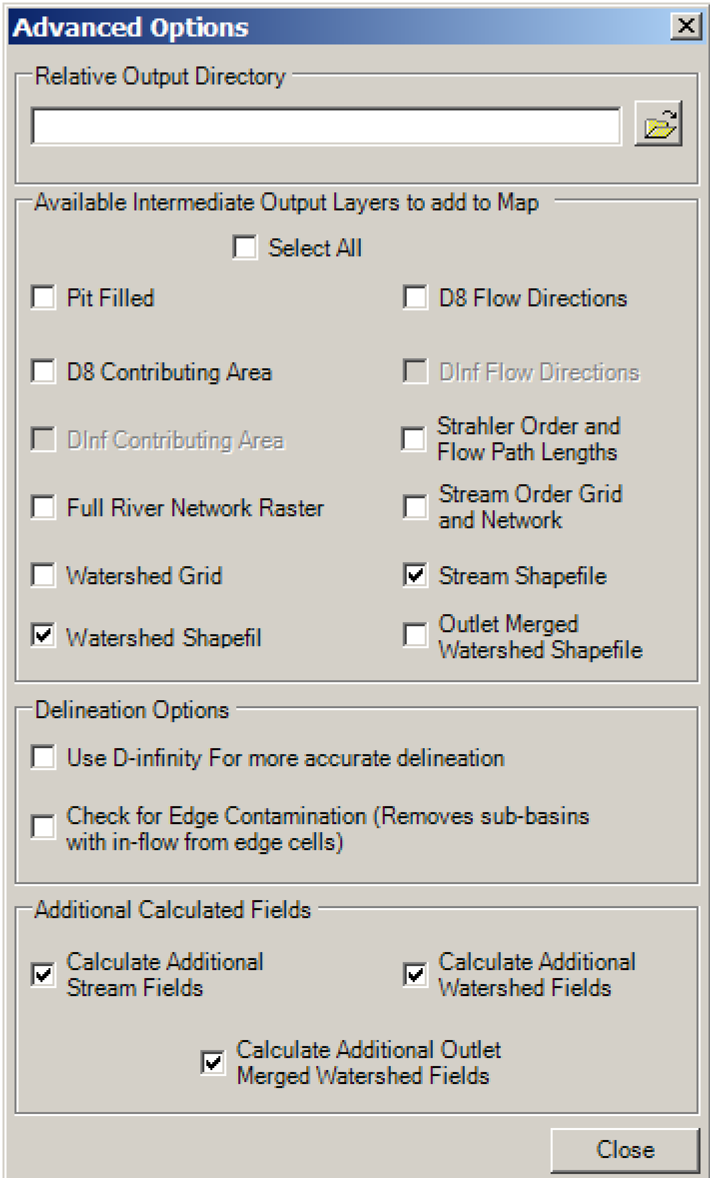
- Click the **Run** button within the **Delineation** frame. At this point the stream network will be computed based upon the input threshold level.

- (Optional) Check the **Use an Custom Outlets Layer** box to add additional outlets not already computed based on the threshold. The user may add a custom outlets layer through a choice of means. One way is to click the associated button, then browse for the stream segment outlet point layer. The other way is to use the **Draw Outlets** button to place the outlets on the map in a point-and-click process. Either way only the selected outlets will be used in creating subbasins. The **Select Outlets** button is used to return to the map and adjust which outlets are selected. The **Snap Threshold** and **Snap Preview** button are used to move the specified points to locations on the stream network within the specified tolerance.

- Click the **Run** button within the **Custom Outlet Definition and Delineation Completion** frame. At this point the subbasins will be computed based upon the specifications of the form.

- (Optional) The user may return to the delineation threshold or custom outlets steps to refine the delineation after seeing the computed subbasins and stream network.

- (Optional) Check the **Advanced Settings** box, and a form will appear include several advanced TauDEM options, including options to control which layers are added to the map, options for delineation algorithms, and options controlling additional fields that might be calculated as desired. Full TauDEM documentation is available online.



- The **Run All** button performs the functions of all three **Run** buttons on this form consecutively. Using this button a user may set all inputs on this form initially and then do all processing with one click. The program will process the delineation task then return to the main form with the new Watershed Shapefile and Stream Reach Shapefile displayed on the map window.

Automatic Watershed Delineation Output Data

Watershed Shapefile (Subbasins) Layer Data Fields

Field Name	Description
Shape_Id	Shape identifier
PolygonID	Polygon identifier
AveSlope	Average subbasin slope [%]
Area_M	Area in square meters
Area_Acre	Area in acres
Area_SqMi	Area in square miles
StreamLink	Identifier of corresponding stream segment
StreamLen	Length of corresponding stream segment [meters]
DSWSID	PolygonID of downstream watershed
US1WSID	PolygonID of first upstream watershed
US2WSID	PolygonID of second upstream watershed

Streams Layer Data Fields

Field Name	Description
Shape_id	Shape Identifier
LINKNO	Link Number. A unique number associated with each link (segment of channel between junctions); corresponds to StreamLink in the Watershed Shapefile
DSLINKNO	Link Number of the downstream link. -1 indicates that this does not exist.
USLINKNO1	Link Number of first upstream link
USLINKNO2	Link Number of second upstream link.
DSNODEID	Node identifier for node at downstream end of stream reach. This identifier corresponds to the ‘id’ attribute from the Outlets shapefile used to designate nodes.
Order	Strahler Stream Order
Length	Length of the link [meters]
Magnitude	Shreve Magnitude of the link. This is the total number of sources upstream

DS_Cont_Ar	Drainage area at the downstream end of the link [square meters]. Generally this is one grid cell upstream of the downstream end because the drainage area at the downstream end grid cell includes the area of the stream being joined.
Drop	Drop in elevation from the start to the end of the link [meters]
Slope	Average slope of the link (computed as drop/length) in percent
Straight_L	Straight line distance from the start to the end of the link [meters]
US_Cont_Ar	Drainage area at the upstream end of the link [square meters]
WSNO	Watershed number. Cross reference to the *w.shp and *w grid files giving the identification number of the watershed draining directly to the link.
DOUT_END	Distance to the outlet from the downstream end of the link [meters]
DOUT_START	Distance to the outlet from the upstream end of the link [meters]
DOUT_MID	Distance to the outlet from the midpoint of the link [meters]
ElevLow	Minimum elevation of the stream reach [meters]
ElevHigh	Maximum elevation of the stream reach [meters]
MeanWidth	Estimated stream reach width [meters]
MeanDepth	Estimated stream reach depth [meters]
DSAreaAcre	Drainage area at the downstream end of the stream segment in acres
DSAreaSqMi	Drainage area at the downstream end of the stream segment in square miles
USAreaAcre	Drainage area at the upstream end of the stream segment in acres
USAreaSqMi	Drainage area at the upstream end of the stream segment in square miles

Note: In the table above, all but the last eight fields are computed by TauDEM. See the TauDEM documentation for full details.

Outlets Layer Data Fields

Field Name	Description
Shape_Id	Shape Identifier
ID	Outlet Identifier

Note: The Automatic Watershed Delineator creates the Outlets Layer only if specified by the user, for the purposes of specifying where subbasin outlets are to be located. PCS locations can be added to *HSPF* by specifying the PCS layer as the Outlets Layer in the *HSPF* Model Setup Plug-in.

Manual Watershed Delineation

The BASINS 4 *Manual Watershed Delineation* tool allows the user to manually subdivide a watershed into several smaller hydrologically connected watersheds for use in watershed characterization and modeling. A single watershed or a watershed system containing multiple subwatersheds can be delineated. The tool is further enhanced to provide users the flexibility in editing shapes and attributes of manually delineated watersheds, outlets and generating stream networks.

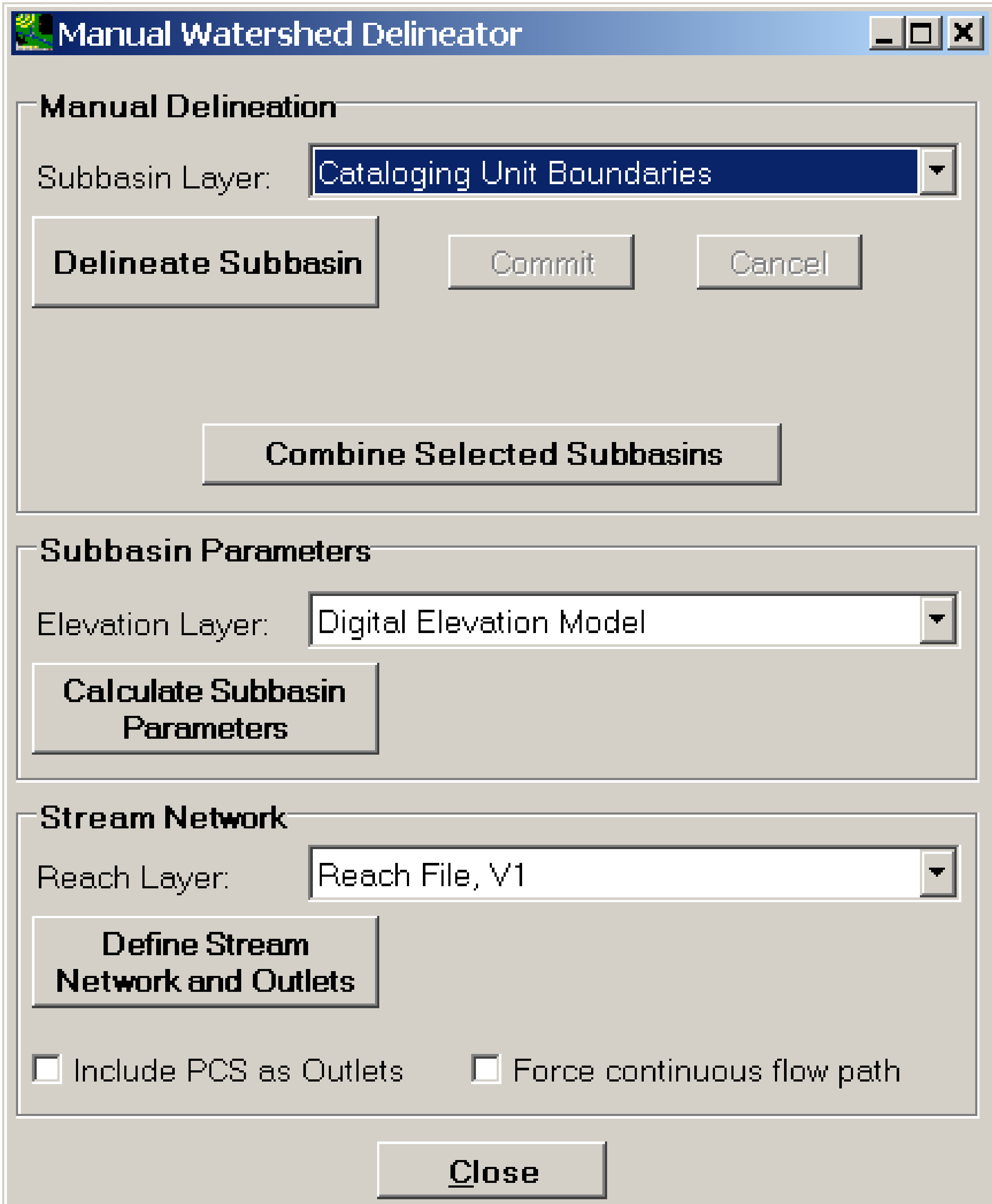
The procedures for using the *Watershed Delineation* tool are described below for single and multiple watershed delineations. Watershed delineation procedures are the same for Reach File, V1 or NHD/NHDPlus stream segments.

Key Procedures

Single-Watershed Delineation

- Download a DEM grid via the **File:Download Data** menu item. The BASINS DEM Grid (DEMG) has a 100 m resolution, while the National Elevation Dataset (NED) has a 30 m resolution. A DEM shapefile can also be used.
- Download a stream polyline layer via the **File:Download Data** menu item. The BASINS NHD/NHDPlus layers have a high resolution that works well for detailed watershed analyses, while the Reach File, V1 layer has a low resolution that works well on the grosser HUC-8 scale.
- Make sure the active GIS layers include a watershed boundary polygon layer, a DEM grid layer, and a stream polyline layer.
- Select the **Plug-ins:Manual Delineation** menu item, which will make the manual delineation tool available under the **Watershed Delineation:Manual** menu item.

- Select the **Watershed Delineation:Manual** menu item, and the **Manual Watershed Delineator** form will pop up.



- **To subdivide the watershed into subbasins:**
- Select the watershed boundary layer from the **Subbasin Layer** pull-down menu.

- Click the **Delineate Subbasin** button.
- Change focus to the main BASINS window.
- Draw a new interior boundary to subdivide the watershed by clicking on the beginning and end point, as well as any intermediate vertices, of the new boundary line.

Tip: To delineate your watershed, you need to begin and end the delineation process outside of the existing watershed boundary in which you are working. The new boundary line will appear red. Place the mouse pointer slightly outside the cataloging unit boundary and click the left mouse button to begin delineation. Move the cursor to a point within the cataloging unit boundary and click the left mouse button once to create the first line segment of the watershed outline. Repeat this point-and-click process for each interior vertex.

- To finish the watershed outline, make a final mouse-click at a point outside the existing watershed boundary and right-click; or return to the **Manual Watershed Delineator** form, and click the **Commit** button. Click the **Cancel** button to erase the new boundary line and forego making any changes. It is not necessary to delineate the portion of your watershed that coincides with the existing watershed boundary. The delineation tool automatically clips your watershed at the existing watershed boundary.

Tip: Best results are produced by an "out-and-back" procedure; that is, delineate in the direction of the watershed's pour point (on one side of the stream segment) and return to the cataloging unit boundary on the other side of the stream. Start the watershed delineation at the upper most stream segment (headwaters) within the study area and work down stream.

To calculate subbasin parameters for the newly delineated watershed:

- Select the DEM grid from the **Elevation Layer** pull-down menu.
- Click the **Calculate Subbasin Parameters** button.

Tip: The new subbasin parameters will be stored in the DBF file associated with the watershed layer, and will be available later to provide watershed parameters for watershed model construction. These attributes can be viewed and edited using the Table Editor  utility when the subbasin layer is active on the main BASINS form.

To demarcate the stream segments and their outlets in the newly delineated watershed:

- Select the polyline stream layer from the **Reach Layer** pull-down menu.
- Click the **Define Stream Network and Outlets** button.

Tip: The new stream segment parameters will be stored in the DBF file associated with the stream layer, and will be available later to provide streambed parameters for watershed model construction. These attributes can be viewed and edited using the Table Editor  utility when the stream layer is active on the main BASINS form.

- (Optional) Click the **Include PCS as Outlets** checkbox to include Permit Compliance System (PCS) facilities as outlet points in the stream network. If this option is checked, each PCS facility located within each subbasin will be added as a point in the outlets layer. Doing so provides the connection to the modeling plug-ins that establishes which PCS point source discharges are to be represented in the model.
- (Optional) The **Force continuous flow path** checkbox can be used to create a continuous stream line through each subbasin. With this option off, in most cases the stream line will be continuous throughout each subbasin. However in some cases the stream network specified in the stream layer can have gaps or missing segments. This option can be used to fix incomplete or non-contiguous stream networks.

The **Combine Selected Subbasins** button is used to combine subbasins selected on the map view into a single subbasin shape. This tool is designed for the user with a large number of smaller subbasins that the user has decided to combine for modeling purposes. The user should select a number of subbasins from the currently active subbasin shapefile on the map, and then click this button to combine (merge) them into a single shape. After using this tool as many times as desired, the user should proceed to calculate subbasin parameters and define the stream network and outlets using the corresponding tools within this form.

Manual Watershed Delineation Output Data

Subbasins Layer Data Fields

Field Name	Description
Shape_Id	Shape Identifier
Subbasin	Subbasin number
Slo1	Subbasin slope [%]

AreaAcres	Subbasin area in acres
AreaMi2	Subbasin area in square miles
Bname	Assigned subbasin name

Streams Layer Data Fields

Field Name	Description
Shape_id	Shape Identifier
Subbasin	Subbasin number
Subbasinr	Subbasin number receiving surface water from the subbasin
Len2	Stream reach length [meters]
LArea	Local drainage area [square meters]
TArea	Total cumulative drainage area [square meters]
TAreaAcres	Total cumulative drainage area in acres
TAreaMi2	Total cumulative drainage area in square miles
Wid2	Stream reach width [meters]
Dep2	Stream reach depth [meters]
MinEl	Minimum elevation of the stream reach [meters]
MaxEl	Maximum elevation of the stream reach [meters]
Slo2	Stream reach slope [%]
Sname	Stream name

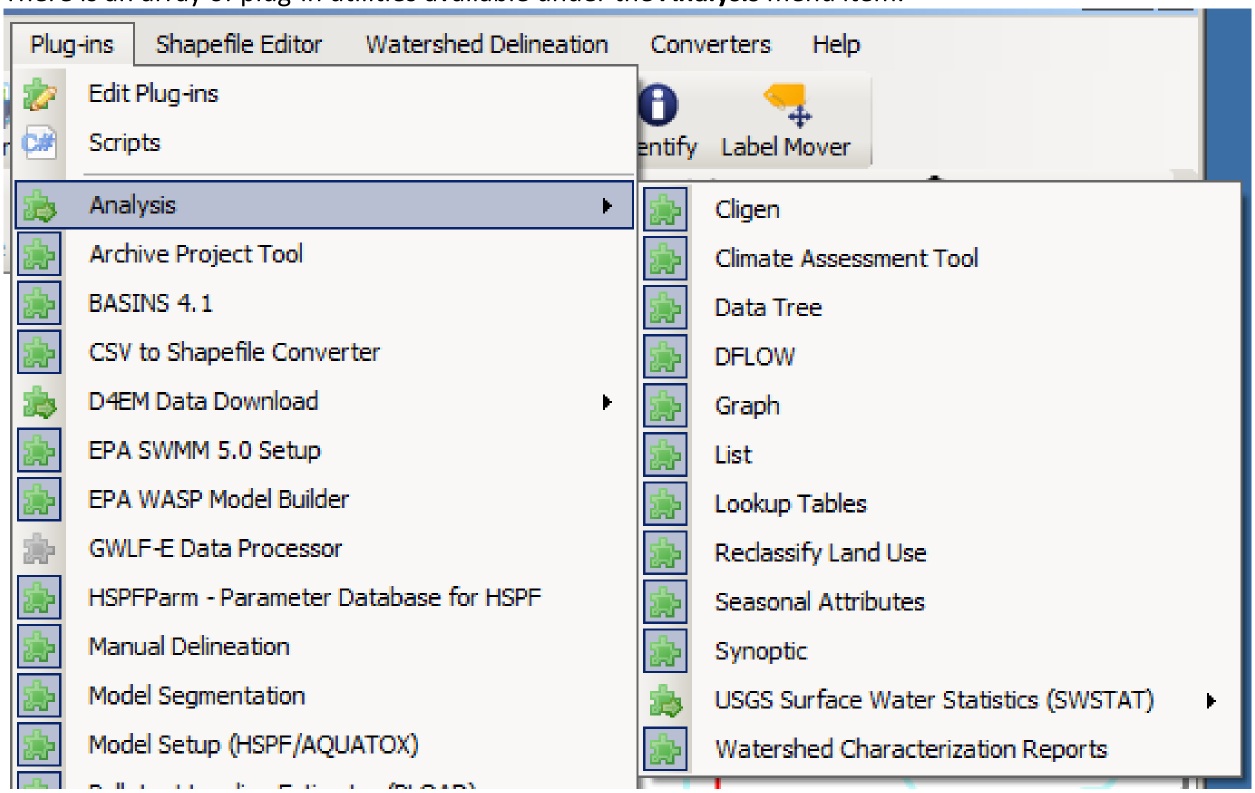
Outlets Layer Data Fields

Field Name	Description
Shape_Id	Shape Identifier
ID	Outlet Identifier

Pcsid	Unique ID from PCS; blank if not a PCS location
Xpr	X coordinate in the current projection
Ypr	Y coordinate in the current projection

Analysis

There is an array of plug-in utilities available under the **Analysis** menu item.



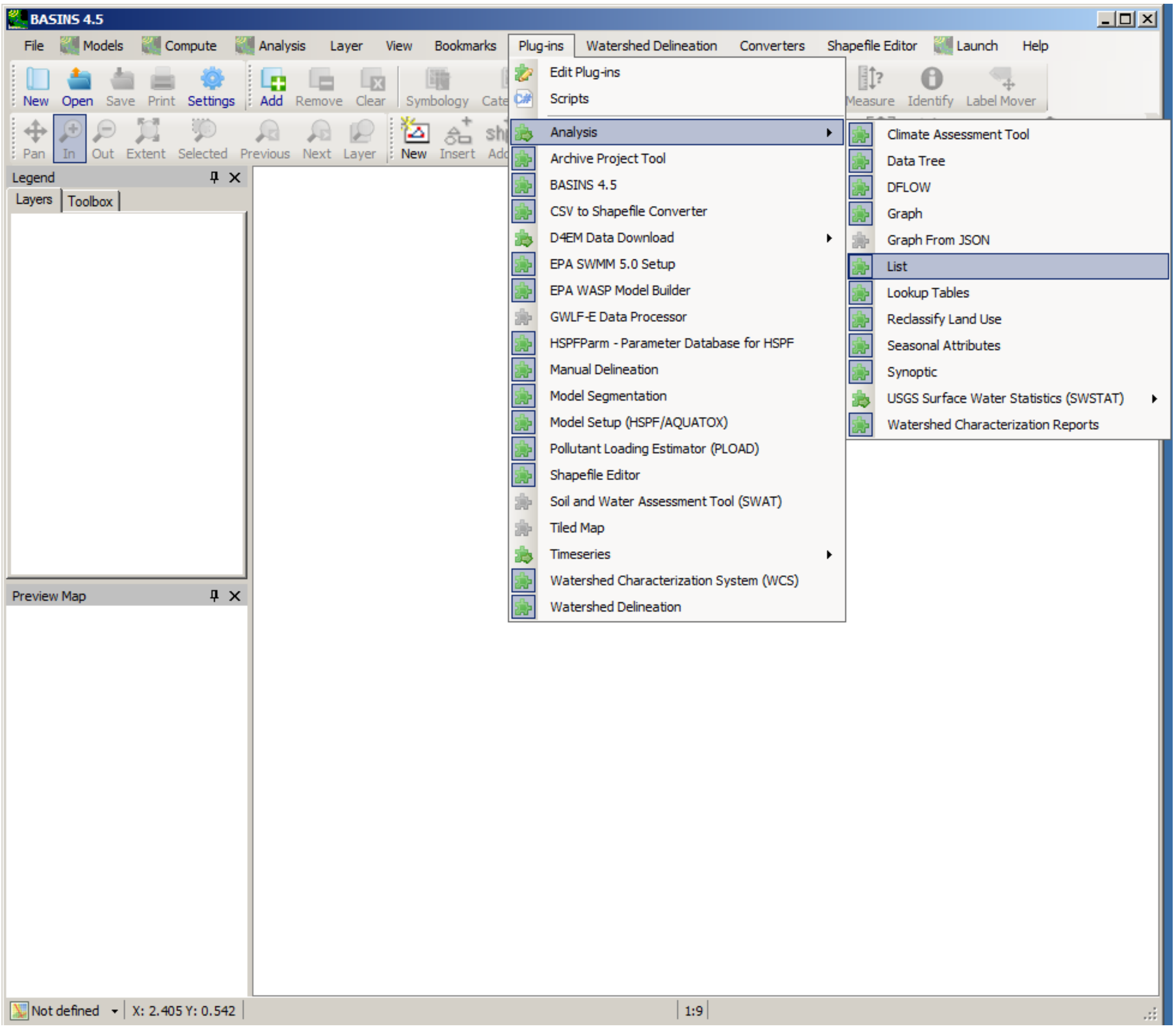
There is a one-to-one correlation between selections from the **Plug-ins:Analysis** submenu and **Analysis** menu items, with the exception of **Lookup Tables**, which has a single entry under **Plug-ins:Analysis** but four entries under **Analysis** (Projection Parameters, STORET Agency Codes, Standard Industrial Classification (SIC) Codes, and 304a Water Quality Criteria). In addition to the aforementioned software links, the following utilities are provided by Analysis plug-ins:

- Time Series Functions
- Lookup Tables
- Reclassify Land Use
- Watershed Characterization Reports

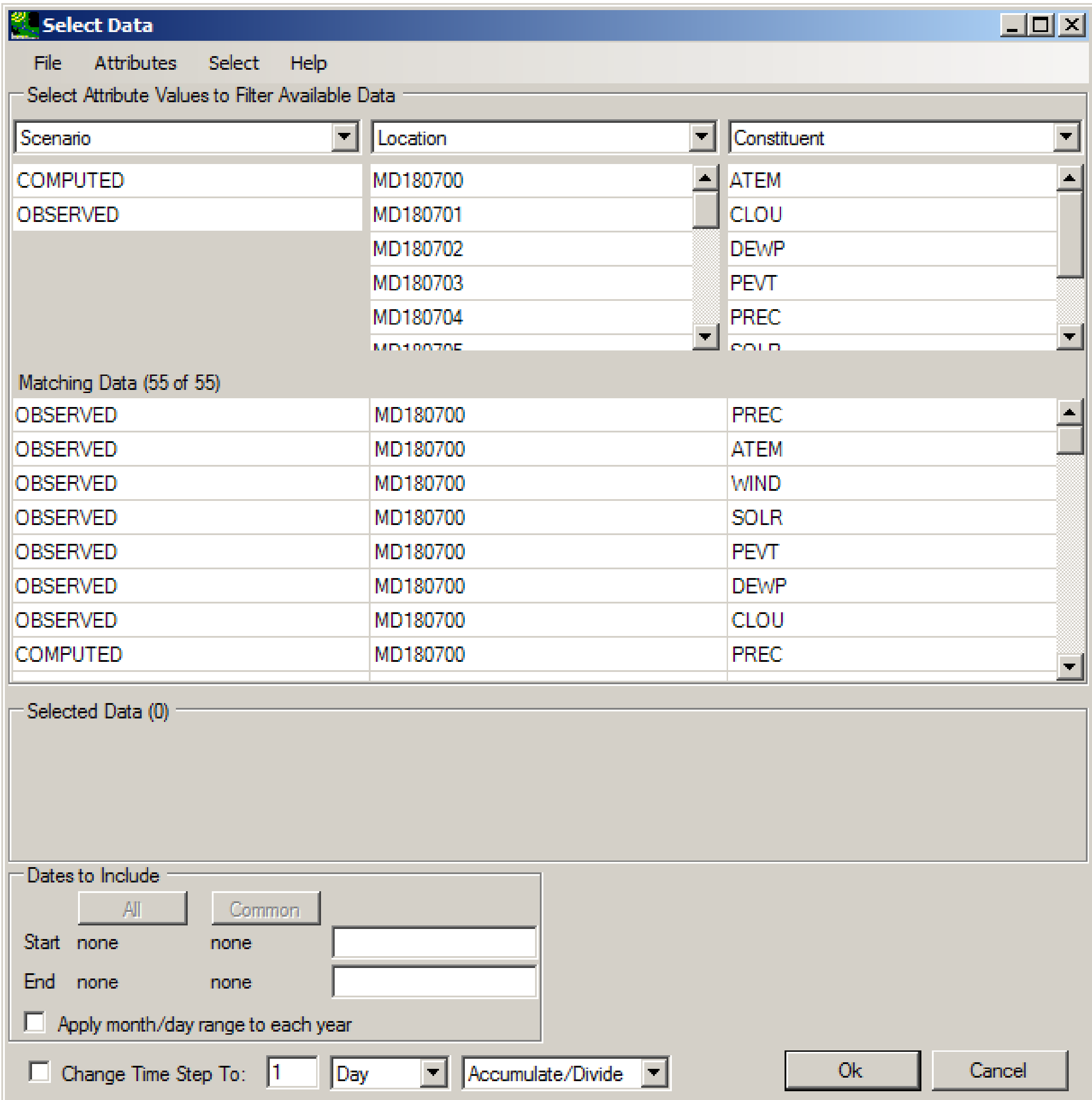
Time Series Functions

Five utilities available via the **Analysis** menu provide the ability to quickly analyze available project time-series data: Data Tree, Graph, Seasonal Attributes, Synoptic Analysis, and List. Project time-series data are managed through the Time-Series Management Utilities. There may be any number of timeseries available in a project, based on which time series files are in the project. *Note: In order for the following*

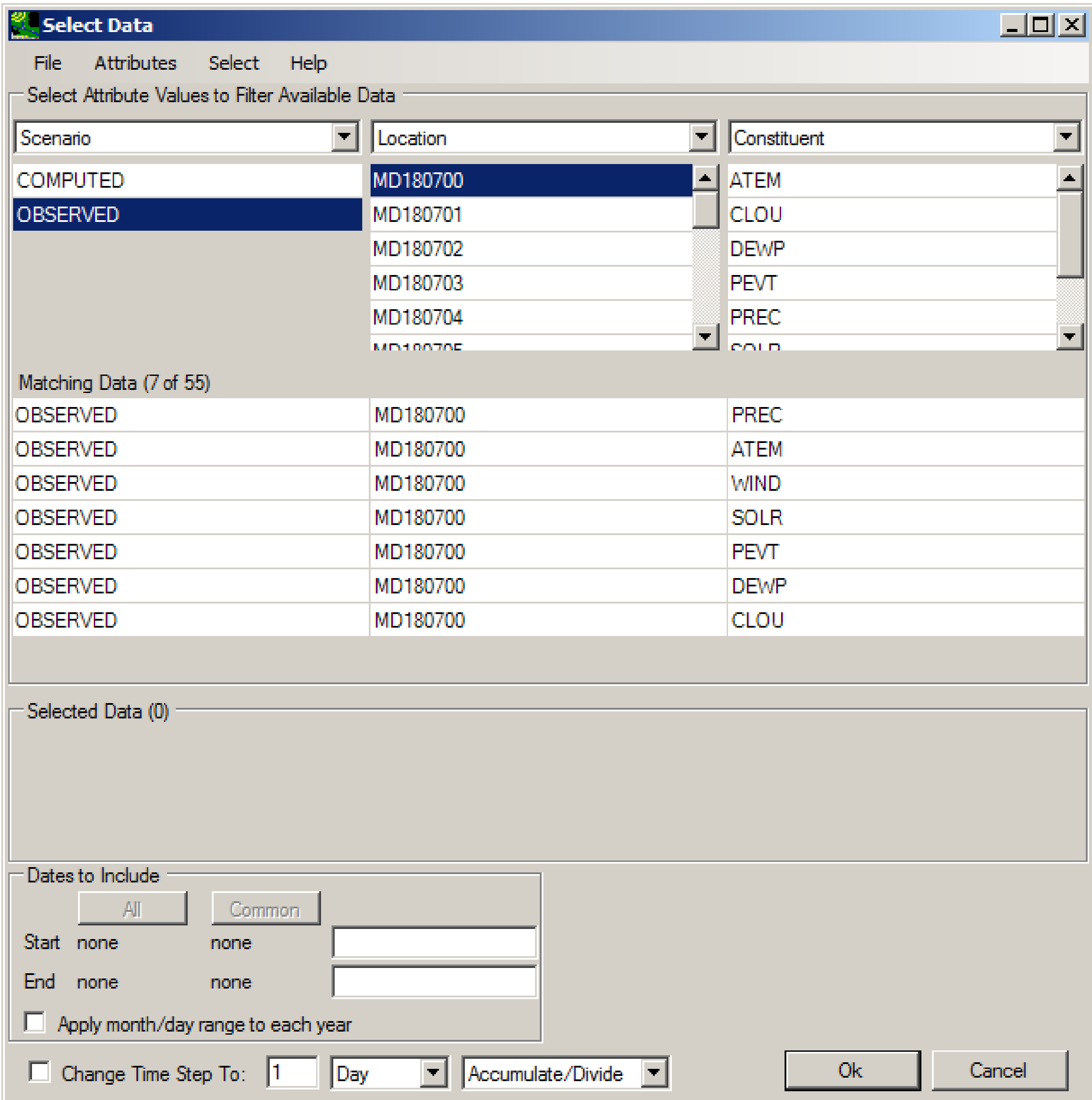
*Time-Series Functions to be accessible, they must be activated from the **Plug-ins:Analysis** menu on the main BASINS screen.*



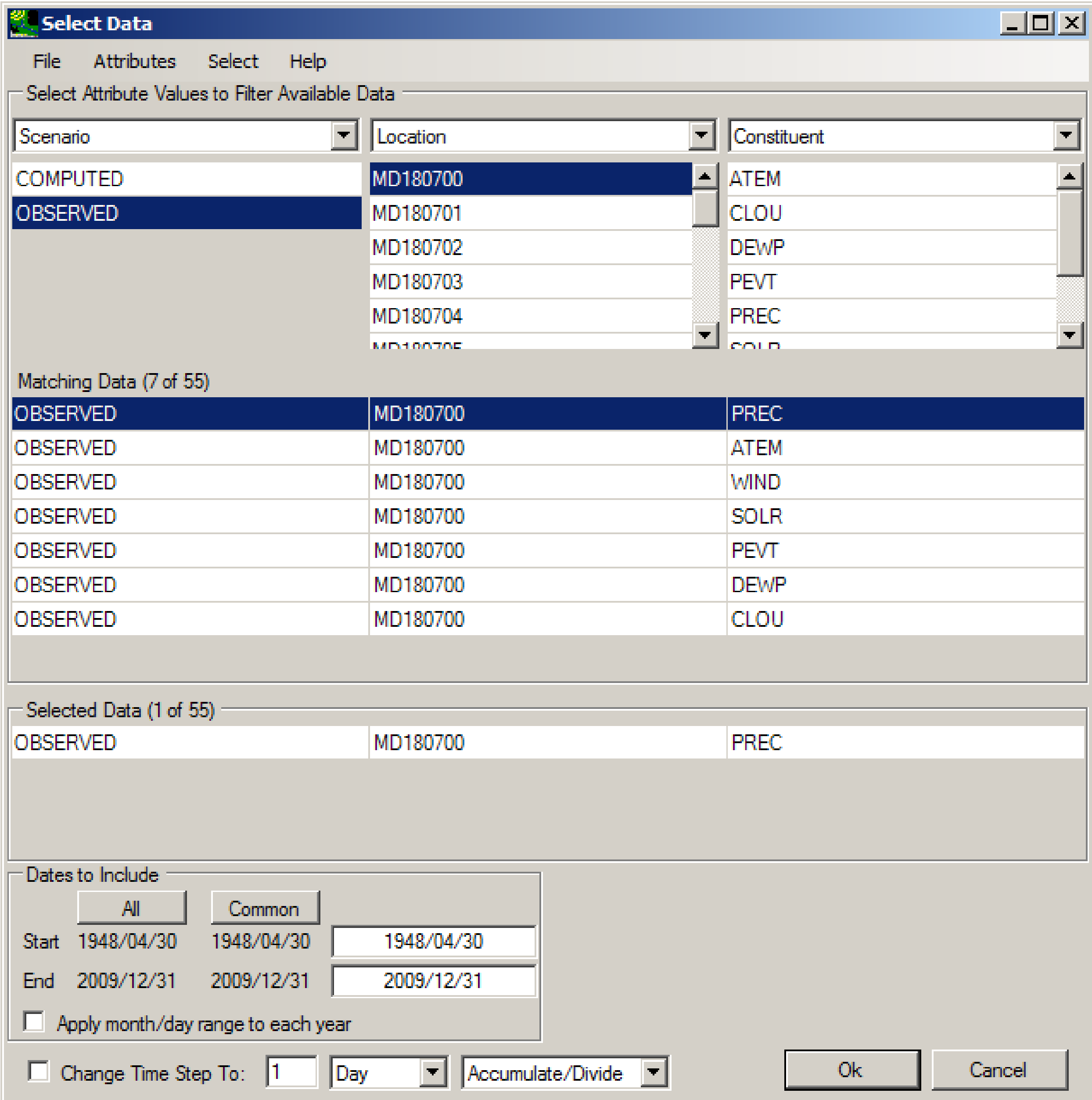
When any one of these five items is selected, the **Select Data** form pops up, allowing the user to filter the available time series based on their attributes.



The top section of this form is titled **Select Attribute Values to Filter Available Data** and contains pull-down lists with time-series attributes. The number and content of these lists can be managed through the **Attributes** menu. When the user selects an attribute from any of these lists, the grid beneath is populated with the range of distinct values for that attribute from all available time series. Then, when the user selects one or more of these values from the list, the middle section of the form, titled **Matching Data**, is populated with all available time series that have the selected value for the given attribute.

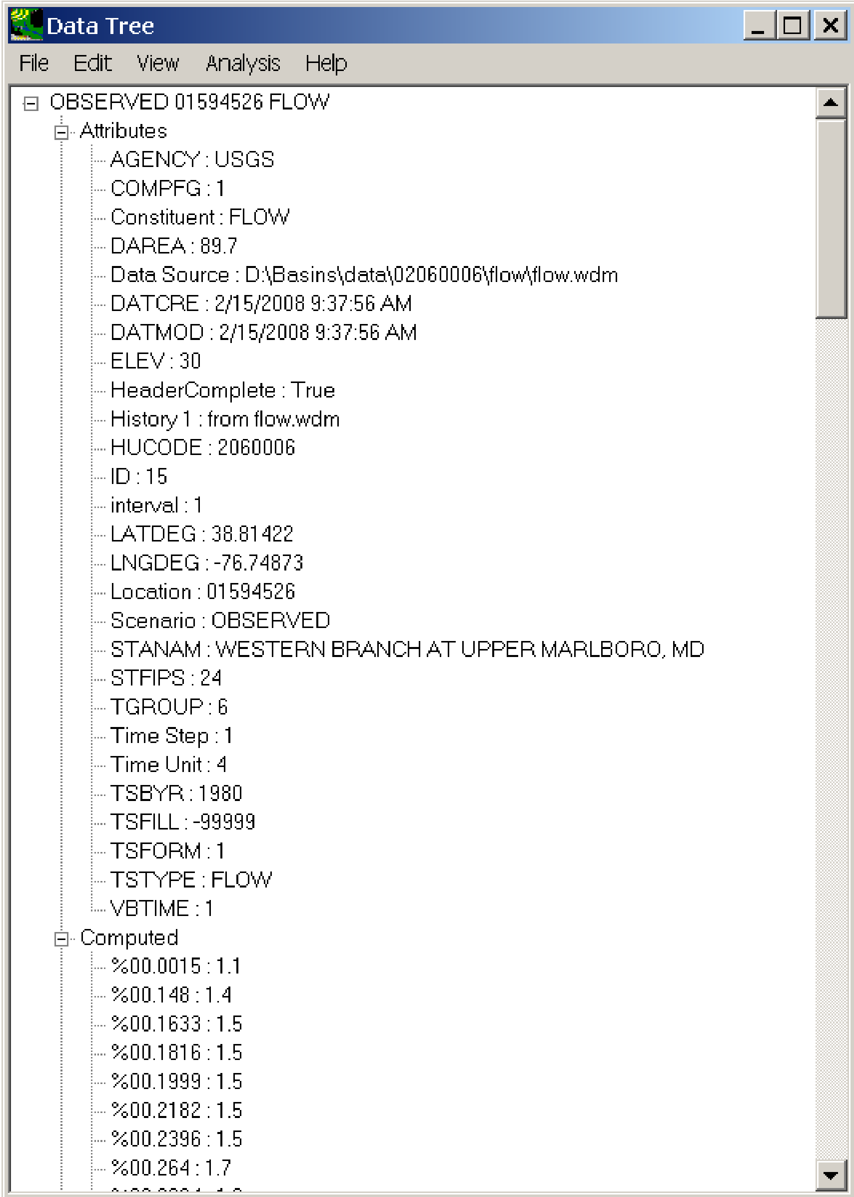


Finally, the user selects from among the time series listed in the **Matching Data** section, and these time series are listed in the bottom section of the form, **Selected Data**. Once time series are selected, clicking on the **OK** button will close that form and invoke the appropriate form for the selected analysis.



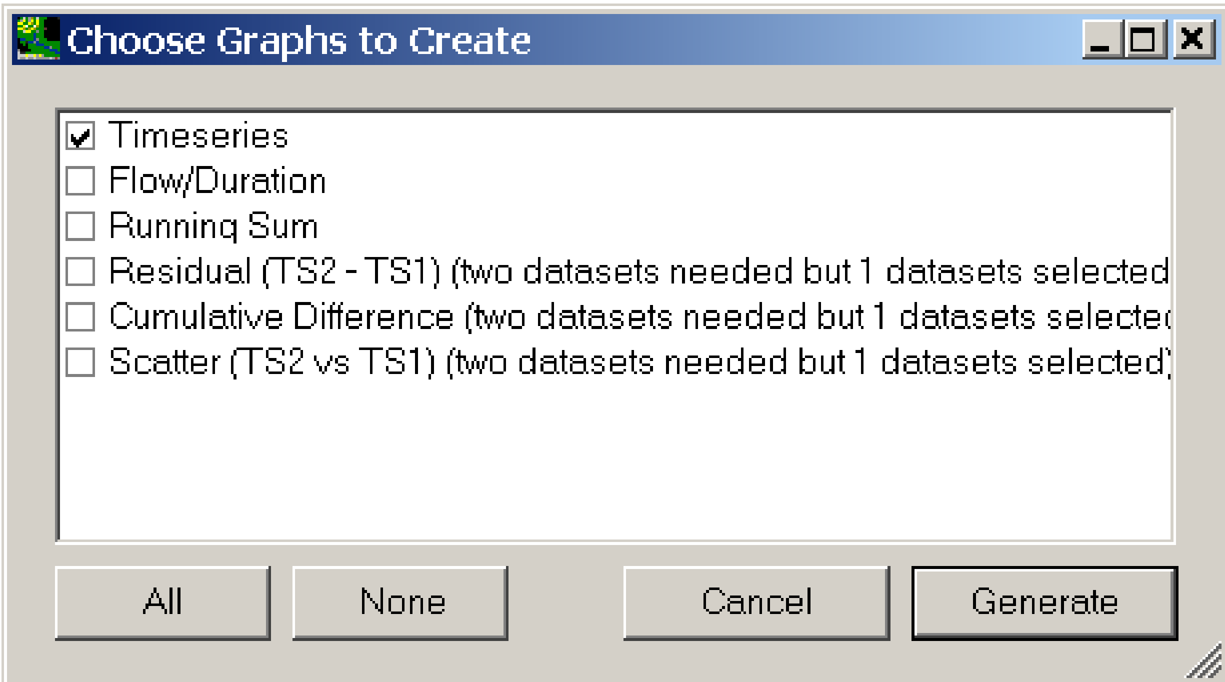
Data Tree

The **Data Tree** submenu item will produce a window listing all of the attributes and many calculated statistics for the selected time series. The Data Tree form has an **Analysis** menu item from which any of the five time series analysis tools covered in this section can be selected.

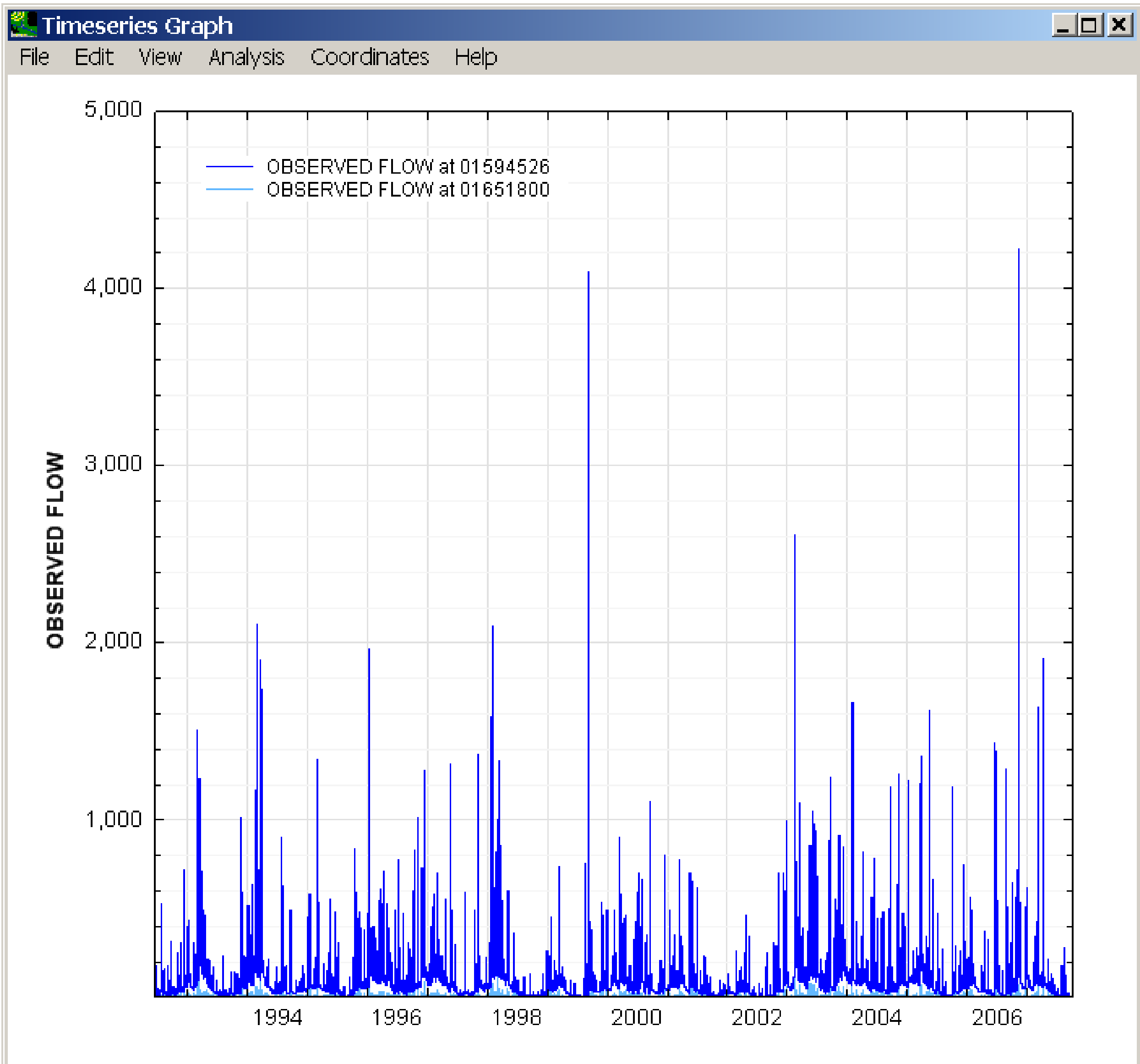


Graph

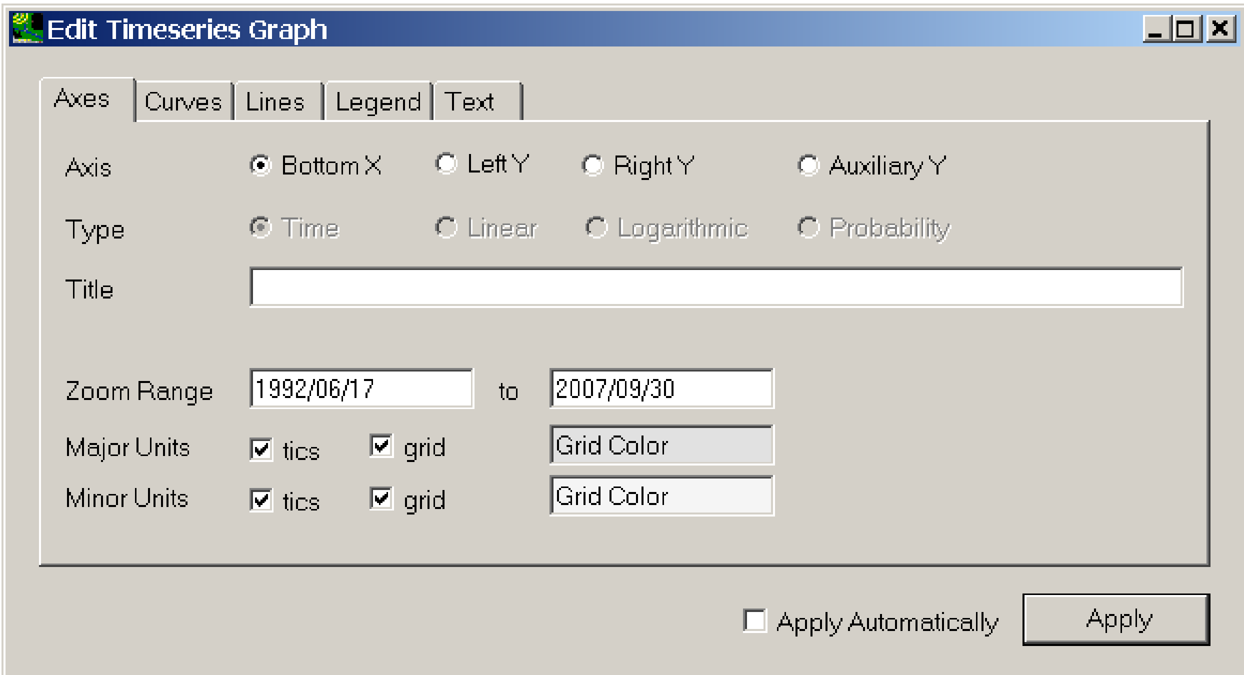
The **Graph** menu item is used to produce graphs of the selected time series. When the ‘Graph’ menu item is selected, a form is produced for choosing from among a set of possible graph types. Among the implemented graph types include Timeseries, Flow/Duration, Running Sum, Residual, Cumulative Difference, and Scatter.



Once the user has selected one or more of the desired graph types and clicks 'Generate', the graphs will be produced. The **File** menu can be used to print the graph or save it to file. The timeseries displayed on the graph can be changed using the 'Select Data' menu item from the 'File' menu.



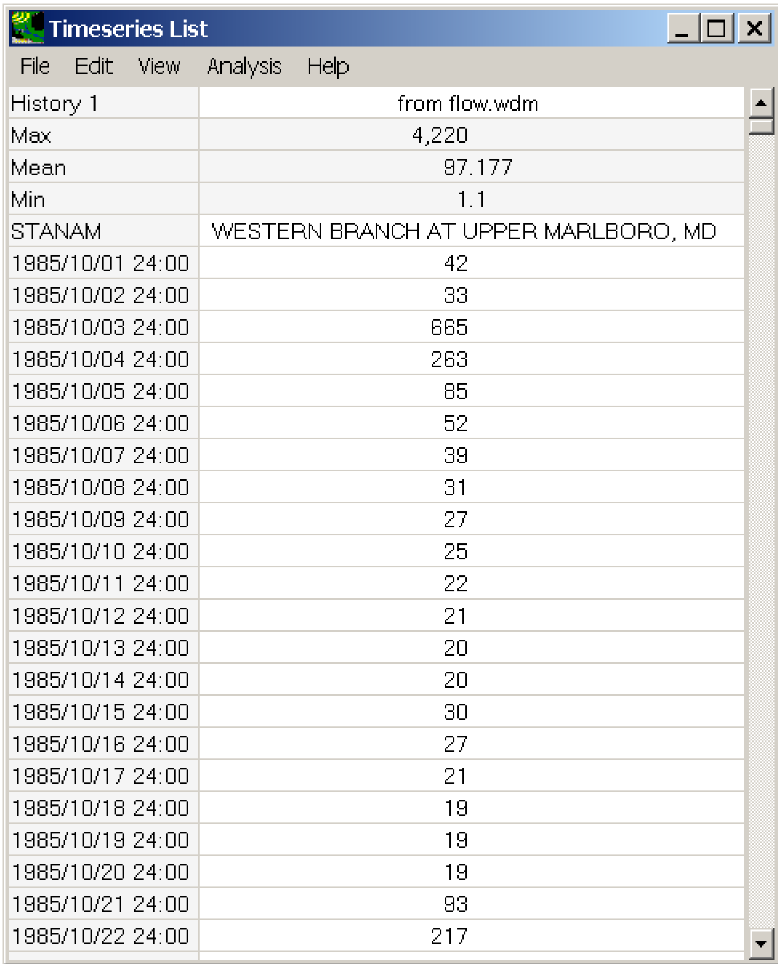
The **Edit** menu can be used to modify the appearance (for instance curves, axes, labels, and so forth) of the graph. The form contains five tabs (Axes, Curves, Lines, Legend, and Text). When a graph is first drawn it is given default values for all these parameters.



Menu items on the **View** menu are used to specify zooming/panning on the horizontal or vertical axes. If the graph has been zoomed in, the 'Zoom to All' menu option returns the graph to the original extents. The **Analysis** menu allows the user to switch to another of the BASINS timeseries data analysis tools directly from the graph. If, for instance, the current graph includes two timeseries, the user chooses the 'List' item from the 'Analysis' menu and obtain a listing of the same two timeseries. The **Coordinates** menu allows the user to turn on a feature that displays the coordinates of the mouse pointer as it is moved over the graph.

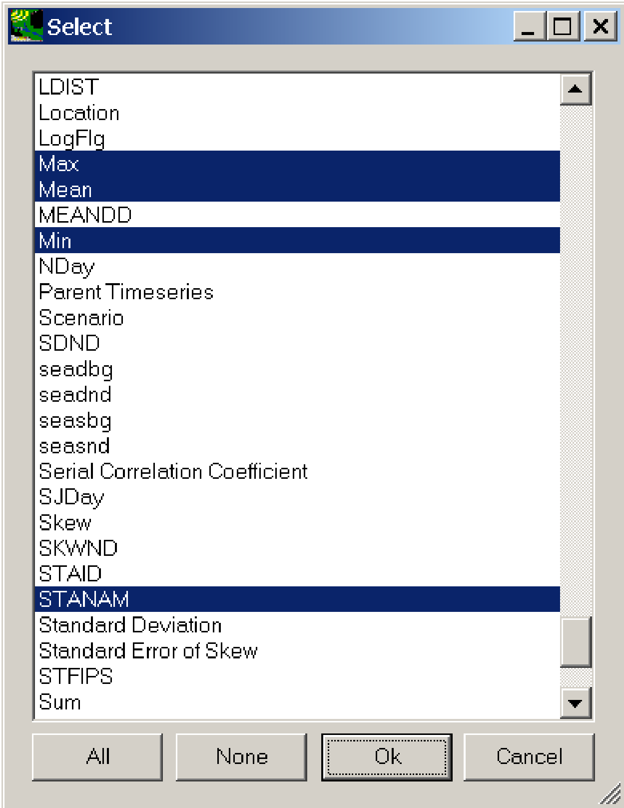
List

The **List** submenu item produces a listing of dates and associated values for the selected time series.



History 1	from flow.wdm
Max	4,220
Mean	97.177
Min	1.1
STANAM	WESTERN BRANCH AT UPPER MARLBORO, MD
1985/10/01 24:00	42
1985/10/02 24:00	33
1985/10/03 24:00	665
1985/10/04 24:00	263
1985/10/05 24:00	85
1985/10/06 24:00	52
1985/10/07 24:00	39
1985/10/08 24:00	31
1985/10/09 24:00	27
1985/10/10 24:00	25
1985/10/11 24:00	22
1985/10/12 24:00	21
1985/10/13 24:00	20
1985/10/14 24:00	20
1985/10/15 24:00	30
1985/10/16 24:00	27
1985/10/17 24:00	21
1985/10/18 24:00	19
1985/10/19 24:00	19
1985/10/20 24:00	19
1985/10/21 24:00	93
1985/10/22 24:00	217

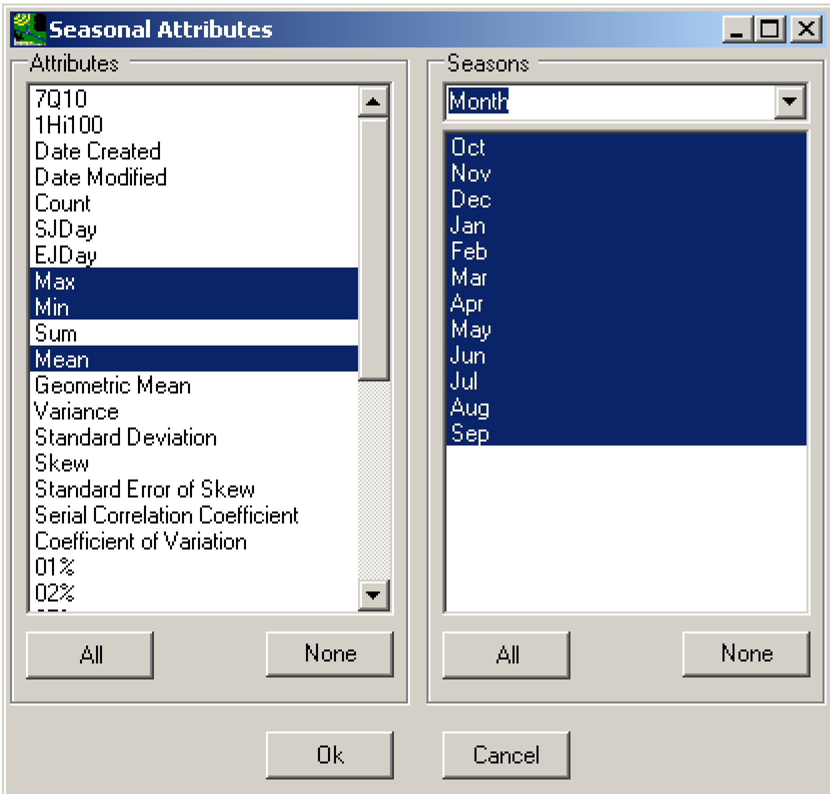
The **View** menu contains a set of customization options for the listing. The **File:Select Attributes** menu item allows the user to select the attributes that will appear at the top of the listing.



Seasonal Attributes

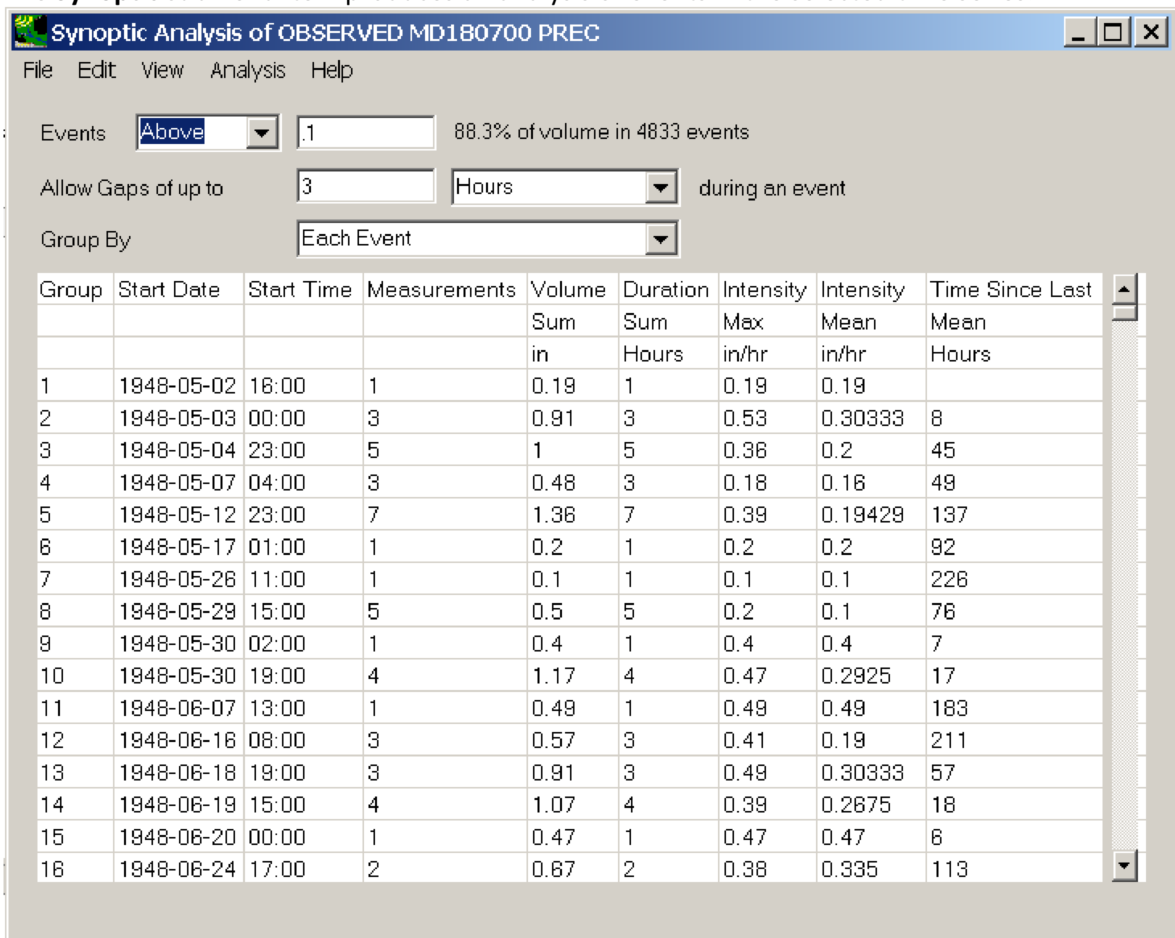
The **Seasonal Attributes** submenu item calculates the value of the selected attribute(s) for each interval in the selected type of season. For calculation purposes, a "season" can be days of the week, months of the year, the traditional four seasons (Autumn, Winter, Spring, Summer), or a variety of other options.

The following form will calculate the mean, minimum, and maximum value for the selected time series during each of the four seasons.



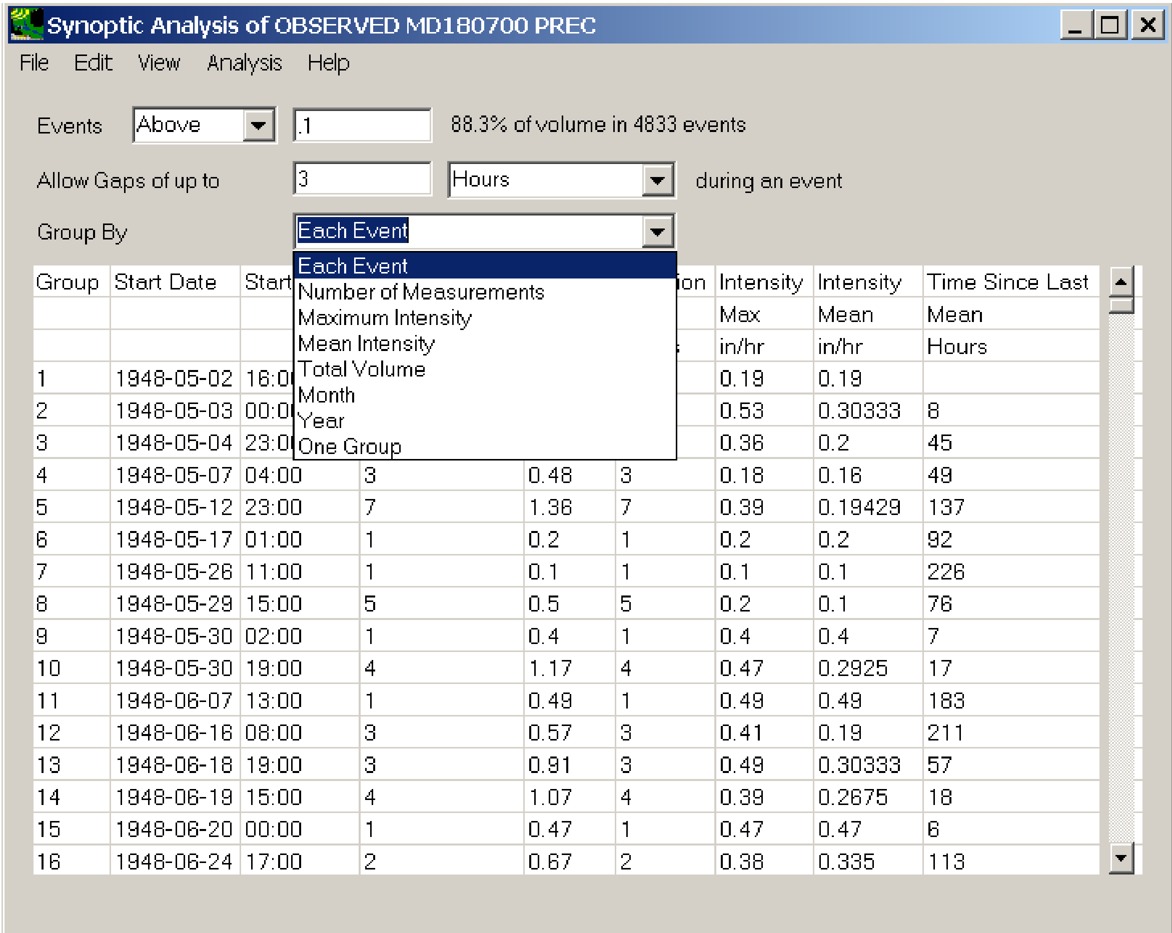
Synoptic Analysis

The **Synoptic** submenu item produces an analysis of events in the selected time series.

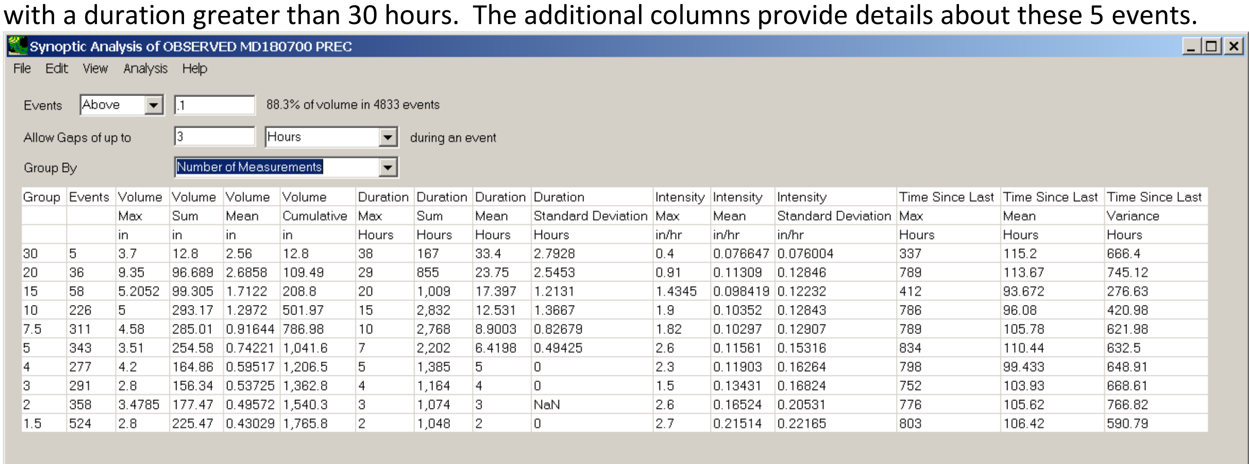


Group	Start Date	Start Time	Measurements	Volume Sum in	Duration Sum Hours	Intensity Max in/hr	Intensity Mean in/hr	Time Since Last Mean Hours
1	1948-05-02	16:00	1	0.19	1	0.19	0.19	
2	1948-05-03	00:00	3	0.91	3	0.53	0.30333	8
3	1948-05-04	23:00	5	1	5	0.36	0.2	45
4	1948-05-07	04:00	3	0.48	3	0.18	0.16	49
5	1948-05-12	23:00	7	1.36	7	0.39	0.19429	137
6	1948-05-17	01:00	1	0.2	1	0.2	0.2	92
7	1948-05-26	11:00	1	0.1	1	0.1	0.1	226
8	1948-05-29	15:00	5	0.5	5	0.2	0.1	76
9	1948-05-30	02:00	1	0.4	1	0.4	0.4	7
10	1948-05-30	19:00	4	1.17	4	0.47	0.2925	17
11	1948-06-07	13:00	1	0.49	1	0.49	0.49	183
12	1948-06-16	08:00	3	0.57	3	0.41	0.19	211
13	1948-06-18	19:00	3	0.91	3	0.49	0.30333	57
14	1948-06-19	15:00	4	1.07	4	0.39	0.2675	18
15	1948-06-20	00:00	1	0.47	1	0.47	0.47	6
16	1948-06-24	17:00	2	0.67	2	0.38	0.335	113

The time series is divided into events based on a specification of threshold and gap values. The event threshold is a value and a conditional (above or below). An event begins when a value in the time series crosses the threshold value into the event space. When a value in the time series crosses back over the threshold, the event conditionally ends. If the time series has an additional value that is in the event space before the time span specified by the gap ends, then the event continues. Otherwise, the event ends at the conditional end. The results of the synoptic analysis are displayed in a table specified by the **Group By** combo box.



The **Event** report provides details about each event. The **Number of Measurements** report summarizes events based on their duration. In the following figure, the first data row shows that there are 5 events with a duration greater than 30 hours. The additional columns provide details about these 5 events.



Group	Events	Volume	Volume	Volume	Volume	Duration	Duration	Duration	Duration	Intensity	Intensity	Intensity	Time Since Last	Time Since Last	Time Since Last
		Max	Sum	Mean	Cumulative	Max	Sum	Mean	Standard Deviation	Max	Mean	Standard Deviation	Max	Mean	Variance
		in	in	in	in	Hours	Hours	Hours	Hours	in/hr	in/hr	in/hr	Hours	Hours	Hours
30	5	3.7	12.8	2.56	12.8	38	167	33.4	2.7928	0.4	0.076647	0.076004	337	115.2	666.4
20	36	9.35	96.689	2.6858	109.49	29	855	23.75	2.5453	0.91	0.11309	0.12846	789	113.67	745.12
15	58	5.2052	99.305	1.7122	208.8	20	1,009	17.397	1.2131	1.4345	0.098419	0.12232	412	93.672	276.63
10	226	5	293.17	1.2972	501.97	15	2,832	12.531	1.3667	1.9	0.10352	0.12843	786	96.08	420.98
7.5	311	4.58	285.01	0.91644	786.98	10	2,768	8.9003	0.82679	1.82	0.10297	0.12907	789	105.78	621.98
5	343	3.51	254.58	0.74221	1,041.6	7	2,202	6.4198	0.49425	2.6	0.11561	0.15316	834	110.44	632.5
4	277	4.2	164.86	0.59517	1,206.5	5	1,385	5	0	2.3	0.11903	0.16264	798	99.433	648.91
3	291	2.8	156.34	0.53725	1,362.8	4	1,164	4	0	1.5	0.13431	0.16824	752	103.93	668.61
2	358	3.4785	177.47	0.49572	1,540.3	3	1,074	3	NaN	2.6	0.16524	0.20531	776	105.62	766.82
1.5	524	2.8	225.47	0.43029	1,765.8	2	1,048	2	0	2.7	0.21514	0.22165	803	106.42	590.79

The **Maximum Intensity** report groups and summarizes events based on their largest single value. In the following figure, the first data row shows that there are 2 events with a maximum values greater than 4.

Synoptic Analysis of OBSERVED MD180700 PREC

File Edit View Analysis Help

Events: Above .1 — 88.3% of volume in 4833 events

Allow Gaps of up to 3 Hours during an event

Group By: Maximum Intensity

Group	Events	Volume Max in	Volume Sum in	Volume Mean in	Volume Cumulative in	Duration Max Hours	Duration Sum Hours	Duration Mean Hours	Duration Standard Deviation Hours	Intensity Max in/hr	Intensity Mean in/hr	Intensity Standard Deviation in/hr	Time Since Last Max Hours	Time Since Last Mean Hours	Time Since Last Variance Hours
4	2	4.735	8.848	4.424	8.848	1	2	1	0	4.735	4.424	0.4398	46	32	16.333
2	9	4.2	27.418	3.0464	36.266	7	37	4.1111	2.1473	2.7	0.74102	0.96269	367	163.33	747.16
1.5	10	4.58	26.13	2.613	62.396	11	43	4.3	3.5606	1.9	0.60767	0.70298	266	91.7	406.44
1	52	5.2052	101.3	1.9481	163.7	19	244	4.6923	4.4613	1.5	0.41517	0.46764	752	98.558	788.65
0.75	88	9.35	135.39	1.5385	299.09	22	406	4.6136	4.4345	1	0.33347	0.33583	509	114.1	649.93
0.5	197	5.7791	243.43	1.2357	542.52	28	993	5.0406	5.2273	0.75	0.24515	0.22728	792	100.35	634.53
0.4	343	5.1	321.96	0.93866	864.48	38	1,863	5.4315	5.3147	0.5	0.17282	0.1581	786	103.2	575.18
0.3	404	3.4	318.37	0.78805	1,182.9	32	2,301	5.6955	5.3506	0.395	0.13836	0.11072	803	108.44	667.65
0.2	828	2.5	444.62	0.53698	1,627.5	34	4,237	5.1171	4.7858	0.298	0.10494	0.077147	1,029	104.45	687.81
0.15	192	1.22	59.8	0.31146	1,687.3	11	470	2.4479	1.9219	0.19465	0.12723	0.0487	10,291	193.45	23,094
0.1	2708	1.8	470.01	0.17356	2,157.3	25	6,312	2.3309	2.7079	0.146	0.074463	0.044871	1,439	93.966	595.73

The **Mean Intensity** report groups and summarizes events based on the event mean value. In the following figure, the first row shows that there are 2 events with event mean values greater than 4.

Synoptic Analysis of OBSERVED MD180700 PREC

File Edit View Analysis Help

Events: Above .1 — 88.3% of volume in 4833 events

Allow Gaps of up to 3 Hours during an event

Group By: Mean Intensity

Group	Events	Volume Max in	Volume Sum in	Volume Mean in	Volume Cumulative in	Duration Max Hours	Duration Sum Hours	Duration Mean Hours	Duration Standard Deviation Hours	Intensity Max in/hr	Intensity Mean in/hr	Intensity Standard Deviation in/hr	Time Since Last Max Hours	Time Since Last Mean Hours	Time Since Last Variance Hours
4	2	4.735	8.848	4.424	8.848	1	2	1	0	4.735	4.424	0.4398	46	32	16.333
1.5	3	1.8	5.1	1.7	13.948	1	3	1	0	1.8	1.7	0.1	31	23	4.6667
1	20	3.4785	32.422	1.6211	46.37	3	27	1.35	0.67082	2.7	1.2008	0.73865	455	125.2	818.61
0.75	30	4.2	36.526	1.2175	82.896	5	43	1.4333	0.85836	2.3	0.84944	0.3859	451	114.7	580.53
0.5	76	4.58	86.339	1.136	169.24	8	144	1.8947	1.5369	2.6	0.59958	0.39717	792	114.58	760.65
0.4	137	9.35	109.78	0.80134	279.02	22	248	1.8102	2.0635	2.0465	0.44267	0.269	757	97.015	608.51
0.3	192	5.2052	153.6	0.79998	432.62	16	458	2.3854	2.3949	2.1	0.33536	0.28322	684	116.31	639.67
0.2	491	5.7791	325.13	0.66217	757.75	28	1,412	2.8758	3.0296	1.4	0.23026	0.17381	1,029	109.12	818.22
0.15	403	5.4	278.27	0.69049	1,036	28	1,647	4.0868	3.8095	1.5	0.16895	0.13321	10,291	144.28	11,466
0.1	2571	3.3	655.18	0.25484	1,691.2	24	5,833	2.2688	2.9782	0.9	0.11232	0.077204	1,439	94.985	607.62
0.075	294	3.7	210.52	0.71604	1,901.7	38	2,496	8.4898	5.6228	0.6	0.084342	0.072804	834	97.027	477.87
0.05	479	2.4	211.27	0.44107	2,113	34	3,513	7.334	4.6709	0.3	0.060141	0.057733	789	97.714	489.98
0.04	110	1.1	35.3	0.32091	2,148.3	24	832	7.5636	3.6158	0.2	0.042428	0.049937	412	84.655	348.15
0.03	25	0.7	9	0.36	2,157.3	19	250	10	3.1754	0.1	0.036	0.048096	789	148.04	1,809.6

The **Total Volume** report groups and summarizes events based on the event total volume.

Synoptic Analysis of OBSERVED MD180700 PREC

File Edit View Analysis Help

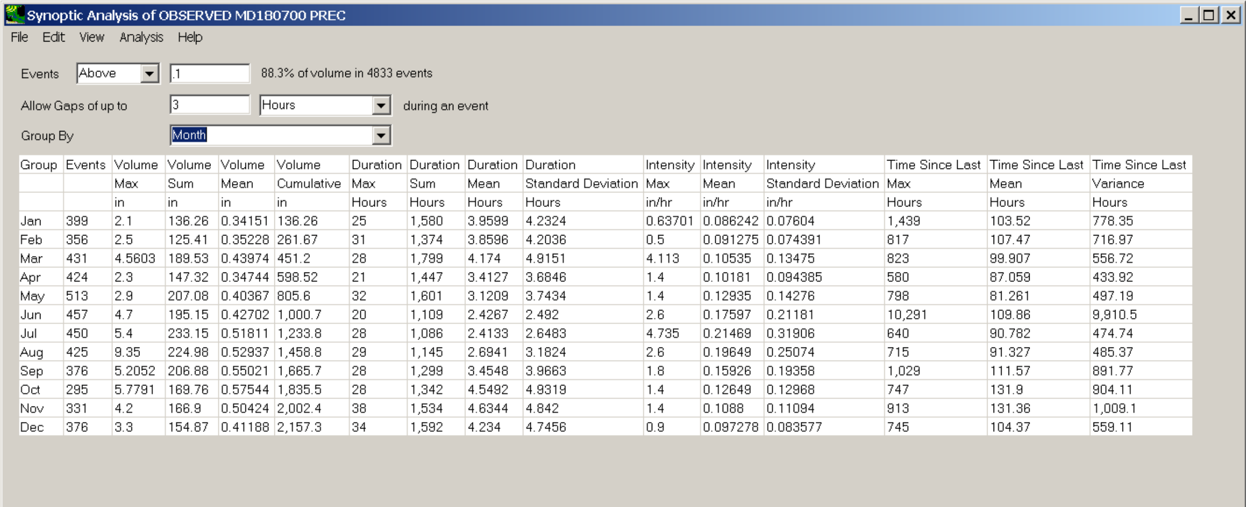
Events: Above .1 — 88.3% of volume in 4833 events

Allow Gaps of up to 3 Hours during an event

Group By: Total Volume

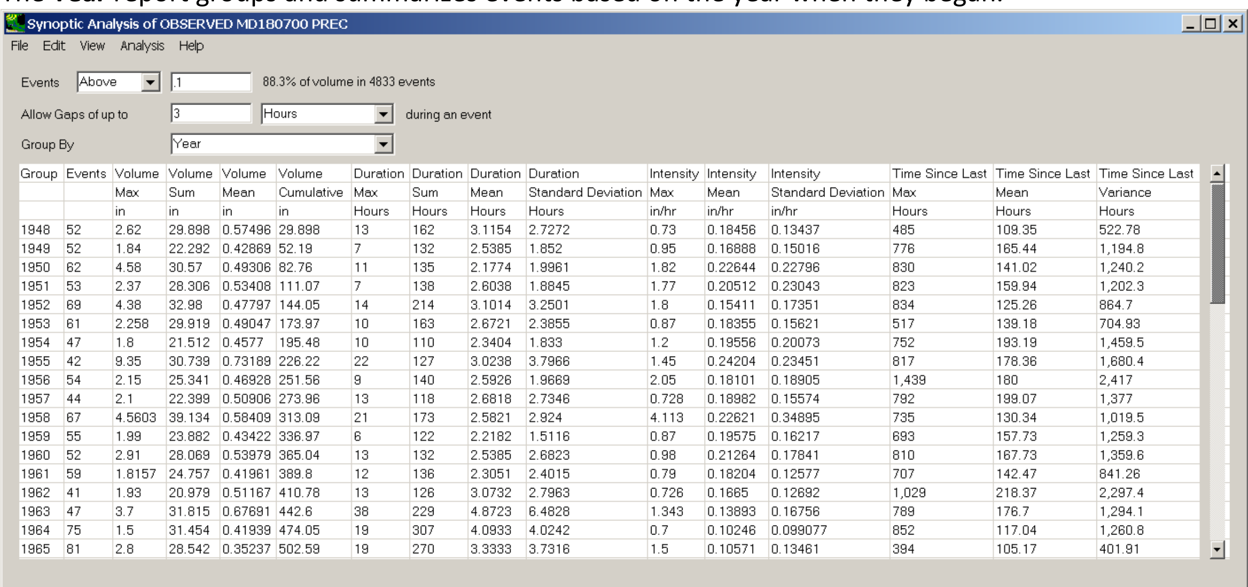
Group	Events	Volume Max in	Volume Sum in	Volume Mean in	Volume Cumulative in	Duration Max Hours	Duration Sum Hours	Duration Mean Hours	Duration Standard Deviation Hours	Intensity Max in/hr	Intensity Mean in/hr	Intensity Standard Deviation in/hr	Time Since Last Max Hours	Time Since Last Mean Hours	Time Since Last Variance Hours
7.5	1	9.35	9.35	9.35	9.35	22	22	22	NaN	0.91	0.425	0.223	113	113	NaN
5	5	5.7791	26.484	5.2969	35.834	28	115	23	6.8557	1.4345	0.2303	0.22584	277	137.8	662.53
4	11	4.735	47.838	4.3489	83.672	21	123	11.182	7.2363	4.735	0.38893	0.63583	236	95.545	248.37
3	15	4	51.088	3.4059	134.76	38	206	13.733	9.7795	2.6	0.248	0.38924	367	87.2	398.42
2	81	2.9895	191.36	2.3625	326.12	34	1,137	14.037	7.996	2.7	0.1683	0.24796	463	103.07	436.83
1.5	137	2	230.76	1.6844	556.88	31	1,438	10.496	5.7255	1.8	0.16048	0.21094	786	106.68	815.31
1	315	1.5	375.09	1.1907	931.97	25	2,560	8.127	4.5627	1.4546	0.14652	0.17614	789	112.46	666.6
0.75	292	1	250.87	0.85916	1,182.8	20	1,775	6.0788	4.0347	1	0.14134	0.16826	823	104.07	611.22
0.5	580	0.75	343.84	0.59283	1,526.6	19	3,232	5.5724	3.3242	0.73	0.10639	0.11278	834	113.33	714.27
0.4	340	0.5	143.11	0.42091	1,669.7	13	1,295	3.8088	2.5914	0.5	0.11051	0.1172	738	94.729	530.94
0.3	463	0.4	144.35	0.31178	1,814.1	9	1,555	3.3585	2.0196	0.39394	0.092831	0.084821	789	97.685	566.02
0.2	668	0.3	141.27	0.21148	1,955.4	5	1,525	2.2829	1.2532	0.296	0.092633	0.068313	1,029	105.13	650.99
0.15	88	0.1906	14.76	0.16773	1,970.2	1	88	1	0	0.1906	0.16773	0.015088	10,291	248.41	49,580
0.1	1837	0.142	187.11	0.10185	2,157.3	1	1,837	1	0	0.142	0.10185	0.0068282	1,439	91.174	613.29

The **Month** report groups and summarizes events based on the month when they began.



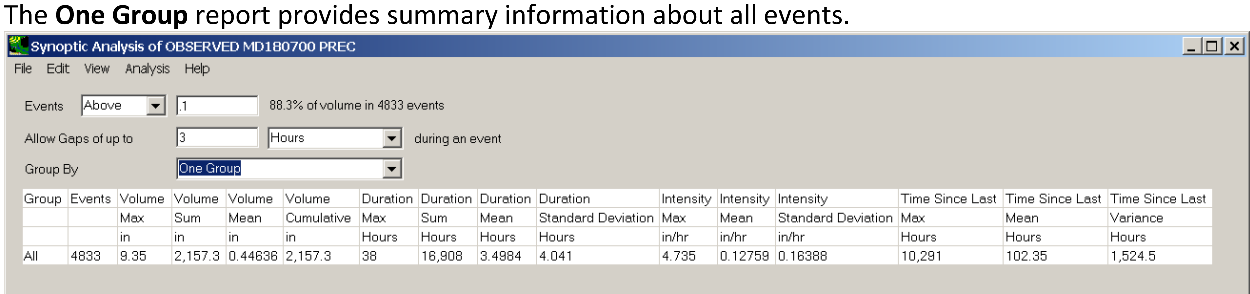
Group	Events	Volume	Volume	Volume	Volume	Duration	Duration	Duration	Duration	Intensity	Intensity	Intensity	Time Since Last	Time Since Last	Time Since Last
		Max	Sum	Mean	Cumulative	Max	Sum	Mean	Standard Deviation	Max	Mean	Standard Deviation	Max	Mean	Variance
		in	in	in	in	Hours	Hours	Hours	Hours	in/hr	in/hr	in/hr	Hours	Hours	Hours
Jan	399	2.1	136.26	0.34151	136.26	25	1,580	3.9599	4.2324	0.63701	0.086242	0.07604	1,439	103.52	778.35
Feb	356	2.5	125.41	0.35228	261.67	31	1,374	3.8596	4.2036	0.5	0.091275	0.074391	817	107.47	716.97
Mar	431	4.5603	189.53	0.43974	451.2	28	1,799	4.174	4.9151	4.113	0.10535	0.13475	823	99.907	556.72
Apr	424	2.3	147.32	0.34744	598.52	21	1,447	3.4127	3.6846	1.4	0.10181	0.094385	580	87.059	433.92
May	513	2.9	207.08	0.40367	805.6	32	1,601	3.1209	3.7434	1.4	0.12935	0.14276	798	81.261	497.19
Jun	457	4.7	195.15	0.42702	1,000.7	20	1,109	2.4267	2.492	2.6	0.17597	0.21181	10,291	109.86	9,910.5
Jul	450	5.4	233.15	0.51811	1,233.8	28	1,086	2.4133	2.6483	4.735	0.21469	0.31906	640	90.782	474.74
Aug	425	9.35	224.98	0.52937	1,458.8	29	1,145	2.6941	3.1824	2.6	0.19649	0.25074	715	91.327	485.37
Sep	376	5.2052	206.88	0.55021	1,665.7	28	1,299	3.4548	3.9663	1.8	0.15926	0.19358	1,029	111.57	891.77
Oct	295	5.7791	169.76	0.57544	1,835.5	28	1,342	4.5492	4.9319	1.4	0.12649	0.12968	747	131.9	904.11
Nov	331	4.2	166.9	0.50424	2,002.4	38	1,534	4.6344	4.842	1.4	0.1088	0.11094	913	131.36	1,009.1
Dec	376	3.3	154.87	0.41188	2,157.3	34	1,592	4.234	4.7456	0.9	0.097278	0.083577	745	104.37	559.11

The **Year** report groups and summarizes events based on the year when they began.



Group	Events	Volume	Volume	Volume	Volume	Duration	Duration	Duration	Duration	Intensity	Intensity	Intensity	Time Since Last	Time Since Last	Time Since Last
		Max	Sum	Mean	Cumulative	Max	Sum	Mean	Standard Deviation	Max	Mean	Standard Deviation	Max	Mean	Variance
		in	in	in	in	Hours	Hours	Hours	Hours	in/hr	in/hr	in/hr	Hours	Hours	Hours
1948	52	2.62	29.898	0.57496	29.898	13	162	3.1154	2.7272	0.73	0.18456	0.13437	485	109.35	522.78
1949	52	1.84	22.292	0.42869	52.19	7	132	2.5385	1.852	0.95	0.16888	0.15016	776	165.44	1,194.8
1950	62	4.58	30.57	0.49306	82.76	11	135	2.1774	1.9961	1.82	0.22644	0.22796	830	141.02	1,240.2
1951	53	2.37	28.306	0.53408	111.07	7	138	2.6038	1.8845	1.77	0.20512	0.23043	823	159.94	1,202.3
1952	69	4.38	32.98	0.47797	144.05	14	214	3.1014	3.2501	1.8	0.15411	0.17351	834	125.26	864.7
1953	61	2.258	29.919	0.49047	173.97	10	163	2.6721	2.3855	0.87	0.18355	0.15621	517	139.18	704.93
1954	47	1.8	21.512	0.4577	195.48	10	110	2.3404	1.833	1.2	0.19556	0.20073	752	193.19	1,459.5
1955	42	9.35	30.739	0.73189	226.22	22	127	3.0238	3.7966	1.45	0.24204	0.23451	817	178.36	1,680.4
1956	54	2.15	25.341	0.46928	251.56	9	140	2.5926	1.9669	2.05	0.18101	0.18905	1,439	180	2,417
1957	44	2.1	22.399	0.50906	273.96	13	118	2.6818	2.7346	0.728	0.18982	0.15574	792	199.07	1,377
1958	67	4.5603	39.134	0.58409	313.09	21	173	2.5821	2.924	4.113	0.22621	0.34895	735	130.34	1,019.5
1959	55	1.99	23.882	0.43422	336.97	6	122	2.2182	1.5116	0.87	0.19575	0.16217	693	157.73	1,259.3
1960	52	2.91	28.069	0.53979	365.04	13	132	2.5385	2.6823	0.98	0.21264	0.17841	810	167.73	1,359.6
1961	59	1.8157	24.757	0.41961	389.8	12	136	2.3051	2.4015	0.79	0.18204	0.12577	707	142.47	841.26
1962	41	1.93	20.979	0.51167	410.78	13	126	3.0732	2.7963	0.726	0.1665	0.12692	1,029	218.37	2,297.4
1963	47	3.7	31.815	0.67691	442.6	38	229	4.8723	6.4828	1.343	0.13893	0.16756	789	176.7	1,294.1
1964	75	1.5	31.454	0.41939	474.05	19	307	4.0933	4.0242	0.7	0.10246	0.099077	852	117.04	1,260.8
1965	81	2.8	28.542	0.35237	502.59	19	270	3.3333	3.7316	1.5	0.10571	0.13461	394	105.17	401.91

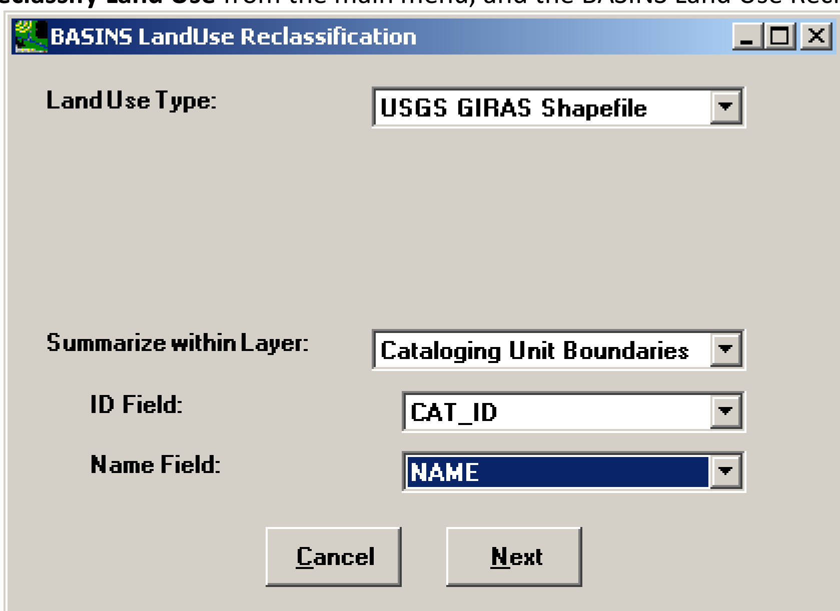
The **One Group** report provides summary information about all events.



Group	Events	Volume	Volume	Volume	Volume	Duration	Duration	Duration	Duration	Intensity	Intensity	Intensity	Time Since Last	Time Since Last	Time Since Last
		Max	Sum	Mean	Cumulative	Max	Sum	Mean	Standard Deviation	Max	Mean	Standard Deviation	Max	Mean	Variance
		in	in	in	in	Hours	Hours	Hours	Hours	in/hr	in/hr	in/hr	Hours	Hours	Hours
All	4833	9.35	2,157.3	0.44636	2,157.3	38	16,908	3.4984	4.041	4.735	0.12759	0.16388	10,291	102.35	1,524.5

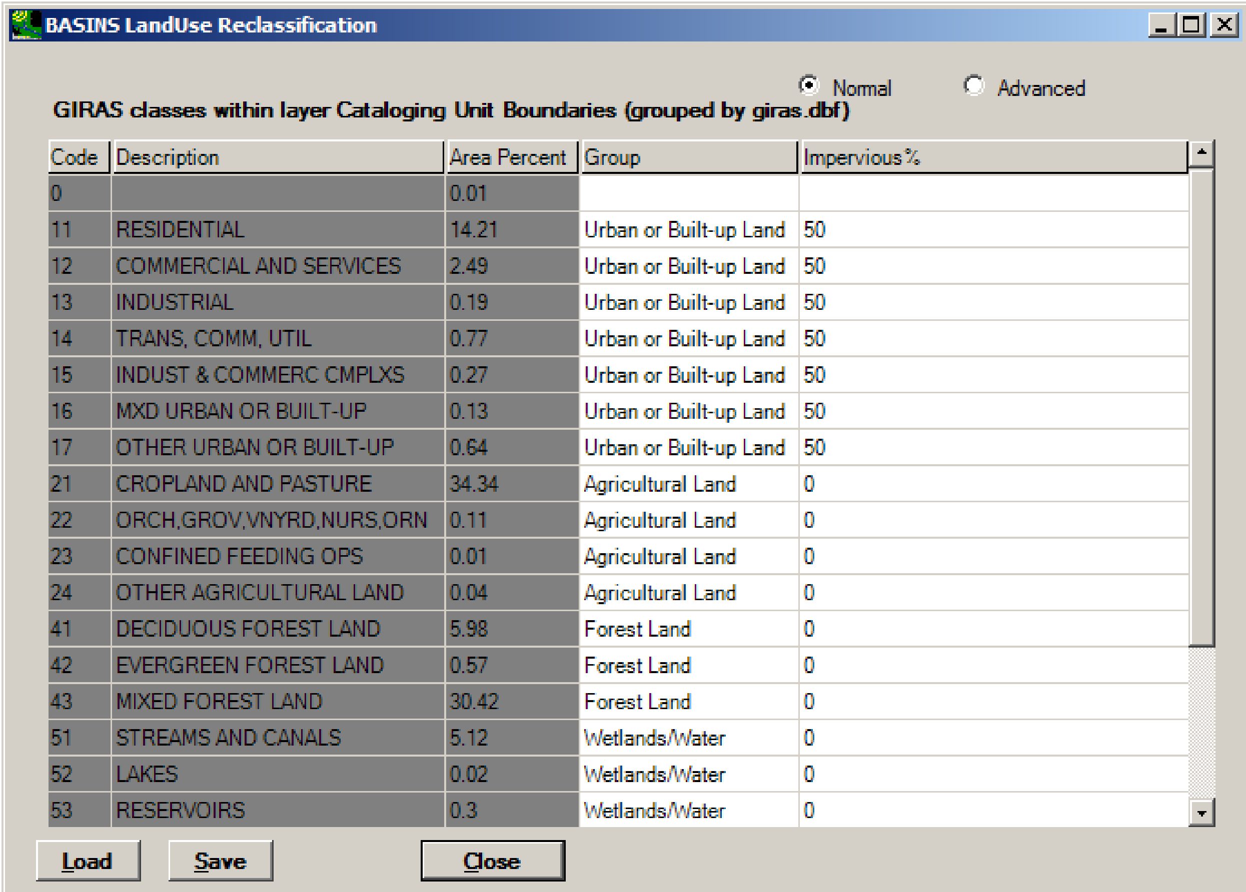
Reclassify Land Use

The BASINS Land Use Reclassification tool is used to group detailed land use classes, based on their code and name, into broad categories. Conversely, it can also break out a single land use category into multiple categories (e.g., create High-density and Low-density from a single Residential category or create Corn and Soybeans from a single Cropland category) based on user-defined fractions. The land use reclassification tool produces a DBF table that can be used later to define land use categories and quantify pervious and impervious drainage areas in support of nonpoint source modeling. Reclassification of land use is often required to update existing land use data files, to regroup land use types, or to evaluate water quality impacts or management alternatives based on changes to land use over time. For example, changes in water quality due to urbanization can be accounted for by converting agricultural or forested land that is likely to be developed into an urban land classification. In addition, land use classes that have similar characteristics can be grouped into a single classification to simplify modeling. This tool may be used with any boundary polygon layer, but most often is used after watershed delineation and before setting up a watershed model. The land use layer to reclassify should already be downloaded and available on the map. *Key Procedures*

- Select **Reclassify Land Use** from the **Plug-ins:Analysis** submenu.
- Select **Analysis:Reclassify Land Use** from the main menu, and the BASINS Land Use Reclassification 

form will pop up.
- Select the land use layer from the top pull-down listbox and the boundary layer from the Summarize within Layer listbox beneath. Once the boundary layer is selected, the ID Field and Name Field listboxes are populated with the names of all fields from the DBF for that layer; select the appropriate ID and Name fields. When the appropriate selections have been made click the **Next**

button, and, after calculating the area distribution, the following table will appear.



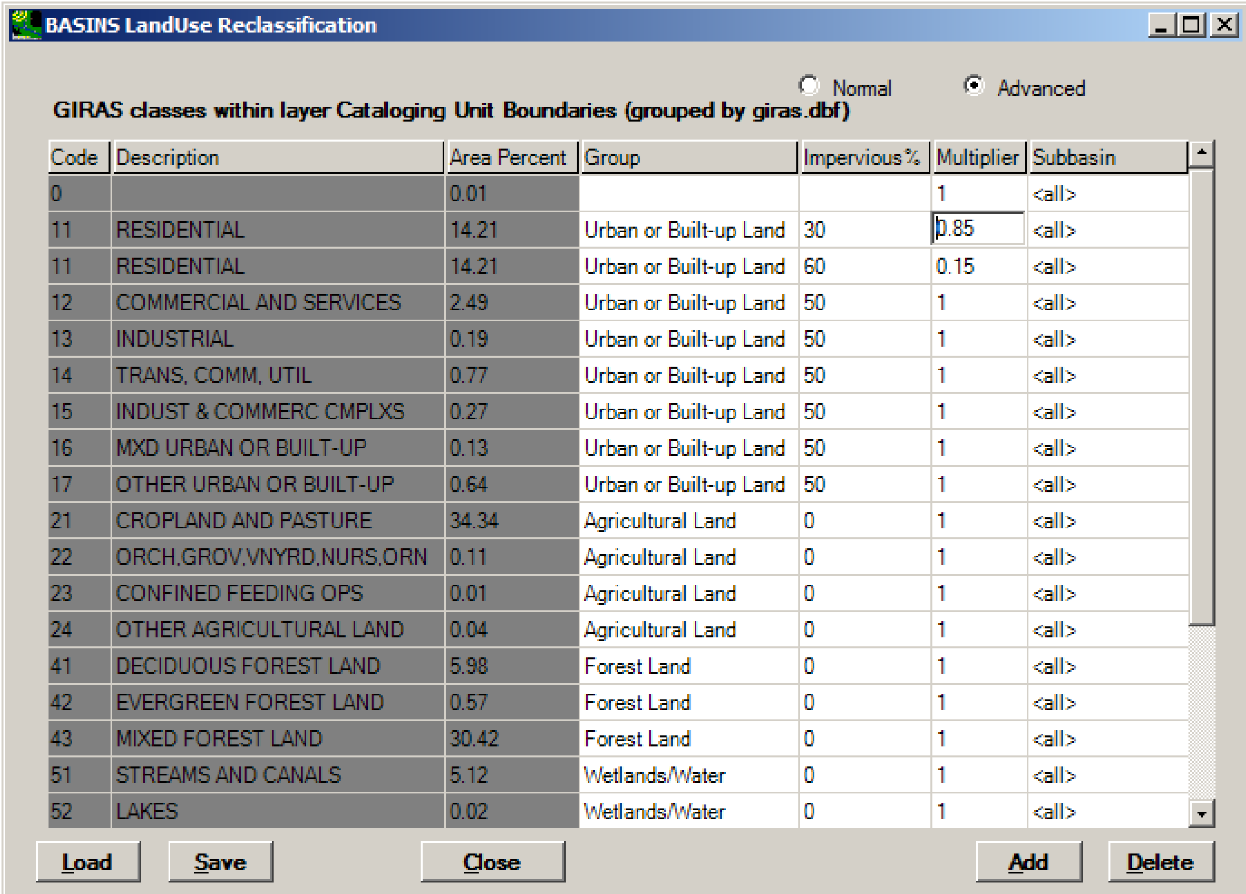
Code	Description	Area Percent	Group	Impervious%
0		0.01		
11	RESIDENTIAL	14.21	Urban or Built-up Land	50
12	COMMERCIAL AND SERVICES	2.49	Urban or Built-up Land	50
13	INDUSTRIAL	0.19	Urban or Built-up Land	50
14	TRANS, COMM, UTIL	0.77	Urban or Built-up Land	50
15	INDUST & COMMERC CMPLXS	0.27	Urban or Built-up Land	50
16	MXD URBAN OR BUILT-UP	0.13	Urban or Built-up Land	50
17	OTHER URBAN OR BUILT-UP	0.64	Urban or Built-up Land	50
21	CROPLAND AND PASTURE	34.34	Agricultural Land	0
22	ORCH,GROV,VNYRD,NURS,ORN	0.11	Agricultural Land	0
23	CONFINED FEEDING OPS	0.01	Agricultural Land	0
24	OTHER AGRICULTURAL LAND	0.04	Agricultural Land	0
41	DECIDUOUS FOREST LAND	5.98	Forest Land	0
42	EVERGREEN FOREST LAND	0.57	Forest Land	0
43	MIXED FOREST LAND	30.42	Forest Land	0
51	STREAMS AND CANALS	5.12	Wetlands/Water	0
52	LAKES	0.02	Wetlands/Water	0
53	RESERVOIRS	0.3	Wetlands/Water	0

- *OPTIONAL* An existing land use grouping scheme can be loaded from a DBF file by clicking on the **Load** button. Also, the current scheme can be saved to a DBF file for later recall by clicking the **Save** button. The default scheme is kept in the 'BASINS\etc\giras.dbf' file for the USGS GIRAS land use data, and the 'nlcd.dbf' file for the NLCD data.

- For the **Normal** reclassification procedure, the Group and Impervious% columns are edited to combine multiple categories into a single category with the desired distribution of pervious/impervious area.

- There are an additional two columns for the **Advanced** reclassification procedure, Multiplier and Subbasin. These columns are used for breaking out a single land use category into multiple categories (e.g., creating High Density and Low Density from a single Residential category). There are also two buttons added to the form, **Add** and **Delete**, which perform the indicated function to whichever row is selected. To break a single category into two, click any cell on the row of that category, click **Add**, then fill in the Group, Impervious%, Multiplier and Subbasin cells for those two rows (the sum of the Multipliers should equal 1.0). The following BASINS Land Use Reclassification form will result in the Residential category from the GIRAS land use layer being divided into 85% low density (with 70% pervious and 30% impervious area) and 15% high density (with 40% pervious and

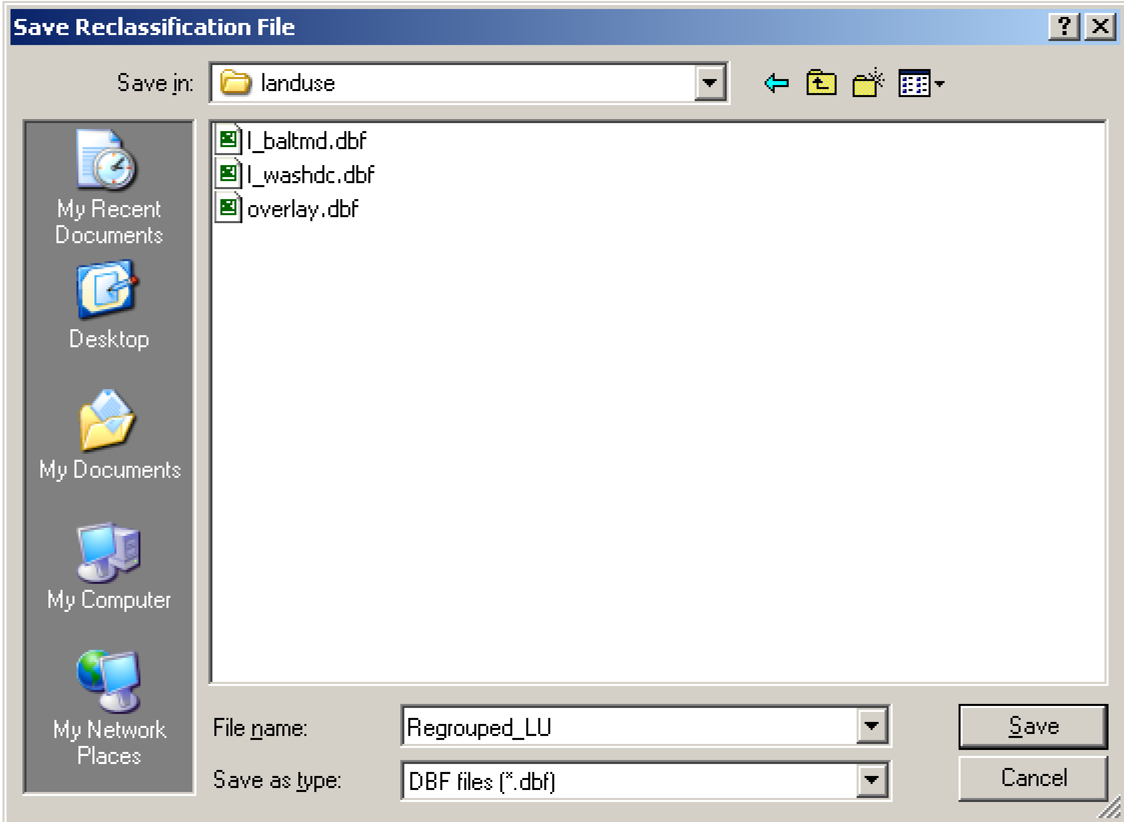
60% impervious area).



Code	Description	Area Percent	Group	Impervious%	Multiplier	Subbasin
0		0.01			1	<all>
11	RESIDENTIAL	14.21	Urban or Built-up Land	30	0.85	<all>
11	RESIDENTIAL	14.21	Urban or Built-up Land	60	0.15	<all>
12	COMMERCIAL AND SERVICES	2.49	Urban or Built-up Land	50	1	<all>
13	INDUSTRIAL	0.19	Urban or Built-up Land	50	1	<all>
14	TRANS, COMM, UTIL	0.77	Urban or Built-up Land	50	1	<all>
15	INDUST & COMMERC CMPLXS	0.27	Urban or Built-up Land	50	1	<all>
16	MXD URBAN OR BUILT-UP	0.13	Urban or Built-up Land	50	1	<all>
17	OTHER URBAN OR BUILT-UP	0.64	Urban or Built-up Land	50	1	<all>
21	CROPLAND AND PASTURE	34.34	Agricultural Land	0	1	<all>
22	ORCH,GROV,VNYRD,NURS,ORN	0.11	Agricultural Land	0	1	<all>
23	CONFINED FEEDING OPS	0.01	Agricultural Land	0	1	<all>
24	OTHER AGRICULTURAL LAND	0.04	Agricultural Land	0	1	<all>
41	DECIDUOUS FOREST LAND	5.98	Forest Land	0	1	<all>
42	EVERGREEN FOREST LAND	0.57	Forest Land	0	1	<all>
43	MIXED FOREST LAND	30.42	Forest Land	0	1	<all>
51	STREAMS AND CANALS	5.12	Wetlands/Water	0	1	<all>
52	LAKES	0.02	Wetlands/Water	0	1	<all>

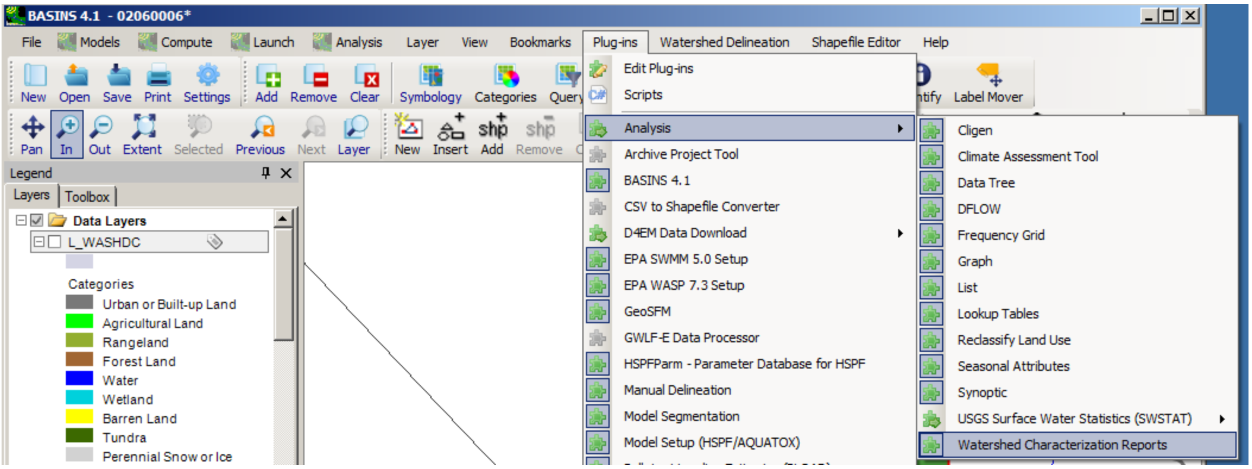
- The **Subbasin** column is used to specify the subbasin(s) to which the Impervious% and Multiplier should apply. For instance, a user might wish to specify that for a certain subbasin the Impervious% is higher than for others. This might be the case where the user might know that a given subbasin is densely developed and thus more impervious than the nearby less urbanized subbasins. The default value for the **Subbasin** is 'all', which indicates that the values on a given row will apply within all subbasins. If within a given land use type one row has a subbasin specified and others are set to 'all', the values corresponding to 'all' will apply to all values except the one row with a subbasin specified. Only one subbasin (or 'all') may be specified in the subbasin field on a given row.

- Click the **Save** button to save the current land use aggregation/division scheme to a DBF file.

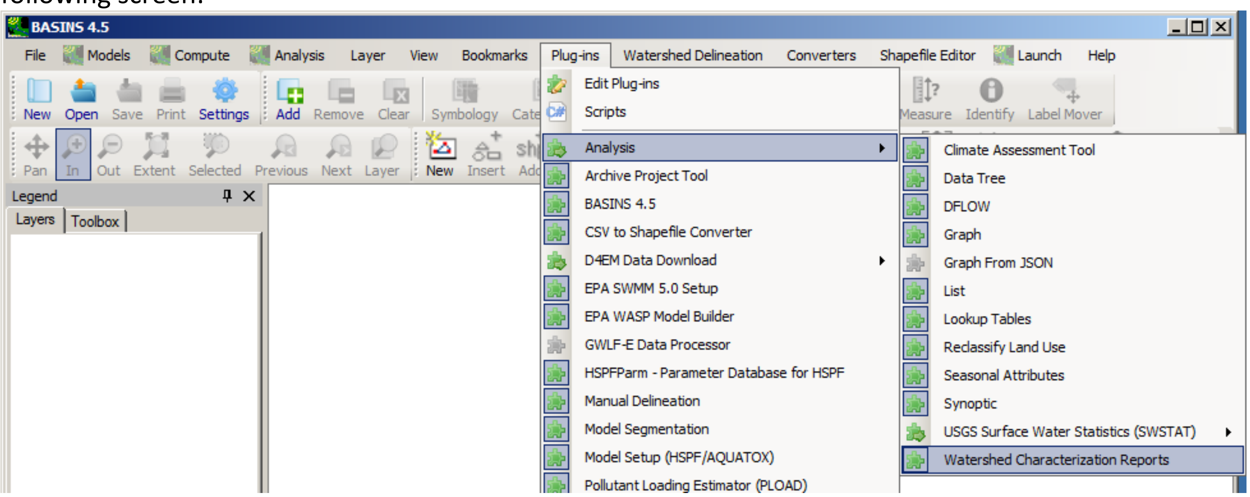


Watershed Characterization Reports

The BASINS system includes tools designed to assist in summarizing key watershed information in a format suitable for preparing watershed characterization reports. These tools produce tables that inventory and characterize both point and nonpoint sources at the watershed and subwatershed scales. Watershed characterization is key to understanding water quality issues and pollution sources in the watershed. In addition to evaluation of the watershed condition, it provides the necessary information to assess monitoring programs, identify data gaps, and develop watershed-water quality modeling strategies. In order to access the Watershed Characterization Reports, first activate plug-in via **Plug-ins:Analysis** on the main BASINS window.



This activates a **Watershed Characterization Reports** option under the **Analysis** menu, which opens the following screen:



BASINS 4 provides users the capability to generate several different types of watershed characterization reports, each in tabular form:

- 1990 Population and Sewerage by Census Tract
- 2000 Population and Census Tract Table
- Landuse Distribution Table
- Permitted Point Source Facilities Table
- Point Source Discharge Concentration and Loading Table

Other user-defined reports can be added by creating scripts and inserting them into the '\BASINS\etc\Reports' folder. Any VB.NET script residing in this folder will be added to the list of available reports viewed from the **Reports** menu. The tables generated by these tools are displayed both on the screen in their own window and written to a tab-delimited text file in the '\BASINS\Reports\'

directory. These text files can be directly imported into any standard spreadsheet or word processor for further formatting and incorporation into other watershed characterization reports.

1990 Population and Sewerage by Census Tract

The **1990 Population and Sewerage by Census Tract** summarizes the selected area by census tract ID. For each census tract, the report lists the population, number of housing units, type of residential sewer system, and spatial percentage of that tract located within the subject watershed area. The BASINS Census GIS layers, which are available via **File:Data Download** menu selection, are the data source for this report. The information generated for this report is summarized in tabular form in a pop-up window (see below) and in an output text file.

Watershed Characterization Report

1990 Population and Sewerage by Census Tract Table

AreaID	AreaName	TractID	Population	HouseUnits	SewerPublic	SewerSeptic	SewerOther	%inArea
1	PATUXENT	7520	6906	2162	513	1584	65	1.0
1	PATUXENT	6040	8748	2885	4	2824	57	77.6
1	PATUXENT	6030	7592	2551	48	2453	50	63.0
1	PATUXENT	700298	2084	734	23	686	25	29.4
1	PATUXENT	6070	0	0	0	0	0	100.0
1	PATUXENT	6021	3985	1463	993	470	0	6.7
1	PATUXENT	700202	6127	2201	1505	680	16	32.4
1	PATUXENT	6022	6151	2286	2106	180	0	94.4
1	PATUXENT	700103	2992	972	16	946	10	77.8
1	PATUXENT	602301	15482	5304	4961	343	0	94.6
1	PATUXENT	6028	3584	1407	1293	114	0	2.6

The **1990 Population and Sewerage by Census Tract** can be used to examine specific areas for population density and the prevalence of septic systems, which can be significant sources of pathogens, household chemicals, and nutrients (especially nitrate) escaping into groundwater and nearby receiving water bodies.

2000 Population and Census Tract Table

The **2000 Population and Census Tract Table** summarizes population in the selected area by census tract ID, and it also lists the spatial percentage of each tract that lies within the subject watershed area. The BASINS Census layers, which are available via **File:Data Download** menu selection, are the data source for this report. The information generated for this report is summarized in tabular form in a pop-up window (see below) and in an output text file.

Watershed Characterization Report

2000 Population by Census Tract Table

AreaID	AreaName	TractID	Population	%inArea
1	PATUXENT	7520	10392	1.0
1	PATUXENT	604001	5838	64.7
1	PATUXENT	6030	10645	62.9
1	PATUXENT	604002	5835	89.5
1	PATUXENT	700204	1949	29.7
1	PATUXENT	6021	6788	6.6
1	PATUXENT	700202	6777	32.5
1	PATUXENT	6022	7970	94.4
1	PATUXENT	700103	4530	78.5
1	PATUXENT	602303	3879	100.0
1	PATUXENT	6028	5265	2.0

The **2000 Population and Census Tract Table** can be used to examine specific areas for population density. Comparing this report to the 1990 population by census tract can help identify growth trends in particular areas.

Landuse Distribution Table

The **Landuse Distribution Table** provides a summary of landuse distribution within the selected watershed(s). There are two primary landuse layers available for download through the BASINS system: the USGS Geographic Information Retrieval and Analysis System (GIRAS), which uses the Anderson Level II classification, and the 1992 National Land Cover Dataset. The GIRAS and 1992 NLCD GIS landuse layers, which are available via **File:Data Download** menu selection, are the data source for this report. The information generated in this report is summarized in tabular form in a pop-up window (see below) and in an output text file.

Watershed Characterization Report

GIRAS Landuse Table in Acres

	1
	PATUXENT
<No Data>	32
Agricultural Land	203560
Barren Land	11754
Forest Land	218070
Urban or Built-up Land	110238
Wetlands/Water	46228

The **Landuse Distribution Report** can be used to examine the various land uses in the study area (by subwatershed) to assist in developing a modeling strategy such as the selection of nonpoint source segments (subwatershed) and the land use classes to be represented in the nonpoint source model. It can also be used to assess the need for a nonpoint source monitoring program and to determine areas where monitoring data are most useful for model parameterization and calibration.

Permitted Point Source Facilities Table

The **Permitted Point Source Facilities Table** provides a summary of discharge facilities in a given watershed. The report relies on the EPA Permit Compliance System (PCS) database to identify permitted facilities in the selected study area. The Permit Compliance System GIS layer, which one of the BASINS core layers downloaded as BASINS project is built, is the data source for this report. The information generated for this report is summarized in tabular form in a pop-up window (see below) and in an output text file.

Watershed Characterization Report

Permitted Point Source Facilities Table

AreaID	AreaName	NPDES	Facility Name	SIC	SIC Name	City
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	2023	CONDENSED AND EVAPORATED MILK	LAUREL
1	PATUXENT	MD0001155	GENERAL ELECTRIC APP PARKEAST	3631	HOUSEHOLD COOKING EQUIPMENT	COLUMBIA
1	PATUXENT	MD0002658	PEPCO CHALK POINT GEN. STATION	4911	ELECTRICAL SERVICES	AQUASCO
1	PATUXENT	MD0003093	ACADEMY OF NATURAL SCIENCE	8733	NONCOMMERCIAL RESEARCH ORGANI	BENEDICT
1	PATUXENT	MD0020150	PATUX. RIV. NAVAL AIR STATION	9711	NATIONAL SECURITY	PATUXENT
1	PATUXENT	MD0021628	CITY OF BOWIE WWTP	4952	SEWERAGE SYSTEMS	BOWIE
1	PATUXENT	MD0021652	PATUXENT WATER RECLAMATION FAC	4952	SEWERAGE SYSTEMS	ANNE ARU
1	PATUXENT	MD0021717	FT GEORGE G. MEADE	9711	NATIONAL SECURITY	FORT GEC
1	PATUXENT	MD0021725	PARKWAY WWTP	4952	SEWERAGE SYSTEMS	LAUREL
1	PATUXENT	MD0021733	HORSEPEN BRANCH	4952	SEWERAGE SYSTEMS	BOWIE
1	PATUXENT	MD0021741	WESTERN BRANCH WWTP	4952	SEWERAGE SYSTEMS	HYATTSVI

The **Permitted Point Source Facilities Table** is useful for identifying sources of pollutant loadings in a given watershed. Potential applications of this report tool include rapid identification of point sources and evaluation of their proximity to major streams. A summary of discharge concentrations and loading associated with each facility is provided in the Point Source Discharge Concentration and Loading Table.

Point Source Discharge Concentration and Loading Table

The **Point Source Discharge Concentration and Loading Table** summarizes the annual flow rate, concentration, and load for a range of reported pollutants. The PCS Discharge GIS layer, which is available via **File:Data Download** menu selection, is the data source for this report. The information generated for this report is summarized in tabular form in a pop-up window (see below) and in an output text file.

Watershed Characterization Report

Point Source Discharge Concentration and Loading Table

AreaID	AreaName	NPDES	Facility Name	Parameter	Year	Flow (MGD)	Avg. Conc. (mg/l)	Load (lbs/yr)
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1990	0.15610	9.24000	4390.56000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1991	0.18460	8.29000	4873.30000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1992	0.16640	8.03640	4096.96000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1993	0.13320	8.24750	3520.71000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1994	0.01820	7.54750	464.87000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1995	0.00000	7.35500	0.56000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1996	0.00000	8.30220	0.00000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1997	0.00000	6.52630	0.00000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1998	0.01930	7.24630	472.35000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	OXYGEN, DISSOLVED (DO)	1999	0.11340	8.56620	3068.56000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	BOD, 5-DAY (20 DEG. C)	1990	0.15610	7.01160	3147.67000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	BOD, 5-DAY (20 DEG. C)	1991	0.18460	11.48450	6220.17000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	BOD, 5-DAY (20 DEG. C)	1992	0.16640	12.05590	6174.13000
1	PATUXENT	MD0000469	MARYLAND & VIRGINIA MILK PRO.	BOD, 5-DAY (20 DEG. C)	1993	0.13320	47.35250	20438.45000

The summary of discharge concentrations and loads allows the user to perform a planning-level assessment of the magnitude and severity of point source contributions. Analyzing the data for different years can provide information to evaluate changes in contributions from various point sources over time and support trend analysis.

Watershed Characterization System

The BASINS Watershed Characterization System can be used to select and generate several standard reports designed to describe the physical characteristics of watersheds (subbasins) you have defined. This feature is more customized version of the Watershed Characterization Reports. The following reports are available:

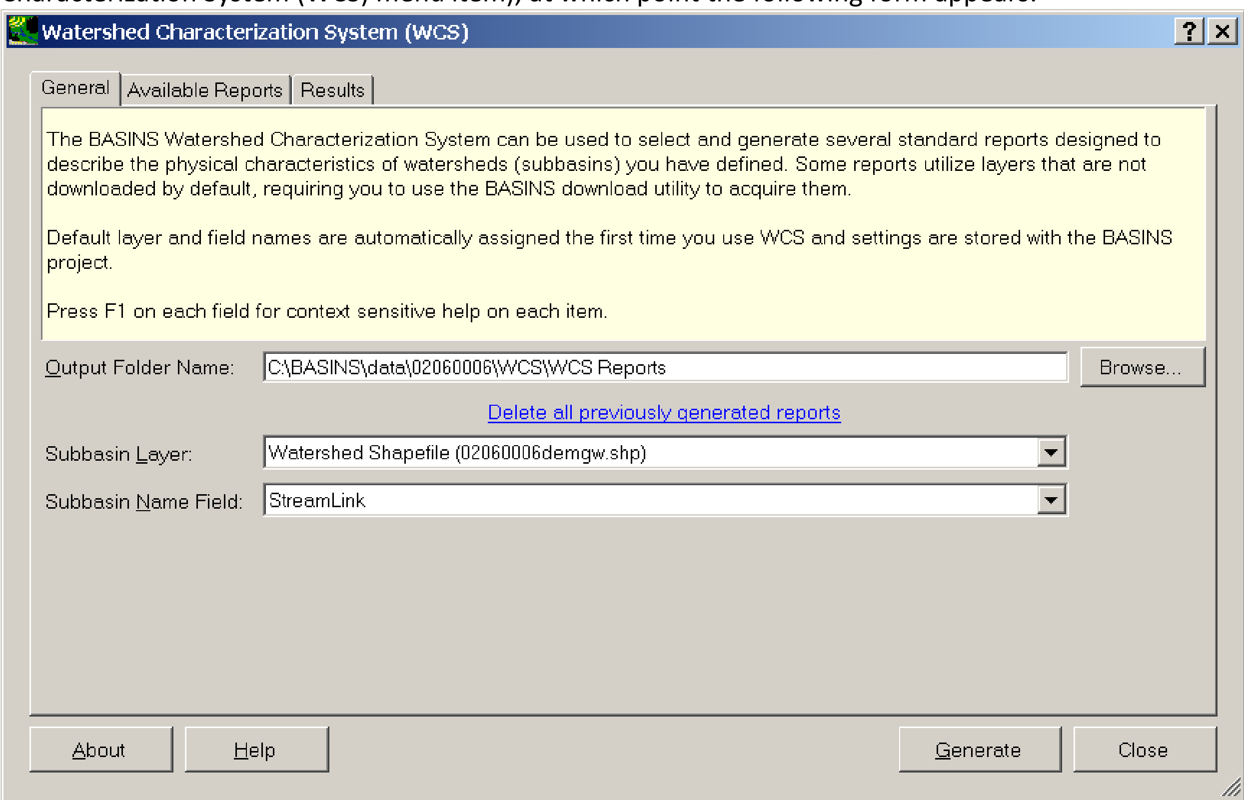
- Water Bodies
- Population Estimates
- Housing and Sewage
- Soil Characteristics
- Landuse Characterization
- Permitted Point Sources

- Data Summary

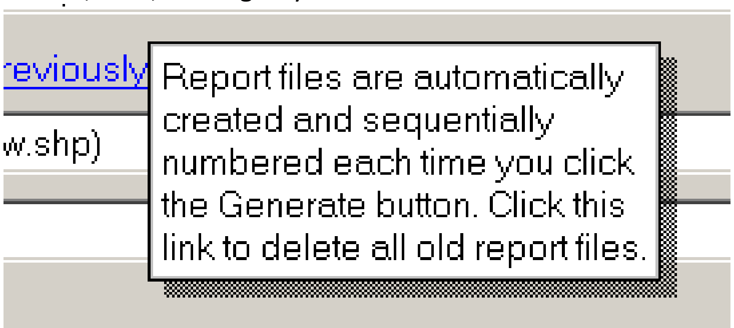
All reports require that a subbasins layer be defined in advance. In addition, each report has its own unique set of required layers (e.g., the Landuse Characterization report requires that a landuse grid or shapefile be loaded and identified). All required layers can be easily downloaded using the built-in BASINS download tool. Default layer and field names are automatically assigned the first time you use WCS; settings are stored in a separate data file along with the BASINS project data files.

Getting Started

The user must first open or create a BASINS project, which is generally defined by an eight-digit HUC somewhere in the U.S. Next, you must define one or more subbasins for which you want to perform a detailed analysis. The subbasin layer is a closed polygon layer containing at least one field which describes each subbasin's name or ID. The BASINS Watershed Delineation tools may be used to create the subbasins layer. The WCS plugin must then be loaded and activated (using the Analysis : Watershed Characterization System (WCS) menu item), at which point the following form appears:



Context-sensitive help is available for all fields on this form by moving to that field and then pressing F1 key. Alternatively, you can click the '?' button in the upper right portion of the form, then click the button, field, list or grid you want information about. You will see popup help like this:

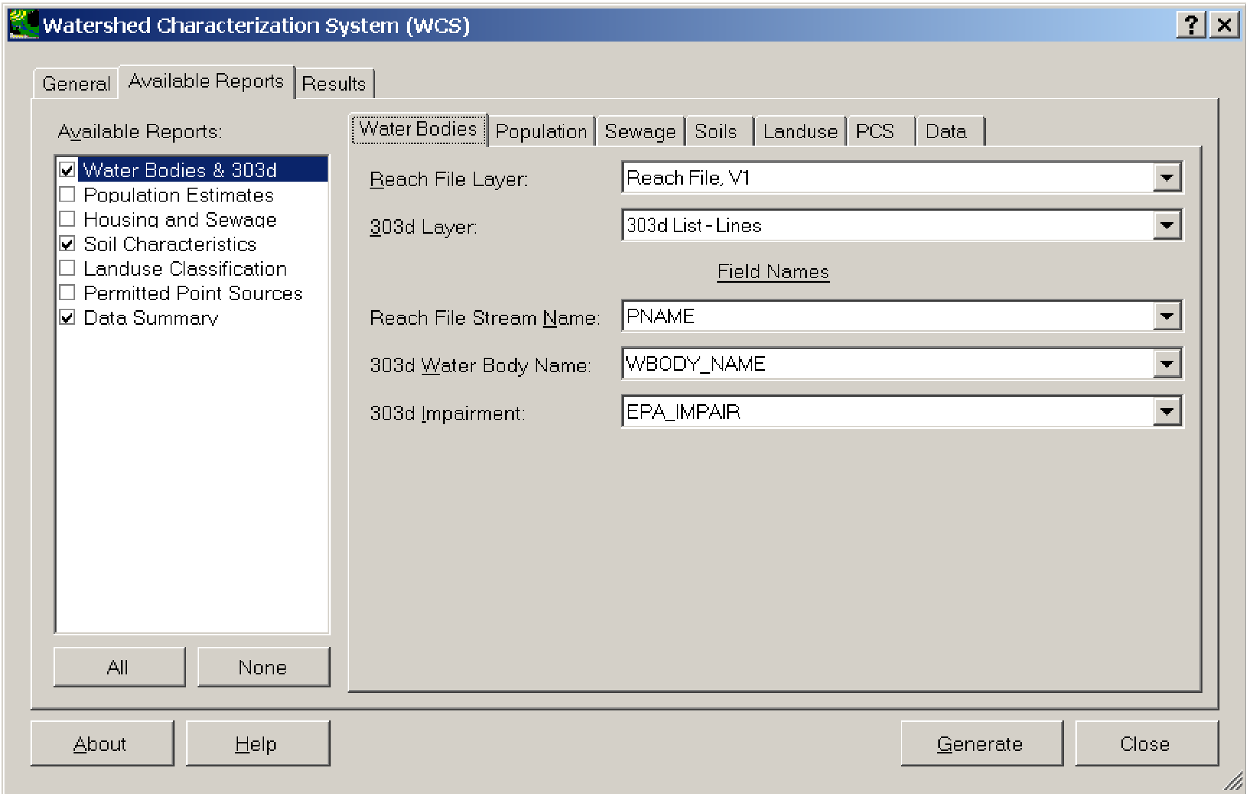


The General Tab

On the General tab, enter or browse to the folder where you wish generated reports to be saved. By default, this folder is saved under the data folder associated with the BASINS project you are working on. Every time you generate a report, a new, uniquely named output file is created. You can quickly delete previously generated report files using the link on this tab. Next, select the shape file layer containing the polygon(s) that define your subbasin(s). Note that the reports always analyze all subbasins in the layer. You must also select the field which contains the subbasin name to be used in the report. The BASINS watershed delineation routine by default just creates a field containing an integer subbasin number; you may choose to add an additional field into which you enter a more descriptive name and use it instead. When selecting layers, WCS knows the type of layer required (e.g., line shapefile, polygon shapefile, or grid). Only layers of the appropriate type are available for selection in the drop-down list. Once the layer is selected, the field name drop-down list is automatically populated with the fields found in the attribute table associated with that layer. Furthermore, the expected field names will be automatically selected if found. This scheme allows the WCS tool to work most easily with the standard shape files distributed with BASINS yet still gives you the flexibility to use custom shape files if you wish.

The Available Reports Tab

Use this tab to define which reports you want to generate, and what layers and fields are logically associated with the required input information.



As you select each report in the list on the left, the tab associated with that report is displayed on the right. You can run the reports individually or select several so that the reports are all generated at once. Each report has its own unique set of layers needed to run, and you usually need to download additional layers than those automatically compiled for you when you create the BASINS project. For example, in the above figure the "Reach File, V1" layer was initially provided when the project was set up, but the 303d shapefile had to be downloaded separately using the BASINS download tool. The purpose and contents of the individual reports is self-explanatory, however a few comments are in order:

- WCS expects the user to select reasonable layers and fields. If a transportation layer is selected for reach layer, it may be possible for the report to be generated without error, but the results would obviously be invalid.

- Empty portions of a report usually indicate that no such features were found in any of the subbasins you've defined. For example, there may be no 303d waterbodies located in your subbasins, so there will be no entries in that report table.

- The Population Estimates report is intended to characterize changes in population over time, so it is expected that two distinct census periods will be selected, and each attribute table will have identical fields and matching shapes. Census results by census tract may violate this requirement if tracts are created or eliminated from one census to the next. If this occurs within any of your subbasins, an error message will be shown.

- The Soil Characteristics report relies on a polygon shapefile and single soil ID field. Soil characteristics are obtained by linking the value found in the soil ID field with the data found in the file SoilNames.txt. This is a tab-delimited text file containing Soil ID, Soil Name, and Soil Group columns located in the plug-ins folder for WCS. You can edit this file using a text editor or spreadsheet to add soil characteristics for your state or region.

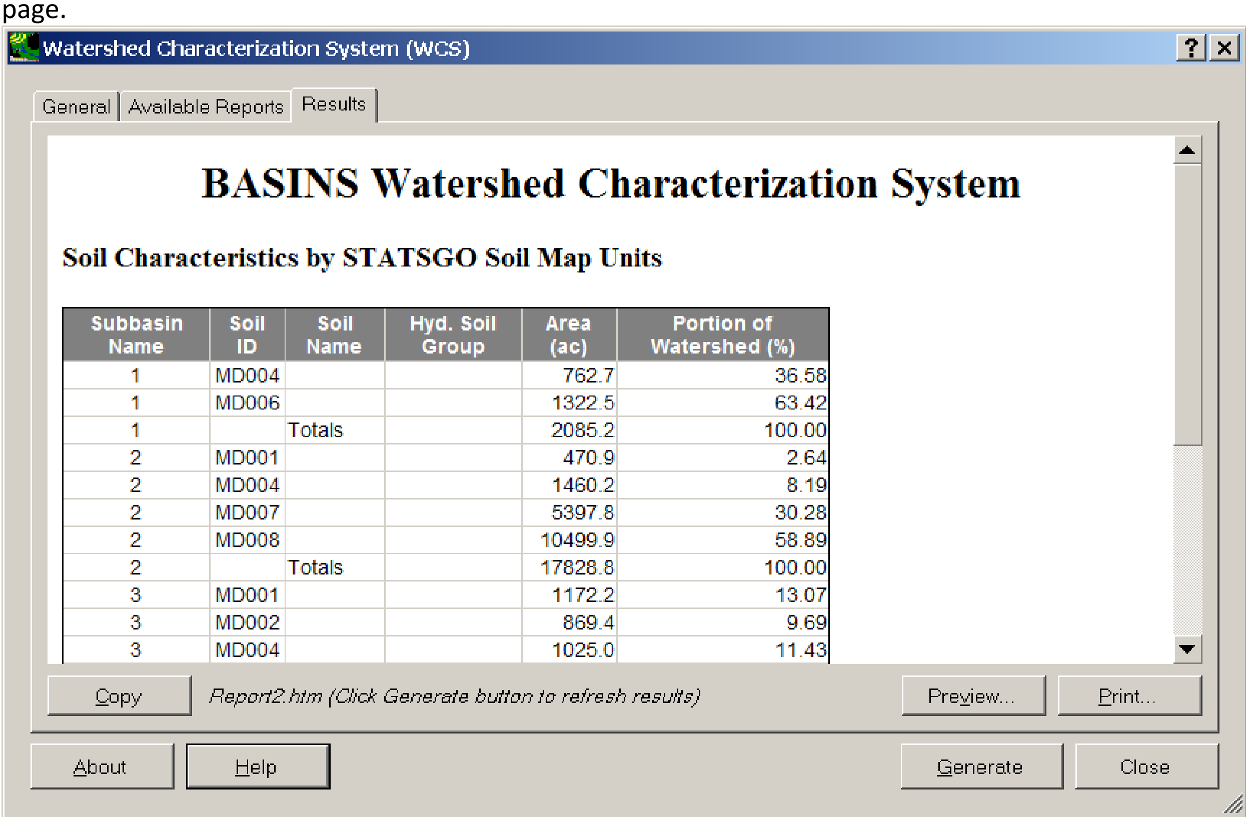
- Landuse data can be taken from one of five different sources: USGS GIRAS shapefiles, NLCD grids (1992 or 2001), User shapefile, or User grid. Like soils information, the shapefile or grid contains a single field or value defining a landuse ID; the ID is related to landuse characteristics using a tab-delimited text file found in the WCS plug-in folder called LandUses.txt. This file stores IDs and names for all five types of landuse data sources and can be edited using a text editor or spreadsheet program.

- Data reports are intended to summarize time series data previously acquired using the BASINS Download tool; all data sources will automatically be listed in the form.

- Note that most lists in the WCS form (e.g., layer lists) are populated when the form is first opened; if you add layers while WCS is open, it may be necessary to close then reopen the form to refresh it.

The Results Tab

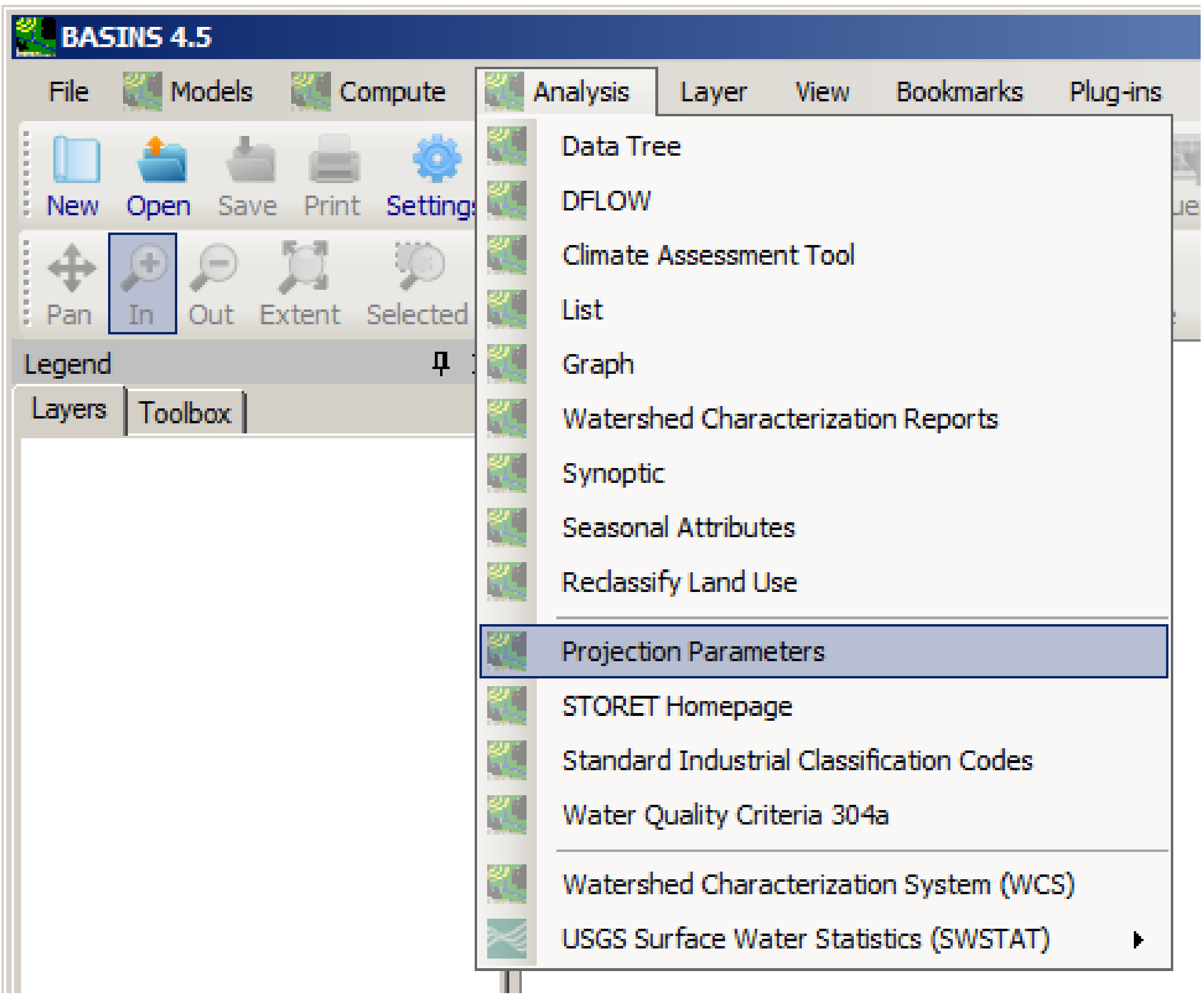
Each report is generated into an HTML-formatted file which is displayed on the Results tab. HTML reports are ideal for creating web pages or interpretation by word processing and spreadsheet programs. They automatically resize the columns to fit the available width of the printed or displayed page.



The report can be copied to the clipboard, printed, or used directly. Each time a report is generated, a new HTML file is created and given a unique name. You can delete all previously generated reports using a link provided on the General tab.

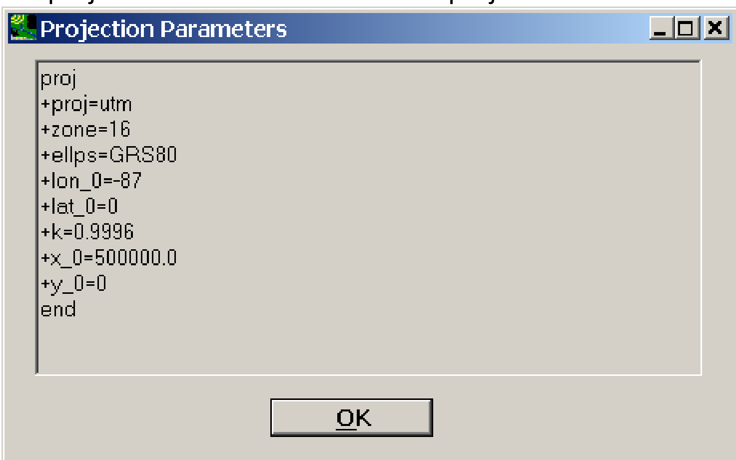
Projection Parameters

The **Projection Parameters** utility allows the user to determine what projection the current BASINS MapWindow project is in. To activate this option, click on **Lookup tables** from the **Plug-ins:Analysis** menu option on the main BASINS menu. Then, click on the **Analysis** menu option on the main BASINS menu, and select **Projection Parameters.**



The **Analysis:Projection Parameters** menu item simply displays the fundamental parameter data for the

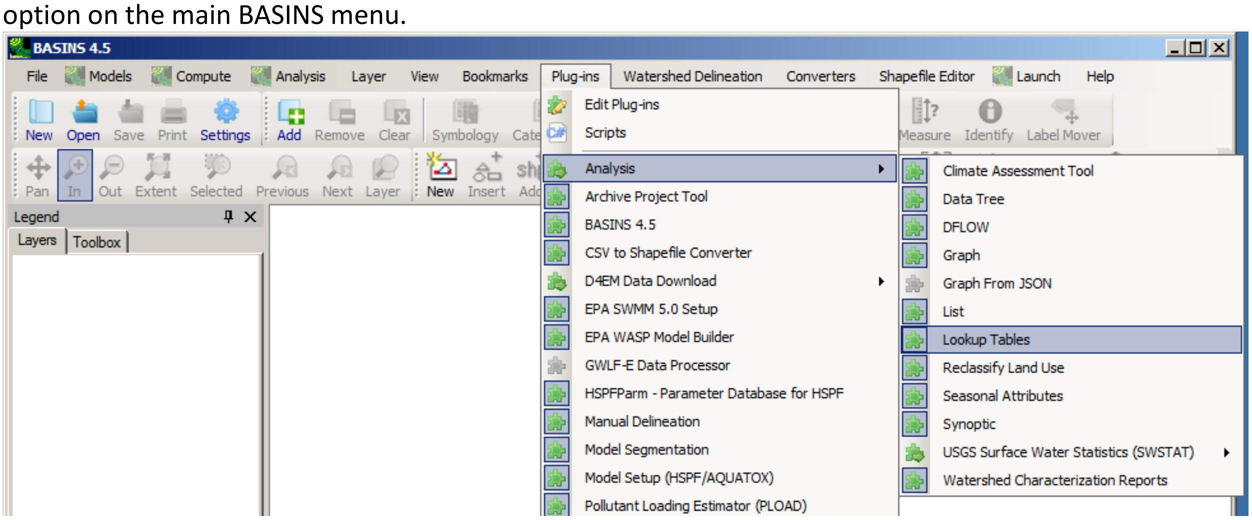
GIS projection selected for the active project.



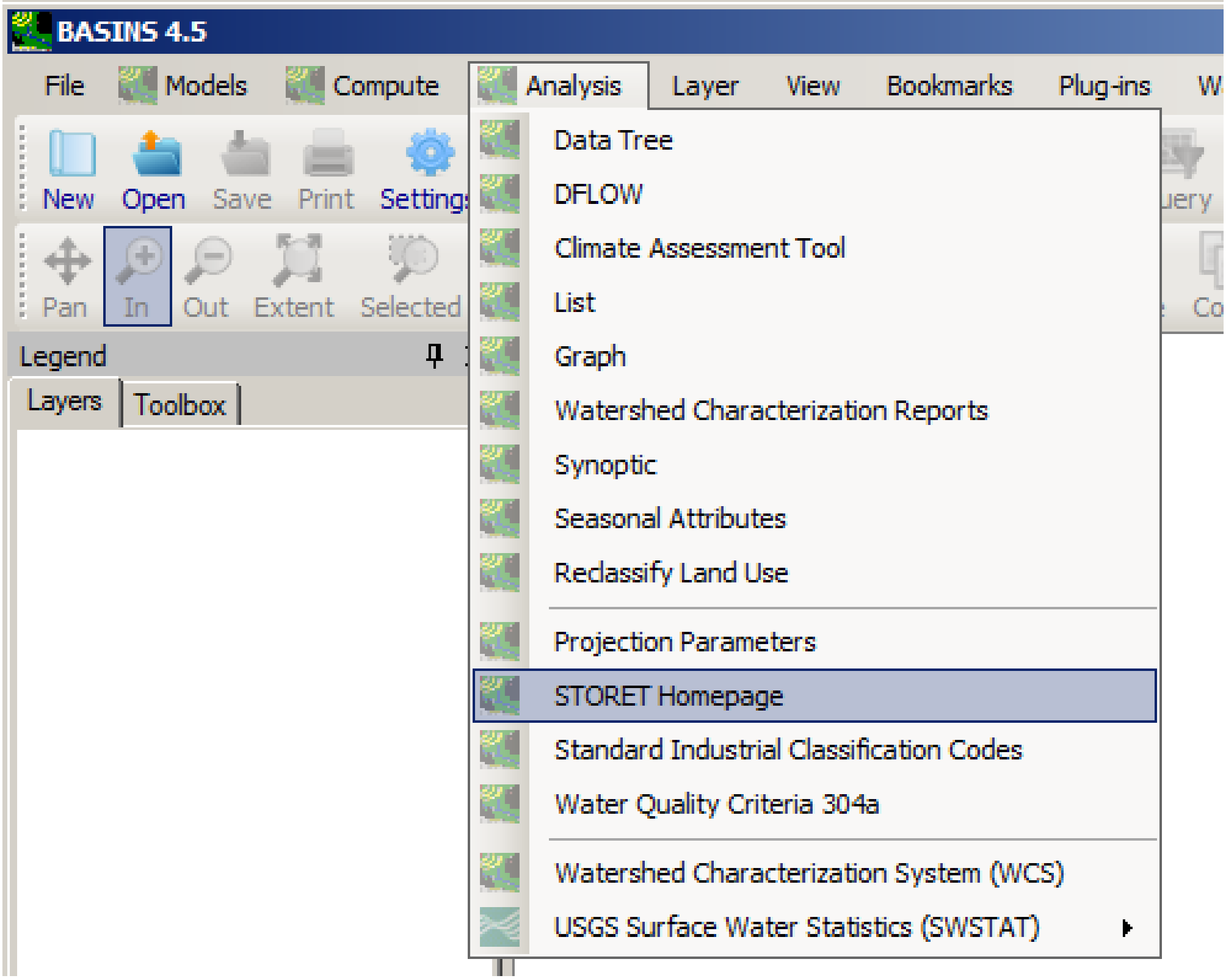
The data cannot be edited, but rather the GIS layers must be reprojected. For new spatial data to be displayed in the same map extent as the existing data, the map projection parameters specified in the lookup table should be used during reprojection. (For information about modifying projections during project creation, see Projections)

Codes and Criteria

For additional support in watershed analysis, the four **Analysis:Lookup Tables** options provide users quick and easy access to important reference information including the STORET homepage, Standard Industrial Classification (SIC) codes, and water quality criteria and threshold values for both priority and non-priority pollutants. To access these features, select **Lookup Tables** from the **Plug-ins:Analysis** menu option on the main BASINS menu.

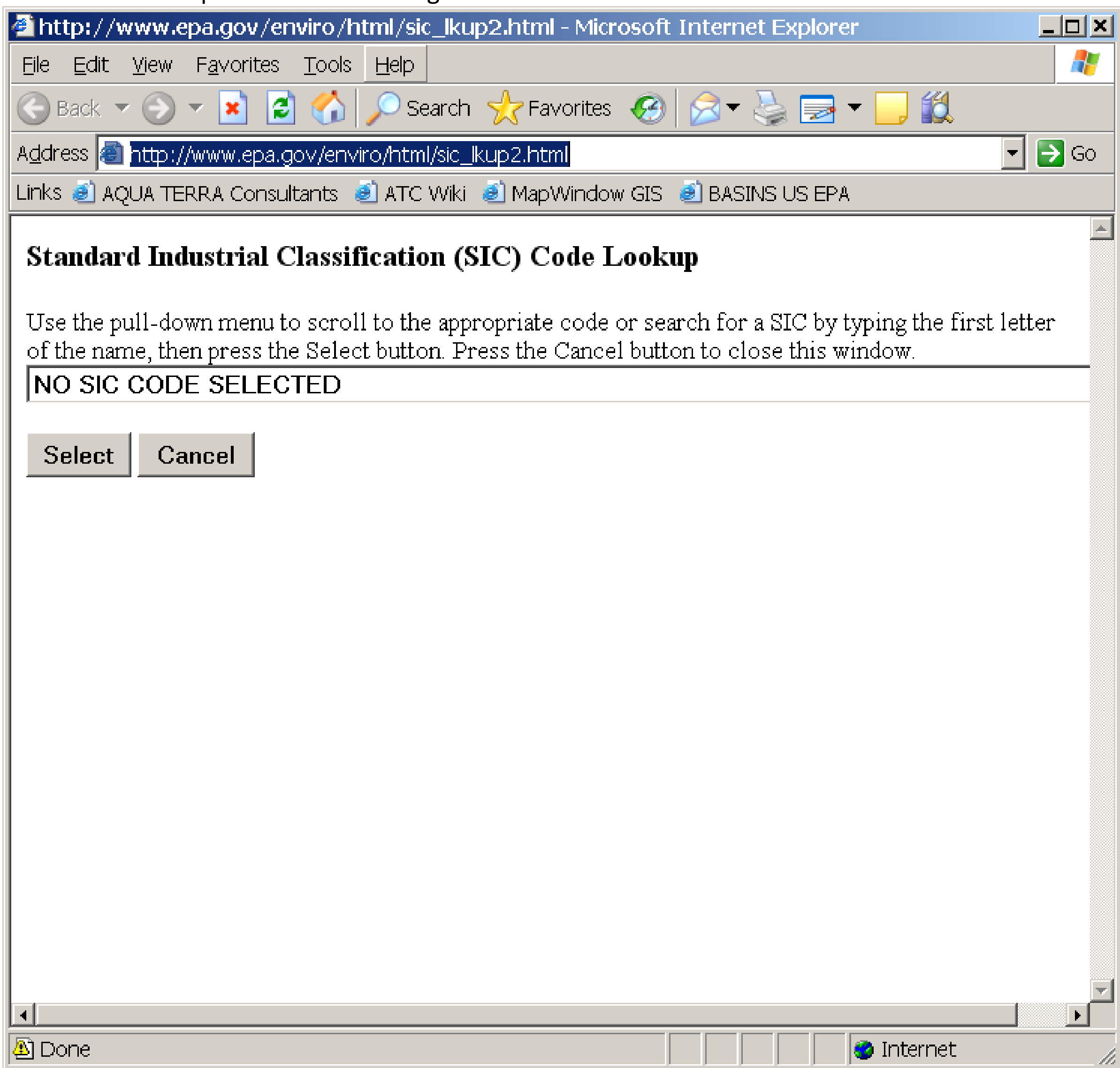


Once **Lookup Tables** has been activated, the following four menu options are available:

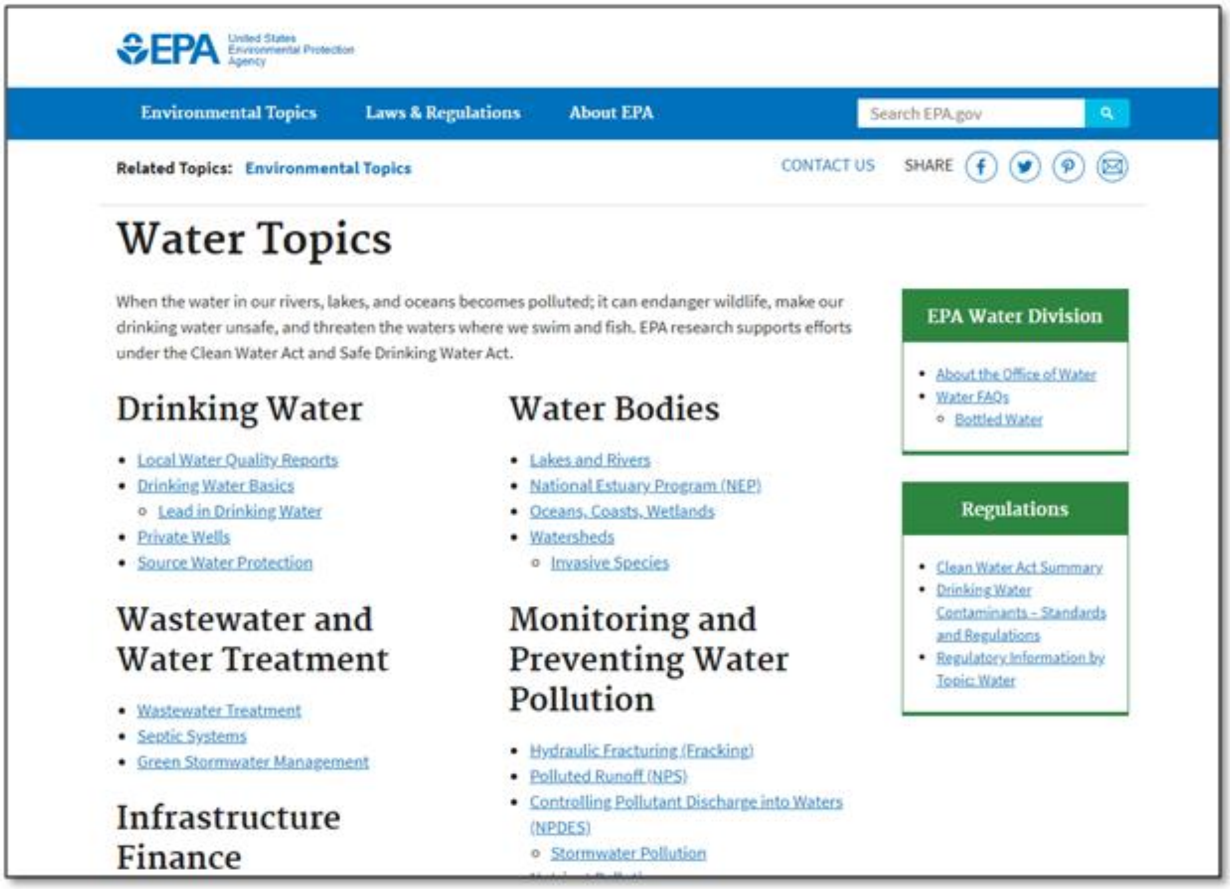


- **STORET Homepage**: A link to the Water Quality Data (WQX) homepage, the successor of STORET for further investigation into the EPA monitoring data.

- **Standard Industrial Classification (SIC) Codes**: Pull-down menu for lookup SIC codes based on alphabetic listing of their equivalent names. Can be used as a reference to identify the industrial classification of a point source discharger.



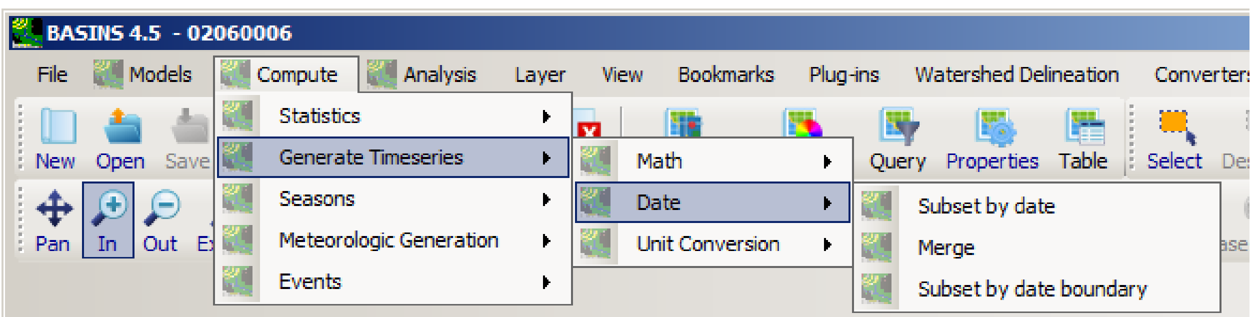
- **Water Quality Criteria 304a**: Provides information on numerous water topics relative to the Clean Water Act and the Safe Drinking Water Act.



- **Projection Parameters**

Compute

The **Compute** menu item pops open a series of submenus that avail a wide range of time series utilities. All computations produce a time series in the memory buffer, which can then be written to a WDM file via the **File:Save Data In** menu option.

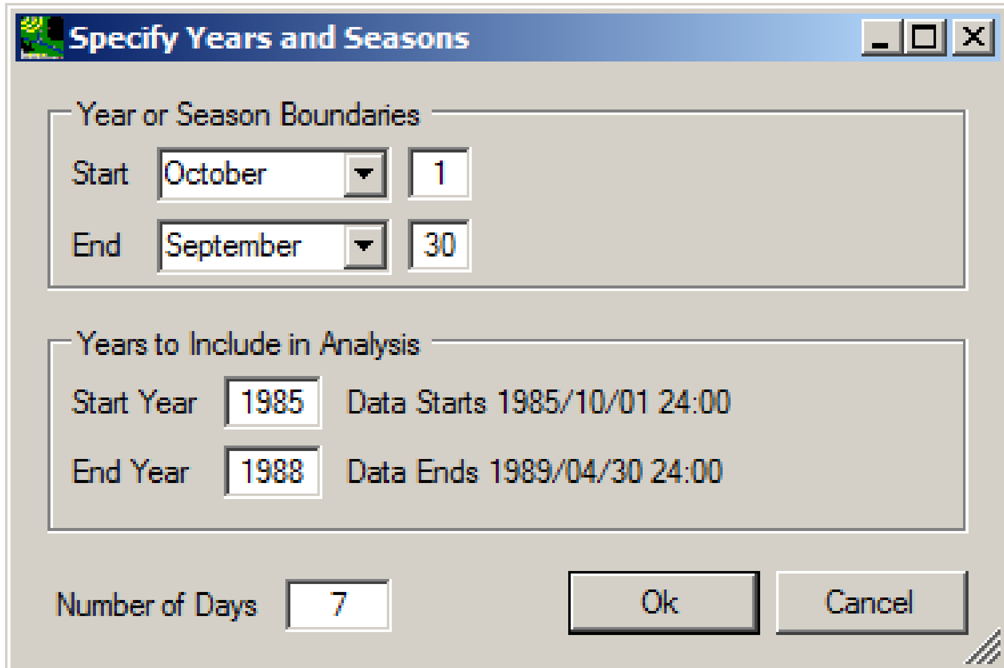


As seen on the menu, when all available computation plug-ins are selected, there are 5 main categories of time series computations:

Category	Description
Statistics	Calculates average annual flood and low-flow frequency analyses for user-defined return periods. The following form will produce an annual (each year running from October 1 - September 30) time series with the

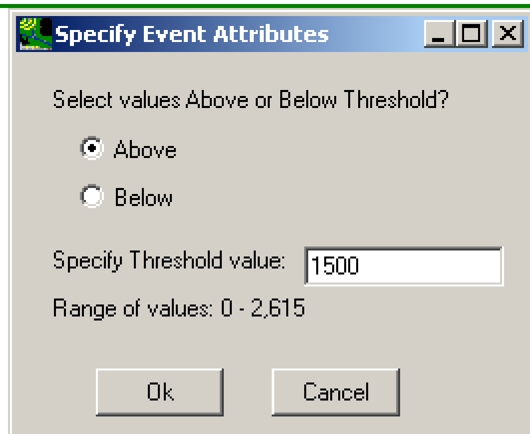
average 7-day high flow over the course of each year.

.



Seasons	Splits a single time series into multiple; one containing the data from each of the user-selected intervals (e.g., 2 time series produced for **AM or PM**, 7 time series produced for **Day of Week**, etc...). No additional selections besides the input time series are necessary.
Events	Creates a separate time series for each event having successive values above a threshold specified on the **Specify Event Attributes** form. The range of values in the base time series is displayed near the bottom of the form. The following form will produce a separate time series for each continuous event from the base time series that maintains a value above 1500.

·



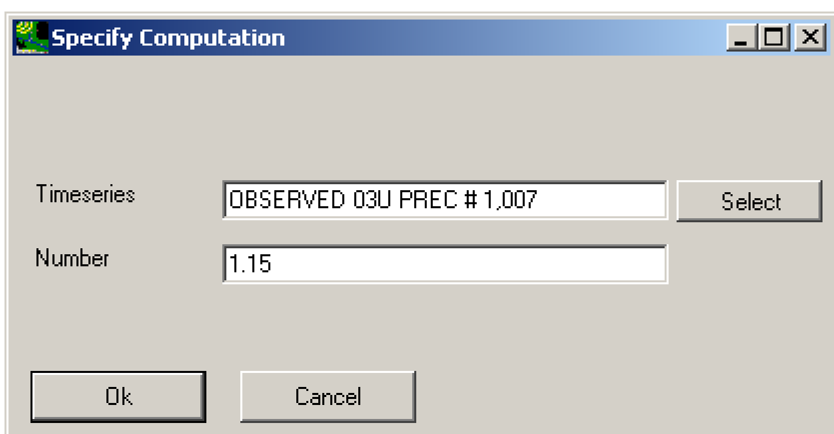
Meteorological Generation

There are 13 methods of generating new meteorological time series based on existing time series. Each of these 13 has a distinctly different methodology. There are six in the general category of Computations, which use internal algorithms to calculate output time series with the same time step as the input time series. There are six in the category of Disaggregations, which distribute daily values to an hourly time step based on another hourly time series, a user-defined distribution, or the latitude where the input data was observed. Finally, the CliGen option allows the user to update the monthly statistical values for the observation station to then generate an alternative time series. Meteorologic Generation contains an extensive enough array of utilities that separate sections of documentation are prepared for Computations, Disaggregations, and Cligen. Many of the Meteorologic Generation methods were previously available as part of WDMUtil.

Generate Time Series

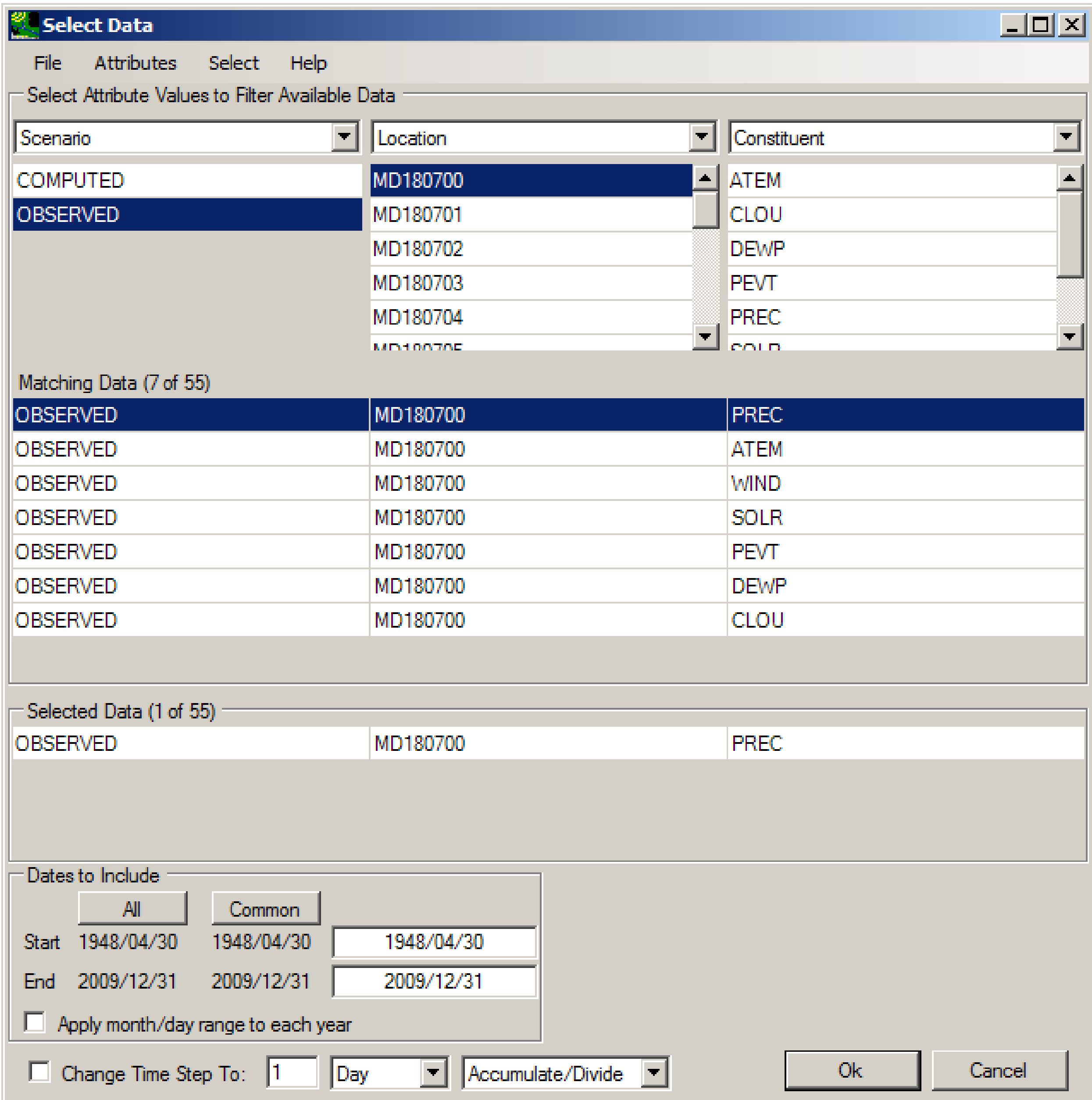
Creates a new time series as the product of an existing time series and the selected mathematical operation.

·

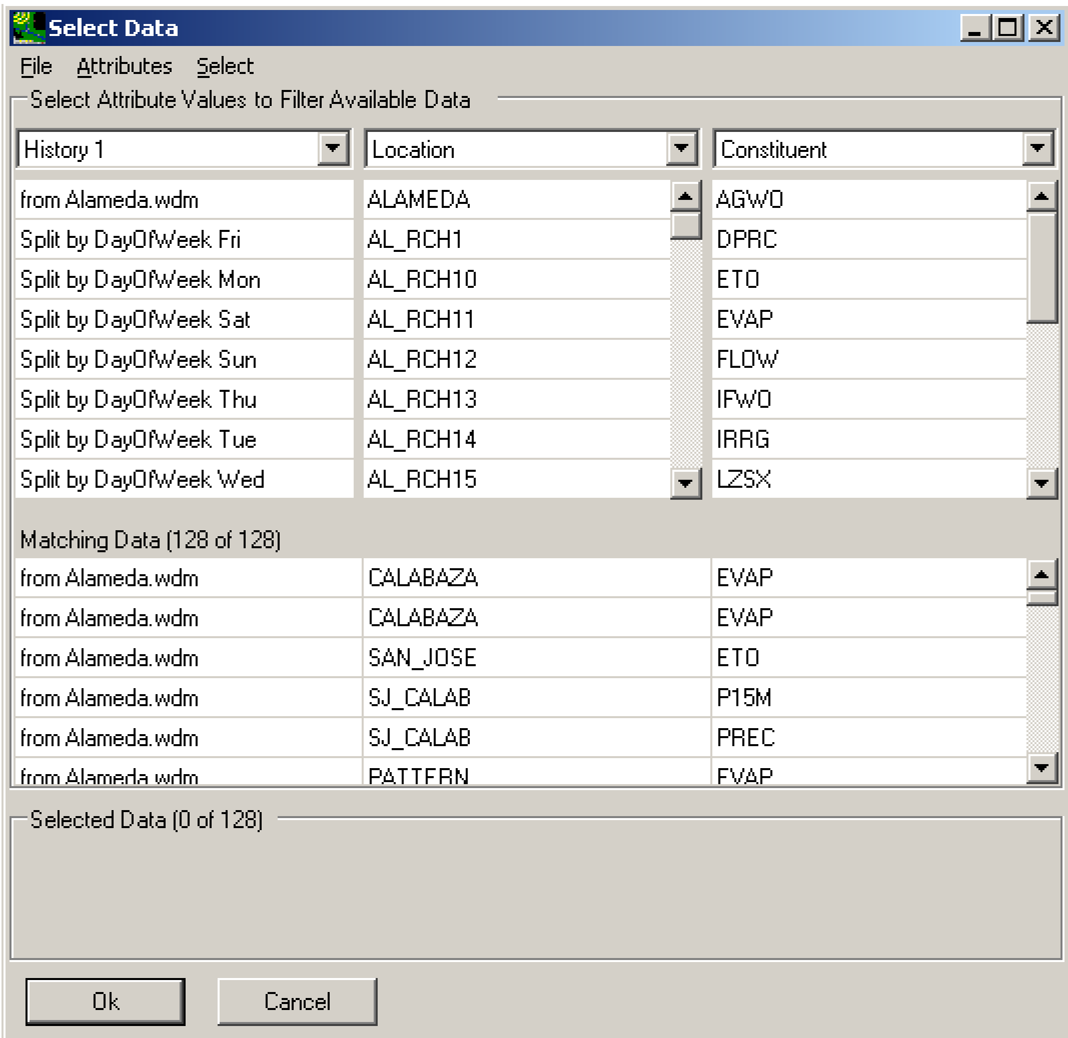


Note: Events and Meteorological Generation are subject to the **Time Series:Event**, **Time Series:Meteorological Generation**, and **Time Series:Cligen** Plug-ins being selected.

Before the selected computation can be made, the user must select one or more time series from those available. Source data files can be added and removed via the Time-Series Management Utilities. Once the desired source data files have been added to the project and the **Compute** menu item has been selected, the user is ready to click on a selection from the **Select a Computation** window and click **Ok**. The **Select Data** form will pop up, and the user should select the desired time series then click **Ok**.



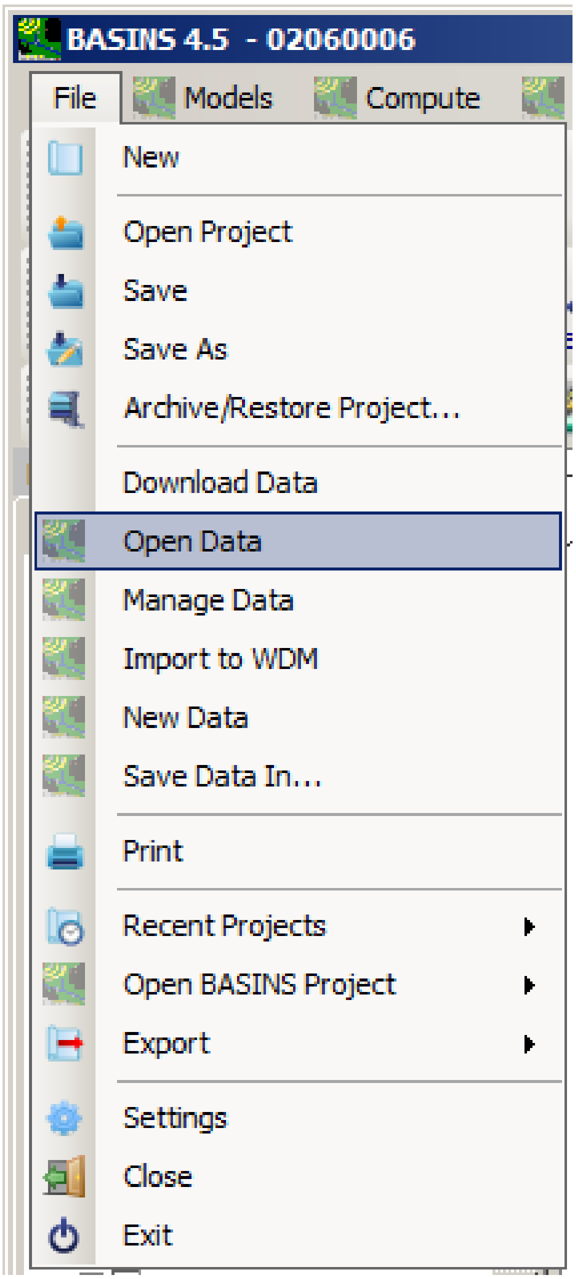
Once the time series have been selected and the computations completed, the resulting time series are put into a memory buffer and are henceforth available to be selected via the ubiquitous **Select Data** form. The newly computed time series will retain most of the same attributes as their source time series, which can make them difficult to distinguish when filtering by attribute values. The key to successfully identifying the newly created time series on the **Select Data** form is to filter by the attribute **History 1**, which will contain the name of the computation performed for the new time series. For example, the following form shows time series filtered by **History 1** after a **Seasons:Split:Day of Week** computation was performed.



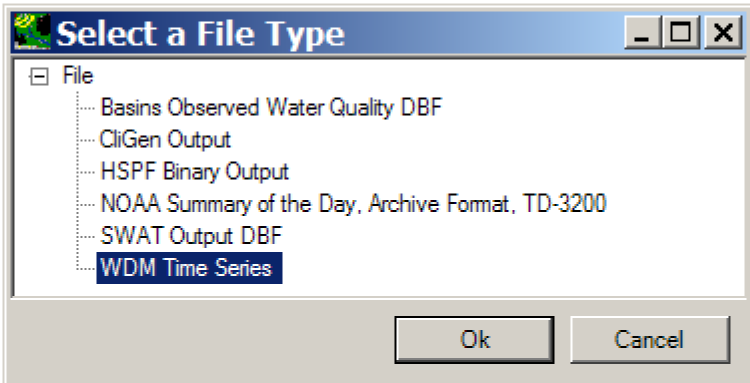
Events

This function will create a separate time series for each event with values above a specified threshold.

To use the **Events** tool, first open a *.wdm dataset using **File:Open Data**.

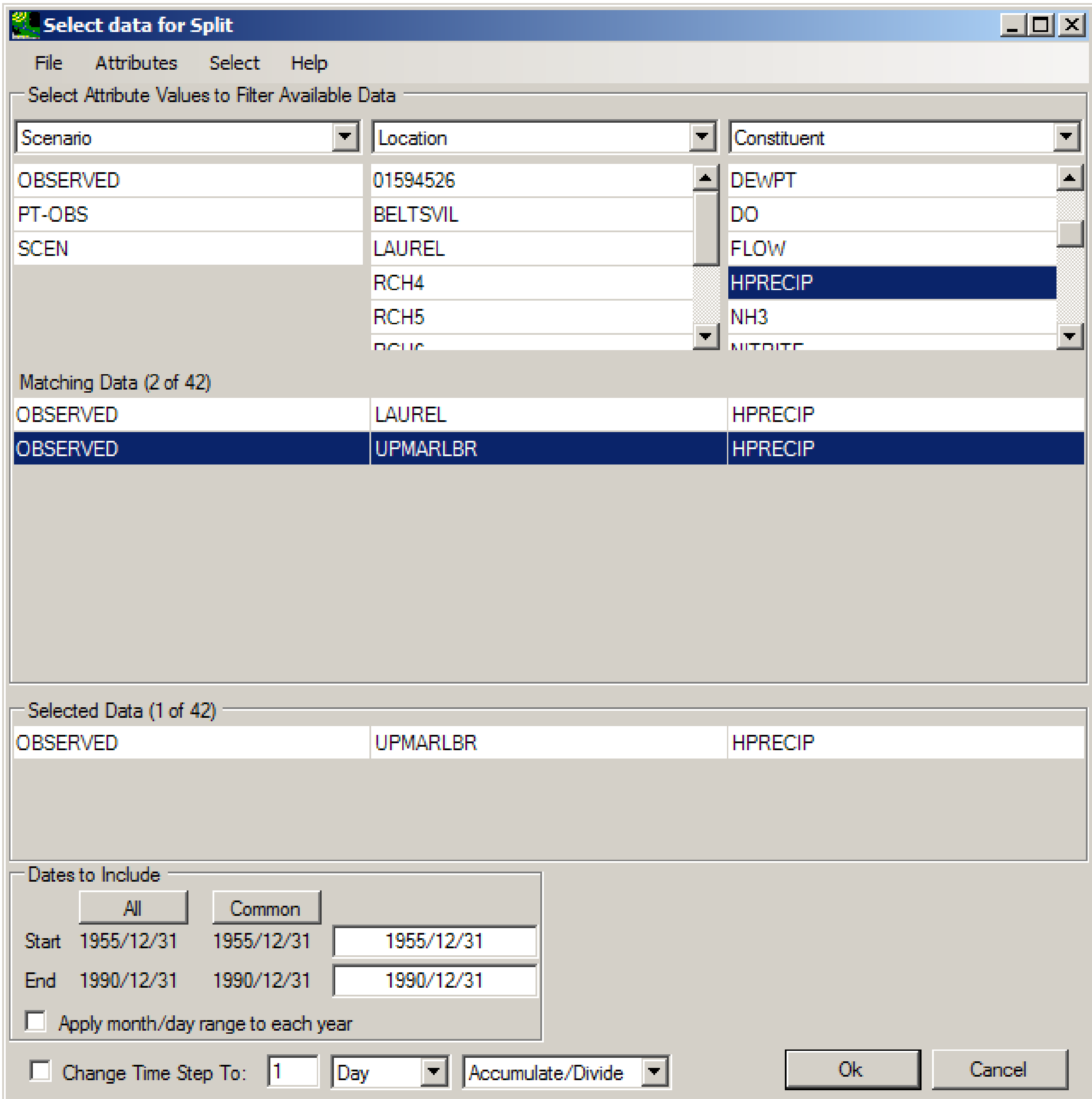


Select **WDM Time Series**, and then open Basins/data/Climate/base.wdm.

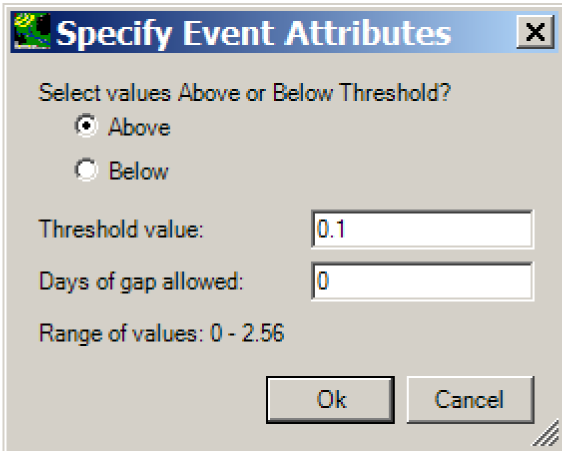


Select **Compute:Events:Split** from the main BASINS window, which will open the **Select data for Split** window.

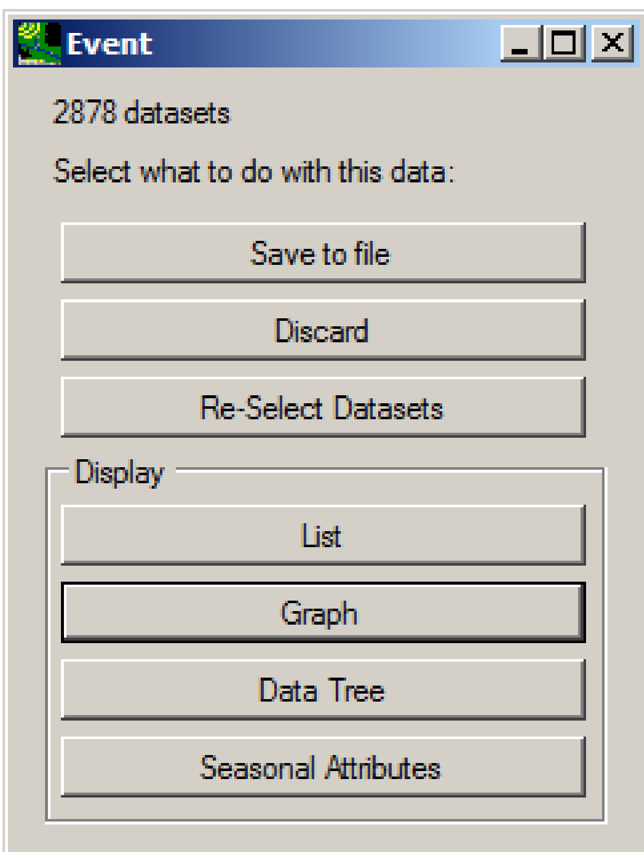
Select HPRECIP from the Constituent column and OBSERVED UPMARLBR from the Matching Data.



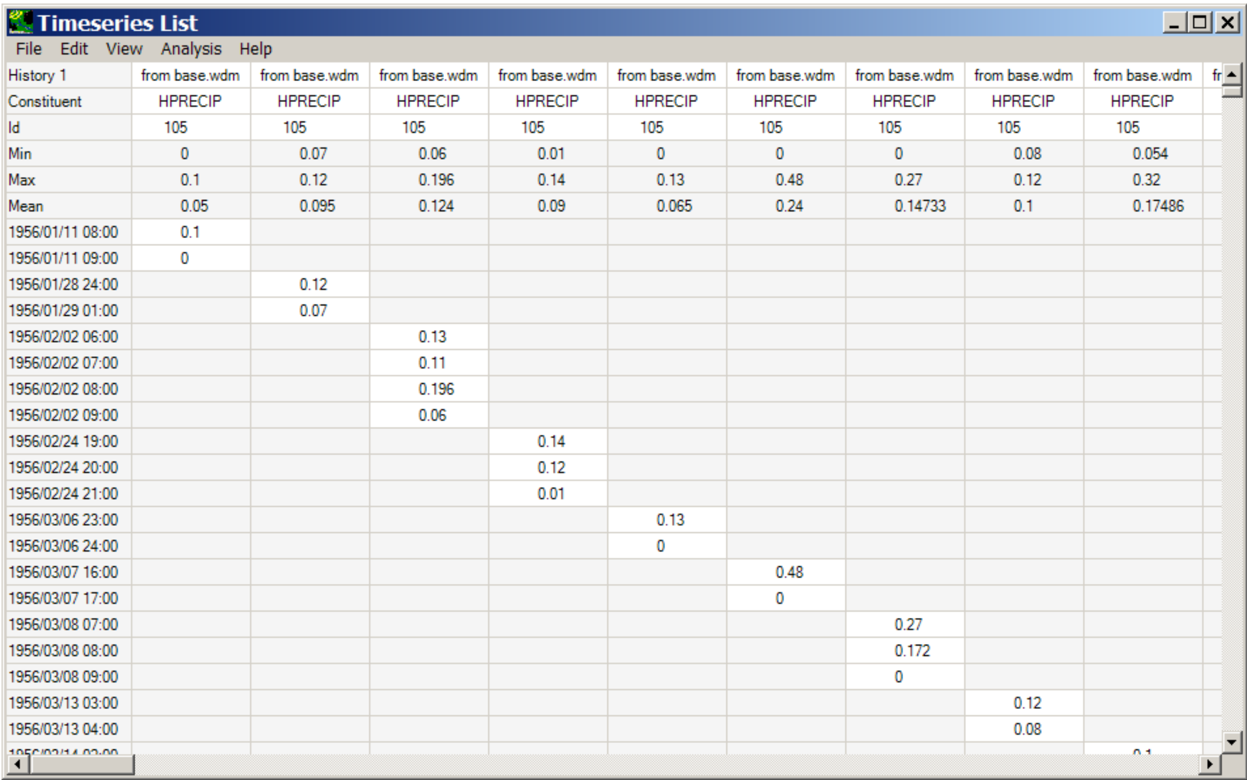
The **Specify Event Attributes** window will pop up. The user must specify which events will be separated into individual time series, by selected either Above or Below, and a Threshold Value. The range of values within the dataset is shown at the bottom of the window. For this example, select events **Above**, and type the threshold value of 0.1.



By clicking on **Ok**, separate time series will be created for each day with HPRECIP over 0.1. The **Events** window will now appear, informing the user that there have been 2,878 datasets created. From this screen, the user can chose to save the new file with these time series, discard all time series, add or remove specific datasets, or display the data (as a list, graph, data tree, or by seasonal attributes).

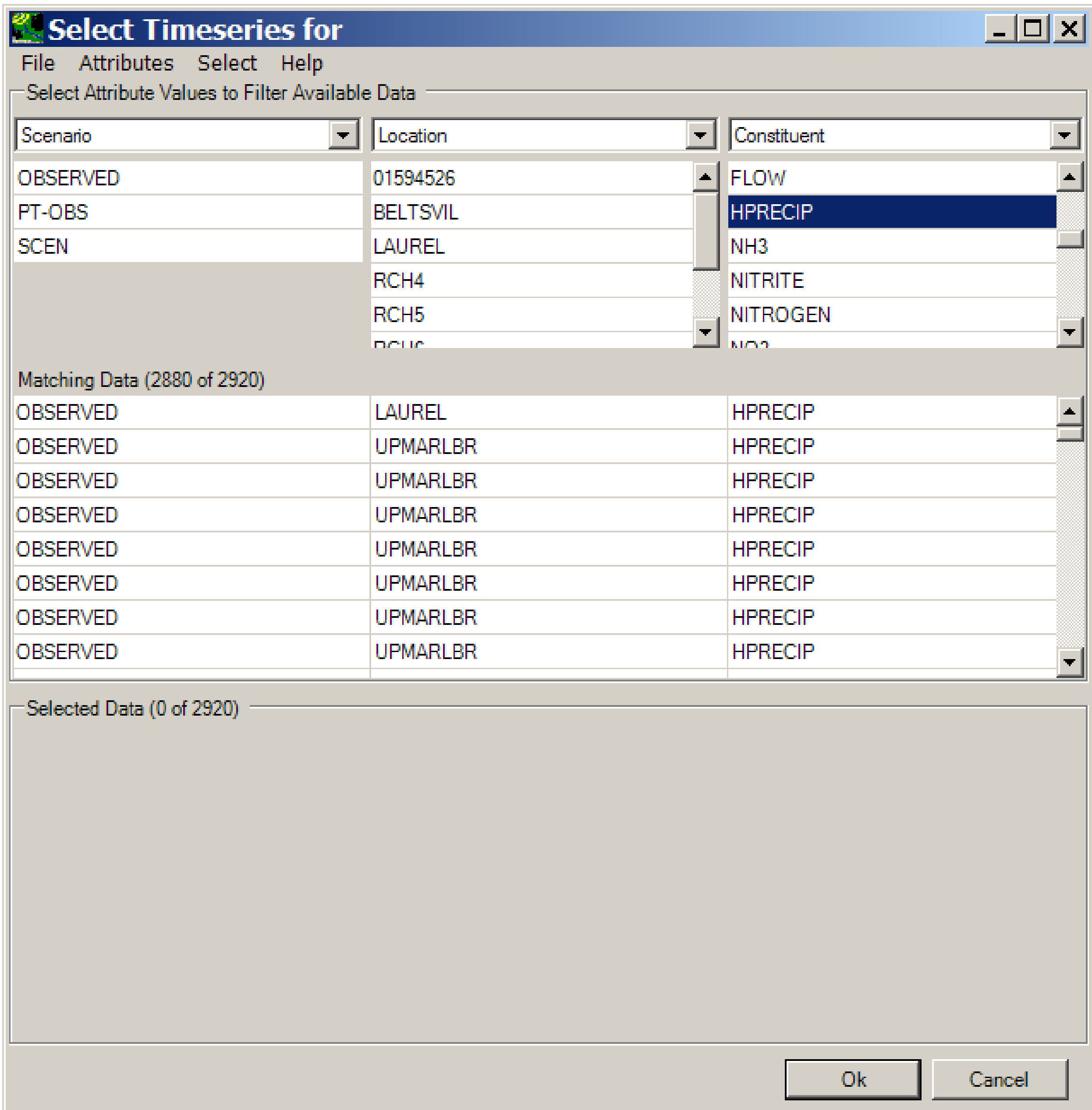


The **List** option shows the new time series datasets:

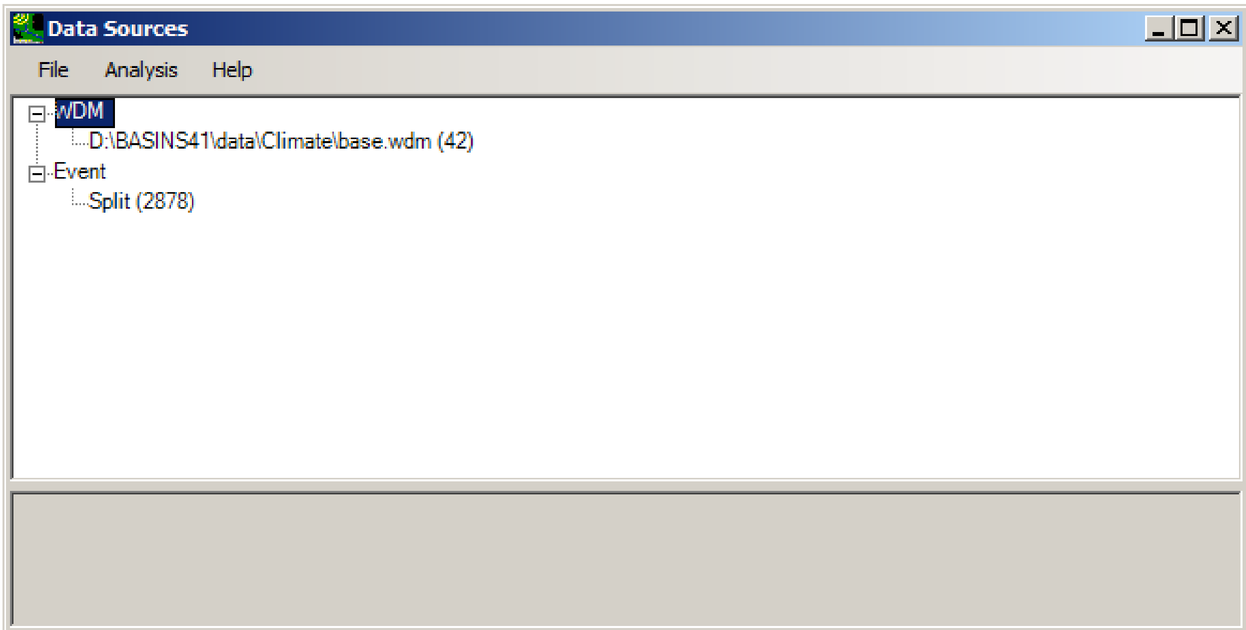


History 1	from base.wdm	from base.wdm	from base.wdm	from base.wdm	from base.wdm	from base.wdm	from base.wdm	from base.wdm	from base.wdm
Constituent	HPRECIP	HPRECIP	HPRECIP	HPRECIP	HPRECIP	HPRECIP	HPRECIP	HPRECIP	HPRECIP
Id	105	105	105	105	105	105	105	105	105
Min	0	0.07	0.06	0.01	0	0	0	0.08	0.054
Max	0.1	0.12	0.196	0.14	0.13	0.48	0.27	0.12	0.32
Mean	0.05	0.095	0.124	0.09	0.065	0.24	0.14733	0.1	0.17486
1956/01/11 08:00	0.1								
1956/01/11 09:00	0								
1956/01/28 24:00		0.12							
1956/01/29 01:00		0.07							
1956/02/02 06:00			0.13						
1956/02/02 07:00			0.11						
1956/02/02 08:00			0.196						
1956/02/02 09:00			0.06						
1956/02/24 19:00				0.14					
1956/02/24 20:00				0.12					
1956/02/24 21:00				0.01					
1956/03/06 23:00					0.13				
1956/03/06 24:00					0				
1956/03/07 16:00						0.48			
1956/03/07 17:00						0			
1956/03/08 07:00							0.27		
1956/03/08 08:00							0.172		
1956/03/08 09:00							0		
1956/03/13 03:00								0.12	
1956/03/13 04:00								0.08	

Note: Unless the results are discarded, these newly created time series will appear when selecting data in the future. For example, there are now 2,880 OBSERVED UPMARLBR datasets in the selectable data list:

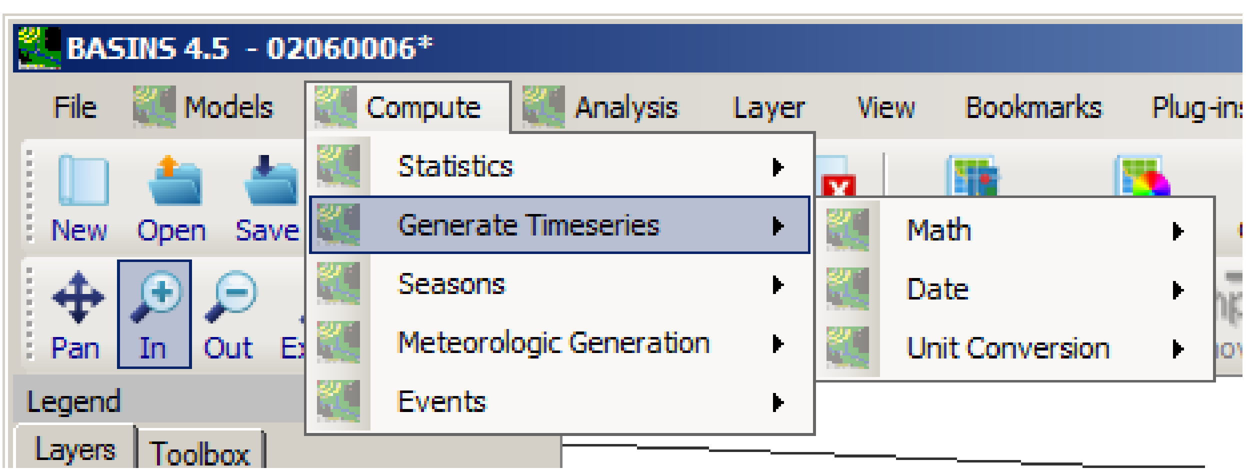


The user may wish to select these new results. Otherwise, to discard the newly created time series, either select "Discard" from the **Event** window, or go to **File:Manage Data**, click on **Split**, and then choose **File:Close Selected**.

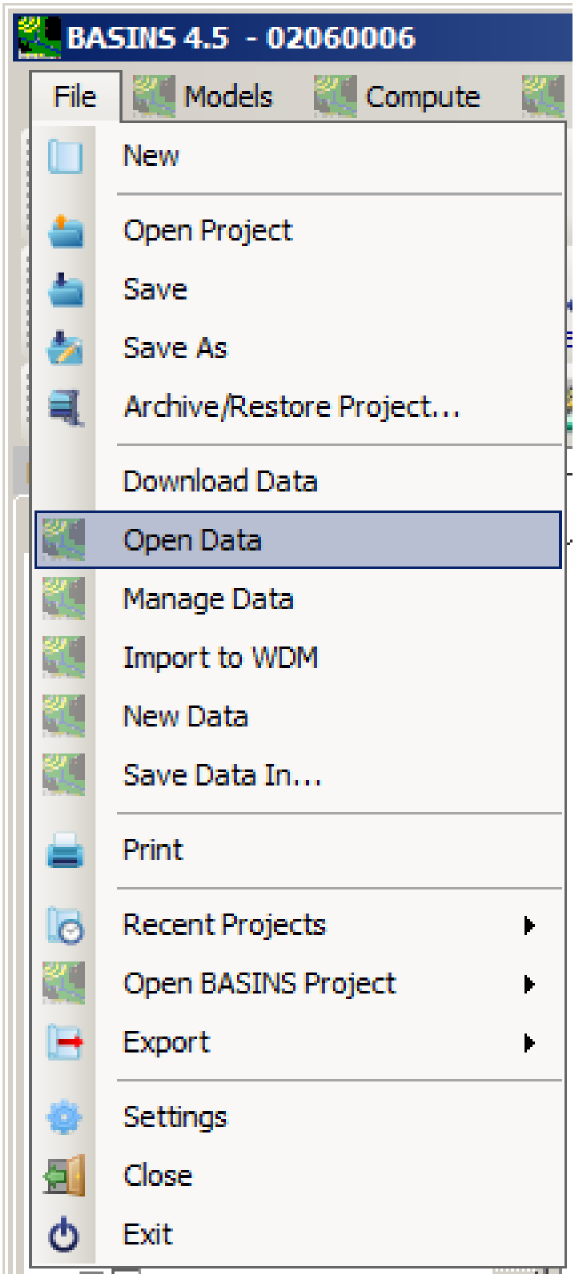


Generate Time Series

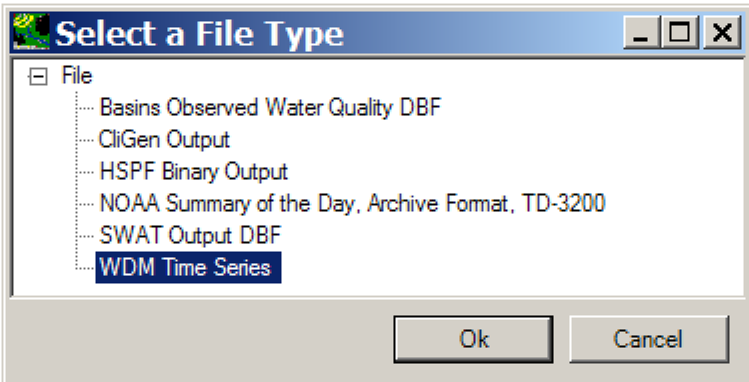
The **Generate Time Series** menu has three options: Date, Math, and Unit Conversion.



To use the **Generate Time Series** tool, first open a *.wdm dataset using **File:Open Data**.

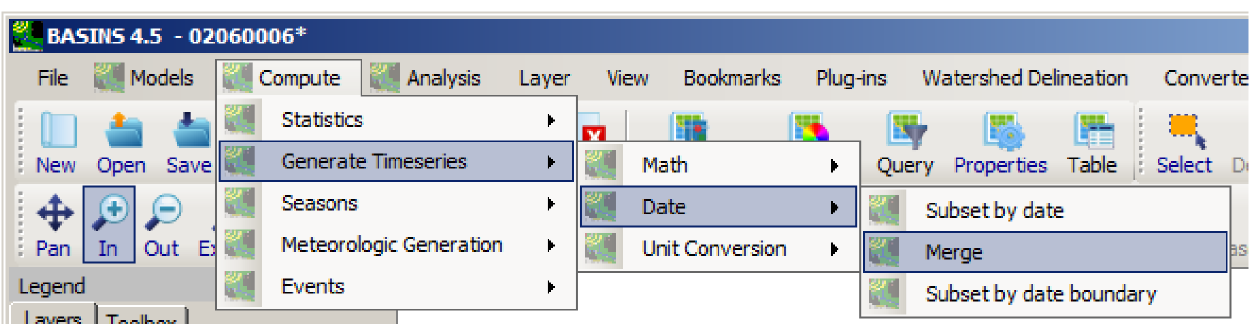


Select **WDM Time Series**, and then open Basins/data/Climate/base.wdm.



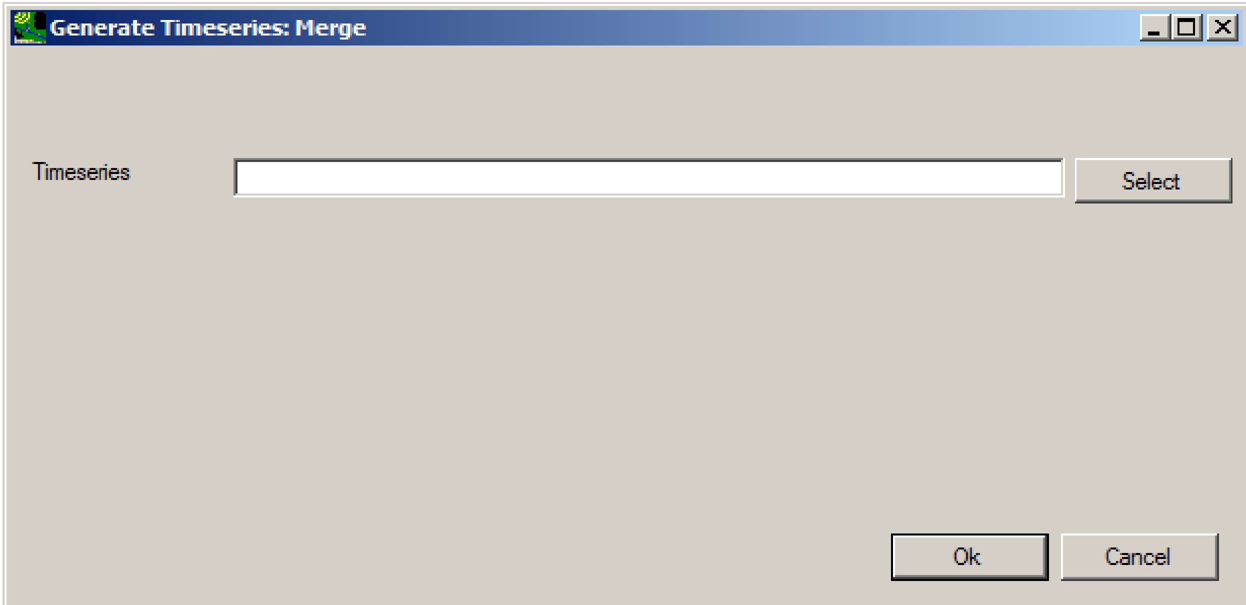
Date

There are three options under the **Date** menu: Merge, Subset by Data, and Subset by Date Boundary.

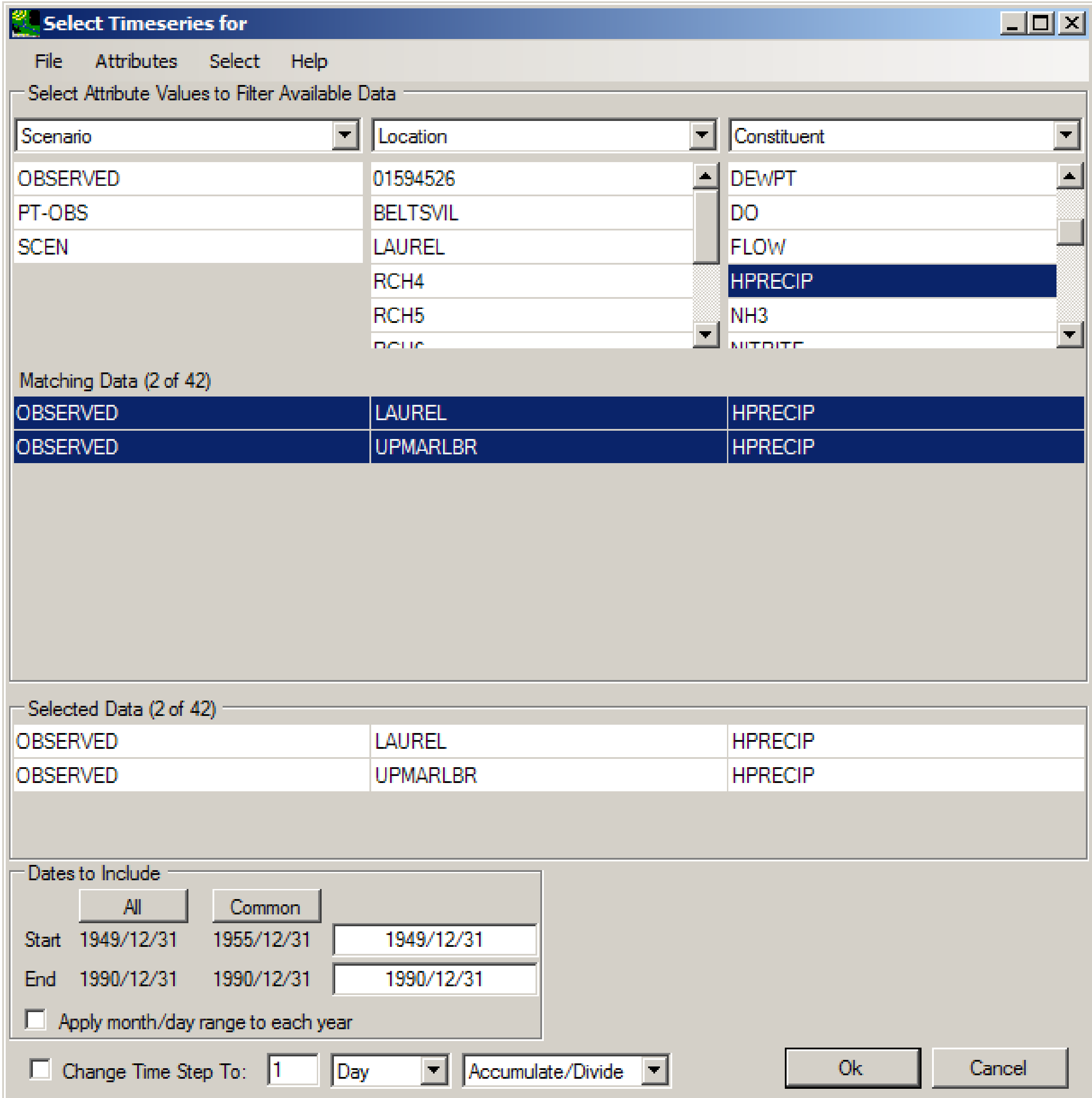


- **Merge**
- This option allows the user to merge time series data that has been collected for the disjoint dates into one dataset. *Note:* When there are duplicate dates, the data will be used for the dataset that was selected first. After selecting the **Merge** option, the **Generate Timeseries:Merge** window will

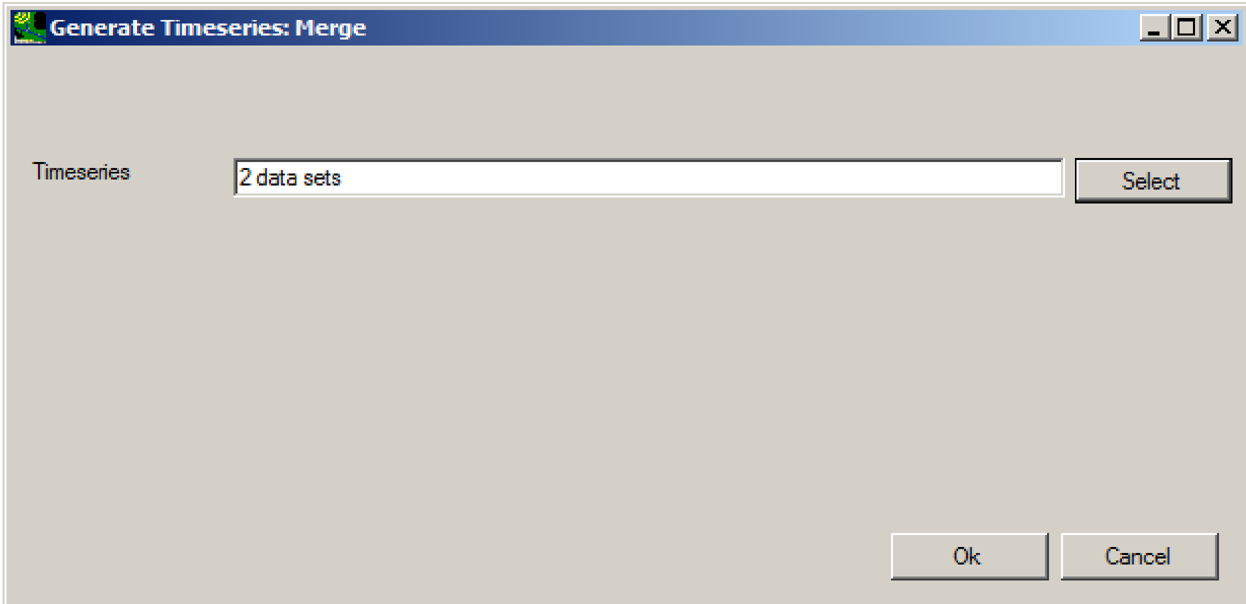
appear. Click on **Select**.



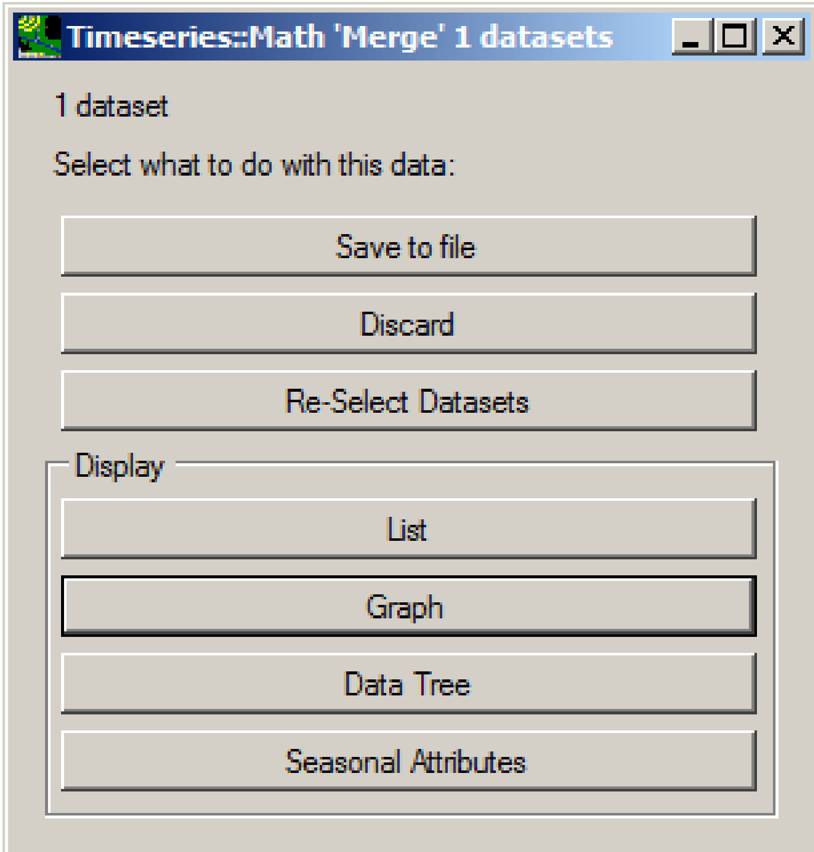
- The **Select Timeseries for** window will pop up. Select HPRECIP from the Constituent column, and both OBSERVED LAUREL and OBSERVED UPMARLBR from the Matching Data, then click **Ok**.



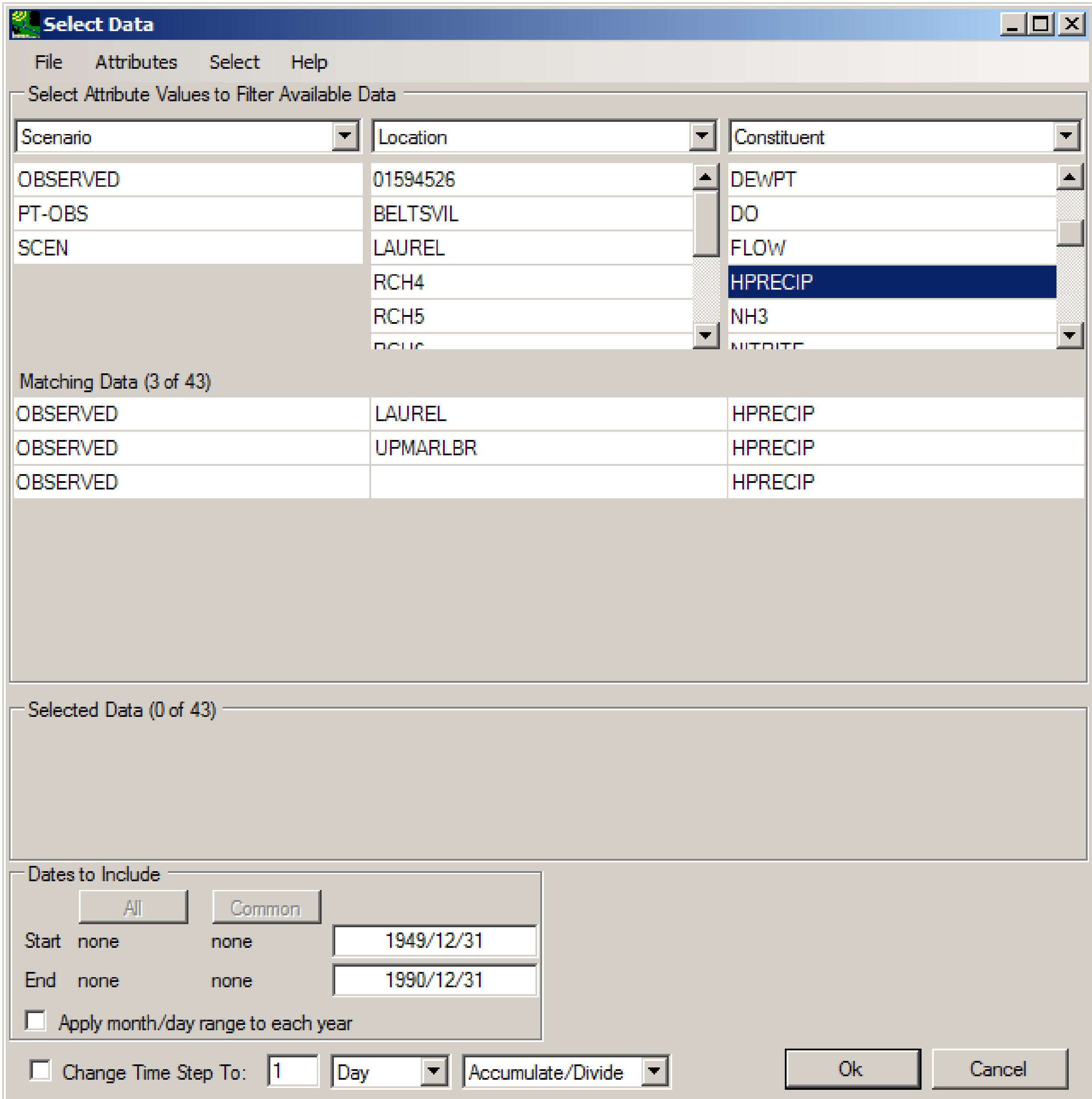
- The **Generate Timeseries:Merge** window will now reflect that two time series have been selected to merge by date. Click **Ok**.



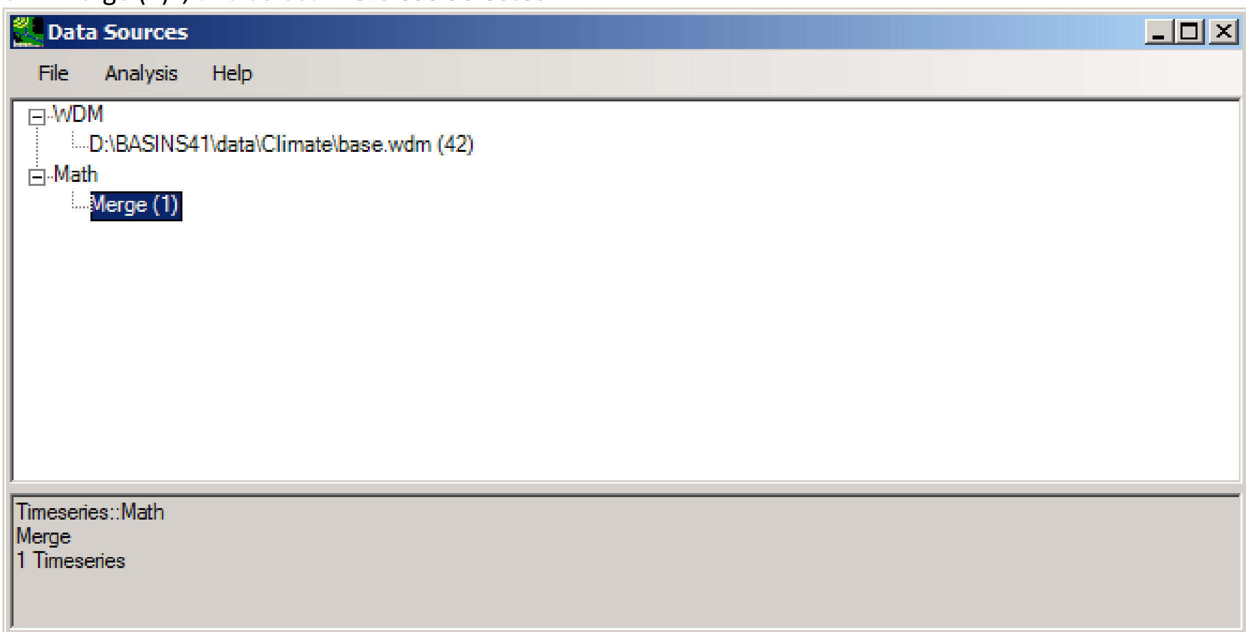
- The **Timeseries::Math 'Merge' 1 datasets** window will now appear. At the top, it says "1 dataset", to reflect that the two datasets were merged by date. The user now has the option of saving or discarding the results, or Adding/Removing datasets to merge. The user can also display the data as a list, graph, data tree, or seasonal attribute table.



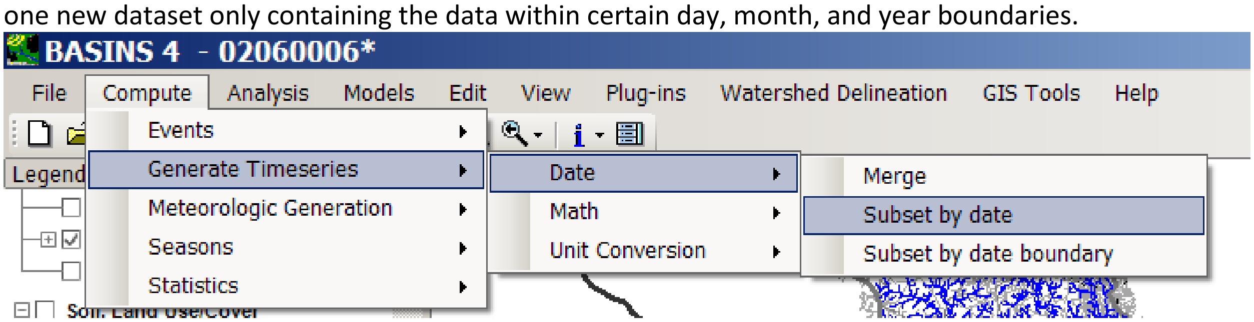
- *Note:* Unless the results are discarded, the newly created time series will appear when selecting data in the future. For example, there is now a third HPRECIP dataset:



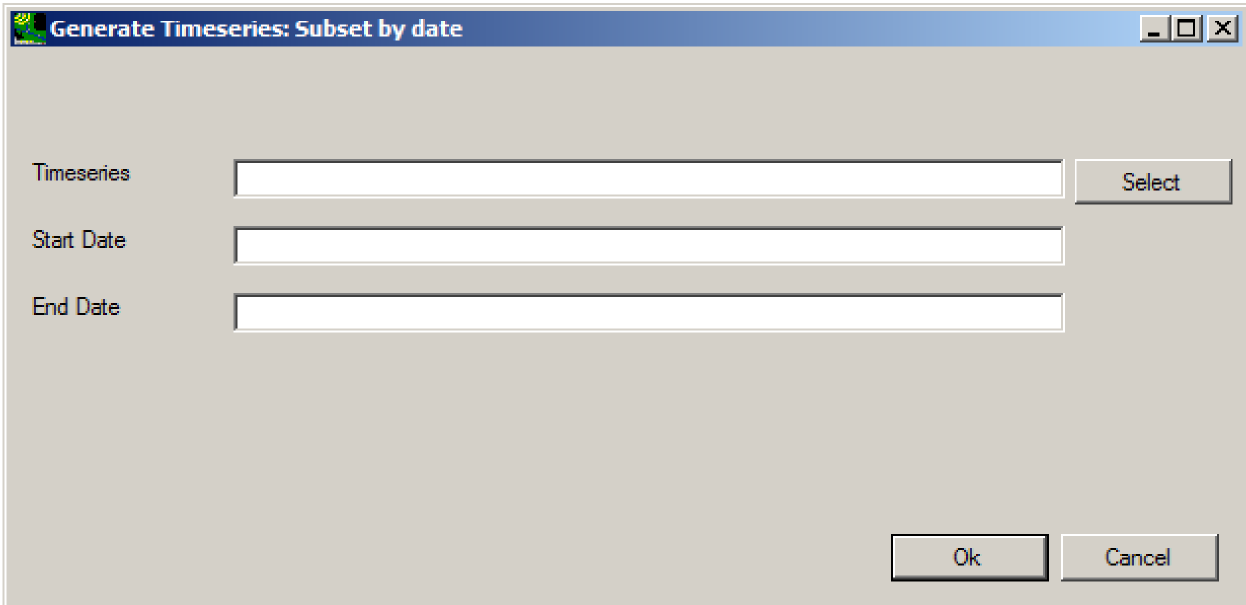
- The user may wish to select these new results. Otherwise, to discard the newly created timeseries, either select "Discard" from the **Timeseries::Math 'Merge'** window, or go to **File:Manage Data**, click on “Merge (1)”, and select **File:Close Selected**.



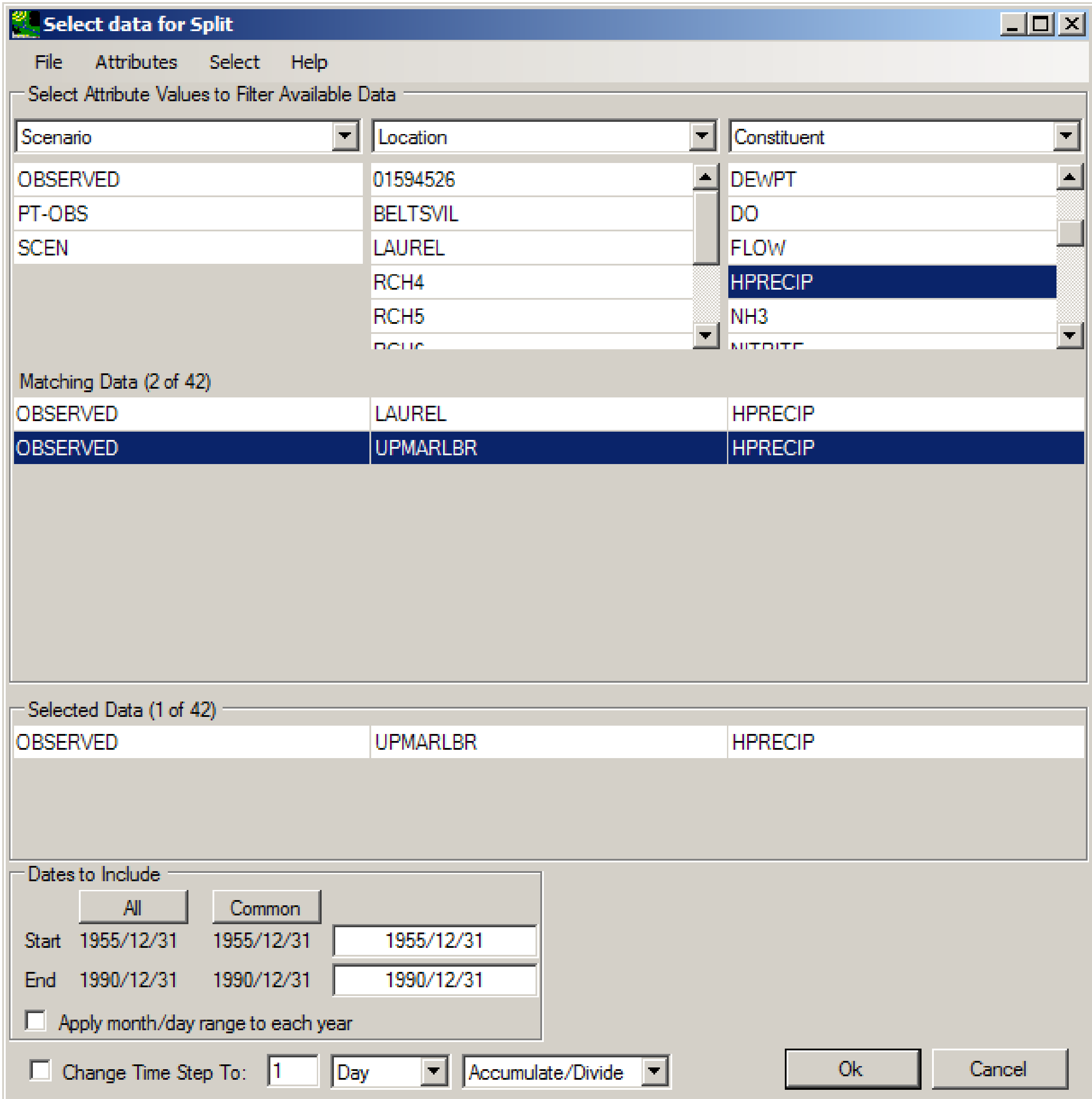
- **Subset by Date**
- The **Generate Time Series:Data:Subset by Date** option allows the user to use one dataset to create one new dataset only containing the data within certain day, month, and year boundaries.



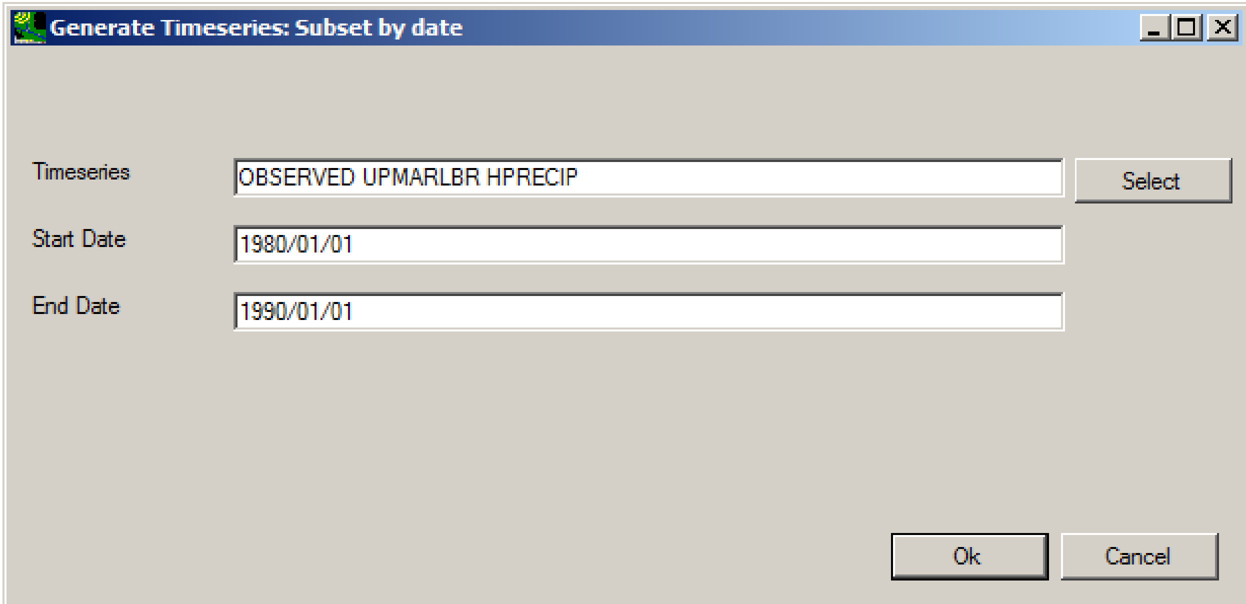
- Clicking on **Subset by Date** opens the **Generate Time Series:Data:Subset by Date** window. Click **Select** to choose one time series.



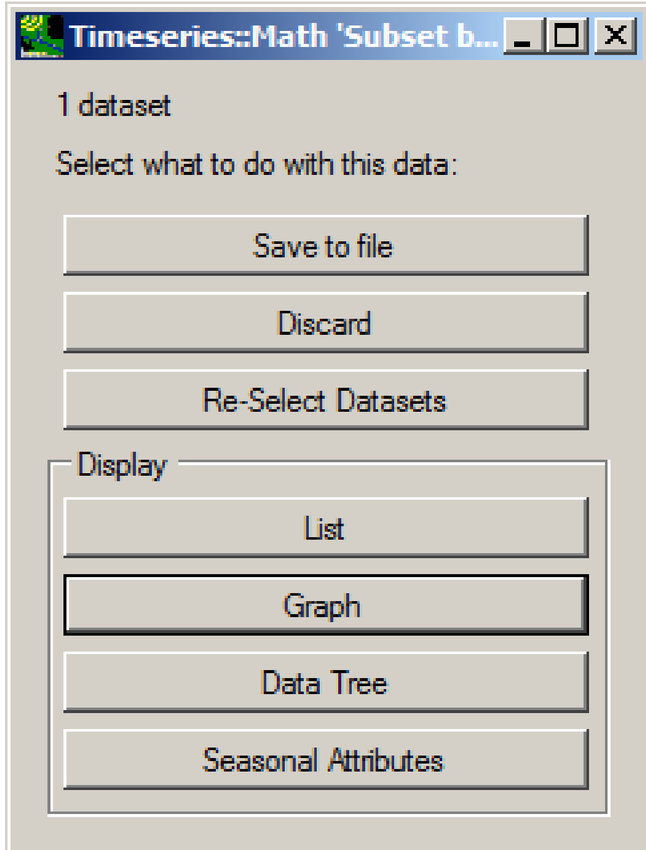
- Select HPRECIP from the Constituent column, and OBSERVED UPMARLBR from the Matching Data, then click **Ok**.



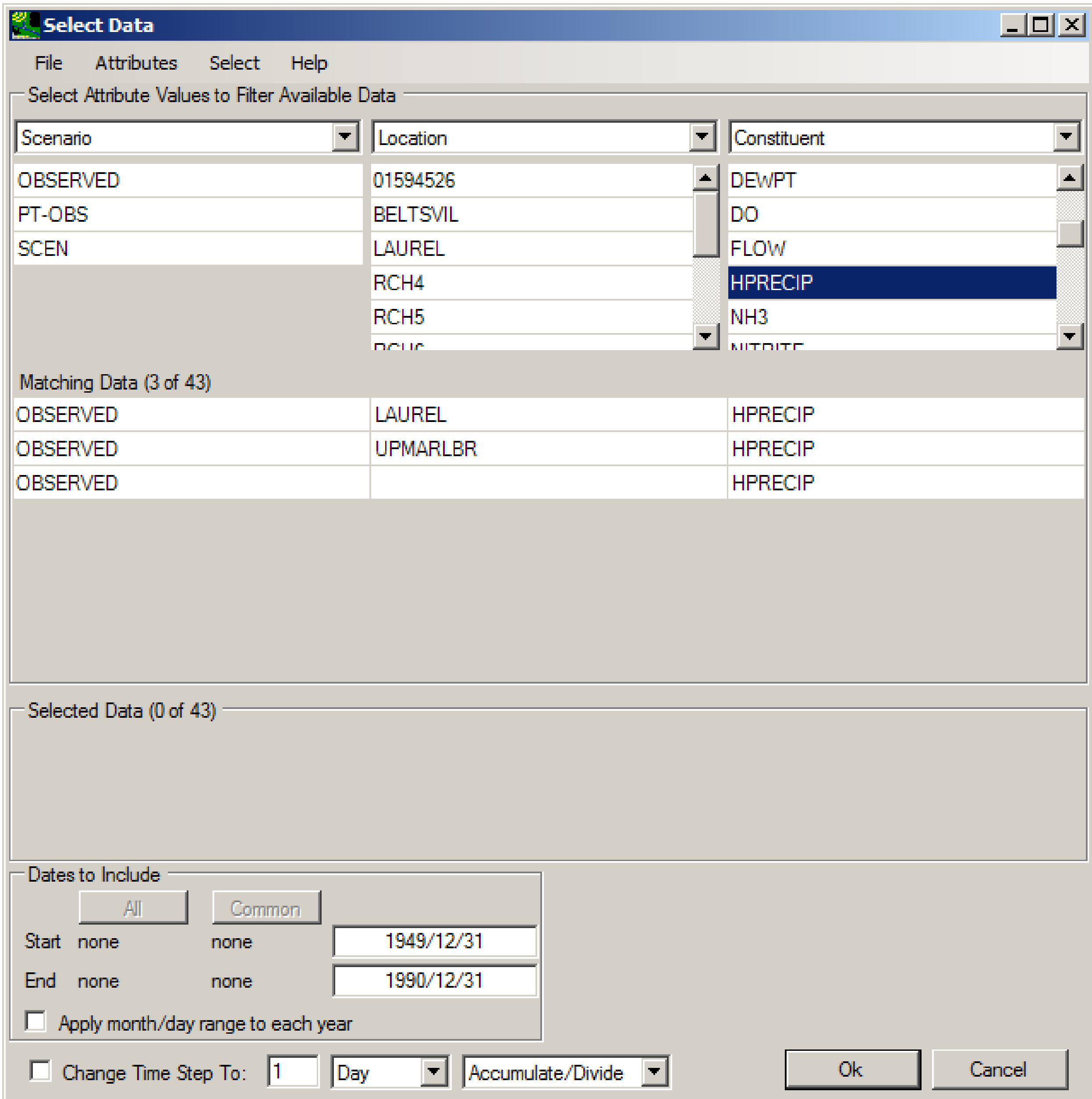
- Now type in the desired **Start Date** and **End Date**, in YYYY/MM/DD format. For this example, you may use 1980/01/01 as a start date and 1990/01/01 as an end date. Click on **Ok**.



- The **Timeseries::Math 'Subset by date' 1 datasets** window will appear, giving the user the option to save or discard the results or Adding/Removing datasets. The user can also display the data as a list, graph, data tree, or seasonal attribute table.

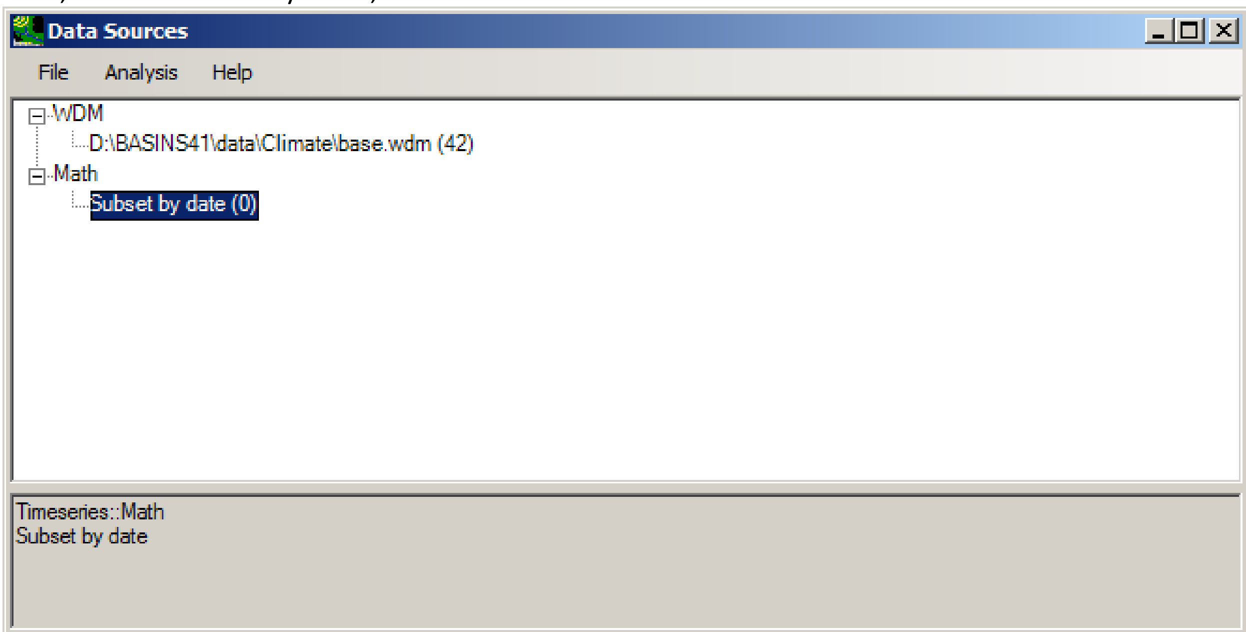


- *Note:* Unless the results are discarded, the newly created time series will appear when selecting data in the future. For example, there is now a third HPRECIP dataset:



The user may wish to select these new results. Otherwise, to discard the newly created timeseries, either select "Discard" from the **Timeseries::Math 'Subset by date'** window, or go to **File:Manage**

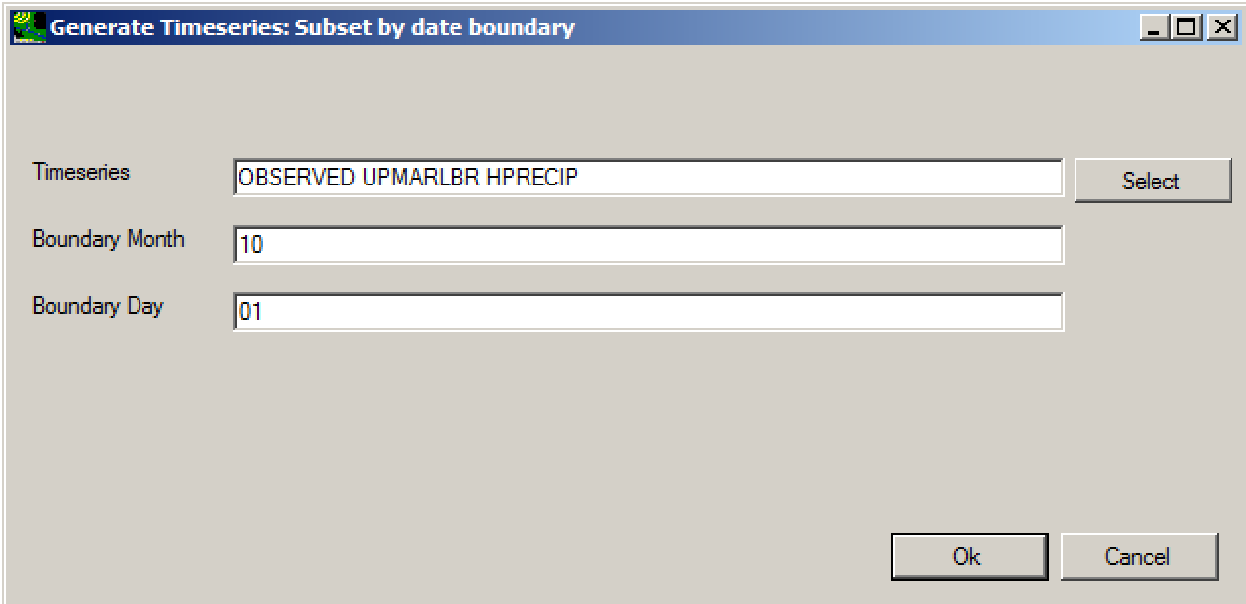
Data, click on "Subset by date", and click **File:Close Selected**.



- **Subset by Date Boundary** Generating time series with **Subset by Date Boundary** lets the user select one time series and creates one new time series with different year boundaries. The user chooses a month and day to begin and end the new dataset. Therefore, the new dataset has all the same data EXCEPT the data in the first year which precedes the chosen month and day, and the data in the last year which falls after the chosen month and day. This allows the user to organize the data into different "years", which start on any day, such as a "water year".

- Click on **Subset by Date Boundary** to open the **Generate Timeseries:Subset by Date Boundary** window, then click **Select**. As was done in the above example for **Subset by Date**, select the HPRECIP OBSERVED UPMARLBR dataset. Type 10 for the boundary month (October), and 01 for the boundary day. This will delete all data before October 1 in the first year of data, and all data after

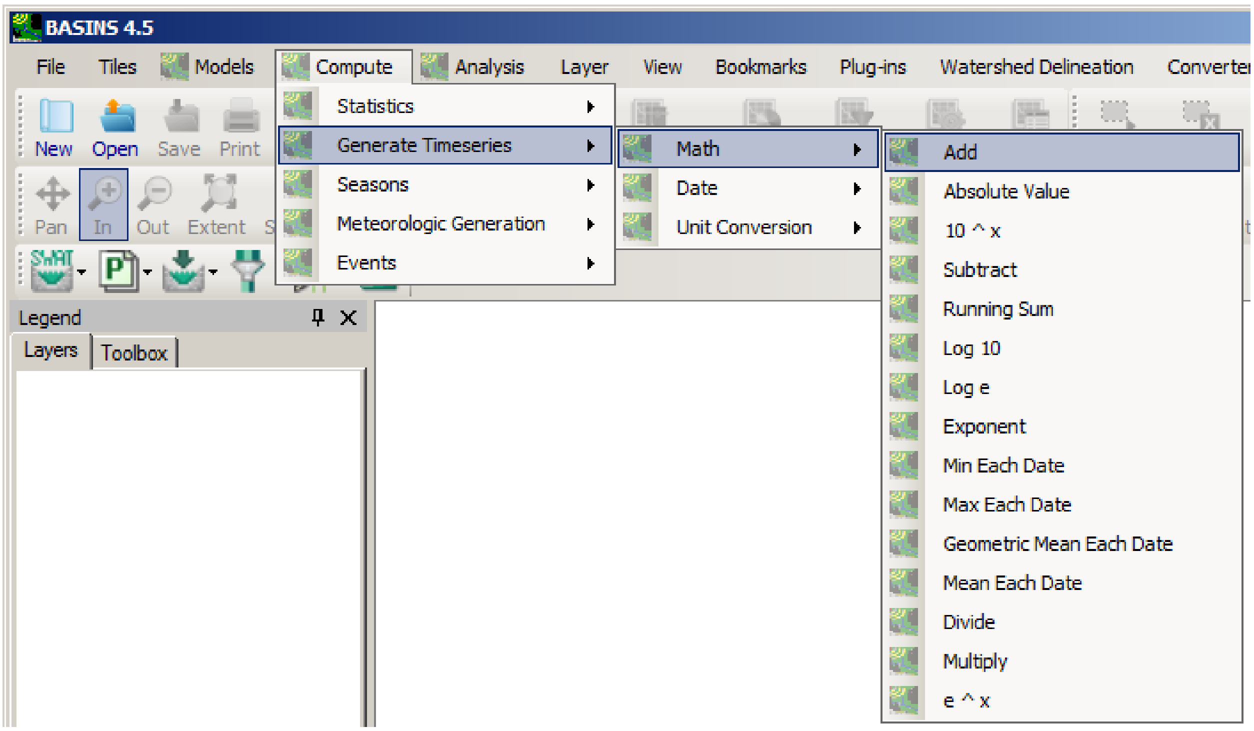
October 1 in the last year of data, keeping all data in between.



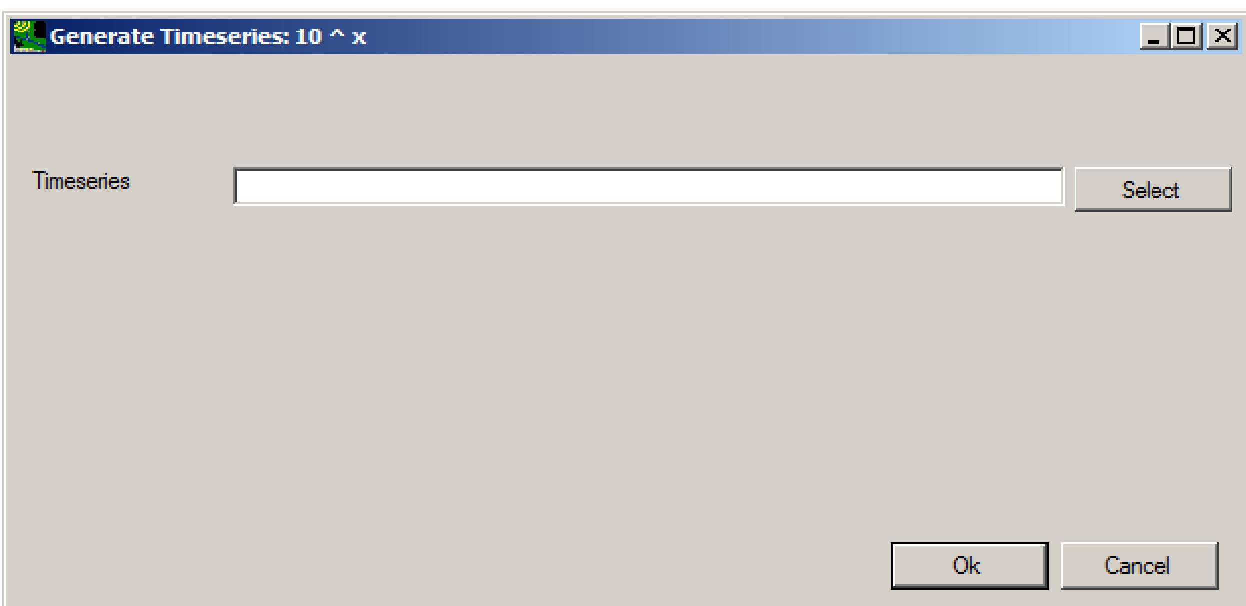
- Clicking **Ok** gives the familiar **Timeseries** screen, with options as explained above.

Math

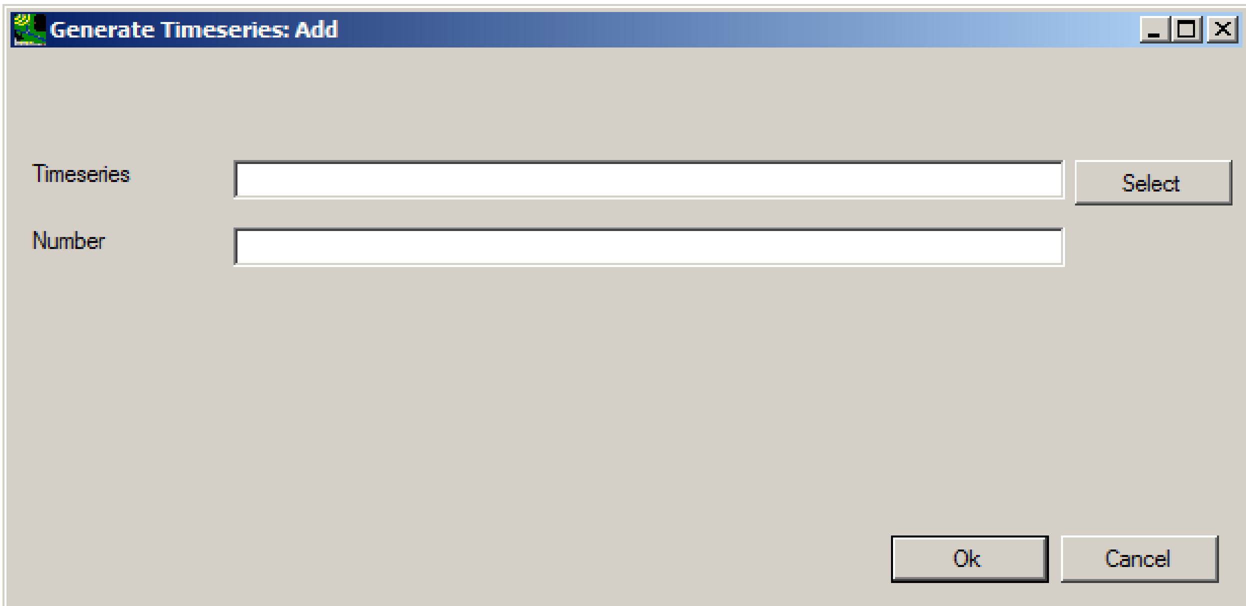
The **Generate Time Series:Math** menu includes 15 mathematical operations that can be done to the entire time-series dataset.



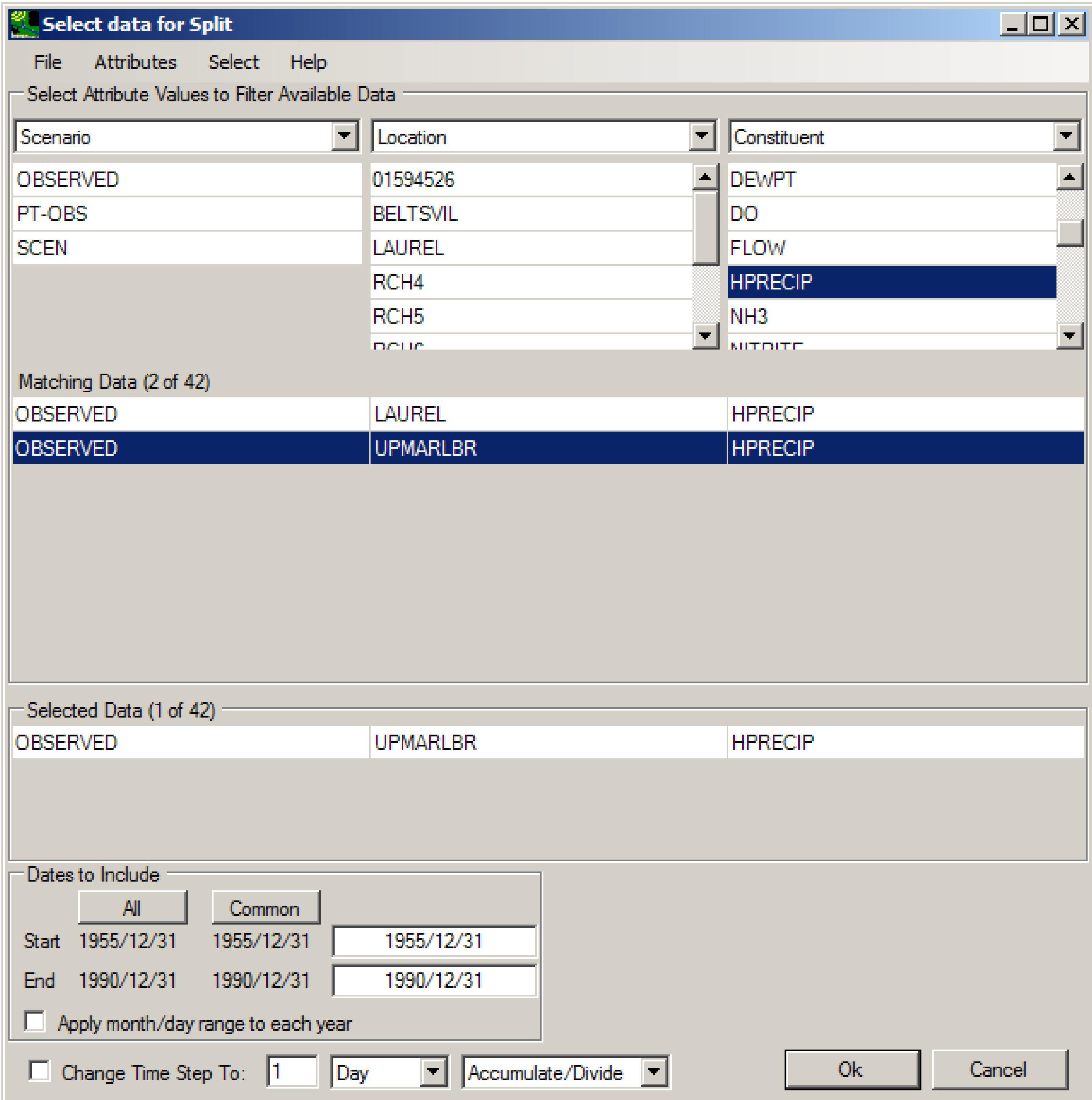
With any of these options, the **Generate Timeseries** window appears. Click on the **Select** button to select a time series to perform the calculation on.



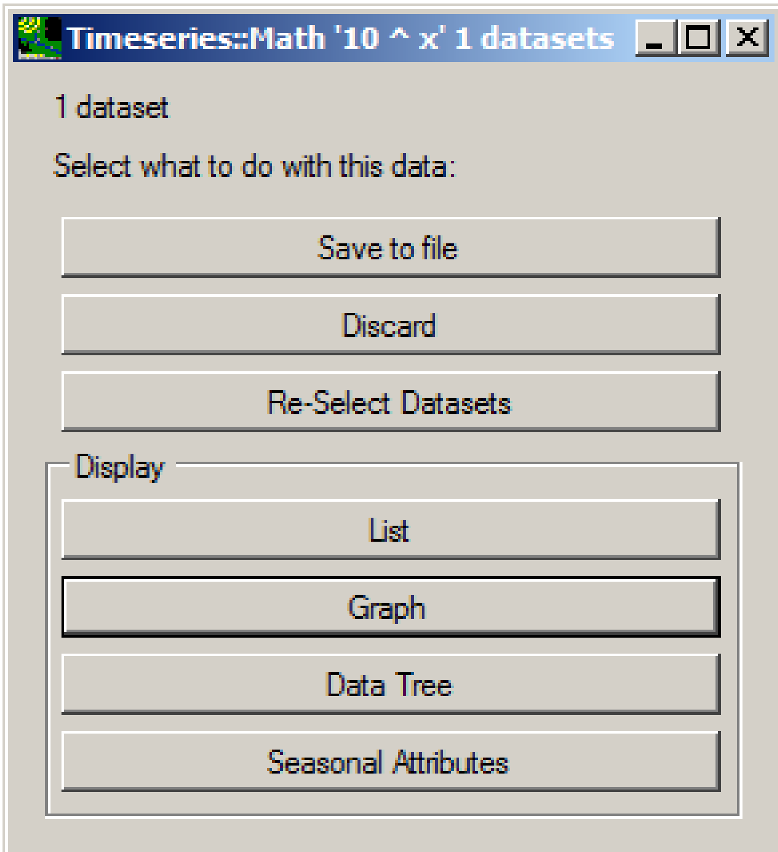
Some functions may lead to a slightly modified **Generate Timeseries** window, such as the **Add** option:



This will open the **Select Timeseries for** window. Select HPRECIP from the Constituent column, and OBSERVED UPMARLBR from the Matching Data, then click **Ok**.

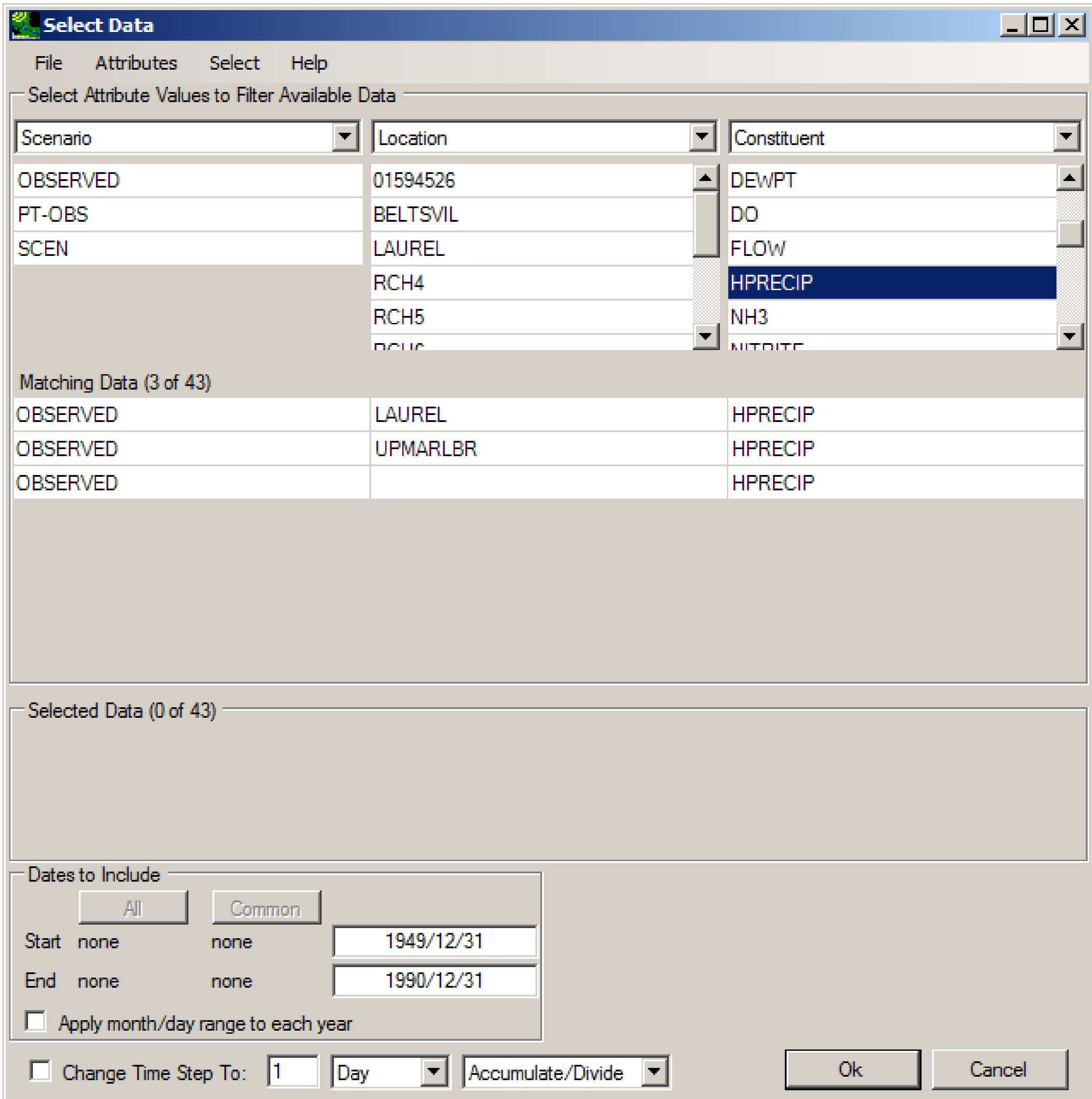


Depending on which math function was selected, the name in the frame of the **Timeseries** window will now reflect the function that was performed. For example, if the **10^ x** function was selected, the following **Timeseries** window will appear:

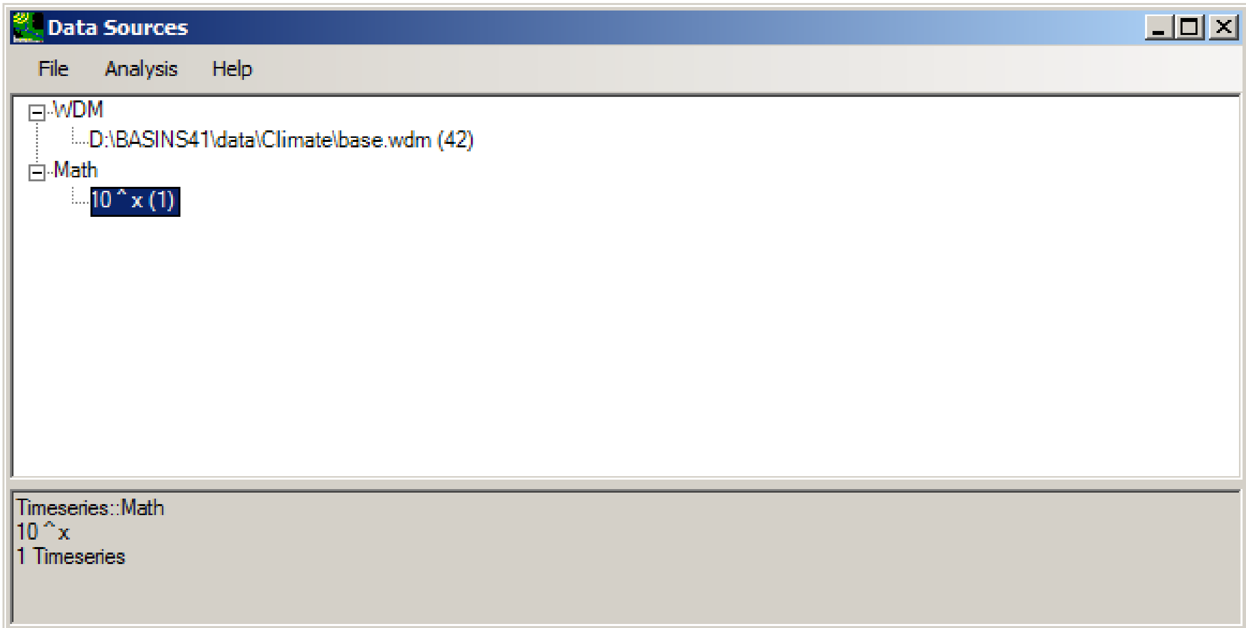


This gives the user the option to save or discard the results or Add/Remove datasets. The user can also display the data as a list, graph, data tree, or seasonal attribute table.

Note: Unless the results are discarded, the newly created time series will appear when selecting data in the future. For example, there is now a third HPRECIP dataset:



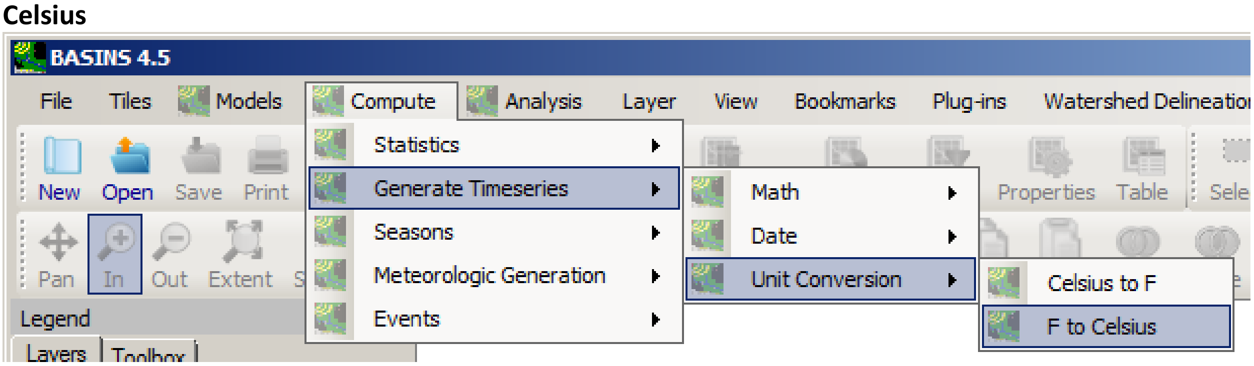
To discard the newly created timeseries, either select "Discard" from the **Timeseries::Math 'Subset by date'** window, or go to **File:Manage Data**, click on "10^x (1)", and choose **File:Close Selected**.



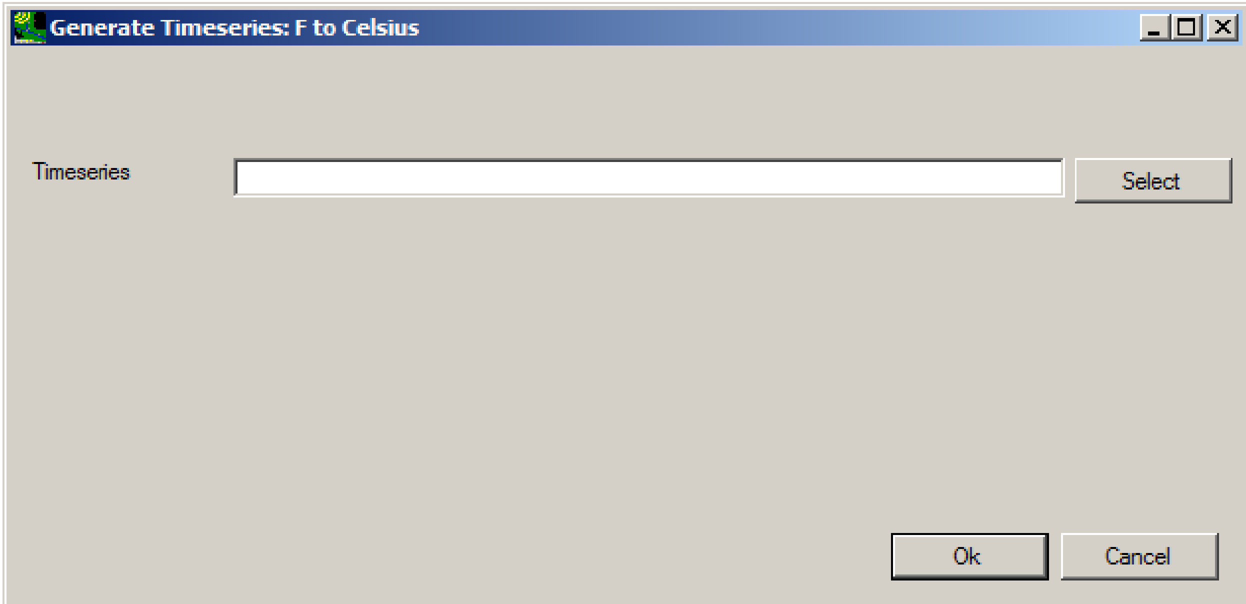
Unit Conversion

There are two options for unit conversion:

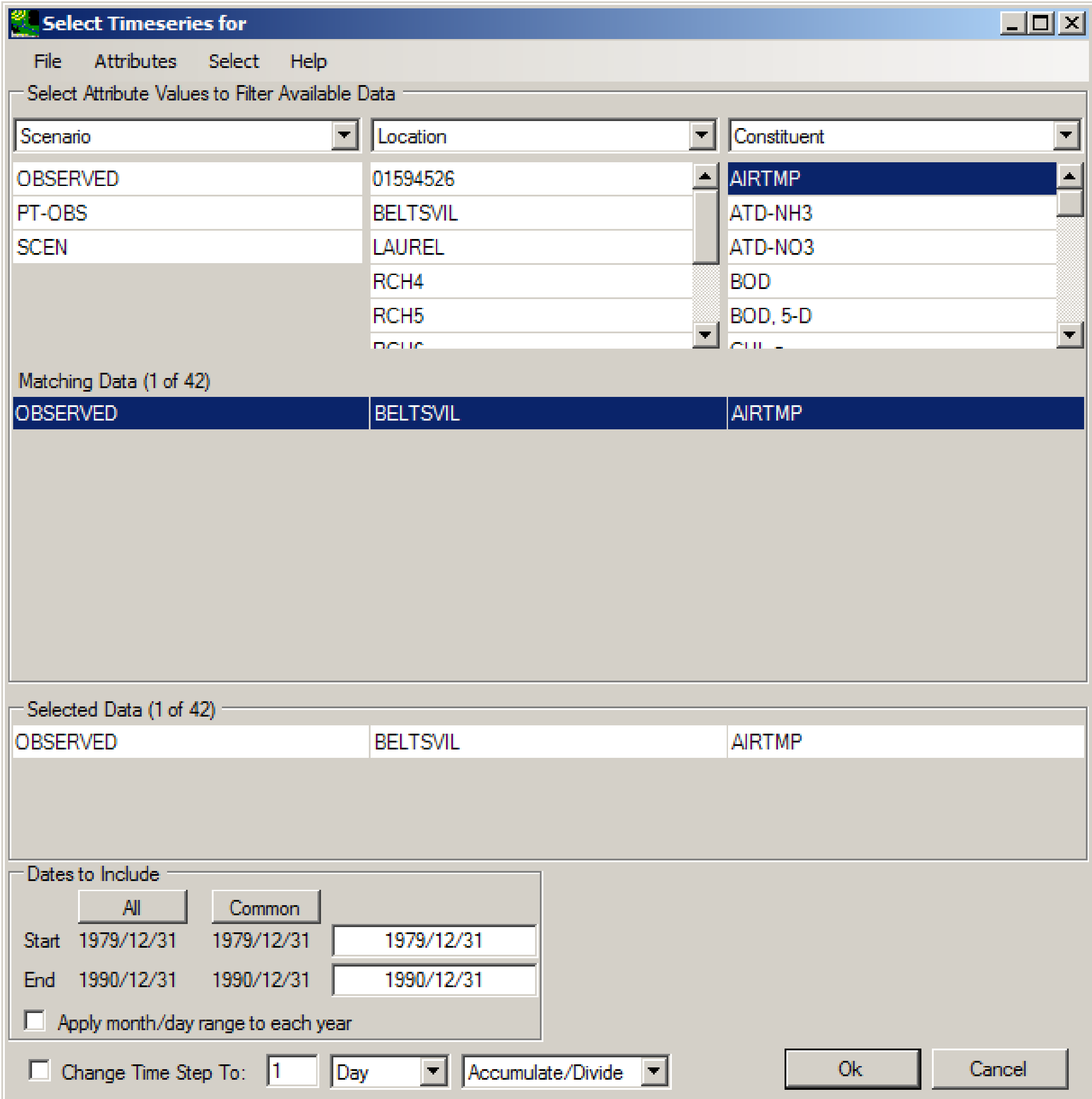
- **Celsius to F**
- **F to Celsius**



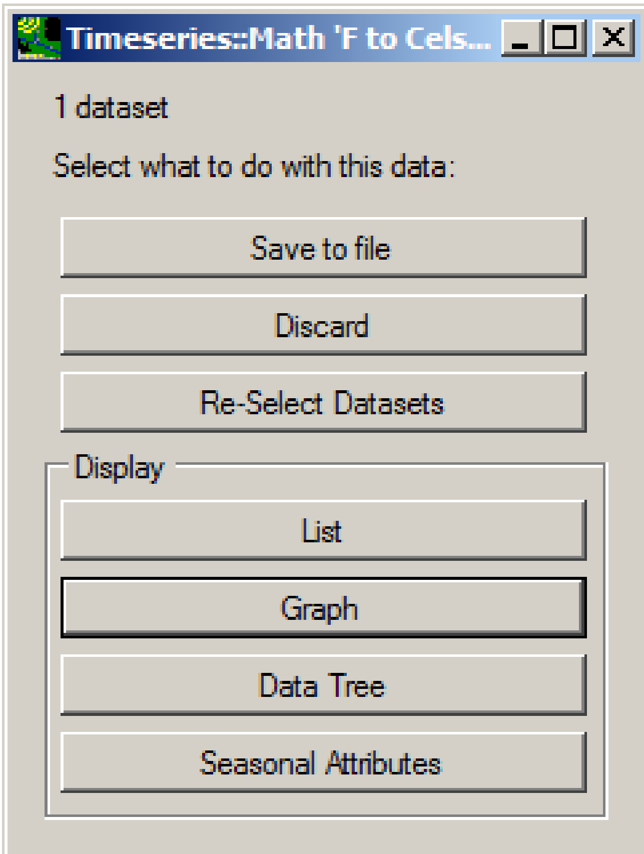
- Both options open the **Generate Timeseries** window. Click on the **Select** button to select a time series to perform the calculation on.



- This will open the **Select Timeseries for** window. Select AIRTMP from the Constituent column, and OBSERVED BELTSVIL from the Matching Data, then click **Ok**.



- Depending on which unit conversion function was selected, the name in the frame of the **Timeseries** window will now reflect the function that was performed. This gives the user the option to save or discard the results, or Add/Remove datasets. The user can also display the data as a list, graph, data tree, or seasonal attribute table.



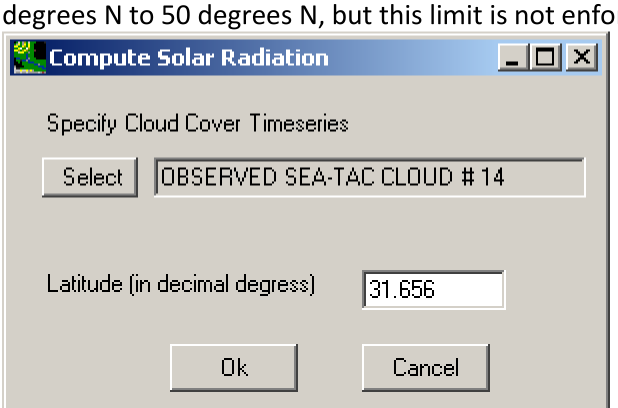
- *Note:* Unless the results are discarded, the newly created time series will appear when selecting data in the future. The user may wish to select these new results. Otherwise, to discard the newly created timeseries, either select "Discard" from the **Timeseries::Math** window, or go to **File:Manage Data**, click on **Math:F to Celsius(1)**, and choose **File:Close Selected**.

Computations

The algorithms for calculating output meteorological time series with the **Meteorologic Generation:Computations** utilities on the Compute form are documented in this section.

- Solar Radiation

  This procedure computes the total daily solar radiation (langleys) based on empirical curves of radiation as a function of latitude (Hamon et al, 1954). The inputs are latitude in decimal degrees and daily cloud cover in tenths (ranges from 0 to 10). This method is limited to latitudes from 25 degrees N to 50 degrees N, but this limit is not enforced by the program.

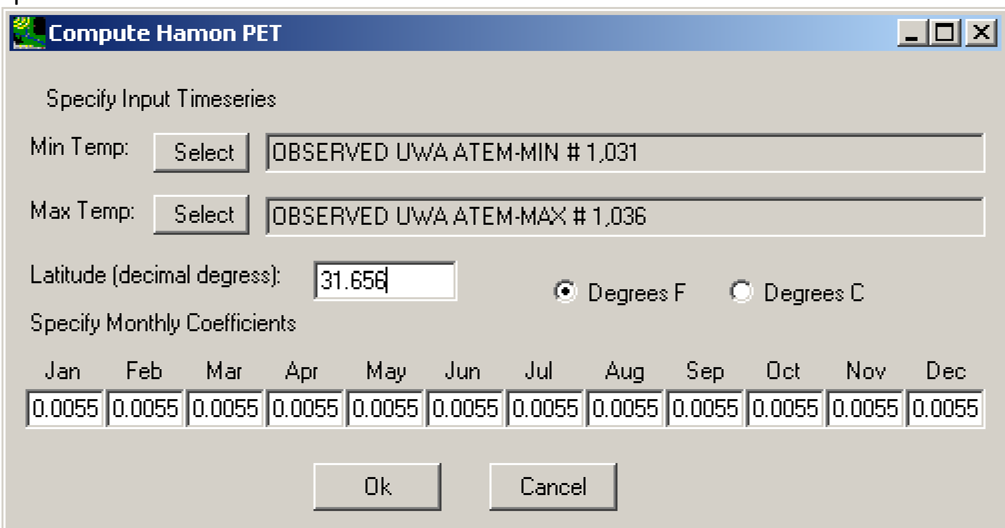


- Hamon PET

  This method generates daily potential evapotranspiration (inches) using air temperature (F or C), a monthly variable coefficient, the number of hours of sunshine (computed from latitude), and absolute humidity (computed from air temperature). The computations are based on the Hamon (1961) formula.

```
PET = CTS * DYL * DYL * VDSAT
where
PET = daily potential evapotranspiration (in)
CTS = monthly variable coefficient
DYL =                possible hours of sunshine, in units of 12 hours,
                     computed as a function of latitude and time of year
VDSAT =              saturated water vapor density (absolute humidity)
                     at the daily mean air temperature (g/cm3)
VDSAT = (216.7 * VPSAT)/(TAVC + 273.3) where
VPSAT = saturated vapor pressure at the air temperature
TAVC  =              mean daily air temperature,
computed from the daily max-min data (C)
VPSAT = 6.108 * EXP((17.26939 * TAVC)/(TAVC + 237.3))
```

Hamon (1961) suggests a constant value of 0.0055 for CTS. However, this has been found to underestimate PET in some areas, especially for winter months. Therefore, monthly values can be specified.



- Jensen PET

This procedure generates daily potential evapotranspiration (inches) using a coefficient for the month, the daily average air temperature (F), a coefficient, and solar radiation (langleys/day). The computations are based on the Jensen and Haise (1963) formula.

```
PET = CTS * (TAVF - CTX) * RIN

where      PET = daily potential evapotranspiration (in)
CTS = monthly variable coefficient
TAVF = mean daily air temperature (F), computed from max-min
CTX = coefficient
RIN = daily solar radiation expressed in inches of evaporation
RIN = SWRD/(597.3 - (.57 * TAVC)) * 2.54
where
SWRD = daily solar radiation (langleys)
TAVC = mean daily air temperature (C)
```

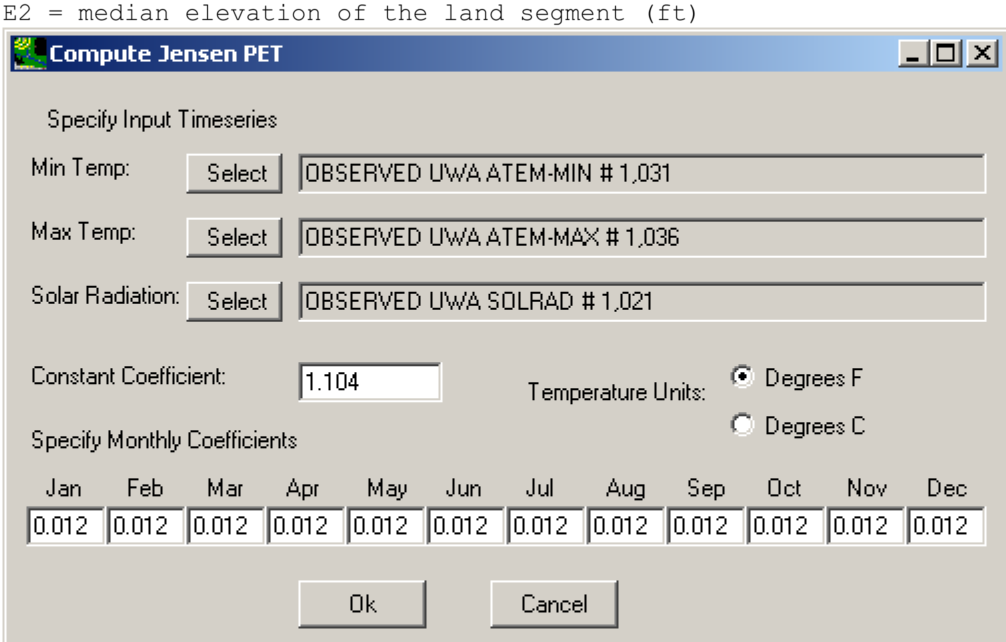
The following is abstracted from the PRMS manual (Leavesley, et al., 1983): As with the Hamon procedure, the Jensen-Haise procedure tends to underestimate winter PET; therefore, monthly variable CTS coefficients are included. Values of CTS and CTX for the warmer months can be estimated using regional air temperature, elevation, vapor pressure, and vegetation data (Jensen et al. 1969). For aerodynamically rough crops (assumed to include forests), CTS can be computed for the watershed by:

```
CTS = 1/[C1 + (13.0 * CH)] where
C1 = an elevation correction factor
CH = humidity index
C1 = 68.0 - [3.6 * E1/1000] where
E1 = median elevation of the watershed (ft)
```

```
CH = 50/(e2 - e1) where
e2 =                    saturation vapor pressure (mb) for the mean maximum
                        air temperature for the warmest month of the year
e1 =                    saturation vapor pressure (mb) for the mean minimum
                        air temperature for the warmest month of the year
```

CTX is computed for each land segment as:

```
CTX = 27.5 - 0.25 * (e2 - e1) - (E2/1000) where
E2 = median elevation of the land segment (ft)
```



- Penman Pan Evaporation

This procedure estimates daily pan evaporation (inches) using daily average air temperature (F), dewpoint (F), wind movement (miles/day), and solar radiation (langleys/day). The method is that of Kohler, Nordensen, and Fox (1955), and it is based on the Penman (1948) formula; the following description is abstracted from Hydrocomp (1977):

```
E = (Q*DEL + Ea*GAM)/(DEL + GAM)                   (1)
where
E   =                   pan evaporation
Q   =                   net radiation exchange
DEL =                   slope of the saturation vapor pressure
curve at the air temperature
GAM =                   0.0105 inches Hg/deg F (defined by Bowen's Ratio)
Ea  =                   pan evaporation (assuming air temperature equals
                        water temperature)
```

To express the above equation in terms of available meteorological data, empirical curve fitting of data points is used. An empirical expression for Q*DEL, which can be treated as a single parameter, is

```
Q*DEL = exp[(Ta -212) (0.1024 - 0.01066 ln R)] - 0.000    (2) where
```

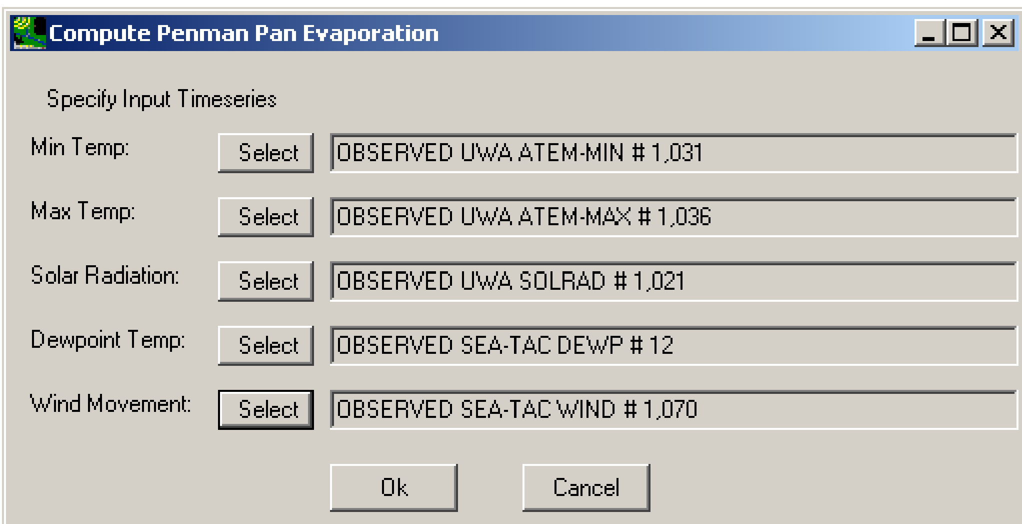
```
Ta = air temperature (F)        R  = daily solar radiation (langleys)
```
An expression for Ea is

```
Ea   = (0.37 + 0.0041 Up) * (es - ea)**0.88
              (3) where (es - ea) =      vapor pressure deficit between
surface and dewpoint temperature and
Up   = total daily wind movement (miles)
```

The Clausius-Clapeyron equation can be used to express e, the vapor pressure, and DEL, the slope of the saturation vapor pressure curve at air temperature Ta:

```
e = exp{[-7482.6/(Ta + 398.36)] + 15.674}                (4)
DEL = [7482.6/Ta+398.36)**2] exp[15.674-7482.6/(Ta+398.36)] (5)
```

To calculate evaporation, the procedure uses Eqn 1. Parameters needed for the evaluation of Eqn 1 are found using Eqns 2-5. Air temperature is estimated as the average of maximum and minimum daily temperature. If dewpoint temperatures are not available, minimum daily temperatures can be substituted.



- Wind Travel

This procedure computes total daily wind travel (miles) from average daily wind speed (miles per hour). The average daily wind speed is multiplied by 24 to generate the total daily wind travel. No additional selections besides the input time series are necessary.

- Cloud Cover

This procedure computes daily percent cloud cover from daily percent sunshine. No additional selections besides the input time series are necessary. The relationship between these two constituents is extracted from the algorithms developed by Hamon, Weiss, and Wilson (1954) for Solar Radiation. Specifically, the relationship is as follows:

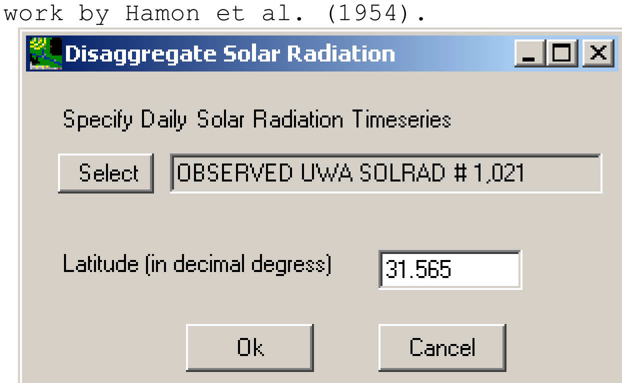
```
CC = 100 * (1 - PSS/100)**0.6where
CC = percent cloud cover
PSS = percent sunshine
```

Disaggregations

The algorithms for disaggregating meteorological time series from daily to hourly with the **Meteorologic Generation:Disaggregations** utilities on the Compute form are documented in this section.

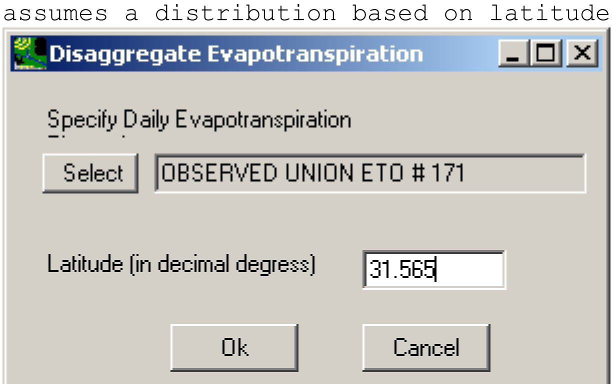
- Solar Radiation

```
This procedure distributes daily solar radiation to hourly values by assuming an
empirical distribution over daylight hours that are computed from latitude and
time of year.  It is limited to latitudes from 25 degrees N to 50 degrees N, but
this limit is not enforced by the program.  It is an empirical method based on
work by Hamon et al. (1954).
```



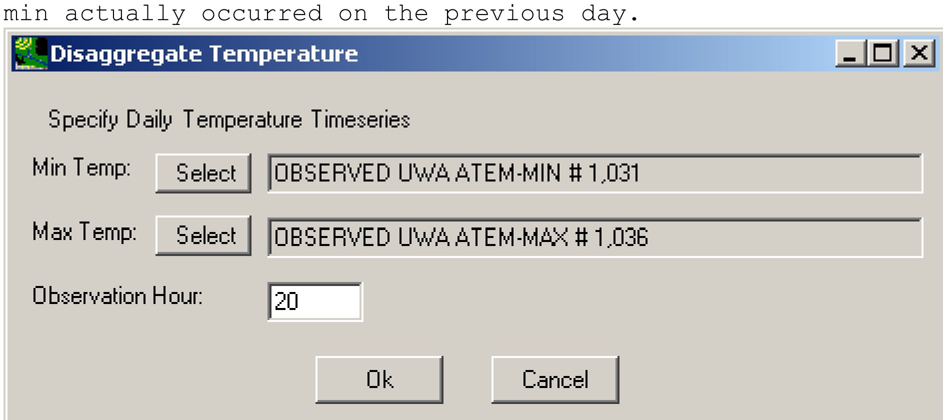
- Evapotranspiration

```
This procedure distributes daily evapotranspiration to hourly values; it
assumes a distribution based on latitude and time of year.
```



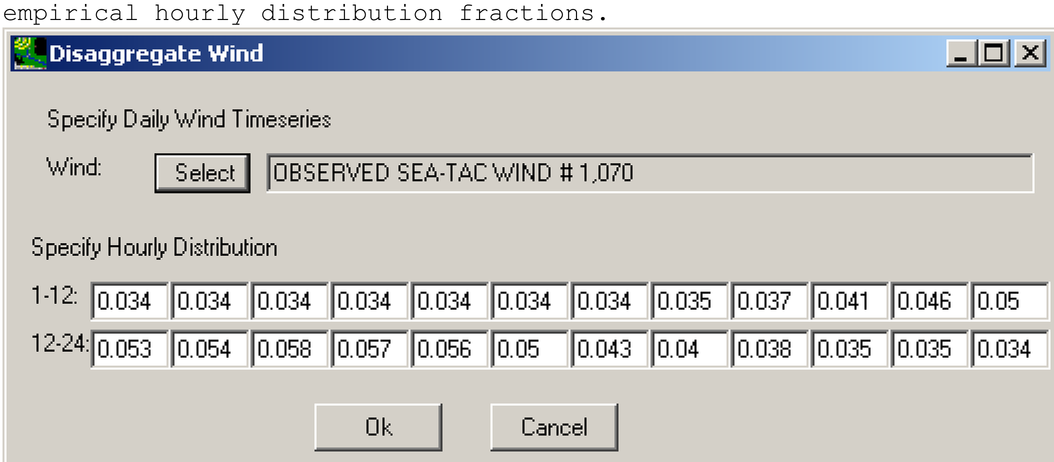
- Temperature

  This procedure distributes daily max-min temperatures to hourly values; it assumes the minimum occurs at 6 AM and the maximum occurs at 4 PM. The observation hour (1-24) is the hour at which these max and min temperatures are recorded. If this hour is 17-24, then both the input max and min actually occurred on that day. If the hour is 6-16, then the input max actually occurred on the previous day. If the hour is 1-5, then both the input max and min actually occurred on the previous day.



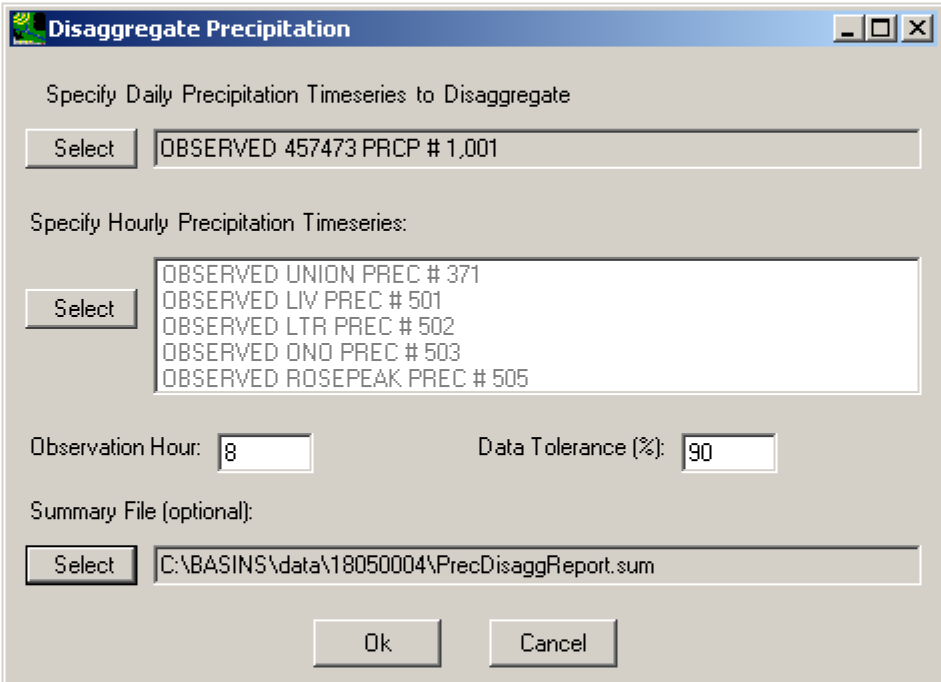
- Wind

  This procedure distributes daily wind movement (any length units) to hourly values (same as input length unit); it allows the user to adjust the default empirical hourly distribution fractions.



- Precipitation

  This procedure distributes daily precipitation to hourly values based on hourly time series from nearby stations (up to 5). The daily precipitation time series must not contain any missing periods as indicated by negative values. It distributes the data according to one of several secondary hourly stations, using the one whose daily total is closest to the daily value. If the daily total for the hourly stations being used are not within a user-specified tolerance of the daily value, the daily value is distributed using a triangular distribution centered around the middle of the day. The tolerance is expressed as a ratio of the total to the daily value being disaggregated. One hundred percent means that any daily total (from the hourly stations) is acceptable. Zero percent means that the daily total must match the daily value exactly. Fifty percent means that the daily total must be between one half and double the daily value. The observation hour (1-24) at the station where the data was recorded must be indicated. An optional summary output file may be produced reporting either: 1) which hourly station was used to disaggregate each daily value, or 2) no suitable hourly station was found so triangular distribution was used.



- Dewpoint
  This procedure distributes average daily dewpoint temperature (F or C) to hourly values. It assumes that the daily average is constant over the 24-hour period.

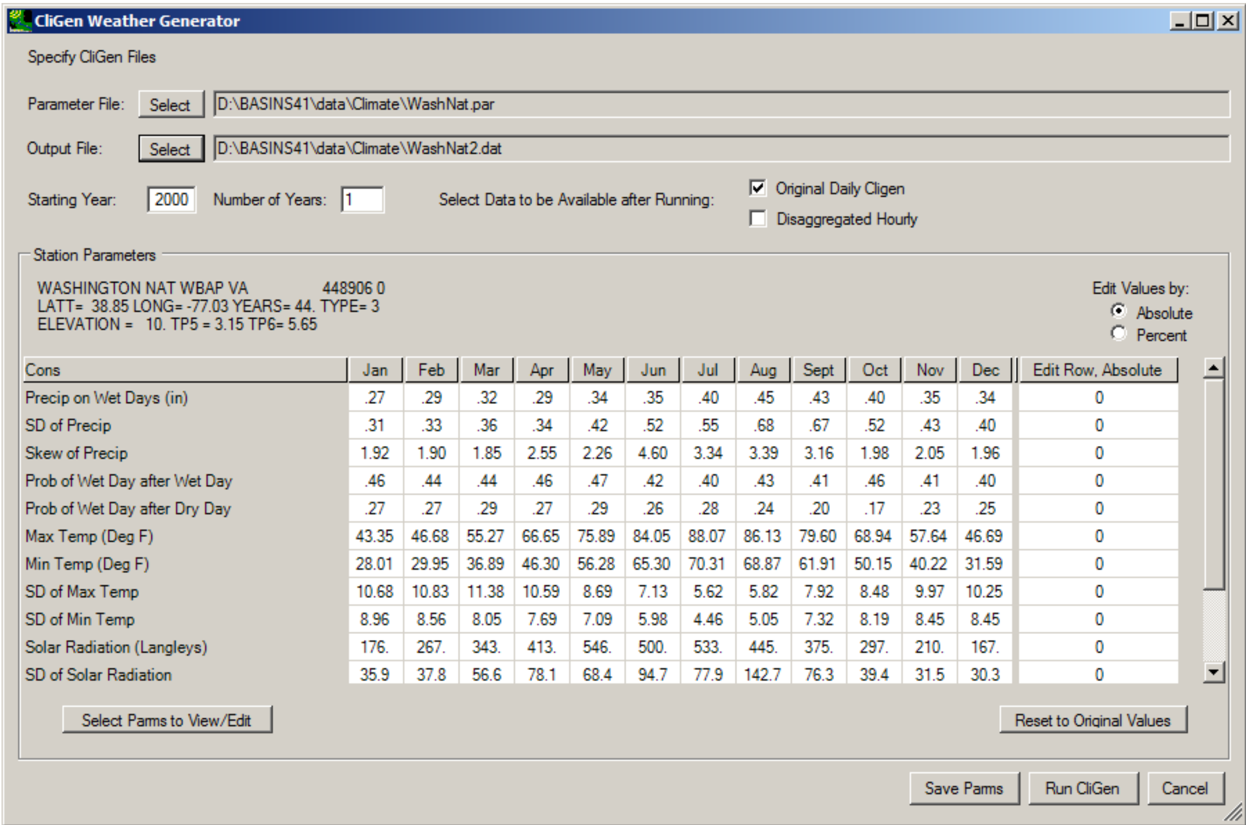
Cligen

CliGen is a stand-alone model that generates daily meteorological data for an observation station based on that station's historical values. Required inputs to run CliGen are:

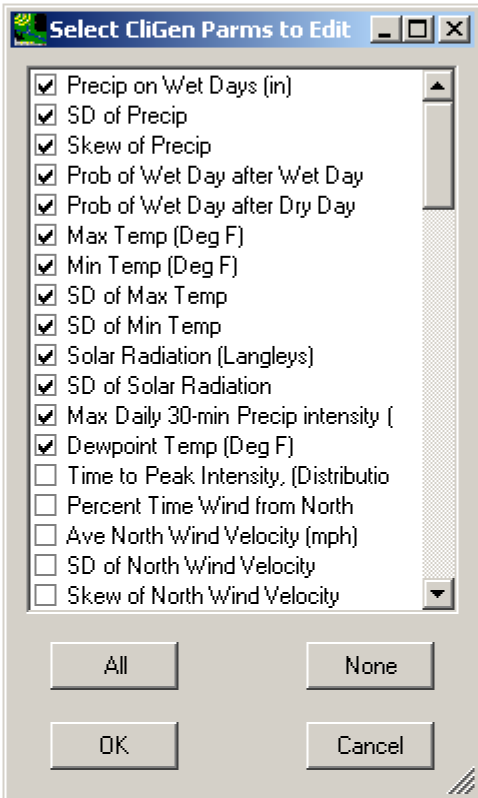
- parameter file (*.par) containing station's stats
- starting year for which to generate data
- number of years of data to generate
- output file (*.dat) to house generated data

CliGen is accessible from the **Compute:Meteorologic Generation** menu.

The CliGen form allows for the specification of the above input requirements. Additionally, it allows the user to update the monthly statistical values for the observation station to then generate an alternative set of met data.



The parameter file contains monthly averages for a large number of different constituents, especially wind data (3 records for each of the 12 wind directions). The user has the ability to control which parameters are displayed in the grid for editing by clicking on the **Select Params to View/Edit** button. When this button is selected, the entire list of available parameters is shown with a check box next to each one that can be clicked 'on' or 'off'. Those constituents clicked 'on' will then be displayed on the editing grid and those 'off' will not. (These selections are stored in a file called CliGenEdit.prm, in the same directory as the executable).

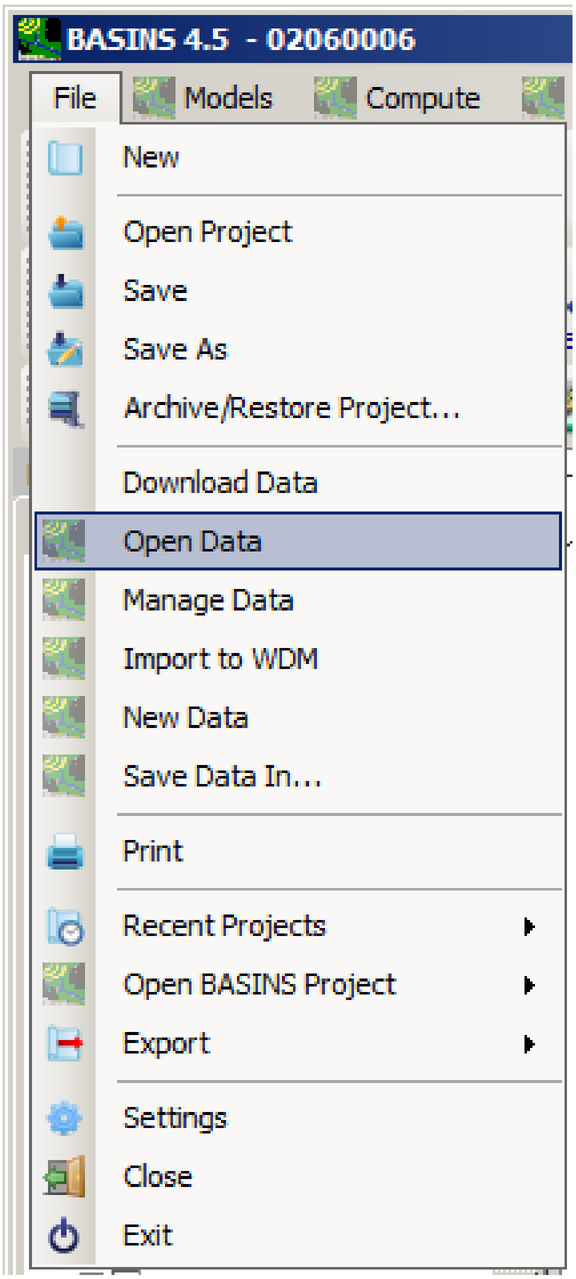


Monthly values in the grid may then be edited cell by cell or by using the far right column to adjust a whole row of values. When a value is entered for a cell in the far right column, every other cell in that row is adjusted by the entered value. The radio buttons above the far right column dictate whether the adjustment is absolute (i.e. add the entered value to every cell in the row) or by percent (i.e. multiply every value in the row by the entered percentage). When the **Run CliGen** button is selected, CliGen is run using the specified inputs and a suite of 10 meteorological time series are created and become available in memory.

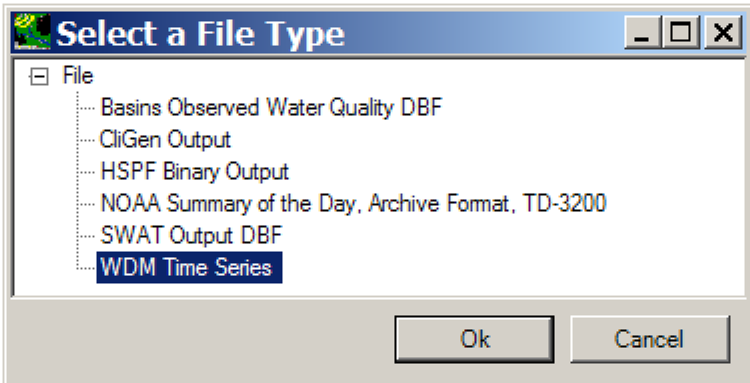
Seasons

The **Generate Time Series:Seasons** function has 10 options to split a single time series into multiple new time series. For example, two time series are produced for the “AM or PM::Split” option, and 7 time series are produced for the “Day of Week::Split” option.

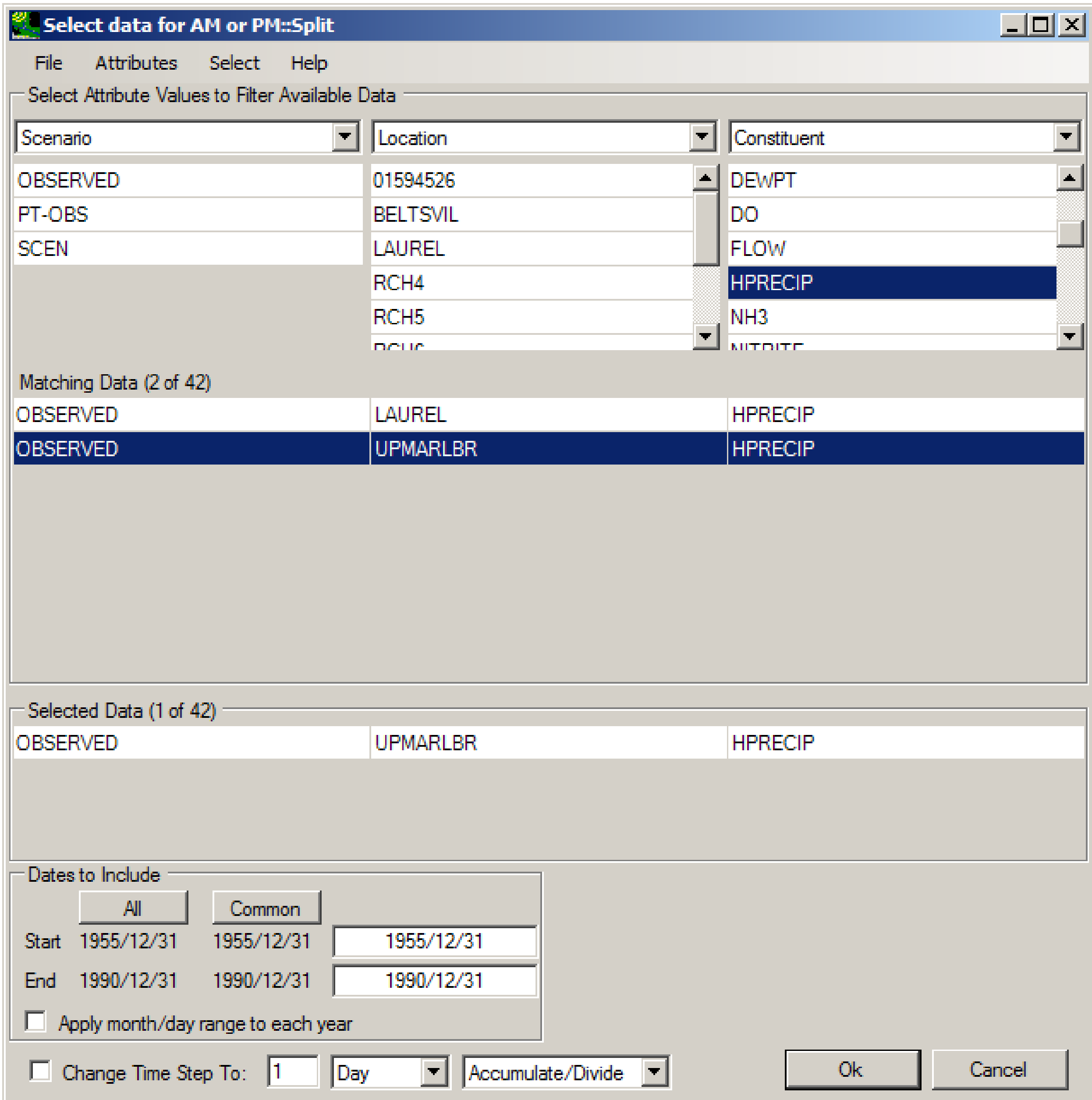
To use the **Seasons** tool, first open a *.wdm dataset using **File:Open Data**.



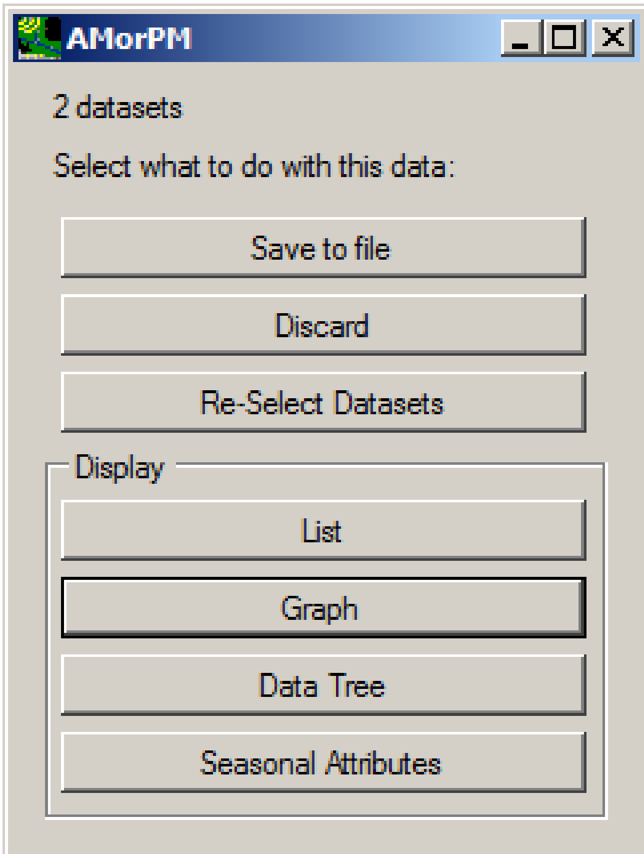
Select **WDM Time Series**, and then open Basins/data/Climate/base.wdm.



Click on **Compute: Seasons: Split: AM or PM::Split**, which will open the **Select data for AM or PM::Split** window. Select the dataset to divide into two datasets, one with the data collected in the AM, and one with PM data. For this example, select precipitation (**HPRECIP**) from the Constituent column, and OBSERVED UPMARLBR HPRECIP from the Matching Data section. Then click on **Ok**.



A window will pop up with the title of the **Seasons** calculation, in this case, **AMorPM**. This window gives the user options to save or discard results, or display the results as a list, graph, data tree, or seasonal attribute table. The top of the window will show that "2 datasets" have been created.



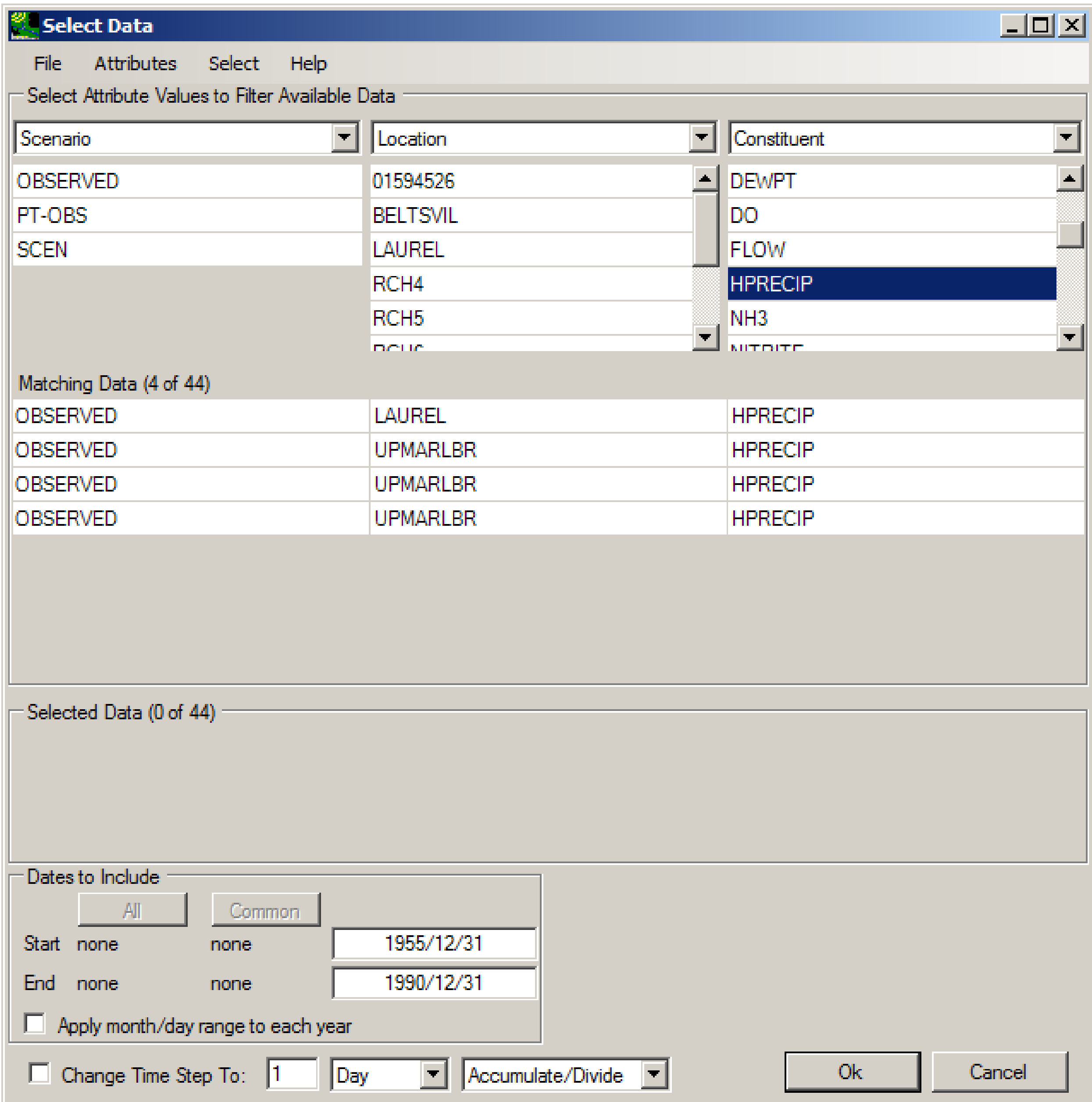
One way to display the results is with a **List**. Click on the **List** button. The **Timeseries List** window will pop up, listing the two new time series. Note that one dataset contains all of the data collected in the AM, and the other with the PM data.

Timeseries List

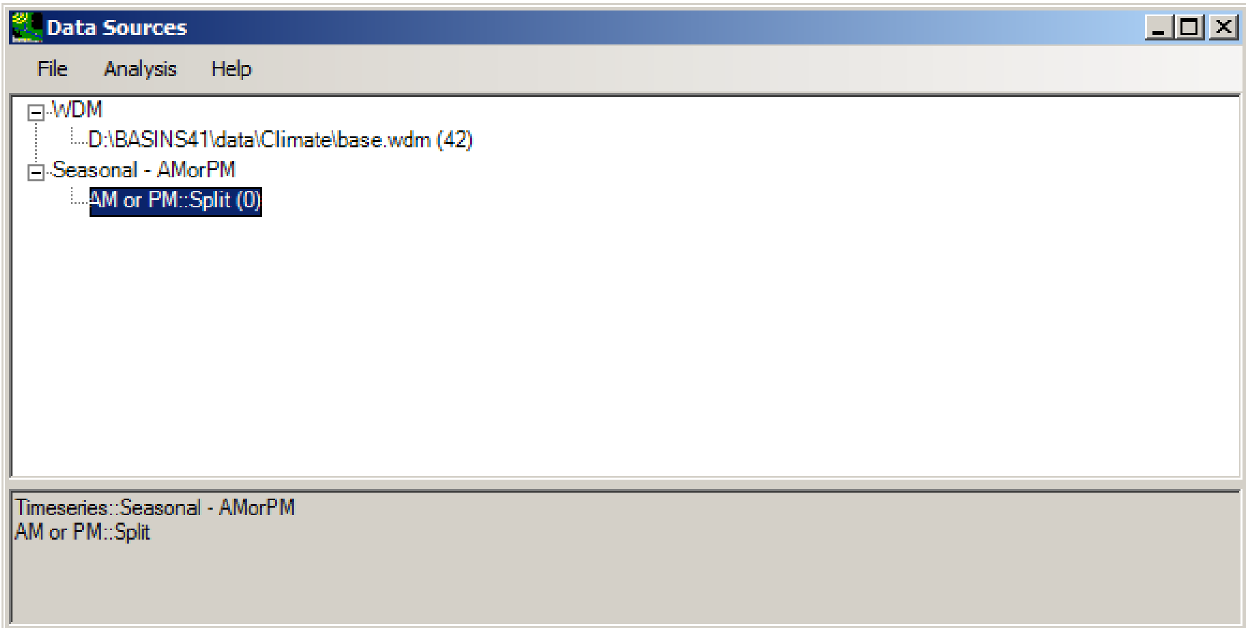
File Edit View Analysis Help

History 1	from base.wdm	from base.wdm
Constituent	HPRECIP	HPRECIP
Id	105	105
Min	0	0
Max	1.84	2.56
Mean	0.0042679	0.0053644
1955/12/31 09:00	0	
1955/12/31 10:00	0	
1955/12/31 11:00	0	
1955/12/31 12:00	0	NaN
1955/12/31 13:00		0
1955/12/31 14:00		0
1955/12/31 15:00		0
1955/12/31 16:00		0
1955/12/31 17:00		0
1955/12/31 18:00		0
1955/12/31 19:00		0
1955/12/31 20:00		0
1955/12/31 21:00		0
1955/12/31 22:00		0
1955/12/31 23:00		0
1955/12/31 24:00	NaN	0
1956/01/01 01:00	0	
1956/01/01 02:00	0	
1956/01/01 03:00	0	
1956/01/01 04:00	0	
1956/01/01 05:00	0	
1956/01/01 06:00	0	
1956/01/01 07:00	0	
1956/01/01 08:00	0	
1956/01/01 09:00	0	
1956/01/01 10:00	0	
1956/01/01 11:00	0	
1956/01/01 12:00	0	NaN
1956/01/01 13:00		0

Note: Unless the results are discarded, these two newly created time series will appear when selecting data in the future. For example, there are now three HPRECIP dataset for UPMARLBR:



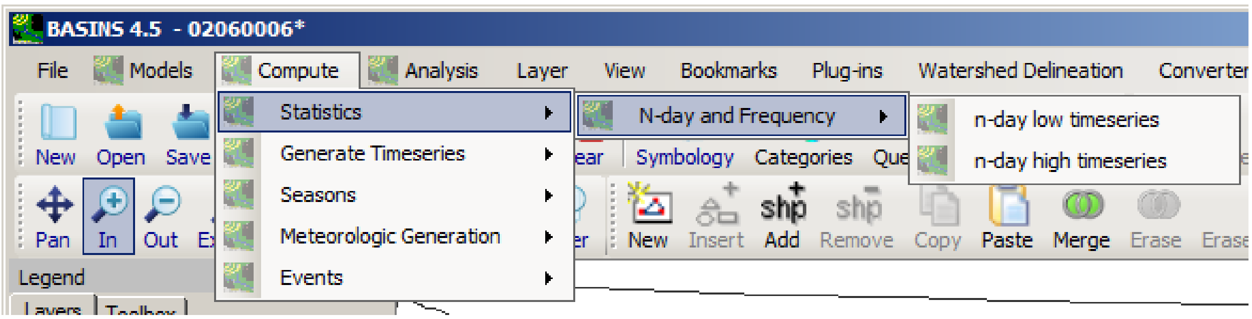
The user may wish to select these new results. Otherwise, to discard the newly created time series, either select "Discard", or go to **File:Manage Data**, click on **AM or PM**, and choose **File:Close Selected**.



Statistics

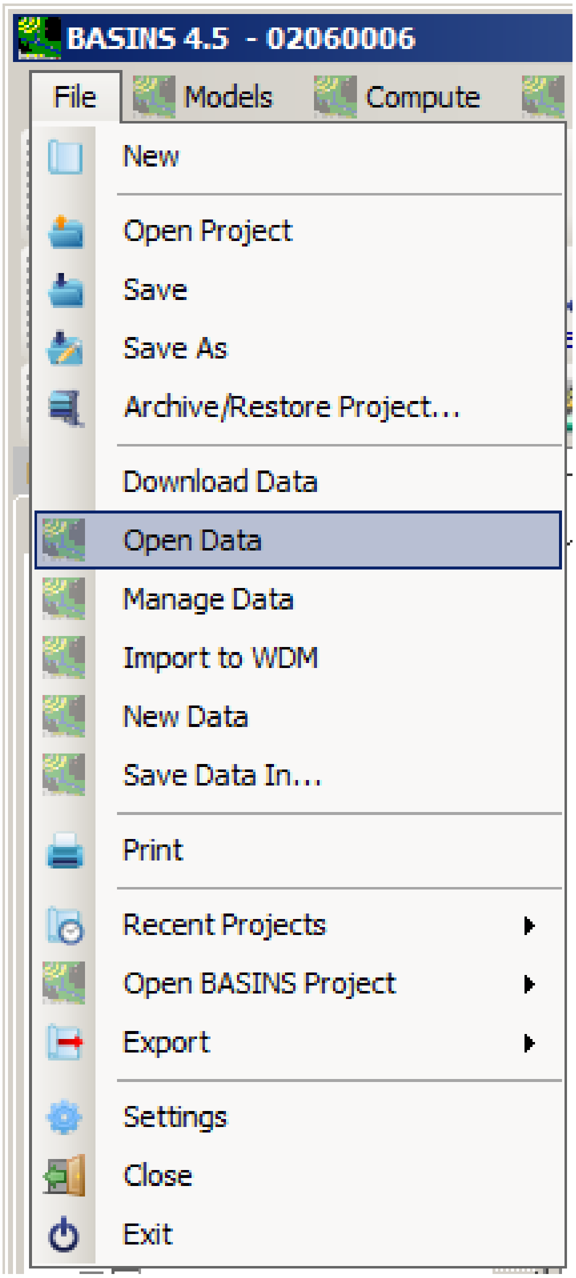
The **Compute:Statistics** option on the main BASINS menu yields the **N-day and Frequency** Option, with two choices:

- n-day high time series
- n-day low time series

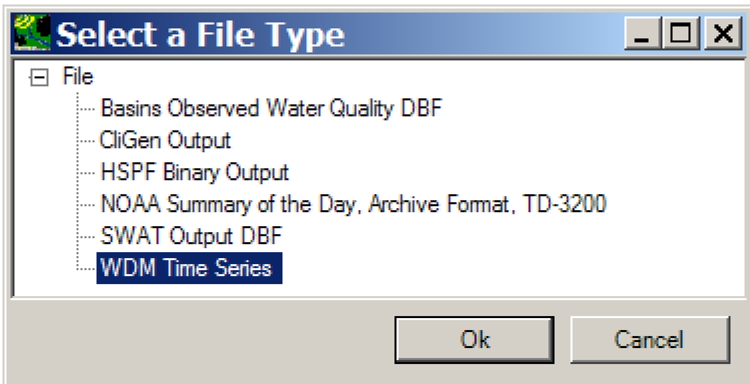


These options will produce an annual time series (based on the dates specified) with the average n-day high or low flow over the course of each year. Therefore, one value is generated for each year within the bounds of the calculation. The following example will produce a 7-day high flow over each year from October 1-September 30.

To use the **Statistics** tool, first open a *.wdm dataset using **File:Open Data**.

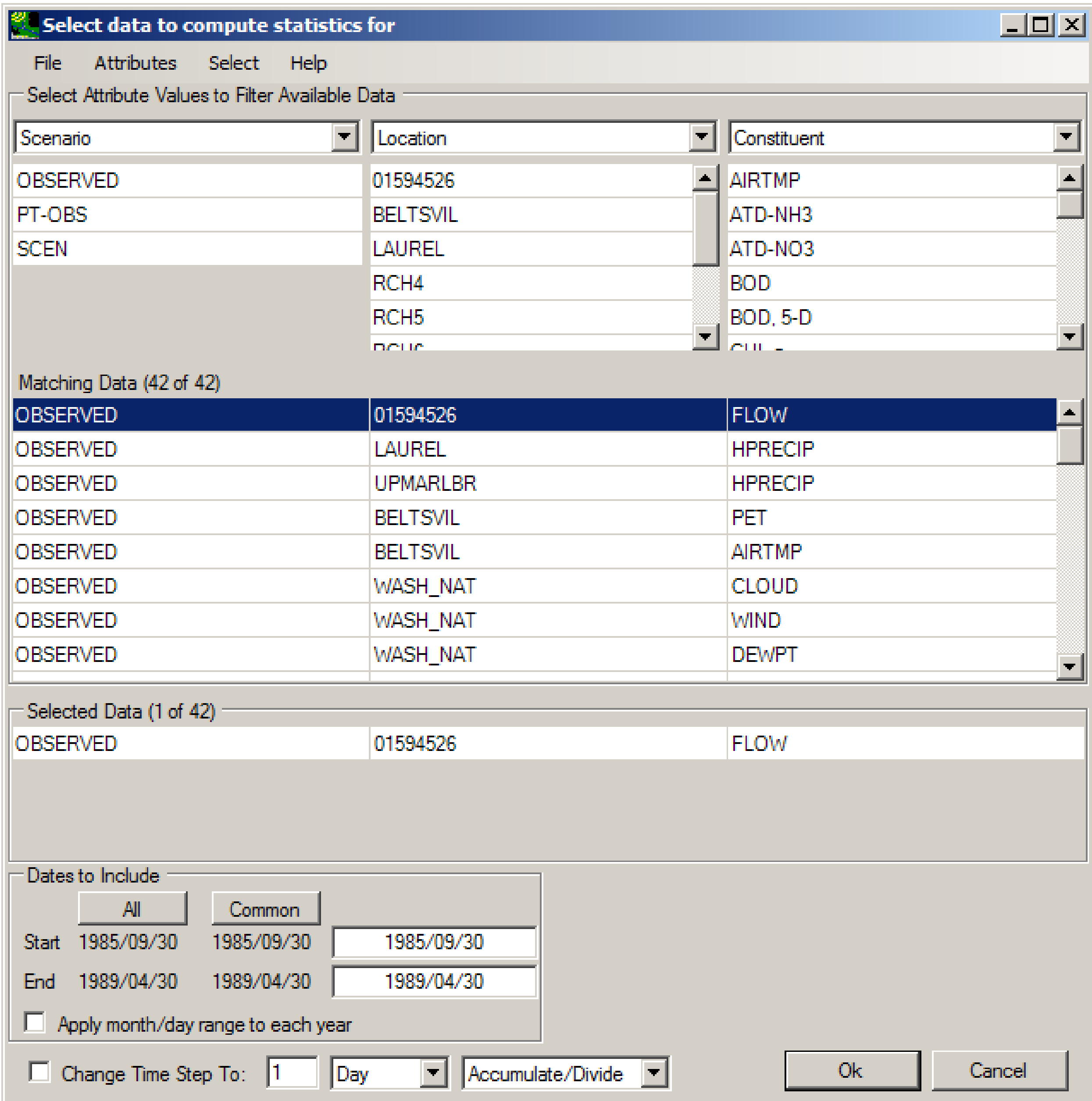


Select **WDM Time Series**, and then open Basins/data/Climate/base.wdm.

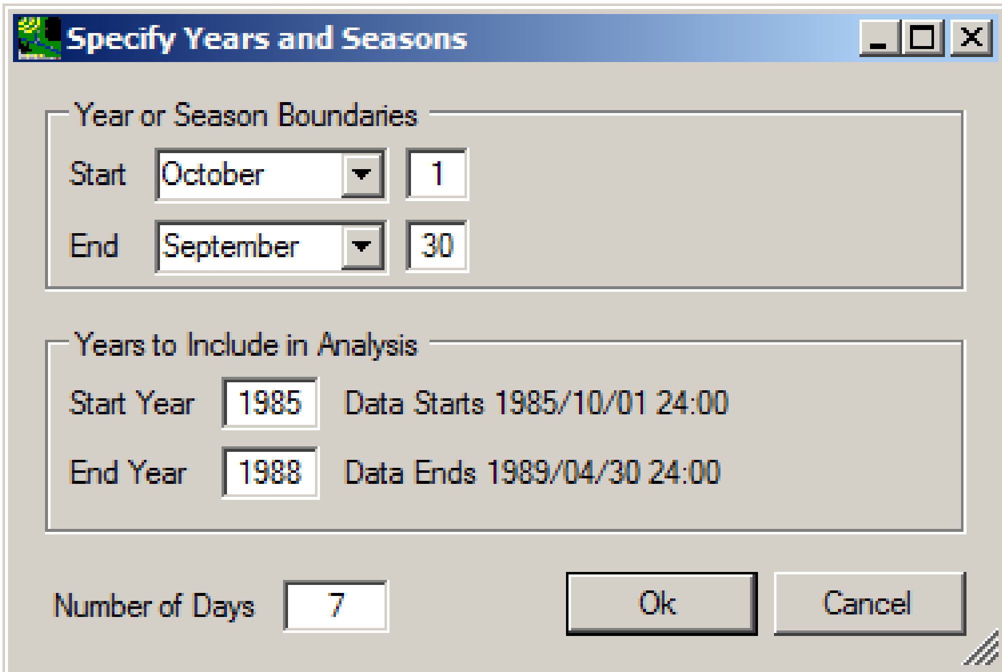


Open the **Statistics** tool from the **Compute:Statistics:N-day and frequency:n-day high timeseries** menu on the main BASINS menu.

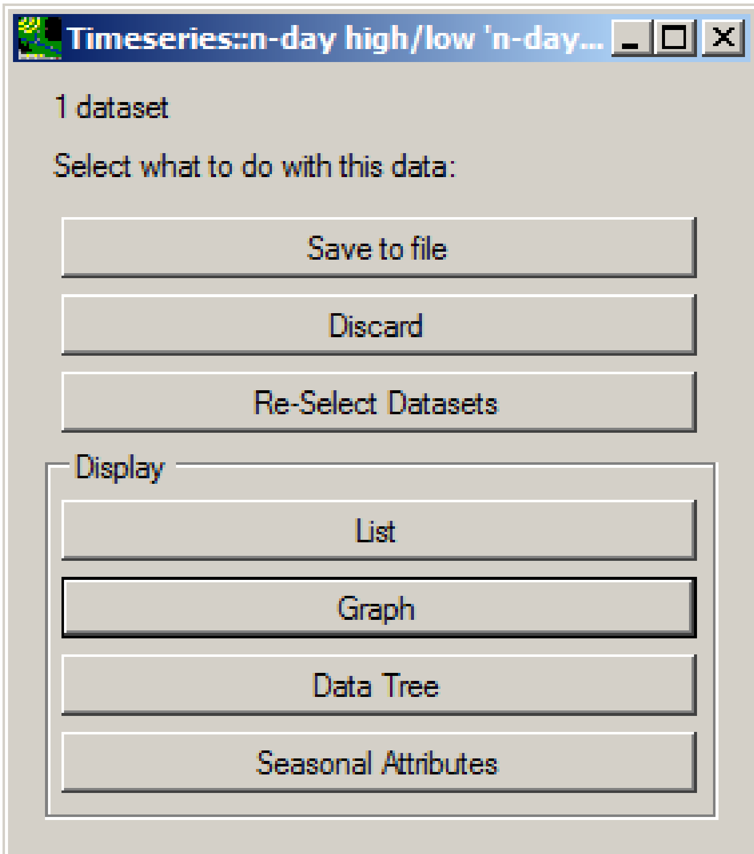
This will open the **Select data to compute statistics for** window. Select FLOW from the Constituent column and OBSERVED 01594526 from the Matching Data section. Click **Ok** at the bottom of the window.



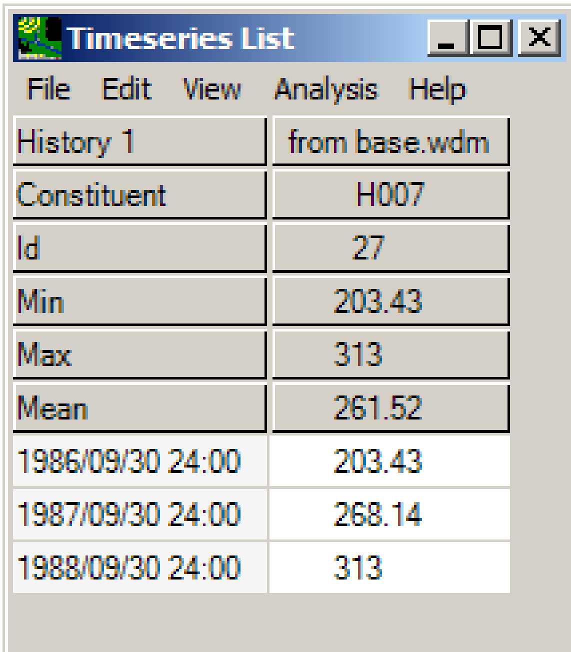
The **Specify Years and Seasons** window will appear. This gives the user the ability to determine how to define the year or season. For example, the user can choose to define "water years" that begin on October 1 and end on September 30. In this example, use the years 1985 and 1988 as the boundaries. By entering the "Number of Days" on this form, the user determines the duration of the high flow. Entering seven means the calculation will be done for the 7-day high flow period of each year. Click **Ok**.



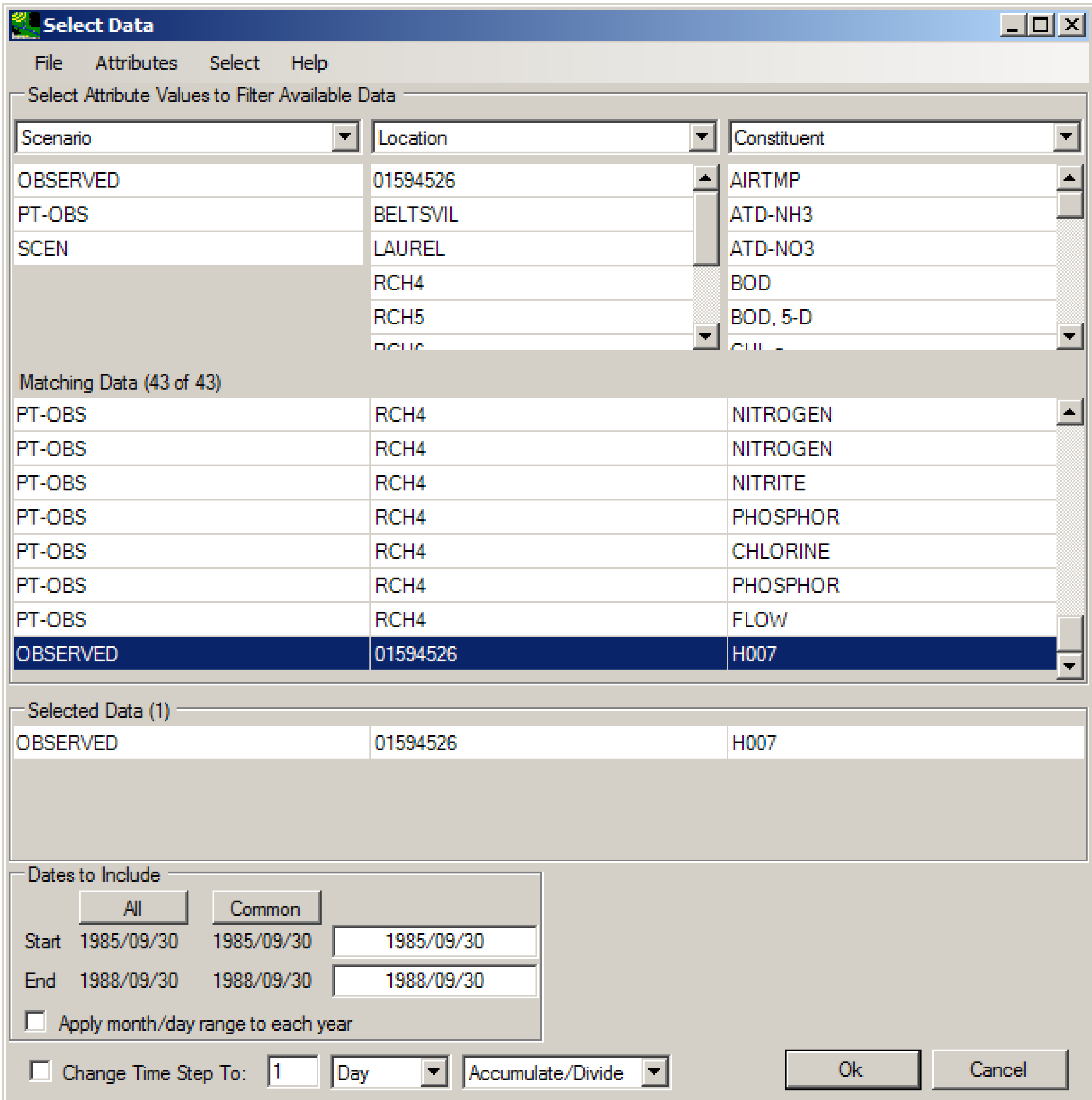
The **Timeseries::n-day high/low 'n-day high timeseries' 1 datasets** window will appear, showing at the top that "1 dataset" has been created. This window gives the user options to save or discard data or add/remove datasets. It also has options for displaying the data as a list, graph, data tree, or seasonal attribute table.



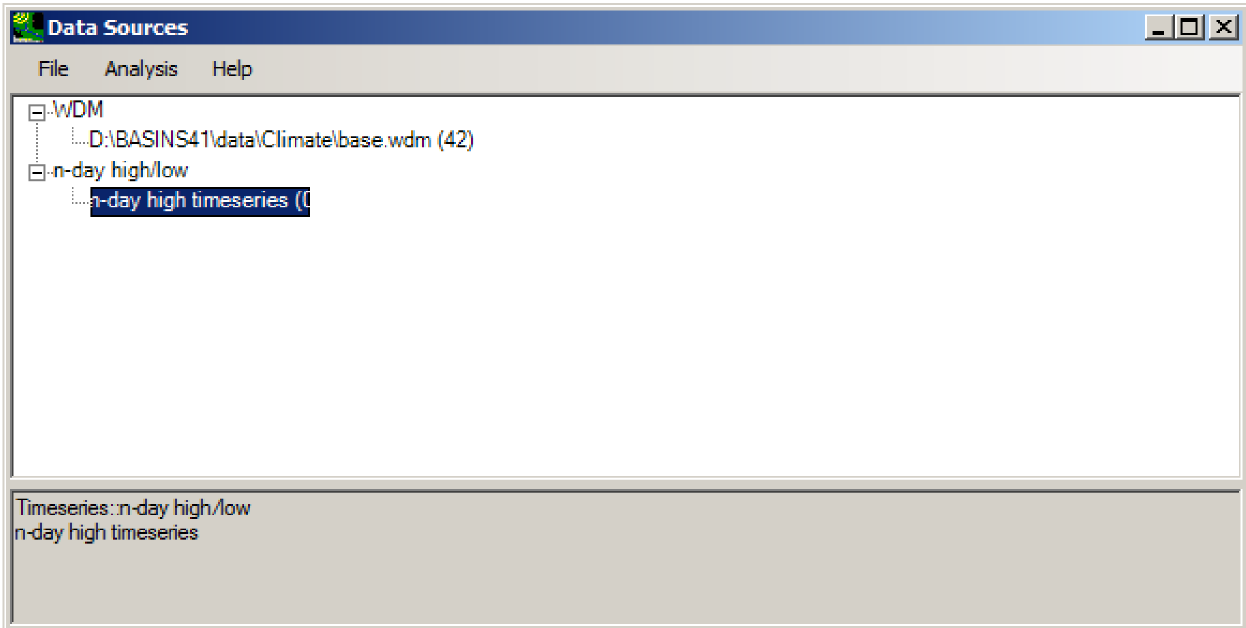
Click on the **List** display option, which will open the following window. This shows one value for each year from 1985 to 1988. Each value is the 7-day high value for FLOW.



Note: Unless the results are discarded, this newly created time series will appear when selecting data in the future. For example, there is now an OBSERVED 01594526 dataset called H007 which was added to the data list:



The user may wish to select these new results. Otherwise, to discard the newly created time series, either select "Discard" from the **Timeseries::n-day high/low** window, or go to **File:Manage Data**, click on **Timeseries::n-day high/low**, and choose **File:Close Selected**.


Data Sources
File
Analysis
Help
WDM
D:\BASINS41\data\Climate\base.wdm (42)
n-day high/low
n-day high timeseries (
Timeseries::n-day high/low
n-day high timeseries

Tutorial

This section describes a walkthrough of BASINS 4.5 that demonstrates some major features and functionality.

First, the user will build a BASINS project and populate it with BASINS core data.

Next, the procedure to download additional data will be shown.

Using data downloaded in the previous step, the user will reclassify land use into user-defined categories.

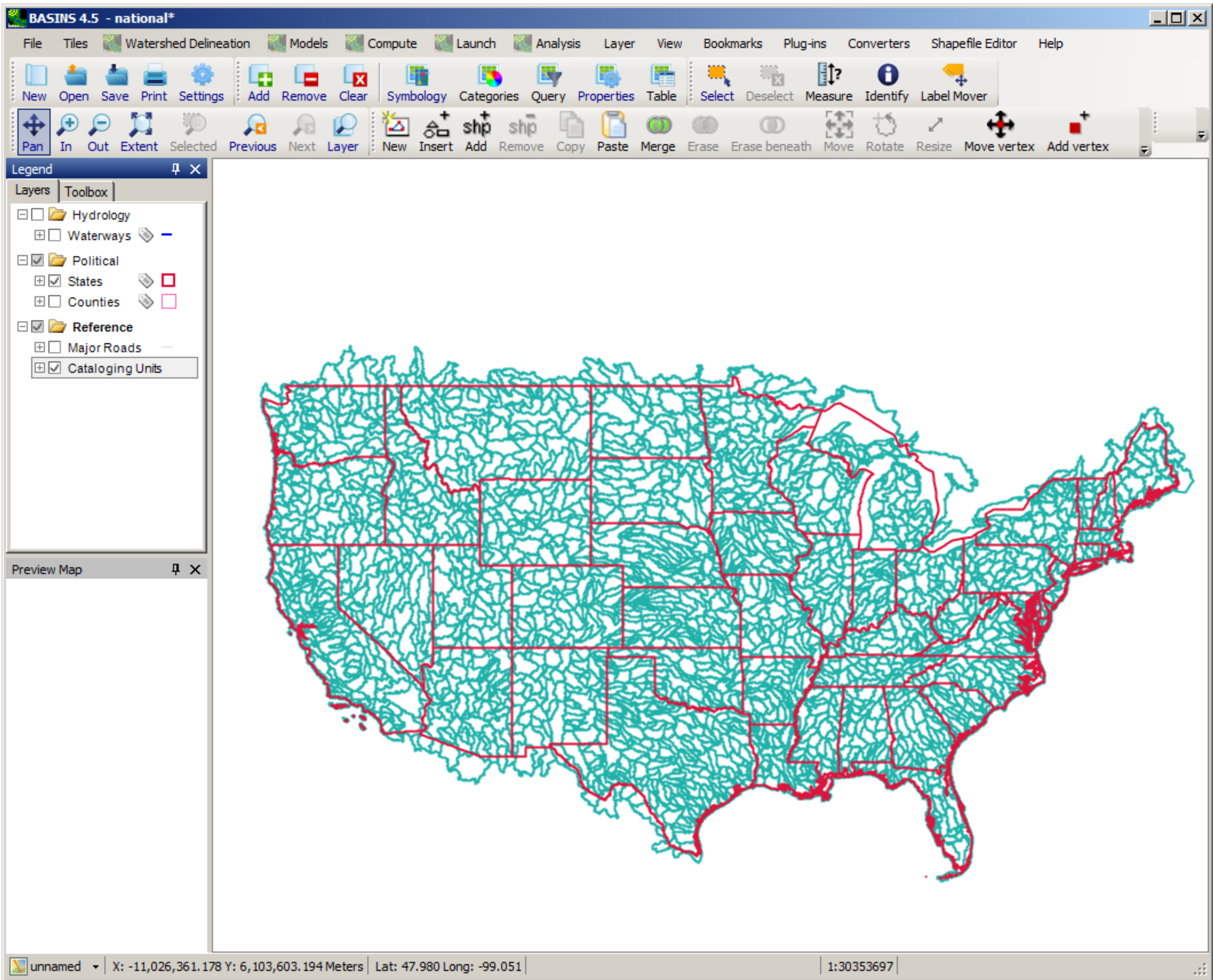
Based on the digital elevation model (DEM) layer, the automatic delineation of subwatersheds will then be completed.

Building a BASINS Project

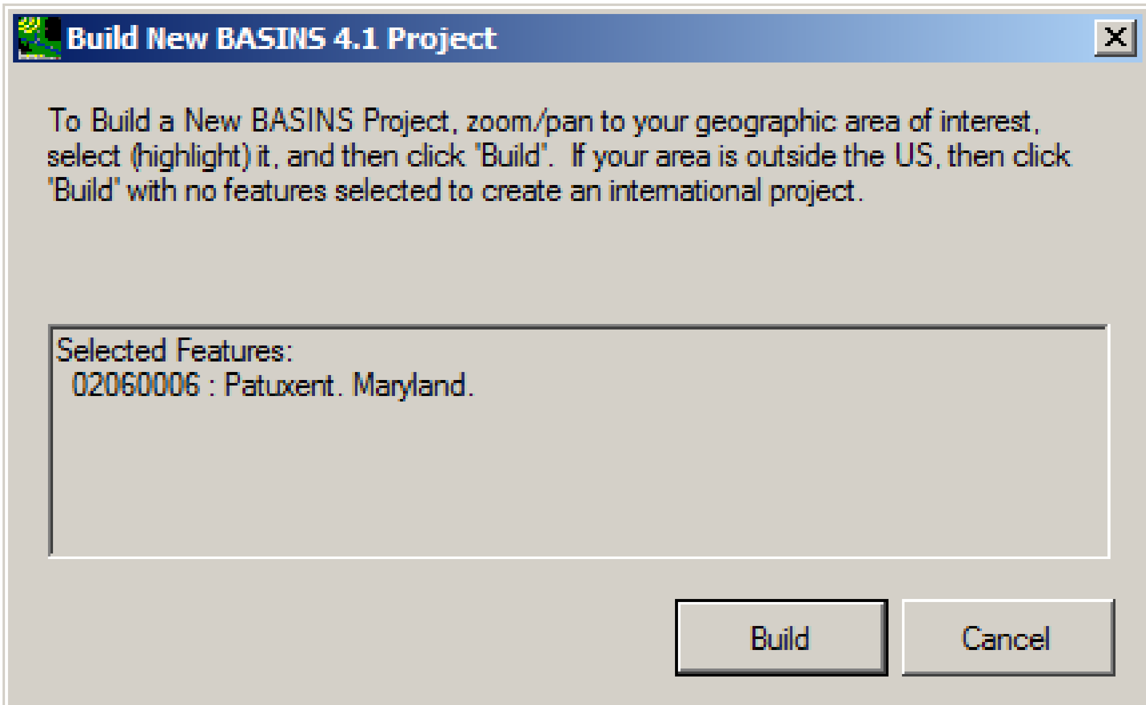
When BASINS first initializes, the following window is displayed:

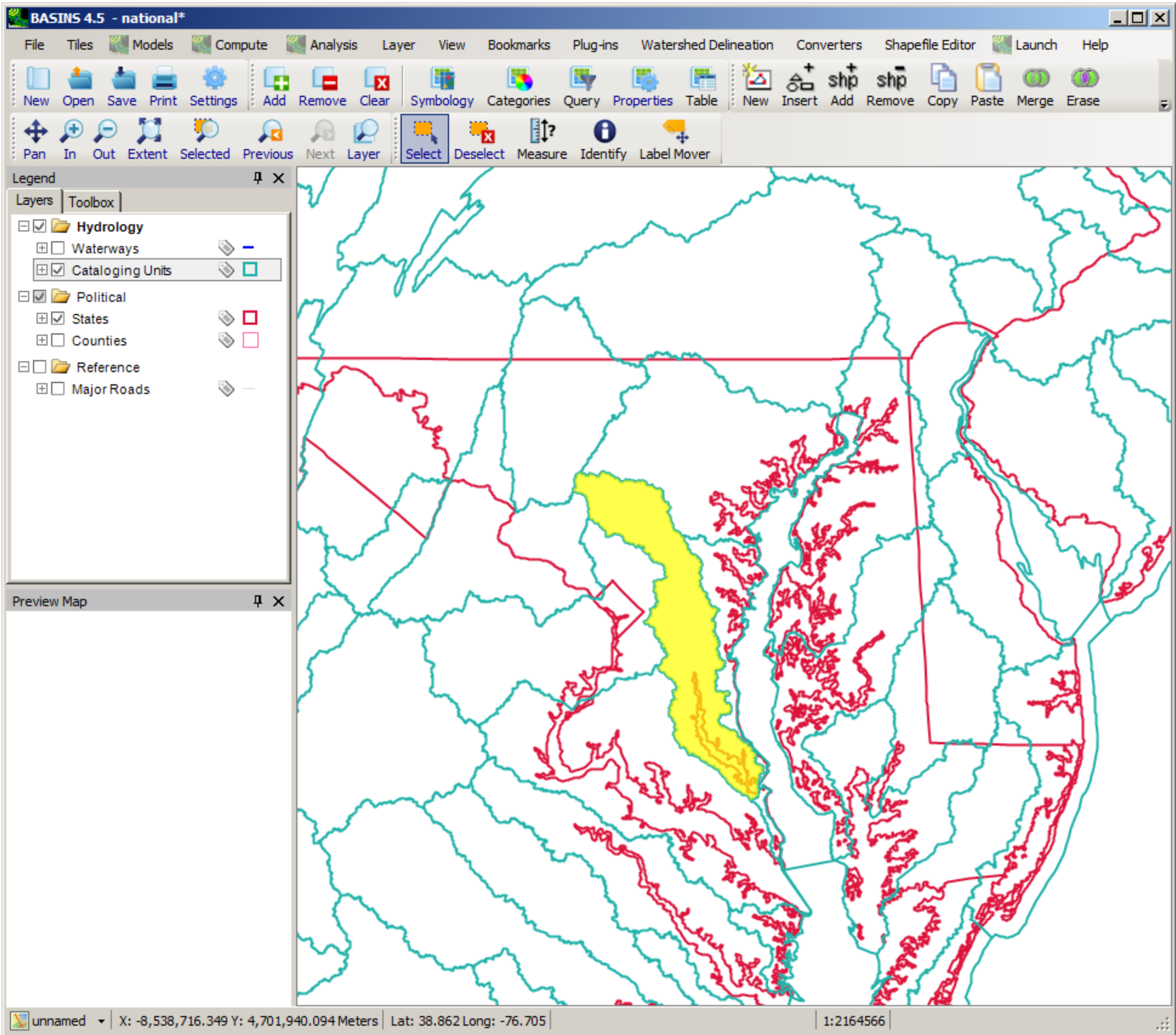
Execute the following steps to build a BASINS project and download a cache of standard data for the selected HUC-8 area.

Select **Build BASINS Project** , and a map of the United States will appear, as will the smaller **Build New BASINS 4.5 Project** window. Do not click the **Build** button on the smaller window until AFTER the HUC-8 has been selected and highlighted yellow on the main BASINS form.



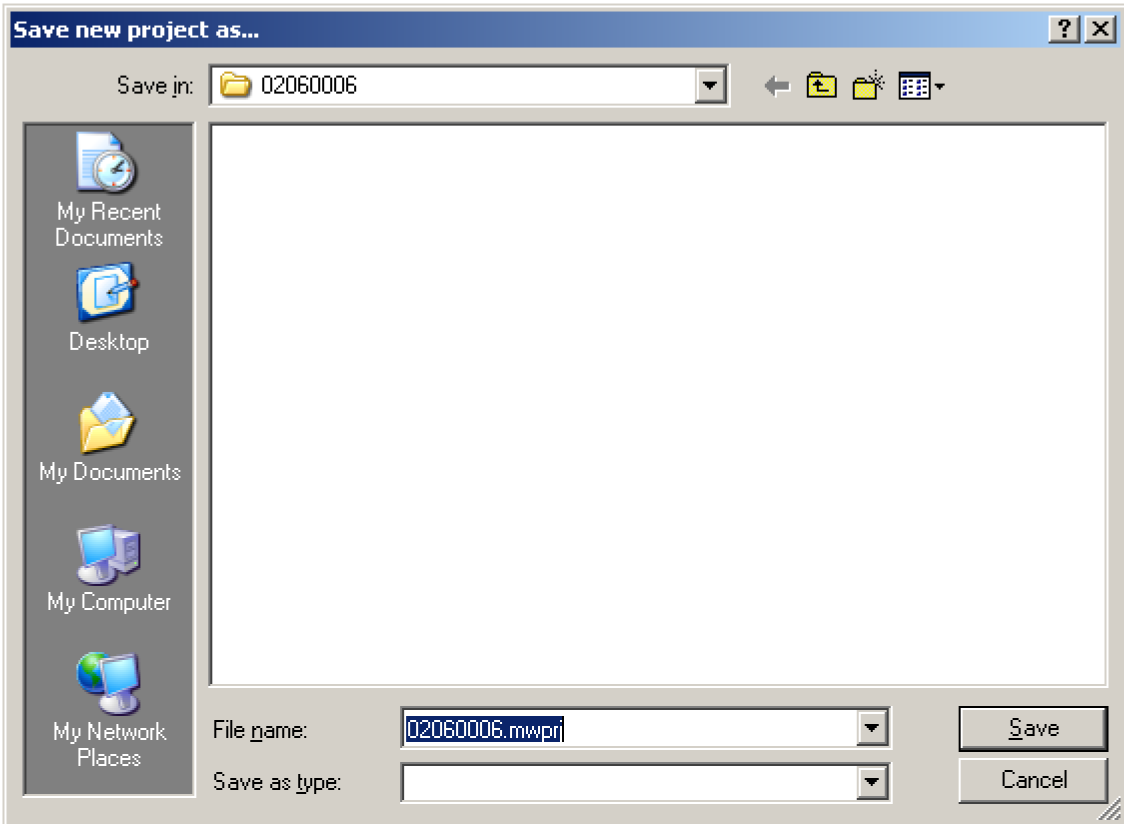
On the main form, use the MapWindow **Zoom In**  and **Pan**  tools to navigate to the Virginia/Maryland area. Then use the **Select**  tool to select the Patuxent Watershed (02060006), which should then be highlighted yellow. To see which watershed has been selected, check the **Build New Basins Project** window.


Build New BASINS 4.1 Project
To Build a New BASINS Project, zoom/pan to your geographic area of interest, select (highlight) it, and then click "Build". If your area is outside the US, then click "Build" with no features selected to create an international project.
Selected Features:
02060006 : Patuxent. Maryland.
Build
Cancel

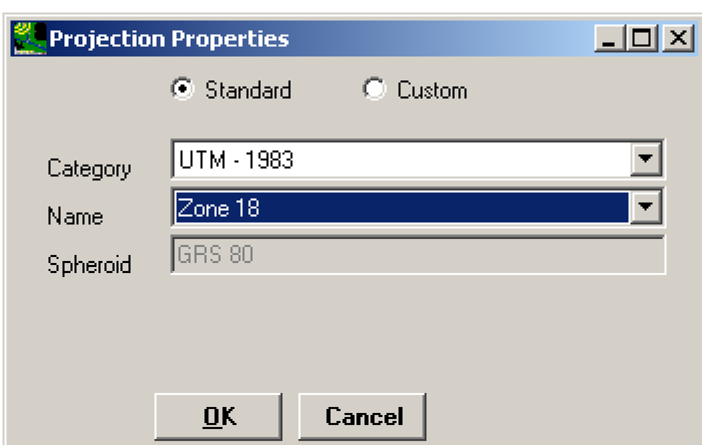


Click the **Build** button on the **Build New BASINS 4.5 Project** window.

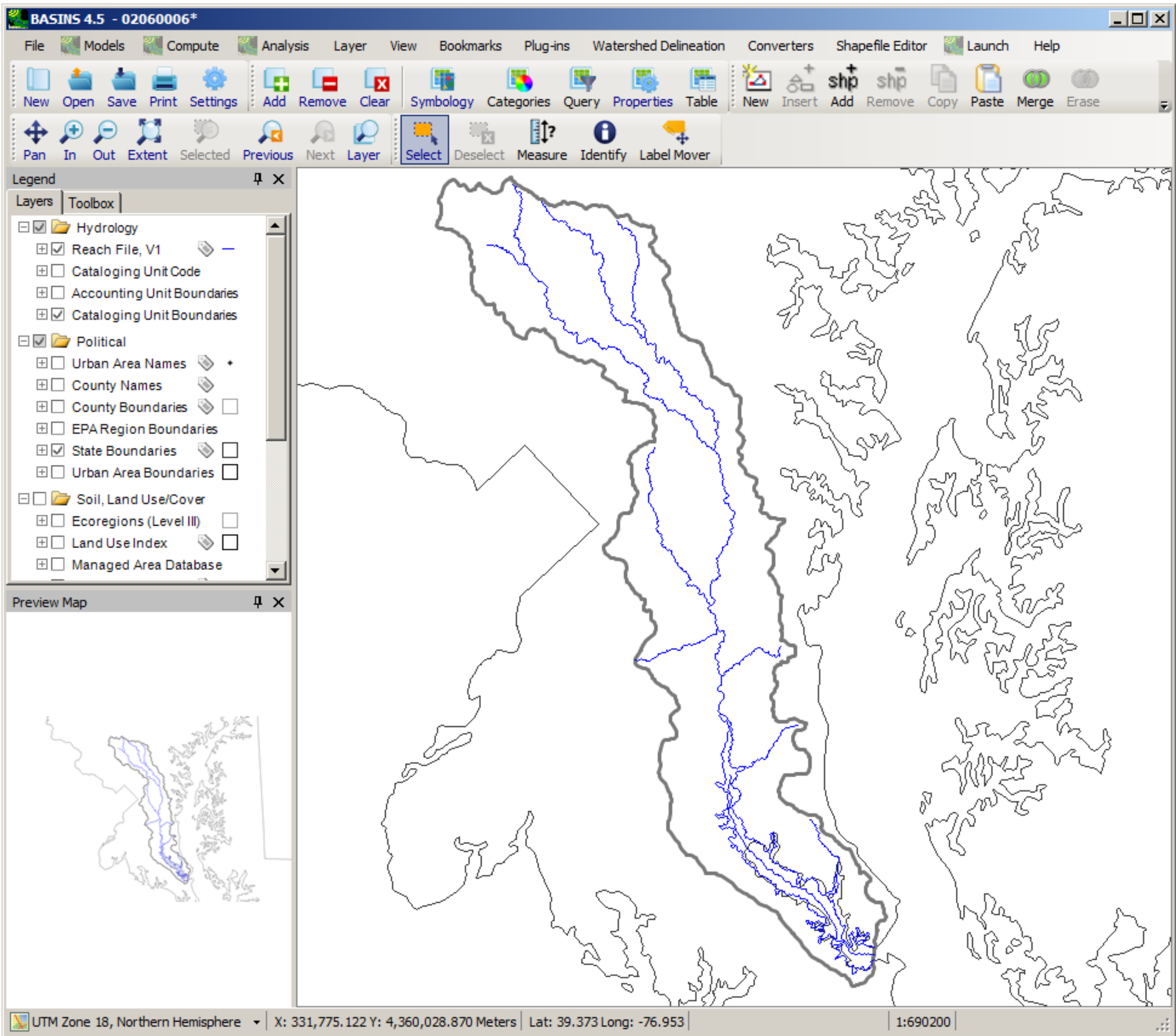
A new folder named after the HUC-8 code will be created in the '\BASINS\Data\' directory, and you will be prompted to name the BASINS 4.5 project file. Stick with the HUC-8 code for this as well by clicking **Save** on the **Save new project as** window. If you have already saved a project with that name, you will be prompted to name the project by the HUC-8 code followed by a dash 1 (for example, 02060006-1).



You will be prompted to provide projection properties. Any one will do, but it is essential that all layers throughout the BASINS project have the same projection. Choose **UTM-1983** and **Zone 18**. For more information about projections, see Projection or Projection Parameters.



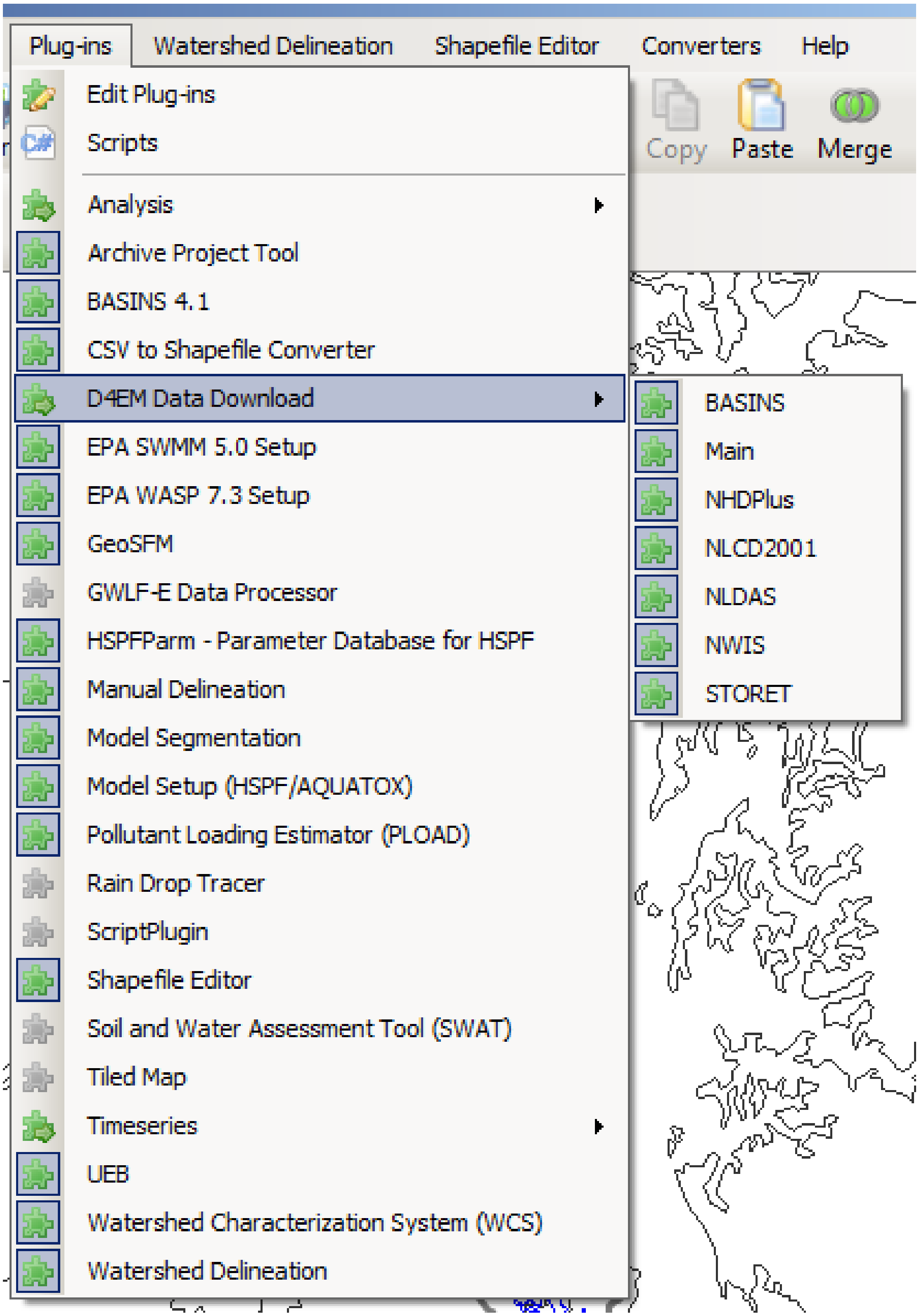
The program will take a minute to download the standard BASINS support files, then the new BASINS project will open in MapWindow. Become familiar with its layers by clicking on the checkboxes in the table of contents and observing the results on the map display.



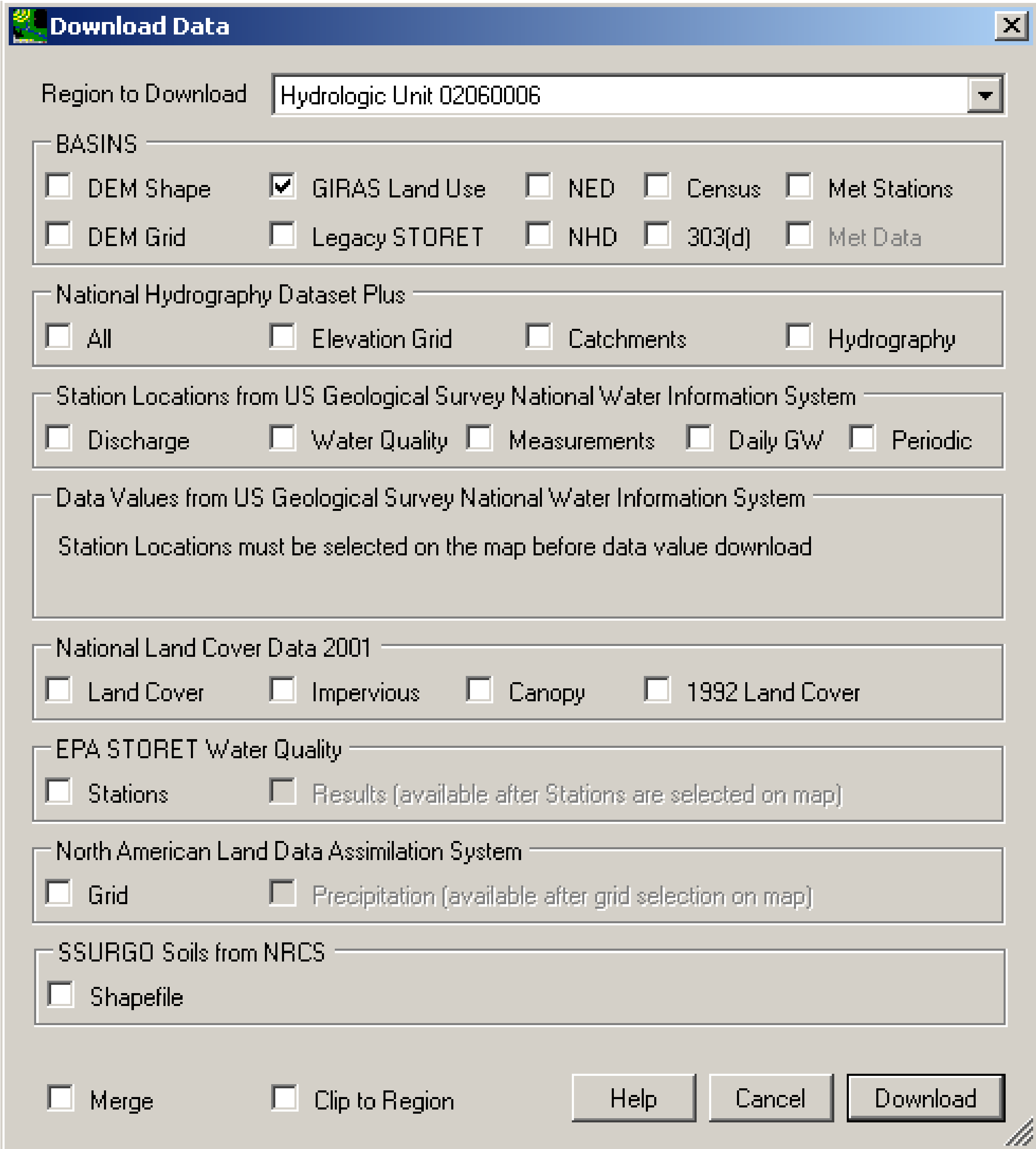
Downloading Additional Data

Significant additional data pertaining to your watershed area (beyond the standard cache downloaded in the first lesson of this tutorial) is available through the BASINS interface. Execute the following steps to download additional GIS and time-series data.

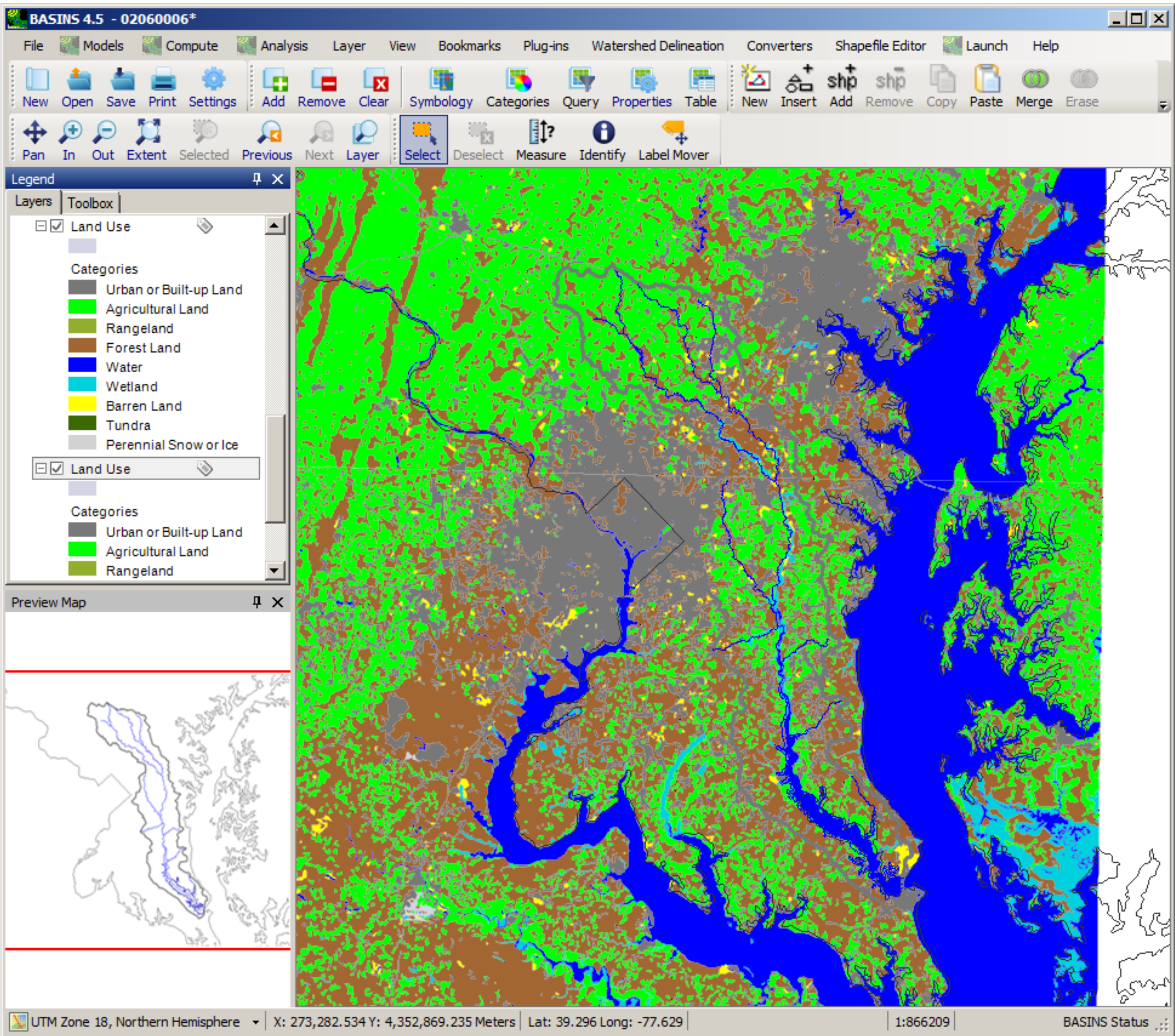
Before downloading additional data for your BASINS project, make sure the **BASINS 4.5** Plug-in is active, along with the BASINS, Main, NHDPlus, NLCD2001, and NWIS plug-ins under D4EM Data Download. The available plug-ins are listed under the **Plug-ins** menu on the main form. For later parts of this tutorial you will also want to activate the **Watershed Delineation** plug-in.


Plug-ins
Watershed Delineation
Shapefile Editor
Converters
Help
Edit Plug-ins
Scripts
Copy
Paste
Merge
Analysis
Archive Project Tool
BASINS 4.1
CSV to Shapefile Converter
D4EM Data Download
BASINS
Main
NHDPlus
NLCD2001
NLDAS
NWIS
STORET
EPA SWMM 5.0 Setup
EPA WASP 7.3 Setup
GeoSFM
GWLF-E Data Processor
HSPFParm - Parameter Database for HSPF
Manual Delineation
Model Segmentation
Model Setup (HSPF/AQUATOX)
Pollutant Loading Estimator (PLOAD)
Rain Drop Tracer
ScriptPlugin
Shapefile Editor
Soil and Water Assessment Tool (SWAT)
Tiled Map
Timeseries
UEB
Watershed Characterization System (WCS)
Watershed Delineation

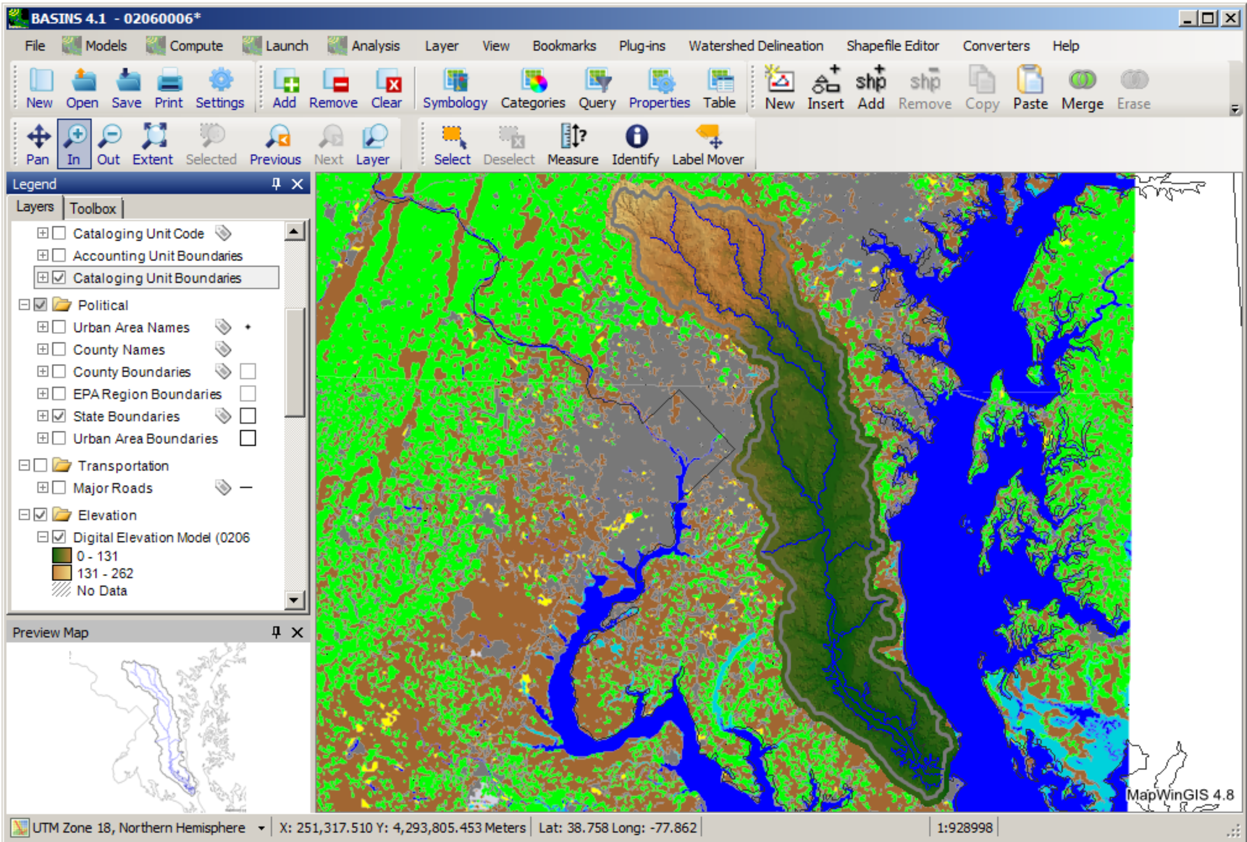
Select **File:Download Data** from the main menu, and the **Download Data** form will appear. Click on the checkbox next to **GIRAS Land Use**.



Click on the **Download** button. Two GIRAS Land Use layers are downloaded in order to cover the entire Patuxent HUC-8 watershed area. These layers are automatically displayed on the main form.



Repeat the Data Download process for the **DEM Grid**. Doing so will add the DEM grid in GeoTiff format. The GIRAS landuse and DEM grid will now appear in the main window.

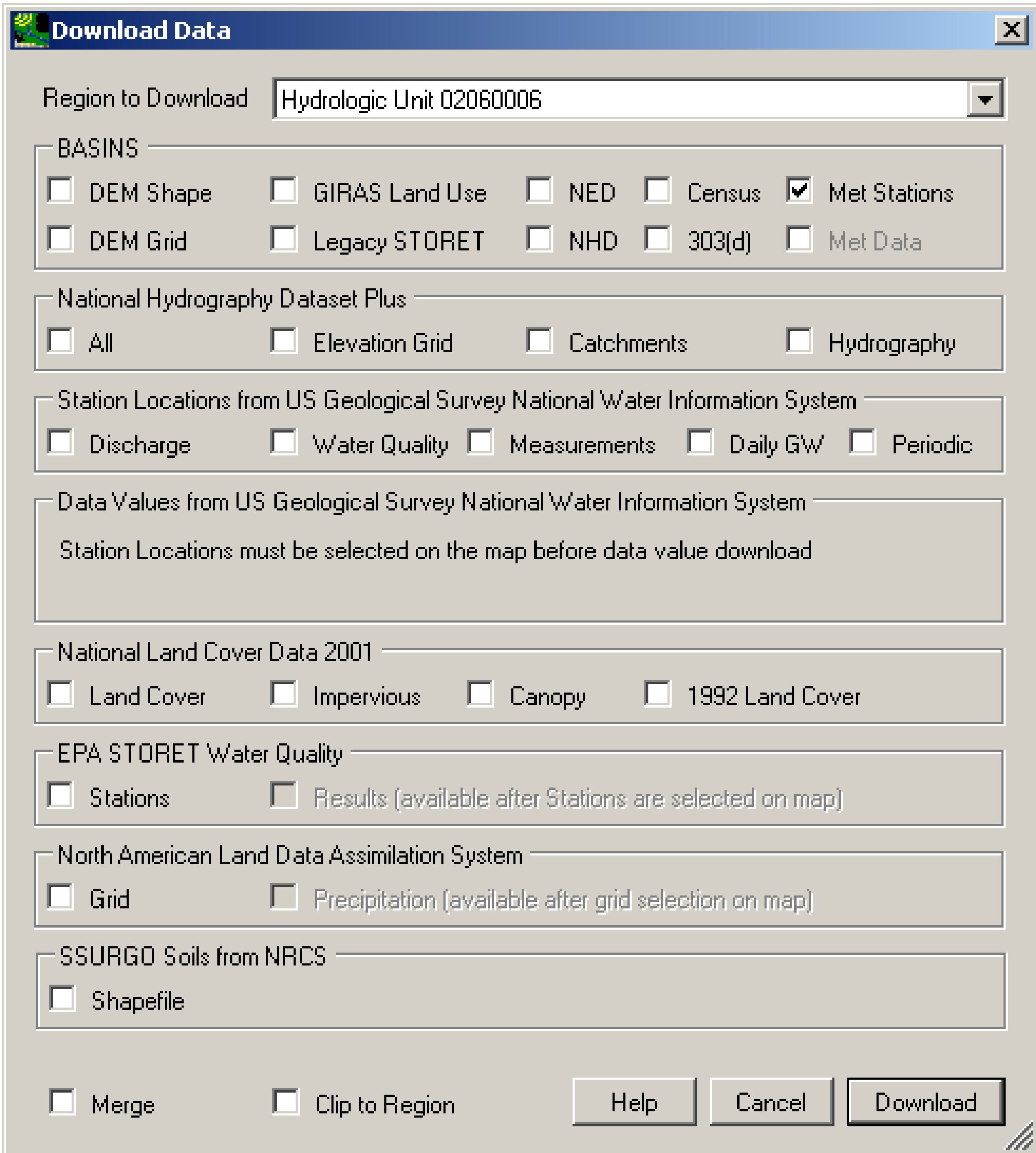


For more information about these data sets, please refer to the GIS and Time-Series Data section of the Manual.

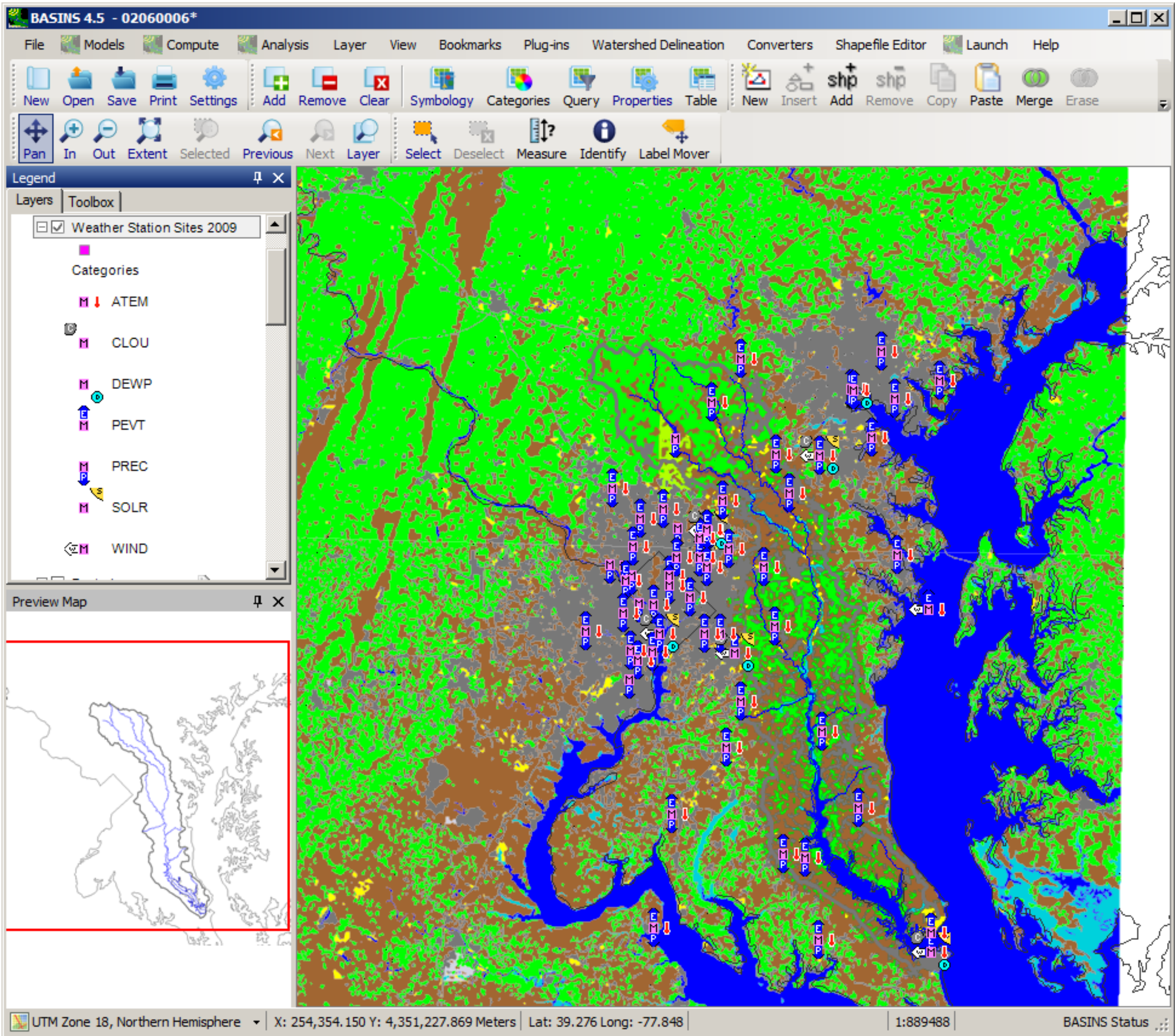
In order to help establish some points of reference in the new BASINS project, go back and download the BASINS **Census** data, which includes the TIGER line data as well. The census data will also allow you to produce the Watershed Characterization Reports based on the 1990 and 2000 data.

Next, download the BASINS **NHD** data (not the NHDPlus), since the BASINS NHD data is necessary for the Manual Delineation lesson.

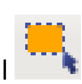
Finish the Data Download process by retrieving the BASINS **Meteorologic** data for the study area (which will be required for the Starting HSPF lesson). The BASINS Meteorological data is downloaded in two steps. First, download the Met Stations.

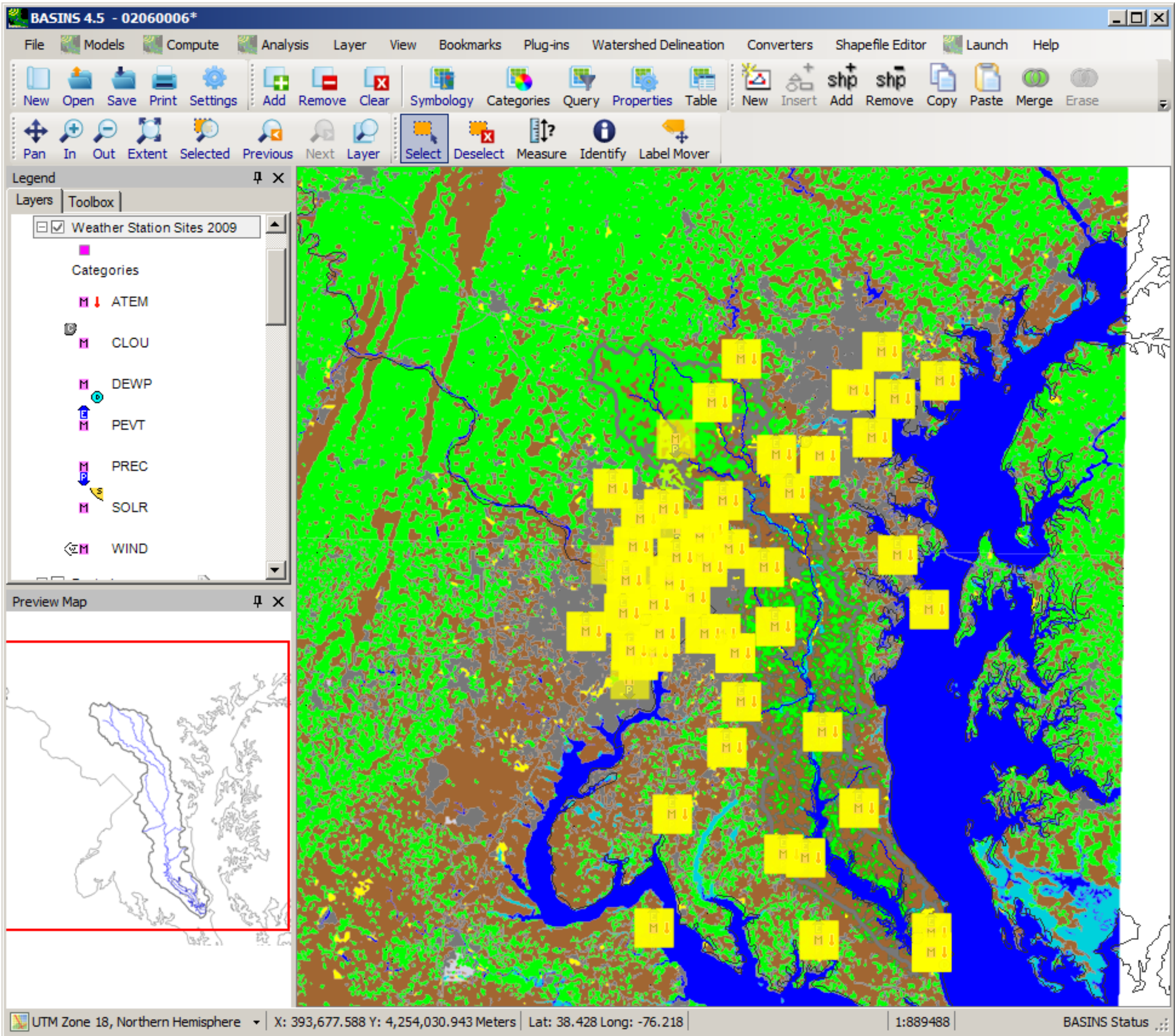


The **Weather Station Sites 2009** layer will be added to the map, with its suite of distinct icons graphically representing which constituents are available at each meteorologic station.

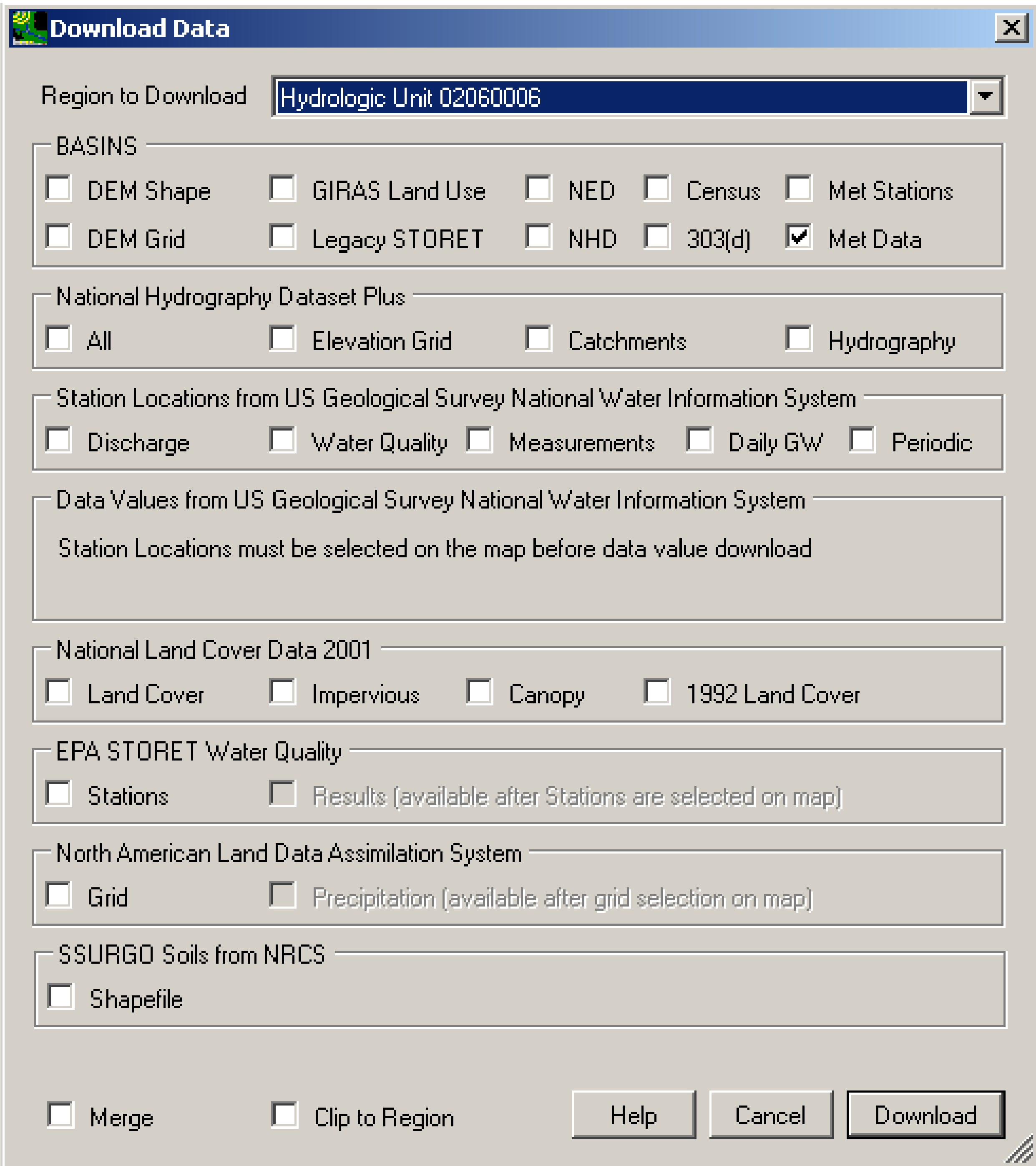


More information about the weather station icons is provided in the BASINS Data Types section of the Manual.

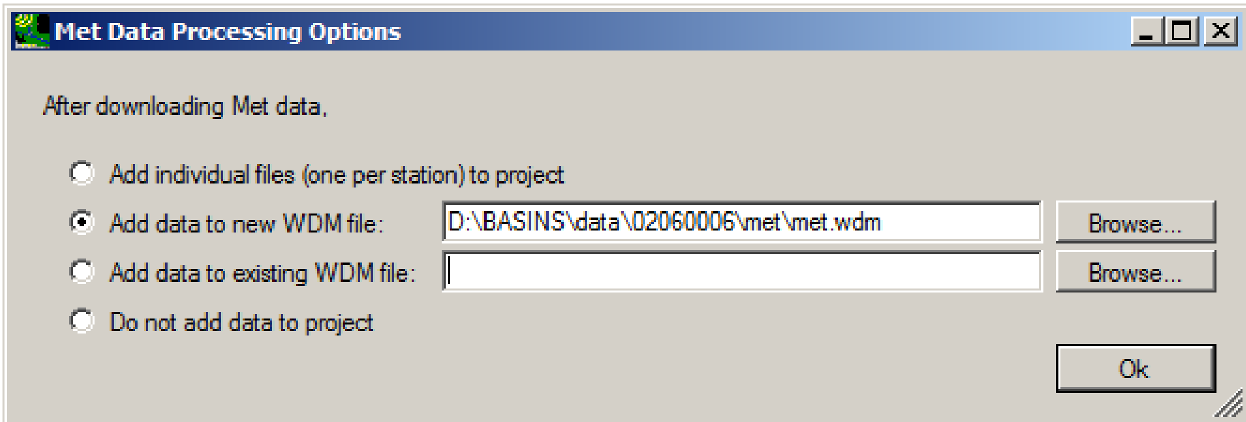
With the **Weather Station Sites 2009** layer active, use the selection tool  to draw a selection box around all the met stations on the map. The result will look like the image below.



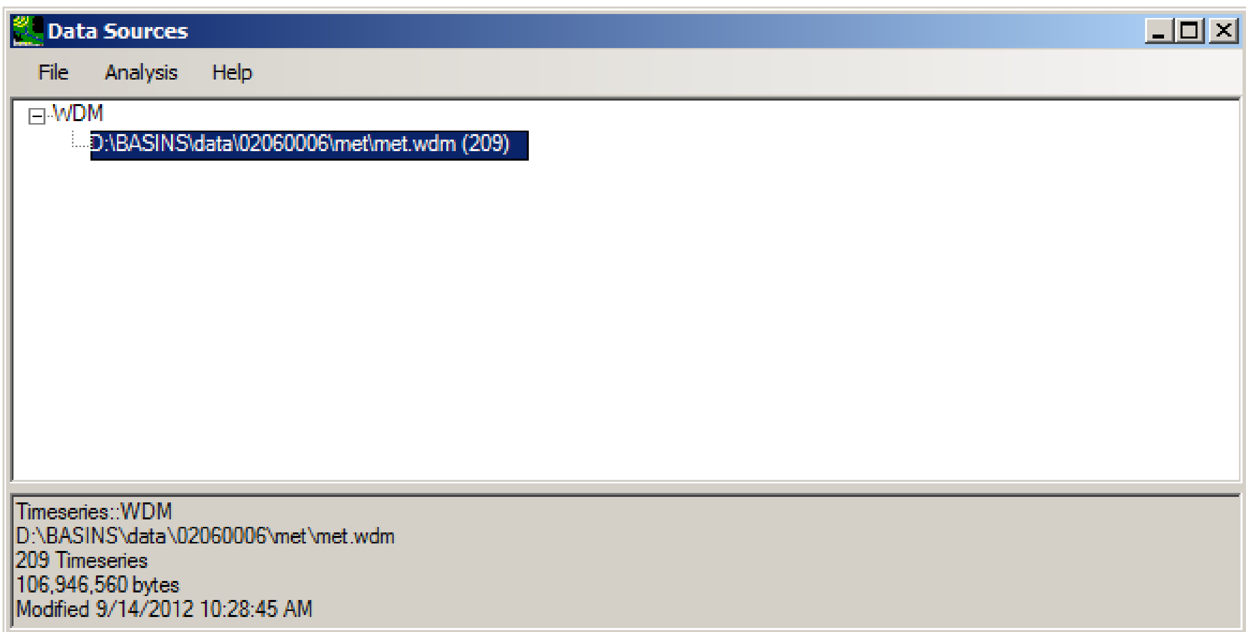
Now use the Download Data tool to download the Met Data for the selected stations.



When the download is complete, the user is prompted for a location to save the Met Data. Accept the default location.



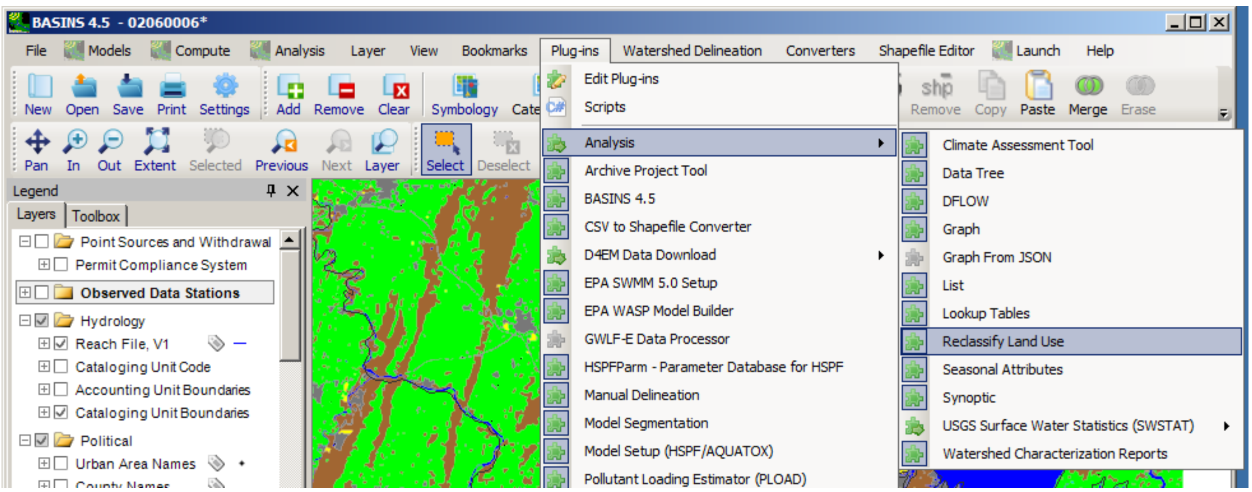
The Data Sources window is displayed, showing that the Met Data has now been added to the BASINS project. Close this window, and save the BASINS project (using the **File:Save menu** option).



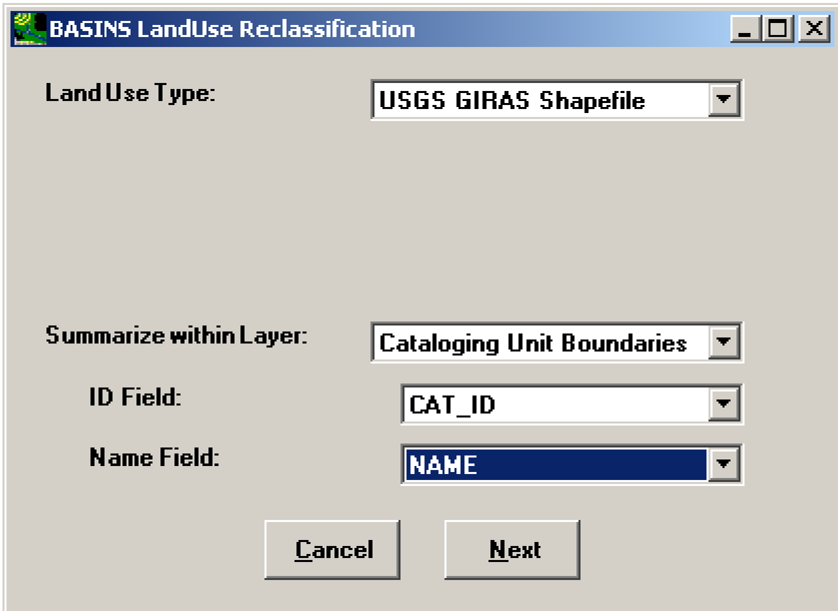
Reclassifying Land Use

The GIRAS Land Use layer downloaded in the previous lesson (Downloading Additional Data) contains 20 categories of land use within the Patuxent watershed. You may wish to group certain categories together (e.g., Deciduous, Evergreen, and Mixed Forest land into simply Forest) or break one category out into multiple (e.g., Residential into Low Density and High Density). Execute the following steps to reclassify the GIRAS Land Use layer into customized categories.

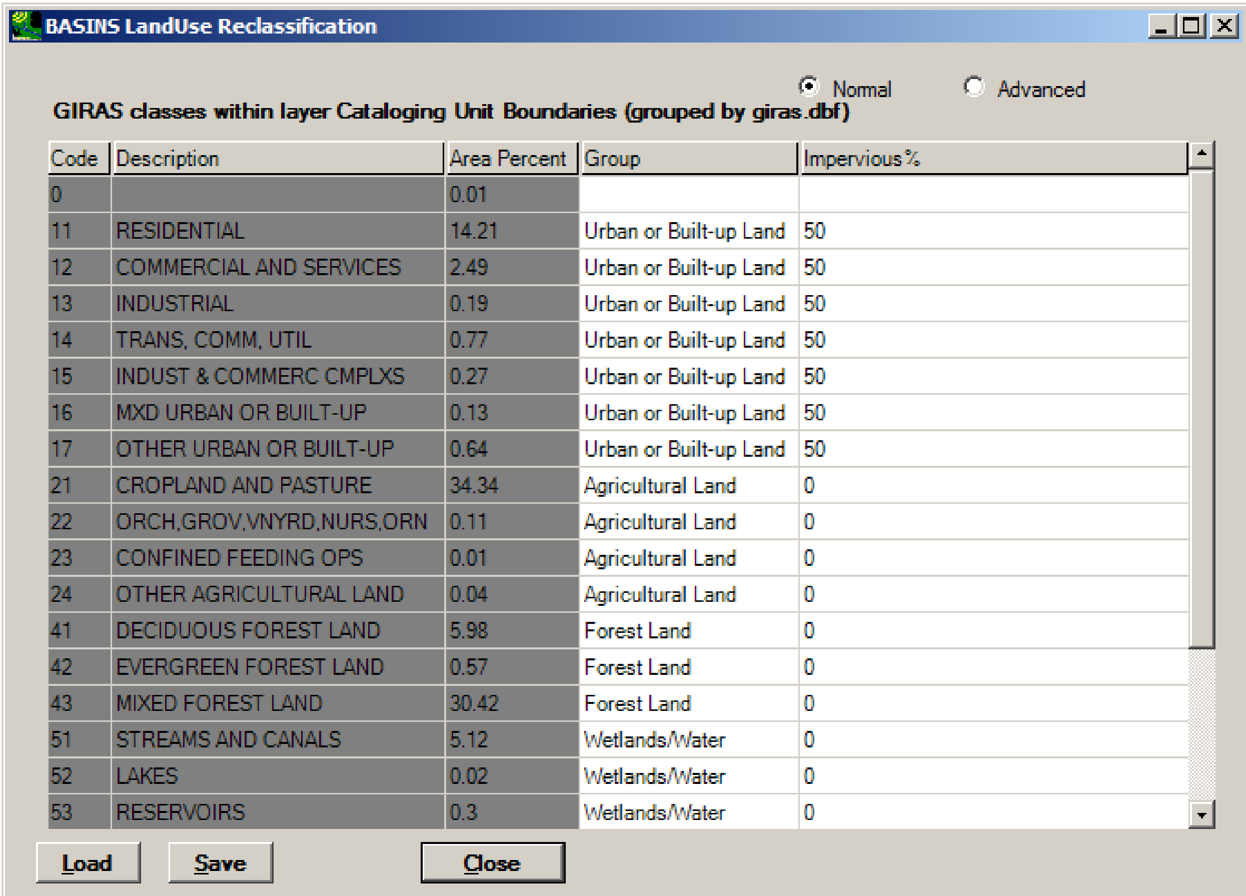
Select **Reclassify Land Use** from the **Plug-ins:Analysis** submenu so that it is active. This will add **Reclassify Land Use** to the **Analysis** menu.



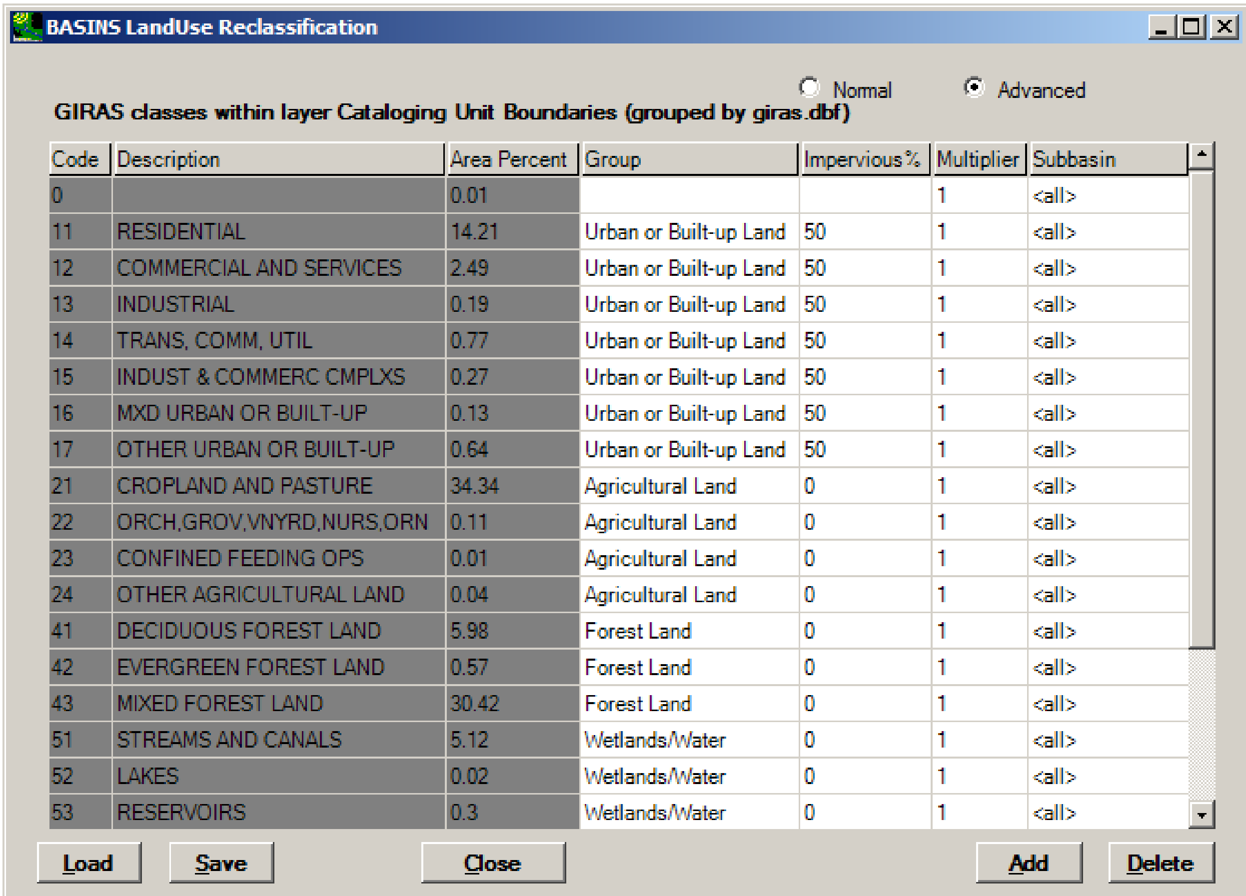
Select **Analysis:Reclassify Land Use** , and the **BASINS LandUse Reclassification** form will appear.



Make the selections from the four pull-down menus indicated on the above form, and then click the **Next** button. After a bit of processing, the BASINS LandUse Reclassification form will update to display a chart of the GIRAS landuse distribution and a proposed aggregation scheme. Shaded columns contain the input data, while the aggregation parameters are defined in the columns with white background.

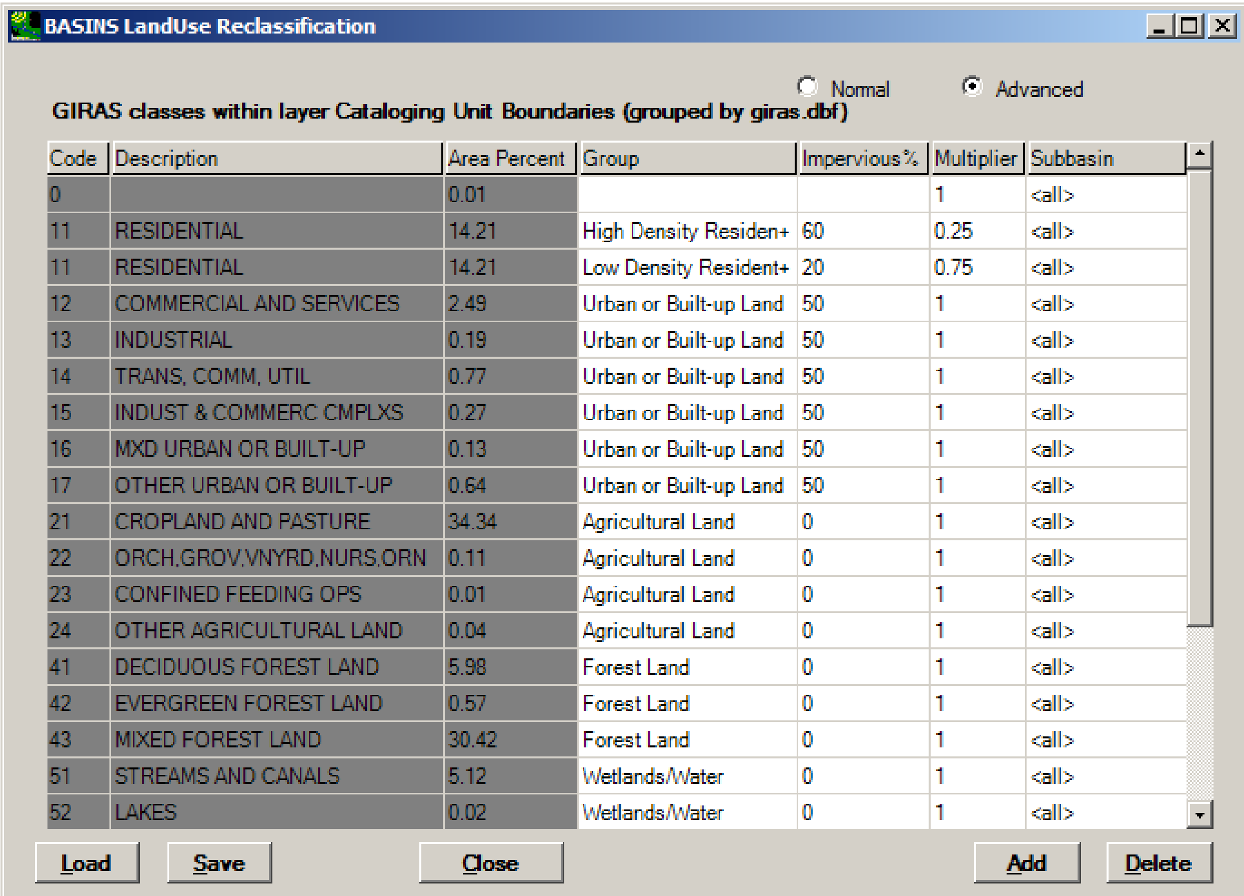


Click the **Advanced** button on the top right of the form, and two new columns will appear on the right side of the grid, **Multiplier** and **Subbasin**.



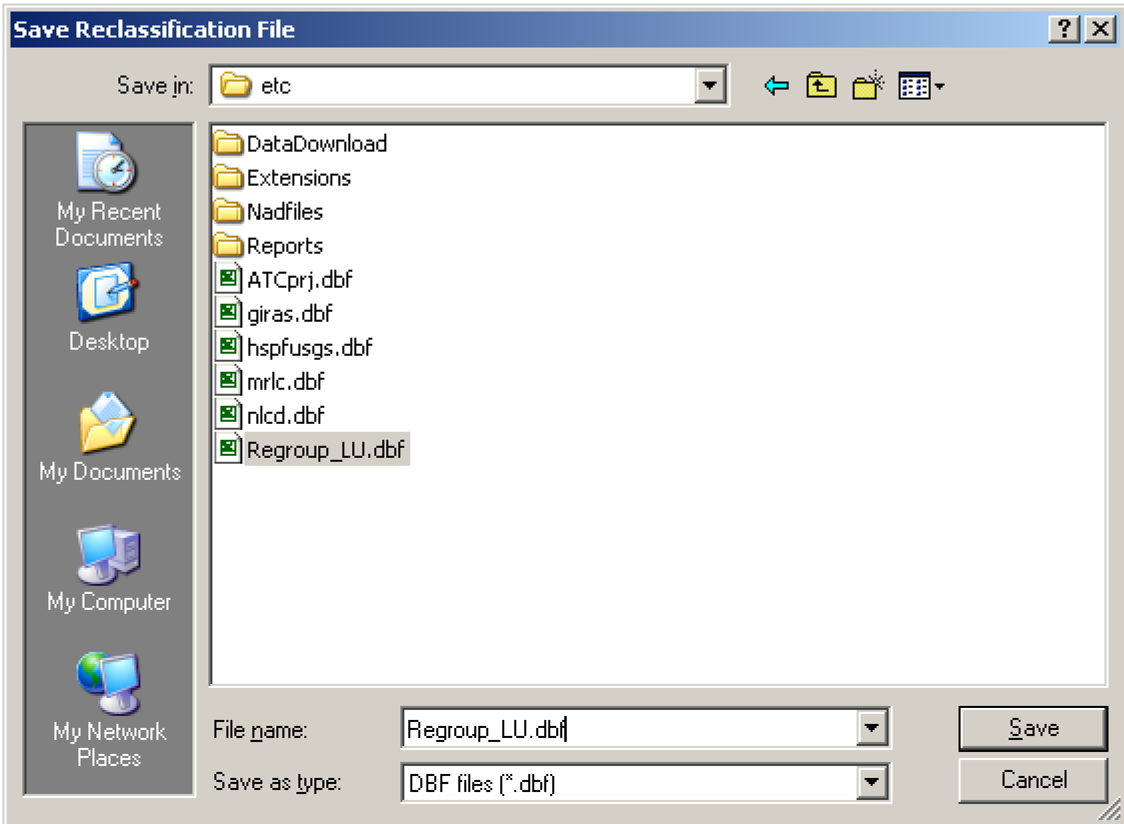
Code	Description	Area Percent	Group	Impervious %	Multiplier	Subbasin
0		0.01			1	<all>
11	RESIDENTIAL	14.21	Urban or Built-up Land	50	1	<all>
12	COMMERCIAL AND SERVICES	2.49	Urban or Built-up Land	50	1	<all>
13	INDUSTRIAL	0.19	Urban or Built-up Land	50	1	<all>
14	TRANS, COMM, UTIL	0.77	Urban or Built-up Land	50	1	<all>
15	INDUST & COMMERC CMPLXS	0.27	Urban or Built-up Land	50	1	<all>
16	MXD URBAN OR BUILT-UP	0.13	Urban or Built-up Land	50	1	<all>
17	OTHER URBAN OR BUILT-UP	0.64	Urban or Built-up Land	50	1	<all>
21	CROPLAND AND PASTURE	34.34	Agricultural Land	0	1	<all>
22	ORCH,GROV,VNYRD,NURS,ORN	0.11	Agricultural Land	0	1	<all>
23	CONFINED FEEDING OPS	0.01	Agricultural Land	0	1	<all>
24	OTHER AGRICULTURAL LAND	0.04	Agricultural Land	0	1	<all>
41	DECIDUOUS FOREST LAND	5.98	Forest Land	0	1	<all>
42	EVERGREEN FOREST LAND	0.57	Forest Land	0	1	<all>
43	MIXED FOREST LAND	30.42	Forest Land	0	1	<all>
51	STREAMS AND CANALS	5.12	Wetlands/Water	0	1	<all>
52	LAKES	0.02	Wetlands/Water	0	1	<all>
53	RESERVOIRS	0.3	Wetlands/Water	0	1	<all>

Select any cell on the 'RESIDENTIAL' row then click the **Add** button, and an identical row will be inserted below the original. Divide 'RESIDENTIAL' into 'High Density Residential' (60% impervious and 25% of the original RESIDENTIAL land area) and 'Low Density Residential' (20% impervious and 75% of the original RESIDENTIAL land area) as shown on the following form. It is important that the multipliers sum to 1.0 so that land area is neither created nor lost. If desired, the reclassification scheme could be limited to certain subbasins within the watershed area by entering those ID's in the Subbasin column. If you would rather apply the scheme to the entire watershed, leave the subbasin column cells showing <all> so that the scheme is applied to the entire watershed.



Code	Description	Area Percent	Group	Impervious %	Multiplier	Subbasin
0		0.01			1	<all>
11	RESIDENTIAL	14.21	High Density Residen+	60	0.25	<all>
11	RESIDENTIAL	14.21	Low Density Resident+	20	0.75	<all>
12	COMMERCIAL AND SERVICES	2.49	Urban or Built-up Land	50	1	<all>
13	INDUSTRIAL	0.19	Urban or Built-up Land	50	1	<all>
14	TRANS, COMM, UTIL	0.77	Urban or Built-up Land	50	1	<all>
15	INDUST & COMMERC CMPLXS	0.27	Urban or Built-up Land	50	1	<all>
16	MXD URBAN OR BUILT-UP	0.13	Urban or Built-up Land	50	1	<all>
17	OTHER URBAN OR BUILT-UP	0.64	Urban or Built-up Land	50	1	<all>
21	CROPLAND AND PASTURE	34.34	Agricultural Land	0	1	<all>
22	ORCH,GROV,VNYRD,NURS,ORN	0.11	Agricultural Land	0	1	<all>
23	CONFINED FEEDING OPS	0.01	Agricultural Land	0	1	<all>
24	OTHER AGRICULTURAL LAND	0.04	Agricultural Land	0	1	<all>
41	DECIDUOUS FOREST LAND	5.98	Forest Land	0	1	<all>
42	EVERGREEN FOREST LAND	0.57	Forest Land	0	1	<all>
43	MIXED FOREST LAND	30.42	Forest Land	0	1	<all>
51	STREAMS AND CANALS	5.12	Wetlands/Water	0	1	<all>
52	LAKES	0.02	Wetlands/Water	0	1	<all>

Click the **Save** button to save the current land use aggregation/division scheme to a DBF file, which can be used later to quantify pervious and impervious drainage areas in support of nonpoint source modeling. Store the new file in the '\BASINS\etc\' directory along with the default 'giras.dbf' file.



Click the **Close** button and return to the main form.

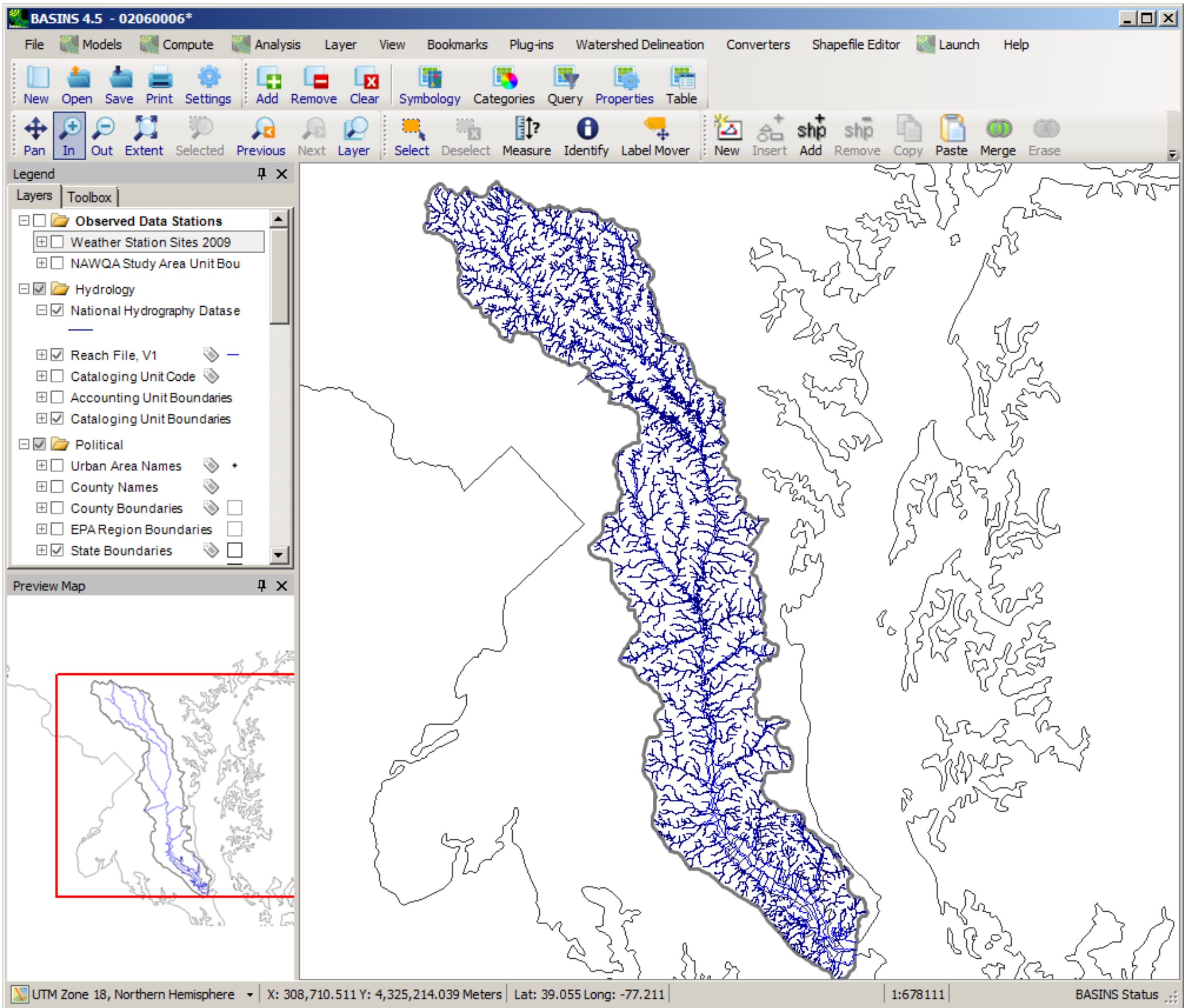
Manual Delineation

The Manual Watershed Delineation tool allows you to divide a watershed into two or more hydrologically connected subwatersheds. This is useful in watershed characterization and modeling. The tool provides you with flexibility in editing shapes and attributes of manually delineated watersheds and outlets, and in generating stream networks.

The Manual Watershed Delineation tool allows you to define and create a boundary around the entire land area contributing to flow in a stream. Watersheds can be delineated based on Reach File, V1; NHD; or user-defined blue lines, depending on which reach data will be used for modeling. Analysis can be performed on delineated watersheds using the BASINS Watershed Characterization Report tools. Modeling can be performed on one or more delineated watersheds using a watershed model such as *HSPF*.

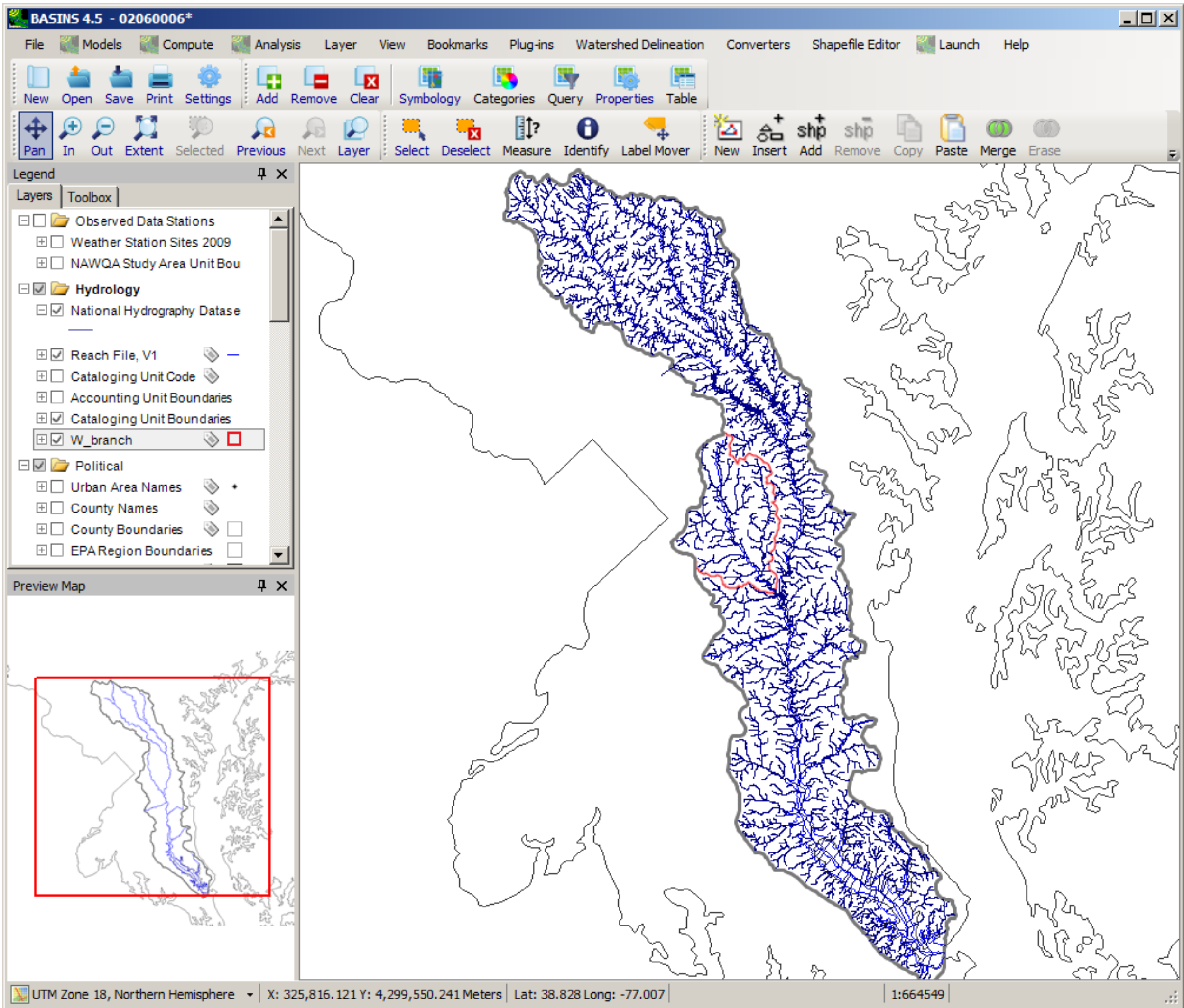
Execute the following steps to subdivide a HUC-8 into multiple subwatersheds using the Manual Watershed Delineation tool of BASINS 4.5.

To get started with this tutorial, make sure you have the BASINS DEMG and NHD data loaded into your project. Only the layers for NHD, Cataloging Units, and State Boundaries should be active. Your project should look like the one below.



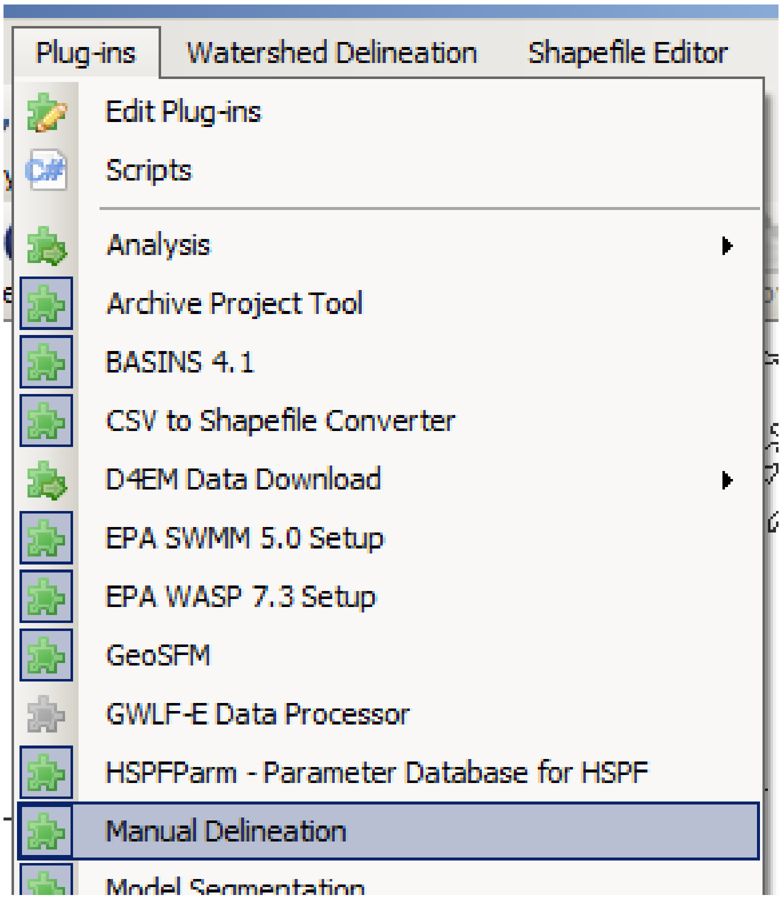
The Manual Delineator is used to subdivide any existing watershed polygon into smaller subwatersheds. This tool can be used on an entire 8-digit HUC, but for the purposes of this tutorial we will start with a smaller unit, in this case the Western Branch of the Patuxent River.

A shapefile representing the Western Branch of the Patuxent River has been included with the BASINS 4.5 installation. Add this file to the map using the **Add Layer** tool, which is shaped like a plus sign on the toolbar. The file is located in the folder '\BASINS\data\tutorial' (where \BASINS\ is the folder where BASINS was installed) and is named 'W_branch.shp'.

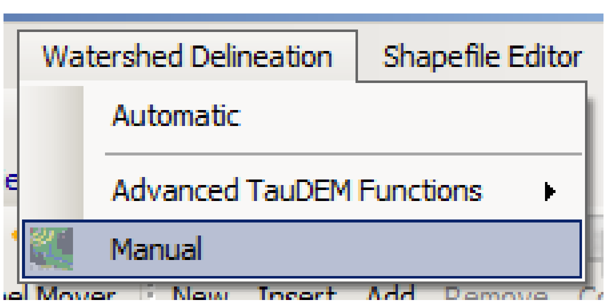


After you add this layer move it down on the map so that the NHD streams are drawn on top of it, as shown above.

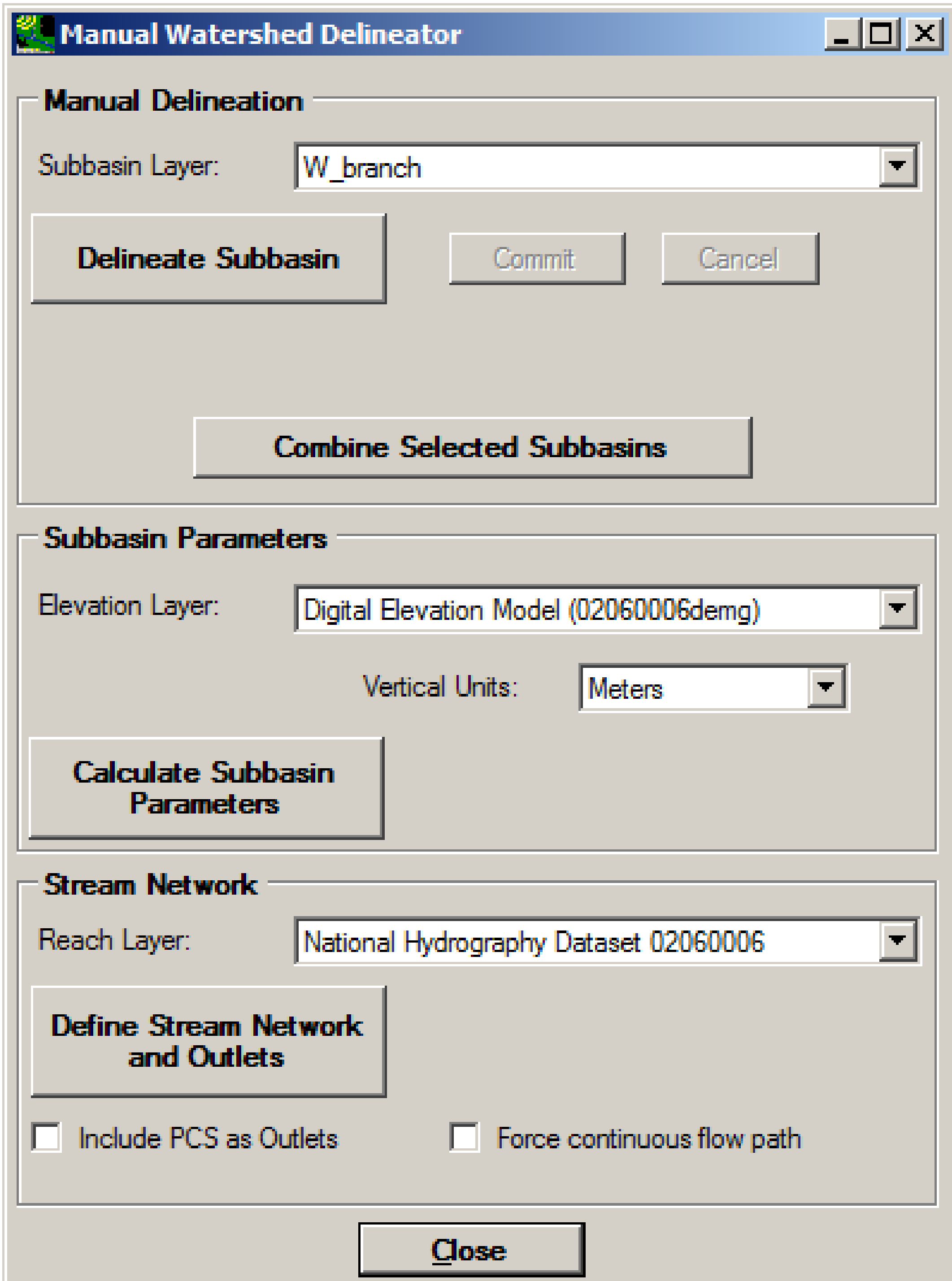
Before starting the Manual Delineator, make sure this plug-in is loaded by using the **Plug-ins** menu and making sure **Manual Delineation** is active.



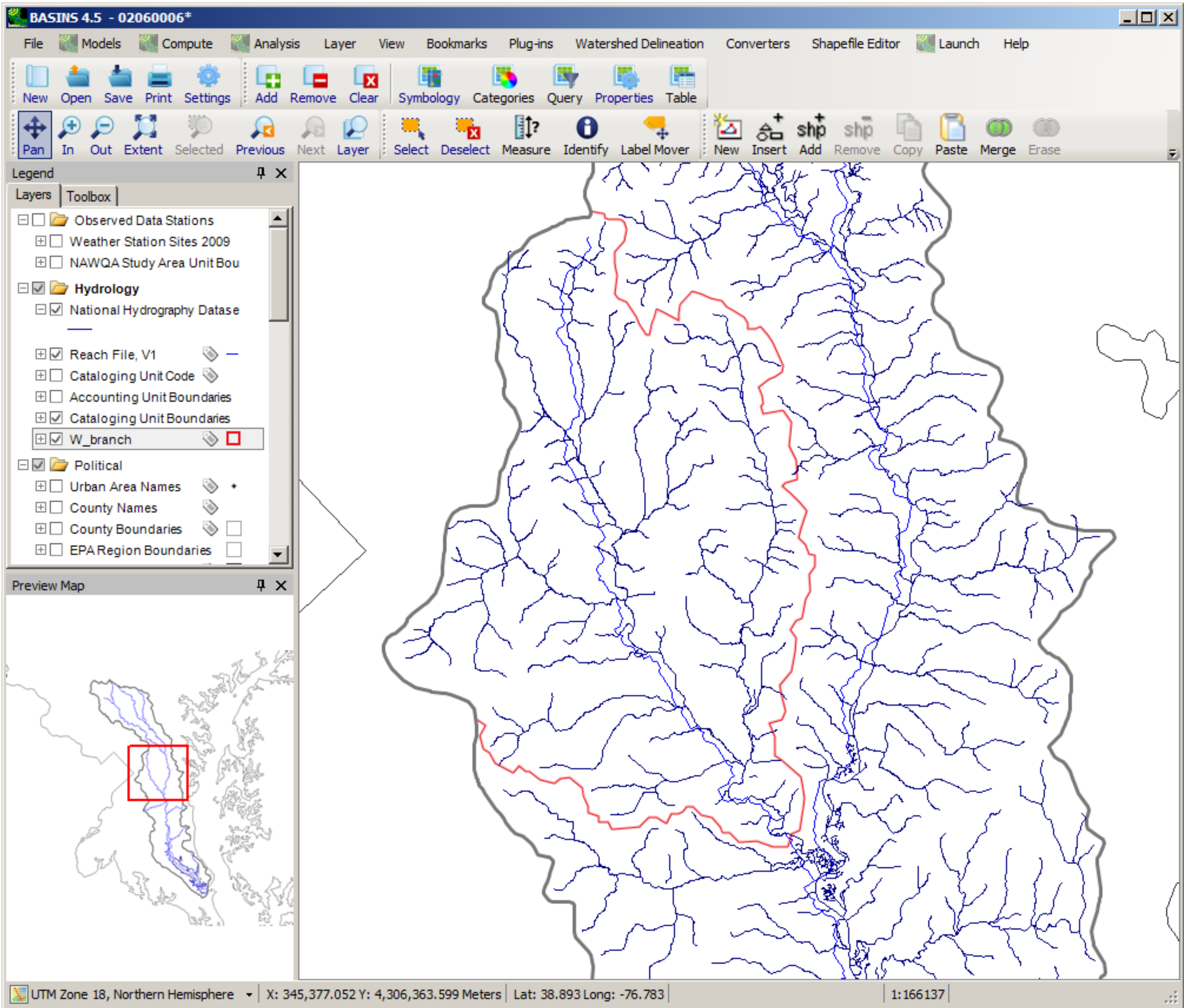
From the **Watershed Delineation** menu, choose **Manual**.



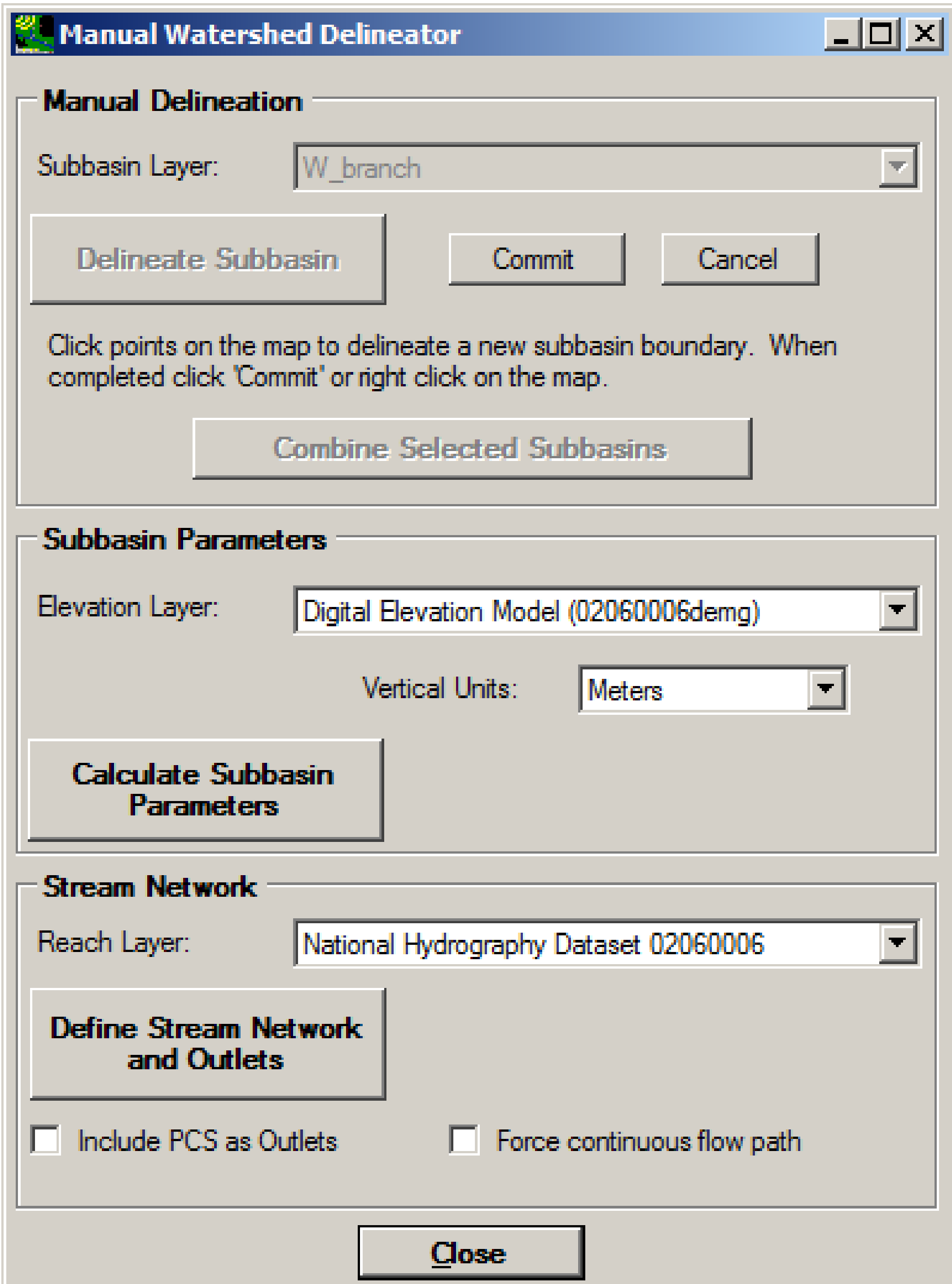
The **Manual Watershed Delineator** window will appear.



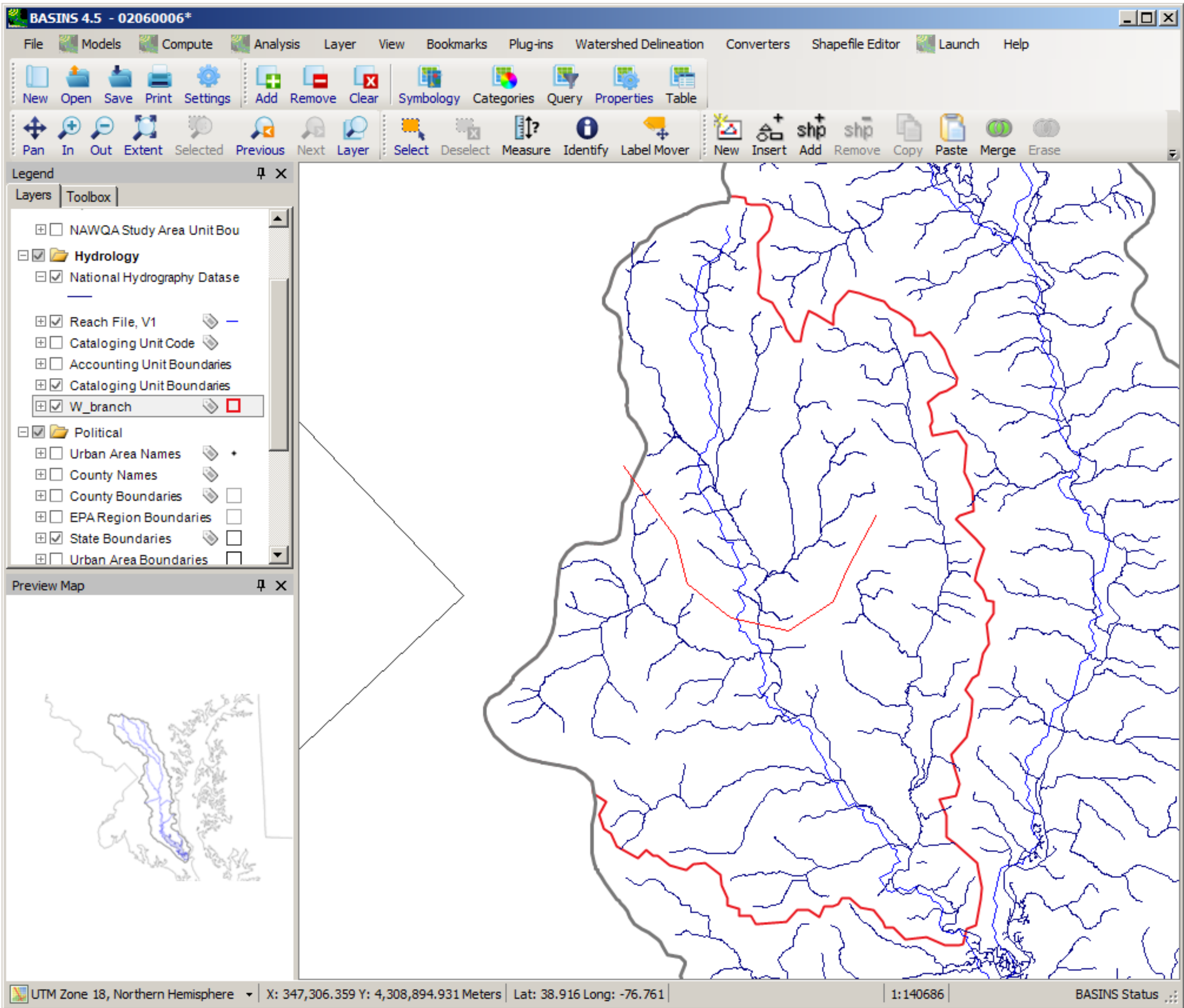
Zoom into the Western Branch by right-clicking on the W_branch map layer and selecting **Zoom to Layer**.



Click the **Delineate Subbasin** button to begin drawing the line to divide the existing watershed into two parts.

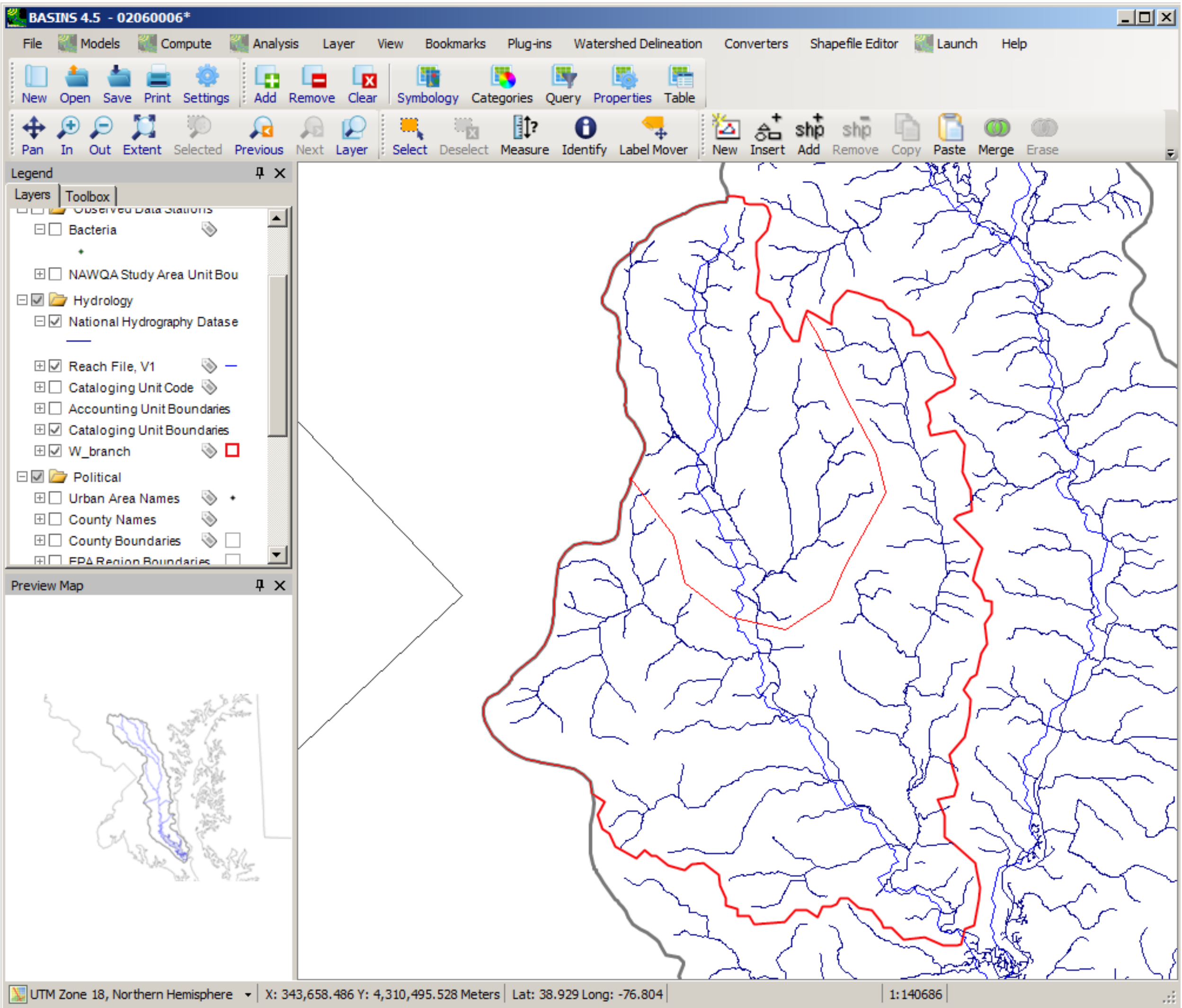


Now click on the map just outside of where you want the subbasin boundary to be. Continue clicking vertices along the intended subbasin boundary.

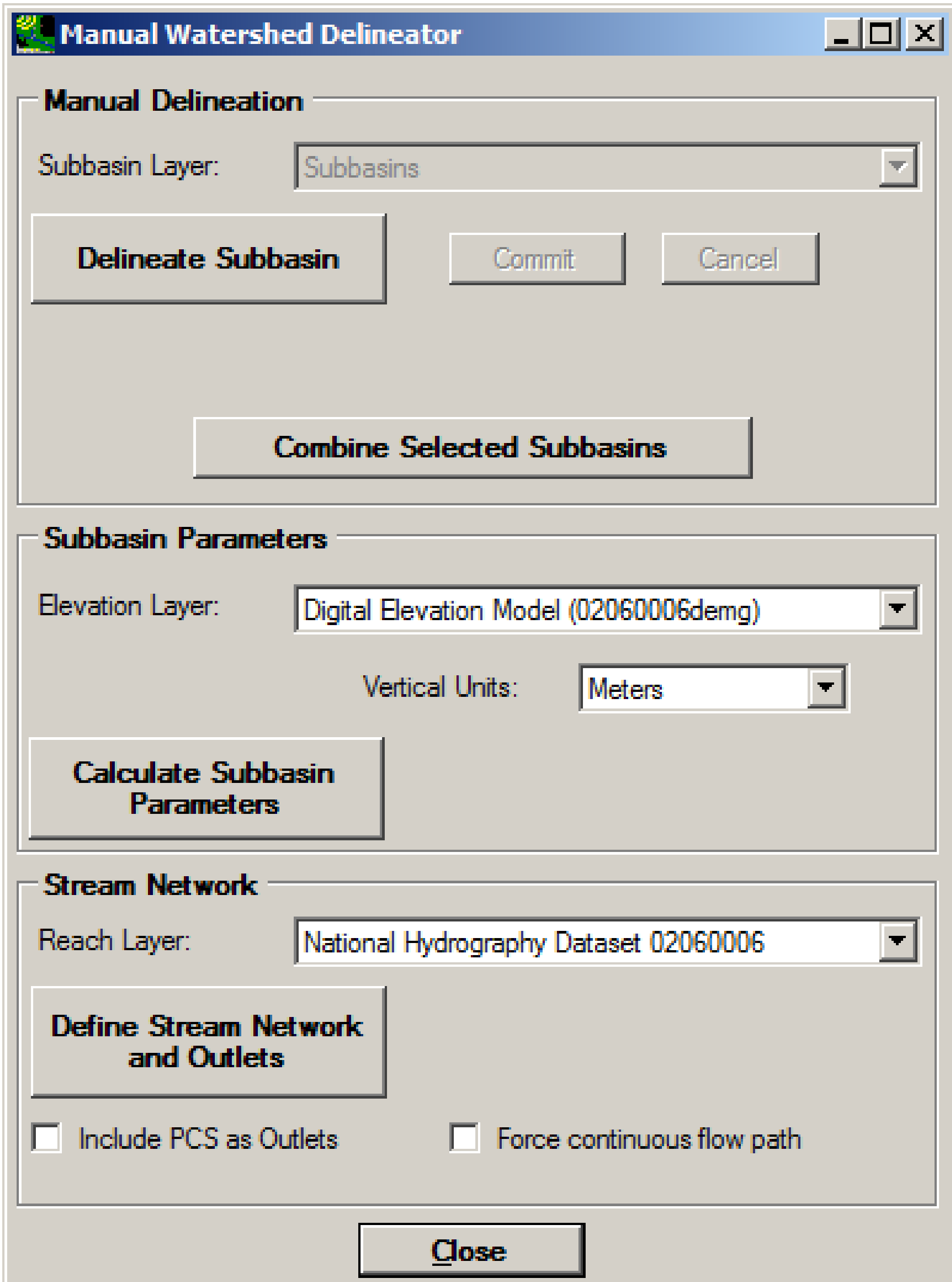


When you reach the border of the original watershed boundary, cross the boundary and right click, just outside the original watershed boundary. Doing so indicates that you are ready to commit the line as drawn. If you prefer you can use the **Commit** button of the **Manual Watershed Delineator** window. The **Cancel** button of the **Manual Watershed Delineator** window is used if you decide you want to stop the line you are in the process of drawing to start again.

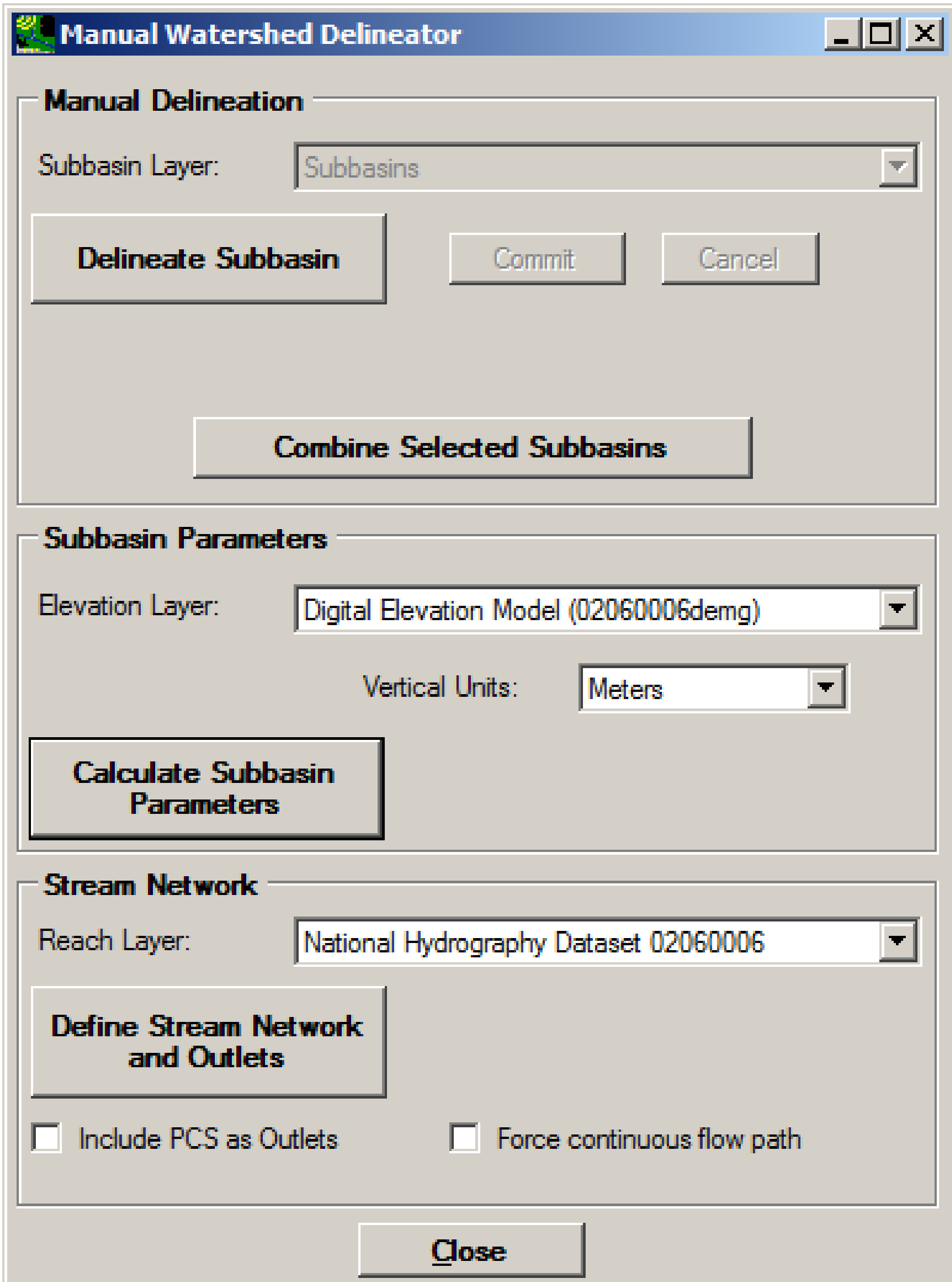
Note: It is not necessary to delineate the portion of your watershed that coincides with the 'W_branch' subwatershed boundary. The delineation tool automatically clips your watershed at the watershed boundary that is "active" and includes the portion of the boundary to which it was clipped in the new subwatershed.



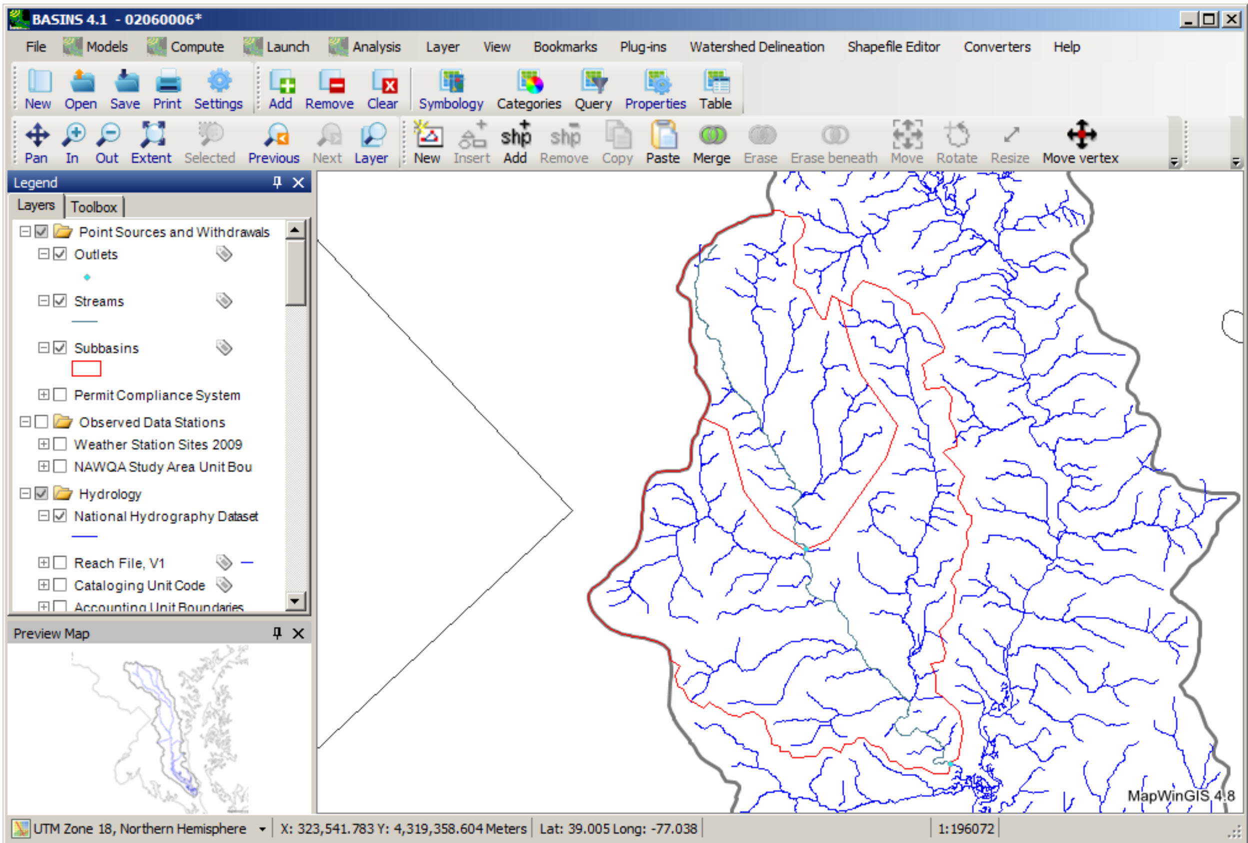
You can continue delineating subbasins as desired. Once you have the subbasins as you want them, set the Elevation Layer in the drop down list to 'DEM Elevation Model' and click **Calculate Subbasin Parameters**. Doing so will create a unique identifier for each subbasin and compute its average slope from the DEM.



After the subbasin parameters have been calculated, set the Reach Layer to your NHD layer, and click **Define Stream Network and Outlets**. Clicking this button will create a stream layer with one stream segment per subbasin, as is suitable for modeling. Each stream segment will include lengths and endpoint elevations. An outlets layer will also be created, with one point at the outlet of each subbasin. If you have checked the **Include PCS as Outlets** checkbox, the outlets layer will include information to link the PCS facility to a particular stream segment.



The **Define Stream Network and Outlets** process might take a few minutes. The end result looks like that shown below.



Notes: The Manual Delineator can be used with any existing layer of subbasin polygons. Specify the existing layer as the 'Subbasin Layer' in the Manual Watershed Delineator dialog. Even if the user does not want to break the existing subbasin polygons into additional pieces, this tool can be used to calculate the necessary parameters on the subbasins required for use in modeling, given a DEM layer. The associated stream network can also be calculated given an existing layer of subbasin polygons and a stream layer such as the NHD.

The user may edit subbasin boundaries using the MapWindow Shapefile Editor tools. Subbasins may also be combined by using the **Combine Selected Subbasins** button. After the subbasin boundaries have been adjusted, the user should use the **Calculate Subbasin Parameters** and **Define Stream Network and Outlets** buttons to compute the necessary layers and parameters for modeling.

Automatic Delineation

When modeling a watershed, it is often necessary to subdivide the hydrologic unit into subbasins in order to provide a more detailed, higher resolution model of the watershed area.

Basic Automatic Delineation provides an explanation of developing subbasins within an entire 8-digit HUC.

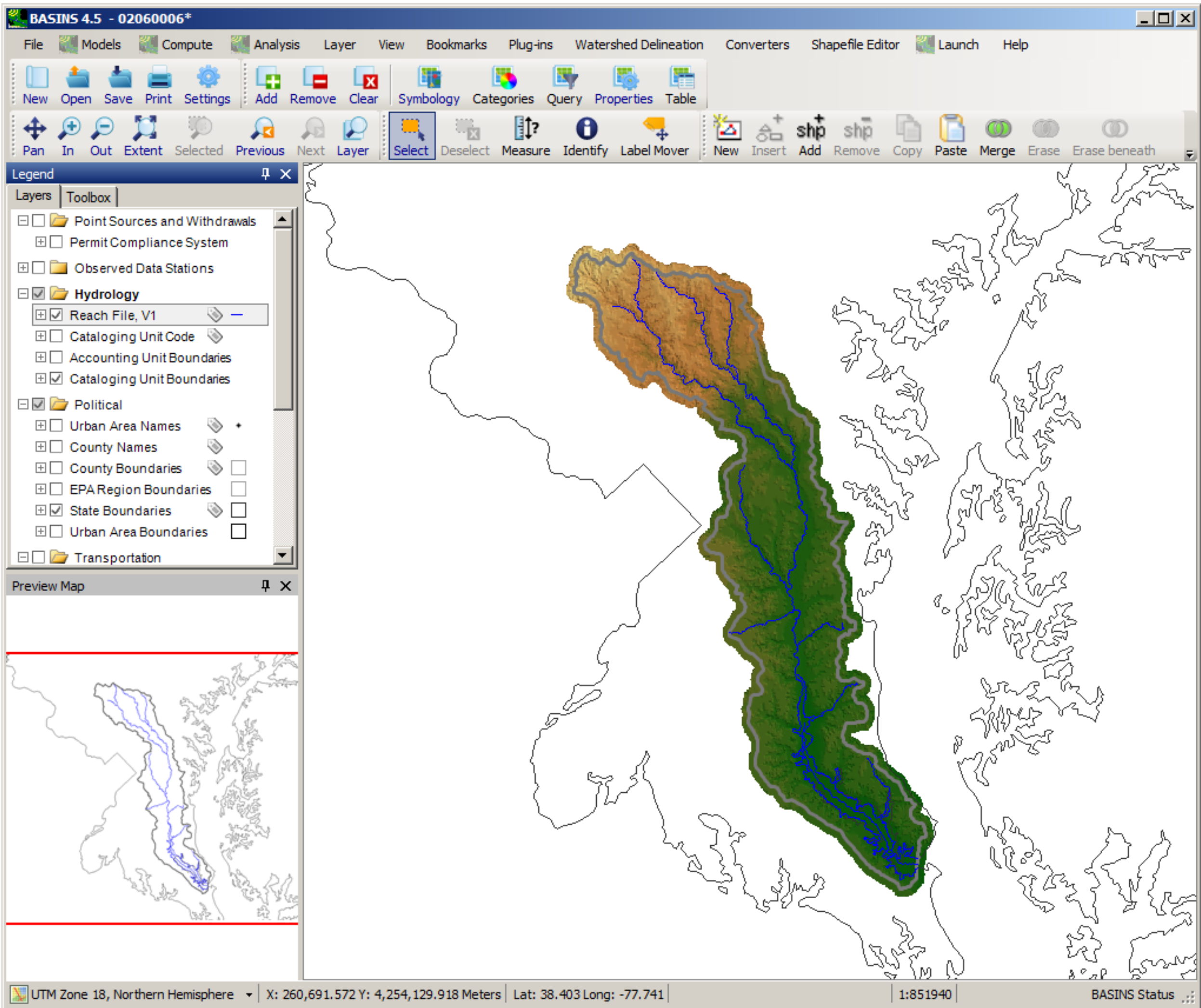
For more focus on a specific watershed area within an 8-digit HUC for delineation, adding user-defined outlet points, and for details on additional automatic delineation functionality, see Advanced Automatic Delineation Functions

Basic Automatic Delineation

Execute the following steps to subdivide a HUC-8 into multiple subwatersheds.

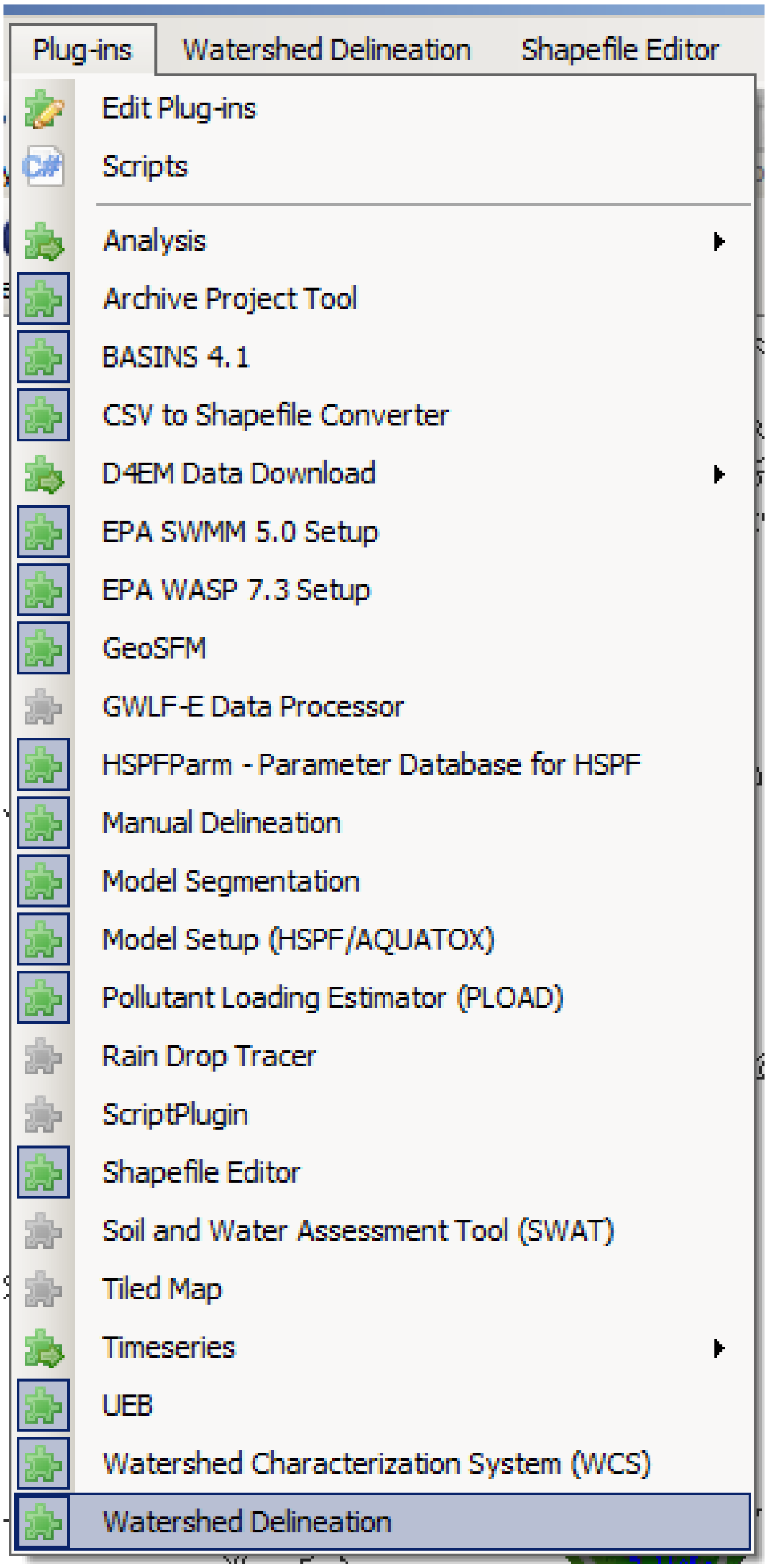
Delineating an 8-Digit HUC

Select the DEM Elevation Model, Cataloging Unit Boundary layer, and Reach File, V1 layer (downloaded in the previous Building a BASINS Project and Downloading Additional Data lessons) so they are displayed on the main form.

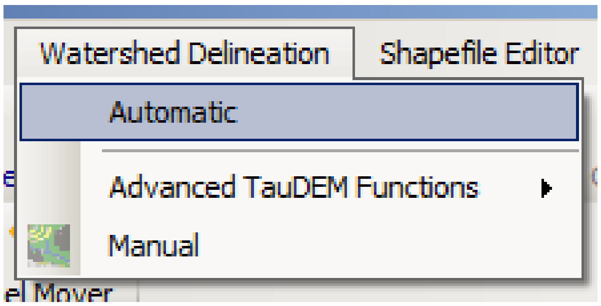


Select **Watershed Delineation** from the **Plug-ins** menu so that it is active. This will add **Automatic** and **Advanced TauDEM Functions** to the **Watershed Delineation** menu. As the name implies, the latter menu option is for advanced MapWindow users (full TauDEM documentation is available online).

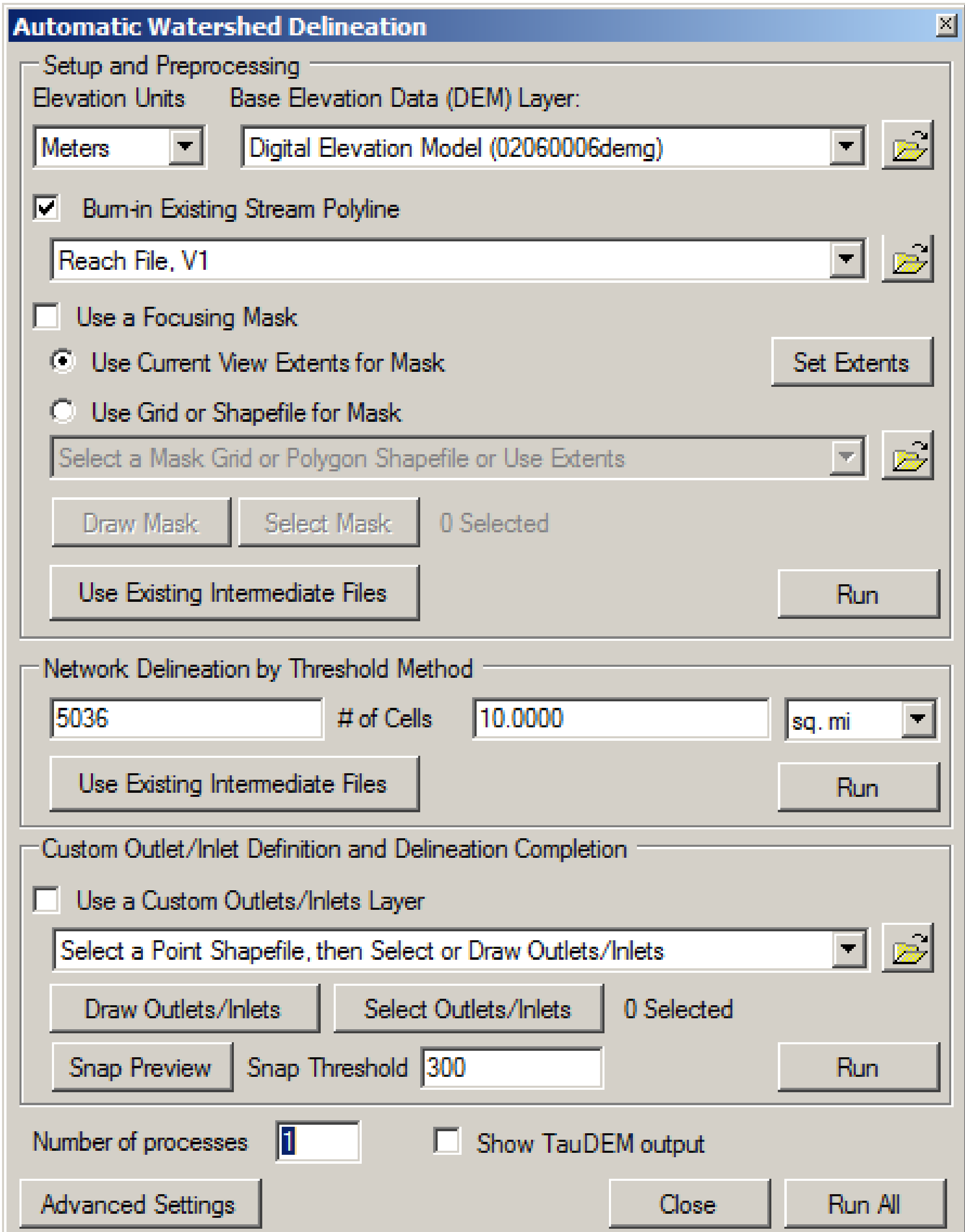
Note: When choosing whether to use the 30m resolution NED grid or the 100m resolution DEMG grid as the basis for delineating subbasins within a watershed, it is important to consider the scale of the watershed area. If an entire HUC-8 is being modeled, the DEMG is probably a better choice due to performance considerations, while the NED would provide enhanced detail for significantly smaller watersheds. The same consideration should be given to stream layers when burning them in.


Plug-ins
Watershed Delineation
Shapefile Editor
Edit Plug-ins
Scripts
Analysis
Archive Project Tool
BASINS 4.1
CSV to Shapefile Converter
D4EM Data Download
EPA SWMM 5.0 Setup
EPA WASP 7.3 Setup
GeoSFM
GWLF-E Data Processor
HSPFParm - Parameter Database for HSPF
Manual Delineation
Model Segmentation
Model Setup (HSPF/AQUATOX)
Pollutant Loading Estimator (PLOAD)
Rain Drop Tracer
ScriptPlugin
Shapefile Editor
Soil and Water Assessment Tool (SWAT)
Tiled Map
Timeseries
UEB
Watershed Characterization System (WCS)
Watershed Delineation

Invoke the Automatic Watershed Delineation tool by selecting **Automatic** from the **Watershed Delineation** menu.

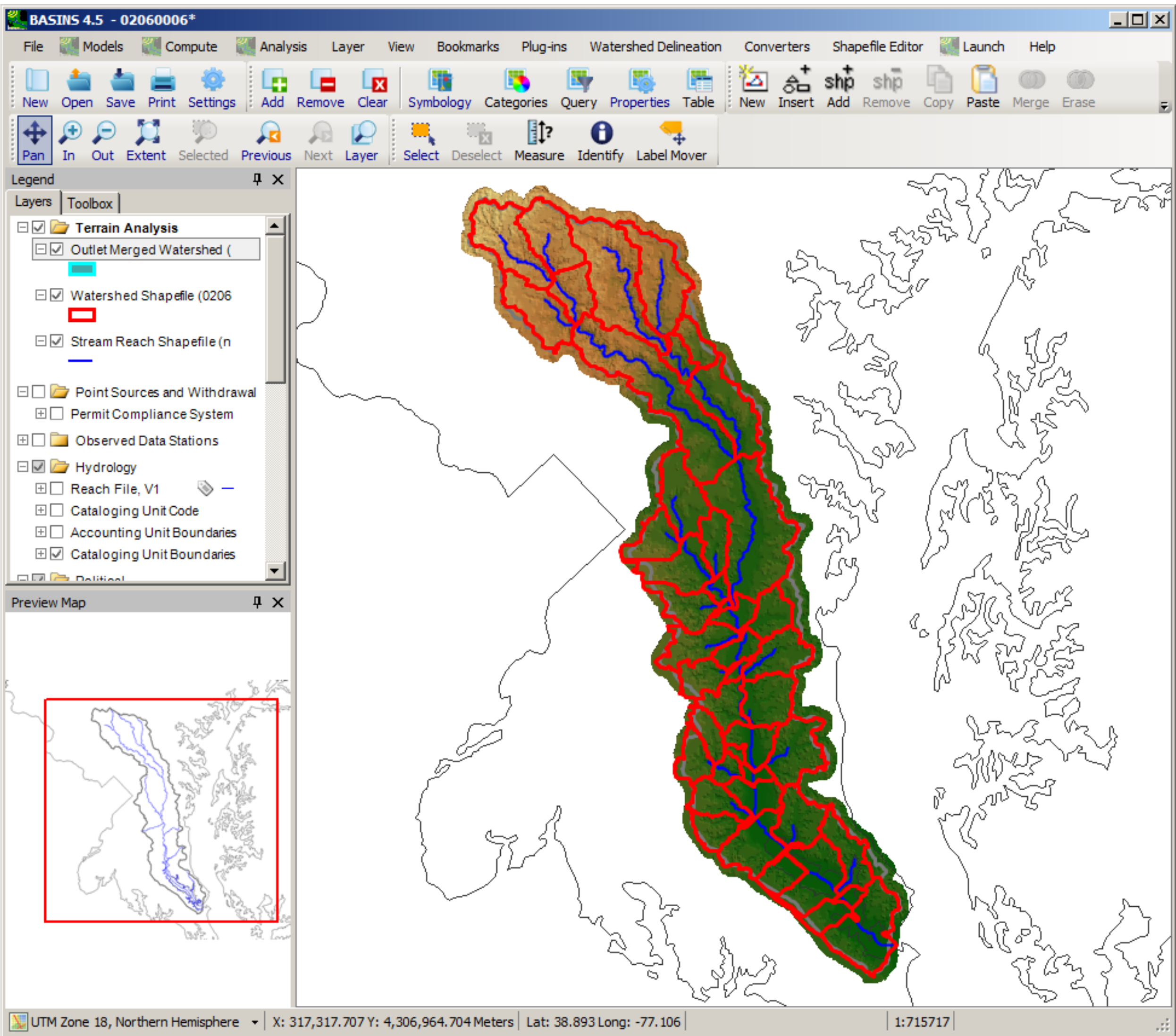


In the Automatic Watershed Delineation dialog, specify the DEM Layer as the 'DEM Elevation Model' (DEMG) already loaded onto the map. Choose a threshold size (10 square miles works nicely for a demo). Click on the **Burn-in Existing Stream Polyline** checkbox and select 'Reach File, V1' from the pull-down menu. Then click **Run All**.


Automatic Watershed Delineation
Setup and Preprocessing
Elevation Units
Base Elevation Data (DEM) Layer:
Meters
Digital Elevation Model (02060006demg)
Burn-in Existing Stream Polyline
Reach File, V1
Use a Focusing Mask
Use Current View Extents for Mask
Set Extents
Use Grid or Shapefile for Mask
Select a Mask Grid or Polygon Shapefile or Use Extents
Draw Mask
Select Mask
0 Selected
Use Existing Intermediate Files
Run
Network Delineation by Threshold Method
5036
# of Cells
10.0000
sq. mi
Use Existing Intermediate Files
Run
Custom Outlet/Inlet Definition and Delineation Completion
Use a Custom Outlets/Inlets Layer
Select a Point Shapefile, then Select or Draw Outlets/Inlets
Draw Outlets/Inlets
Select Outlets/Inlets
0 Selected
Snap Preview
Snap Threshold
300
Run
Number of processes
1
Show TauDEM output
Advanced Settings
Close
Run All

Note: By selecting **Burn-in Existing Stream Polyline** option we are specifying a reach file on which the new delineation reach file (created with the automatic delineation tool) will be based.

During processing you will see status messages at the bottom of the map window, informing you of things such as 'Pit Fill', 'D8', 'D8 Flow Directions', etc. When processing is completed you will see the Watershed and Stream Reach Shapefiles on the map.



Note: The *Starting HSPF* tutorial continues from this point. You may wish to proceed to that tutorial or continue with the *Advanced Automatic Delineation* tutorial to learn about more features within the Automatic Delineation tool.

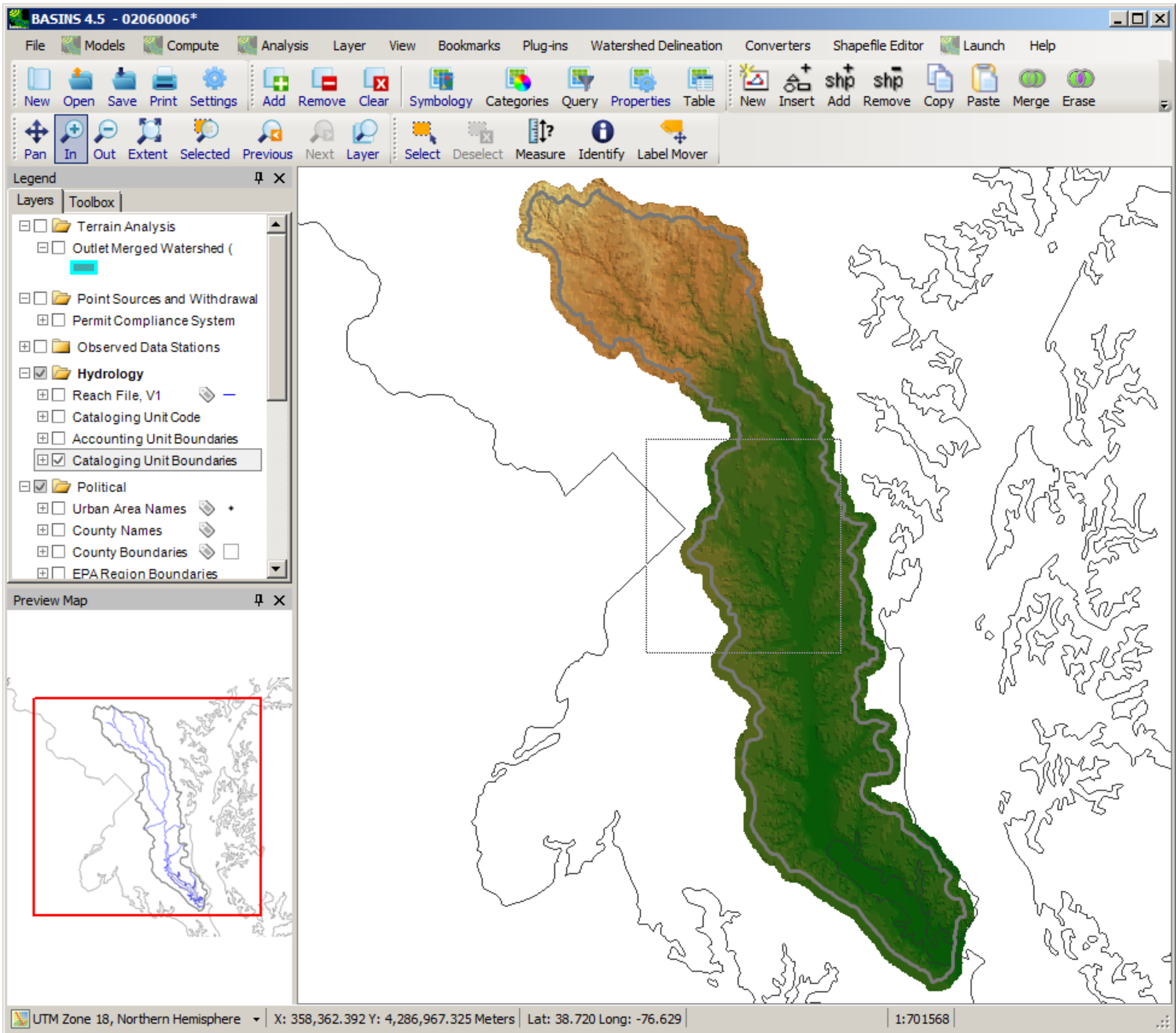
Advanced Automatic Delineation Functions

Often a user's study area includes only a small portion of an 8-digit HUC. In many cases a user wishes to delineate to a specific point on a stream, such as a USGS gage. This section provides details for performing these operations through the BASINS Automatic Delineation tools.

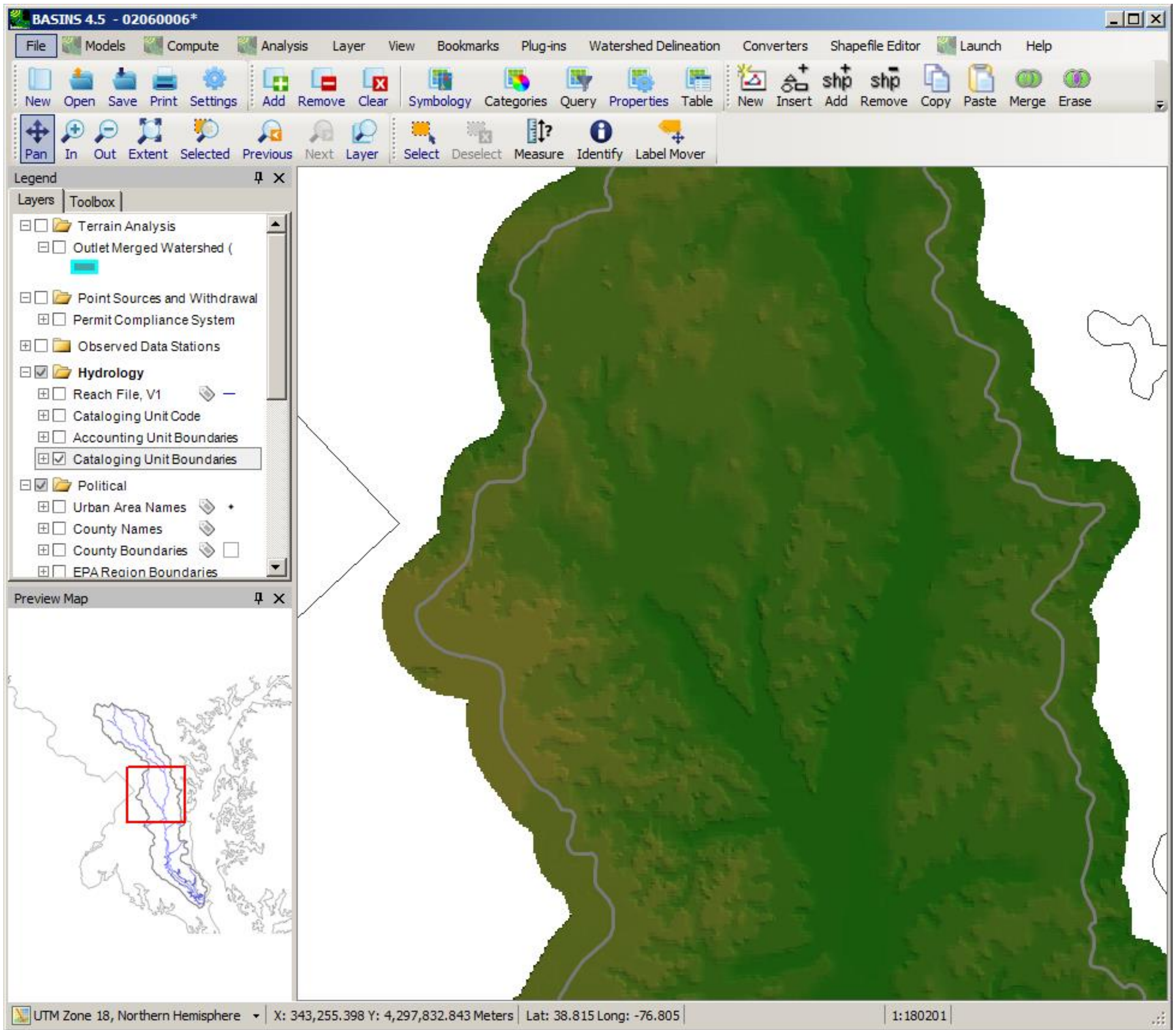
Delineating a Portion of an 8-Digit HUC

First, we will delineate subbasins only with a small portion of the 8-digit HUC. To minimize confusion, remove the 'Watershed Shapefile' and the 'Stream Reach Shapefile' from the previous delineation from the map, and the 'Streams', 'Subbasins', and 'Outlets' shapefiles if they are present. The only layers that should be active are Cataloging Unit Boundaries, DEM Elevation Model, and State Boundaries.

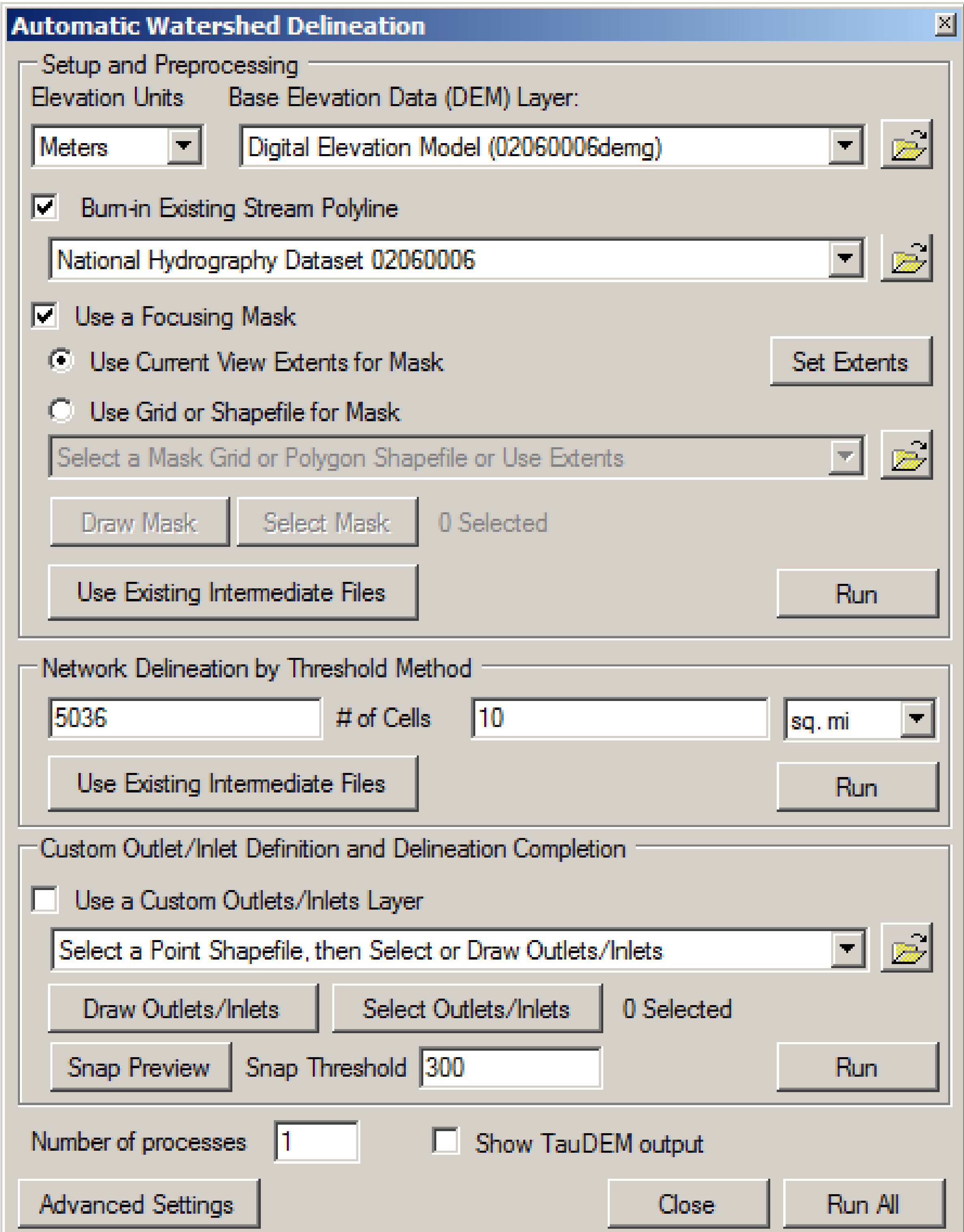
Zoom in on a small portion of the 8-digit HUC, as shown below.



Your map view should look something like the following:

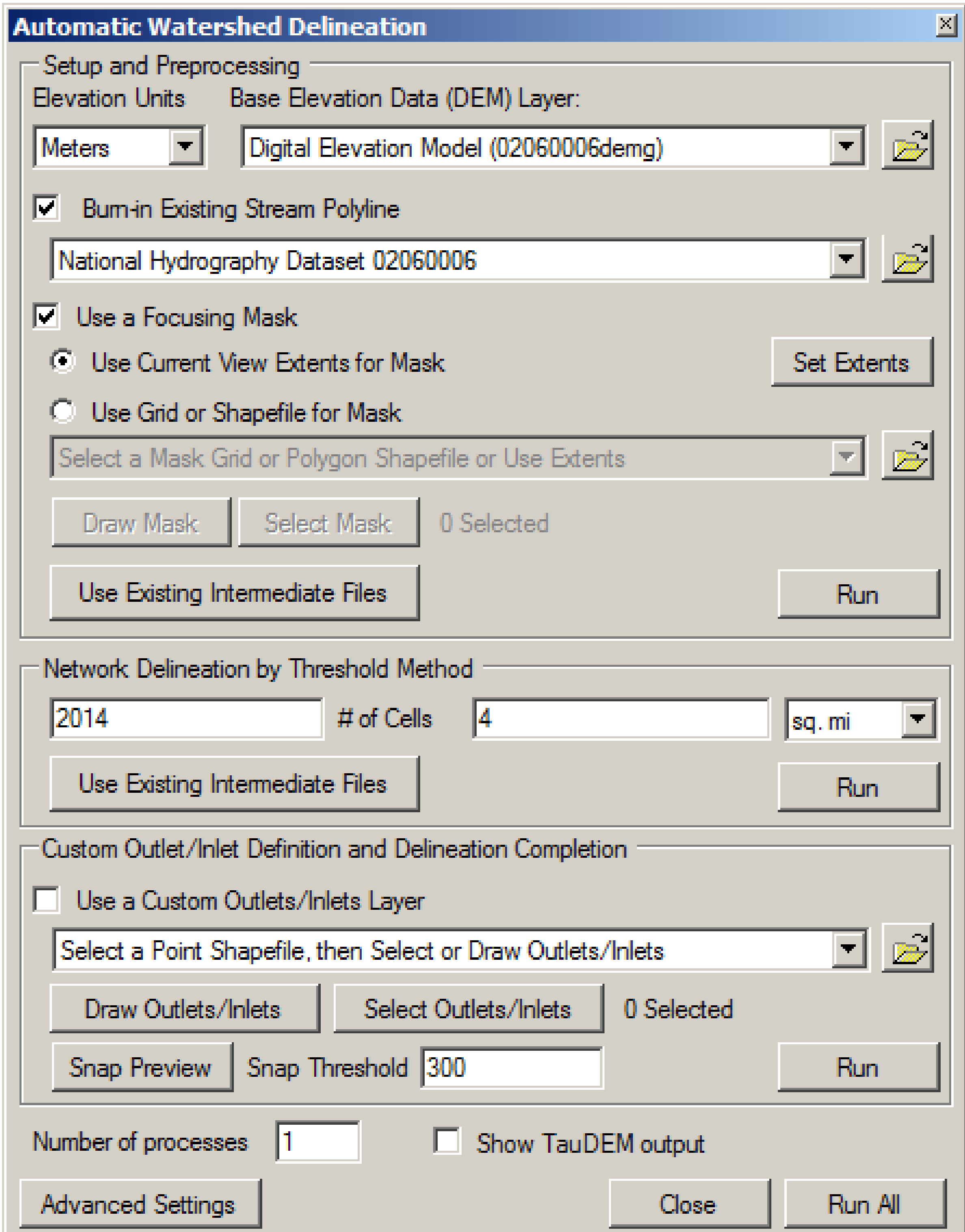


Now start the Automatic Delineation tool again. Choose the 'DEM Elevation Model' as the Base DEM. Turn on the **burn-in** option and choose the NHD layer as the layer to burn-in (remember that the NHD is a more detailed hydrography dataset than the Reach File). This time we will turn on the check box labeled **Use a Focusing Mask** . We have the option of digitizing the polygon within which we want to delineate, choosing an existing map layer within which we want to delineate, or using the current map extents. Select the radio button next to **Use Current View Extents for Mask** . Click the **Run** button within the **Setup and Preprocessing** frame. The setup and preprocessing with take a few moments.

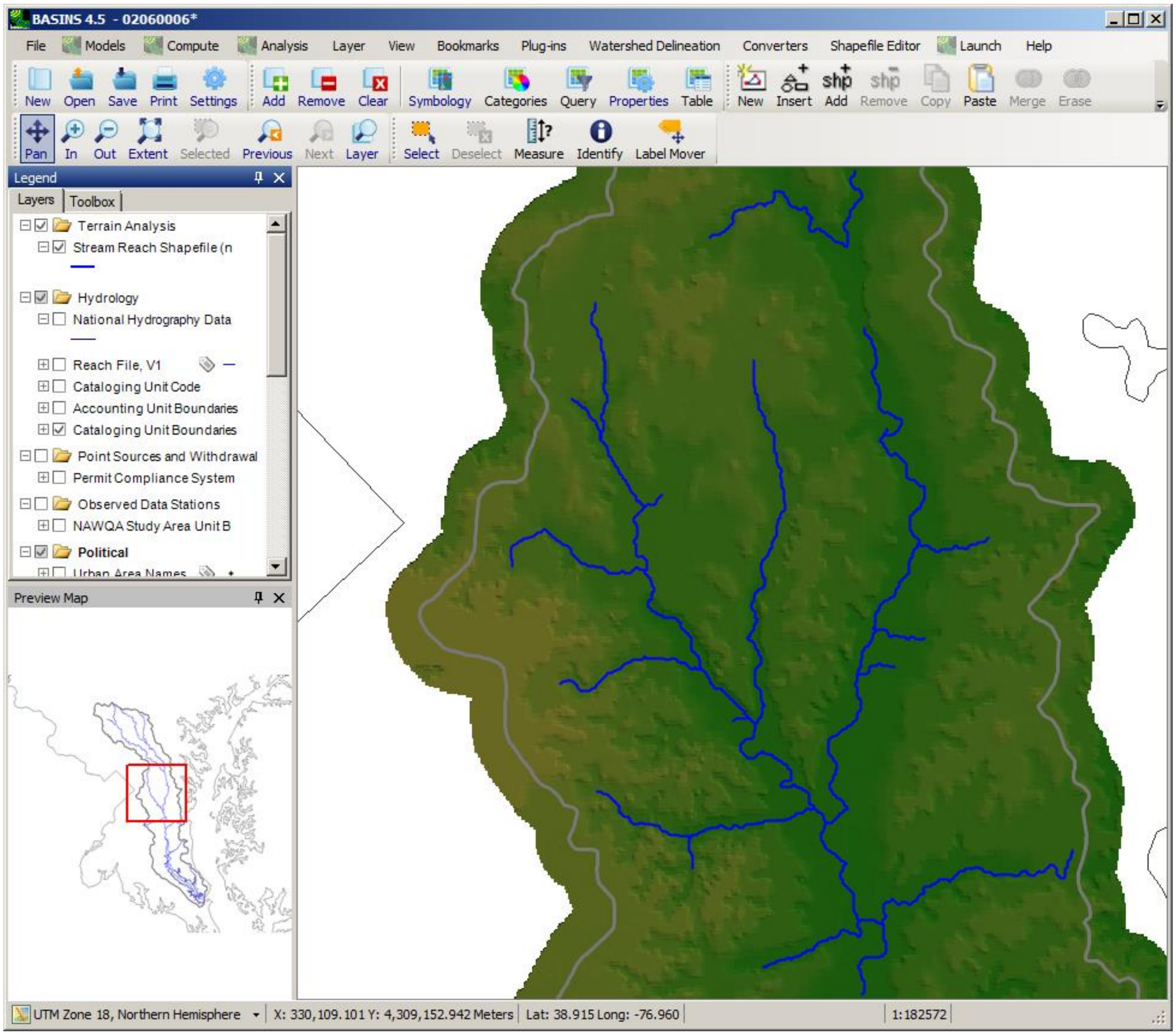

Automatic Watershed Delineation
Setup and Preprocessing
Elevation Units
Base Elevation Data (DEM) Layer:
Meters
Digital Elevation Model (02060006demg)
Burn-in Existing Stream Polyline
National Hydrography Dataset 02060006
Use a Focusing Mask
Use Current View Extents for Mask
Set Extents
Use Grid or Shapefile for Mask
Select a Mask Grid or Polygon Shapefile or Use Extents
Draw Mask
Select Mask
0 Selected
Use Existing Intermediate Files
Run
Network Delineation by Threshold Method
5036
# of Cells
10
sq. mi
Use Existing Intermediate Files
Run
Custom Outlet/Inlet Definition and Delineation Completion
Use a Custom Outlets/Inlets Layer
Select a Point Shapefile, then Select or Draw Outlets/Inlets
Draw Outlets/Inlets
Select Outlets/Inlets
0 Selected
Snap Preview
Snap Threshold
300
Run
Number of processes
1
Show TauDEM output
Advanced Settings
Close
Run All

Note: By selecting **Burn-in Existing Stream Polyline** option we are specifying a reach file on which the new delineation reach file (created with the automatic delineation tool) will be based.

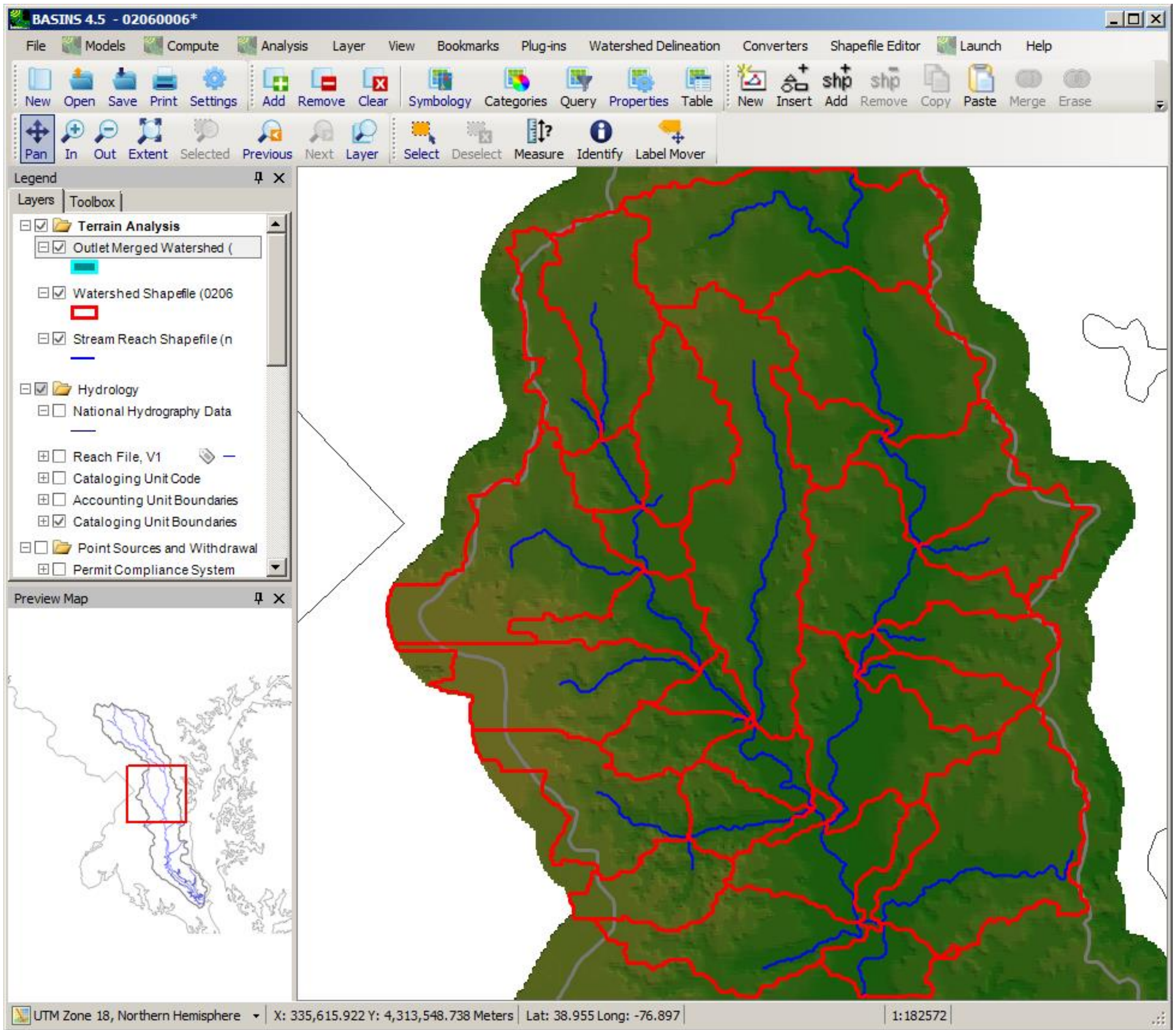
Once the setup and preprocessing has completed set the delineation threshold to 4 square miles. Click the **Run** button within the **Delineation by Threshold Method** frame.


Automatic Watershed Delineation
Setup and Preprocessing
Elevation Units
Base Elevation Data (DEM) Layer:
Meters
Digital Elevation Model (02060006demg)
Burn-in Existing Stream Polyline
National Hydrography Dataset 02060006
Use a Focusing Mask
Use Current View Extents for Mask
Set Extents
Use Grid or Shapefile for Mask
Select a Mask Grid or Polygon Shapefile or Use Extents
Draw Mask
Select Mask
0 Selected
Use Existing Intermediate Files
Run
Network Delineation by Threshold Method
2014
# of Cells
4
sq. mi
Use Existing Intermediate Files
Run
Custom Outlet/Inlet Definition and Delineation Completion
Use a Custom Outlets/Inlets Layer
Select a Point Shapefile, then Select or Draw Outlets/Inlets
Draw Outlets/Inlets
Select Outlets/Inlets
0 Selected
Snap Preview
Snap Threshold
300
Run
Number of processes
1
Show TauDEM output
Advanced Settings
Close
Run All

When the delineation is complete you will see the new stream reach shapefile on the map.



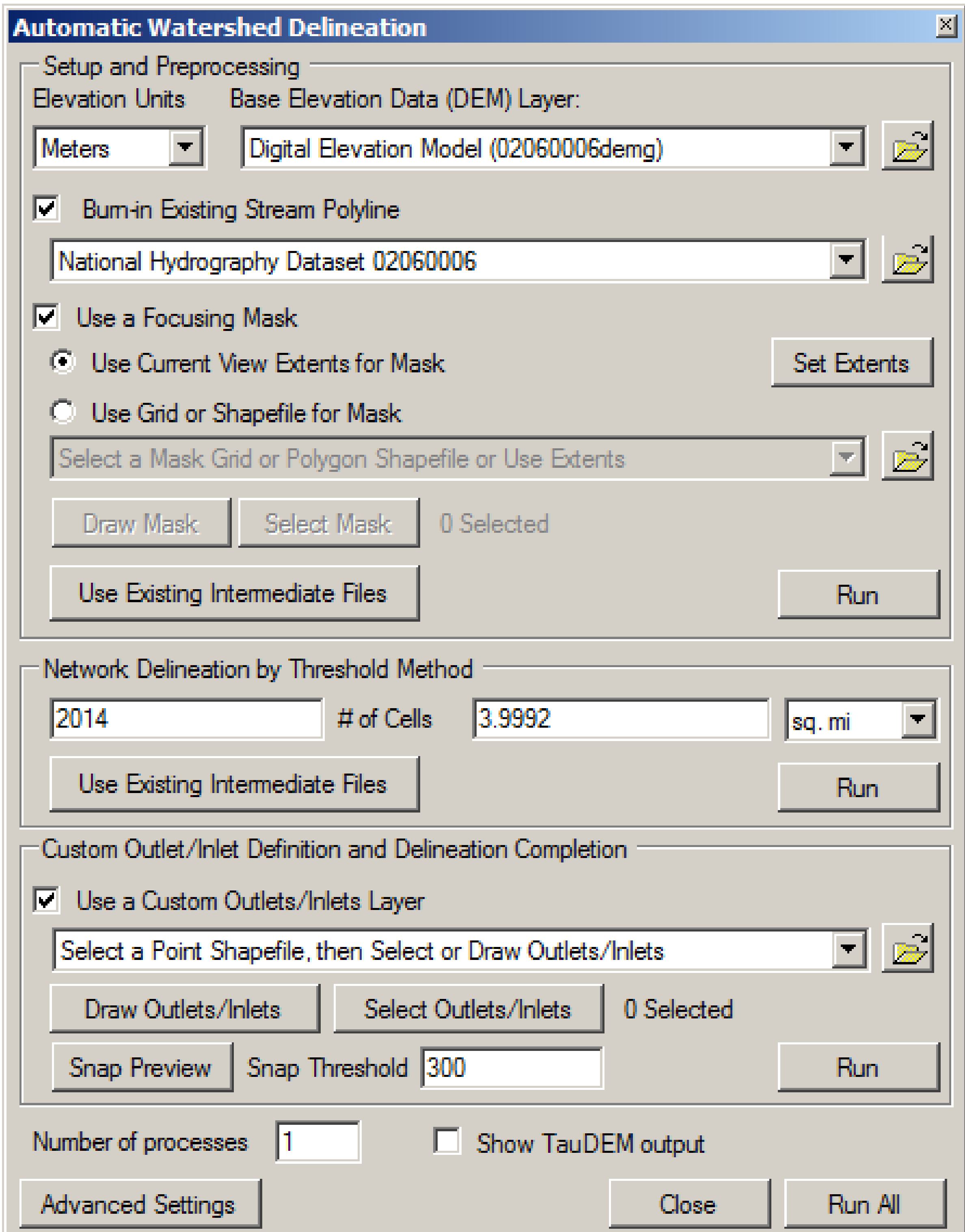
Now before selecting an outlets layer we will compute the subbasins. Leave the **Use a Custom Outlet/Inlets Layer** box unchecked. Click the **Run** button within the **Custom Outlet Definition and Delineation Completion** frame. The subbasins will be computed and drawn on the map.



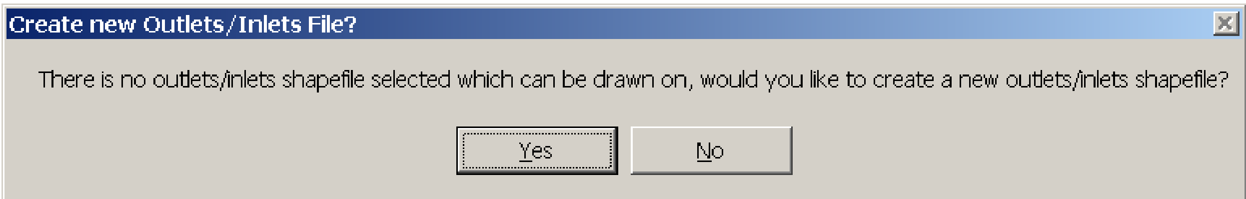
Delineating to a Point on a Stream

Very often in watershed modeling a user wishes to delineate to a particular point on a stream corresponding to the location of a flow gage. The following steps provide the sequence necessary to delineate to a point on a stream.

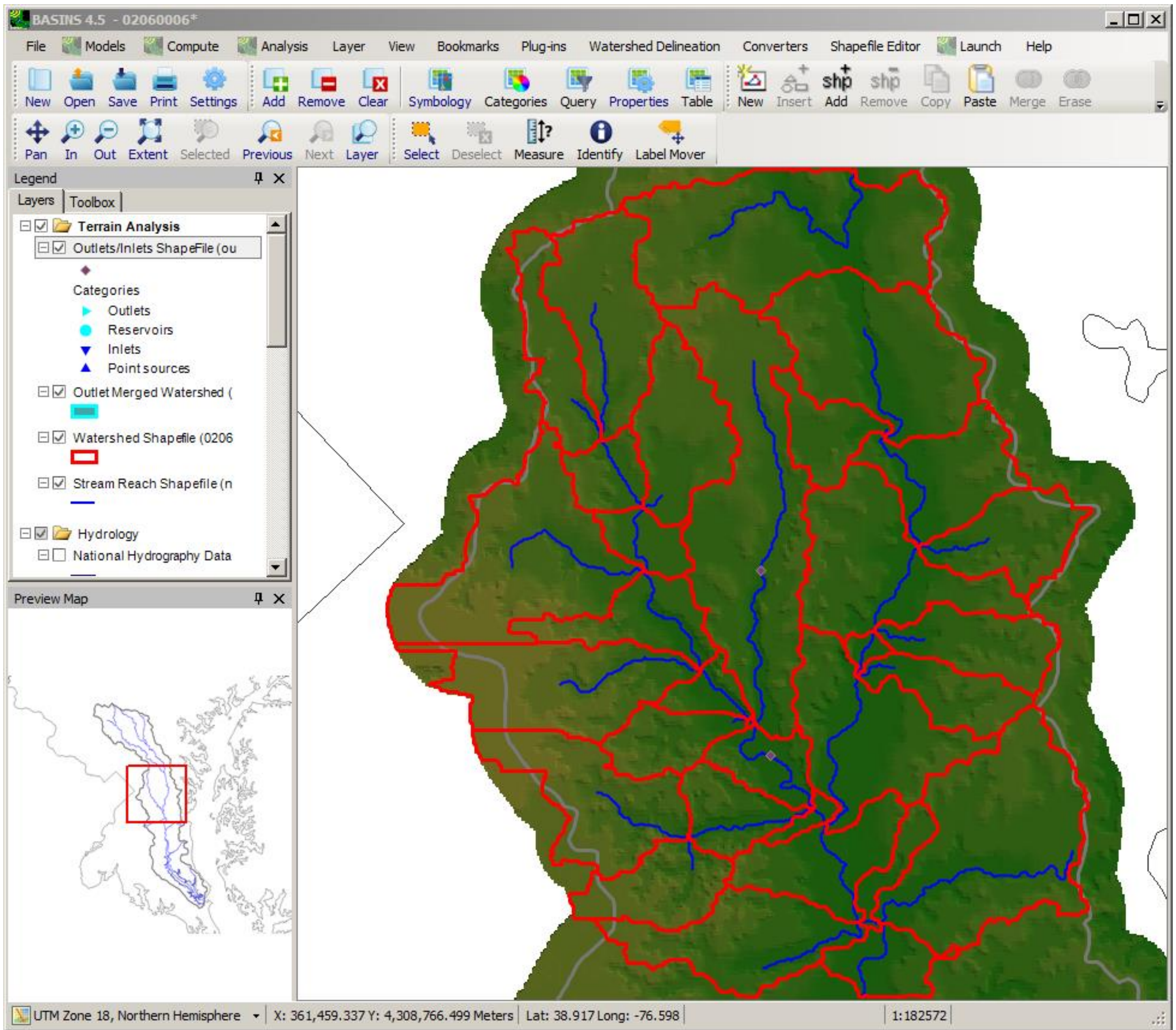
Turn on the check box labeled **Use a Custom Outlets Layer**.


Automatic Watershed Delineation
Setup and Preprocessing
Elevation Units
Base Elevation Data (DEM) Layer:
Meters
Digital Elevation Model (02060006demg)
Burn-in Existing Stream Polyline
National Hydrography Dataset 02060006
Use a Focusing Mask
Use Current View Extents for Mask
Set Extents
Use Grid or Shapefile for Mask
Select a Mask Grid or Polygon Shapefile or Use Extents
Draw Mask
Select Mask
0 Selected
Use Existing Intermediate Files
Run
Network Delineation by Threshold Method
2014
# of Cells
3.9992
sq. mi
Use Existing Intermediate Files
Run
Custom Outlet/Inlet Definition and Delineation Completion
Use a Custom Outlets/Inlets Layer
Select a Point Shapefile, then Select or Draw Outlets/Inlets
Draw Outlets/Inlets
Select Outlets/Inlets
0 Selected
Snap Preview
Snap Threshold
300
Run
Number of processes
1
Show TauDEM output
Advanced Settings
Close
Run All

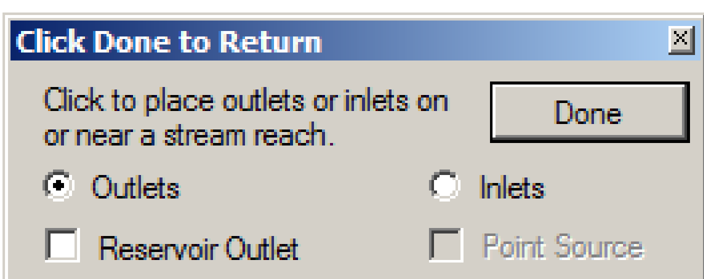
Click on the **Draw Outlets/Inlets** button. The following message will appear, asking if you would like to create a new outlets layer. You may choose to use an existing outlets layer at this point. For this tutorial we will choose to create a new outlets layer. Click **Yes** to create a new outlets layer.



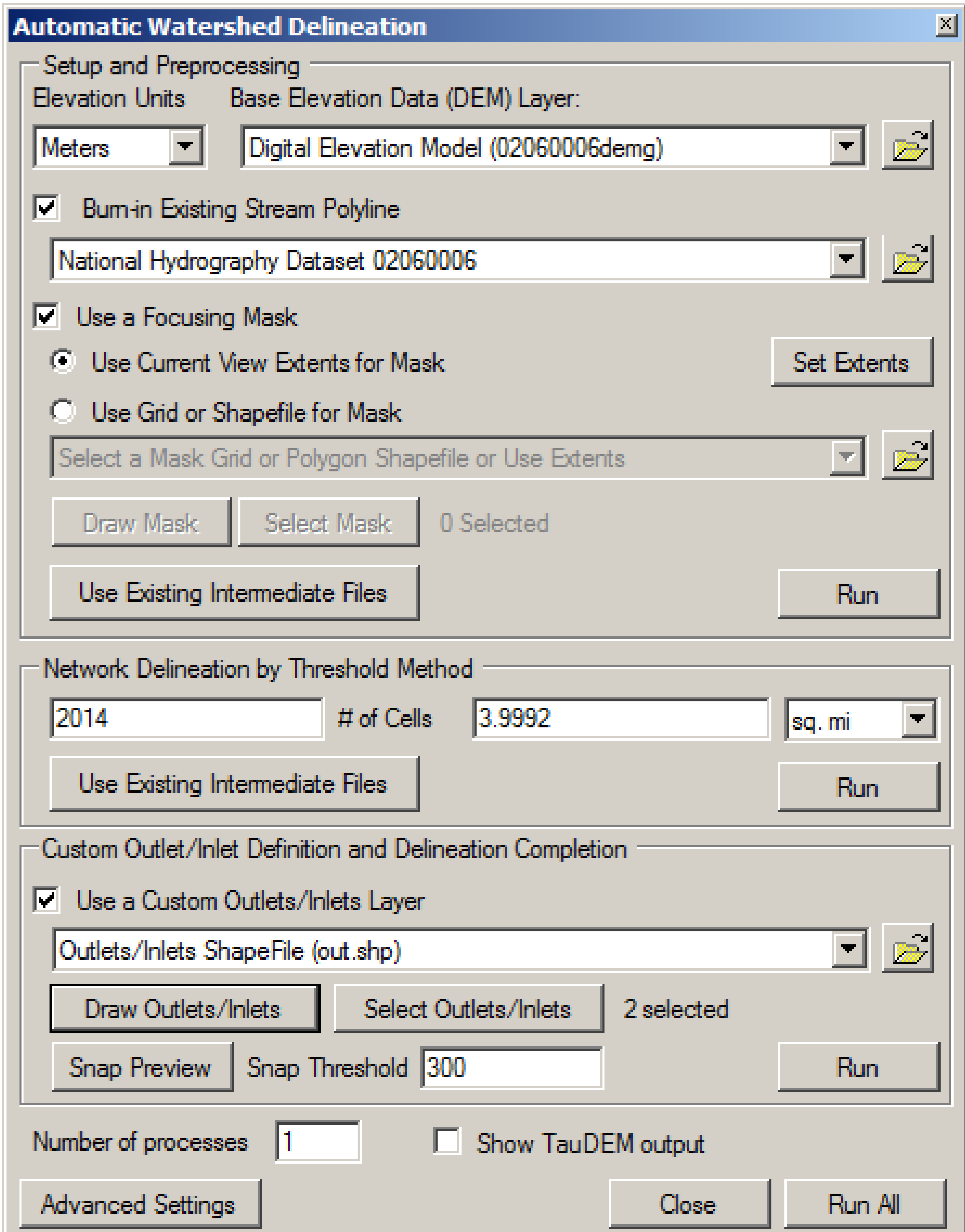
You will be prompted to enter the name of the new outlets layer. You may choose any file name; we chose the name 'out.shp' for our outlets layer. Save it in the same folder. Focus will return to the map. Click on two points on the map where you want to add outlets, such as the points shown below.



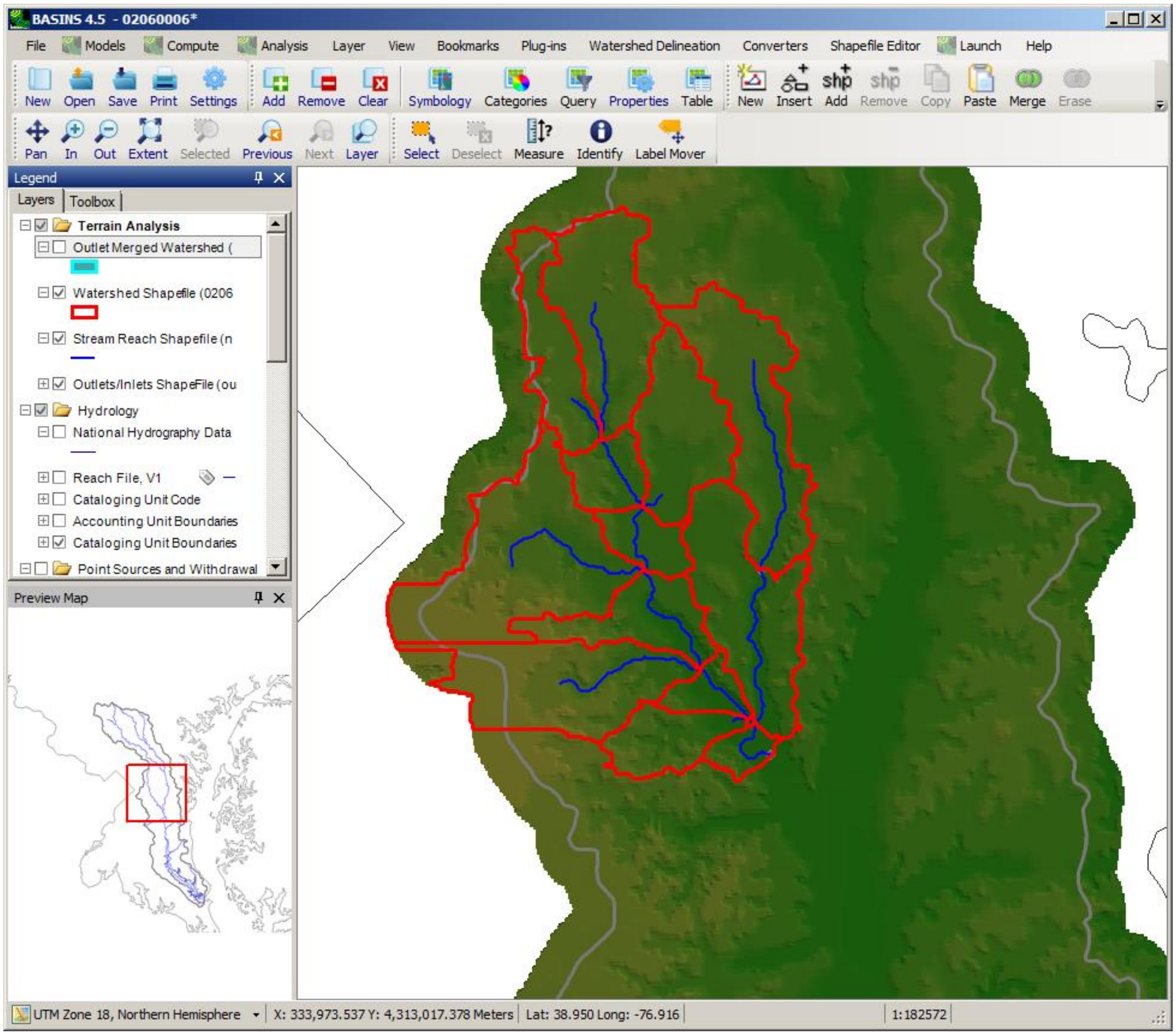
When finished click **Done** in the small window below.



Notice that our outlets layer is now specified as the custom outlets layer. We could change the snap threshold to adjust the snapping tolerance with which the program will look for a stream segment near each specified outlet. We will leave that threshold at 300, indicating that an outlet within 300 meters (the distance unit BASINS project) will be 'snapped' to the nearest stream segment. Now click the **Run** button within the **Custom Outlet Definition and Delineation Completion** frame.


Automatic Watershed Delineation
Setup and Preprocessing
Elevation Units
Base Elevation Data (DEM) Layer:
Meters
Digital Elevation Model (02060006demg)
Burn-in Existing Stream Polyline
National Hydrography Dataset 02060006
Use a Focusing Mask
Use Current View Extents for Mask
Set Extents
Use Grid or Shapefile for Mask
Select a Mask Grid or Polygon Shapefile or Use Extents
Draw Mask
Select Mask
0 Selected
Use Existing Intermediate Files
Run
Network Delineation by Threshold Method
2014
# of Cells
3.9992
sq. mi
Use Existing Intermediate Files
Run
Custom Outlet/Inlet Definition and Delineation Completion
Use a Custom Outlets/Inlets Layer
Outlets/Inlets ShapeFile (out.shp)
Draw Outlets/Inlets
Select Outlets/Inlets
2 selected
Snap Preview
Snap Threshold
300
Run
Number of processes
1
Show TauDEM output
Advanced Settings
Close
Run All

The results of the delineation are shown below. Notice that we have delineated subbasins only above the two specified outlet points.



Frequently Asked Questions

Frequently Asked Questions (**FAQs**)

- Installation
- Do I need to have administrator privileges to install BASINS?

- Getting Started
- How do I start a project? (or take the Tutorial)
- How do I use MapWindow?
- What are the differences between MapWindow and ArcView?

- GIS Tasks
- How do I change symbolization of a shapefile?
- How do I select or deselect features?
- What is the difference between Reach Files and the National Hydrography Dataset (NHD)?
- How do I import other shapefiles?

- Other
- How do I open the Welcome window?
- Are there keyboard shortcuts in MapWindow?
- Why can’t I find something in the Analysis menu?
- What happened to *insert BASINS 3.1 tool here*?

Administrator Privileges

Do I need to have administrator privileges to install BASINS?

Yes, depending upon the security settings of the individual computer.

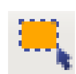
Missing Menu Options

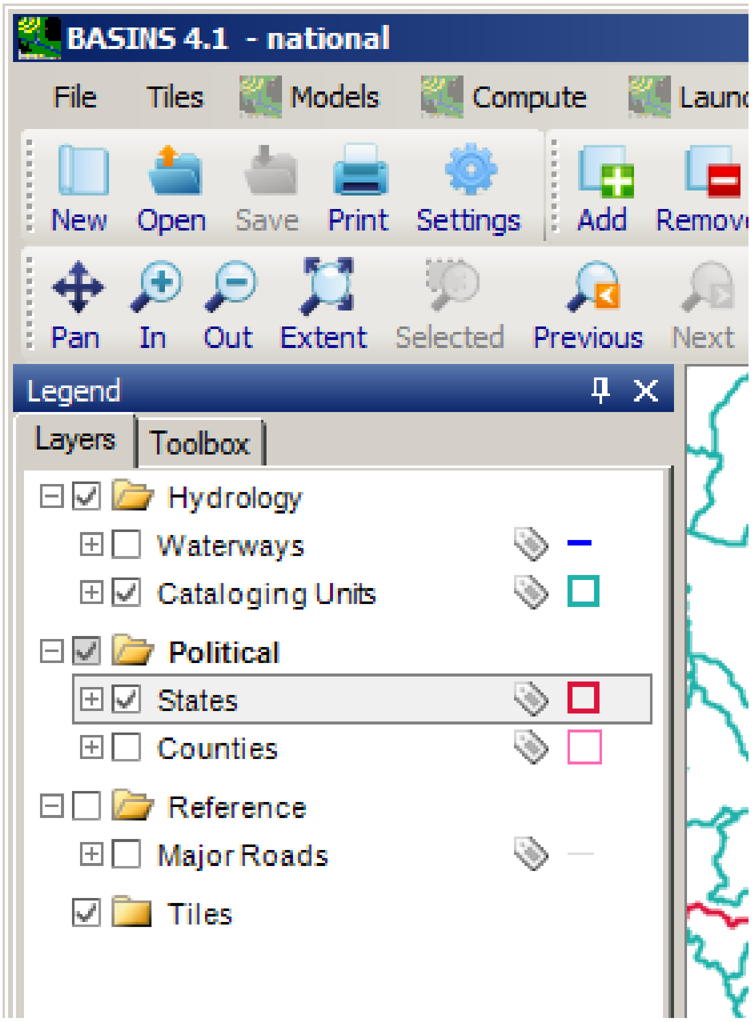
Why is a menu option missing?

- The Plug-ins associated with the menu option is not turned on.

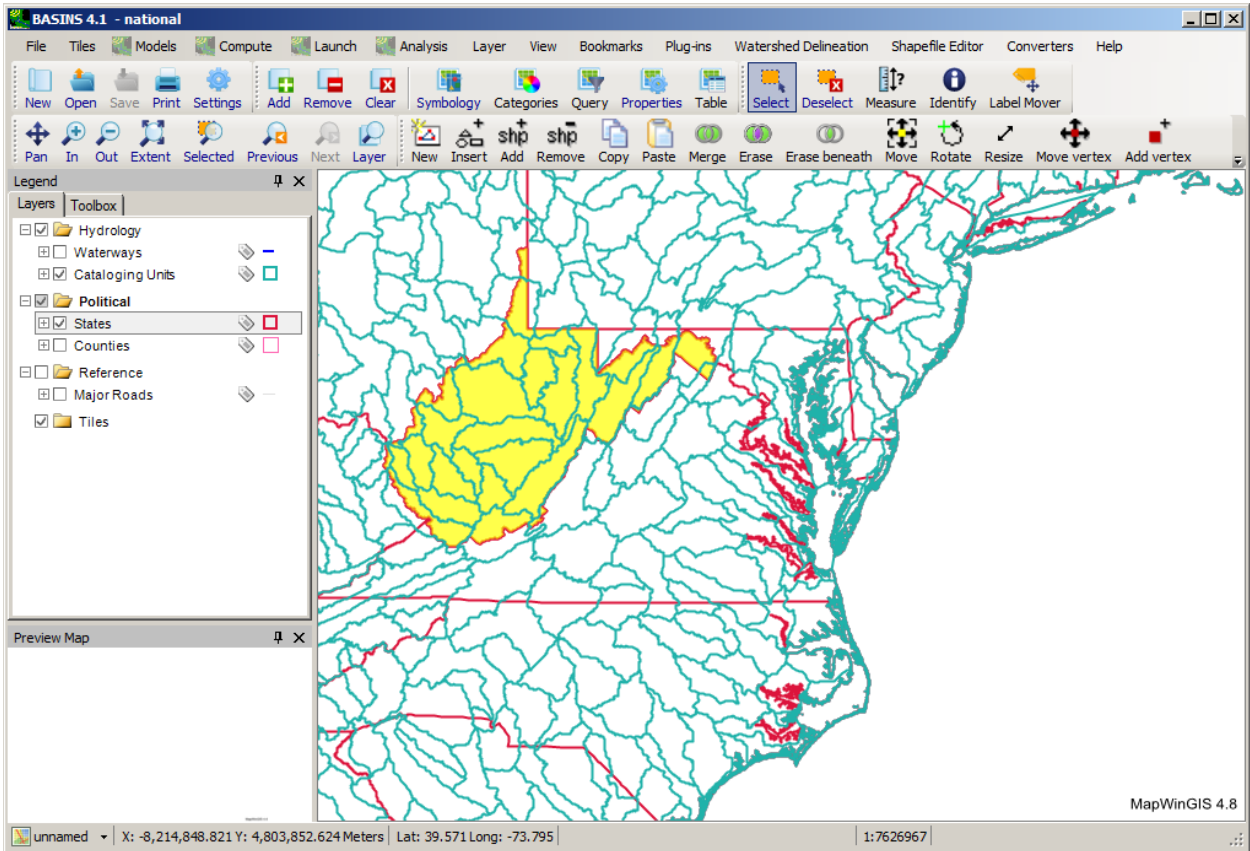
Select Features

How do I select and deselect features?

- On the main BASINS toolbar, click the select icon: 
- Click on the layer name in the **Legend** containing the features you wish to select.

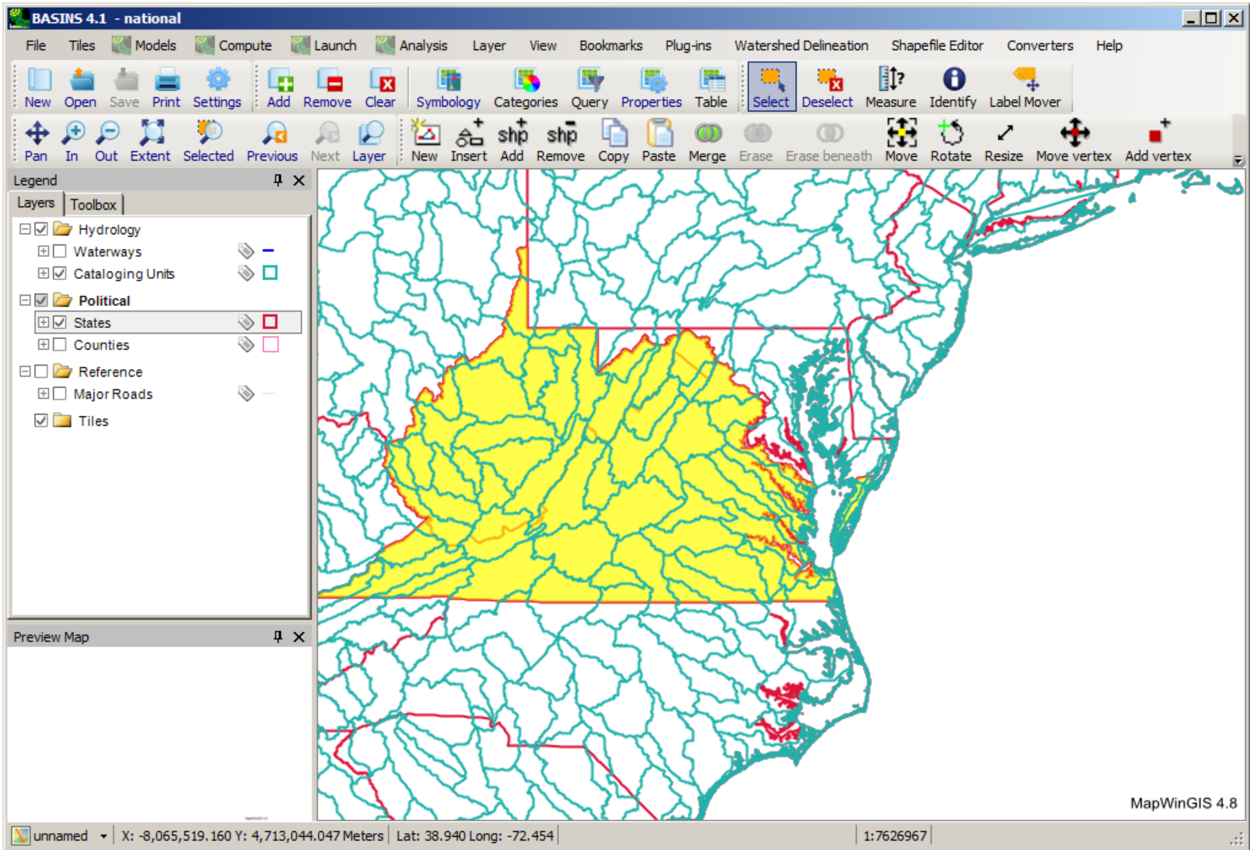


- Then, click any features on the current MapWindow project to select them.



BASINS 4.1 - national
File
Tiles
Models
Compute
Launch
Analysis
Layer
View
Bookmarks
Plug-ins
Watershed Delineation
Shapefile Editor
Converters
Help
New
Open
Save
Print
Settings
Add
Remove
Clear
Symbology
Categories
Query
Properties
Table
Select
Deselect
Measure
Identify
Label Mover
Pan
In
Out
Extent
Selected
Previous
Next
Layer
New
Insert
Add
Remove
Copy
Paste
Merge
Erase
Erase beneath
Move
Rotate
Resize
Move vertex
Add vertex
Legend
Layers
Toolbox
Hydrology
Waterways
Cataloging Units
Political
States
Counties
Reference
Major Roads
Tiles
Preview Map
MapWinGIS 4.8
unnamed
X: -8,214,848.821 Y: 4,803,852.624 Meters
Lat: 39.571 Long: -73.795
1:7626967

- To select more than one feature, hold down the CTRL key while clicking.



- To **deselect** a feature that is already selected, hold the CTRL key while clicking on the feature again.

Import Shapefiles

Users can either import BASINS data that comes with the BASINS software (also detailed in the tutorial), or import their own additional GIS layers (e.g., a study area boundary). Users can import their own shapefile layers using the 'Add layer' tool.

- From the **Layer** menu on the main BASINS window, select **Add Layer**, or click the  button.
- Navigate to the desired layer and click **Open**.
- The layer will be added to the **Legend** and turned on.

References

The following documents are recommended for assistance in watershed and water quality modeling applications.

Ambrose, B, Jr., T.A. Wool, and J.L. Martin, "The Water Quality Analysis Simulation Program, WASP5; Part A: Model Documentation," U.S. Environmental Protection Agency, Center for Exposure Assessment Modeling, Athens, GA, June, 1993.

Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr., T.H. Jobes, and A.S. Donigian, Jr. 2005. Hydrological Simulation Program - Fortran (HSPF). User's Manual for Release 12.2. U.S. EPA National Exposure Research Laboratory, Athens, GA, in cooperation with U.S. Geological Survey, Water Resources Division, Reston, VA.

Evans, B.M., D.W. Lehning, K.J. Corradini, G.W. Petersen, E. Nizeyimana, J.M. Hamlett, P.D. Robillard, R.L. Day, 2002. A comprehensive GIS-based modelling approach for predicting nutrient loads in watersheds. J. Spatial Hydrology 2(2), (www.spatialhydrology.com).

Flanagan, D.C., and S.J. Livingston, (eds.) 1995. WEPP User Summary. NSERL Rep. No. 11. West Lafayette, IN: USDA ARS NSERL.

Flynn K.M., Hummel P., Lumb A., Kittle J.L. 1995. User's Manual for ANNIE, Version 2, A Computer Program for Interactive Hydrologic Data Management. Reston (VA): U.S. Geological Survey. Water-Resources Investigations Report 95-4085.

Haith, D.A. and L.L. Shoemaker, 1987. Generalized Watershed Loading Functions for Stream Flow Nutrients. Water Resources Bulletin, 23(3), pp. 471-478.

Hamon R.W., Weiss L.L., Wilson W.T. 1954. Insolation as an empirical function of daily sunshine duration. Monthly Weather Review, 82(6 June):141-146.

Hamon R.W. 1961. Estimating Potential Evapotranspiration. Proceedings of the American Society of Civil Engineers; Journal of the Hydraulic Division, 87(HY3):107-120.

Hydrocomp. 1977. Hydrocomp Water Quality Operations Manual. Palo Alto (CA): Hydrocomp.

[IPCC-TGCIA] Intergovernmental Panel on Climate Change Task Group on Scenarios for Climate Impact Assessment, prepared by Carter T.R., Hulme M., and Lal M. 1999. Guidelines on the Use of Scenario Data for Climate Impact and Adaptation Assessment, Version 1, 69pp. Available from: http://www.ipcc-data.org/guidelines/ggm_no1_v1_12-1999.pdf

Jensen M.E., Haise H.R. 1963. Estimating evapotranspiration from solar radiation. Proceedings of the American Society of Civil Engineers; Journal of Irrigation and Drainage, 89(IR4):15-41.

Jensen M.E., Rob D.C.N., Franzoy C.E. 1969. Scheduling irrigations usingclimate-crop-soil data. Proceedings of the National Conference on Water Resources Engineering of the American Society of Civil Engineers; 1969 New Orleans. 20 pp.

Kohler M.A., Nordenson T.J., Fox W.E. 1955. Evaporation from Pans and Lakes. Research Paper No. 38, U.S. Weather Bureau.

Lahlou M., Shoemaker L., Paquette M., Bo J., Choudhury S., Elmer R., Xia F. 1996. Better Assessment Science Integrating Point and Nonpoint Sources, BASINS Version 1.0 User's Manual. EPA 823-R-96-001. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

Leavesley, G.H., Lichty, R.W., Troutman, B.M., and Saindon, L.G., 1983, Precipitation Runoff Modeling System: User's Manual, Water Resources Investigations 83-4238, U.S. Geological Survey, Denver, CO.

Lumb A.M., McCammon R.B., Kittle J.L. 1994. Users Manual for an Expert System (HSPEXP) for Calibration of the Hydrological Simulation Program-FORTRAN. Water-Resources Investigations Report 94-4168. Reston (VA): U.S. Geological Survey.

Mearns L.O., Giorgi F., Whetton P., Pabon D., Hulme M., Lal M. 2003. Guidelines for Use of Climate Scenarios Developed from RegionalClimate Model Experiments. Available from: http://www.ipcc-data.org/guidelines/dgm_no1_v1_10-2003.pdf

Mills W.B., Borcella B.B., Ungs M.J., Gherini S.A., Summers K.V., Lingsung M., Rupp G.L., Bowie G.L., Haith D.A. 1985. Water Quality Assessment: A screening procedure for toxic and conventional pollutants in surface and ground water, Parts 1 and 2. EPA 600/6-85/002a,b. Athens (GA): U.S. Environmental Protection Agency, Environmental Research Laboratory.

Neitsch, S. L., A. G. Arnold, J. R. Kiniry, J. R. Srinivasan, and J. R. Williams. 2005. Soil and Water Assessment Tool User's Manual: Version 2005. TR 192. College Station, TX: Texas Water Resources Institute.

Penman H.L. 1948. Natural Evaporation from Open Water, Bare Soil, and Grass. Proceedings of the Royal Society of London, Ser. A, 193(1032):120-145.

Rossman L.A. 2008. Storm Water Management Model User's Manual, Version 5.0. EPA 600/R-05/040. Cincinnati, OH: U.S. Environmental Protection Agency, National Risk Management Research Laboratory.

Shoemaker L., Lahlou M., Bryer M., Kumar D., and Kratt K. 1997. Compendium of Tools for Watershed Assessment and TMDL Development. EPA 841-B-97-006. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

USEPA. 1985. Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling, 2nd ed. EPA 600/3-85/040. Athens(GA): U.S. Environmental Protection Agency, Environmental Research Laboratory.

USEPA. 1997. Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2: Streams and Rivers, Part 1: Biochemical Oxygen Demand/Dissolved Oxygen and Nutrients/Eutrophication. EPA 823-B-97-002. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

Watry G., Ames D.P., Michaelis C. 2007. Introduction to MapWindow Version 4.3. Florida State University Center for Ocean-Atmospheric Prediction Studies. Available from: http://gis.coaps.fsu.edu/FOSS_GIS/Introduction_to_MapWindow_GIS_Ver_4_3.pdf.

Watry G., Ames D.P., Michaelis, C. Introduction to MapWindow Version 4.2. Florida State University Center for Ocean-Atmospheric Prediction Studies. Available from: http://www.mapwindow.org/tutorials/Mapwindow_GIS_lesson02_Fall_2006.pdf.

Wilby R.L., Charles S.P., Zorita E., Timbal B., Whetton P., Mearns L.O. 2004. Guidelines for use of climate scenarios developed from statistical downscaling methods, Supplemental material prepared for consideration by the IPCC at the request of its Task Group on Data and Scenario Support for Impacts and Climate Analysis. Available from: http://ipcc-ddc.cptec.inpe.br/ipccddc/html/guidelines/dgm_no2_v1_09_2004.pdf

Appendix A - GIS Data Dictionary

BASINS is distributed as a downloadable software installation package. When installed, the software links to internet sources of geographic and environmental data for each 8 digit HUC. The BASINS Data Download tool downloads and extracts data that facilitate watershed analysis and modeling. Some of the data downloaded using this tool have been preprocessed for use in BASINS. These data provide a starting point for watershed analysis, but users are encouraged to add additional data sets where locally derived data may be at a higher resolution or compiled more recently. Other data that can be downloaded using the Data Download tool have not been preprocessed and are extracted directly from the agency responsible for collecting the data. Section A.1 shows, in alphabetical order, all the preprocessed BASINS data products with the corresponding layer and related file names that are used to reference the data within the BASINS GIS environment. Section A.2 contains tables listing all field attributes within each data product and their data definitions. More detailed documentation following the Federal Geographic Data Committee (FGDC) metadata standard is available from EPA's National Geospatial Program at http://www.epa.gov/geospatial and https://www.epa.gov/ceam/basins-metadata

A.1 BASINS Preprocessed Data Products

BASINS Data Product	Layer Name	File Name
Bacteria Monitoring Stations & Data Summaries Related Table Names:	Bacteria Stations Bacteria Data 70-74 Bacteria Data 75-79 Bacteria Data 80-84 Bacteria Data 85-89 Bacteria Data 90-94 Bacteria Data 95-97 Bacteria Parameter Table	bac_stat.dbf bac_stat.shp bac_stat.shx bc_d7074.dbf bc_d7579.dbf bc_d8084.dbf bc_d8589.dbf bc_d9094.dbf bc_d9597.dbf bc_parm.dbf
Census	2002 Tiger Nonvisible Feature 2002 Tiger Physical Feature 2002 Tiger Landmark 2000 Block Group 1990 Block Group 2000 County 1990 County 2000 Place 1990 Place 2000 Tract 1990 Tract 2000 Zip Code	(cu)_tgr_f.dbf (cu)_tgr_f.shp (cu)_tgr_f.shx (cu)_tgr_e.dbf (cu)_tgr_e.shp (cu)_tgr_e.shx (cu)_tgr_d.dbf (cu)_tgr_d.shp (cu)_tgr_d.shx (cu)_tgr_bg00.dbf (cu)_tgr_bg00.shp (cu)_tgr_bg00.shx (cu)_tgr_bg90.dbf (cu)_tgr_bg90.shp (cu)_tgr_bg90.shx (cu)_tgr_co00.dbf (cu)_tgr_co00.shp (cu)_tgr_co00.shx (cu)_tgr_co90.dbf (cu)_tgr_co90.shp (cu)_tgr_co90.shx (cu)_tgr_pl00.dbf (cu)_tgr_pl00.shp

		(cu)_tgr_pl00.shx (cu)_tgr_pl90.dbf (cu)_tgr_pl90.shp (cu)_tgr_pl90.shx (cu)_tgr_tr00.dbf (cu)_tgr_tr00.shp (cu)_tgr_tr00.shx (cu)_tgr_tr90.dbf (cu)_tgr_tr90.shp (cu)_tgr_tr90.shx (cu)_tgr_zt00.dbf (cu)_tgr_zt00.shp (cu)_tgr_zt00.shx
Digital Elevation Model Shape	DEM (CU)	(cu).dbf (cu).shp (cu).shx
Digital Elevation Model Grid	DEM (CU-demg)	(cu)demg.tif
EPA Regions	EPA Region Boundaries	epa_reg.dbf epa_reg.shp epa_reg.shx
EPA Ecoregions	Ecoregions (Level III)	ecoreg.dbf ecoreg.shp ecoreg.shx
Hydrologic Unit Boundaries	Accounting Unit Boundaries Cataloging Unit Boundaries Cataloging Unit Codes	acc.dbf acc.shp acc.shx cat.dbf cat.shp cat.shx catpt.dbf catpt.shp catpt.shx
Land Use and Land Cover	Land Use Index L_(USGS Quadrangle Name)	lulcndx.dbf lulcndx.shp lulcndx.shx l_(quad).dbf l_(quad).shp l_(quad).shx
Legacy STORET	Legacy STORET Stations L_(USGS Quadrangle Name)	(cu)_lstoret.dbf (cu)_lstoret.shp (cu)_lstoret.shx
Lookup Tables Related Table Names:	Water Quality Criteria Table State Agency Codes Standard Industrial Classification Codes	wqcriter.dbf storetag.dbf sic.dbf
Major Roads	Major Roads	fhards.dbf fhards.shp fhards.shx
Managed Area Database	Managed Area Database	mad.dbf mad.shp mad.shx
National Elevation Dataset Grid	National Elevation Dataset (CU-ned)	(cu)ned.tif
National Hydrography	National Hydrography Dataset CU	nhd\(cu).dbf nhd\(cu).shp

Dataset		nhd\(cu).shx
National Water Quality Assessment Study Unit Boundaries	NAWQA Study Unit Boundaries	nawqa.dbf nawqa.shp nawqa.shx
Permit Compliance System (PCS) Sites and Computed Loadings Related Table Names:	Permit Compliance System Permitted Discharges Parameter Table Permitted Discharges (cu)	pcs3.dbf pcs3.shp pcs3.shx pcs3_prm.dbf (cu).dbf
Reach File, Version 1 (RF1)	Reach File, V1	rf1.dbf rf1.shp rf1.shx
State and County Boundaries	State Boundaries County Boundaries County Names	st.dbf st.shp st.shx cnty.dbf cnty.shp cnty.shx cntypt.dbf cntypt.shp cntypt.shx
State Soil and Geographic (STATSGO) Database Related Table Names:	State Soil Soil Component Data Soil Layer Data	statsgo.dbf statsgo.shp statsgo.shx statsgoc.dbf statsgol.dbf
Transportation	2002 Tiger Provisional 2002 Tiger Misc Ground 2002 Tiger Railroad 2002 Tiger Road	(cu)_tgr_p.dbf (cu)_tgr_p.shp (cu)_tgr_p.shx (cu)_tgr_c.dbf (cu)_tgr_c.shp (cu)_tgr_c.shx (cu)_tgr_b.dbf (cu)_tgr_b.shp (cu)_tgr_b.shx (cu)_tgr_a.dbf (cu)_tgr_a.shp (cu)_tgr_a.shx
Urbanized Areas	Urban Area Boundaries Urban Area Names	urban.dbf urban.shp urban.shx urban_nm.dbf urban_nm.shp urban_nm.shx
Meteorological Data	Weather Station Sites 2009 Related Data:	met.dbf met.shp met.shx met.wdm

A.2 BASINS Data Product’s Fields and Definitions

Data Product: Bacteria Monitoring Stations & Data Summaries

Layer Name: Bacteria Stations

Field Name	Description
SHAPE_ID	MapWindow internal field
ID	BASINS assigned unique identifier based on station and agency codes

STATION	station code
AGENCY	agency code
LOCATION	description of location
CU	cataloging unit code
SEG	Reach File, V1 segment number
MILEP	Reach File, V1 mile point
ONOFF	on/off reach indicator
COUNTY	county name
STFIPS	state FIPS code
STATE	state postal abbreviation
LONG	longitude
LAT	latitude
TYPE	station type
STCOFIPS	state and county FIPS code
BACID	BASINS assigned number
BCU	BASINS assigned cataloging unit

Data Product: Bacteria Monitoring Stations & Data Summaries

Related Table Name: Bacteria Data 70-74,75-79,80-84,85-89, 90-94,95-97

Field Name	Description
ID	BASINS assigned unique identifier based on station and agency codes
STATION	station code
AGENCY	agency code
BACID	BASINS assigned number
PARAMETER	EPA STORET parameter code

NO OBS	number of observations
MEAN	mean value
A15TH_P	15th percentile value
A25TH_P	25th percentile value
A50TH_P	50th percentile value
A75TH_P	75th percentile value
A85TH_P	85th percentile value
STD	standard deviation
BCU	BASINS assigned cataloging unit

Data Product: Bacteria Monitoring Stations & Data Summaries

Related Table Name: Bacteria Parameter Table

Field Name	Description
PARM_CODE	EPA STORET parameter code
PARM_NAME	parameter name
UNITS	units
SAMPLE_TYP	sample type
UP_REF_LVL	upper reference level
LW_REF_LVL	lower reference level
UNKNOWN	type of standard
REF_LVLSRC	reference level source

Data Product: Digital Elevation Model Shape

Layer Name: DEM (CU)

Field Name	Description

SHAPE_ID	MapWindow internal field
ELEV_M	land surface elevation in meters
ELEV_FT	land surface elevation in feet

Data Product: Digital Elevation Model Grid

Layer Name: DEM (CU-demg)

Field Name	Description
GRIDCODE	Elevation in meters

Data Product: EPA Regions

Layer Name: EPA Regional Boundaries

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
EPA_REG_	ArcInfo internal field
EPA_REG_ID	ArcInfo internal field
EPAREG	U.S. EPA region number
LABEL_REG	U.S. EPA region number (Roman numeral)

Data Product: EPA Ecoregions

Layer Name: Ecoregions (Level III)

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units

PERIMETER	perimeter of polygon in map units
ECOREG_	ArcInfo internal field
ECOREG_ID	ArcInfo internal field
ECO	EPA Ecoregion number
Name	EPA Ecoregion name

Data Product: Hydrologic Unit Boundaries

Layer Name: Accounting Unit Boundaries

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
ACC_	ArcInfo internal field
ACC_ID	ArcInfo internal field
ACC	accounting unit number
NAME	name of accounting unit

Data Product: Hydrologic Unit Boundaries

Layer Name: Cataloging Unit Boundaries

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
TMP_B_	ArcInfo internal field
TMP_B_ID	ArcInfo internal field

CAT_	ArcInfo internal field
CAT_ID	ArcInfo internal field
PLYTYPE	polygon type
HUC	cataloging unit code (numeric)
WORKB	disregard data element
ACC_UNIT	accounting unit code
CU	cataloging unit code (character)
BEXT	BASINS internal field
CRS1	BASINS internal field

Data Product: Hydrologic Unit Boundaries

Layer Name: Cataloging Unit Codes

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
CAT_	MapWindow internal field
CAT_ID	disregard data element
HUC	cataloging unit code (numeric)
ACC	accounting unit code
NAME	name of cataloging unit
CU	cataloging unit code (character)
BEXT	BASINS internal field
CRS1	BASINS internal field

Data Product: Land Use and Land Cover

Layer Name: Land Use Index

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
LULCNDX#_	MapWindow internal field
LULCNDX#_I	disregard data element
COVERNAME	coverage name
COVNAME	alternate coverage name
QNAME	quadrangle name
EPA_REG	U.S. EPA region number
CREATE_DAT	date coverage was created
VERIFY_DAT	date coverage was verified
COMMENT1	comments concerning the coverage

Data Product: Land Use and Land Cover

Layer Name: L_(USGS Quadrangle Map Name, e.g., L_BANGME)

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
L_(QUAD)_	MapWindow assigned polygon ID
L_(QUAD)_I	disregard data element
LUCODE	Anderson level I land use code
LEVEL2	Anderson level II land use code

Data Product: Legacy STORET

Layer Name: Legacy STORET Stations

Field Name	Description
SHAPE_ID	MapWindow internal field
Agency	Agency code
Station	Station code
Station Na	Station name
FIPS	Federal information processing standard code
Latitude	Latitude in decimal degrees
Longitude	Longitude in decimal degrees
HUC	Hydrologic unit code
Rchmile Se	Unknown
Miles Up R	Unknown
Rchonoff	Unknown
Rchname	Reach name
Station Al	Unknown
Station Ty	Station type
Station De	Unknown
Depth Unit	Unknown
Surface Gr	Unknown
Descriptio	Unknown

Data Product: Lookup Tables

Related Table Name: Water Quality Criteria Table

Field Name	Description

PARM_CODE	EPA STORET parameter code
CAS_NUMBER	Chemical Abstract Service number
PARM_NAME	parameter name
SAMPLE_TYP	sample type
UNITS	units
FRES_ACUTE	threshold value (standard) for acute freshwater
FRES_CHRON	threshold value (standard) for chronic freshwater
MARI_ACUTE	threshold value (standard) for acute marine
MARI_CHRON	threshold value (standard) for chronic marine
HHPC_WATER	threshold value (standard) for human health (published criteria) in water
HHPC_ORGAN	threshold value (standard) for human health (published criteria) in organic tissue
HHRV_WATER	threshold value (standard) for human health (recalculated value) in water
HHRV_ORGAN	threshold value (standard) for human health (recalculated value) in organic tissue
DR_WTR_MCL	drinking water maximum contaminant level
UNKNOWN	Related unknown
REF_LVL_SRC	reference level source

Data Product: Lookup Tables

Related Table Name: STORET Agency Codes

Field Name	Description
AGENCY	agency code
PROGRAM	name of program
CONTACT	contact person
PHONE	telephone number

Data Product: Lookup Tables

Related Table Name: Standard Industrial Classification Codes

Field Name	Description
SIC_1987	1987 Standard Industrial Classification (SIC) code
SIC_NAME	SIC name
NAICS_1997	1997 North American Industry Classification System (NAICS) code
NAICS_NAME	NAICS name

Data Product: Major Roads

Layer Name: Major Roads

Field Name	Description
SHAPE_ID	MapWindow internal field
FNODE_	ArcInfo internal field
TNODE_	ArcInfo internal field
LPOLY_	ArcInfo internal field
RPOLY_	ArcInfo internal field
LENGTH	length of line segment in coverage units
FHARDS_	ArcInfo internal field
FHARDS_ID	ArcInfo internal field
RECTYPE	character which defines type of file from dataset
VERSION	file version number
RECID	unique line identification number
SOURCE	flag used to identify original source of coordinate information
STFIPS	two-digit state FIPS code
CTFIPS	three-digit county FIPS code
ORNL_ID	Oakridge National Laboratory assigned identifier

LGURB	large urbanized area
SMURB	adjusted small urban area
FNODE	record in node file that corresponds to starting position of link
TNODE	record in node file that corresponds to ending position of link
SIGN1	primary sign route
SIGN2	alternate sign route
SIGN3	alternate sign route
LNAME	name or identification for the link
MILES	accurate measurement in miles of link chain
KM	accurate measurement in kilometers of link chain
FACTYPE	permissible flow of traffic over the link
TOLL	links with one or more toll features
LANES	number of lanes in both directions
ACONTROL	degree of access control to link from adjoining roads
MEDIAN	type of median
SURFACE	predominant surface
FCLASS	assigned functional class of each link
ACLASS	administrative class associated with the link
RUCODE	rural/urban classification
STATUS	availability of link to through traffic
NHS	subnetwork for proposed National Highway System
STRAHNET	special subnetwork for Strategic Highway Corridor Network
TRANSAM	special subnetwork for the Trans-America Corridor

Data Product: Managed Area Database

Layer Name: Managed Area Database

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	degenerate area of point in map units
PERIMETER	degenerate perimeter of point in map units
MAD_POLY_ID	ArcInfo internal field
MAD_POLY_ID	ArcInfo internal field
SITE_CODE	unique number for each area for database relations
SITE_CODE2	unique number for each area for database relations
SITE_CODE3	unique number for each area for database relations
AREANAME	proper name of each managed area represented
AREANAME2	alternate name of each managed area represented
AREANAME3	alternate name of each managed area represented
CMCCODE	unused WCMC variable
LAT	latitudinal location
LONG	longitudinal location
ISLATLON	unused WCMC variable
DESIGNATE	designation type for each managed area
DESIGNATE2	designation type for each managed area
DESIGNATE3	designation type for each managed area
LUCNCAT	code used by WCMC representing level of protection status for each designation type
LUCNCAT2	code used by WCMC representing level of protection status for each designation type
LUCNCAT3	code used by WCMC representing level of protection status for each designation type
GAPCAT	level of management based on GAP program
GAPCAT2	level of management based on GAP program
GAPCAT3	level of management based on GAP program

SIZE	area size as published by WCMC
YEAR	year of area establishment as published by WCMC
REALM	unused WCMC variable
PROVINCE	unused WCMC variable
BIOME	unused WCMC variable
STATE	state in which area is located
SOURCE	map source where the polygon borders were taken
AVSORT	condensed list of management designations

Data Product: National Elevation Dataset Grid

Layer Name: National Elevation Dataset

Field Name	Description
GRIDCODE	Elevation in centimeters

Data Product: National Hydrography Dataset

Layer Name: National Hydrography Dataset CU

Field Name	Description
SHAPE_ID	MapWindow internal field
RCH_	Internal field
RCH_ID	Internal field
COM_ID	Common identifier
RCH_CODE	Numeric code that uniquely identifies a reach
RCH_DATE	Date that the RCH_CODE was assigned
LEVEL	Stream level
METERS	Reach length in meters

GNIS_ID	Unique ID assigned by Federal GNIS
NAME	Reach name
RCHID	Reach ID
DSRCHID	Downstream Reach ID

Data Product: National Water Quality Assessment Study Unit Boundaries

Layer Name: NAWQA Study Unit Boundaries

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
NAWQA_DD_	ArcInfo internal field
NAWQA_DD_ID	Arcinfo internal field
NAWQA	NAWQA study unit number
NAME	river basin name
GROUP	group number
PILOT	pilot code
ABBV	river basin name abbreviation
CANADA	code to designate study units that crosses Canadian boundary
MI2	area in square miles
RANK	rank
REGION	region designation (northeastern, southeastern, central, western US)

Data Product: PCS Sites and Computed Loadings

Layer Name: Permit Compliance System

Field Name	Description
SHAPE_ID	MapWindow internal field
NPDES	PCS unique ID copied from attribute ID
FAC_NAME	name of the facility or site
OWNERSHIP	three-digit code describing ownership classification
NEW_STATUS	New Source/New Discharge, indicates a new facility with no previous discharge permit
STREAM_CLS	facility Receiving Stream Classification
NEW_DATE	new source/new discharge date (mmddyy)
PRETREAT	indicates if the permitted municipality is required to develop a pretreatment program
FAC_UPDATE	facility last update date (mmddyy)
REC_POTW	receiving POTW ID - Municipal POTWs that receive discharge from Industrial Users to be monitored by PPETS
PCS_LAT	latitude, from PCS database, of facility, site, or operable unit
PCS_LONG	longitude, from PCS database, of facility, site, or operable unit
LATLONG_AC	technical accuracy of the latitude and longitude data
EF_LAT	latitude based on data from USEPA's Envirofacts Locational Reference Tables (LRT)
EF_LONG	longitude based on data from USEPA's Envirofacts Locational Reference Tables (LRT)
EF_ACC_M	technical accuracy of latitude and longitude data in meters
BLAT	latitude based on best available data
BLONG	longitude based on best available data
BFIPS	FIPS (state and county code) on best available data
STATE_ID	State Permit Number to identify or classify the state's permit
PERM_TYPE	identifies standard permits, general permit, and non-permitted National Pollutant Discharge Elimination System (NPDES) facilities
ACTIVE	code which indicates whether facility is currently active
MAJOR_ID	major or minor discharger code

SIC2	four-digit code for the principal activity causing the discharge at the facility as defined by the 1987 Standard Industrial Classification (SIC) Manual
SIC2D	description of SIC code
IND_CLASS	industrial classification of the facility
EPA_REG	two-digit code, 01 through 10, used to identify the EPA Region in which the facility is located
STATE	two-character alphabetic state code as defined by the Federal Information Processing Standards (FIPS)
CITY	name of city or town where facility is located
COUNTY	name of county where facility is located
LOC_NAME	name of entity located at the facility's physical address
ADDRESS1	street address of entity
ADDRESS2	street address of entity
FAC_CITY	name of the mailing city or town of the facility
FAC_STATE	state or territory code in which the facility is physically located
ZIP_CODE	zip code of the address of the physical location of the facility
TELE	telephone number of the facility
RIV_BASIN	major/minor river basin name
CU	facility Hydrologic Unit Code - 8-digit code assigned USGS
STREAM_SEG	four-character code assigned for facilities by EPA to identify stretches of water from one significant event to another, where significant event represents the mouth of a body of water, the confluence of two streams, etc
REC_WATER	name of water body into which the effluent is discharged
STREAM_MIL	five-character field giving the length of a particular facility stream segment in miles downstream from the beginning of the stream segment
PERM_AGENC	type of Permit issued - indicator whether EPA or state
LIMIT_ID	facility is considered to be on final effluent limits when the permittee has completed all necessary construction to achieve the ultimate effluent limitation in the permit reflecting secondary treatment, best practicable control technology (BPT), best available technology (BAT), or more stringent limitations, such as state required

	limitations or water quality-based limitations, or less stringent limitations established by a variance or a waiver
BSOURCE	source of LAT/LONG data, either EF or PCS
FLOW_RATE	average flow facility designed to accommodate in million gallons/day
BSEG	three-digit stream segment identifier
PERM_ISSUE	date (mmddyy) current permit was issued/signed
INACTIVE	date (mmddyy) on which facility become inactive or active
PERMIT_DAT	date (mmddyy) current permit was issued/signed
PERMIT_EXP	date (mmddyy) current permit will expire
PERMIT_EFF	permit effective date (mmddyy)
PERMIT_MOD	permit modification date (mmddyy)
BCU	cataloging unit assigned from ArcView spatial join with USGS CU
EFF_GUIDE	Effluent Limitation Guidelines (ELG) for the facility
MAJOR_STAT	previous status - indicates the last change and the current value of the major rating status
APP_TYPE	type of application form the facility submit

Data Product: PCS Sites and Computed Loadings

Related Table Name: Permitted Discharges (cu)

Field Name	Description
PARM	five digit parameter code - usually the STORET parameter code; however, for toxicity testing parameters, it is a PCS-devised parameter code
NPDES	nine character code used to uniquely identify a permitted NPDES facility
YEAR	year for which the loading was reported
CONC	concentration of loading (lbs/year)
FLOW	conduit based flow at the facility for reported year (MGD)
LOAD	estimated loading calculated with remarked data set to detection limit (lb/year)

CONC_FW	flow-weighted concentration of loading
ERROR	standard error of loadings
MONTH	number of months with loadings report

Data Product: PCS Sites and Computed Loadings

Related Table Name: Permitted Discharges Parameter Table

Field Name	Description
PARM	five-digit parameter code - usually the STORET parameter code; however, for toxicity testing parameters, it is a PCS-devised parameter
PARM_NAME	parameter name
NUM_NPID	number of PCS Facilities that contain this PARM
TOTAL_OBS	total number of observations/measurements of this PARM

Data Product: Reach File, Version 1 (RF1)

Layer Name: Reach File, V1

Field Name	Description
SHAPE_ID	MapWindow internal field
HUC	cataloging unit code
FNODE_	ArcInfo internal field
TNODE_	ArcInfo internal field
LPOLY_	ArcInfo internal field
RPOLY_	ArcInfo internal field
LENGTH	ArcInfo internal field
RF1_	ArcInfo internal field
RF1_ID	ArcInfo internal field
SEG	reach segment number

MILEPT	indicates the beginning of the reach
SEQNO	reach sequence number
RFLAG	reach flag “1” is a stream reach
OWFLAG	open water flag “1” is a open water reach
TFLAG	terminal reach flag “1” is a terminal reach
SFLAG	start reach flag “1” is a start reach
TYPE	reach segment type
SEGL	length of the reach in miles
LEV	reach level order
J	reach junction number
K	reach divergence number
PMILE	path mile
ARBSUM	mileage distance upstream from the stream discharge
USDIR	upstream reach direction
TERMID	terminal stream system ID
TRMBLV	terminal base level
PNAME	primary reach name
PNMCD	primary name code
OWNAME	open water name
OWNMCD	open water name code
DSHUC	downstream cataloging unit number
DSSEG	downstream reach segment number
DSMLPT	downstream mile point
MNFLOW	mean flow in the reach in cfs
SVTNFLOW	seven/ten low flow in the reach in cfs

MNVELO	stream velocity in the reach at mean flow in ft/s
SVTNVELO	stream velocity in the reach at seven/ten low flow in ft/s
RIVRCH	reach number
CU	cataloging unit
DESSEQ	downstream segment number
USSEQ	upstream segment number
USDIR	upstream reach direction (L or R)
DSCSM	downstream CU, segment, mile point
CCSM	complement CU, segment, mile point
CDIR	complement bank direction
ULCSM	upstream left CU, segment, mile point
URCSM	upstream right CU, segment, mile point
MDLAT	midpoint latitude
MDLONG	midpoint longitude
PSNPDAT	date of snapshot (yymm); zero if current
PLOWFL	stream-only low flow in cfs
PMEANFL	stream-only mean flow in cfs
PTOPELE	top of reach elevation in feet
PBOTELE	bottom of reach elevation in feet
PSLOPE	slope: NOT DERIVED from elevations
PDEPTH	mean depth (feet)
PWIDTH	mean width (feet)
PTEMP	mean temperature in Celsius
PPH	mean pH
PLOWVEL	total low-flow velocity in cfs

PK1	CBOD decay rate constant (if known)
PK2	reaeration rate constant (if known)
PK3	NH3 decay rate constant (if known)
PMANN	“Roughness” coefficient (if known)
PSOD	sediment oxygen demand in mg/L
PBGDO	background DO in mg/L
PBGNH3	background NH3 in mg/L
PBGBOD5	background CBOD in mg/L
PBGNBOD	background NBOD in mg/L

Data Product: State and County Boundaries

Layer Name: State Boundaries

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
ST_	ArcInfo internal field
ST_ID_	ArcInfo internal field
ST	state name abbreviation
EPAREG	state region

Data Product: State and County Boundaries

Layer Name: County Boundaries

Field Name	Description
SHAPE_ID	MapWindow internal field

AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
CNTY_	ArcInfo internal field
CNTY_ID	ArcInfo internal field
FIPS	county FIPS code
ST	state postal abbreviations
CNTYNAME	county name
PLYTYPE	polygon type
WORKB	BASINS internal field
STCOFIPS	state and county FIPS code
BEXT	BASINS internal field

Data Product: State and County Boundaries

Layer Name: County Names

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
TMP_B_	ArcInfo internal field
TMP_B_ID	ArcInfo internal field
CNTY	ArcInfo internal field
CNTY_ID	ArcInfo internal field
FIPS	county FIPS code
ST	state postal abbreviations
CNTYNAME	county name

PLYTYPE	polygon type
WORKB	BASINS internal field
STCOFIPS	state and county FIPS code
BEXT	BASINS internal field

Data Product: State Soil and Geographic (STATSGO) Database

Layer Name: State Soil

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
MUID	map unit identification symbol created by concatenation of state FIPS code and a three-digit Arabic number

Data Product: State Soil and Geographic (STATSGO) Database

Related Table Name: Soil Component Data

Field Name	Description
MUID	map unit identification symbol created by concatenation of state FIPS code and a three-digit Arabic number
SEQNUM	identifies sequence of components in a map unit
MUIDSEQNUM	concatenation of MUID and sequence number
COMPNAME	soil series name associated with component or sequence number
S5ID	soil interpretation record
COMPPCT	percentage of the component of the map unit
SLOPEL	minimum value for range of slope of a soil component in percent
SLOPEH	maximum value for range of slope of a soil component in percent

SURFTEX	surface layer soil texture using USDA codes
ANFLOOD	annual flooding frequency
WTDEPL	minimum value for range in depth to water table in feet
WTDEPH	maximum value for range in depth to water table in feet
WTKIND	type of water table
ROCKDEPL	minimum value for range in depth to bedrock in inches
ROCKDEPH	maximum value for range in depth to bedrock in inches
HYDGRP	soil hydrologic group
DRAINAGE	soil drainage class identifying natural drainage condition of the soil
HYDRIC	hydric soil rating
CLNIRR	non-irrigated capability class
CLIRR	irrigated capability class
PRIMFML	prime farmland classification

Data Product: State Soil and Geographic (STATSGO) Database

Related Table Name: Soil Layer Data

Field Name	Description
MUID	map unit identification symbol created by concatenation of state FIPS code and a three-digit Arabic number
SEQNUM	identifies sequence of components in a map unit
MIEDSEQNUM	concatenation of MUID and sequence number
S5ID	soil interpretation record
LAYERNUM	identifies sequence in the soil profile
LAYDEPL	depth to upper boundary of soil layer or horizon in inches
LAYDEPH	depth to lower boundary of soil layer or horizon in inches
TEXTURE1	USDA soil texture class for specified layer

TEXTURE2	USDA soil texture class for specified layer
TEXTURE3	USDA soil texture class for specified layer
KFACT	soil erodibility factor
KFFACT	soil erodibility factor, rock fragments free
TFACT	soil loss tolerance factor
WEG	wind erodibility group
NO200L	percent passing sieve no. 200-minimum value
NO200H	percent passing sieve no. 200-maximum value
CLAYL	percent clay-minimum value
CLAYH	percent clay-maximum value
LLL	minimum percent liquid limit
LLH	maximum percent liquid limit
PIL	minimum percent plasticity limit
PIH	maximum percent plasticity limit
UNIFIED1	Unified Engineering Classification (1)
UNIFIED2	Unified Engineering Classification (2)
UNIFIED3	Unified Engineering Classification (3)
UNIFIED4	Unified Engineering Classification (4)
AASHTO1	ASSHTO Engineering Classification (1)
AASHTO2	ASSHTO Engineering Classification (2)
AASHTO3	ASSHTO Engineering Classification (3)
AASHTO4	ASSHTO Engineering Classification (4)
AWCL	low available water capacity (in/in)
AWCH	high available water capacity (in/in)
BDL	low bulk density (g/cc)

BDH	high bulk density (g/cc)
OML	minimum percent organic matter
OMH	maximum percent organic matter
PHL	minimum pH value
PHH	maximum pH value
SALINL	minimum salinity value (mmhos/cm)
SALINH	maximum salinity value (mmhos/cm)
SARL	minimum sodium absorbtion ratio
SARH	maximum sodium absorbtion ratio
CECL	lower cation exchange capacity
CECH	higher cation exchange capacity
CACO3L	minimum percent calcium carbonate
CACO3H	maximum percent calcium carbonate
GYPSUML	minimum percent sulfate
GYPSUMH	maximum percent sulfate
PERML	minimum permeability (in/hr)
PERMH	maximum permeability (in/hr)
SHRINKSW	shrink-swell potential upon drying and wetting

Data Product: Urbanized Areas

Layer Name: Urban Area Boundaries

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units

TMP_B_	ArcInfo internal field
TMP_B_ID	ArcInfo internal field
POLY_	ArcInfo internal field
POLY_ID	ArcInfo internal field
RINGS_OK	ArcInfo internal field
RINGS_NOK	ArcInfo internal field
URBAN_	ArcInfo internal field
URBAN_ID	ArcInfo internal field
CITYNAME	urbanized area name

Data Product: Urbanized Areas

Layer Name: Urban Area Names

Field Name	Description
SHAPE_ID	MapWindow internal field
AREA	area of polygon in map units
PERIMETER	perimeter of polygon in map units
TMP_B_	ArcInfo internal field
TMP_B_ID	ArcInfo internal field
ANAME_	ArcInfo internal field
UANAME_ID	ArcInfo internal field
UA_CODE	unique code for the urbanized area
CITYNAME	urbanized area name

Data Product: Meteorological Data

Layer Name: Weather Station Sites 2009

Field Name	Description
SHAPE_ID	MapWindow internal field
DSN	WDM data set position
LOCATION	location code
STANAM	weather station name
LATITUDE	latitude of weather station in decimal degrees
LONGITUDE	longitude of weather station in decimal degrees
CONSTITUENT	constituent type code
STARTDATE	data of first record in WDM file
ENDDATE	date of last record in WDM file
COUNT	count of data values

Appendix B - Weather Data Files (WDM) Distributed Prior to Version 4.0

Nonpoint source modeling using BASINS requires the development of a Watershed Data Management (WDM) file. The WDM file is a binary file containing time-series data for all meteorological parameters required by Hydrological Simulation Program - FORTRAN (HSPF) algorithms. Section B.1 provides a summary of the general procedure required to develop WDM files. Section B.2 provides a description of the specific procedures followed during the development of the WDM files provided with BASINS Version 2.0. Section B.2.1 provides a list of coverages used in the BASINS WDM files development and Section B.2.2 provides a list of the available weather stations in these files. **Note:** The WDM files referenced in this appendix are those distributed with earlier versions of BASINS. These files have been updated for BASINS 4.0.

B.1 Developing WDM Files

- Obtain meteorological data for the desired period. (See Section B.2 for meteorological data sources used in the BASINS 2.0 - 3.1 WDM files.) BASINS requires data collected at hourly intervals for nonpoint source modeling, although daily data can be converted to hourly data through the use of *WDMUtil*. If all meteorological parameters are not available, *WDMUtil* can be used to calculate a number of parameters, including potential evapotranspiration, evaporation, and solar radiation. See the Meteorological Data Transformations section of the *WDMUtil* manual for details on disaggregating daily data to hourly and calculating meteorological parameters. BASINS currently supports the use of standard U.S. units. The required input data and units are as follows:

Data Description	U.S. Units
Measured air temperature	deg. F
Measured precipitation	in/hr
Measured dewpoint temperature	deg. F
Measured wind movement	mph
Measured solar radiation	Ly/hr
Cloud cover (range: 0-10)	tenths
Potential evapotranspiration	in/hr
Potential surface evaporation	in/hr

- Using the *WDMUtil* program, either create a new, or open an existing, WDM file. Using the Import feature of *WDMUtil*, read the meteorological data into WDM data sets. For details on these steps see the Data Access and Selection section of the *WDMUtil* manual.

- Perform quality assurance checks on imported meteorological data. Due to the nature of the *HSPF* model, every parameter but measured precipitation must have a value for each record during the entire time period of the file. For measured precipitation, a value must be present for every hour of each day precipitation was recorded. If data are missing, appropriate values must be assigned. The Summarize Data function in *WDMUtil* identifies and reports missing data values for WDM data sets.

B.2 BASINS WDM Files

WDM files, providing meteorological coverage for the United States and U.S. territories were prepared for BASINS 2.0 - 3.1 through the following steps:

- Data were obtained from the following sources.
- Hourly observed precipitation data for the United States and U.S. territories were obtained from the National Climatic Data Center (NCDC) Hourly and Fifteen Minute Precipitation database, compiled by EarthInfo, Inc. This four CD-ROM data set contains precipitation data from NCDC's TD-3240 file. Included in the database are over 6000 weather stations with recorded precipitation for the general period of 1948-1995.
- Hourly surface observation data for the United States and U.S. territories were obtained from NCDC's Solar and Meteorological Surface Observational Network (SAMSON) and Hourly U.S. Weather Observations 1990-1995 (HUSWO) databases. SAMSON is a three CD-ROM data set containing both observational and modeled hourly solar radiation data, as well as hourly cloud cover, drybulb temperature, dewpoint temperature, and wind movement data from 237 NWS stations for the period of 1961-1990. The HUSWO data set, contained on a single CD-ROM, updates meteorological data from the SAMSON data set, excluding solar radiation data for the period of 1990-1995.
- The remaining parameters potential evapotranspiration, evaporation, and solar radiation (for the period of 1991-1995) were calculated using METCMP.
- A coverage of WDM weather stations for BASINS 2.0 was created in ArcView using latitude and longitude coordinates from selected weather stations included in NCDC's Hourly and Fifteen Minute Precipitation database. These stations, which included the precipitation data, were then assigned meteorological data from the set of NWS stations available from the SAMSON data set. The selection of weather stations used to create the WDM station coverage, as well as the assignment of meteorological data to these stations, was performed in ArcView using an array of GIS coverages. This was done to provide a spatially distributed coverage of the United States and U.S. territories, based on information relating to annual rainfall, climatic divisions in the conterminous United States, completeness of weather station data, elevation, physical divisions in the conterminous United States, and proximity to NWS stations. A complete list of the ArcView coverages used in the selection of WDM weather stations is detailed in B.2.2.a. The resulting ArcView coverage consisted of 477 WDM weather stations for the United States and U.S. territories. This coverage was then divided by EPA regions. EPA regional coverage included WDM weather stations that closely

bordered the region or were contained within HUCs intersecting the region. A complete list of the WDM stations is included in B.2.2.b.

- The data were extracted and converted into a sequential time-series format.
- Hourly precipitation data were extracted from the EarthInfo, Inc., NCDC Hourly and Fifteen Minute Precipitation database by exporting data for individual stations into ASCII tabular formatted files. These raw data were then preprocessed through a FORTRAN program for conversion to a sequential file format. Missing precipitation data were assigned appropriate values. A value of 0.0 was normally used where no reading was available. Preprocessing also included the identification and editing of rainfall accumulation values within the file. Rainfall accumulation values occurred where hourly precipitation values for a time period were not recorded. The following assumptions and corresponding actions refer to rainfall accumulation data.
- If an accumulation value was recorded for an accumulation period of 24 hours, then the accumulation value was divided by the number of hours in the period.
- If the resulting hourly value was 0.01 in. and.TXT).
- If the resulting hourly value was.TXT).
- If the resulting hourly value was 2.0 in., then each hour in the accumulation period was given a value of 0.0 in. The accumulation value is additionally deleted from the record. This prevented the existence of a large spike precipitation value in the data (which in all situations was 4.0 in. for the accumulation period). The state code and station identifier number, the accumulation period end date and hour, accumulation value, number of hours in the accumulation period, and "Calculated Value > 2.0, Accumulated Value Deleted" were listed in a text file (BASINS\DATA\MET-DATA\.TXT).
- If an accumulation value was recorded for an accumulation period of > 24 hours, then the accumulation value was not distributed evenly over the accumulation period.
- If the accumulation value was 24 hrs and Observed Value.TXT).
- If the accumulation value was 2.0 in., then the value was deleted from the record. The state code and station identifier number, the accumulation period end date and hour, accumulation value, number of hours in the accumulation period, and "Accumulation Interval > 24 hrs and Observed Value > 2 Accumulated Value Deleted" were listed in a text file (BASINS\DATA\MET-DATA\.TXT).

Hourly meteorological data were extracted from NOAA's Solar and Meteorological Surface Observational Network (SAMSON) database by exporting the yearly data files for an individual station from a CD ROM and unzipping them into an ASCII text file. These raw data were then preprocessed through a FORTRAN program to organize the data into a sequential time-series format, convert the data into U.S. units, and calculate daily variables required by METCMP for the estimation of Solar Radiation (for the years 1991-95), Pan Evaporation, and Potential Evapotranspiration.

Hourly data files included:

- ATEM - average hourly air temperature
- WIND - average hourly wind speed
- SOLR - total hourly solar radiation
- DEWP - average hourly dew point temperature
- CLOU - average hourly cloud cover

Daily data files included:

- TMAX - maximum daily air temperature
- TMIN - minimum daily air temperature
- DWND - total daily wind movement
- DSOL - total daily solar radiation
- DPTP - average daily dew point temperature
- DCLO - average daily cloud cover

Due to the nature of the data, missing data was assigned the previously recorded value.

Data conversions included:

- ATEM and DEWP from C to F
- WIND from m/s to mph
- SOLR from Wh/m2 to Langleys (calories/cm2)

Data calculations included:

- TMAX from ATEM
- TMIN from ATEM
- DCLO from CLOU
- DPTP from DEWP
- DSOL from SOLR
- DWND from WIND

WDM files were created using the import capabilities of *HSPF*. The WDM files allocated 20 data set fields relating to specific meteorological parameters for each WDM station. The following list displays data sets and a brief description of the information contained in each data set, for a template WDM file used to import both hourly and daily data sets for 10 WDM stations.

Data set Fields	Data set	Data set Numbers	Description Parameter
1	PREC	(11,31,51,...191)	hourly precipitation
2	EVAP	(12,32,52,...192)	hourly evaporation
3	ATEM	(13,33,53,...193)	hourly temperature
4	WIND	(14,34,54,...194)	hourly windspeed
5	SOLR	(15,35,55,...195)	hourly solar radiation
6	PEVT	(16,36,56,...196)	hourly potential evapotranspiration
7	DEWP	(17,37,57,...197)	hourly dewpoint temperature
8	CLOU	(18,38,58,...198)	hourly cloud cover
9	TMAX	(19,39,59,...199)	daily maximum temperature
10	TMIN	(20,40,60,...200)	daily minimum temperature
11	DWND	(21,41,61,...201)	daily windspeed
12	DCLO	(22,42,62,...202)	daily cloud cover
13	DPTP	(23,43,63,...203)	daily dewpoint temperature

14	DSOL	(24,44,64,...204)	daily solar radiation
15	DEVT	(25,45,65,...205)	daily evapotranspiration
16	DEVP	(26,46,66,...206)	daily evaporation
17		(27,47,67,...207)	empty
18		(28,48,68,...208)	empty
19		(29,49,69,...209)	empty
20		(30,50,70,...210)	empty

Once time-series data for precipitation and other meteorological data were imported into WDM file data sets, additional meteorological time-series data were created. This was done using METCMP (computer program for meteorological data generation - *HSPF*). METCMP enables a user to calculate additional meteorological time-series data required by *HSPF* algorithms, as well as disaggregate daily time-series data into hourly time-series data for certain meteorological parameters.

- Daily solar radiation for the period 1991-1995 was computed in METCMP using daily cloud cover (DCLO) as an input. The daily solar radiation time-series was placed in the DSOL data set. The METCMP disaggregate function then was used to distribute daily solar radiation into hourly values. Hourly solar radiation values were placed in the SOLR data set.

- Daily pan evaporation was computed using the Penman Method in METCMP. Required inputs were: daily maximum (TMAX) and daily minimum (TMIN) temperatures, daily dewpoint temperature (DPTP), daily wind movement (DWND), and daily solar radiation (DSOL). Daily evapotransporation was placed in the DEVP data set. Daily evaporation was distributed into hourly values using the disaggregate function. Hourly evaporation values were placed in the EVAP data set.

- Daily potential evapotranspiration was computed using the Hamon Method in METCMP. Required inputs were: daily maximum (TMAX) and daily minimum (TMIN) temperatures. Daily evapotranspiration was placed in the DEVT data set. Daily potential evapotranspiration was distributed into hourly values using the disaggregate function. Hourly potential evapotranspiration values were placed in the PEVT data set.

B.2.1 Coverages used in BASINS WDM File Development

- A coverage of cooperative network stations from NCDC's Hourly and Fifteen Minute Precipitation database data set created using latitude and longitude coordinates. The information in this coverage includes:

Station ID#	a cooperative network index number between 1-9999.
State	the state's 2-digit postal code.
Station name	NCDC's assigned station name.
Begin date	first month, day, and year of the period of record.
End date	last month, day, and year of the period of record.
Elevation	meters above sea level (this was converted to feet).
Latitude	
in degrees and minutes (always North) (this was converted to decimal degrees).	
Longitude	in degrees and minutes (always west) (this was converted to decimal degrees).
Recorded years	the number of years with recorded data (there may be gaps).
Percent coverage	percent of the days between begin and end dates that have reported data.
Precipitation data	a column denoting the database containing the hourly precipitation data.
Relate column	an empty column reserved for the ID# of the NOAA weather station containing meteorological data that will be assigned to the station.

- A coverage of National Weather Service stations from NOAA's Solar and Meteorological Surface Observation Network (SAMSON) data set created using latitude and longitude coordinates. The information included in this coverage included:

Station ID#	the stations Weather Bureau Army Navy number.
State	the state's 2 digit postal code.
Station name	NCDC's assigned station name.
Timezone	lagged by universal time.
Elevation	meters above sea level (this was converted to feet).
Latitude	in degrees and minutes (always North) (this was converted to decimal degrees).
Longitude	in degrees and minutes (always west) (this was converted to decimal degrees).
Evap data	a column denoting the database containing the hourly evaporation data.
Temp data	a column denoting the database containing the hourly temperature data.
Wind data	a column denoting the database containing the hourly windspeed data.
Solar data	a column denoting the database containing the hourly solar radiation data.
Pevt data	a column denoting the database containing the hourly potential evapotranspiration data.
Dew pt data	a column denoting the database containing the hourly dew point temperature data.
Cloud data	a column denoting the database containing the hourly cloud cover data.

- A coverage of the U.S. state boundaries provided by ESRI on-line ArcData (www.esri.com).
- A coverage of annual precipitation for North America provided by ESRI on-line ArcData (www.esri.com). This data set was intended as a thematic data layer representing average annual precipitation, in millimeters per year, for North America.
- A coverage of Climate Divisions provided by the National Climatic Data Center (NCDC). This coverage was used to display seasonal maps of precipitation and temperature for the conterminous United States.
- A coverage of Hydrologic Unit Boundaries and Codes provided by the National Climatic Data Center (NCDC). This data set was used to display drainage basins for the conterminous United States.
- A coverage of Physiographic Divisions in the conterminous United States provided by the National Climatic Data Center (NCDC). It was automated from Fennemans 1:7,000,000-scale map, "Physical Divisions of the United States," which is based on eight major divisions, 25 provinces, and 86 sections representing distinctive areas having common topography, rock types and structure, and geologic and geomorphic history.

- A coverage of average annual runoff in the conterminous United States, 1951-1980 provided by the National Climatic Data Center (NCDC). This coverage is intended as a thematic data layer representing average annual runoff, in inches per year, for the conterminous United States. Appropriate maps of the data can show the geographical distribution of runoff in tributary streams for the years 1951-80 and can describe the magnitudes and variations of runoff nationwide. The data was prepared to reflect the runoff of tributary streams rather than in major rivers in order to represent more accurately the local or small-scale variation in runoff with precipitation and other geographical characteristics.
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B.2.2 BASINS WDM Files Weather Station List

State	Sta_#	Sta_Name	COOP_ID	Lat_dd	Long_dd
AK	1	ANCHORAGE WSCMO AP	280	61.1667	-150.017
AK	2	ANNETTE WSO AIRPORT	352	55.0333	-131.567
AK	3	COLD BAY WSO AIRPORT	2102	55.2	-162.717
AK	4	FAIRBANKS WSO AIRPOR	2968	64.8167	-147.867
AK	5	KING SALMON WSO AP	4766	58.6833	-156.65
AK	6	MCGRATH WSO AIRPORT	5769	62.9667	-155.617
AK	7	ST PAUL ISLAND WSO A	8118	57.15	-170.217
AK	8	YAKUTAT WSO AIRPORT	9941	59.5167	-139.667
AL	1	ABBEVILLE 1 NNW	8	31.5833	-85.2833
AL	2	BIRMINGHAM FAA ARPT	831	33.5667	-86.7
AL	3	DADEVILLE 2	2124	32.8333	-85.75

AL	4	HALEYVILLE	3620	34.2333	-87.6333
AL	5	HUNTSVILLE WSO AP	4064	34.65	-86.7833
AL	6	JACKSONVILLE	4209	33.8167	-85.7667
AL	7	MOBILE WSO ARPT	5478	30.6833	-88.25
AL	8	MONTGOMERY WSO ARPT	5550	32.3	-86.4
AL	9	THOMASVILLE	8178	31.9167	-87.7333
AL	10	TUSCALOOSA OLIVER DA	8385	33.2167	-87.6
AR	1	ALUM FORK	130	34.8	-92.85
AR	2	BATESVILLE LIVESTOCK	458	35.8333	-91.7667
AR	3	BULL SHOALS DAM	1020	36.3667	-92.5667
AR	4	CLARKSVILLE 6 NE	1457	35.5333	-93.4
AR	5	EUREKA SPRINGS 3 WNW	2356	36.4167	-93.7833
AR	6	FORT SMITH WSO AIRPO	2574	35.3333	-94.3667
AR	7	MENA	4756	34.5667	-94.2667
AR	8	MILLWOOD DAM	4839	33.6833	-93.9833
AR	9	MONTICELLO 3 SW	4900	33.6	-91.8
AR	10	STUTTGART 9 ESE	6920	34.4667	-91.4167
AZ	1	AJO	80	32.3667	-112.867
AZ	2	COCHISE 4 SSE	1870	32.0667	-109.9
AZ	3	FLAGSTAFF AP	3010	35.1333	-111.667
AZ	4	KEAMS CANYON	4586	35.8167	-110.2
AZ	5	PAYSON	6323	34.2333	-111.333
AZ	6	PHOENIX AIRPORT	6481	33.4333	-111.983
AZ	7	TUCSON WSO AP	8820	32.1333	-110.933
AZ	8	TUWEEP	8895	36.2833	-113.067

AZ	9	WHITERIVER 1 SW	9271	33.8167	-109.983
AZ	10	YUMA WSO AP	9660	32.6667	-114.6
CA	1	BAKERSFIELD AP	442	35.4333	-119.05
CA	2	BLUE CANYON	897	39.2833	-120.7
CA	3	EUREKA WFO WOODLEY I	2910	40.8	-124.167
CA	4	FRESNO AIR TERMINAL	3257	36.7833	-119.717
CA	5	LOS ANGELES WSO ARPT	5114	33.9333	-118.4
CA	6	SACRAMENTO FAA ARPT	7630	38.5167	-121.5
CA	7	SAN DIEGO WSO AIRPOR	7740	32.7333	-117.167
CA	8	SAN FRANCISCO WSO AP	7769	37.6167	-122.383
CA	9	SANTA MARIA WSO ARPT	7946	34.9	-120.45
CA	10	YOSEMITE PARK HDQTRS	9855	37.75	-119.583
CO	1	AKRON 4 E	109	40.15	-103.15
CO	2	ALAMOSA WSO AP	130	37.45	-105.867
CO	3	BOULDER 2	843	40.0333	-105.283
CO	4	COLORADO SPRINGS WSO	1778	38.8167	-104.717
CO	5	GRAND JUNCTION WSO A	3488	39.1	-108.5
CO	6	KIM 15 NNE	4538	37.45	-103.317
CO	7	NUNN	6023	40.7	-104.783
CO	8	PUEBLO WSO AP	6740	38.2833	-104.5
CO	9	SUGARLOAF RESERVOIR	8064	39.25	-106.367
CO	10	TELLURIDE 4 WNW	8204	37.95	-107.867
CT	1	BRIDGEPORT SIKORSKY	806	41.1667	-73.1333
CT	2	HARTFORD BRADLEY AP	3456	41.9333	-72.6833
CT	3	JEWETT CITY	3857	41.6333	-71.9

CT	4	THOMASTON DAM	8330	41.7	-73.05
DE	1	GEORGETOWN 5 SW	3570	38.6333	-75.45
DE	2	WILMINGTN NEW CASTLE	9595	39.6667	-75.6
FL	1	DAYTONA BEACH REG AP	2158	29.1833	-81.05
FL	2	JACKSONVILLE INTL AP	4358	30.4833	-81.7
FL	3	KEY WEST INTL ARPT	4570	24.55	-81.75
FL	4	MIAMI INTL ARPT	5663	25.8	-80.3
FL	5	NICEVILLE	6240	30.5167	-86.5
FL	6	ORTONA LOCK 2	6657	26.7833	-81.3
FL	7	RAIFORD STATE PRISON	7440	30.0667	-82.1833
FL	8	TALLAHASSEE MUNI AP	8758	30.3833	-84.3667
FL	9	TAMPA INTL ARPT	8788	27.9667	-82.5333
FL	10	W PALM BEACH INTL AP	9525	26.6833	-80.1167
GA	1	ATHENS MUNI AP	435	33.95	-83.3167
GA	2	ATLANTA HARTSFIELD	451	33.65	-84.4333
GA	3	AUGUSTA BUSH FIELD	495	33.3667	-81.9667
GA	4	CALHOUN EXP STATION	1474	34.4833	-84.9667
GA	5	COLUMBUS METRO AP	2166	32.5167	-84.95
GA	6	DAHLONEGA 3 NNW	2479	34.5833	-84
GA	7	EDISON	3028	31.5667	-84.7333
GA	8	JESUP	4671	31.6167	-81.8833
GA	9	MACON LEWIS B WILSON	5443	32.7	-83.65
GA	10	SAVANNAH INTL AP	7847	32.1333	-81.2
HI	1	HILO WSO AP 87	1492	19.7167	-155.067
HI	2	HONOLULU WSFO AP 703	1919	21.3333	-157.917

HI	3	KAHULUI WSO AP 398	2572	20.9	-156.433
HI	4	KANALOHULUHULU 1075	3099	22.1333	-159.667
HI	5	KEAIWA CAMP 22.1	3925	19.2333	-155.483
HI	6	KUALAPUU 534	4778	21.15	-157.033
HI	7	LALAMILO FLD OF 191.	5260	20.0167	-155.683
HI	8	LIHUE WSO AP 1020.1	5580	21.9833	-159.35
HI	9	PAAKEA 350	7194	20.8167	-156.117
HI	10	PUNALUU PUMP 905.2	8314	21.5833	-157.9
IA	1	CENTERVILLE	1354	40.7333	-92.8667
IA	2	DES MOINES AP	2203	41.5333	-93.6667
IA	3	IRWIN 3 ESE	4174	41.7833	-95.15
IA	4	LARRABEE	4644	42.8667	-95.55
IA	5	LENOX	4746	40.8833	-94.5667
IA	6	MCGREGOR	5315	43.0167	-91.1833
IA	7	MOUNT PLEASANT 1 SSW	5796	40.95	-91.5667
IA	8	ST ANSGAR	7326	43.3833	-92.9167
IA	9	SIOUX CITY AP	7708	42.4	-96.3833
IA	10	WATERLOO WSO AP	8706	42.55	-92.4
ID	1	BOISE WSFO AIRPORT	1022	43.5667	-116.217
ID	2	CALDER	1370	47.2667	-116.183
ID	3	CASCADE 1 NW	1514	44.5333	-116.05
ID	4	FENN RANGER STATION	3143	46.1167	-115.567
ID	5	GOODING 1 S	3677	42.9167	-114.7
ID	6	GRASMERE 3 S	3811	42.3333	-115.883
ID	7	LEADORE	5169	44.6833	-113.367

ID	8	POCATELLO WSO AP	7211	42.9167	-112.6
ID	9	SANDPOINT EXP STATIO	8137	48.2833	-116.567
ID	10	TETONIA EXPERIMENT S	9065	43.85	-111.267
IL	1	AUGUSTA	330	40.2333	-90.95
IL	2	BELLEVILLE SIU RESEA	510	38.5167	-89.85
IL	3	CHICAGO MIDWAY AP 3	1577	41.7333	-87.7833
IL	4	MOLINE WSO AP	5751	41.4333	-90.5
IL	5	MURPHYSBORO 2 SW	5983	37.7667	-89.3667
IL	6	NEWTON 6 SSE	6159	38.9167	-88.1167
IL	7	PEORIA WSO AIRPORT	6711	40.6667	-89.6833
IL	8	PIPER CITY	6819	40.7	-88.1833
IL	9	ROCKFORD WSO AP	7382	42.2	-89.1
IL	10	SPRINGFIELD WSO AP	8179	39.85	-89.6833
IN	1	EVANSVILLE WSO AP	2738	38.05	-87.5333
IN	2	FORT WAYNE WSO AP	3037	41	-85.2
IN	3	INDIANAPOLIS WSFO AP	4259	39.7333	-86.2667
IN	4	PERU WASTE WATER PLA	6864	40.75	-86.0667
IN	5	RICHMOND WTR WKS	7370	39.8833	-84.8833
IN	6	SHOALS HIWAY 50 BRID	8036	38.6667	-86.8
IN	7	SOUTH BEND WSO AP	8187	41.75	-86.1667
IN	8	VALPARAISO WATERWORK	8999	41.5167	-87.0333
IN	9	VERSAILLES WATERWORK	9069	39.0667	-85.25
IN	10	WEST LAFAYETTE 6 NW	9430	40.4667	-87
KS	1	BIG BOW 4 WSW	802	37.55	-101.633
KS	2	COLLYER 10 S	1730	38.9	-100.117

KS	3	COLUMBUS 1 SW	1740	37.1667	-94.85
KS	4	CONCORDIA WSO ARPT	1767	39.55	-97.65
KS	5	DODGE CITY WFO AP	2164	37.7667	-99.9667
KS	6	FALL RIVER LAKE	2686	37.65	-96.0833
KS	7	GOODLAND WFO	3153	39.3667	-101.7
KS	8	PHILLIPSBURG 1 SSE	6374	39.7333	-99.3167
KS	9	TOPEKA WSFO AIRPORT	8167	39.0667	-95.6333
KS	10	WICHITA WSO ARPT	8830	37.65	-97.4333
KY	1	BUCKHORN LAKE	1080	37.35	-83.3833
KY	2	CLINTON 4 S	1631	36.6167	-88.9667
KY	3	COVINGTON WSO AIRPOR	1855	39.05	-84.6667
KY	4	HODGENVILLE-LINCOLN	3929	37.5333	-85.7333
KY	5	LEXINGTON WSO AIRPOR	4746	38.0333	-84.6
KY	6	LOUISA 2 S	4946	38.1167	-82.6
KY	7	LOUISVILLE WSFO AP	4954	38.1833	-85.7333
KY	8	PADUCAH WALKER BOAT	6117	37.05	-88.55
KY	9	SOMERSET 2 NE	7508	37.1167	-84.6
KY	10	WOODBURY	8824	37.1833	-86.6333
LA	1	ALEXANDRIA	98	31.3167	-92.4667
LA	2	BATON ROUGE WSO AP	549	30.5333	-91.1333
LA	3	CALHOUN RESEARCH STN	1411	32.5167	-92.3333
LA	4	LAFAYETTE	5021	30.2167	-92.0667
LA	5	LAKE CHARLES AP	5078	30.1333	-93.2167
LA	6	MORGAN CITY	6394	29.6833	-91.1833
LA	7	NATCHITOCHES	6582	31.7667	-93.1

LA	8	NEW ORLEANS WSCMO AR	6660	29.9833	-90.25
LA	9	SHREVEPORT AP	8440	32.45	-93.8167
LA	10	WINNSBORO 5 SSE	9806	32.1	-91.7167
MA	1	BIRCH HILL DAM	666	42.6333	-72.1167
MA	2	BOSTON LOGAN INTL AP	770	42.3667	-71.0333
MA	3	BRIDGEWATER	840	41.95	-70.95
MA	4	HYANNIS	3821	41.6667	-70.3
MA	5	KNIGHTVILLE DAM	3985	42.2833	-72.8667
MA	6	NEW BEDFORD	5246	41.6333	-70.9333
MA	7	PROVINCETOWN	6681	42.05	-70.1833
MA	8	WORCESTER MUNI AP	9923	42.2667	-71.8667
MD	1	BALT-WASHGTN INTL AP	465	39.1833	-76.6667
MD	2	BELTSVILLE	700	39.0333	-76.8833
MD	3	HANCOCK	4030	39.7	-78.1833
MD	4	SAVAGE RIVER DAM	8065	39.5167	-79.1333
MD	5	UNIONVILLE	9030	39.45	-77.1833
ME	1	AUGUSTA	273	44.3	-69.7833
ME	2	CARIBOU MUNI ARPT	1175	46.8667	-68.0167
ME	3	CLAYTON LAKE	1472	46.6167	-69.5333
ME	4	EASTPORT	2426	44.9167	-67
ME	5	GRAND LAKE STREAM	3261	45.1833	-67.7833
ME	6	MILLINOCKET	5304	45.65	-68.7
ME	7	ORONO 2	6435	44.8833	-68.6667
ME	8	PORTLAND INTL JETPRT	6905	43.65	-70.3
ME	9	ROCKLAND 1 W	7255	44.1	-69.1167

ME	10	SKOWHEGAN	7827	44.7667	-69.7167
MI	1	ALPENA WSO AIRPORT	164	45.0667	-83.5667
MI	2	BERRIEN SPRINGS 5 W	735	41.9667	-86.4333
MI	3	DETROIT CITY AIRPORT	2102	42.4167	-83.0167
MI	4	FLINT WSCMO	2846	42.9667	-83.75
MI	5	GRAND RAPIDS WSFO	3333	42.8833	-85.5167
MI	6	HANCOCK MCLAIN ST PK	3551	47.2333	-88.6167
MI	7	LANSING WSO AIRPORT	4641	42.7667	-84.6
MI	8	MUSKEGON WSO AIRPORT	5712	43.1667	-86.25
MI	9	SAULT STE MARIE WSO	7366	46.4667	-84.35
MI	10	TRAVERSE CITY	8246	44.7667	-85.5667
MN	1	DULUTH WSO AP	2248	46.8333	-92.2167
MN	2	INT FALLS WSO AP	4026	48.5667	-93.3833
MN	3	MINNEAPOLIS WSFO AP	5435	44.8833	-93.2167
MN	4	ROCHESTER WSO AP	7004	43.9167	-92.5
MN	5	ST CLOUD WSO AP	7294	45.55	-94.0667
MN	6	SHERBURN 3 WSW	7602	43.6333	-94.7667
MN	7	THIEF LAKE REFUGE	8235	48.4833	-95.95
MN	8	TRACY	8323	44.2333	-95.6333
MN	9	WINNIBIGOSHISH DAM	9059	47.4333	-94.0667
MN	10	WINTON POWER PLANT	9101	47.9333	-91.7667
MO	1	COLUMBIA AIRPORT	1791	38.8167	-92.2167
MO	2	KANSAS CITY WSMO AP	4358	39.3167	-94.7167
MO	3	NEVADA WATER PLANT	5987	37.8333	-94.3667
MO	4	PATTONSBURG 2 S	6563	40.0333	-94.1333

MO	5	ROLLA UNI OF MISSOUR	7263	37.95	-91.7833
MO	6	ST LOUIS WSCMO AIRPO	7455	38.75	-90.3667
MO	7	SPRINGFIELD REG AP	7976	37.2333	-93.3833
MO	8	STEFFENVILLE	8051	39.9667	-91.8833
MO	9	WAPPAPELLO DAM	8700	36.9333	-90.2833
MO	10	WEST PLAINS	8880	36.75	-91.8333
MS	1	ARKABUTLA DAM	237	34.75	-90.1333
MS	2	BOONEVILLE	955	34.6667	-88.5667
MS	3	CALHOUN CITY 2 NW	1314	33.8667	-89.35
MS	4	CLEVELAND 3 N	1743	33.8	-90.7167
MS	5	JACKSON WSFO AIRPORT	4472	32.3167	-90.0833
MS	6	LEAKESVILLE	4966	31.15	-88.55
MS	7	LEXINGTON 2 NNW	5062	33.1333	-90.0667
MS	8	MERIDIAN WSO ARPT	5776	32.3333	-88.75
MS	9	RUTH 1 SE	7714	31.3667	-90.3
MS	10	SAUCIER EXP FOREST	7840	30.6333	-89.05
MT	1	BILLINGS WSO	807	45.8	-108.533
MT	2	CLARK CANYON DAM	1781	45	-112.867
MT	3	CUT BANK FCWOS	2173	48.6	-112.367
MT	4	GLASGOW WSO AIRPORT	3558	48.2167	-106.617
MT	5	GREAT FALLS WSCMO AI	3751	47.4833	-111.367
MT	6	HELENA WSO	4055	46.6	-112
MT	7	HILGER	4143	47.25	-109.35
MT	8	ISMAY	4442	46.5	-104.8
MT	9	KALISPELL WSO AIRPOR	4558	48.3	-114.267

MT	10	MISSOULA WSO AP	5745	46.9333	-114.1
NC	1	ASHEVILLE REGIONL AP	300	35.4333	-82.55
NC	2	CAPE HATTERAS NWS	1458	35.2667	-75.55
NC	3	CHARLOTTE DOUGLAS AP	1690	35.2167	-80.9333
NC	4	ELIZABETH CITY	2719	36.3167	-76.2
NC	5	GRNSBR,HGH PT,W-S AP	3630	36.0833	-79.95
NC	6	HELTON	3957	36.55	-81.5
NC	7	LAURINBURG	4860	34.75	-79.45
NC	8	MOREHEAD CITY 2 WNW	5830	34.7333	-76.7333
NC	9	RALEIGH DURHAM AP	7069	35.8667	-78.7833
NC	10	WILMINGTON NEW HANVR	9457	34.2667	-77.9
ND	1	ASHLEY	382	46.0333	-99.3667
ND	2	BALDHILL DAM	450	47.0333	-98.0833
ND	3	BISMARCK WSFO AP	819	46.7667	-100.75
ND	4	BOWMAN	995	46.1833	-103.4
ND	5	FARGO WSO AP	2859	46.9333	-96.8167
ND	6	MINOT EXPERIMENT STN	5993	48.1833	-101.3
ND	7	RICHARDTON ABBEY	7530	46.8833	-102.317
ND	8	ROLETTE	7655	48.6667	-99.8333
ND	9	TROTTERS 3 SSE	8812	47.2833	-103.9
ND	10	WILLISTON WSO	9425	48.1833	-103.633
NE	1	AMELIA 2 W	180	42.2333	-98.95
NE	2	EDISON	2560	40.2833	-99.7833
NE	3	GRAND ISLAND WSO AP	3395	40.9667	-98.3167
NE	4	HEBRON	3735	40.1667	-97.5833

NE	5	MALMO 3 E	5112	41.2667	-96.65
NE	6	NORFOLK AIRPORT	5995	41.9833	-97.4333
NE	7	NORTH PLATTE WSO ARP	6065	41.1333	-100.7
NE	8	OSHKOSH 10 NE	6386	41.5	-102.183
NE	9	SCOTTSBLUFF AP	7665	41.8667	-103.6
NE	10	VALENTINE WSO AP	8760	42.8833	-100.55
NH	1	BRISTOL	998	43.6	-71.7167
NH	2	CONCORD MUNI AP	1683	43.2	-71.5
NH	3	DURHAM	2174	43.15	-70.95
NH	4	ERROL	2842	44.7833	-71.1333
NH	5	LINCOLN	4732	44.05	-71.6667
NH	6	MOUNT WASHINGTON	5639	44.2667	-71.3
NH	7	NEW DURHAM 3 NNW	5780	43.4833	-71.1833
NH	8	NORTH STRATFORD	6234	44.75	-71.6333
NH	9	PITTSBURG RESERVOIR	6856	45.05	-71.3833
NH	10	SURRY MOUNTAIN LAKE	8539	43	-72.3167
NJ	1	ATLANTIC CITY INT AP	311	39.45	-74.5667
NJ	2	CAPE MAY 2 NW	1351	38.95	-74.9333
NJ	3	CLINTON 2 N	1754	40.6667	-74.9167
NJ	4	GLASSBORO 2 W	3291	39.7	-75.1167
NJ	5	NEWARK INTL ARPT	6026	40.7	-74.1667
NJ	6	NEW BRUNSWICK 3 SE	6055	40.4667	-74.4333
NJ	7	SPRINGFIELD	8423	40.7167	-74.3167
NJ	8	WANAQUE RAYMOND DAM	9187	41.05	-74.3
NJ	9	WATCHUNG	9271	40.6667	-74.4167

NJ	10	WINDSOR	9761	40.25	-74.5833
NM	1	ALBUQUERQUE WSFO AIR	234	35.05	-106.617
NM	2	ANIMAS	417	31.95	-108.817
NM	3	AUGUSTINE 2 E	640	34.0833	-107.617
NM	4	CARLSBAD	1469	32.4333	-104.25
NM	5	CARRIZOZO 1 SW	1515	33.6333	-105.883
NM	6	CUBA	2241	36.0167	-106.967
NM	7	DURAN	2665	34.4667	-105.4
NM	8	JORNADA EXP RANGE	4426	32.6167	-106.733
NM	9	OCATE 2 NW	6275	36.2	-105.067
NM	10	TUCUMCARI 4 NE	9156	35.2	-103.683
NV	1	BEATTY 8 N	718	37	-116.717
NV	2	CONTACT	1905	41.7667	-114.75
NV	3	ELKO FCWOS	2573	40.8333	-115.8
NV	4	ELY ASOS	2631	39.2833	-114.85
NV	5	LAS VEGAS AP	4436	36.0833	-115.167
NV	6	LEONARD CREEK RANCH	4527	41.5167	-118.717
NV	7	PAHRANAGAT W L REFUG	5880	37.2667	-115.117
NV	8	RENO AIRPORT	6779	39.5	-119.783
NV	9	SMOKEY VALLEY	7620	38.7833	-117.167
NV	10	WINNEMUCCA AIRPORT	9171	40.9	-117.8
NY	1	ALBANY COUNTY AP	42	42.75	-73.8
NY	2	BINGHAMTON LINK FLD	687	42.2167	-75.9833
NY	3	BUFFALO GR BUFFLO AP	1012	42.9333	-78.7333
NY	4	CANTON 4 SE	1185	44.5667	-75.1167

NY	5	NEW YORK CNTRL PARK	5801	40.7833	-73.9667
NY	6	OLD FORGE	6184	43.7167	-74.9833
NY	7	ROCHESTER INTL AP	7167	43.1333	-77.6667
NY	8	SYRACUSE HANCOCK AP	8383	43.1167	-76.1167
NY	9	WELLSVILLE	9072	42.1167	-77.95
NY	10	WHITEHALL	9389	43.55	-73.4
OH	1	AKRON CANTON WSO AP	58	40.9167	-81.4333
OH	2	CLEVELAND WSFO AP	1657	41.4167	-81.8667
OH	3	COLUMBUS WSO AIRPORT	1786	40	-82.8833
OH	4	DAYTON WSO AIRPORT	2075	39.9	-84.2
OH	5	MANSFIELD WSO AP	4865	40.8167	-82.5167
OH	6	PANDORA	6405	40.95	-83.9667
OH	7	PORTSMOUTH SCIOTOVIL	6781	38.75	-82.8833
OH	8	TOLEDO EXPRESS WSO A	8357	41.6	-83.8
OH	9	TOM JENKINS DAM-BURR	8378	39.55	-82.0667
OH	10	YOUNGSTOWN WSO AP	9406	41.25	-80.6667
OK	1	CARTER TOWER	1544	34.2667	-94.7833
OK	2	FORT SUPPLY DAM	3304	36.55	-99.5833
OK	3	GOODWELL RESEARCH ST	3628	36.6	-101.617
OK	4	GREAT SALT PLAINS DA	3740	36.75	-98.1333
OK	5	LEHIGH	5108	34.4667	-96.2167
OK	6	MAYFIELD	5648	35.3333	-99.8667
OK	7	OKLAHOMA CITY AIRPOR	6661	35.3833	-97.6
OK	8	TULSA INTL AIRPORT	8992	36.2	-95.8833
OK	9	WEBBERS FALLS DAM	9450	35.55	-95.1667

OK	10	WICHITA MTN WL REF	9629	34.7333	-98.7167
OR	1	ALLEGANY	126	43.4333	-124.033
OR	2	ASTORIA WSO AIRPORT	328	46.15	-123.883
OR	3	BEULAH	723	43.9167	-118.167
OR	4	EUGENE WSO AIRPORT	2709	44.1167	-123.217
OR	5	LA GRANDE	4622	45.3167	-118.067
OR	6	MEDFORD WSO AP	5429	42.3833	-122.883
OR	7	OCHOCO DAM	6238	44.3	-120.733
OR	8	PENDLETON WSO AIRPOR	6546	45.6833	-118.85
OR	9	PORTLAND INTL AIRPOR	6751	45.6	-122.617
OR	10	SALEM WSO AIRPORT	7500	44.9167	-123
PA	1	ALLENTOWN A-B-E INTL	106	40.65	-75.4333
PA	2	ALVIN R BUSH DAM	147	41.3667	-77.9333
PA	3	ERIE INTL ARPT	2682	42.0833	-80.1833
PA	4	JOHNSTOWN 2	4390	40.3167	-78.9167
PA	5	KANE 1 NNE	4432	41.6833	-78.8
PA	6	PHILADELPHIA INTL AP	6889	39.8833	-75.25
PA	7	PITTSBURGH GR P’BURG	6993	40.5	-80.2167
PA	8	PUTNEYVILLE 2 SE DAM	7229	40.9333	-79.2833
PA	9	WILKES-BARRE SCRANTN	9705	41.3333	-75.7333
PA	10	YORK 1 S FILTER PLAN	9938	39.9333	-76.7333
PR	1	COROZAL SUBSTATION	2934	18.3333	-66.3667
PR	2	PONCE 4 E	7292	18.0167	-66.5333
PR	3	SAN JUAN ISLA VERDE	8812	18.4333	-66
PR	4	SAN SEBASTIAN 2 WNW	8881	18.35	-67.0167

PR	5	YABUCOA 1 NNE	9829	18.0667	-65.8667
RI	1	BLOCK IS STATE AP	896	41.1667	-71.5833
RI	2	NEWPORT ROSE	5215	41.5	-71.35
RI	3	PROVIDENCE GREEN ST	6698	41.7333	-71.4333
SC	1	BISHOPVILLE 8 NNW	736	34.3333	-80.3
SC	2	CHARLESTON INTL ARPT	1544	32.9	-80.0333
SC	3	CLARK HILL 1 W	1726	33.6667	-82.1833
SC	4	COLUMBIA METRO AP	1939	33.95	-81.1167
SC	5	GEORGETOWN 2 E	3468	33.35	-79.25
SC	6	GREER GREENV'L-SPART	3747	34.9	-82.2167
SC	7	JOCASSEE 8 WNW	4581	34.9833	-83.0667
SC	8	LAURENS	5017	34.5	-82.0333
SC	9	MULLINS 4 W	6114	34.2	-79.3167
SC	10	SANTEE COOP SPLWY	7712	33.45	-80.15
SD	1	BUFFALO	1114	45.6	-103.55
SD	2	EDGEMONT	2557	43.3	-103.833
SD	3	HURON AP	4127	44.4	-98.2167
SD	4	ISABEL	4268	45.4	-101.433
SD	5	LA CREEK NATL WILDLI	4651	43.1	-101.567
SD	6	OAHE DAM	6170	44.45	-100.417
SD	7	PICKSTOWN	6574	43.0667	-98.5333
SD	8	RAPID CITY WSO AP	6937	44.05	-103.05
SD	9	SIOUX FALLS WSFO	7667	43.5667	-96.7333
SD	10	WAUBAY NATL WILDLIFE	8980	45.4333	-97.3333
TN	1	BRISTOL WSO AIRPORT	1094	36.4833	-82.4

TN	2	BROWNSVILLE SEWAGE P	1150	35.5833	-89.2667
TN	3	CHATTANOOGA WSO AP	1656	35.0167	-85.2
TN	4	KNOXVILLE WSO AIRPOR	4950	35.8333	-83.9833
TN	5	LEWISBURG EXP STN	5187	35.4167	-86.8
TN	6	MEMPHIS WSCMO AP	5954	35.05	-90
TN	7	MONTEREY	6170	36.15	-85.2667
TN	8	NASHVILLE NWSCMO AP	6402	36.1167	-86.6833
TN	9	PORTLAND SEWAGE PLAN	7359	36.5833	-86.5333
TN	10	SAMBURG WILDLIFE REF	8065	36.45	-89.3167
TX	1	ABILENE WSO AIRPORT	16	32.4167	-99.6833
TX	2	AMARILLO WSO AIRPORT	211	35.2333	-101.7
TX	3	BROWNSVILLE WSO AP	1136	25.9	-97.4333
TX	4	CORPUS CHRISTI WSFO	2015	27.7667	-97.5
TX	5	EL PASO AP	2797	31.8	-106.4
TX	6	HOUSTON WSCMO AP	4300	29.9667	-95.35
TX	7	SAN ANGELO WSO AP	7943	31.3667	-100.483
TX	8	SAN ANTONIO INTL AP	7945	29.5333	-98.4667
TX	9	WACO WSO AP	9419	31.6167	-97.2167
TX	10	WICHITA FALLS WSO AP	9729	33.9833	-98.5
UT	1	BLANDING	738	37.6167	-109.483
UT	2	DUGWAY	2257	40.1833	-112.917
UT	3	EPHRAIM SORENSENS FL	2578	39.3667	-111.583
UT	4	HANKSVILLE	3611	38.3667	-110.717
UT	5	LOGAN UTAH STATE UNI	5186	41.75	-111.8
UT	6	MILFORD	5654	38.4	-113.017

UT	7	OGDEN PIONEER P H	6404	41.25	-111.95
UT	8	ROOSEVELT RADIO	7395	40.2833	-109.967
UT	9	ST GEORGE	7516	37.1167	-113.567
UT	10	SALT LAKE CITY NWSFO	7598	40.7667	-111.95
VA	1	HURLEY	4180	37.4167	-82.0167
VA	2	JOHN H KERR DAM	4414	36.6	-78.2833
VA	3	LYNCHBURG MUNI AP	5120	37.3333	-79.2
VA	4	NORFOLK INTL ARPT	6139	36.9	-76.2
VA	5	PIEDMONT RESEARCH ST	6712	38.2167	-78.1167
VA	6	RICHMOND BYRD AP	7201	37.5167	-77.3333
VA	7	ROANOKE WOODRUM AP	7285	37.3167	-79.9667
VA	8	THE PLAINS 2 NNE	8396	38.9	-77.75
VA	9	WASHINGTN DC NATL AP	8906	38.85	-77.0333
VA	10	WYTHEVILLE 1 S	9301	36.9333	-81.0833
VI	1	BETH UPPER NEW WORKS	480	17.7167	-64.8
VI	2	CANEEL BAY PLANTATIO	1316	18.35	-64.7833
VT	1	BALL MOUNTAIN LAKE	277	43.1167	-72.8
VT	2	BURLINGTON INTL AP	1081	44.4667	-73.15
VT	3	CORINTH	1565	44.0167	-72.2833
VT	4	HIGHGATE FALLS	3914	44.9333	-73.05
VT	5	MORRISVILLE	5366	44.5667	-72.6
VT	6	NEWPORT	5542	44.9333	-72.2
VT	7	NORTH HARTLAND LAKE	5768	43.6	-72.35
VT	8	NORTH SPRINGFIELD LA	5982	43.3333	-72.5
VT	9	SAINT JOHNSBURY	7054	44.4167	-72.0167

VT	10	SEARSBURG STATION	7152	42.8667	-72.9167
WA	1	COUGAR 4 SW	1759	46.0167	-122.35
WA	2	FRANCES	2984	46.55	-123.5
WA	3	MARBLEMOUNT RANGER S	4999	48.5333	-121.45
WA	4	OLYMPIA AIRPORT	6114	46.9667	-122.9
WA	5	QUILLAYUTE WSCMO AP	6858	47.95	-124.55
WA	6	SEATTLE TACOMA AIRPO	7473	47.45	-122.3
WA	7	SNOQUALMIE PASS	7781	47.4167	-121.417
WA	8	SPOKANE WSO AIRPORT	7938	47.6333	-117.533
WA	9	WHITMAN MISSION	9200	46.05	-118.45
WA	10	YAKIMA WSO AP	9465	46.5667	-120.533
WI	1	ASHLAND EXP FARM	349	46.5667	-90.9667
WI	2	CHIPPEWA FALLS	1578	44.9333	-91.3833
WI	3	GREEN BAY WSO	3269	44.5	-88.1167
WI	4	LA FARGE	4404	43.5667	-90.6333
WI	5	LANCASTER 4 WSW	4546	42.8333	-90.7833
WI	6	MADISON WSO AIRPORT	4961	43.1333	-89.3333
WI	7	MARSHFIELD EXP FARM	5120	44.6333	-90.1333
WI	8	MILWAUKEE WSO AIRPOR	5479	42.95	-87.9
WI	9	PHELPS	6518	46.0667	-89.0667
WI	10	SPOONER EXPERMNT FAR	8027	45.8167	-91.8833
WV	1	BECKLEY WSO AP	582	37.7833	-81.1167
WV	2	CHARLESTON AP	1570	38.3667	-81.6
WV	3	ELKINS WSO AIRPORT	2718	38.8833	-79.85
WV	4	HUNTINGTON WSO AP	4393	38.3667	-82.55

WV	5	LAKE LYNN	5002	39.7167	-79.85
WV	6	LIVERPOOL	5323	38.9	-81.5333
WV	7	MOOREFIELD 2 SSE	6163	39.0333	-78.9667
WV	8	TERRA ALTA NO 1	8777	39.45	-79.55
WV	9	TYGART DAM	8986	39.3167	-80.0333
WV	10	VALLEY HEAD	9086	38.5333	-80.0333
WY	1	CASPER WSCMO	1570	42.9	-106.467
WY	2	CHEYENNE WSFO AP	1675	41.15	-104.817
WY	3	MORAN 5 WNW	6440	43.85	-110.583
WY	4	ENCAMPMENT	3050	41.2167	-106.783
WY	5	JACKSON	4910	43.4833	-110.767
WY	6	LAKE YELLOWSTONE	5345	44.55	-110.4
WY	7	LANDER AP	5390	42.8167	-108.733
WY	8	MOUNTAIN VIEW	6555	41.2833	-110.317
WY	9	OSAGE	6935	43.9833	-104.417
WY	10	SHERIDAN AP	8155	44.7667	-106.967

Appendix C - BASINS 4.0 Meteorological Data (Version 2009)

For BASINS 4.0 the BASINS meteorological database was updated to contain the most current data for the original stations and for a substantially greater number of stations throughout the U.S. The updated database contains data at over 16,000 stations, though not all stations are still active and most of them contain only a subset of all the meteorological constituents used in BASINS. For those stations that are current, data have been updated through the year 2009.

Database Content Changes

Besides a dramatic increase in the number of available meteorological stations, there are some key differences between the original database and the updated:

The Pan Evaporation (EVAP) dataset has been removed - The original database contained both this computed Pan Evaporation dataset and a computed Potential Evapotranspiration (PEVT) dataset. Besides frequently causing end-user confusion, it was strongly suggested by modeling experts that the PEVT dataset is more appropriate as an input to the HSPF model.

Many stations do not contain the full suite of seven meteorological constituents - Whereas the original database contained only stations with all eight potentially-needed constituents, the updated database has greatly expanded the number of available stations, many of which contain a subset of the seven meteorological constituents used in BASINS.

Some stations contain multiple precipitation records - Using the more than 2000 active observed hourly stations (and more than 3500 with 10+ years of record), the daily observed precipitation values were disaggregated to an hourly time interval. This resulted in some stations having both an observed and a disaggregated precipitation record. When only one form of hourly precipitation exists, it has been assigned a data-set number ending in 1 (e.g. 1, 11, etc.). When both forms of hourly precipitation data exist, the observed data set is assigned a number ending in 1 and the disaggregated data set is assigned a number ending in 0 (e.g. 10, 20, etc.)

Ancillary Data

Additional datasets may be available for downloaded stations but are not merged into the project's met.wdm file. These may be found in the individual station WDM files (e.g. GA090451.WDM) in \BASINS\cache\clsBasins\met. These data were involved in the development of the revised database and are provided as an additional reference. They are organized on the WDM files by data-set number in one of the three categories:

- 1000 series - These data are original observed daily or hourly data that were used in the development of the final hourly datasets.
- 1100 series - These data are computed daily or hourly data that were used in the development of the final hourly datasets.
- 2000 series - These data are from the BASINS 3.1 meteorological database.

Processing Steps

The effort to update the BASINS meteorological database for BASINS 4.0 required a number of data processing, management, and manipulation steps. This section provides detailed information on each of the steps taken during the effort. Log files showing details of the meteorological database development are available through EPA. These files provide records of potentially suspect values, how data correction was performed, and how daily precipitation data were disaggregated to hourly.

Acquire data from NOAA's National Climatic Data Center (NCDC)

In reviewing national meteorological data sources, the most extensive and reliable collections were from NOAA's National Climatic Data Center (NCDC). A review of their available products revealed three data sources useful for the updating process:

- Cooperative Summary of the Day (SOD) - a compilation of daily observations from more than 20,000 cooperative weather stations in the United States. It contained daily observations of precipitation and minimum and maximum temperature for each station's period of record (typically 1948 - 2005 for quality stations).
- Hourly Precipitation Dataset (HPD) - a compilation of hourly precipitation amounts for more than 2500 active stations and close to 7000 total stations. It contains hourly precipitation for each station's period of record (typically 1948 - 2005 for complete stations).
- Integrated Surface Hourly (ISH) - integrated from all of the NCDC and Navy surface hourly data (TD3280), NCDC hourly precipitation data (TD3240), and Air Force DATSAV3 surface hourly data. It contained hourly observations of precipitation, wind speed, air and dewpoint temperatures, and sky cover for the period 1995 - 2005.

The majority of these data were ordered on-line from NCDC's web site. However, some of the most recent updates required direct contact with NCDC personnel.

Extract data from CDs and DVDs to Disk

Summary of the Day (SOD)

Hourly Precipitation Data (HPD)

Integrated Surface Hourly (ISH)

Build Station Information database (DBF) files

Each of the three data sources contained a station information/history file. These files contained information such as station identification number and name, geographic location, and period of record. Information was extracted from each data source's most current station file and then stored in a corresponding DBF file. The DBF files provided an efficient format for use in the ensuing data processing scripts.

For the SOD data, the station file contained a significant level of station history information. Thus, many stations had multiple records showing variations in station information (e.g. station name, secondary IDs, lat/long coordinates) through its period of record. A script was developed to read this file and extract only the most current information needed for storage in the DBF file.

For HPD data, the most current station file contained only one record for each station. This file was imported into Excel and then saved in DBF format.

For ISH data, the most current station file was already in Excel format. Records for stations in the U.S. with valid State values were extracted from this file and saved in DBF format.

Read data files into binary compressed data sets using VB.Net scripts

VB code was developed to read the various data types into standard timeseries class objects. Scripts were then developed to read through the data files and store the timeseries as binary compressed data sets. The watershed data management (WDM) format was chosen due to its prior usage in BASINS and efficiency. Details of the rules and assumptions for reading each data type (SOD, HPD, ISH) were described in separate files for each type (SOD Reading.doc, HPD Reading.doc, ISH Reading.doc). See Appendix B for the contents of these files.

To provide the greatest flexibility, separate WDM files were created for each station encountered. The WDM files were named using the 6-character station number (e.g. 010008.wdm) and grouped by state FIPS code (i.e. the first 2 characters of the station ID). Since SOD and HPD data used the same station identifiers, both data types were stored on one WDM file when each type existed for the same station. ISH data were stored on WDM files named after their 6-character station number (e.g. 722230.wdm) and were grouped by 2-character state abbreviation (i.e. "ga"). Since all three data types contained a base dataset and one or more updates, two scripts were developed for each data type. The first script read the base data set and the second script read the data updates.

Develop Missing Data Summary database for all timeseries

All three data sources contained flags indicating periods of missing values and missing time distributions (aka accumulated data). The scripts used to read these values into WDM files tagged these data with -999 for missing data and -998 (followed by the accumulated value) for missing time distribution. To help determine data quality, a script was developed to summarize the amount of missing data for each timeseries. This summary included the total number of data values, counts of missing data occurrences, total number of missing data values, and percentage of missing data values. A summary record for each timeseries was then saved on an output DBF file.

Remove unneeded constituents from WDM files

Both the SOD and ISH datasets contain meteorological constituents that were not needed for the BASINS Met dataset (e.g. snow/snow water equivalent, soil temperature, visibility, atmospheric pressure). A script was developed to browse each WDM file created in the previous step and save only the datasets containing needed constituents. Since WDM files do not decrease in size when datasets are deleted, a new WDM file was written containing only the needed constituents. If an original WDM file contained only unneeded constituents, a new version of it was not written. For those datasets that were saved, its record on the MissingSummary.DBF file was located and the percent missing value from the record was stored as an attribute (UBC200) of the dataset.

Shift ISH data from Universal Time Code (UTC) to appropriate local station Time Zone

Since ISH data came from a worldwide network of stations, all values were recorded in Universal Time Code (UTC) values. To have these values stored at their station's time zone, the values had to be shifted back in time by the difference between UTC and the local time zone (values of 5 to 8 hours for continental U.S.). A script was developed to determine each station's time zone and then shift the station's values back in time by the appropriate amount.

Convert SkyCond values to Cloud Cover values

The SkyCond element of the ISH data provided the most extensive cloud cover dataset. These values were reported in Oktas with values ranging from 0 to 8, where 1 Okta represents 1/8 of the celestial dome. The ISH data documentation provides a table to convert these values to the standard cloud cover units, which range from 0 (clear) to 10 (overcast). A script was developed to perform this conversion. It is run prior to the data correction process so that missing periods are filled or interpolated using the cloud cover units.

Develop master list of stations containing needed data constituents

Combining the station information from the three data sources was needed for improved efficiency during ensuing processing steps. A script was developed to read through the missing data summary database to locate each station containing data. For each station, its ID, name, state code, lat/lng and elevation values were extracted from the appropriate Station information database (generated in step 2) and stored on the resulting master list DBF file.

Reproject station locations to generate distance values

Comparing the distance between stations was essential to the ensuing data correction process. In preparation for the correction of missing data, a master station file was developed by combining the station information from each data source's station DBF file. The geographic (latitude/longitude) coordinates for each station were projected, using an Albers Equal Area projection, into XY coordinates using standard GIS projection transformation functions. Distances between projected station locations were then determined from those projected coordinates using simple geometry. Projecting the station locations is necessary for accuracy because the geometric distance between equal intervals of decimal degrees varies depending upon the location on the globe, as degrees of longitude are much closer in proximity near the global poles and much further apart near the equator.

Store historical values on datasets for use in correcting missing data

In preparation for the ensuing filling and correcting of missing data, historical averages of meteorological data across the country were stored on each station's datasets. The Parameter-elevation Regressions on Independent Slopes Model (PRISM) (Daly, 2006), stores historical averages in a national grid for a variety of constituents. Historical values were extracted from the PRISM database for Precipitation and Temperature. These averages were then used to account for spatial variation when correcting missing data using a nearby station. The ratio between the station being corrected and the nearby station was applied to the value(s) from the nearby station as they were used in the correction process.

Correct periods of missing values or time distribution

Data read in step 3 were processed to identify periods of missing values and time distributions. For some constituents (Air and Dewpoint Temperatures, Cloud Cover, Wind), short periods (

Remove any remaining missing values

It was possible that after the FillMissing script is run that some timeseries still contained missing data. This usually occurred for timeseries that had very long periods of record (prior to 1948) and did not have any nearby stations to fill from. Since missing values would cause significant problems in running BASINS models, it was necessary to remove them. A script was developed to find remaining missing periods and remove them by only saving the non-missing portion of the timeseries.

Generate additional meteorological components

Several of the meteorological constituents needed by BASINS were generated from other constituents. The meteorological generation and disaggregation methods found in WDMUtil (U.S. EPA, 2004) were used in this process. These included:

- Computing daily Potential Evapotranspiration (PET) from daily Min/Max Temperature using Hamon's method (Hamon, 1961),
- Computing daily Solar Radiation from Cloud Cover (Hamon et al, 1954),

- Disaggregating daily PET and Solar Radiation to hourly (Hamon et al, 1954),
- Disaggregating daily Min/Max Temperature to hourly

These transformations were incorporated into several scripts to generate the needed constituents.

Compile final WDM files

The previous steps generated all of the timeseries that to be stored on the final database. This step takes the desired timeseries and stores them on WDM files that will make up the final database. For flexibility and ease of use in BASINS, there will be one WDM file for each unique station.

Since the ISH datasets uses a different primary identification scheme than the SOD, it is necessary to determine which ISH stations share the same location as an SOD station. This is done by comparing their WBAN numbers, a secondary identification number used by both datasets. A query was developed, using the station dbf files developed in step 2, to generate a new dbf file (Matching_ISH+SOD.dbf) containing stations common to both the ISH and SOD datasets.

A script was developed to look through all of the WDM files created through step 13 and select the timeseries from them that are useful in BASINS. These selected timeseries are then written to the final WDM files using the following dataset numbers and constituent names:

Dataset #	Constituent Name
1	PREC
3	ATEM
4	WIND
5	SOLR
6	PEVT
7	DEWP
8	CLOU

The numbers and names follow the same pattern used in the pre-existing BASINS Met WDM files. Dataset number 2, EVAP, was removed to use a more appropriate evapotranspiration term, PEVT, and to eliminate confusion between the two.

The script saves portions of the original SOD and ISH data that could serve as reference timeseries, such as daily precipitation and min/max temperature. These timeseries are stored in dataset numbers starting at 1000.

The script also handles pre-existing BASINS met stations in a specialized manner in order to assure upward compatibility. These stations were identified using the shape files that described the pre-existing stations. For each pre-existing station, the shape files also included the nearest station that contained the full suite of required constituents. Many new stations containing all needed constituents are being added to the database. Thus, the list of closest stations was updated to reflect these additions and stored as an updated dbf (BASINS31Map.dbf).

When updating a pre-existing BASINS met station, the script performs the following actions:

- For hourly precipitation (PREC), the entire period of record is saved, overwriting any pre-existing data for the period. This is due to the improved methods and greater number of nearby stations used in the filling/correcting process. NOTE: all pre-existing BASINS stations contained updated hourly precipitation data.
- For all other constituents, any timeseries available at the station are appended to the pre-existing data. For constituents not available at the station, the nearest station containing that constituent is read from the BASINS31Map.dbf file and that station's timeseries are used to update those constituents.
- All pre-existing BASINS data are saved as reference timeseries starting at dataset number 2001.

Disaggregate daily precipitation to hourly timeseries

A script was developed to disaggregate the daily precipitation data into hourly timeseries using a method similar to that used in distributing accumulated values (see step 11). For the station being disaggregated, a buffer of the 30 nearest geographic stations is developed. The station to use for disaggregation is determined by a combination of geographic distance and similarity in precipitation amounts for the day being disaggregated. A tolerance flag is used to only select stations that have a precipitation total within a certain percentage of the daily value. Once the nearest station is found, the daily value is then distributed using the same pattern as the nearby station. If no acceptable nearby station is found, the daily value is disaggregated using a triangular distribution centered at the middle of the day.

Store disaggregated precipitation timeseries on final WDM files

With the inclusion of disaggregated precipitation data, it is now possible for the same station to have multiple versions of precipitation data. To identify the disaggregated precipitation, it is assigned a scenario attribute value of "computed". A script was developed to dictate where the disaggregated precipitation is stored. If a station has both observed and disaggregated precipitation data, the observed data will remain at dataset number 1 and the disaggregated data will be saved at dataset number 10. If a station has only disaggregated precipitation data, it will be stored at dataset number 1, thus allowing WinHSPF to recognize it as a valid input timeseries during model setup.

Build database file summarizing final database

A script was developed to summarize every timeseries stored on the final database and store it as a dbf (MetStations.dbf). The items reported in this summary include dataset number, WDM file name, station name, latitude, longitude, constituent, start date, end date, and count of values. Besides serving as a useful summary file, the resulting dbf is used during downloading of the new met data. When data are downloaded for a specified area, the download tool builds a shape file for the downloaded stations using the information on the summary file.

Create DVDs containing final WDM files for installation on web site

Appendix D - Cligen Meteorological Data Use in BASINS 4

The Cligen model generates synthesized meteorological data based on historical station data at locations throughout the U.S. This section describes in detail how the initial Cligen data is manipulated for use within BASINS 4. For details on interacting with Cligen within BASINS 4, see the Cligen section of this documentation.

Cligen produces an output file that contains 10 distinct daily time series:

- prcp - precipitation, mm
- dur - duration of precipitation event, hrs
- tp - time to peak precipitation intensity, fraction of *dur*
- ip - peak intensity of precipitation, unitless
- tmax - maximum temperature, Deg C
- tmin - minimum temperature, Deg C
- rad - solar radiation, langleys
- w-vl - wind velocity, m/s
- w-dir - wind direction, degrees
- tdew - dewpoint temperature, Deg C

These time series may be viewed in BASINS 4 after opening an existing Cligen output file or performing a Cligen run.

Since many models have a need for meteorological data with time steps less than a day, an effort has been made to transform the daily Cligen data into hourly. The following list shows the hourly time series that are generated and the method to used to do so:

- Solar Radiation (SRAD) - Daily values are disaggregated to hourly using the algorithm described in the Compute:Disaggregations section of the help file.
- Wind Speed (WIND) - Daily values are converted from m/s to miles/day. The converted data are then used as input to the Wind disaggregation function to produce hourly values in miles/hour. The disaggregation function is described in the Compute:Disaggregation section of the help file.
- Air Temperature (ATMP) - Daily min and max temperature time series are converted from Deg C to Deg F. These time series are then used as inputs to the Temperature disaggregation function, along

with an assumed observation time of 24, to produce hourly values in Deg F. The disaggregation function is described in the Compute:Disaggregation section of the help file.

- Dewpoint Temperature (DEWP) - Daily values are converted from Deg C to Deg F. These values are disaggregated to hourly in two steps. The first simply applies the daily value to every hour of the day. The second compares the hourly values to a corresponding hourly air temperature time series. If the dewpoint value exceeds the air temperature, it is lowered to the temperature value.

- Potential Evapotranspiration (EVAP) - PET values are generated using Hamon's method as described in the Compute:Disaggregations section of the help file. Resulting hourly values are in inches.

- Precipitation (HPCP) - As described above, Cligen produces 4 daily time series (prcp, dur, tp, ip) that define daily precipitation events. BASINS 4 uses the WEPP (Flanagan, 1995) model's method for dividing a daily Cligen precipitation event into breakpoint data. The method involves using a double exponential function to divide the storm into many small intervals, each with a distinct average intensity. BASINS 4 then reaggregates these small intervals into hours to formulate the final hourly precipitation time series.

- Cloud Cover (CLDC) - Daily cloud cover values are generated from Cligen daily solar radiation. This is done using the algorithm for generating solar radiation described in the Compute:Computations section of this documentation. The algorithm was reversed to generate cloud cover. One minor assumption was made in the reversal; the intermediate value of percent sun was calculated based on the ratio of the actual solar radiation divided by the maximum possible solar radiation. The resulting daily cloud cover values were then disaggregated to hourly by applying the daily value to each hour of the day.

Appendix E - NLDAS Meteorological Data in BASINS

Using the full water quality capability of HSPF requires the full suite of meteorological inputs, including precipitation, potential evapotranspiration, air temperature, wind speed, solar radiation, dew point temperature, and cloud cover. An enhancement for BASINS 4.5 allows direct download and/or calculation of this full suite from the North American Land Data Assimilation System (NLDAS) gridded data set. Published by NASA, NLDAS runs in near real-time on a 1/8th-degree grid over central North America, with retrospective NLDAS datasets extending back to January 1979. This enhancement not only allows direct download of this data for a specified region but also facilitate creation of HSPF models driven by this gridded data.

The NLDAS datasets are not specifically designed to populate specific models, such as HSPF; therefore, conversions algorithms are required to transform some NLDAS MET data to meet the specific needs of HSPF. The following table shows the transformations used:

HSPF Parameter	NLDAS Parameter	NLDAS Parameter Description	Transformation Used
Hourly Precipitation	APCPsfc	Precipitation hourly total	Unit conversion only
Hourly Potential Evapotranspiration	PEVAPsfc	Potential Evaporation	Unit conversion only
Hourly Air Temperature	TMP2m	2m above ground temperature	Unit conversion only
Hourly Wind Speed	UGRD10m,VGRD10m	10m above ground zonal wind, 10m above ground meridional wind	Calculated using Euclidean distance and unit conversion
Hourly Solar Radiation	DSWRFsfc	Surface DW shortwave radiation flux	Unit conversion only
Hourly Dew Point Temperature	SPFH2m,TMP2m	2m above ground specific humidity, 2m above ground temperature	Calculated from specific humidity and air temperature plus unit conversion
Hourly Cloud Cover	DSWRFsfc	Surface DW shortwave radiation	Calculated from hourly solar radiation

	flux	plus unit conversion

The method for computing hourly cloud cover based on solar radiation utilizes the BASINS algorithm for computing daily cloud cover based on daily solar radiation and latitude. This routine assumes that percent sun, and thus, cloud cover is essentially the ratio of actual solar radiation to potential max solar radiation. Max solar radiation is based on the HSPII (Hydrocomp, 1978) RADIATION procedure, which is based on empirical curves of radiation as a function of latitude (Hamon et al, 1954, Monthly Weather Review 82(6):141-146.) The daily cloud cover values are then used for each hour of the day.

The method for calculating dew point temperature based on specific humidity follows the method of EOL-UCAR, 2016, where vapor pressure is computed from specific humidity and then the dew point temperature is computed from vapor pressure.

EOL-UCAR. 2016. CEOP Derived Parameter Equations. Coordinated Energy and Water Cycle

Observation Project (CEOP), Earth Observing Laboratory (EOL), University Corporation for

Atmospheric Research (UCAR), Boulder, CO.

https://www.eol.ucar.edu/projects/ceop/dm/documents/refdata_report/eqns.html (last accessed 09.12.18).

Appendix F - Watershed and Instream Models

In versions of BASINS prior to version 4.5, several models were integrated into BASINS which allowed the user to simulate the behavior of toxic chemicals, conventional pollutants, and nutrients on the land surface and instream. Data preparation and visualization tools streamline the use of the models. In BASINS 4.5, these models are installed separately. BASINS 4.5 Core only provides the core functionality of BASINS system without the model plugins. Users of BASINS have to install the available model plugins separately to make them available.

HSPF

HSPF is a watershed model that simulates nonpoint source runoff and pollutant loadings for a watershed and performs flow and water quality routing in reaches. The Windows interface to *HSPF*, known as *WinHSPF*, works with the EPA-supported *HSPF* model (version 12.2 and later) (Bicknell et al., 2005). *WinHSPF* supports a full suite of the *HSPF* model capabilities. Features supported by *WinHSPF* include:

- Estimation of nonpoint source loadings from mixed land uses
- Estimation of fate and transport processes in streams and one-dimensional lakes

WinHSPF can be run on a single watershed or a system of multiple hydrologically connected subwatersheds that have been delineated using the BASINS *Watershed Delineation* tool. The model requires land use data, reach data, meteorological data, and information on the pollutants of concern in the watershed and the reaches. *WinHSPF* is designed to interact with the BASINS utilities and data sets to facilitate the extraction of appropriate information and the preparation of model input files. The reach network is automatically developed based on the subwatershed delineations. Users can modify and adapt input files to site-specific conditions through the use of *WinHSPF* and supporting information provided by the BASINS utilities and reporting functions, as well as locally derived data sources. *WinHSPF* works with postprocessing tools to facilitate display and interpretation of output data.

SWAT

The Soil and Water Assessment Tool (SWAT) model is a river basin, or watershed, scale model developed to predict the impact of land management practices on water, sediment, and agricultural chemical yields on complex watersheds with varying soils, land use, and management conditions. The model combines these with point source contributions and performs flow and water quality routing in stream reaches. The model is physically based and computationally efficient, uses readily available inputs and enables users to study long-term impacts.

SWAT can be run on a single watershed or a system of multiple hydrologically connected subwatersheds that have been delineated using the BASINS Watershed Delineation tool. The user can set up SWAT simulations using the data provided with BASINS (land use, soils, reach data, meteorological, pollutants, etc. data) and/or introduce custom data. Information about SWAT can be downloaded from: http://swatmodel.tamu.edu/

AQUATOX

AQUATOX is a time-variable ecological risk assessment model that simulates the fate and effects of various environmental stressors in aquatic ecosystems. It simulates the fate and transfer of pollutants from loads to the water, sediments, and biotic components, and transfer throughout the food web. Simultaneously it predicts the effects of the stressors on the ecosystem, by simulating the chemical, physical and biological processes that bind the ecosystem together. *AQUATOX* can predict the fate and ecological effects of nutrients, organic toxicants, and bioaccumulative compounds, as well as the expected ecosystem responses to pollution reductions. It considers several trophic levels, including attached and planktonic algae and submerged aquatic vegetation, invertebrates, and forage, bottom-feeding, and game fish; it also represents associated organic toxicants.

Environmental management programs and activities that could benefit from application of *AQUATOX* include water quality criteria and standards, Total Maximum Daily Loads (TMDLs), identification of the cause(s) of biological impairment where there are multiple stressors, and ecological risk assessments.

WASP

The EPA Water Quality Simulation Program (*WASP*) helps users interpret and predict water quality responses to natural phenomena and manmade pollution for various pollution management decisions. WASP is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. WASP also can be linked with hydrodynamic and sediment transport models that can provide flows, depths velocities, temperature, salinity and sediment fluxes. BASINS contains an interface for setting up a WASP 8.x simulation using available GIS and timeseries data.

SWMM

The EPA Storm Water Management Model (*SWMM*) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM is used throughout the world for planning, analysis and design related to storm water runoff, combined sewers, sanitary sewers, and other drainage systems in urban areas. BASINS contains an interface for setting up a SWMM 5 simulation using available GIS and timeseries data.

GWLF-E

The GWLF-E Plug-in included with BASINS is a GIS-based watershed modeling tool created by the Penn State Institutes of Energy and the Environment (PSIEE). GWLF-E is a 'mid-level' model that estimates monthly nutrient and sediment loads within a watershed. This plug-in provides a link between BASINS and PSIEE's newest version of the GWLF watershed model (now called GWLF-E). The core watershed simulation model used in the GWLF-E plug-in is based on the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker (1987). An advantage of GWLF is the ease of use and reliance on input datasets less complex than those required by other watershed-oriented water quality models such as SWAT, SWMM and HSPF.

PLOAD

The Pollutant Loading Estimator (*PLOAD*) is a simple watershed model that computes nonpoint source loads from different subwatersheds and landuses based on annual precipitation, landuses and BMPs. *PLOAD* estimates nonpoint sources of pollution on an annual average basis, for any user-specified pollutant, using either the export coefficient or simple method approach. *PLOAD* was designed to be generic so that it can be applied as a screening tool in typical NPDES stormwater permitting, watershed management, or reservoir protection projects.

Watershed and Instream Model Setup

Previous versions of BASINS included Model Plug-ins to set up seven models based on information in the BASINS project, *HSPF*, *SWAT*, *AQUATOX*, *WASP*, *SWMM*, *GWLF-E*, and *PLOAD*. In BASINS 4.5 Core, these Model Plug-ins are packaged and installed separately.

The *HSPF*, *SWAT*, *AQUATOX*, *WASP*, and *SWMM* options aid the user in setting up powerful external, yet linked, simulation models. The *PLOAD* option provides a very simple watershed model for estimating pollutant loads on an average annual basis. *GWLF-E* is a 'mid-level' model that estimates monthly nutrient and sediment loads within a watershed. This section contains full descriptions of how each model can be setup based on information from the BASINS project, if the user has collected the necessary information using the available BASINS utilities.

The **Models** menu item is a product of both the **Model Setup** and **BASINS 4.5** plug-ins.

Model	Description
HSPF	Sophisticated, high-level watershed model able to perform continuous simulation of surface and subsurface flow and associated physical, chemical, and biologic processes at a tributary level. Complete instructions on setting up the model are detailed in the HSPF section of this documentation. (Maintained by EPA)
SWAT	Physical based, watershed scale model that was developed to predict the impacts of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land uses and management conditions over long periods of time. Complete instructions on setting up the model are detailed in the SWAT section of this documentation. (Not Maintained by EPA)
AQUATOX	Simulation model for aquatic systems that predicts the fate of various pollutants, such as nutrients, organic chemicals, suspended and bedded sediments, and their effects on the ecosystem, including fish, invertebrates, and aquatic plants. Complete instructions on setting up the model are detailed in the AQUATOX section of this documentation. (Maintained by EPA)
WASP	Dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. Complete instructions on setting up the model are detailed in the WASP section of this documentation. (Maintained by EPA)
SWMM	Dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. Complete instructions on setting up the model are detailed in the SWMM section of this documentation. (Not Maintained by EPA)
GWLF-E	'Mid-level' model that estimates monthly nutrient and sediment loads within a watershed. Complete instructions on setting up the model are detailed in the GWLF-E section of this documentation. (Not Maintained by EPA)
PLOAD	Simple watershed model that computes nonpoint source loads from different subwatersheds and landuses based on annual precipitation, landuses and BMPs. Complete instructions on setting up the model are detailed in the PLOAD section of this documentation. (Not Maintained by EPA)

Background

One common objective of water quality modeling studies is to be able to predict the impact of different point and nonpoint source loading scenarios on surface water bodies. The historic reliance on the use of design flows for developing permit limits and for evaluating attainment of water quality standards has done nothing to prepare TMDL practitioners for developing TMDLs on waterbodies that receive inputs from both point sources (steady, continuous loads) and nonpoint sources (unsteady, discontinuous loads). The episodic discharges from the nonpoint sources, occurring as a result of rain or melting snow, enter streams whose assimilative capacities (generally approximated as dilution ratios) are not well represented by the design flows (7Q10 or 4B3) traditionally used for setting permit limits for point sources. While determining the allowable load allocation from the nonpoint sources based on a design flow would be environmentally protective, it probably would be unfair to the point source dischargers and impossible to attain under many conditions. The fact that releases from both point sources and nonpoint sources must be combined for TMDL purposes is totally logical. Fortunately, we can make the process of developing TMDLs easier through intelligent use of today's powerful desktop computers, Geographic Information Systems, environmental databases, and watershed models supported with graphical interfaces that render them faster and easier to use.

The easiest way to envision the necessary integration of loads from point and nonpoint sources is to consider what it would be like if you could continually measure the concentrations of the pollutants of concern in the watershed. Assume that you could locate sensors at appropriate locations and collect data on chemical concentration, stream volume flow, temperature, pH, and other properties continuously (or even daily) for several years, you could develop a database that you could use to evaluate the health of the waterbody or of the watershed. With such a database, you could develop statistical descriptions of the distributions of pollutant concentrations that have resulted from the combination of PS and NPS loadings within the watershed. If you were to continue this monitoring effort for a couple decades, you could then evaluate whether or not water quality criteria (i.e., chemical concentrations) were being exceeded more frequently than specified in the State's water quality standards.

As it is unlikely that you will have either the time or money to develop such a data record for many watersheds, the next best way to generate the data needed to evaluate attainment of water quality standards is to model the watershed. By running a continuous simulation model, you can synthesize a database that is analogous to that described above. In this exercise you would simulate daily values of stream volume flow, pollutant loadings, pollutant concentrations, etc. for an appropriate period of record. The computer output from this watershed modeling study would look very much like the database from the monitoring study and the data would be subjected to the same statistical tests.

Loadings from point sources are based on resources such as the permitted releases of chemicals from municipal and industrial facilities (e.g, EPA's Permit Compliance System database) or from monitoring data collected at these facilities (e.g., Discharge Monitoring Reports). Loadings from non-point sources are estimated by the watershed models; the loads depend on factors such as land use, vegetation cover, and meteorological conditions. The resulting pollutant concentrations are estimated by dividing the daily loadings (total of loads from both PS and NPS) by the model generated daily stream flow. If in-stream concentrations exceed criteria, loads are reduced until standards are attained.

Water Quality Modeling Based on Hydrologic Principles

A continuous simulation model was considered to be critical for a realistic representation of watershed processes. Continuous simulation models combine daily (or other time-step) measurements or synthesized estimates of effluent flows and loads, wet-weather source concentrations and loads, and receiving water flows to calculate receiving water concentrations. A deterministic model is applied to time series of these variables to predict resulting concentrations in chronological order, with the same time sequence as the input variables. This enables a frequency analysis of concentrations at a given point of interest, as will be explained more fully below.

In natural systems, flows typically exhibit correlation in time (serial correlation), so that low flow days tend to follow other low flow days, and high flow days follow high flow days. Precipitation-driven episodic loads often exhibit cross-correlation (correlation between different variables) with receiving water flow, as the same precipitation that generates the load may also increase flow throughout the watershed. Both serial and cross-correlation can have important implications for predicting water quality impacts. For instance, if episodic loads are most likely to occur when flow in the receiving water is high, an adverse impact on water quality is much less likely than if the loads occur when flow in the receiving water is low.

A continuous simulation approach automatically takes into account the serial correlation present in flows and other variables, as well as cross-correlations between measured variables, because real data are used. This is potentially the most powerful method available for accurate prediction of the frequency of receiving water concentrations, but it does have disadvantages. Notably, the method is very data intensive and may require observations over many years to accurately evaluate the frequency of occurrence of water quality excursions. Long time series of monitoring data for wet-weather loads will generally not be available and may have to be simulated from precipitation records using rainfall-runoff models. Simulating data introduces uncertainty; indeed, if good observations of time series of more than one input parameter are lacking it may be preferable to use a statistical simulation approach (such as the Monte Carlo method described below) which allows a direct analysis of the effects of input uncertainty on model predictions.

How Do I Choose Which Model to Use?

There are many factors to consider when selecting the model. The question "Is this the best model?" may be answered by the question "For what purpose?". What data do you have to represent the watershed that you are modeling? What processes in the watershed are important to your study? What are the appropriate scales of resolution, both space (distance) and time? What are the uncertainties associated with the quality of the data? What are the uncertainties associated with the effectiveness of the proposed controls? If the results (model output) of the watershed modeling study are going to be used as (part of the) input to a lake or reservoir model of nutrient eutrophication, is the eutrophication model of the same temporal scale? That is, does the eutrophication model require a seasonal or annual nutrient input or does it simulate processes that account for daily fluctuations in nutrient loads?

At the risk of oversimplifying a very complex issue, the developers of BASINS wish to provide some general guidance. *PLOAD, SWAT* and *HSPF* are spatially distributed, lumped parameter models. They may be used to analyze watersheds and river basins by subdividing the area into homogenous parts.

SWMM is a dynamic rainfall-runoff simulation model used for single event or continuous simulation of runoff quantity and quality from primarily urban areas. *WASP* is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos.

PLOAD is a simple watershed model that computes nonpoint source loads from different subwatersheds and landuses based on annual precipitation, landuses and BMPs. Successful linking of the model to existing BASINS data and user supplied data makes the model useful in estimating nonpoint source loads, relative contributions and load reduction by BMPs. *PLOAD* requires watershed boundary, landuse, best management practices (BMPs), point sources and annual precipitation data to compute pollutant loads. Additionally *PLOAD* requires event mean concentrations (EMCs) and/or loads per acre tables for different land use types. *Use PLOAD when you want estimates of seasonal or annual loadings to feed simple eutrophication models; or where there is great uncertainty in effectiveness of controls and adjustments to the TMDL may be expected after post-implementation monitoring.*

The GWLF-E Plug-in included with BASINS is a GIS-based watershed modeling tool created by the Penn State Institutes of Energy and the Environment (PSIEE). GWLF-E is a 'mid-level' model that estimates monthly nutrient and sediment loads within a watershed. This plug-in provides a link between BASINS and PSIEE's newest version of the GWLF watershed model (now called GWLF-E). The core watershed simulation model used in the GWLF-E plug-in is based on the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker (1987). An advantage of GWLF is the ease of use and reliance on input datasets less complex than those required by other watershed-oriented water quality models such as SWAT, SWMM and HSPF.

SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM5 is supported in BASINS. *Use SWMM for modeling urban areas when you want to route runoff through pipes, channels, etc.*

WASP is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. This model helps users interpret and predict water quality responses to natural phenomena and manmade pollution for various pollution management decisions. WASP also can be linked with hydrodynamic and sediment transport models that can provide flows, depths velocities, temperature, salinity and sediment fluxes. WASP8 is supported in BASINS. *Use WASP for detailed instream modeling.*

AQUATOX is a time-variable ecological risk assessment model that simulates the fate and effects of various environmental stressors in aquatic ecosystems. It simulates the fate and transfer of pollutants from loads to the water, sediments, and biotic components, and transfer throughout the food web. AQUATOX version 3 is supported in BASINS. *Environmental management programs and activities that could benefit from application of AQUATOX include water quality criteria and standards, Total Maximum Daily Loads (TMDLs), identification of the cause(s) of biological impairment where there are multiple stressors, and ecological risk assessments.*

HSPF is a sophisticated, high-level watershed model able to perform continuous simulation of surface and subsurface flow and associated physical, chemical, and biologic processes at a tributary level. HSPF version 12.2 (and later) includes a simplified snow melt algorithm (i.e., degree-day approach), the ability to model land-to-land transfers, high water tables and surface ponding (wetlands), and the addition of new BMP and Reporting modules. The new SNOW module requires only precipitation and air temperature time series, while producing essentially the same output as the current module which requires five additional meteorological time series (evaporation, wind speed, solar radiation, dew point, and cloud cover). *Use HSPF where the BASINS holdings provide hourly meteorological data from a location on or near your watershed. Also, you may use BASINS tools to develop your own file of hourly meteorological data for a more appropriate meterological station than is included in the BASINS holdings. If you do not have a USGS gage station on your watershed (to calibrate the hydrology) you can used the paired watershed approach of calibrating HSPF on a nearby watershed of similar characteristics and then applying the calibrated model to your watershed for the purpose of developing the TMDL. The HSPFParm database included with BASINS supports HSPF modelers with a readily available source of model parameter values as a starting point for developing new watershed applications.*

SWAT simulates hydrology, pesticide and nutrient cycling, bacteria transport, erosion and sediment transport. *SWAT* is ideally suited to predict effects of land use management (such as climate and vegetative changes, agricultural practices, reservoir management, groundwater withdrawals, water transfer) on water, sediment, and chemical yields from river basins. *SWAT* uses a daily time step for simulations running from 1 to 100 years; (*HSPF*, as implemented in BASINS, uses an hourly time step.) We anticipate that *SWAT* will meet many modeling needs for situations where TMDLs need to be developed for watersheds dominated by lands in agricultural operations. The version of SWAT supported in BASINS is SWAT2005. *Use SWAT where there is no nearby meterological station with hourly data and/or where there is no nearby gaged watershed.*

The BASINS system also enables the user to view output from these models in a spatial context. See the Analysis section for more details.

HSPF

HSPF is a watershed model that simulates nonpoint source runoff and pollutant loadings for a watershed, combines these with point source contributions, and performs flow and water quality routing in reaches.

The user interface to *HSPF* through BASINS is known as *WinHSPF*. All features of HSPF are available through *WinHSPF*. It fully supports the MASS-LINK, SCHEMATIC and SPECIAL ACTIONS blocks of the UCI File. This interface also directly reads *HSPF* UCI file. See the WinHSPF User's Manual for instructions on using *WinHSPF*. The HSPF User's Manual is also available for reference.

WinHSPF can be run on a single watershed or a system of multiple hydrologically connected subwatersheds that have been delineated using the BASINS *Watershed Delineation* tool. The model requires land use data, reach data, meteorological data, and information on the pollutants of concern in the watershed and the reaches. *WinHSPF* is designed to interact with the BASINS utilities and data sets to facilitate the extraction of appropriate information and the preparation of model input files. The reach network is automatically developed based on the subwatershed delineations. Users can modify and adapt input files to site-specific conditions through the use of *WinHSPF* and supporting information provided by the BASINS utilities and reporting functions, as well as locally derived data sources. *WinHSPF* works with postprocessing tools to facilitate display and interpretation of output data.

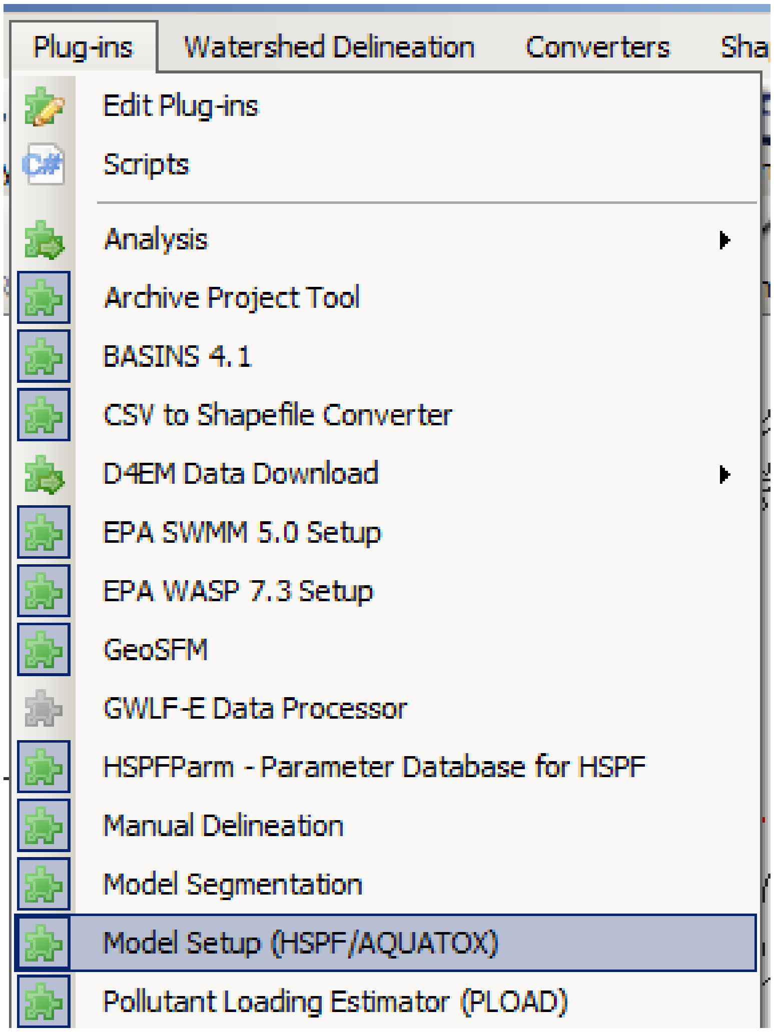
BASINS allows the user to open *WinHSPF* directly from the BASINS user interface. The following sections provide more details on using *WinHSPF* through BASINS:

- Data Requirements for Setting up *HSPF* through BASINS
- Creating a New *HSPF* Project
- Opening an Existing *HSPF* Project
- Introduction to the Main *WinHSPF* Window

HSPF requires Watershed Data Management (WDM) files, which contain input and output time-series data, in order to run. WDM Time-series management functionality is available through the 'File' menu option in BASINS, especially through the 'File:Manage Data' menu option. This functionality is documented under Time-Series Management. WDM data import functionality is available under Read Data with Script.

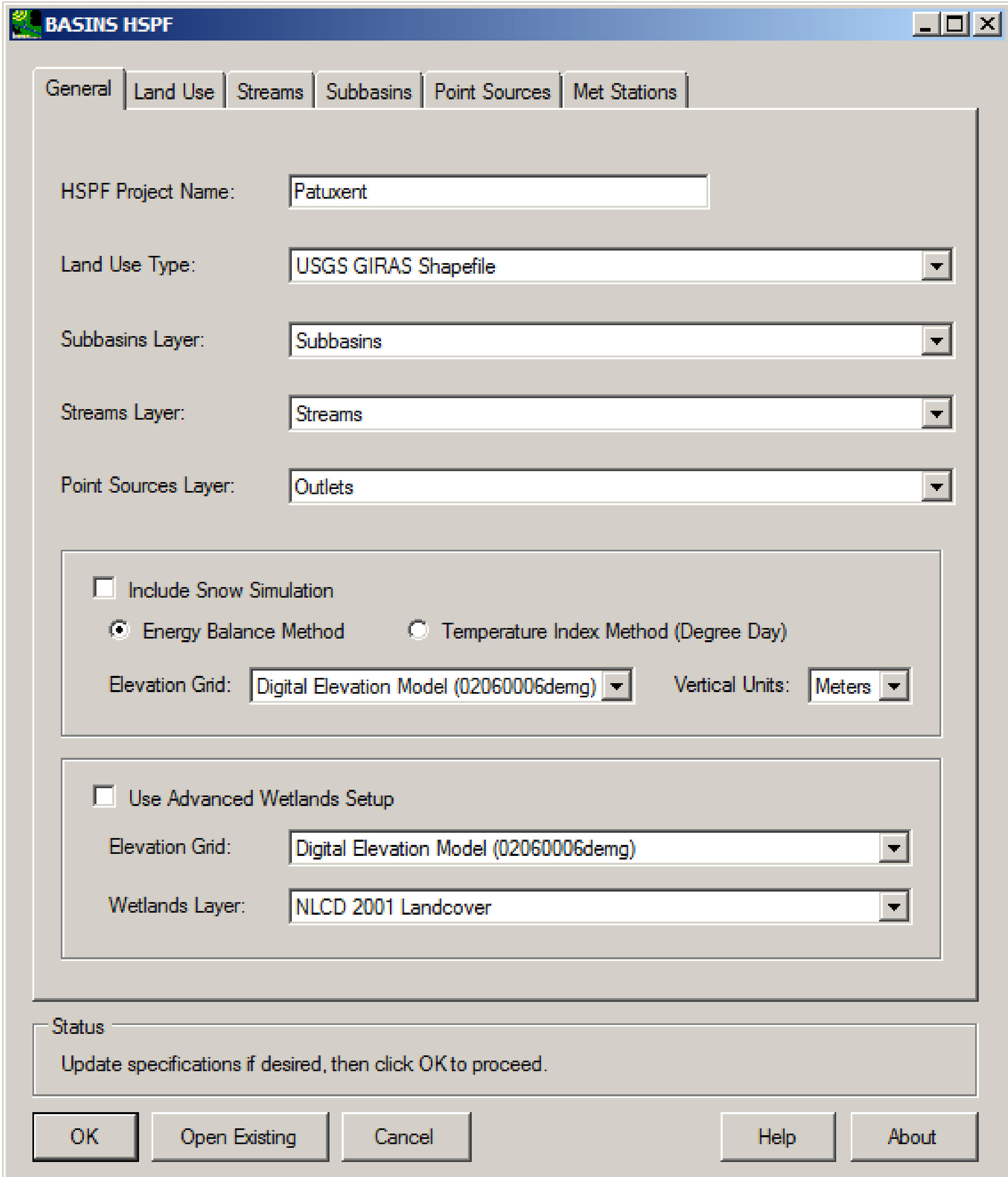
Key Procedures

1. Select **Plug-ins:Model Setup (HSPF/AQUATOX)** from the main menu so that it is active. This will add **HSPF** and **AQUATOX** to the **Models** menu on the main form.



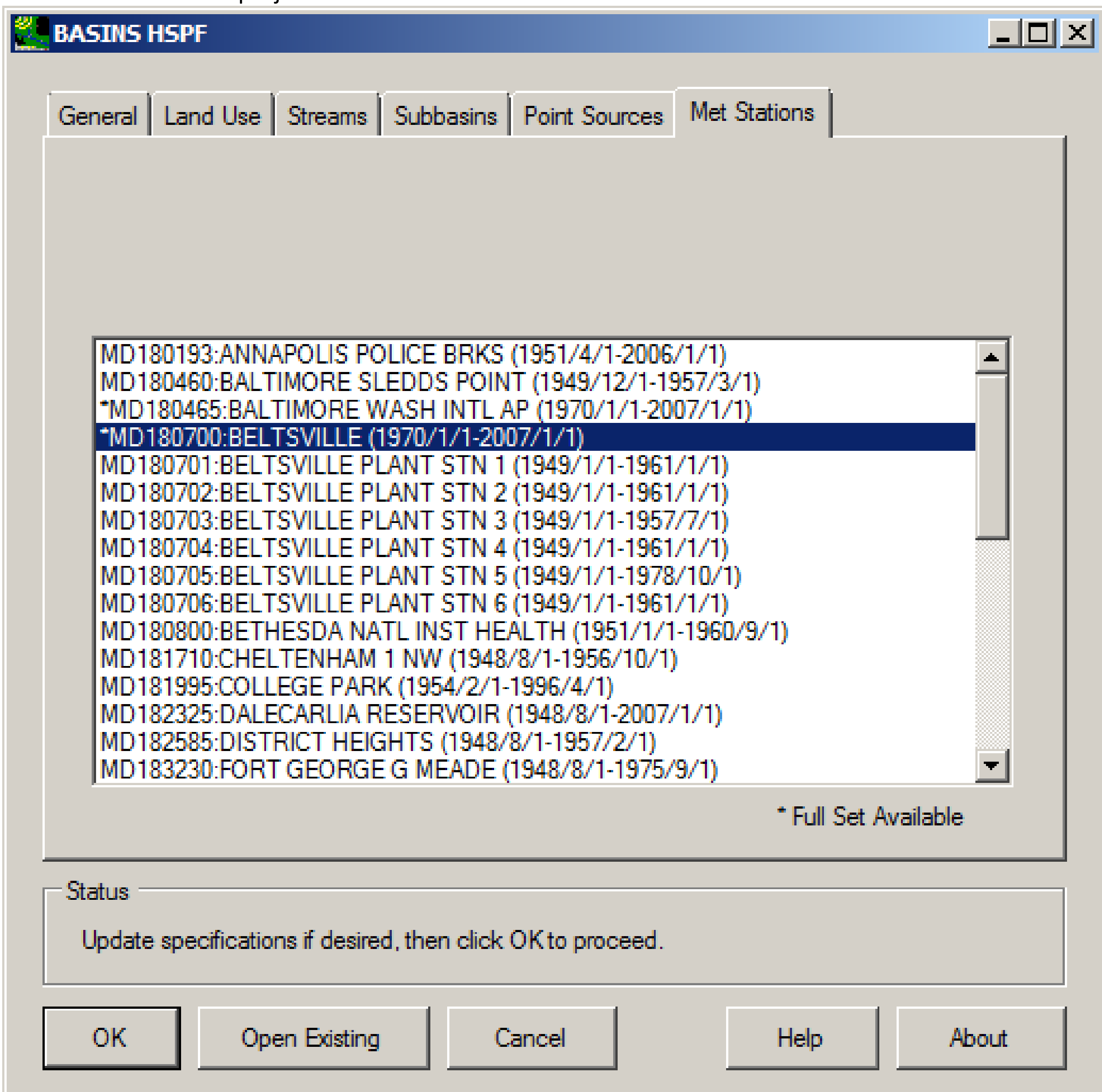
2. Select **Models:HSPF** from the main menu to invoke the **BASINS HSPF** model setup form. All of the fields on the general tab should default appropriately if the BASINS Delineation Tools were

used to create the Subbasins and Streams Layers.



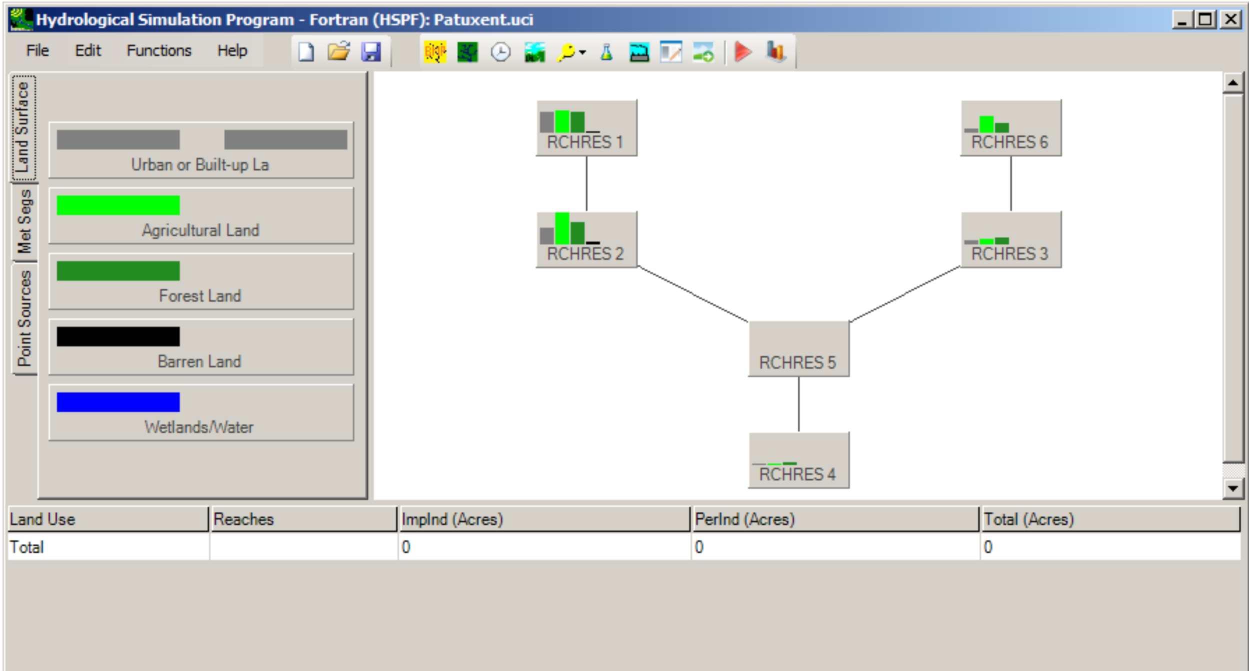
3. Click the Met Stations tab to specify the meteorological data to use in the new HSPF model. The met stations available for selection reflect the available data contained in the WDM files added

to the current BASINS project.



4. Choose the Met Station to use for this project, and then click **OK** to create the *HSPF* UCI file, which will be stored in the '\BASINS\modelout*project*\' directory. After processing, the main

window of *WinHSPF* will appear with the new *HSPF* project.



Note: The *WinHSPF* interface is now active. That program's documentation contains extensive instructions on how to further develop an *HSPF* model.

Data Requirements for Setting up HSPF through BASINS When using BASINS *HSPF* to build an initial *HSPF* User Control Input (UCI) file, the subbasins, streams, and land use data layers must exist on the map. Generally, the 'subbasins' and 'streams' (plus an optional 'point sources' layer) will come from a BASINS delineation tool, although equivalent themes from another delineation tool can be used as well.

BASINS *HSPF* is designed to be flexible in its handling of GIS layers. While the subbasins and streams layers from a BASINS delineator tool will typically be used, such layers from any other delineation tool are also supported. Similarly, while typically a BASINS user will use the USGS GIRAS or NLCD land use layers, BASINS *HSPF* supports use of other vector or raster land use layers.

Additional layers may be required depending upon the options chosen in the BASINS *HSPF* tool. The Point Sources layer is only needed for identifying point source locations. If no point sources are to be included in the model, this layer may be omitted. The Land Use Index theme from BASINS is also required when using the USGS GIRAS land use data.

If snow simulation is desired, the user must specify a choice of simulation methods for snow, a grid of elevations, and the vertical units of that elevation grid. The elevation grid is used in the model setup process to compute the average elevation of each HSPF pervious and impervious model segment (PERLND/IMPLND), which is a required input for HSPF snow simulation.

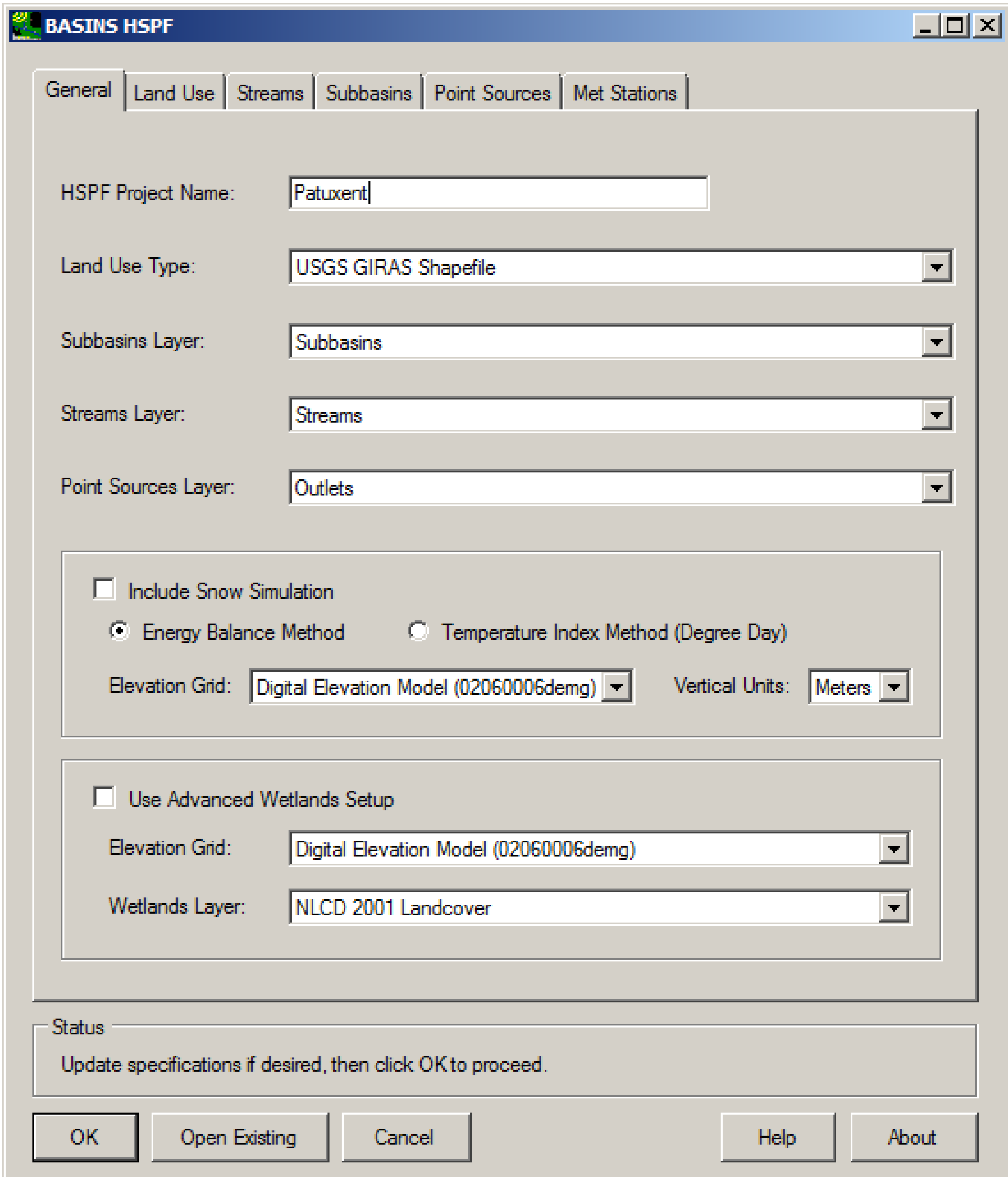
Beginning with BASINS 4.5, a new option is available for simulating wetlands. This option uses a DEM grid and a wetlands map layer to determine the amount of land area draining to a wetland before reaching the stream reach. Using this option, the HSPF project will be created with a wetlands HSPF reach/reservior (RCHRES) operation draining to each stream RCHRES operation.

BASINS *HSPF* may also be used to enter *WinHSPF* with an existing *HSPF* User Control Input (UCI) file. In this case the delineation layers are not required.

Creating a New HSPF Project

BASINS *HSPF* creates a new *HSPF* project using the GIS layers on the map. Layers used by this extension include **Subbasins**, **Streams**, and optionally **Point Sources** or **Outlets**. Depending upon the options chosen, the **Land Use Index** and corresponding land use shape files may also be used. A met stations layer, such as that created by the Data Download tool when downloading meteorologic data, is useful for locating possible met stations for the HSPF model.

The BASINS *HSPF* window opens with the interface populated according to the layers available on the map. The dominant portion of the BASINS *HSPF* window is a tabbed dialog. Below the tabbed dialog is a small status frame and a row of command buttons.



The tabbed dialog contains a **General** tab for specifying general information about the *HSPF* project to be created, along with the map layers to be used in creating the *HSPF* project. The other tabs are used for specifying more details about the Land Use, Subbasins, Streams, Point Sources layers, and the Met Stations to be used in the model setup.

The **General** tab is used to specify the name of the *HSPF* project (the base name of the UCI file), the Land Use Type (USGS GIRAS Shapefile, Other Shapefile, NLCD Grid, or Other Grid), the Subbasins layer, the Streams layer, and the Point Sources layer. By default the *HSPF* Project name will be the base name of the BASINS project, and the Land Use Type will be 'USGS GIRAS Shapefile'. The Point Sources layer does not have to be specified if there are no point sources to be included in the *HSPF* project.

The **General** tab is also used to indicate if snow simulation is desired. If the 'Include Snow Simulation' box is checked, the user must specify a choice of simulation methods for snow, a grid of elevations, and the vertical units of that elevation grid. The elevation grid is used in the model setup process to compute the average elevation of each HSPF pervious and impervious model segment (PERLND/IMPLND), which is a required input for HSPF snow simulation.

A recent addition to the **General** tab is the 'Advanced Wetlands Setup' frame. This option uses a DEM grid and a wetlands map layer to determine the amount of land area draining to a wetland before reaching the stream reach. Using this option, the HSPF project will be created with a wetlands HSPF reach/reservior (RCHRES) operation draining to each stream RCHRES operation.

When entering BASINS *HSPF* from a BASINS project containing the typical BASINS project layers, including the output from a BASINS delineation and downloaded meteorologic data, all fields in the interface will be populated. In this case the user may update any of the specifications in the interface if desired. The met stations to be used in the model are specified through the Met Stations tab, and when ready the user may click **OK** to begin the calculations to produce the new *HSPF* project.

Clicking **OK** produces the BASINS Files (.wsd, .psr, .rch, and .ptf) used in creating a new UCI file in *WinHSPF*. Messages in the **Status** frame give updates on the progress. These intermediate files are documented in detail in the *WinHSPF* Manual. After these files are created, the UCI file is automatically created.

The new UCI file is written to the *HSPF* project folder (in the BASINS\modelout directory). Portions of the UCI file are based on the .wsd, .rch, .psr, and .ptf files created when the **OK** button was clicked in BASINS *HSPF*. Once the UCI file is created the set of files from the BASINS *HSPF* Extension (.wsd, .rch, .psr, and .ptf) are no longer used. Initial values for some parameters important to *HSPF* hydrology calibration are extracted from the 'starter.uci' and deposited into the new UCI file.

A Project WDM File will also be created, using the base file name of the UCI file along with the WDM extension. This file is used to contain the point source inputs to the model as well as any output time series from the *HSPF* simulation.

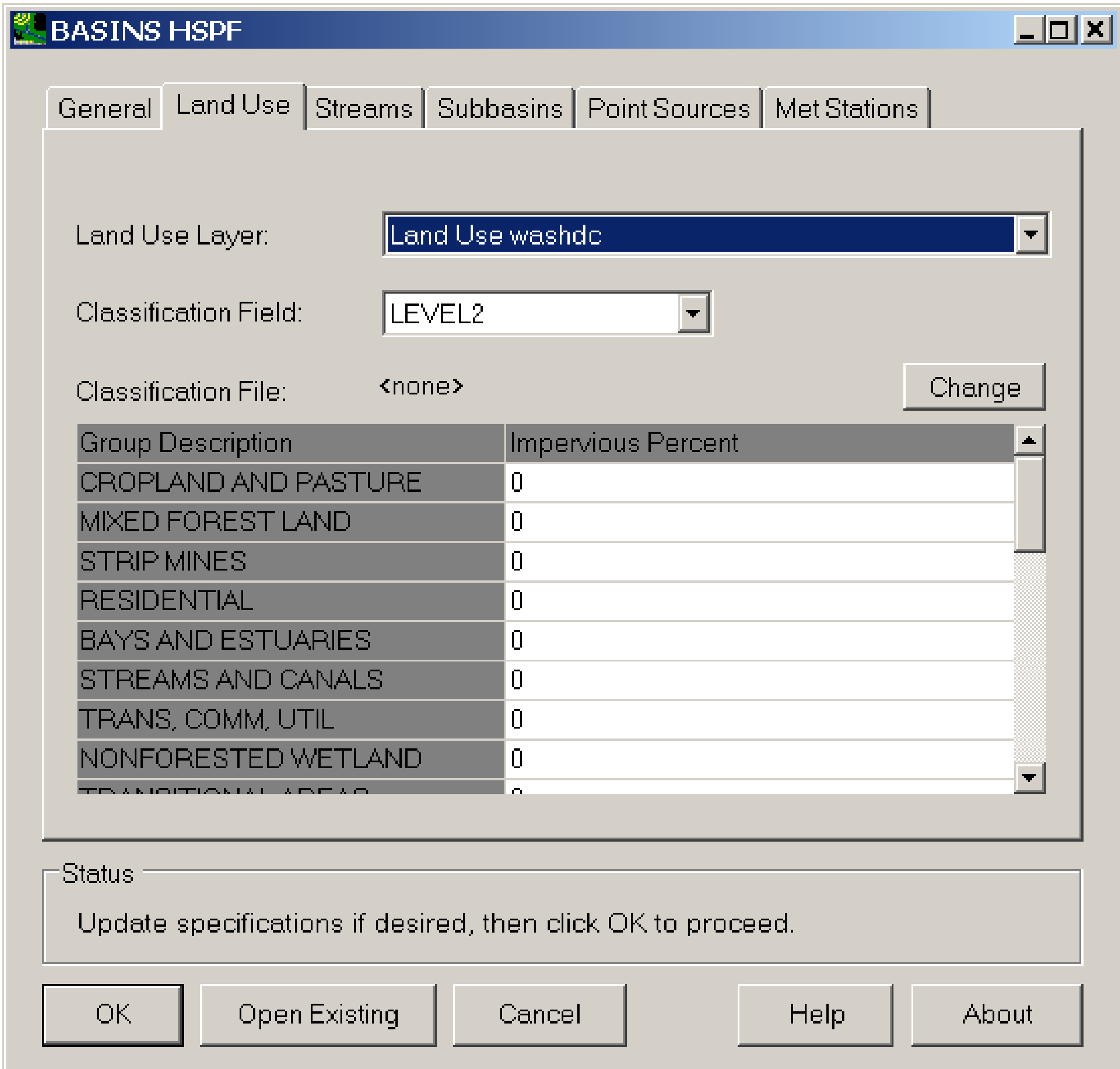
After the UCI is created the main *WinHSPF* window appears, entitled **Hydrological Simulation Program - Fortran (HSPF)**. A schematic diagram of the watershed appears in the main *WinHSPF* window.

Note: If no subbasins are selected in the map, the *HSPF* project will be produced using all of the subbasins in the specified subbasin layer. If specific subbasins are selected, the *HSPF* project will contain only those subbasins.

Land Use Tab

The **Land Use** tab is used to specify details of how land use data is to be extracted for each subbasin. The interface on this form changes depending upon the **Land Use Type** specified in the **General** tab. If the **Land Use Type** on the **General** tab is set to 'USGS GIRAS Shapefile', this tab will include a **Classification File** selection tool and a grid for specifying the impervious percentage of each land use type. When using the USGS GIRAS land use data with the default classification file, the land use types will be reclassified into six categories (forest, agricultural, urban, range land, barren, and wetlands/water).

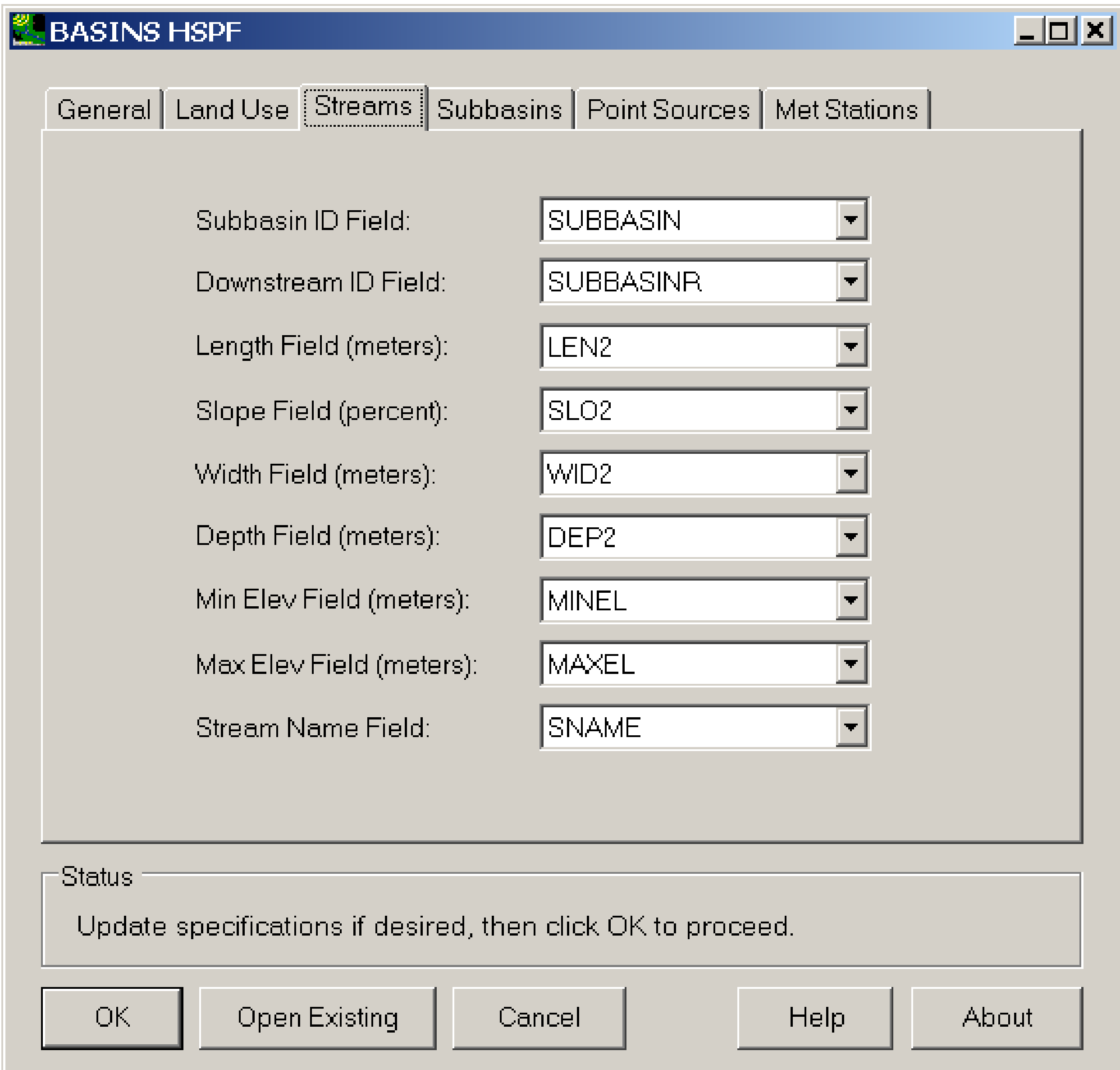
If the 'Other Shapefile', 'NLCD Grid' or 'Other Grid' is specified as the **Land Use Type**, this tab will also include a drop-down list to specify the land use layer to be used. If 'Other Shapefile' is chosen, the **Classification Field** is used to specify the descriptive field in the attribute table of the land use layer that will be used as the land use type in *HSPF*, as reflected in the Impervious Percent grid. The Impervious Percent column of the grid is used to specify the percentage of each land use category that is to be considered impervious.



The Classification file setting is used to specify a .dbf file specifying how the individual land use categories are to be combined into the set of categories in the model. For instance, using the default classification file for GIRAS data, residential, commercial, and industrial land use categories are all grouped together into a broad 'urban' land use type. If no classification file is set, each individual land use category will be represented separately in *HSPF*. The Reclassify Land Use tool in BASINS can be used to build other classification files.

Streams Tab

The **Streams** tab is used to specify details of how data is to be extracted from the streams layer. This tab contains nine drop-down lists used to specify the Subbasin ID Field, Downstream ID Field, Length Field (in meters), Slope Field (as percent), Width Field (meters), Depth Field (meters), Minimum Elevation Field (meters), Maximum Elevation Field (meters), and Stream Name Field. These fields are filled in by default when using a Streams layer produced using one of the BASINS watershed delineation tools. If using a Streams layer from another source, the appropriate field names will have to be specified through this interface. The Subbasin ID field is used to link a stream segment with the subbasin in which it resides, so the values in this field must correspond to the values in the Subbasin ID field in the Subbasins tab. The Downstream ID Field is used to establish connectivity between subbasins.



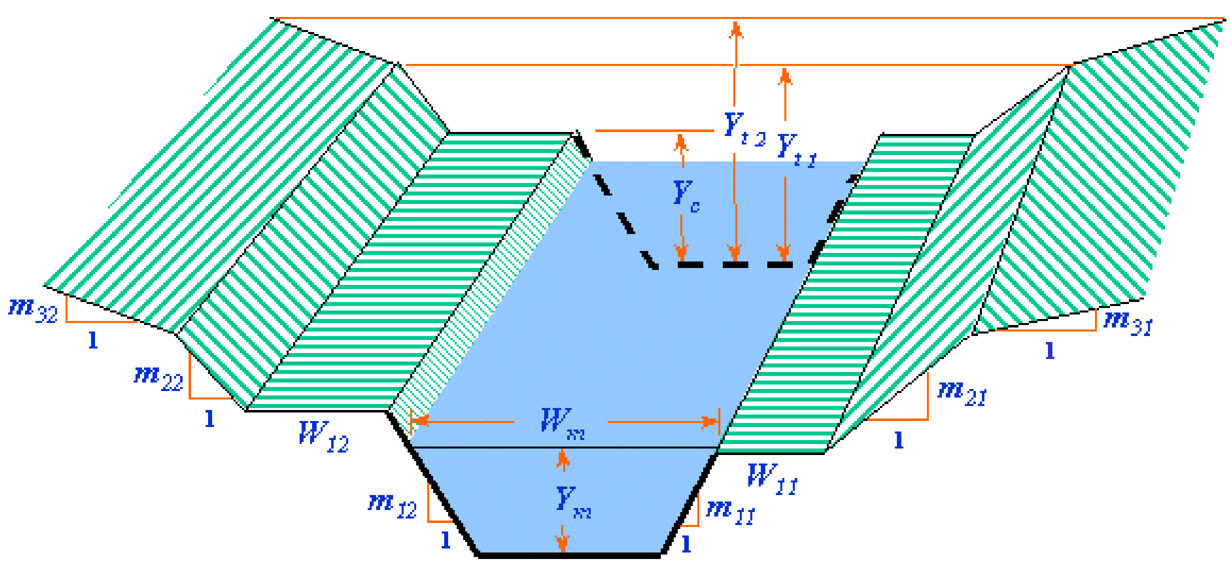
The values in the length field are used as the values of LEN in the RCHRES HYDR-PARM2 HSPF table. The values in the slope, width and depth fields are used in calculating the initial HSPF FTABLES. The values in the minimum and maximum elevation fields are used to calculate the DELTH in the RCHRES HYDR-

PARM2 HSPF table. The values in the stream name field are used as the reach names in the RCHID field of the RCHRES GEN-INFO table.

WinHSPF uses the information in these fields to automatically create FTABLEs by using the depth, width, slope, and length values identified in the Streams Tab. *WinHSPF* uses Manning's equation, together with assumptions about channel geometry, and Manning's n to calculate FTABLE values of volume, surface area, and outflow as a function of depth.

The *HSPF* tool derives the channel cross-section geometry using the mean channel depth and width, along with the following assumptions (see the diagram of the channel cross-section below):

- the channel cross-section is trapezoidal
- the channel sides have slopes of 1:1
- the channel depth is 1.25 times the mean channel depth
- the flood plain width, on each side of the reach, is equal to the mean channel width
- the depth at which the flood plain slope changes is 1.5 times the channel depth
- the default slopes of the upper and lower flood plain are 0.5:1
- the maximum depth in the FTABLE is set to 50 times the channel depth

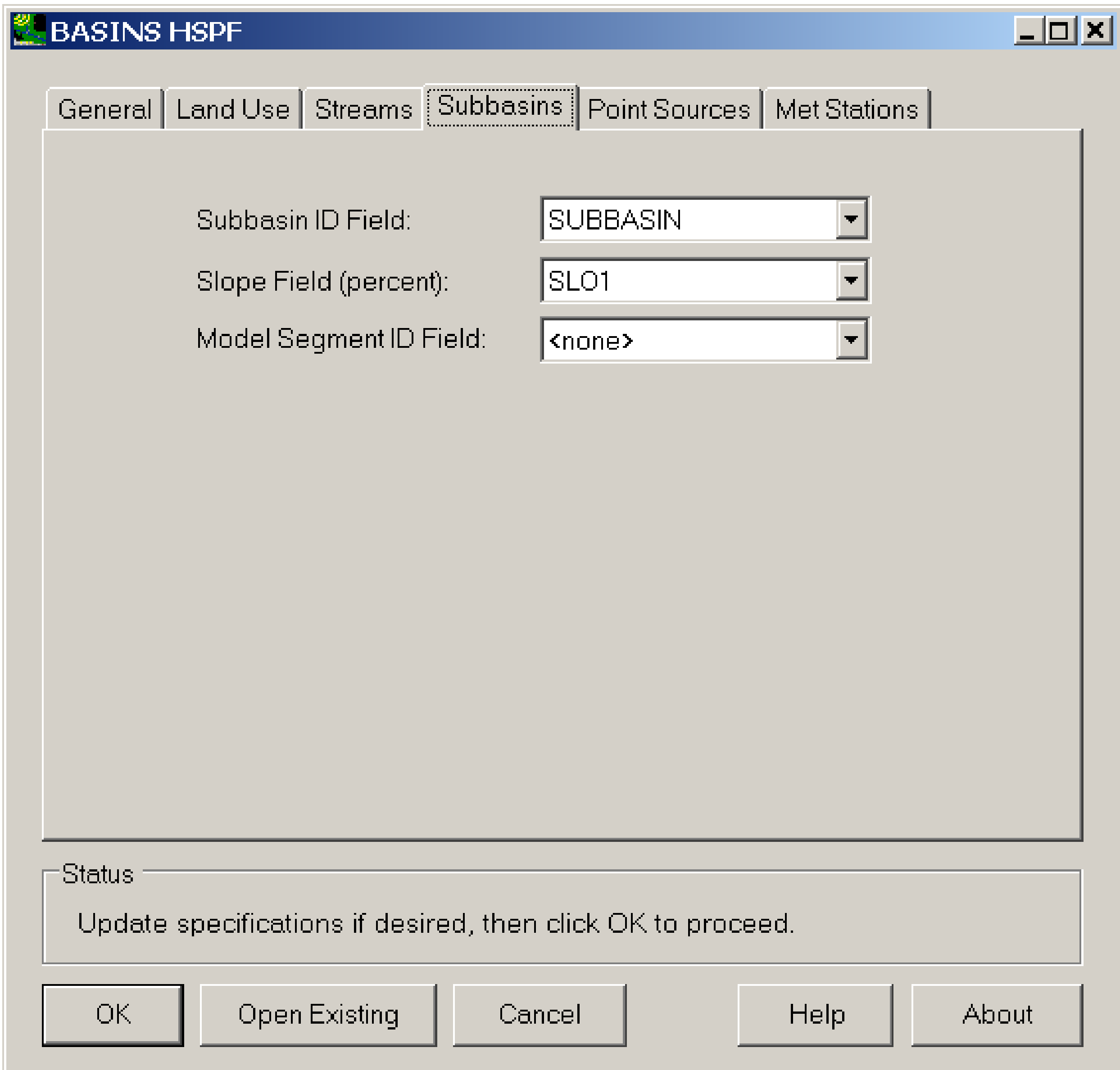


WinHSPF then uses the above cross-sectional geometry, the slope value, and an assumed value of 0.05 for the Manning's n, and Manning's equation, to calculate outflow for different depths. *WinHSPF* uses the channel length, along with the above cross-sectional geometry to calculate the volume and surface area values in the FTABLE. Users may modify the FTABLES or generate new FTABLES using different assumptions using the Reach Editor in *WinHSPF*.

Subbasins Tab

The **Subbasins** tab is used to specify details of how data is to be extracted from the subbasins layer.

This tab contains three drop-down lists used to specify the Subbasin ID Field, the Slope Field in percent, and an optional Model Segment ID Field. These fields are filled in by default when using a Subbasins layer produced using one of the BASINS watershed delineation tools. If using a Subbasins layer from another source, specify a field with a unique identifier for each subbasin as the Subbasin ID Field, and a field containing percent slope values as the Slope Field. The Subbasin ID field is used to connect subbasins to stream segments (see the Streams tab section). The values in the slope field are used as the values of SLSUR in the PERLND PWAT-PARM2/IMPLND IWAT-PARM2 HSPF tables. Upon UCI file creation in *WinHSPF*, the assumed length of the overland flow plane, LSUR, will be estimated from the slope value based upon a typical range of the length parameter for a given slope.



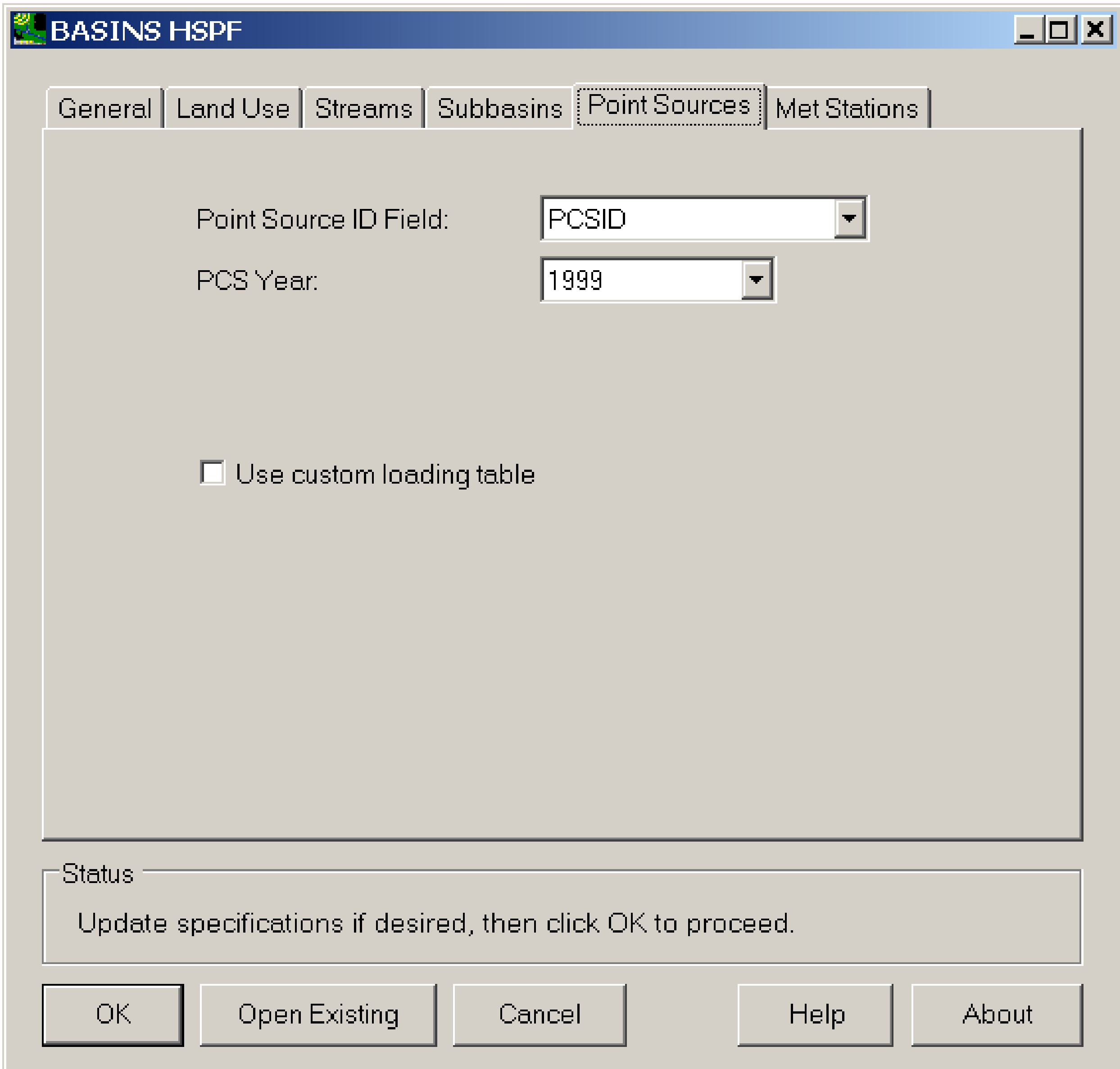
The 'Model Segment ID Field' drop-down list is used to specify a field on the Subbasin shapefile that contains a model segment identifier. The model segment identifier may be either a character string or an integer number. Subbasins that share a common model segment identifier will be grouped into a single HSPF model segment as the UCI is built. Corresponding meteorologic data can be specified for model segments through the 'Met Stations' tab. The 'none' value may be specified if there is no field containing a model segment identifier, in which case the HSPF UCI file will be built using only a single model segment.

Point Sources Tab

The **Point Sources** tab is used to specify details of how data is to be extracted from the point sources layer to represent point source discharges. The PCS layer in BASINS or an outlets layer produced by a BASINS delineation tool can be used as the point sources layer.

This tab contains a drop down list to specify the point source id field, another drop down list to specify the year for which permitted discharges are to be used from the PCS data, plus a check box for specifying if a custom loading table is to be used. The Point Source ID field should be set to the field name on the point source layer containing a unique identifier for each point source discharger. When using the Permit Compliance System data this column will default to the PCSID column, which contains the NPDES identifiers.

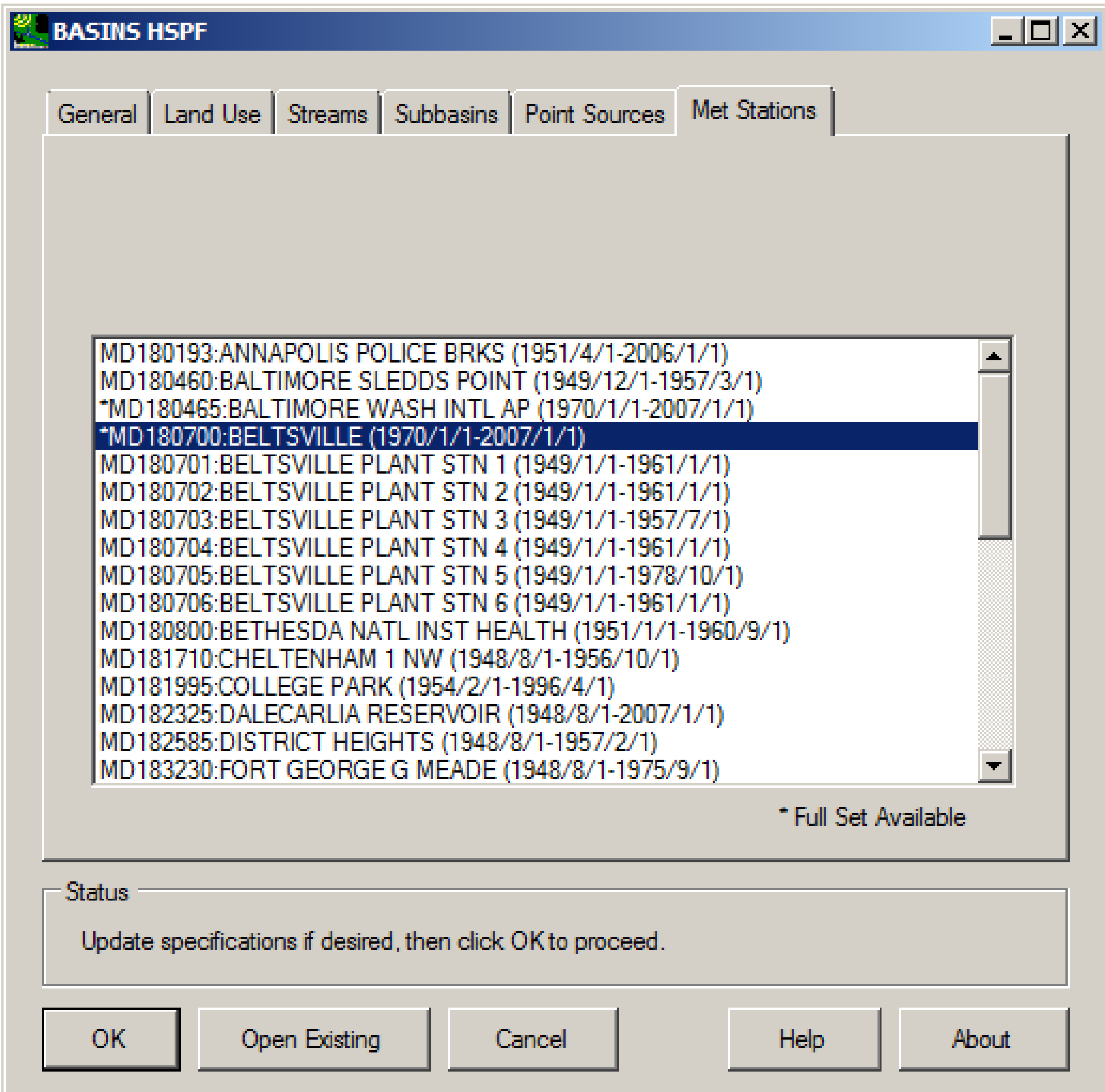
If the Point Sources layer is specified, either as an Outlets layer from a BASINS delineation tool or as the Permit Compliance System (PCS) layer, the PCS Year field is used to specify the year of PCS data to be used as the discharge into the reach network. The discharge values for this year will be used as constant discharges for all years of the simulation.



The check box is used to specify a custom point source loading table. This feature can be used to specify point source loading tables other than those delivered with BASINS. To do so, a Point Source/Outlets layer must be specified, and the Point Source ID field must indicate the field in the Point Source/Outlets layer containing a unique identifier for each point source discharger. When this box is checked, the user will be prompted for the name of the .dbf file containing the loading data. This table of loading data must contain at least the following four fields. There must be a field containing a unique identifier for each point source discharger, and this field must have the same name as the Point Source ID field in the Point Source/Outlets layer. There must be a field named FACNAME containing each facility name. There must be a field named LOAD containing the load in lbs/yr, or in the case of flow data, cfs. And there must be a field named PARM containing the parameter name, which must be FLOW if the data applies to flow data, or any other name for any other constituent. There may be multiple lines in the table corresponding to any one point source discharger.

Met Stations Tab

The **Met Stations** tab contains a list for selecting met stations. The met stations available for selection reflect the available data contained in the WDM files added to the current BASINS project.



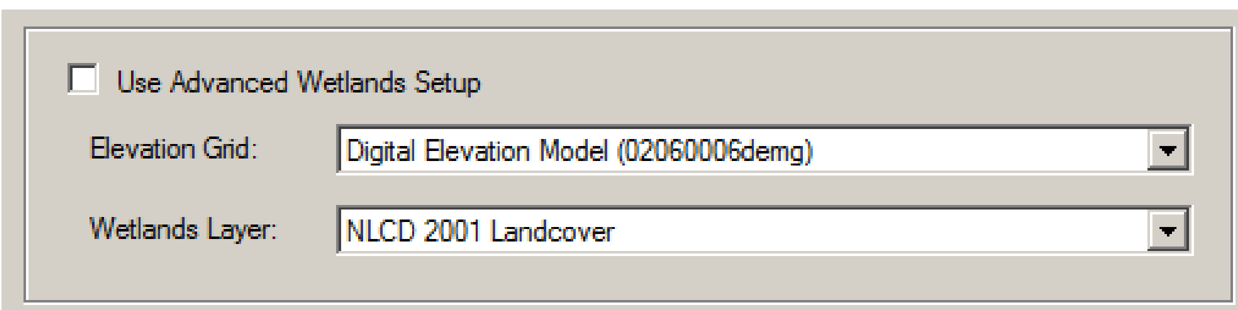
The Met Station list will be populated with the identifier corresponding to Met stations available for use in the new *HSPF* project. One item from this list should be selected in order to have some Met data included in the *HSPF* simulation. (After the new project has been created other Met stations may be added through the *WinHSPF* interface.) If the 'Model Segment ID Field' is set in the Subbasin tab, this list will show each model segment and allow the user to specify a met station for each model segment. In this case one met station should be specified on each line of the grid.

Note: Model segments will be created based on the number of unique model segments implied by the values of the 'Model Segment ID Field' in the Subbasins tab. If this field is set to 'none', a single model segment (one PERLND/IMPLND per land use) will be created for all subbasins. If the 'Model Segment ID Field' is set to something other than 'none', a model segment (one PERLND/IMPLND per land use) will be created for each unique value in the model segment ID field of the Subbasins shapefile.

Advanced Wetlands Setup

A recent addition to the **General** tab is the 'Advanced Wetlands Setup' frame.   This option provides an advanced wetlands setup capability within the BASINS HSPF setup tool, with which a user can choose to represent wetlands as separate RCHRES operations, thus taking into account the water quality improvements that wetlands provide.

With the 'Advanced Wetlands Setup' option checked, a DEM grid and a wetlands map layer are used to determine the amount of land area draining to a wetland before reaching the stream reach. Using this option, a user explicitly models a wetlands RCHRES as well as the normal stream channel RCHRES within each subbasin.



In addition to the 'Streams', 'Subbasins', and 'Point Sources' GIS layers specified as input to the BASINS/HSPF model setup tool, the user supplies a DEM, from which flow direction is determined, as well as a GIS layer indicating areas designated as wetlands. The enhanced model setup tool performs geoprocessing on these GIS layers, producing a new 'ToWetlands' grid indicating areas of the watershed draining to wetlands prior to entering the stream channel. The 'ToWetlands' grid is then used in creating the HSPF UCI file as described below.

Whereas the normal BASINS/HSPF model setup workflow merely overlays the land use with the delineated subbasin boundaries to determine the area contributing to each stream reach, the enhanced model setup tool overlays the land use with both the delineated subbasin boundaries and the 'ToWetlands' grid, calculating the area of each land use contributing to the stream reach as well as the area contributing to each 'wetlands' reach. Thus an HSPF model produced using the 'Advanced

Wetlands Setup' option will contain both a 'wetlands' reach and a stream reach within each subbasin, where the wetlands reach will be a local tributary to the stream reach.

The user should be aware that there are some limitations to this approach of using RCHRES to simulate wetlands:

- An FTABLE will be used to represent the area of the wetlands; as the surface area column of the wetlands RCHRES is variable with depth, there will be under counting of watershed surface area in dry periods and over counting of surface area in wet periods.
- The accuracy of this method is dependent upon the user supplying adequate FTABLES to represent the wetlands.
- Water Quality processes are cut off in RCHRES when the water depth is less than 2 inches; this could be a substantial amount of the simulation time with wetlands represented by RCHRES.

The workflow of the procedure is outlined below:

1. A DEM layer and a wetlands layer must be part of the project. Several sources of DEM data are available through the BASINS Data Download Tool. Data sources and download mechanisms for wetlands data is not automated at this point, but two possible sources of wetlands data include the NLCD 2001 land cover layer and the wetlands layer from the National Wetlands Inventory. Wetlands data from both sources are accommodated in this tool. Both the DEM and the wetlands layer must be loaded as part of the BASINS project.

2. Select the 'Advanced Wetlands Setup' checkbox and specify the DEM and wetlands layers. Set the other options of the BASINS HSPF setup tool as desired.

3. Click 'OK'. During processing, a Flow Direction grid is created based on the input DEM. Then a 'ToWetlands' grid is created using the Flow Direction grid, wetlands GIS layer, and stream reach shapefile. The algorithm for the 'ToWetlands' grid uses a pixel-by-pixel approach to determine if each pixel (grid cell) drains to a wetland or to a stream reach (without first passing through a wetland).

4. Using the 'ToWetlands' grid, the BASINS/HSPF model setup tool automatically determines the area of each land use category contributing to each wetland reach as well as to each stream reach.

5. The section of the BASINS/HSPF model setup code responsible for creating the HSPF User Control Input (UCI) file creates both a 'wetlands' RCHRES and a stream RCHRES within each modeled subbasin.

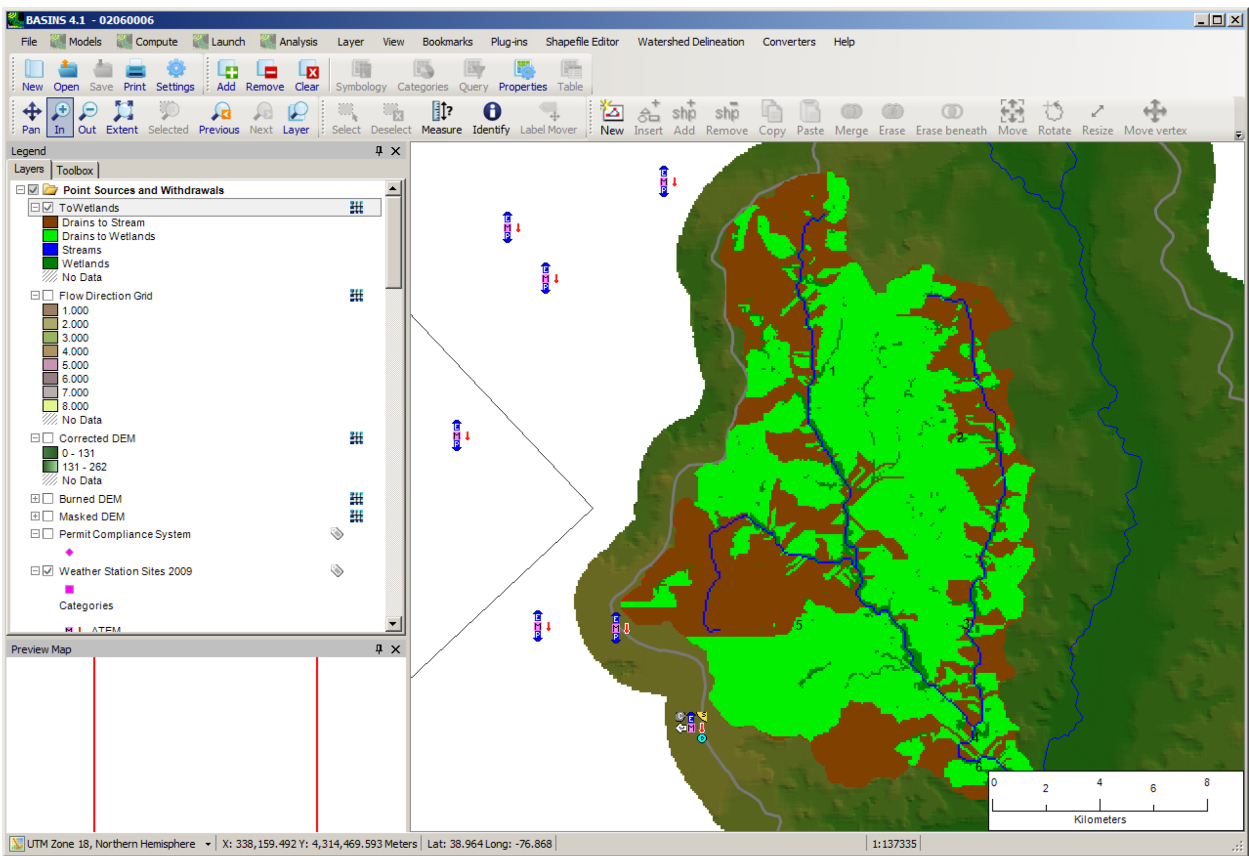
6. As part of UCI creation, assumptions are made about 'wetlands' RCHRES channel dimensions for creating the FTABLE for the 'wetlands' RCHRES operations. Default HSPF parameter values are applied for the 'wetlands' RCHRES operations. Note that the outlets from the new wetlands RCHRES operations are assumed to connect to the corresponding river RCHRES. It is up to the

user to modify the connectivity and parameterization if the default assumptions are not appropriate.

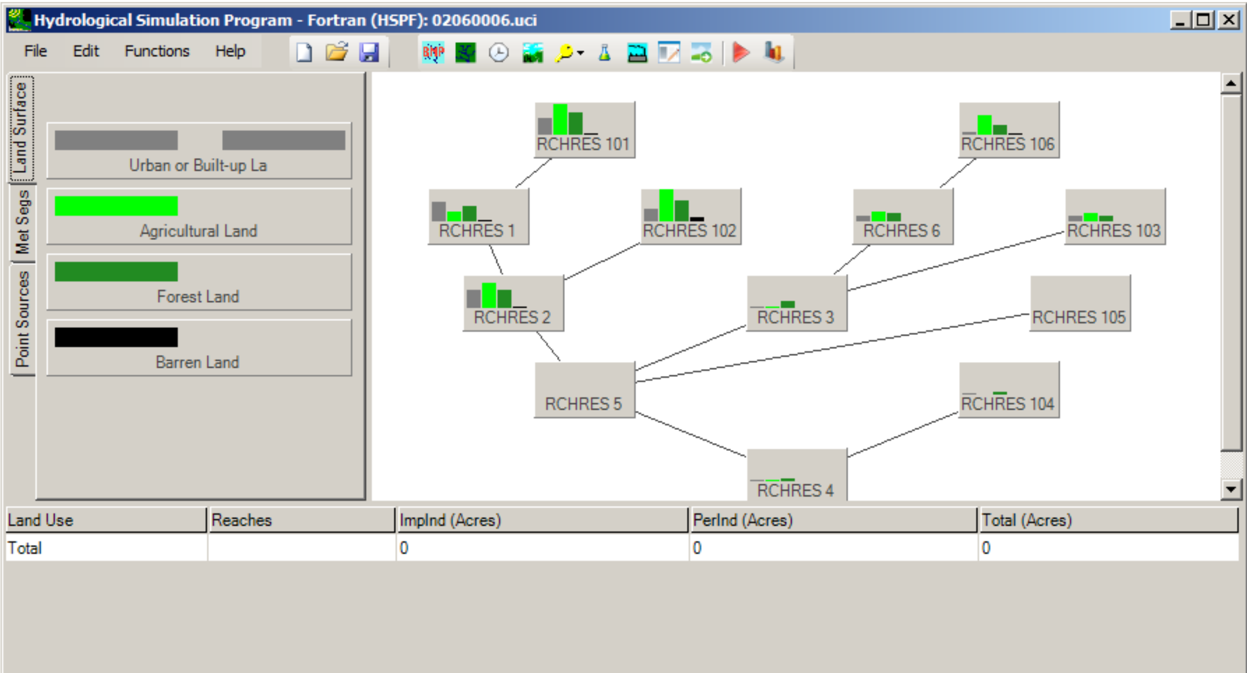
The Wetlands Layer may be either a shapefile or a grid layer. The requirement of the grid layer is that the wetland cells must be coded with a value of 90 or greater, as they are in the NLCD land cover layers.

During processing a grid named 'Corrected DEM' will appear on the map. This layer is the pit-filled DEM, and it is a prerequisite to computing the Flow Direction grid. When computed the Flow Direction grid will also be added to the map.

When the 'ToWetlands' grid is complete, it is added the map as well. An example is shown below. In the resulting grid, cells corresponding to the stream lines are assigned the value 98, cells draining to those stream cells without first passing through a wetland are assigned 28, and cells draining to a wetland before reaching the stream are assigned 29.



The enhanced workflow described above results in an HSPF UCI file which opens in the BASINS HSPF User Interface (WinHSPF), with two RCHRES operations per applicable subbasin, one RCHRES representing the stream channel and one RCHRES representing the wetlands. The 'wetlands' RCHRES includes areas of both riparian and isolated wetlands within the subject subbasin.



The RCHRES block of the UCI has been updated showing new operations from 101 to 106, where RCHRES 101 represents the area draining to wetlands before draining to RCHRES 1. The RCHRES operations with identifiers in the 100s are the wetlands RCHRES operations; notice that there is one per stream reach (RCHRES 101 and RCHRES 1, for instance).

02060006.uci - Notepad

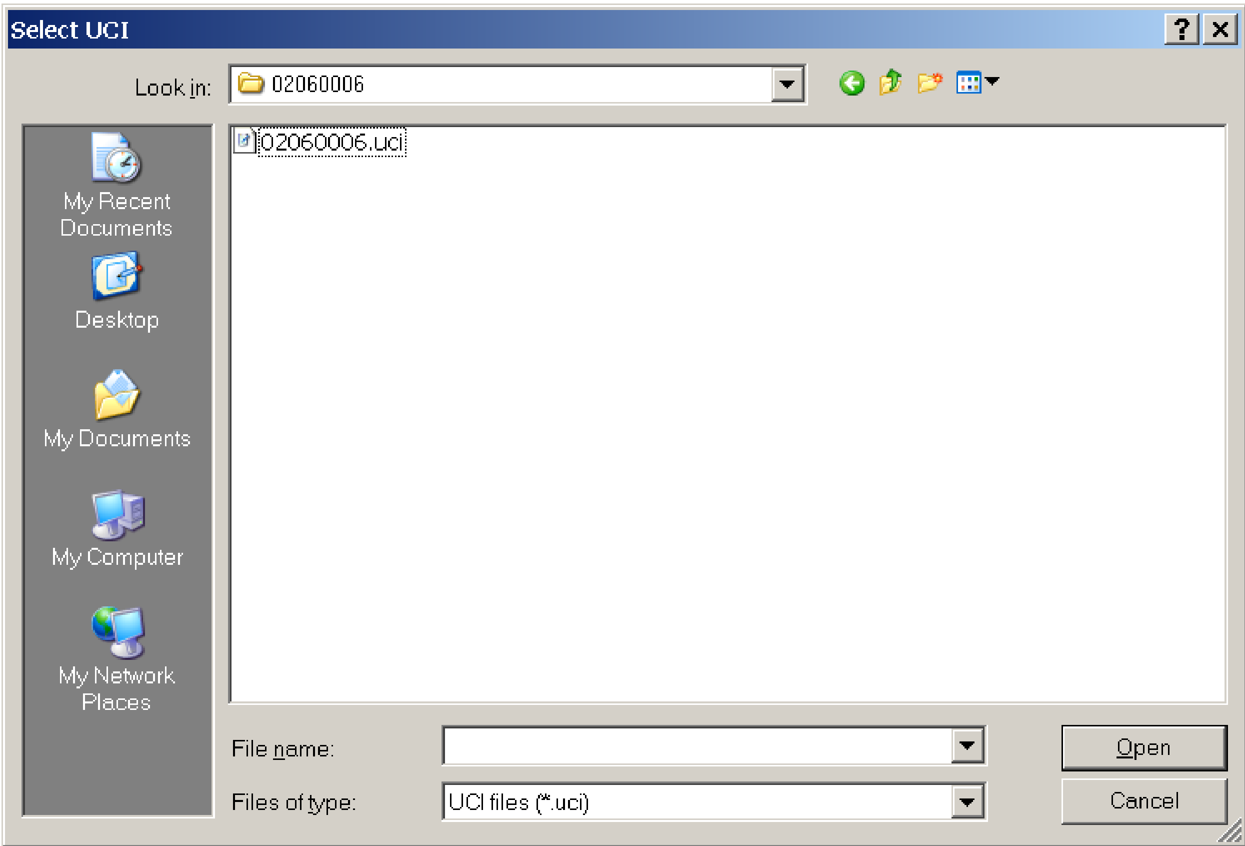
```
RCHRES
  ACTIVITY
*** RCHRES  Active sections
*** x -  x HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG
    1  106    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
*** RCHRES  Printout level flags
*** x -  x HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR
    1  106    4    4    4    4    4    4    4    4    4    4    1    9
  END PRINT-INFO

  BINARY-INFO
*** RCHRES  Binary Output level flags
*** x -  x HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR
    1  106    4    4    4    4    4    4    4    4    4    4    1    9
  END BINARY-INFO

  GEN-INFO
***                Name        Nexits   Unit Systems   Printer
*** RCHRES                                 t-series  Engl Metr LKFG
*** x -  x                                   in  out
    1     Western Branch Patux    1          1    1   91    0    0   92    0
    2     Southwest Branch Wes    1          1    1   91    0    0   92    0
    3     South Collington Bra    1          1    1   91    0    0   92    0
    4     South Reach, Western    1          1    1   91    0    0   92    0
    5     Western Branch Patux    1          1    1   91    0    0   92    0
    6     North Collington Bra    1          1    1   91    0    0   92    0
  101     Wetlands to R1          1          1    1   91    0    0   92    0
  102     Wetlands to R2          1          1    1   91    0    0   92    0
  103     Wetlands to R3          1          1    1   91    0    0   92    0
  104     Wetlands to R4          1          1    1   91    0    0   92    0
  105     Wetlands to R5          1          1    1   91    0    0   92    0
  106     Wetlands to R6          1          1    1   91    0    0   92    0
  END GEN-INFO

  HYDR-PARM1
***         Flags for HYDR section
***RC HRES  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
*** x   - x FG FG FG FG  possible   exit *** possible   exit     possible   exit
    1  106   0  1  1  1    4  0  0  0  0        0  0  0  0  0      1  1  1  1  1
  END HYDR-PARM1

  HYDR-PARM2
*** RCHRES FTBW FTBU        LEN     DELTH      STCOR         KS       DB50
*** x -  x               (miles)     (ft)       (ft)                   (in)
    1         0    1       9.66        56        3.2        0.5       0.01
    2         0    2      12.37       200        3.2        0.5       0.01
```

The default FTABLES for the wetlands reaches are created based on the assumed channel dimensions from BASINS for the corresponding channel reaches, except that the widths of the wetlands are assumed to be an order of magnitude larger than the corresponding channel reach.

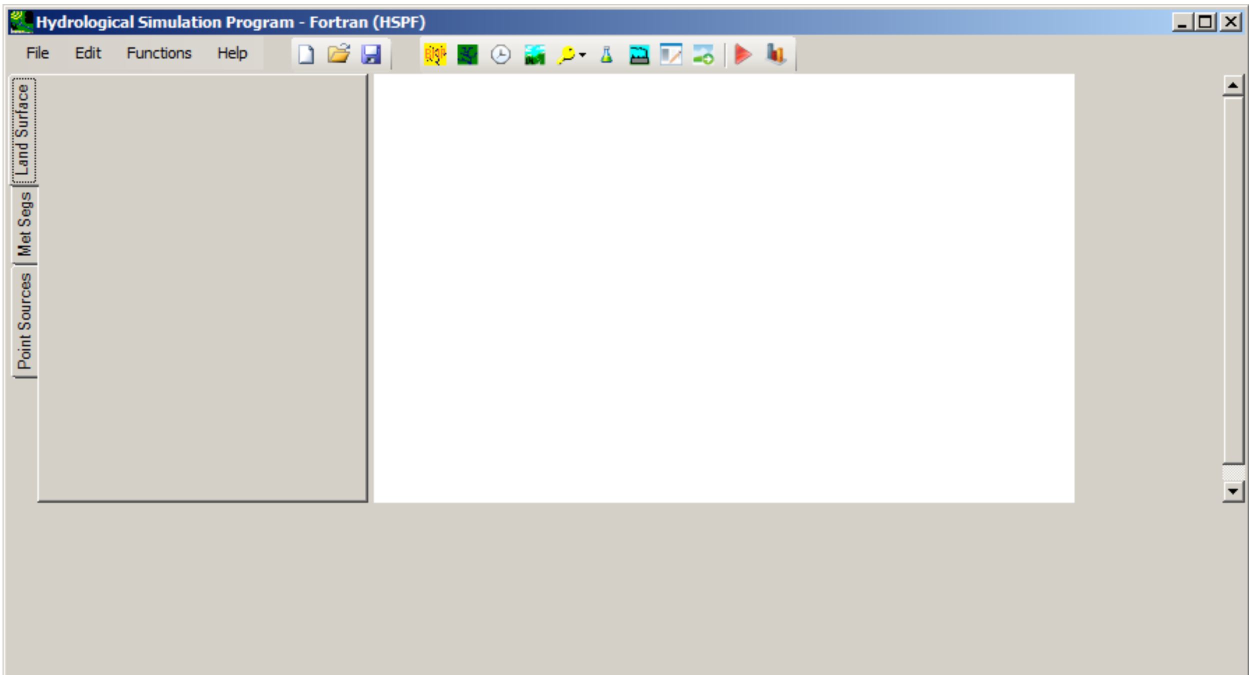
Opening an Existing HSPF Project

The **Open Existing** button is used to open an existing *HSPF* project (UCI file) in *WinHSPF*. To open an existing UCI file, use the **Select UCI** dialog to select the existing UCI file that you would like to open.

Note: UCI files created by BASINS are located within the “modelout” folder, typically in “\BASINS41\modelout*project name*”.

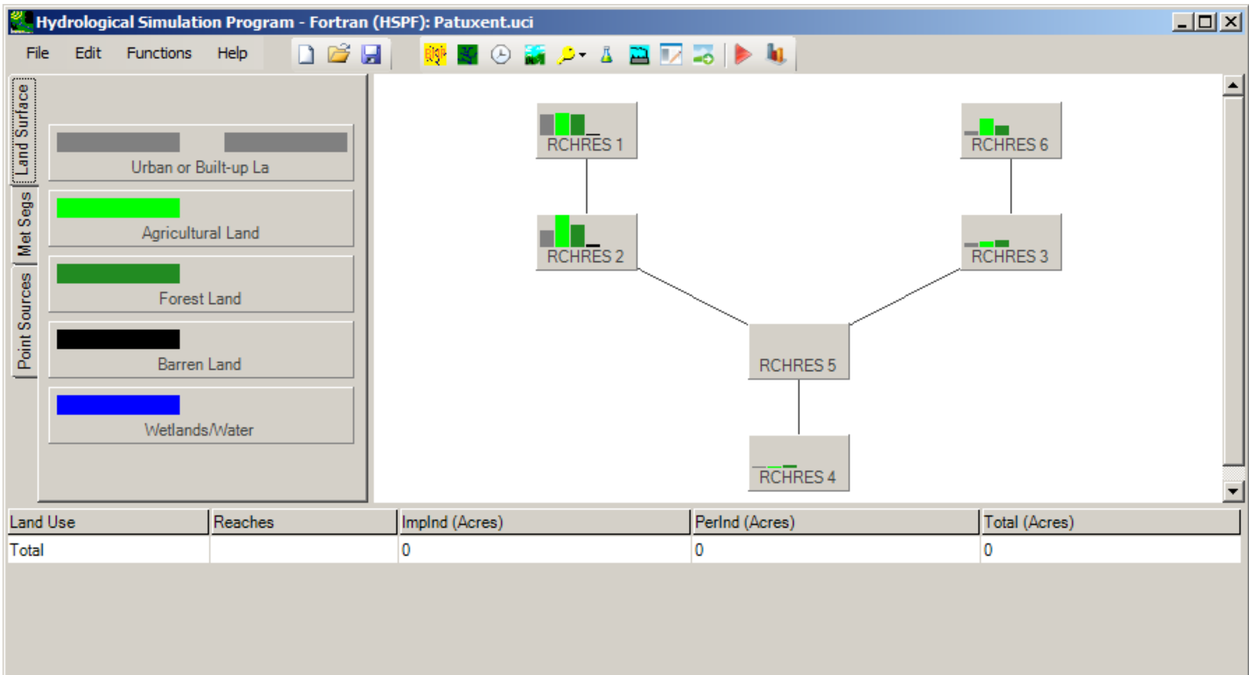


Clicking **Open** will start *WinHSPF*. As *WinHSPF* starts, an initialization process begins, during which the contents of several files are read into memory, including the files 'HspfMsg.mdb' and 'starter.uci'. The progress will be visible in the status window. After initialization the main *WinHSPF* window appears, entitled **Hydrological Simulation Program - Fortran (HSPF)**.



As a UCI file is opened, a status window will provide information related to the progress of reading and interpreting the UCI file. The status window will minimize after the UCI has been processed. A schematic diagram of the watershed will appear in the main WinHSPF window.

Introduction to the Main WinHSPF Window The main window of *WinHSPF* contains a menu, a tool bar, a vertical tab strip, a schematic of the watershed, and an auxiliary table. The tab strip, watershed schematic, and auxiliary table are not active until a project is active. The information on the tab strip and auxiliary table pertain to the project represented by the watershed schematic.



The buttons on the tool bar represent various ways of interacting with the UCI file. The left most buttons can be used for creating, opening, and saving a project (UCI file). The right most buttons on the tool bar are used to perform the simulation, i.e. run *HSPF*, and to view output. The other buttons on the tool bar are used to view and/or modify the contents of various portions of the UCI file.

The tab strip contains three tabs. The tabs work in conjunction with the figures in the watershed schematic to display information about the simulation in the auxiliary table. The tabs are used to select whether to display information related to land surfaces, met segments, or point sources. Highlighting some items in the tab strip in conjunction with highlighting some figures in the watershed schematic results in the data common to both being summarized in the auxiliary table. For example, clicking on the **Forest** land surface and the **RCHRES 1** figure results in the acres of Forested area contributing to RCHRES 1. Selecting a particular land use in the land surface tab highlights all of the reaches where that kind of landuse occurs.

Complete documentation of the *WinHSPF* program is available in the WinHSPF User's Manual.

SWAT

The Soil and Water Assessment Tool (SWAT) is physically based continuous simulation model useful for predicting the impact of land management practices on water, sediments, and different agricultural parameters for watersheds of various scales and complexities. OpenSWAT provides an extensive GIS interface for SWAT through the BASINS GIS application. The version of SWAT supported in BASINS is SWAT2005.

A watershed simulation through SWAT is achieved by subdividing the watershed into Hydrological Response Units (HRUs). HRUs are basically homogeneous subbasins having similar soil, land use, and slope properties. Main input parameters are grouped into categories such as weather, land cover, soil, and management within subbasins, plus ponds/reservoirs, ground water, and the main channel or reach. More information about SWAT can be downloaded here.

Note: SWAT2005 and the SWAT Editor are not included with this package. They may be downloaded from http://swatmodel.tamu.edu/

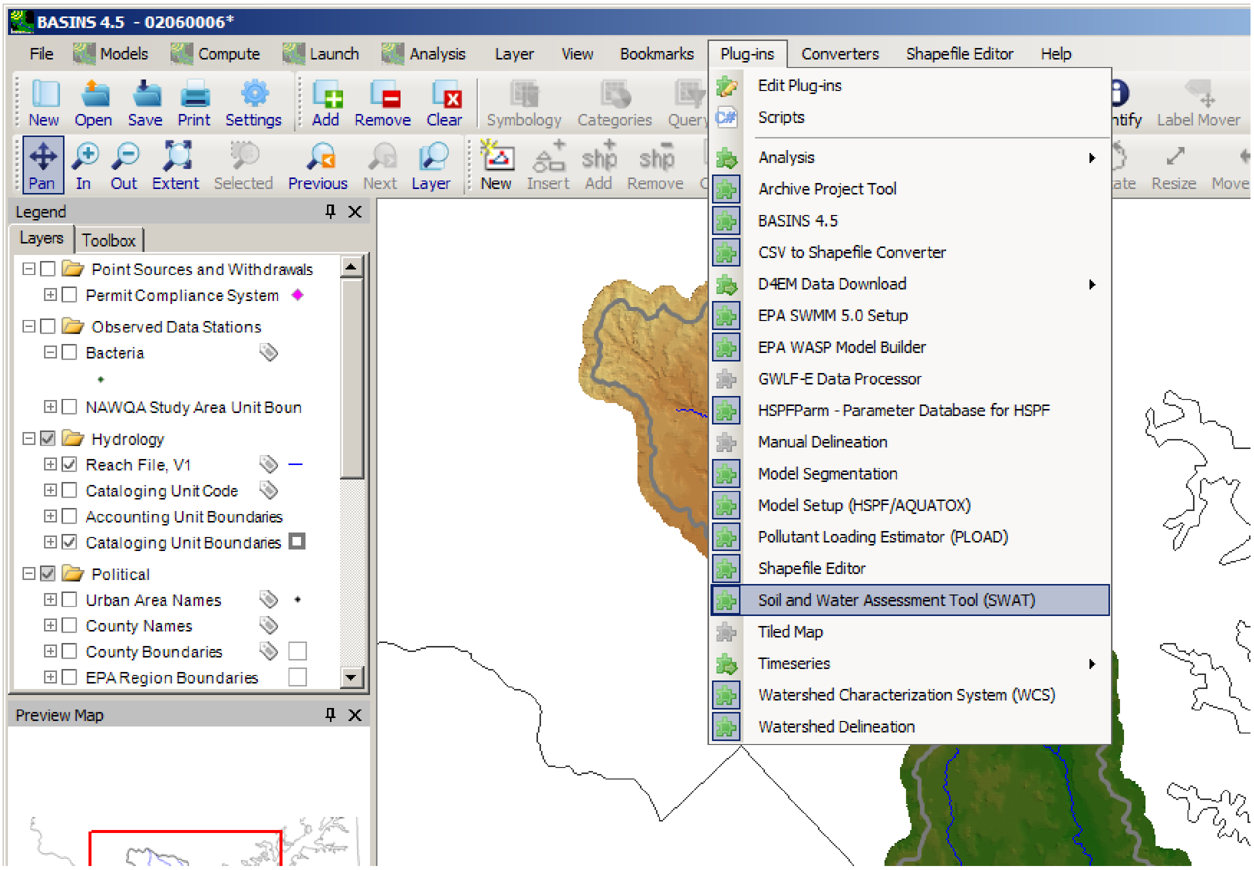
The major steps involved in creating a watershed model using OpenSWAT are listed below:

1. Project Setup
2. Watershed Delineation
3. Land use, soil, slope reclassification
4. Land use, soil, slope, subbasin overlay
5. HRU Definition
6. Weather data definition
7. Model Run

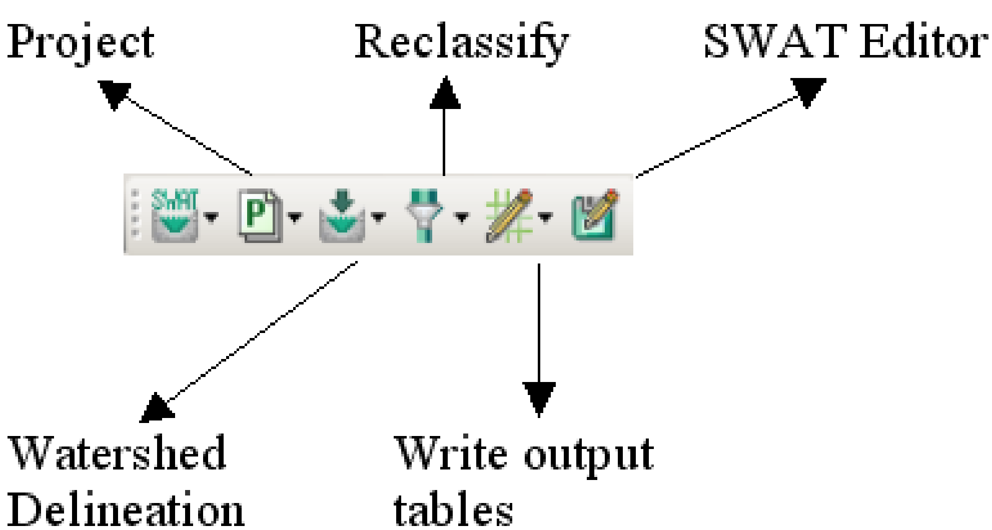
A more complete tutorial for setting up SWAT within BASINS can be found in the Starting SWAT section of the manual.

Enabling the OpenSWAT Plug-In

From the main menu in BASINS, select the Plug-Ins menu and then select the Soil and Water Assessment Tool (SWAT) to activate the OpenSWAT plug-in.

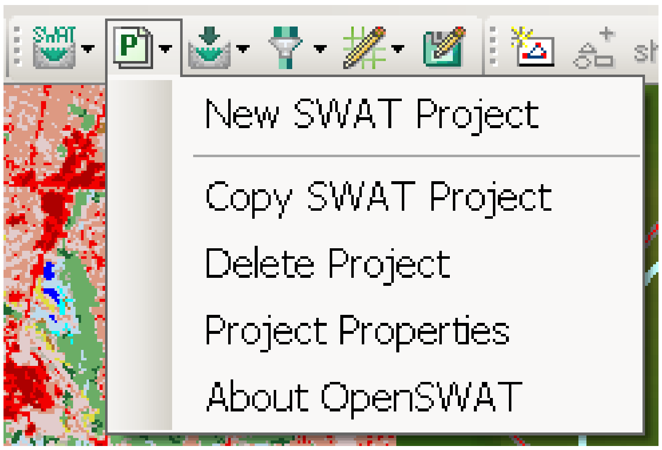


With the Open SWAT plug-in active, you will see the SWAT toolbar.

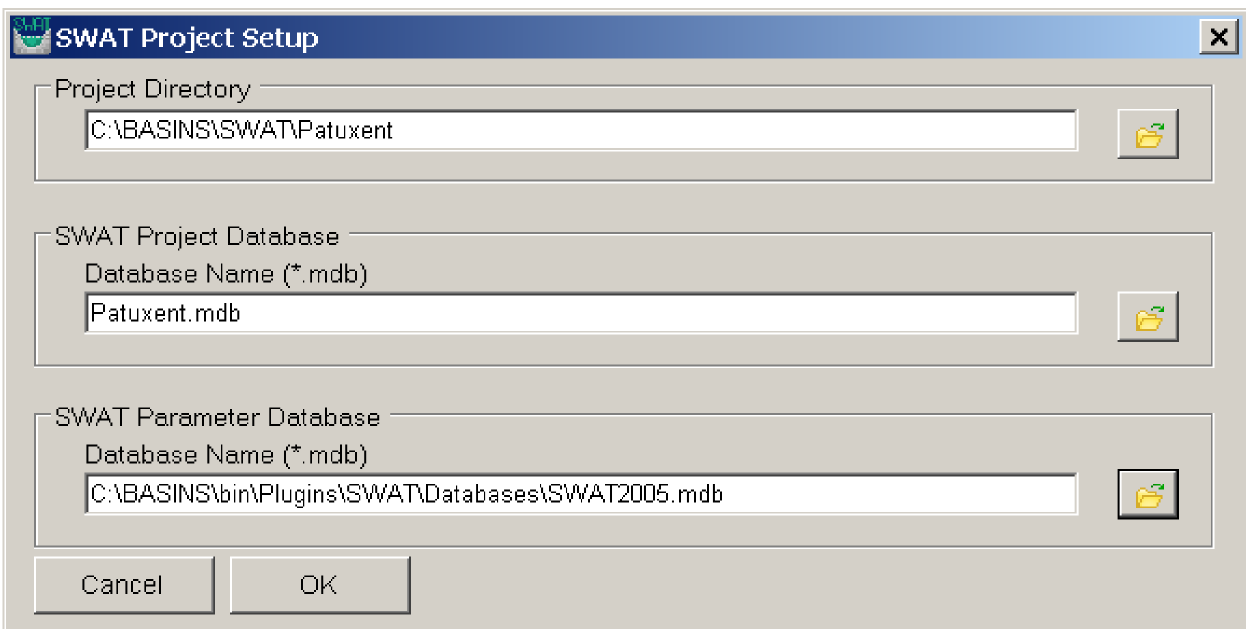


Creating a New SWAT Project

Project-related functionalities are grouped under the SWAT project icon; these functionalities can be accessed by clicking the arrow next to the project icon.



Click the "New SWAT Project" option to create a new project.

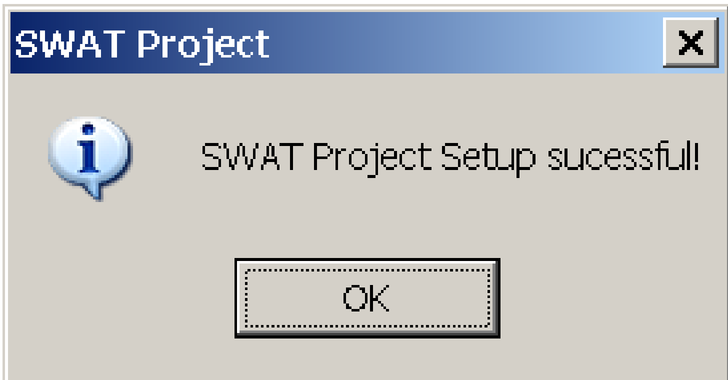


Project Directory: This is the place users should specify where they want to create project related databases and other required files. Users can select a directory by clicking the browse button next to the "Project Directory" name box. A new directory can be created by clicking the "Make New Folder" button in the Windows interface.

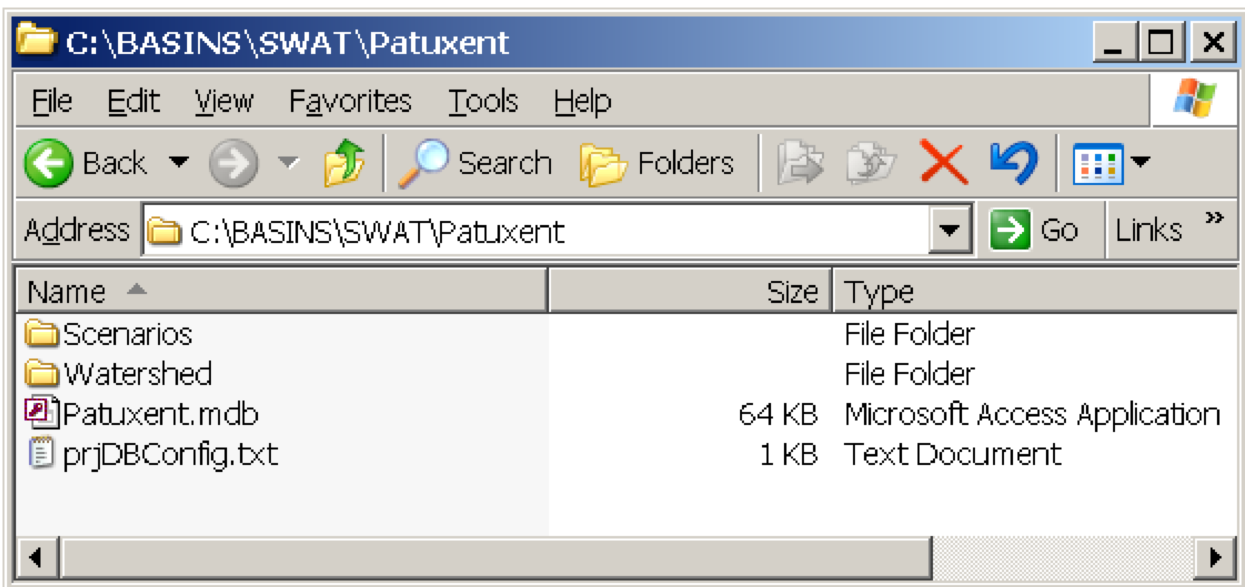
SWAT Project Database: By default, the project database name and project directory name are the same. If users want, they can give a new name for the project database.

SWAT Parameter Database: This database has most of the required parameters for the SWAT Model. This database is installed with the OpenSWAT plug-in.

Once you have given the required parameters for the SWAT Project Setup dialog, press the “OK” button.



The files created during the project setup are shown below:

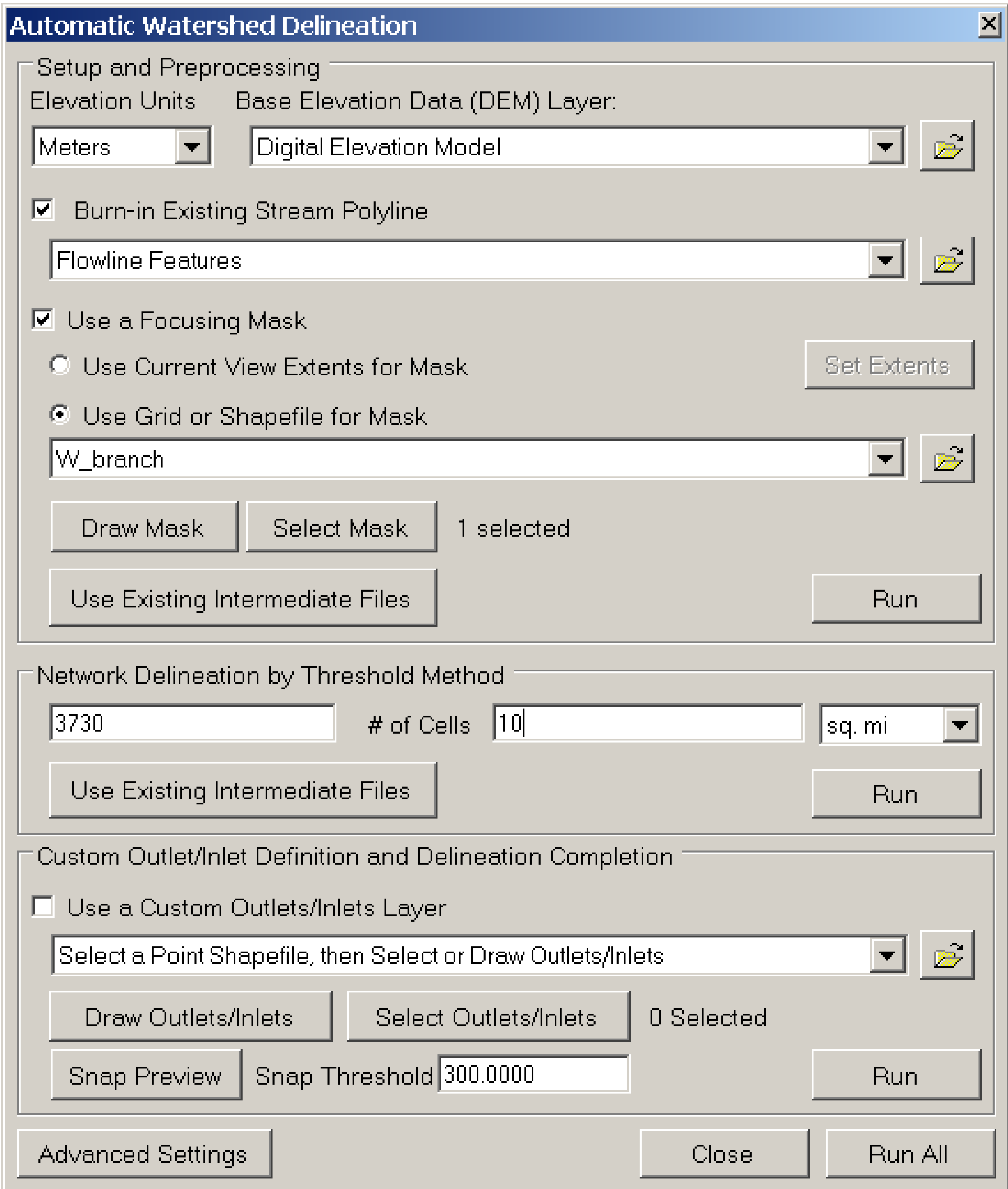


Watershed Delineation

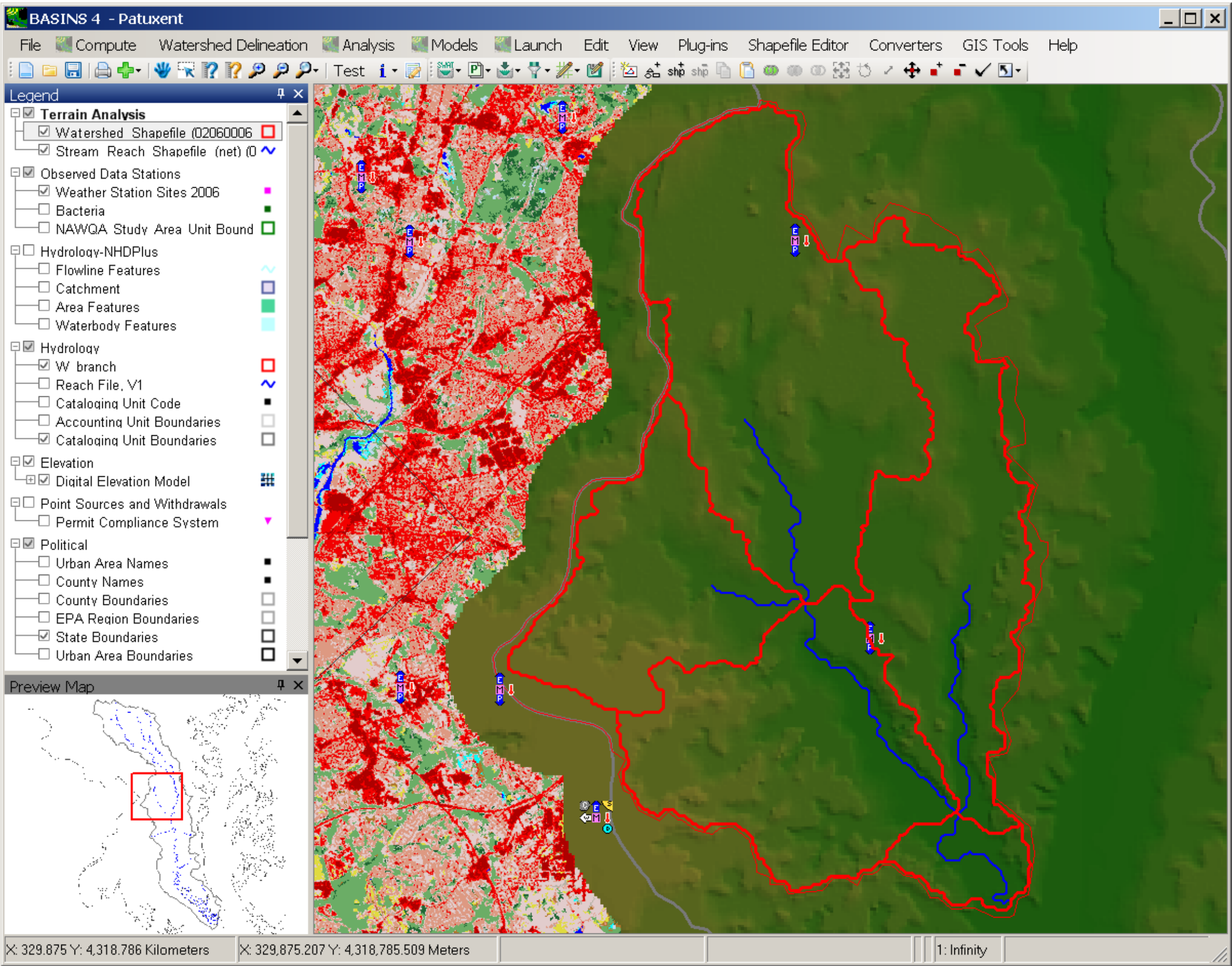
The Watershed Delineation tool on the SWAT toolbar uses a Digital Elevation Model (DEM) grid to create subwatersheds, much like the Automatic Watershed Delineator in BASINS. OpenSWAT may also be used with watershed delineations produced using the BASINS Manual Watershed Delineation tool.

The automatic watershed delineator functions can be accessed though clicking the arrow next to the “Watershed Delineation” icon.

Click the “Automatic Watershed Delineator” to start the watershed delineator.

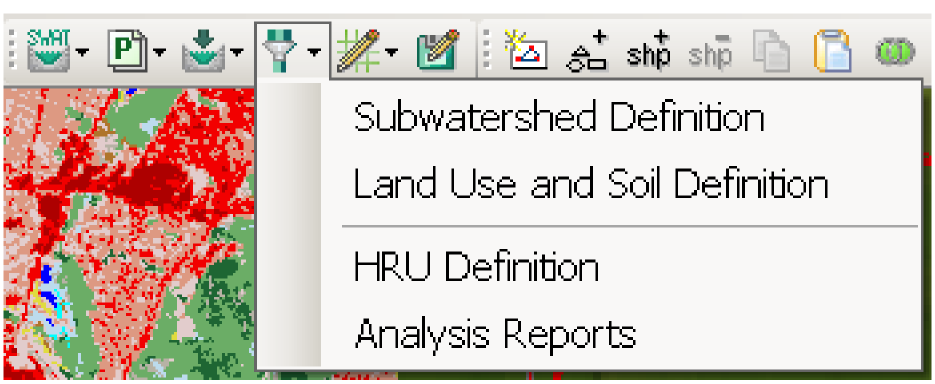


Full details of the Automatic Watershed Delineator can be found in the Automatic Watershed Delineation section of the manual. Example delineation results are shown below.

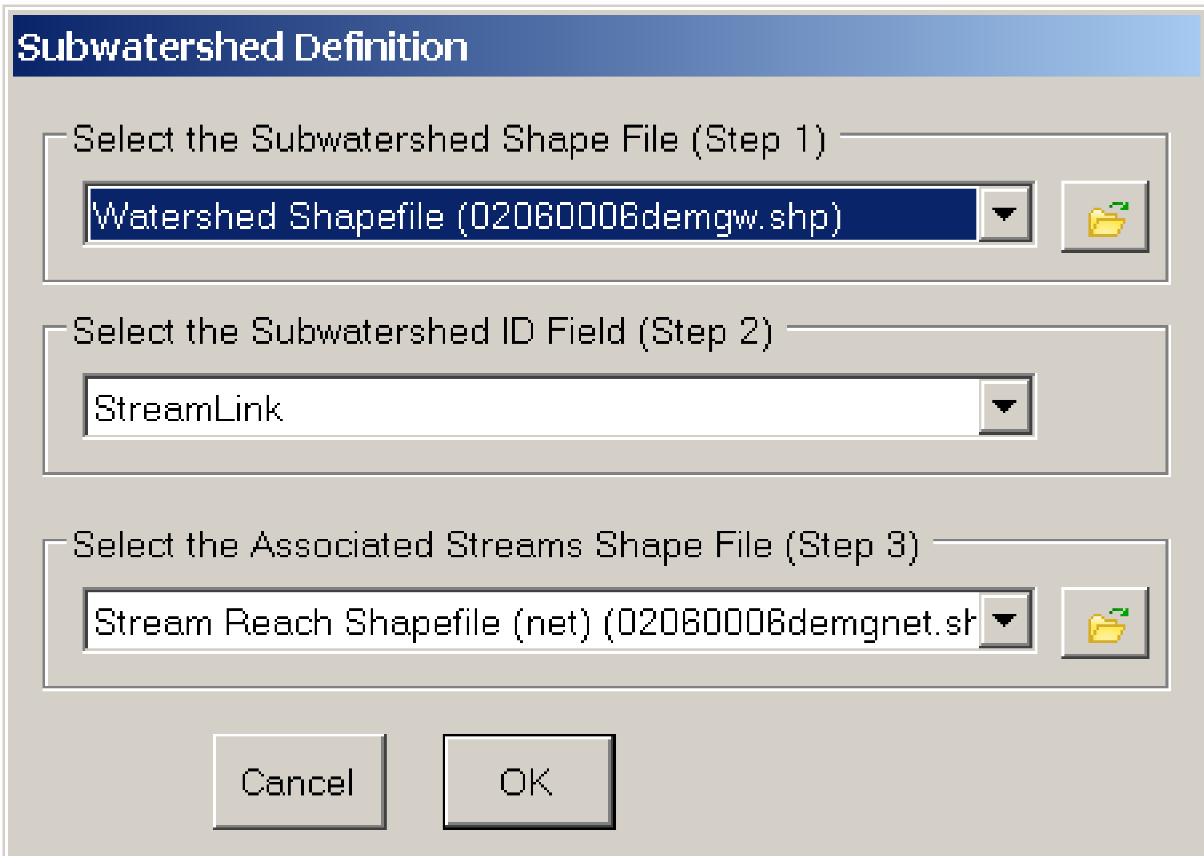


Land use/ Soil/ Slope Reclassification

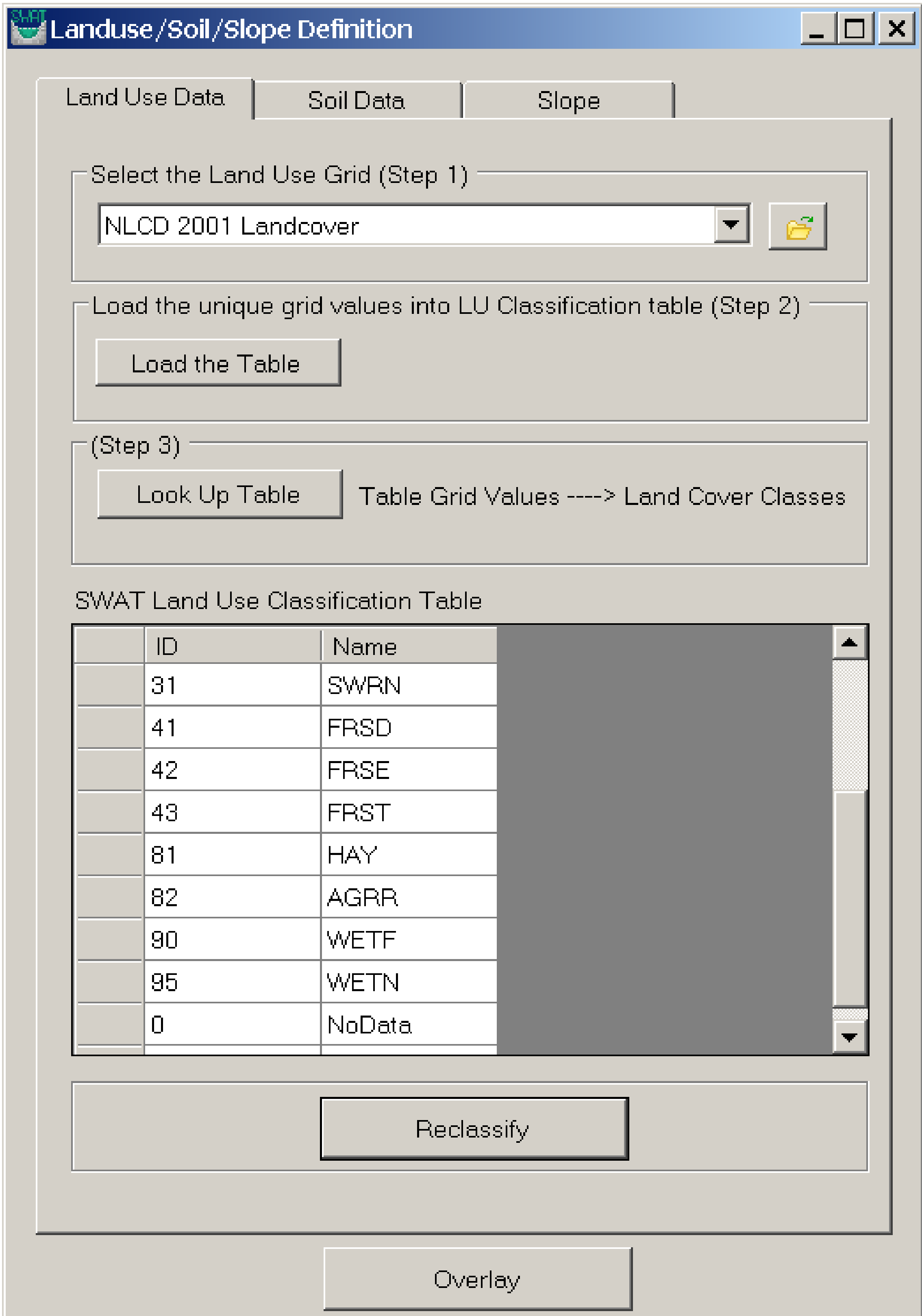
The Land use and Soil definition option in the “Land Use/ Soil/ Slope menu” allows users to specify the land use, soil, and slope layers that will be used for modeling using SWAT. These layers are then used to determine the Hydrological Response Unit (HRU) distribution for each sub watershed.



The “Subwatershed Definition” menu option is used to set the Subwatershed and Streams layers to be used in the reclassification and overlay steps. The user may specify the output of any BASINS watershed delineation process. Output from either the manual or automatic watershed delineation tools may be used.

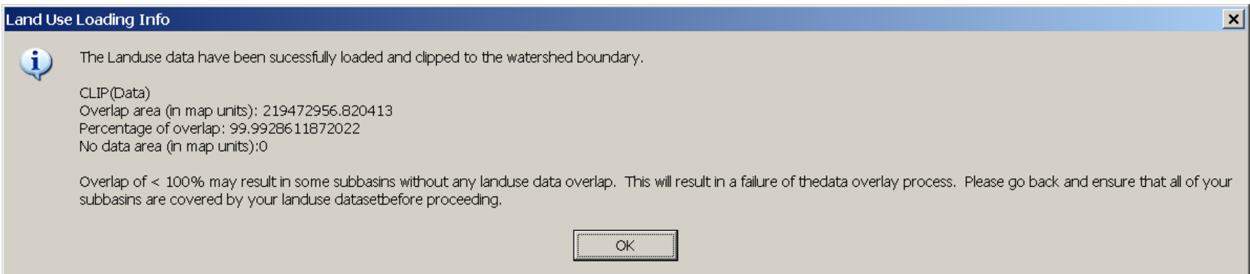


SWAT requires land use data to determine the area of each land category to be simulated within each subwatershed. SWAT also relies on soil and slope data to determine the range of hydrologic characteristics found within each subwatershed. The Land use and Soil Definition option guides the user through the process of specifying the data to be used in the simulation and of ensuring that those data are in the appropriate format.

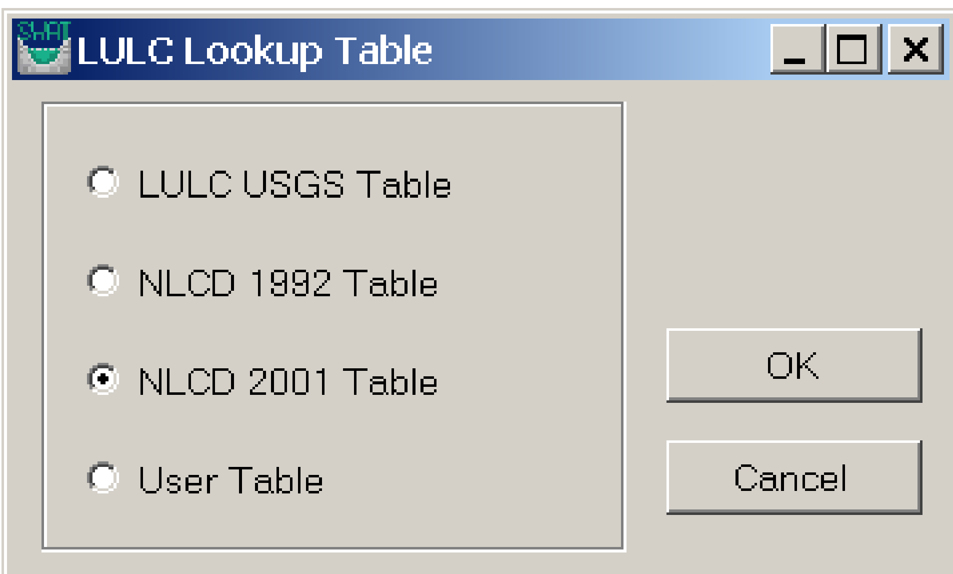

Landuse/Soil/Slope Definition
Land Use Data
Soil Data
Slope
Select the Land Use Grid (Step 1)
NLCD 2001 Landcover
Load the unique grid values into LU Classification table (Step 2)
Load the Table
(Step 3)
Look Up Table
Table Grid Values ----> Land Cover Classes
SWAT Land Use Classification Table
ID
Name
31
SWRN
41
FRSD
42
FRSE
43
FRST
81
HAY
82
AGRR
90
WETF
95
WETN
0
NoData
Reclassify
Overlay

To reclassify Land use and Soil, click on the “Land use and Soil Definition” option. The Land Use/ Soil/ Slope definition window has three different tabs for defining the Land Use, Soil, and Slopes.

To define the Land Use, users should select that LU grid from the “Select the Land use Grid” drop-down list. After selecting the Land use grid, click the “Load the Table” button to load the unique data from the grid to the SWAT Land use classification table. Soon after clicking the “Load the Table”, users will get a message summarizing the information about the grid.



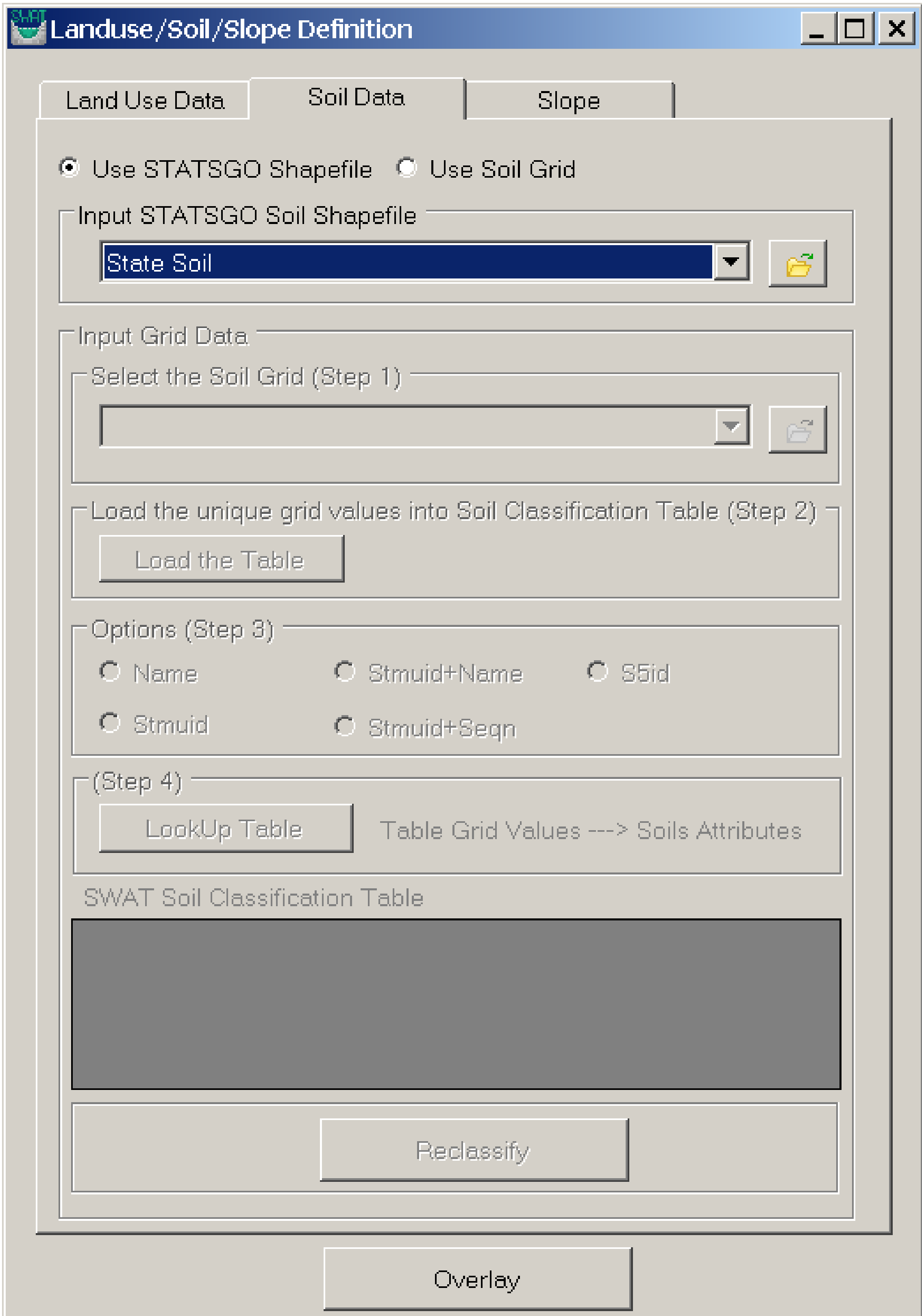
The land use grid codes must be assigned a land cover/plant description. Users may import or manually assign a land cover/plant code. To do so, click on the “Look up Table” button.



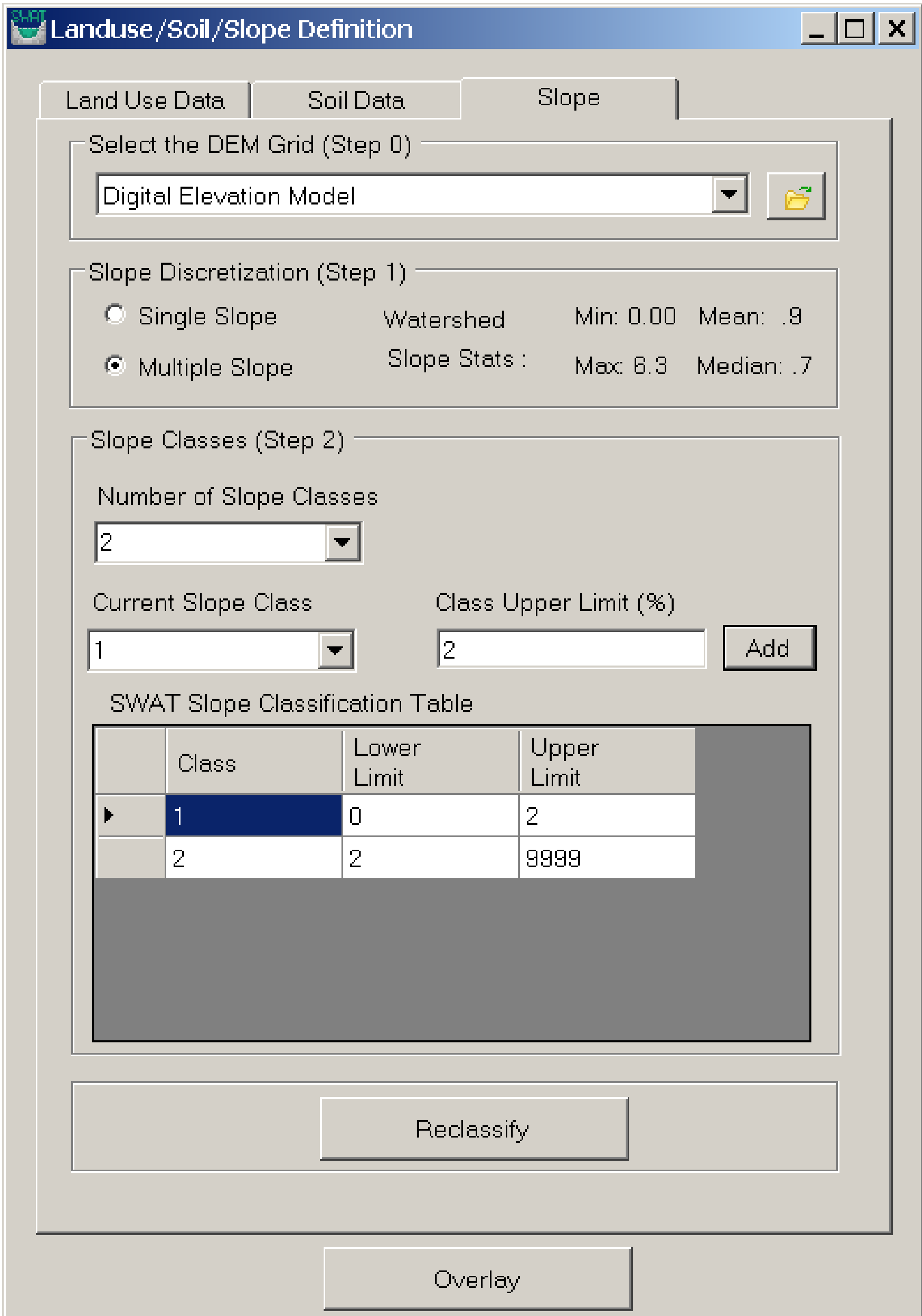
Users can specify many different standard lookup tables, or they may choose their own custom lookup table, or they may enter the values manually. Soon after users specify the lookup tables they can view the Land use descriptions next to the grid values.

Finally users can click the “Reclassify” button to finish the reclassification operation of Land Uses. Upon completion, a notification of the conclusion of the LU Reclassification is shown.

In order to reclassify the soil dataset, go to the “Soil Data” tab. STATSGO soils data is available within BASINS, so a BASINS user will most likely want to choose “Use STATSGO Shapefile”. After choosing this option, select the name of the STATSGO soils layer from the drop-down list.

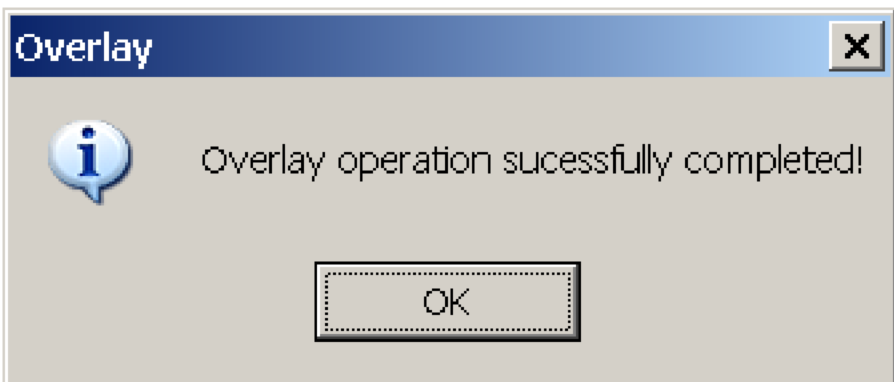

Landuse/Soil/Slope Definition
Land Use Data
Soil Data
Slope
Use STATSGO Shapefile
Use Soil Grid
Input STATSGO Soil Shapefile
State Soil
Input Grid Data
Select the Soil Grid (Step 1)
Load the unique grid values into Soil Classification Table (Step 2)
Load the Table
Options (Step 3)
Name
Stmuid+Name
S5id
Stmuid
Stmuid+Seqn
(Step 4)
LookUp Table
Table Grid Values ---> Soils Attributes
SWAT Soil Classification Table
Reclassify
Overlay

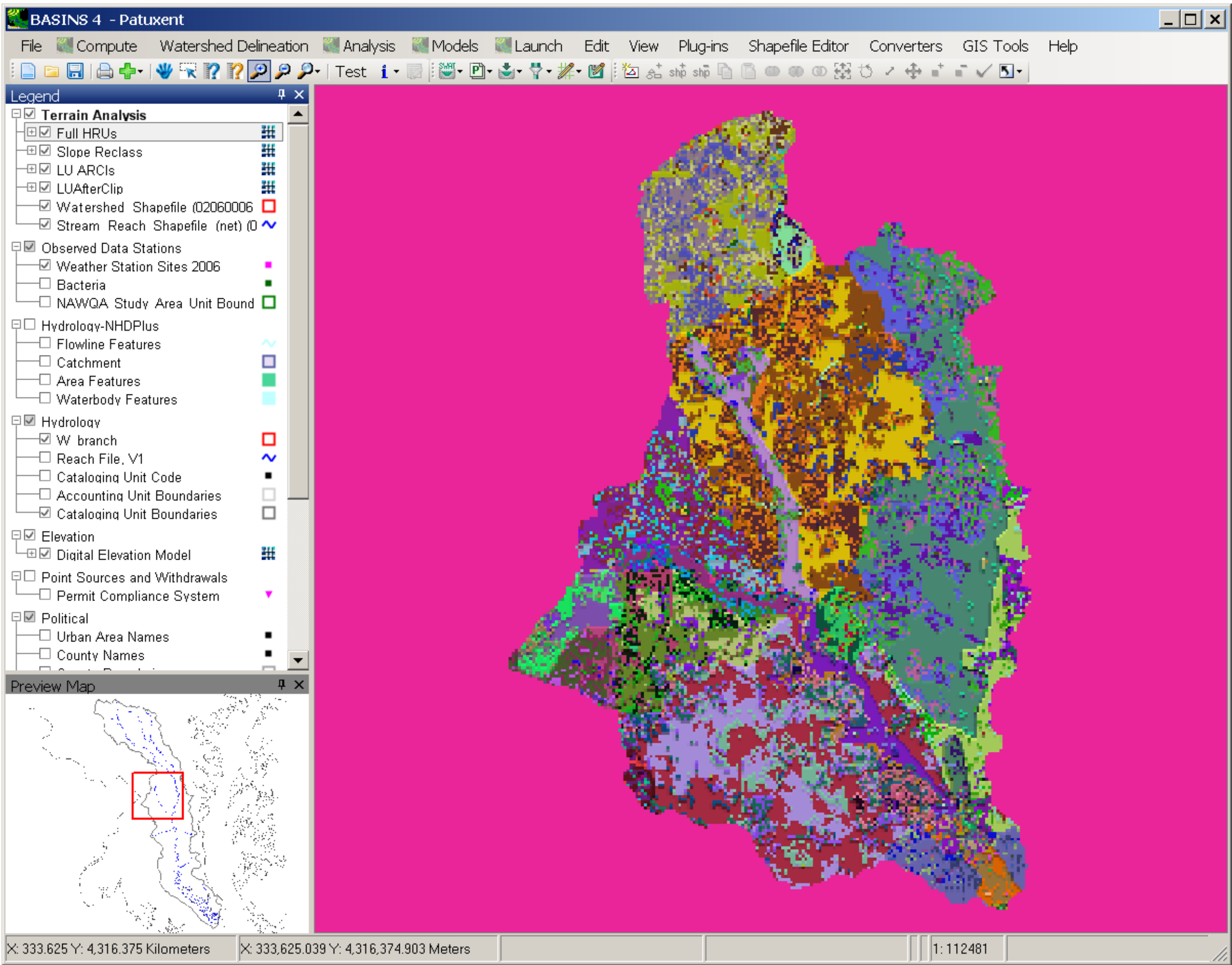
In order to reclassify the slope, users should browse to slope tab. Users can then select “Single slope” or “Multiple slope” options. If the “Multiple Slope” option is selected, click the “Number of Slope Classes” drop-down and select a number of slope classes to define. Then select each “Current Slope Class”, specify a “Class Upper Limit” value, and click “Add” to add them into the “SWAT Slope Classification Table”.


Landuse/Soil/Slope Definition
Land Use Data
Soil Data
Slope
Select the DEM Grid (Step 0)
Digital Elevation Model
Slope Discretization (Step 1)
Single Slope
Multiple Slope
Watershed
Slope Stats :
Min: 0.00
Mean: .9
Max: 6.3
Median: .7
Slope Classes (Step 2)
Number of Slope Classes
2
Current Slope Class
1
Class Upper Limit (%)
2
Add
SWAT Slope Classification Table
Class
Lower Limit
Upper Limit
1
0
2
2
2
9999
Reclassify
Overlay

Select “Reclassify” to complete the slope reclassification.

Finally select “Overlay” near the bottom to overlay “Land Use”, “Soil”, and “Slope” grids. This step will produce a complete Hydrological Response Units (HRUs) map. Upon completion the following confirmation message is displayed.





HRU Definition/ Hydrologic Response Unit Distribution

Before running the SWAT model, the Hydrological Response Units distribution should be defined based on the land use, soil, and slopes defined in the previous step. One or more unique land use/soil/slope combination(s) can be created for each subbasin (there should be at least one HRU per subbasin).

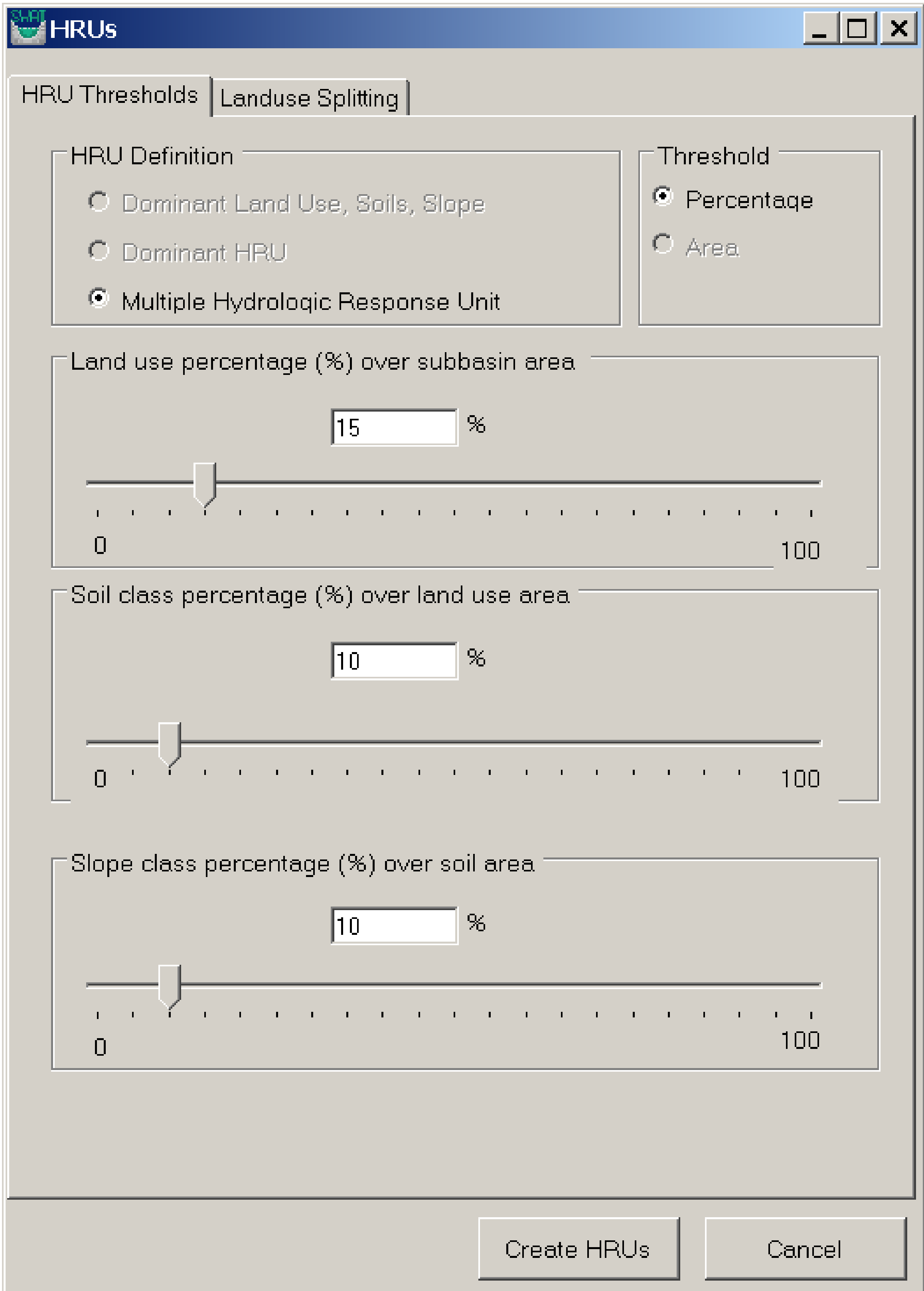
Subdividing the watershed into areas having unique land use, soil, and slope combinations enables the model to reflect differences in meteorologic conditions for various crops and soils. Runoff is predicted separately for each HRU and routed to obtain the total runoff for the watershed, increasing accuracy and giving a more accurate physical description of the water balance.

Users can choose multiple HRU options to create one or more HRUs for each subbasin. In this case users may specify sensitivities for the land use, soil, and slope data that will be used to determine the number and kind of HRUs in each watershed.

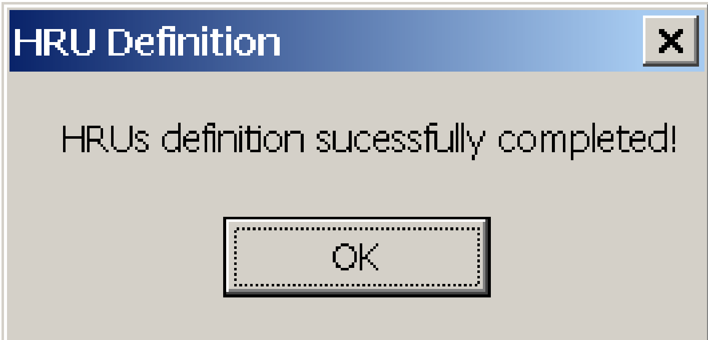
Select the “HRU Definition” from “Land Use/ Soil/ Slope” menu. From this dialog users can specify different threshold values for land use, soil, slope percentages for each subbasin. Users can select the desired threshold values for land use, soil, and slope (for example 15% LU, 10% soil, 10% slope) and click

“OK”. The distributed HRUs can be viewed in the “HRU Distribution Report” by clicking the “Analysis Reports” menu option. If the distribution is not satisfactory, repeat the preceding steps, altering the land use, soil, and slope sensitivities, until a satisfactory distribution is obtained.

Note: Selecting the “multiple hydrological response units” option allows users to eliminate minor land uses in each subbasin. For example, if the threshold for land use is set at 15%, then land uses less than 15% will be eliminated for HRU generation. The soil threshold also works the same way: 10% implies soils with greater than 10% area will be used to assign a HRU. The slope threshold also works the same way: 10% implies slope with greater than 10% area will be used to assign a HRU.

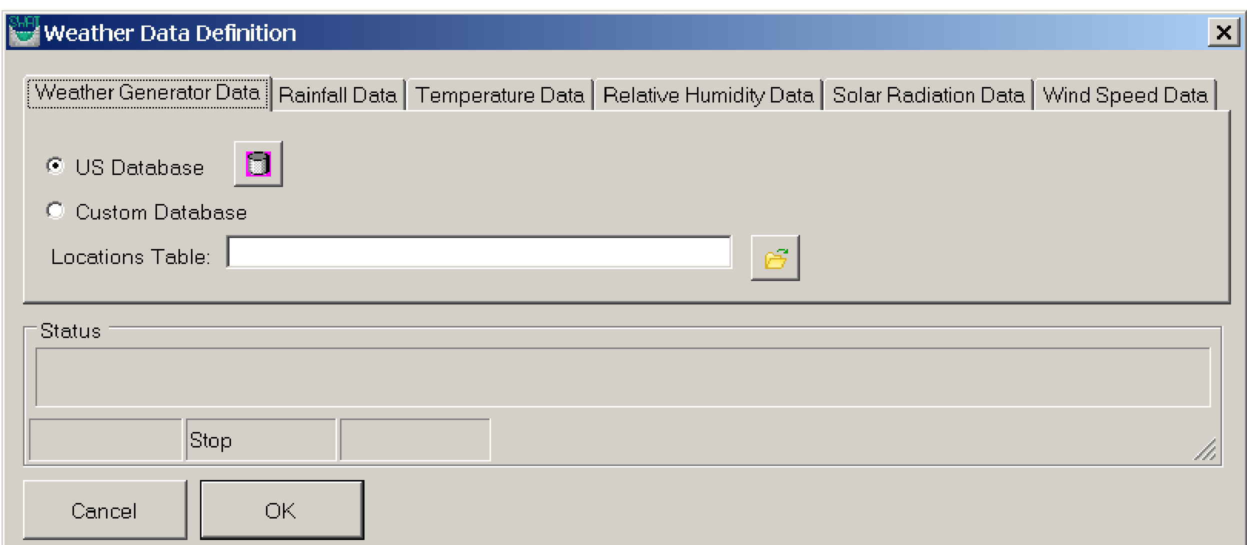

HRUs
HRU Thresholds
Landuse Splitting
HRU Definition
Dominant Land Use, Soils, Slope
Dominant HRU
Multiple Hydrologic Response Unit
Threshold
Percentage
Area
Land use percentage (%) over subbasin area
15
%
0
100
Soil class percentage (%) over land use area
10
%
0
100
Slope class percentage (%) over soil area
10
%
0
100
Create HRUs
Cancel

Upon completion of the HRU distribution, a confirmation message is displayed as shown below.

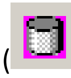


Weather Data Definition

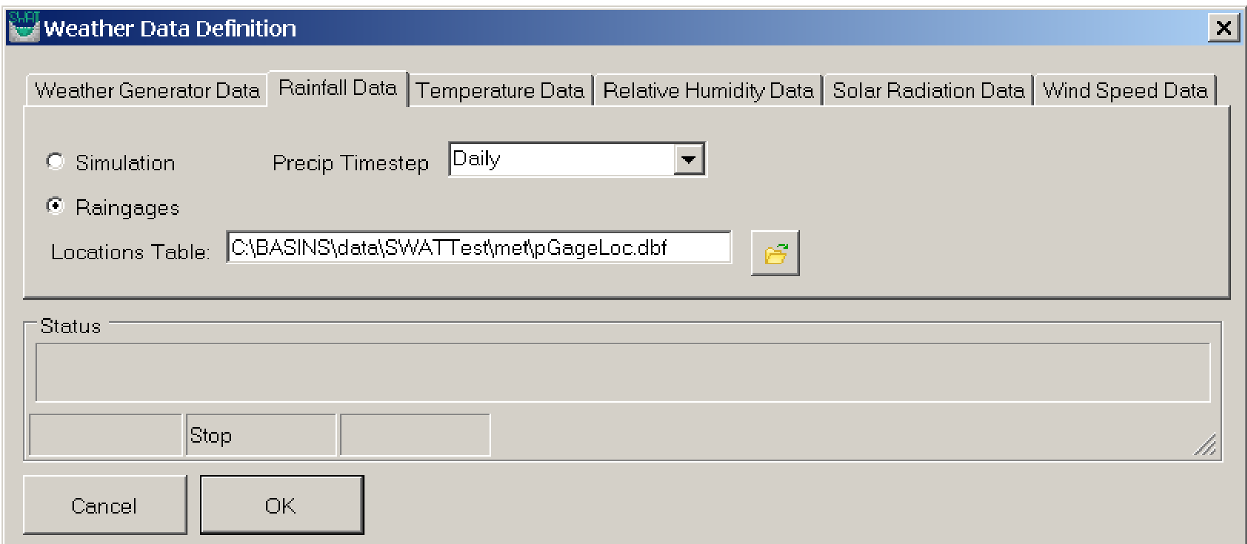
Select the “Weather Stations” option under the “Write Input Tables” menu. A weather data dialog box will be opened. This dialog will let users define the input data for rainfall, temperature, relative humidity, solar radiation, and wind speed. For rainfall and temperature, users have the option of simulating the data in the model or to read from data tables. For the weather data, information can be simulated using a weather generator based on the data from 1112 weather stations around the US stored in a database, or custom weather data can be input though a database tables.



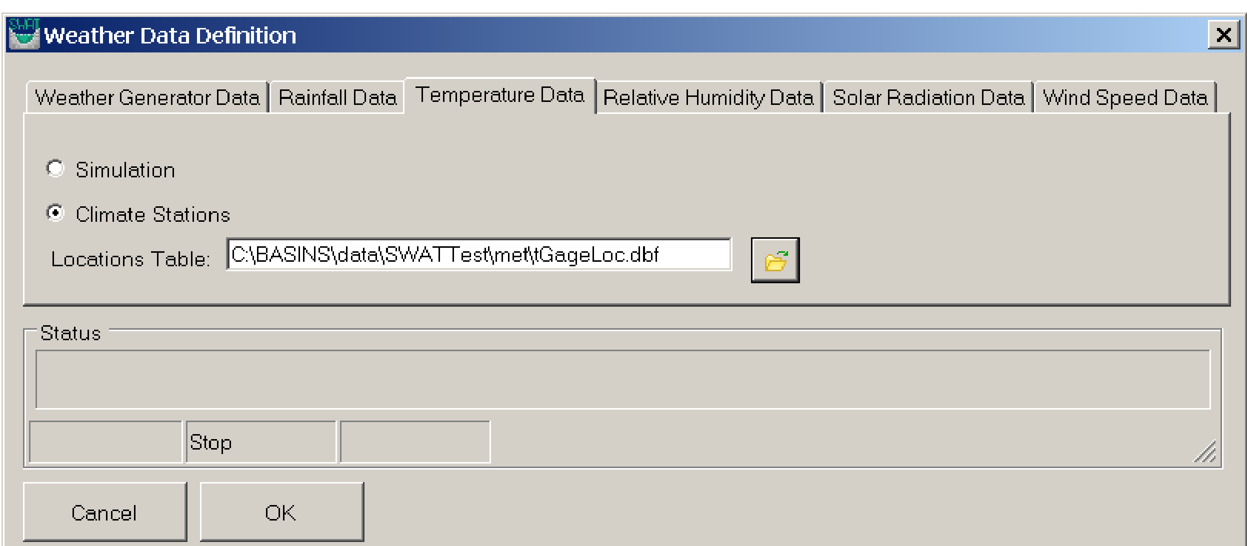
On the 'Weather Generator Data' tab, select the "US Database" Option for weather simulation data.

Then click the cylinder shaped button () to add the weather simulation database automatically.

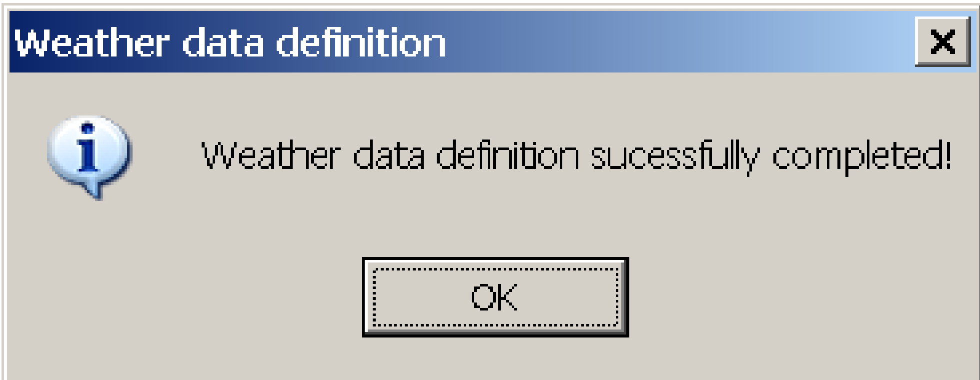
Activate the 'Rainfall Data' tab. Specify the 'Precip Timestep' to be 'Daily' from the dropdown list. Then, check the 'Raingages' radio button. Then, click the browse button () to locate the raingage location file (in dbf file format).



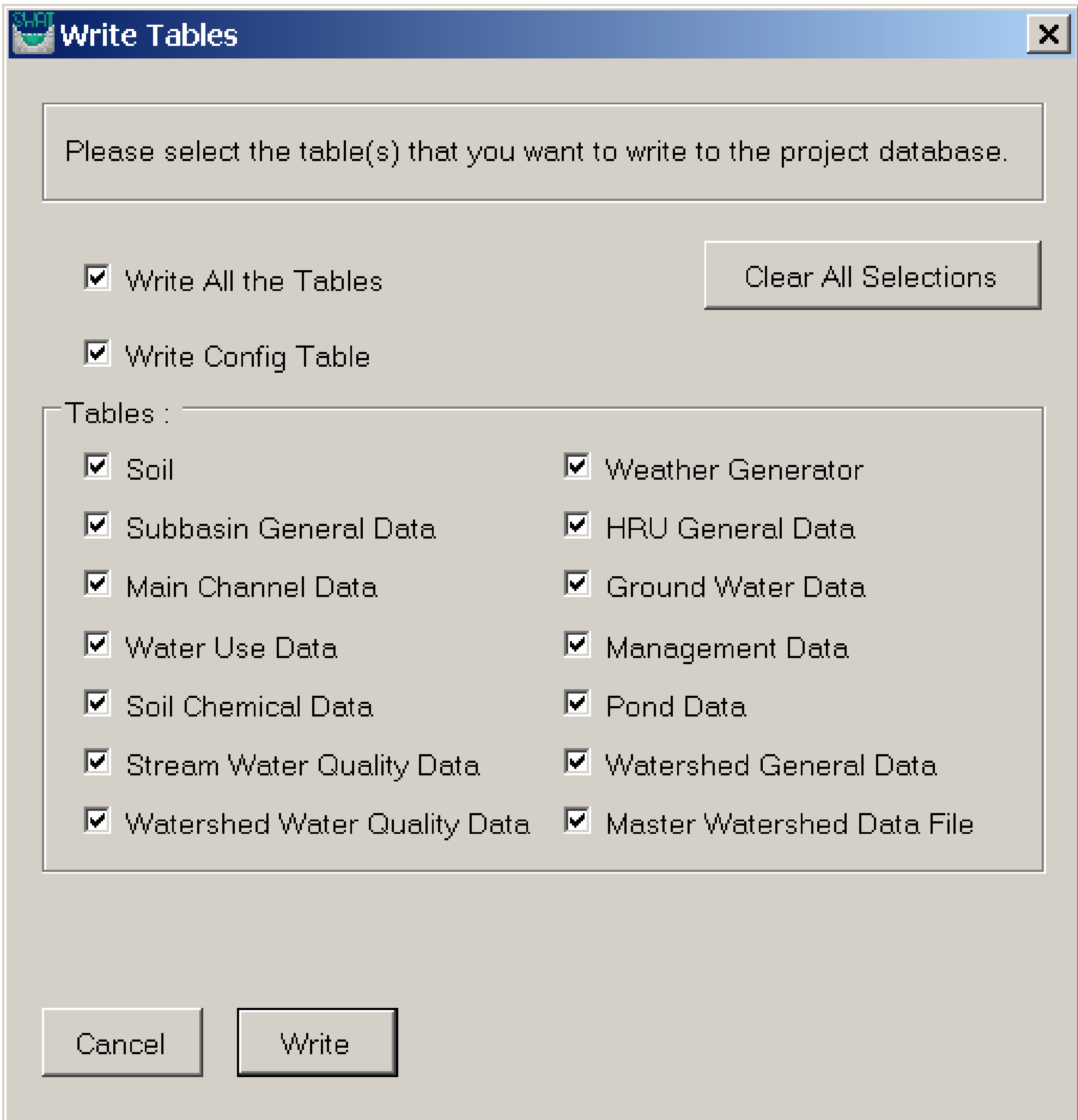
Activate the 'Temperature Data' tab. Select the "Climate Stations" option. Then, click the browse button () next to the "Location Table" text box to locate the temperature gage location file (in dbf file format).



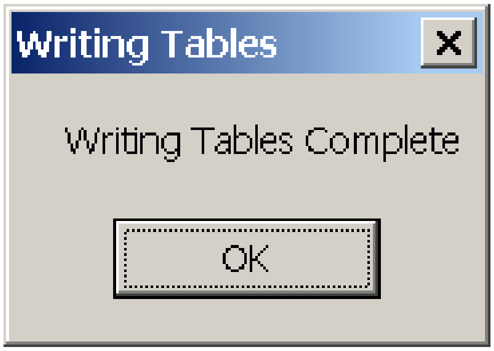
Finally, click the “OK” button at the bottom of the dialog to generate the SWAT weather input data files. Upon its completion, a confirmation message is displayed as shown below:



Writing Input Tables



In order to write the remaining input tables, use the “Write Tables” option under “Write Input Tables” menu as shown above. This brings up a dialog box which has all the input tables required for SWAT model run. To write all the tables, click the “Write All the Tables” check box and then click the write button. By default, Write Config Table is always checked and other tables are unchecked. Users may uncheck “Write Config Table” option or selectively check those tables a user would like to create and click “Write” Option.



Run SWAT Editor

When a user finishes the writing tables operation using OpenSWAT, the next step is to launch the SWAT Editor to continue watershed modeling. This can be done by clicking “Launch SWAT Editor” button () on the OpenSWAT toolbar.

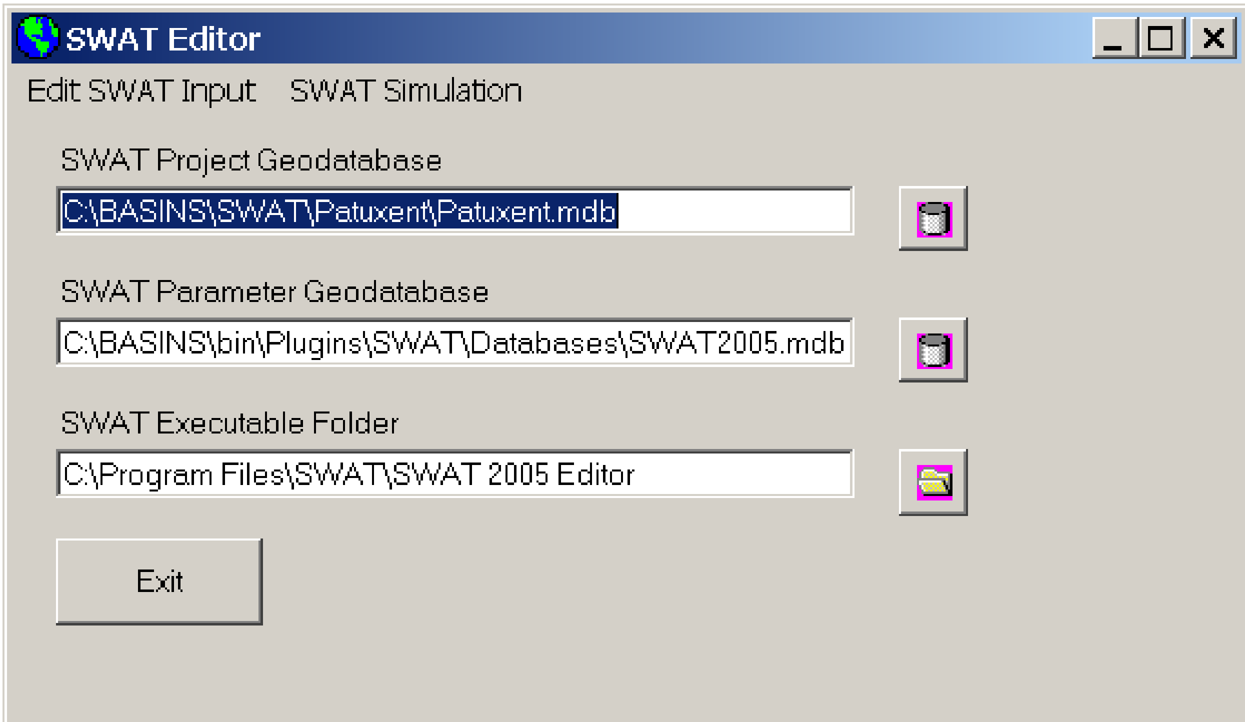
The SWAT Editor is useful for:

- Editing of SWAT Databases
- Editing of SWAT model Parameters
- Editing of model Point source, inlet, and reservoir
- SWAT model setup
- Calibration and sensitivity analysis

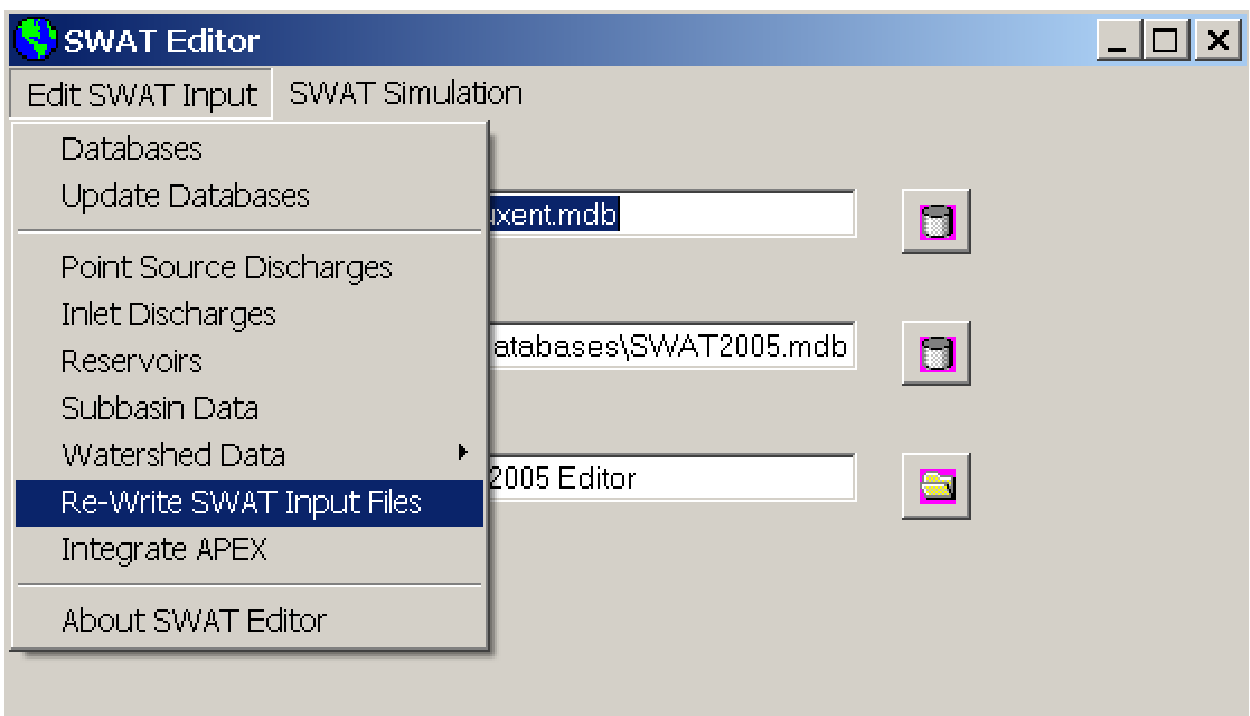
Initially the SWAT Editor has three input files:

1. SWAT Project Geodatabase
2. SWAT Parameter Geodatabase
3. SWAT Executable Folder

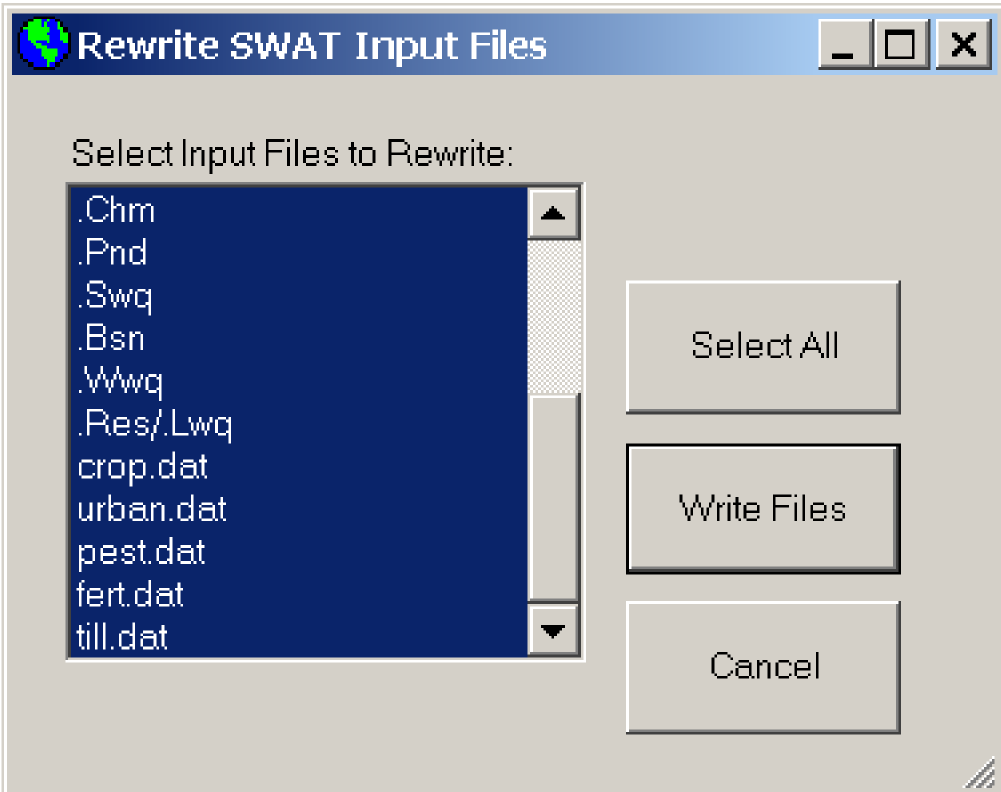
Usually the SWAT project Geodatabase is the one field varies between different projects.



When using the SWAT Editor for the first time for a given project, it is recommended that users re-write all SWAT input files by choosing "Re-Write SWAT Input Files" from the "Edit SWAT Input" menu.



Since OpenSWAT doesn't create any text input files, it is recommended to "Select All" items for the first application and to write them using the "Write Files" option.

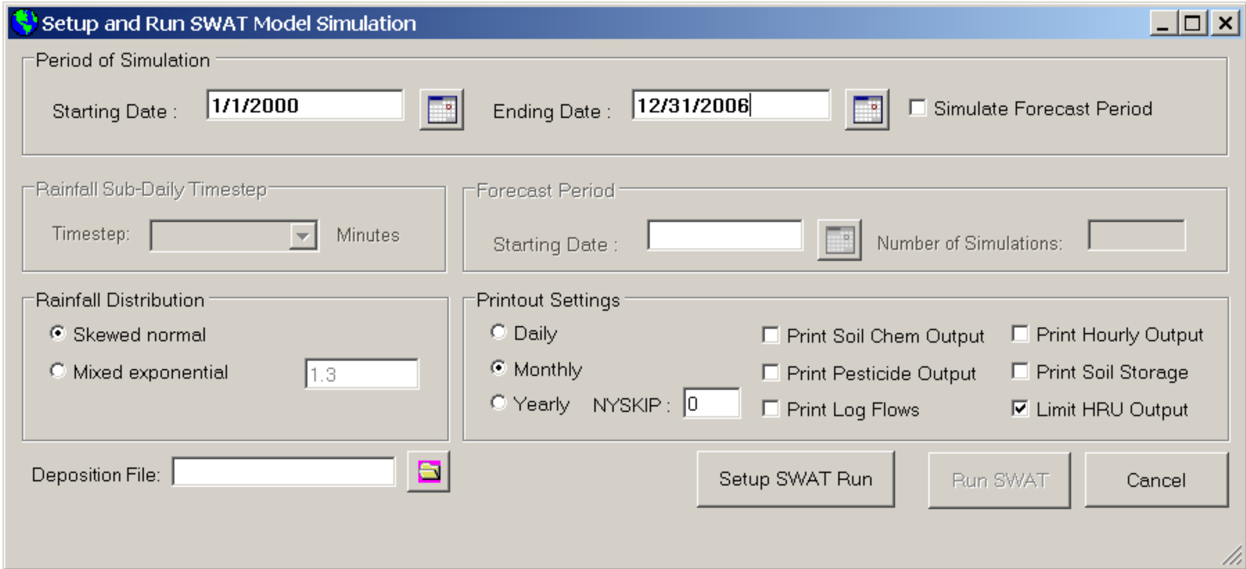


Upon successfully writing input files, a confirmation message is displayed as below.

If users want to edit specific inputs, choose input type from "Edit SWAT Input" menu, edit the values, and save them.

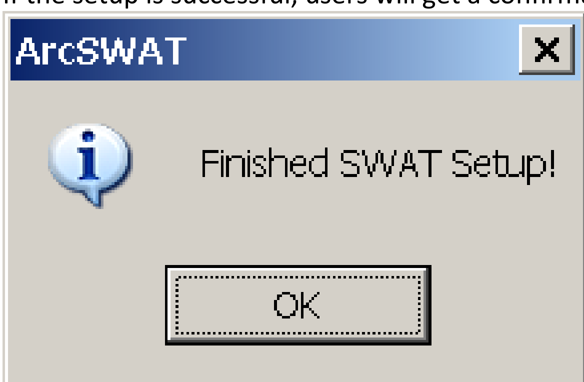
The next step is to run and simulate the model.

1. Go to “SWAT Simulation” and click the “Run SWAT” option. That will bring up the “Setup and Run SWAT Model Simulation” dialog box.



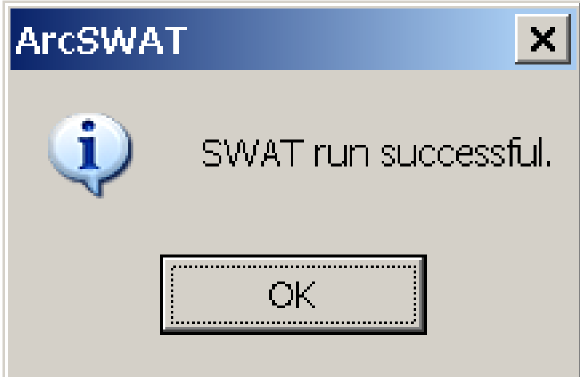
2. Specify the starting and ending simulation dates and then press “Setup SWAT Run.”

3. If the setup is successful, users will get a confirmation message.



4. After that, click the “Run SWAT” button.

5. Users can then view a DOS window showing year of SWAT Run and progress of model run.



AQUATOX

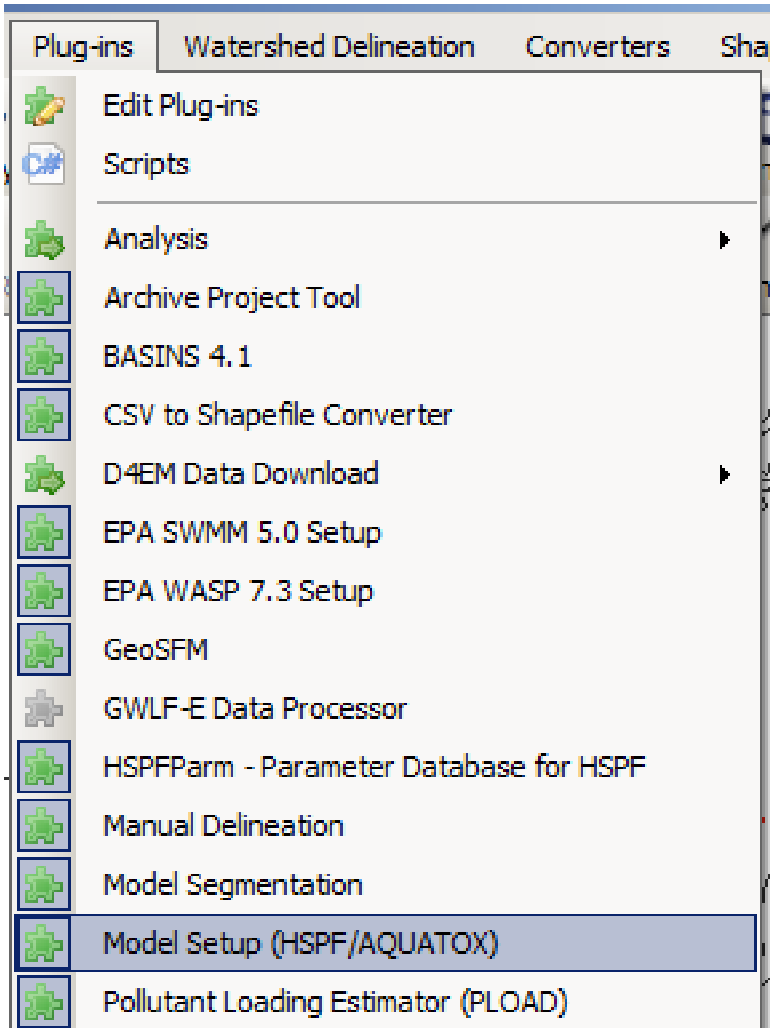
AQUATOX is a time-variable ecological risk assessment model that simulates the fate and effects of various environmental stressors in aquatic ecosystems. It simulates the fate and transfer of pollutants from loads to the water, sediments, and biotic components, and transfer throughout the food web. Simultaneously it predicts the effects of the stressors on the ecosystem, by simulating the chemical, physical and biological processes that bind the ecosystem together. *AQUATOX* can predict the fate and ecological effects of nutrients, organic toxicants, and bioaccumulative compounds, as well as the expected ecosystem responses to pollution reductions. It considers several trophic levels, including attached and planktonic algae and submerged aquatic vegetation, invertebrates, and forage, bottom-feeding, and game fish; it also represents associated organic toxicants.

Environmental management programs and activities that could benefit from application of *AQUATOX* include water quality criteria and standards, Total Maximum Daily Loads (TMDLs), identification of the cause(s) of biological impairment where there are multiple stressors, and ecological risk assessments.

Data Requirements for Setting up AQUATOX through BASINS: When using BASINS to build an initial AQUATOX input file, a 'streams' layers must exist on the map, and a single stream segment from that layer must be selected. Generally, the 'streams' layer will come from a BASINS delineation tool, although equivalent themes from another delineation tool can be used as well.

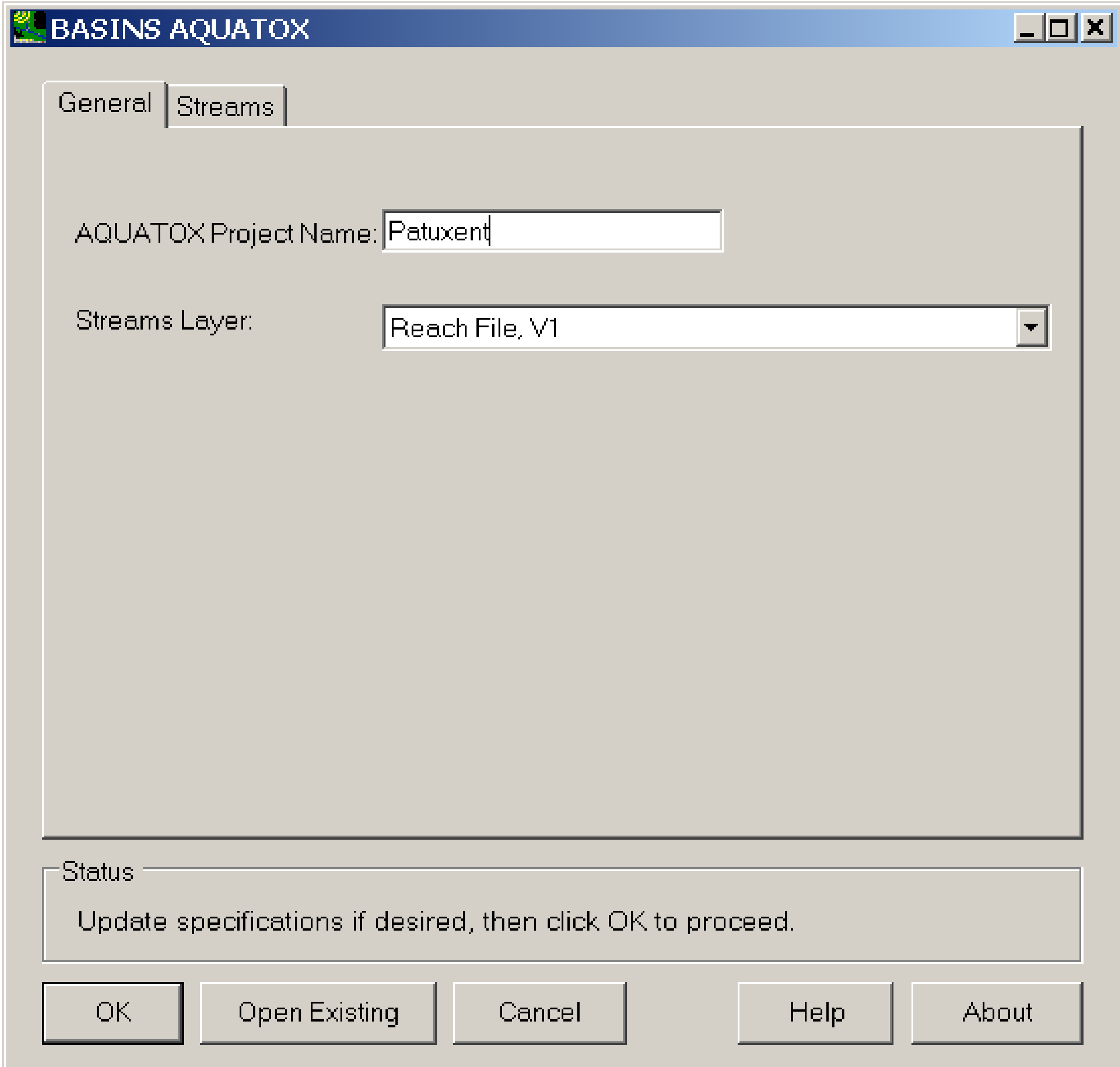
Key Procedures

1. Back on the main BASINS window, select **Model Setup (HSPF/AQUATOX)** from the **Plug-ins** menu so that it is active. This will add **Models** to the menu on the main form.



2. Select **Models:AQUATOX** from the main menu to invoke the **BASINS AQUATOX** form. All of the fields on both the **General** and **Streams** tabs will default appropriately if the BASINS Delineation

Tools were used to create the Stream Reach Shapefile.



3. Click to **Ok** button to open the *AQUATOX* interface.

PLOAD

The BASINS Pollutant Loading Estimator (*PLOAD*) is a simplified, GIS-based model to calculate pollutant loads for watersheds. Based on the *PLOAD* extension developed for BASINS 3.0 by CH2M HILL in Herndon, Virginia, *PLOAD* estimates nonpoint sources (NPS) of pollution on an annual average basis, for any user-specified pollutant. The user may calculate the NPS loads using either of two approaches, using Export Coefficients or the EPA's Simple Method. Optionally, best management practices (BMPs), which serve to reduce NPS loads, point source loads, and loads from stream bank erosion may also be included in computing total watershed loads. *PLOAD* produces maps and tables showing the NPS pollution results, and the tool can be run multiple times to compare results under various scenarios.

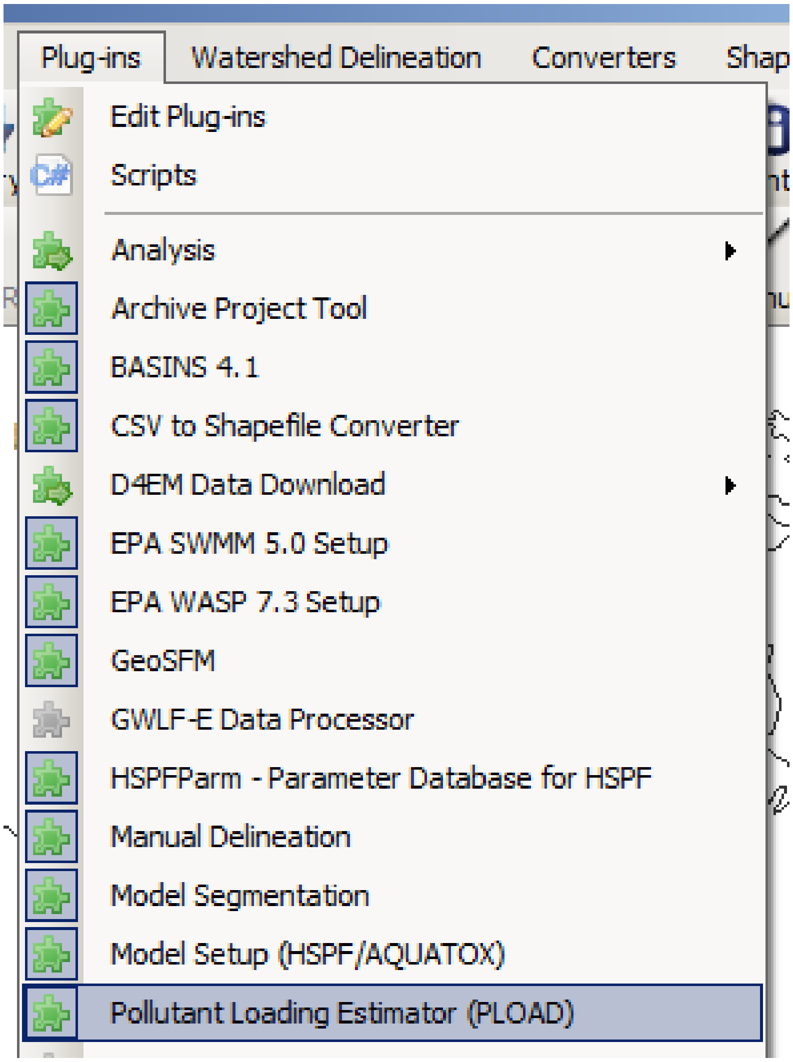
Data Requirements for PLOAD: *PLOAD* calculates loads for any subbasin polygon shapefile, which may be user-supplied or the output of one of the BASINS watershed delineation tools. In addition to this subbasin shapefile, the *PLOAD* application requires pre-processed GIS and tabular input data as listed below:

- GIS land use data
- Pollutant loading rate data tables
- BMP site and area data (optional)
- Impervious terrain factor data tables (for the Simple Method only)
- Pollutant reduction BMP data tables (optional)
- Point source facility locations and loads (optional)
- Bank Erosion data tables (optional)

PLOAD was designed to be generic so that it can be applied as a screening tool in a wide range of applications including NPDES stormwater permitting, watershed management, or reservoir protection projects. Subsequent sections of this manual describe the PLOAD input data, pollutant loading calculations, and instructions for the user interface.

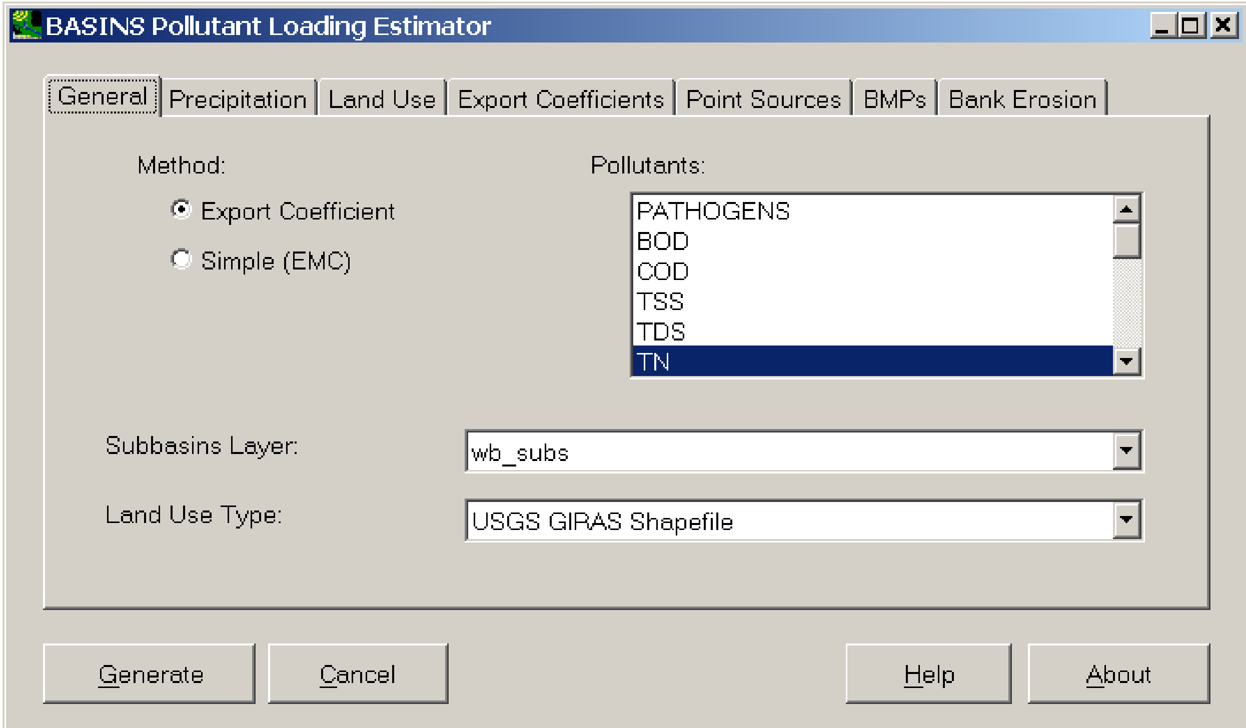
Key Procedures

1. Select **Plug-ins:Pollutant Loading Estimator (PLOAD)** from the plug-ins menu so that it is active. This will add **PLOAD** to the **Models** menu on the main form.



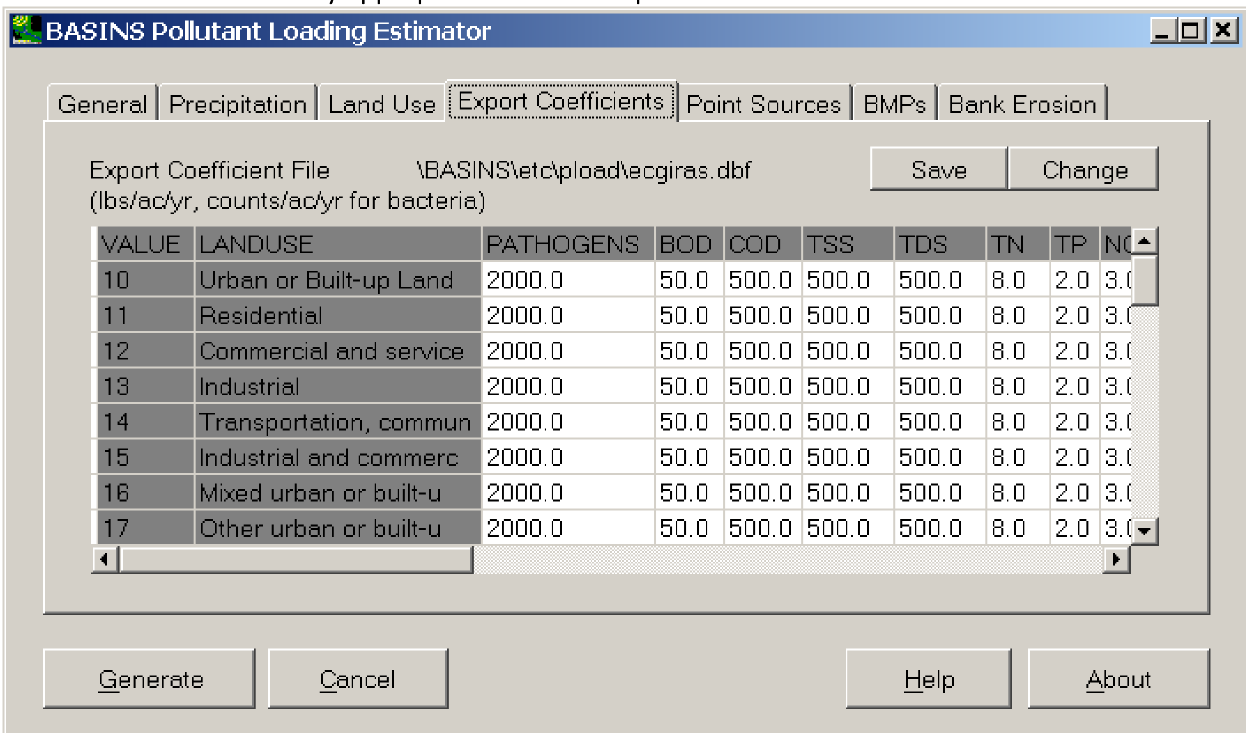
2. Select **Models:PLOAD** from the main menu to invoke the **BASINS Pollutant Loading Estimator** form. The **General** tab of this form contains the major options that must be specified to run *PLOAD*. The user must choose between the Export Coefficient and Simple Method, select the pollutants to model from the list, specify the subbasins layer (in the example below the subbasins are output from a previous watershed delineation process), and specify the type of

land use data. There is no limit to the number of pollultants that can be selected.



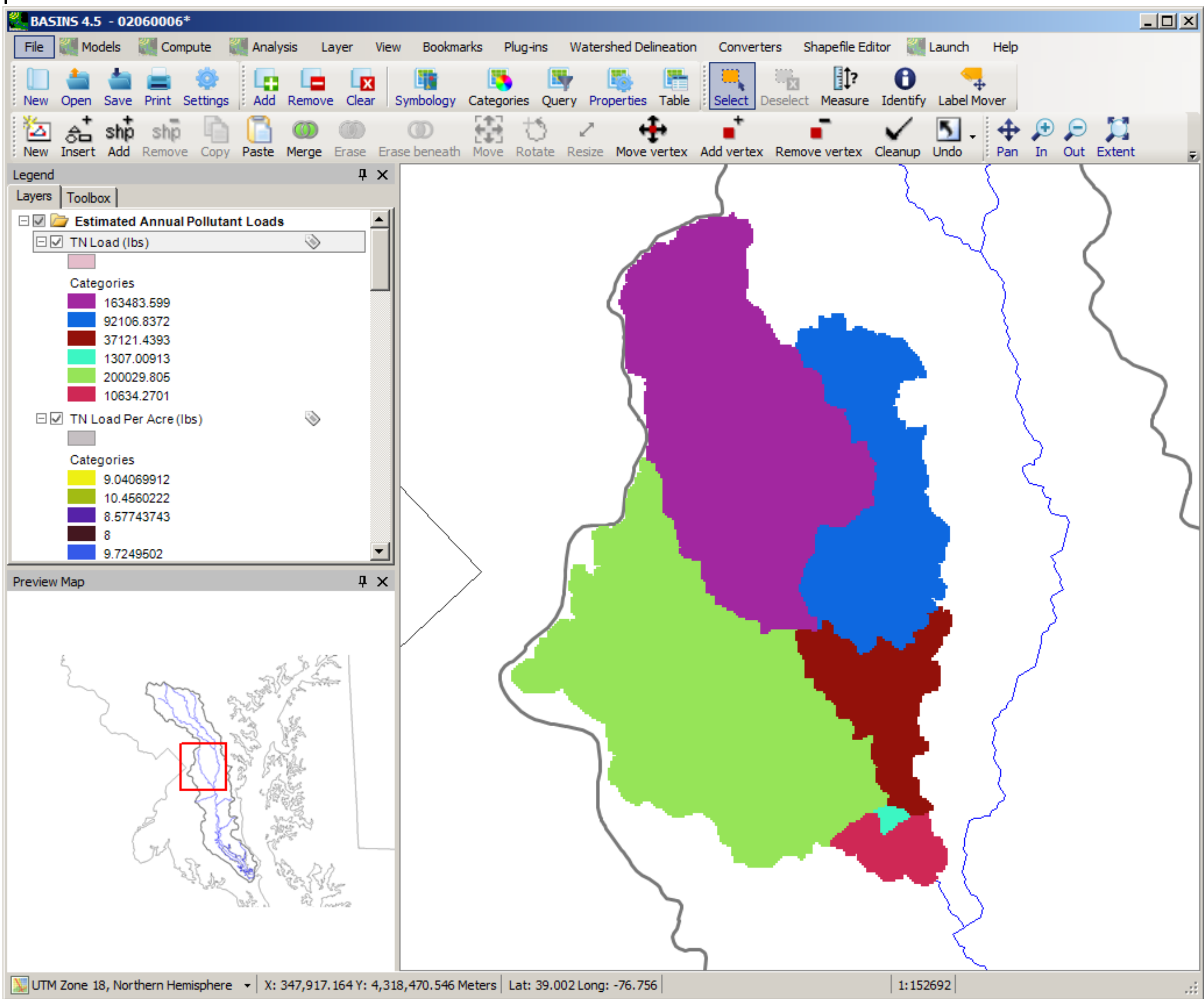
3. Change to the **Export Coefficients** tab. This tab shows a table of export coefficients for each land use category and each pollutant. The tables of export coefficients and event mean concentrations must be reviewed by the user, as only starting values are supplied, and these

numbers are not necessarily appropriate. Edit the export coefficients as needed.



4. Click **Generate** to execute *PLOAD*. When *PLOAD* has finished, new layers will appear on the map, showing the *PLOAD* results as Estimated Annual Pollutant Loads for the selected

pollutants.



Input Data A variety of GIS and tabular source data are accessed by the *PLOAD* model. This section describes the required and optional input data components. Note that the GIS data must be in shapefile format or GeoTiff grid format, while the tabular data must be prepared as dbf files.

GIS Data

Watershed boundary and land-use GIS data layers are required for *PLOAD*. The watersheds define the areas for which the pollutant loads are calculated. The watershed layer must have a code field containing unique identifiers for each watershed. The land use file is essential for calculating the pollutant loads. The land use coverage must also have a code field identifying the land use types, but these types need not be unique. Prior to calculating the pollutant loads, *PLOAD* will spatially overlay the watershed and land use coverages in order to determine the areas of the various land use types for each watershed. The land use layer should encompass the entire watershed. USGS GIRAS land use or NLCD land use, available through BASINS, may be used, or a user-supplied land use shapefile or grid may be used.

BMPs serve to reduce pollutant loads using natural processes (settling, filtration, and biological uptake) for the BMP area of influence. *PLOAD* will account for the influence of either site or areal BMPs. Site BMPs represented as point shapefiles must contain attribute codes describing the BMP type and area of influence. Areal BMPs must be delineated as polygon files coded for BMP type only. The polygon boundaries define the area of influence. BMP input is optional because they may not exist for the area of evaluation or be desired for analysis. Usually, BMPs must be identified and mapped by water resource specialists, then converted as map layers for most evaluation areas. Digital files or hardcopy maps are seldom available for most study areas. BMPs may also be specified in tabular form as a percent removal from each subbasin. Note: Site and areal BMP removals are assumed in parallel and not in series.

Point sources may also be considered in the loading calculations. *PLOAD* will account for the influence of point sources. Point sources may be represented as point shapefiles must contain an attribute code identifying the point source id (such as NPDES number). If point sources are input as a point shapefile, a loading table is also required to specify the load of each pollutant from each point source facility. Point Source input is optional. Point Sources may also be specified in tabular form as a load from each subbasin.

Tabular Data

Pollutant loading rate, point source loading rate (optional), bank erosion loading rate (optional), impervious factor (for the Simple Method), and BMP efficiency information (if BMPs are modeled) must be compiled in tabular files for use in the *PLOAD* application. These files of tabular input data can be provided in dBASE (dbf) tables. The pollutant loading tables consist of the event mean concentration (EMC) and the export coefficient. The EMC and export coefficient tables contain pollutant rates for all land use types. The user may use *PLOAD* to estimate pollutant loads for any pollutant if EMCs or export coefficients are available. Pollutants commonly evaluated include:

- Bacteria
- TSS
- Nitrogen
- Lead
- TDS
- Nitrate plus Nitrite
- Zinc
- BOD
- TKN
- COD

- Ammonia
- Phosphorus

Multiple versions of each type of table may be generated to simulate alternative conditions. Starting values for export coefficients and event mean concentrations are provided for a range of pollutants. A description of each table is provided below.

Export Coefficient Table

The export coefficient table lists loading rates for each pollutant type by land use type. The first record (row) of the table must identify the field names starting with land use type followed by the available pollutants. The table may contain any number of land use and pollutant types. The land use types must be the same in the table as they are in the land use map layer. There should be loading rates for each land use and pollutant type in the evaluation area, otherwise the load for the area will be zero. The rates in the export coefficient table are measured in pounds per acre and are typically used to calculate the pollutant loads for rural land use types.

The columns of pollutants in the export coefficient table represent the range of pollutants available for modeling. The user may add a column to the export coefficient table, and the name of that new pollutant will be available in *PLOAD*. The export coefficient table is developed by water resource engineers generally based on values available from the literature or they can be developed based on analysis of watershed stormwater monitoring data.

Event Mean Concentration Table

The event mean concentration (EMC) table is very similar to the export coefficient table. This table contains a special second column specifying the impervious factor for each land use type. The impervious factor column identifies the percentage of imperviousness for each land use type. It is used to calculate the EMC runoff coefficient. If there is no impervious factor in the table for a particular land use type, then the EMC runoff coefficient will default to zero for areas with that land use. The impervious factors can be developed by water resource engineers and GIS analysts, by analyzing the impervious surfaces of different land uses on aerial photographs, or by use of literature values.

The EMC values are measured in milligrams per liter and typically used to calculate the pollutant loads for urban land use types. The EMC table is developed by water resource engineers, based on values available from the literature, or it can be developed based on analysis of watershed storm water-monitoring data.

Point Source Loading Table

If point sources are input as a point shapefile, a loading table is also required to specify the load of each pollutant from each point source facility. The columns in the table consist of the point source facility identifier followed by the loading values for each pollutant in pounds per year, where each column represents a discharge facility.

If no point source layer is specified but point sources are to be used, the point source loads may be specified in tabular form as a load in pounds per year from each subbasin. The first record (row) of the table identifies the field names starting with Subbasin ID followed by the pollutants under evaluation. The subbasins or pollutant types without loading values are assumed to have no point source loads.

Bank Erosion Loading Table

The bank erosion loading table specifies the load of TSS from streambank erosion within each subbasin in pounds. TSS is the only pollutant to which this option applies. The first record (row) of the table is a header line identifying the field names. Each subsequent record contains the Subbasin ID followed by the annual load of TSS in pounds. The subbasins or pollutant types without loading values are assumed to have no load from bank erosion.

BMP Efficiency Table

The BMP table identifies the percentage of efficiency for reducing pollutant loads for each BMP type. The first record (row) of the table identifies the field names starting with BMP type and BMP name followed by the pollutants under evaluation. The table may contain any number of BMP types. The pollutant types without percentage efficiency multipliers will not reduce the pollutant load for the BMP type. The BMP table is developed by water resource engineers by use of literature values, or by analyzing local monitoring data comparing pollutant loads entering and leaving BMPs.

If no BMP layer is used, the BMP table identifies the percentage of efficiency for reducing pollutant loads for each subbasin. The first record (row) of the table identifies the field names starting with Subbasin ID followed by the pollutants under evaluation. The subbasins or pollutant types without percentage efficiency multipliers will not reduce the pollutant load for the BMP type.

Note: The Export Coefficient and Event Mean Concentration tables provided with BASINS contain "representative" values as presented in the *PLOAD* v3 Users Manual distributed with BASINS 3.1 (available in the *BASINS/docs* folder in the file *PLOAD_v3.pdf*). These values represent a starting point and are based on data from a number of published sources, however they are specific to particular geographic regions. It is important that the user obtain appropriate values from studies in the corresponding geographic region.

Pollutant Loading Calculation Equations Annual pollutant loads may be calculated for each watershed using either areal export coefficients or EPA's Simple Method approach.

The Simple Method is an empirical approach developed for estimating pollutant export from urban development sites in the Washington, DC area (Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Schueler, July 1987). Its application is limited to small drainage areas of less than one square mile. (Compendium of Tools for Watershed Assessment and TMDL Development, EPA, May 1997). The Simple Method has been endorsed by EPA as a viable screening tool for NPDES stormwater projects (e.g. Guidance Manual for the Preparation of Part 2 of the NPDES Permit Application for Discharge from Municipal Separate Storm Sewer Systems, EPA, 1992).

The areal export coefficient model is a similarly empirical approach that provides total loads based on factors containing mass pollutant per unit area, per year. This option is provided for agricultural and undeveloped land uses or larger watersheds for which the Simple Method may not apply.

Optionally, the pollutant loads derived from these methods may be refined based on the remedial effects of BMPs. Loads from Point Sources and TSS loads from streambank erosion may also be included.

Descriptions of the equations used to calculate the pollutant loads follow.

Export Coefficient Method

If the export coefficient method is designated for calculating pollutant loads in *PLOAD*, then the loads are calculated for each specified pollutant type by watershed using the following equation:

$$L_P = \Sigma_U(L_{PU} * A_U)$$

Where: L_P = Pollutant load, lbs;

L_{PU} = Pollutant loading rate for land use type u, lbs/acre/year; and

A_U = Area of land use type u, acres

The loading rates are derived from the export coefficient tables, while the land use areas are interpreted from the land use and watershed GIS data.

Simple Method

If the Simple Method is designated for calculating pollutant loads in *PLOAD*, then two equations are required to calculate the loads for each specified pollutant type. First, the runoff coefficient for each land use type must be derived with the equation:

$$R_{VU} = 0.05 + (0.009 * I_U)$$

Where: R_{VU} = Runoff Coefficient for land use type u, $\text{inches}_{\text{run}}/\text{inches}_{\text{rain}}$

I_U = Percent Imperviousness

Percent impervious is extracted from the second column of the Event Mean Concentration table.

The pollutant loads are then calculated with the following equation:

$$L_P = \Sigma_U (P * P_J * R_{VU} * C_U * A_U * 2.72 / 12)$$

Where: L_P = Pollutant load, lbs

P = Precipitation, inches/year

P_J = Ratio of storms producing runoff (default = 0.9)

R_{VU} = Runoff Coefficient for land use type u, $inches_{run}/inches_{rain}$

C_U = Event Mean Concentration for land use type u, milligrams/liter

A_U = Area of land use type u, acres (In BASINS areas calculated from GIS data are in square meters. PLOAD converts areas from square meters to acres prior to using the information in the above equation)

The precipitation and storm ratio values are entered by the *PLOAD* user interactively. The loading rates are derived from the EMC tables, while the land use areas are interpreted from the land use and watershed GIS data.

BMP Computations

BMPs serve to reduce pollutant loads, and *PLOAD* has an option to calculate loads based on the remedial effects of the various BMP types. This section describes the equations used to calculate pollutant loads influenced by BMPs. BMP types may be represented as either area or site features, but the approach for both is similar. After the raw pollutant loads are calculated using the export coefficient or simple methods, three equations are used to recalculate the pollutant loads.

First, the percent of the watershed area serviced by BMPs are determined using the following equation:

$$\%AS_{BMP} = AS_{BMP} / A_B$$

Where: $\%AS_{BMP}$ = Percent area serviced by the BMP, decimal percent

AS_{BMP} = Area serviced by the BMP, acres

A_B = Area of watershed, acres

The BMP and watershed areas are derived from the BMP and watershed GIS data.

Next, the pollutant loads remaining after removal by each BMP are calculated. Note that BMPs are assumed in parallel and not in series, or in other words, each BMP reduction is calculated coming from the full pollutant load coming off the watershed.

$$L_{BMP} = (L_P * \%AS_{BMP}) * [1 - \%EFF_{BMP}/100]$$

Where: L_{BMP} = BMP load, lbs

L_P = Raw watershed load, lbs

%EFF = Percent load reduction of BMP, percentage

The raw watershed pollutant loads are derived from the results of the export coefficient or simple methods, while the percent load reduction comes from the BMP efficiency tables.

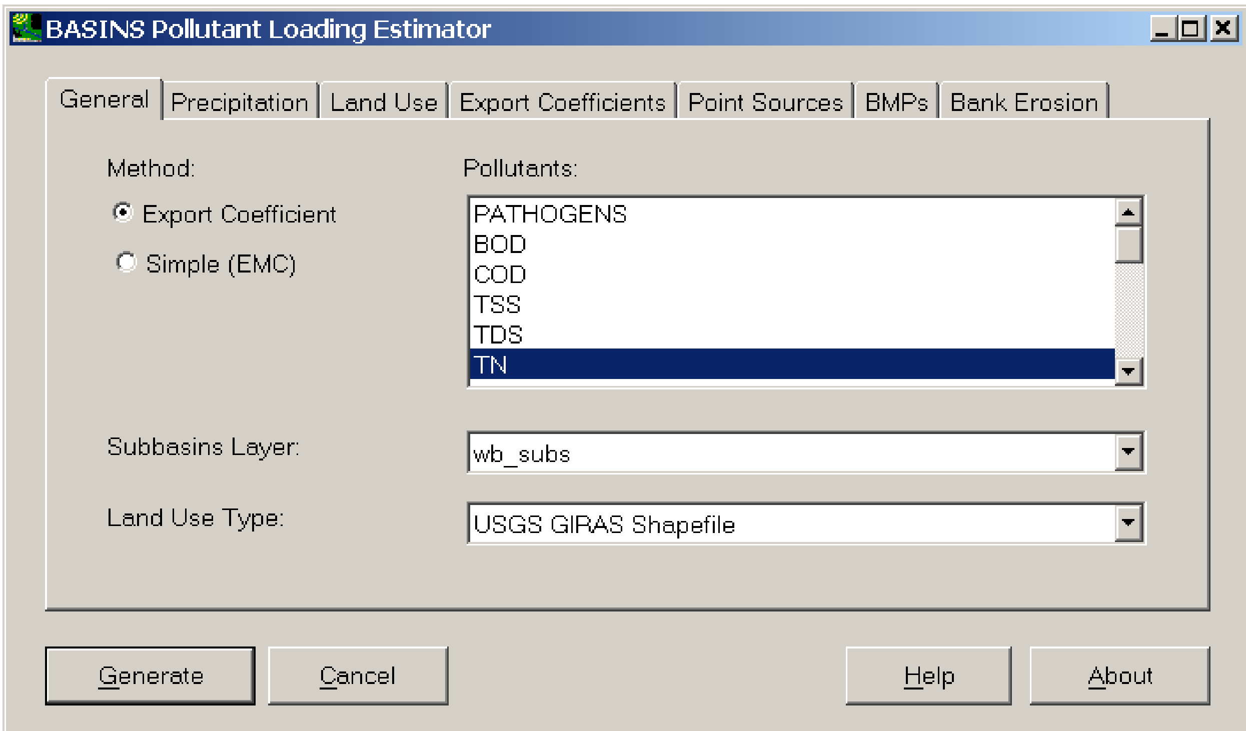
Finally, the total pollutant loads accounting for BMPs are computed by watershed. Each watershed load is a cumulative total of areas that are and are not influenced by BMPs.

$$L = (\Sigma_{BMP} (L_{BMP})) + L_P * (A_B - (\Sigma_{AS} (AS_{BMP}))$$

Point Source and Streambank Erosion Loads

Pollutant loads from Point Sources and Streambank Erosion (for TSS only) are added to the pollutant loads coming from each watershed, after the effects of BMPs (if any) have been considered. Point source and bank erosion loads are included in the total loads reported by *PLOAD* as well as in the per acre loads. Setup and Executing PLOAD The BASINS Pollutant Loading Estimator estimates pollutant loadings using the GIS layers on the map along with additional input tables. Layers used by this plug-in include **Subbasins**, **Land Use**, and optionally **Point Sources** and **BMPs**.

The *PLOAD* window opens with the interface populated according to the layers available on the map. The dominant portion of the *PLOAD* window is a tabbed dialog. Below the tabbed dialog is a row of command buttons.

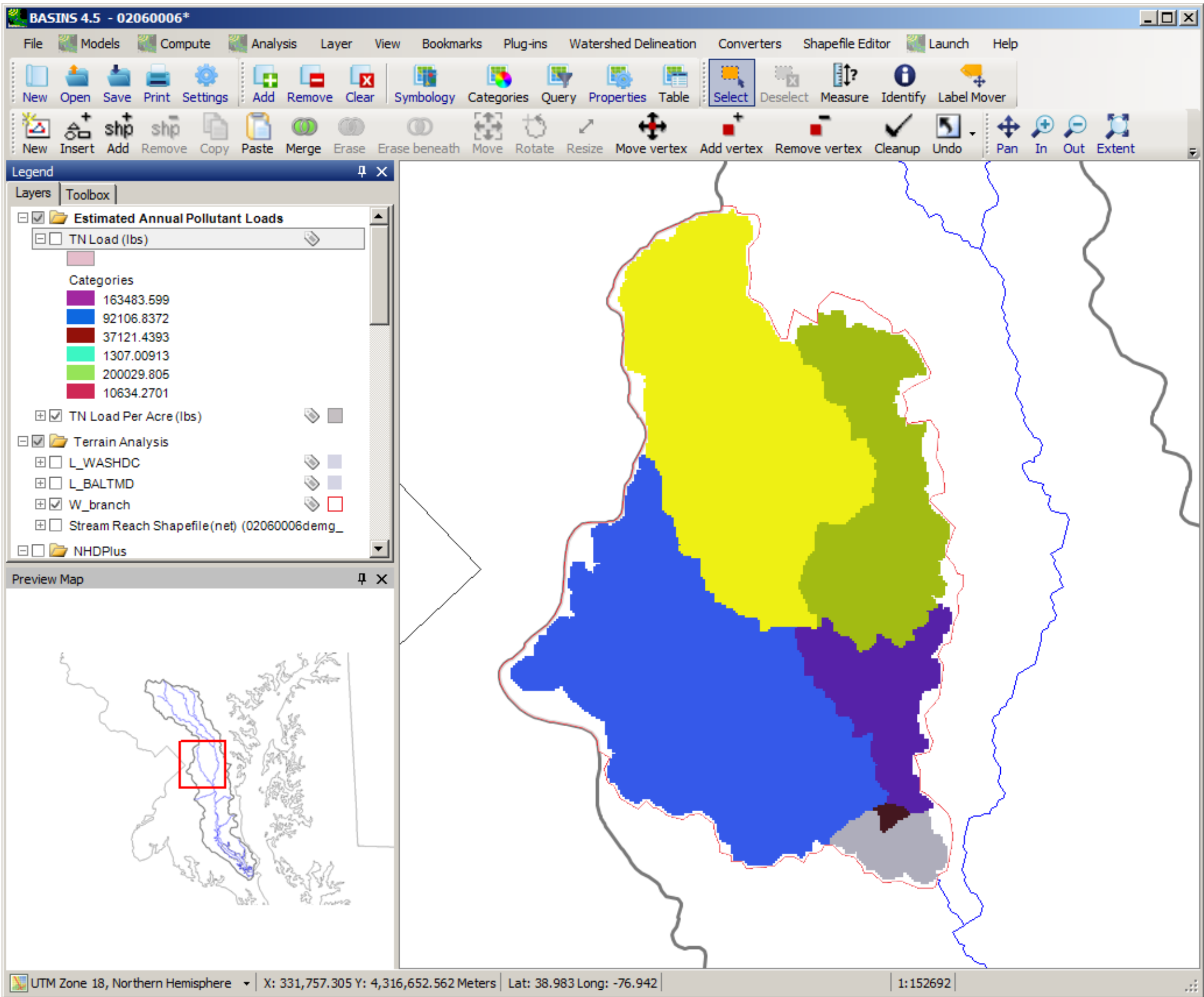


The tabbed dialog contains a **General** tab for specifying general information about the pending *PLOAD* simulation. The other tabs are used for specifying additional details. These tabs include the following:

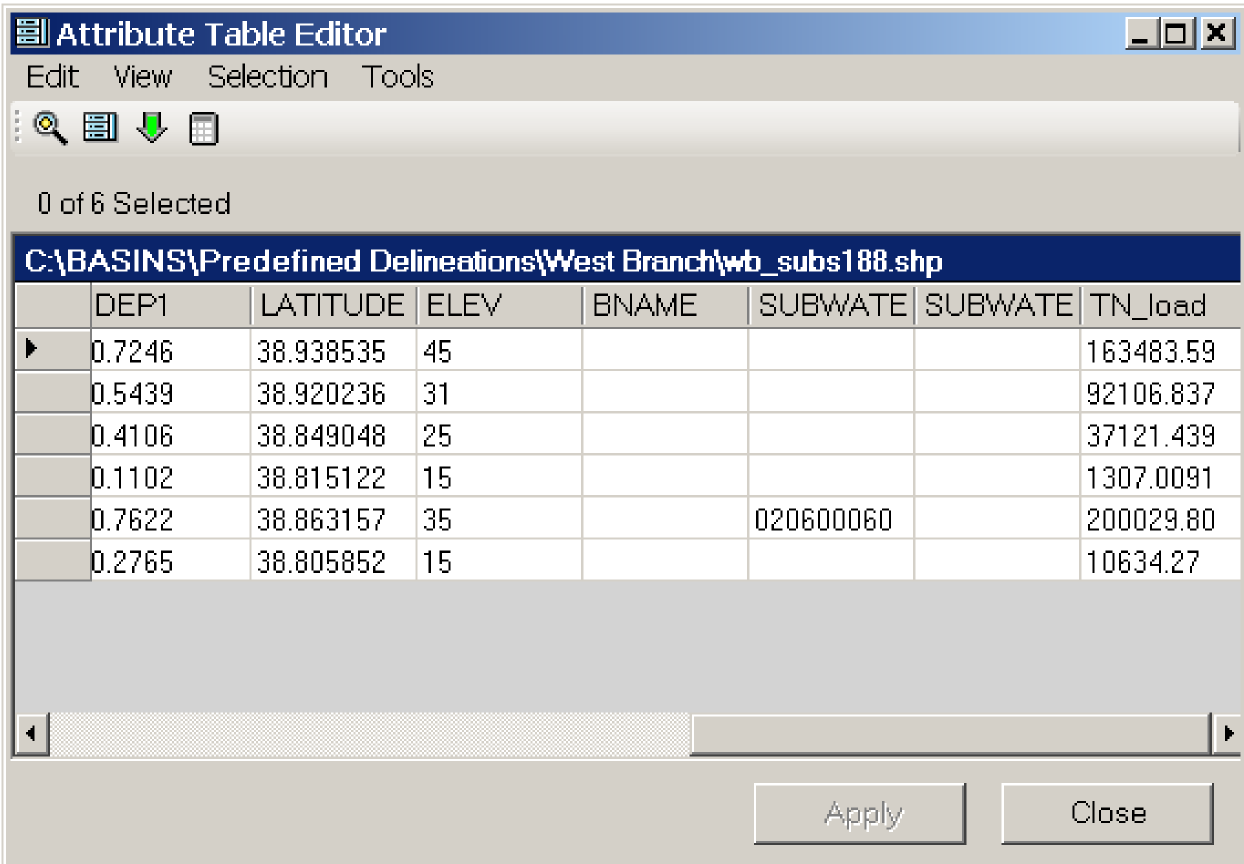
- Precipitation Specifications
- Land Use Specifications
- Export Coefficient or Event Mean Concentrations Specifications
- Point Sources Specifications
- BMP Specifications
- Bank Erosion Specifications

In the **General** Tab the user may choose between the Export Coefficient and Simple (EMC) Methods for computing loads. The user chooses one or more of the pollutants in the list and chooses the land use type. If 'USGS GIRAS Shapefile' is chosen as the land use type, no other specifications are required. If one of the other land use types is chosen, the user must proceed to the **Land Use** tab to specify the corresponding land use layer.

Once the user is satisfied with the input selections, the **Generate** button may be used to begin the *PLOAD* calculations. When the calculations are complete, new layers will be added to the map in a group entitled **Estimated Annual Pollutant Loads**. For each pollutant selected, a layer will be added corresponding to estimated loads for each subbasin, loads per acre for each subbasin, and for the Simple Method only, EMCs within each subbasin.

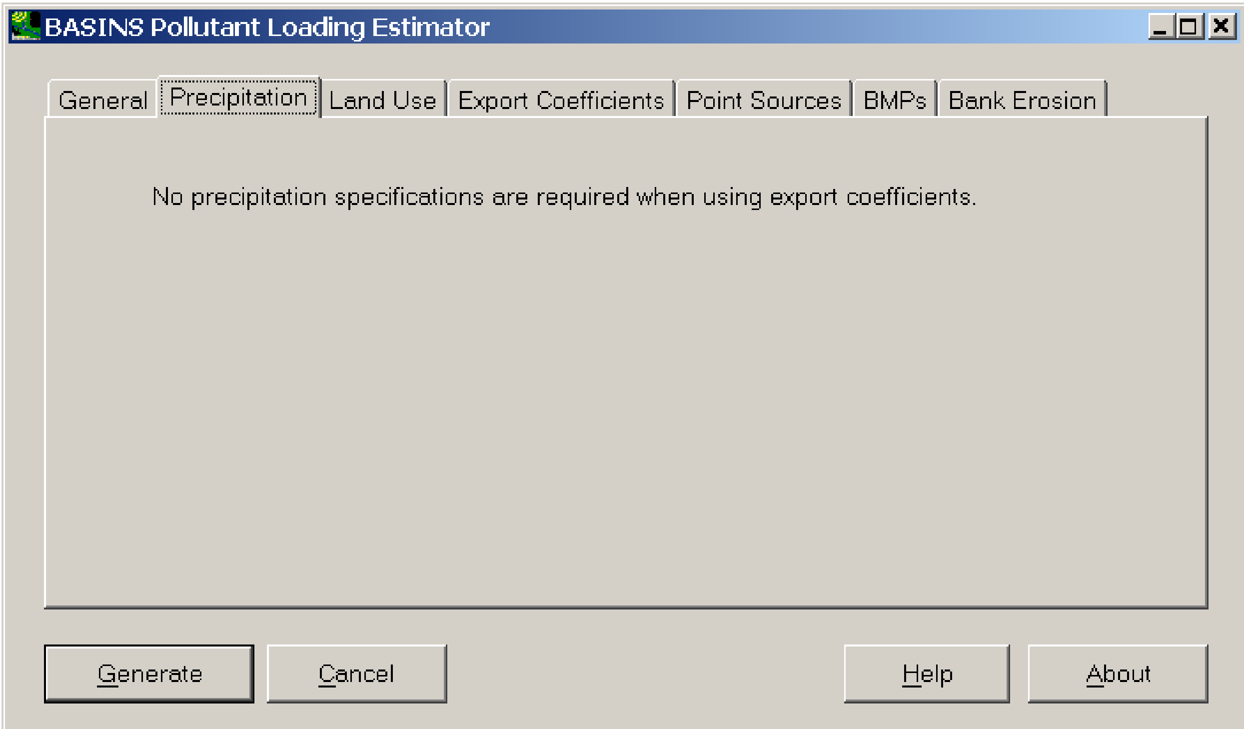


The layers added to the map are copies of the specified subbasin layer, with a field added to the respective attribute table containing the loading data (loads, loads per acre, or EMCs). The values in the table can be viewed using the MapWindow Table Editor.

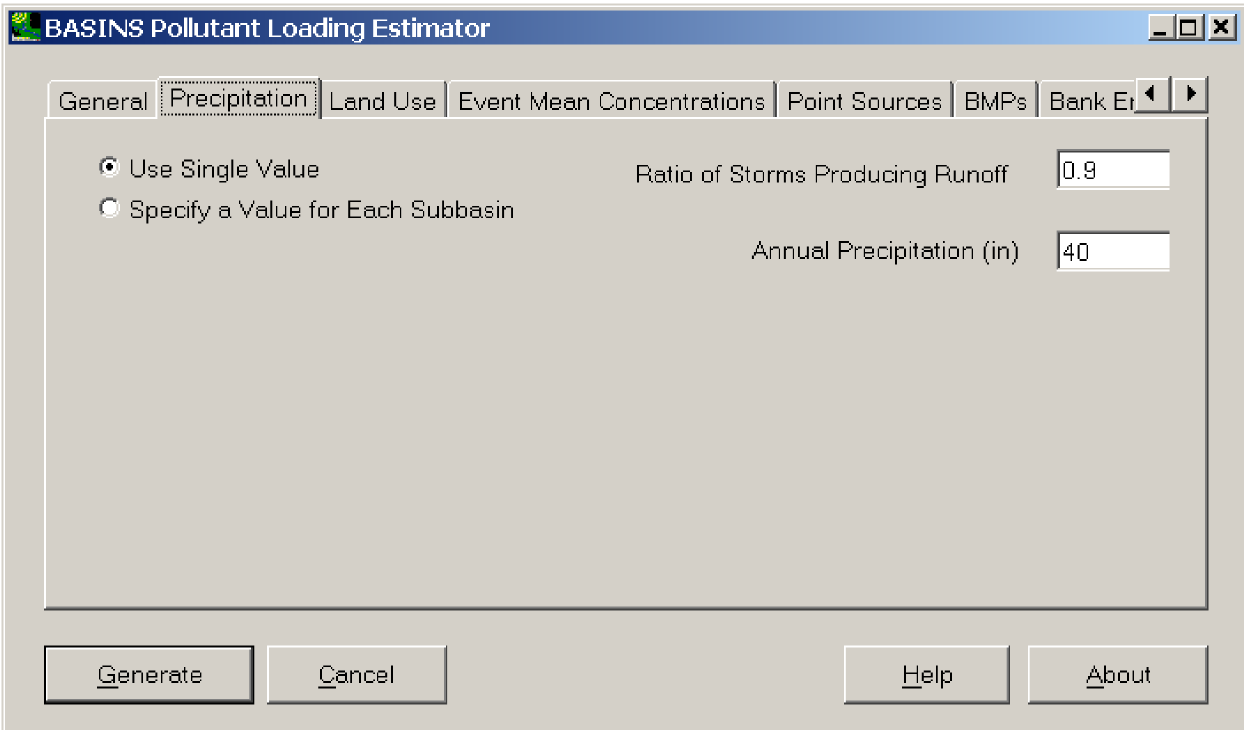


DEP1	LATITUDE	ELEV	BNAME	SUBWATE	SUBWATE	TN_load
0.7246	38.938535	45				163483.59
0.5439	38.920236	31				92106.837
0.4106	38.849048	25				37121.439
0.1102	38.815122	15				1307.0091
0.7622	38.863157	35		020600060		200029.80
0.2765	38.805852	15				10634.27

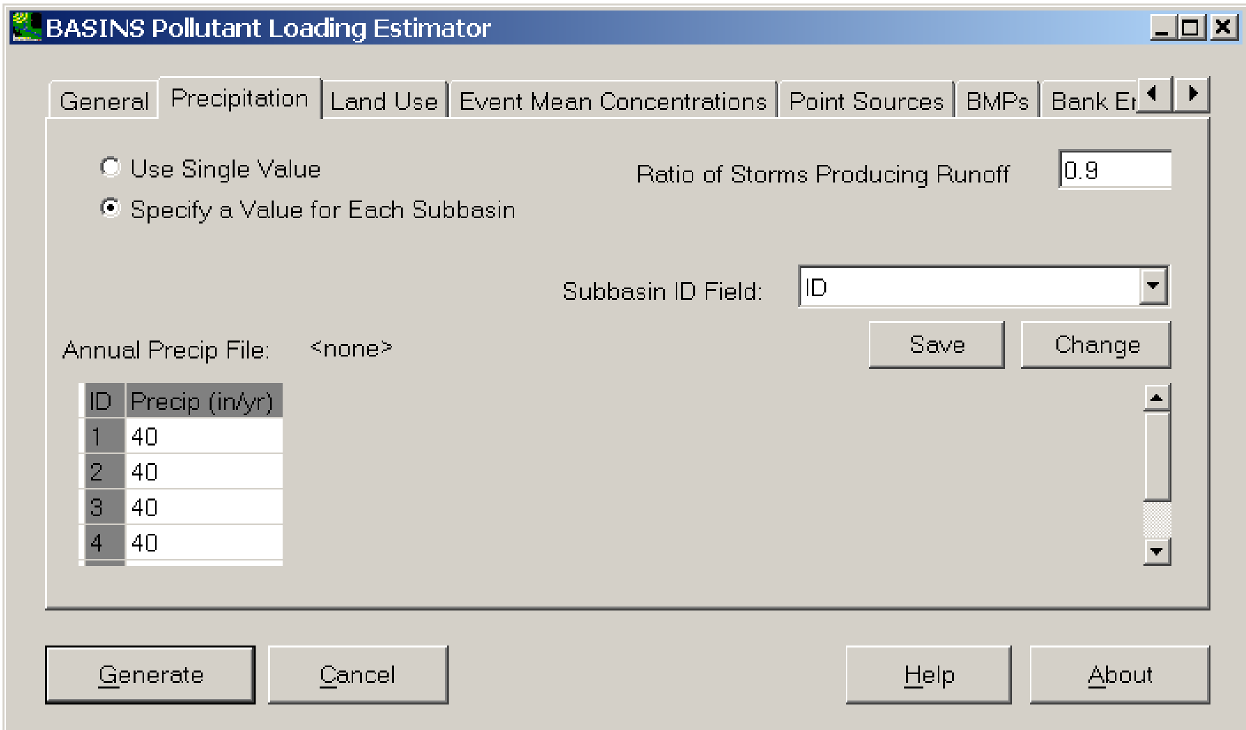
Precipitation Tab The **Precipitation** tab is used to specify the input precipitation values needed for the Simple Method. If using the Export Coefficient Method the tab includes only a message indicating that there is nothing to specify.



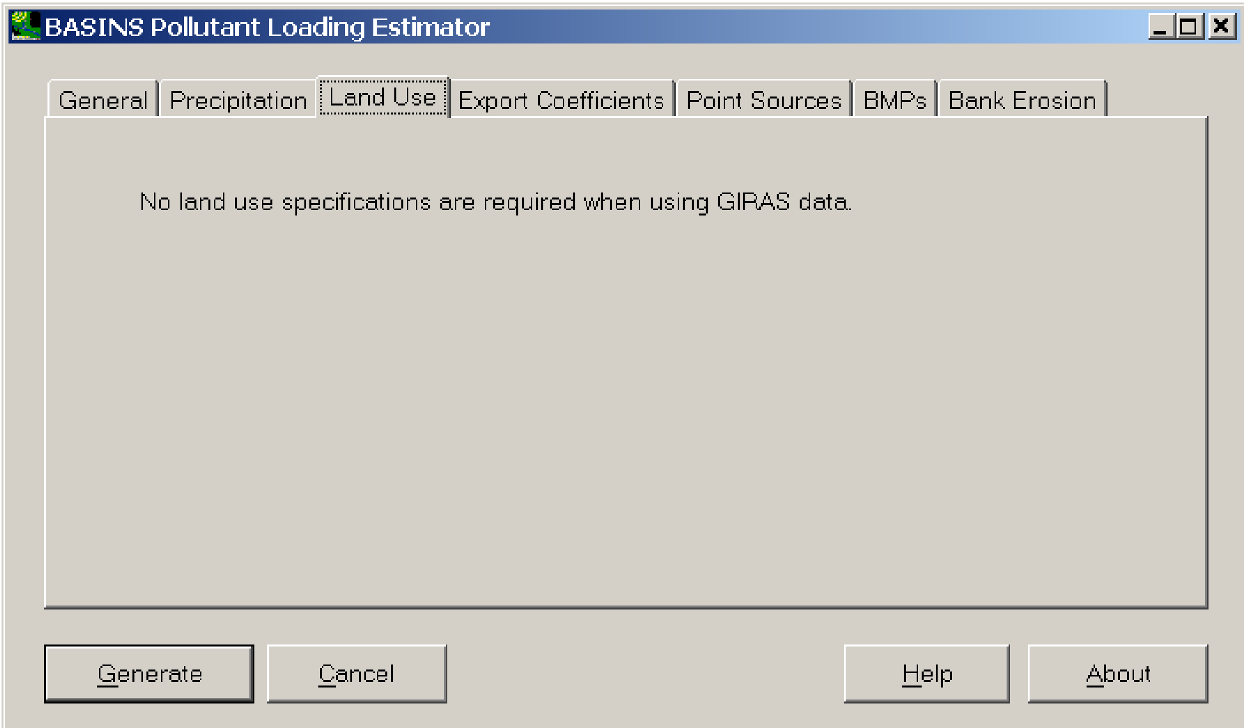
If using the Simple Method a pair of radio buttons appears in the upper left corner for specifying precipitation input options. The user may enter annual precipitation (in inches) as either a single value for all subbasins, or a unique value for each subbasin. If the single value option is chosen, the user enters the annual precipitation and the ratio of storms producing runoff as shown below.



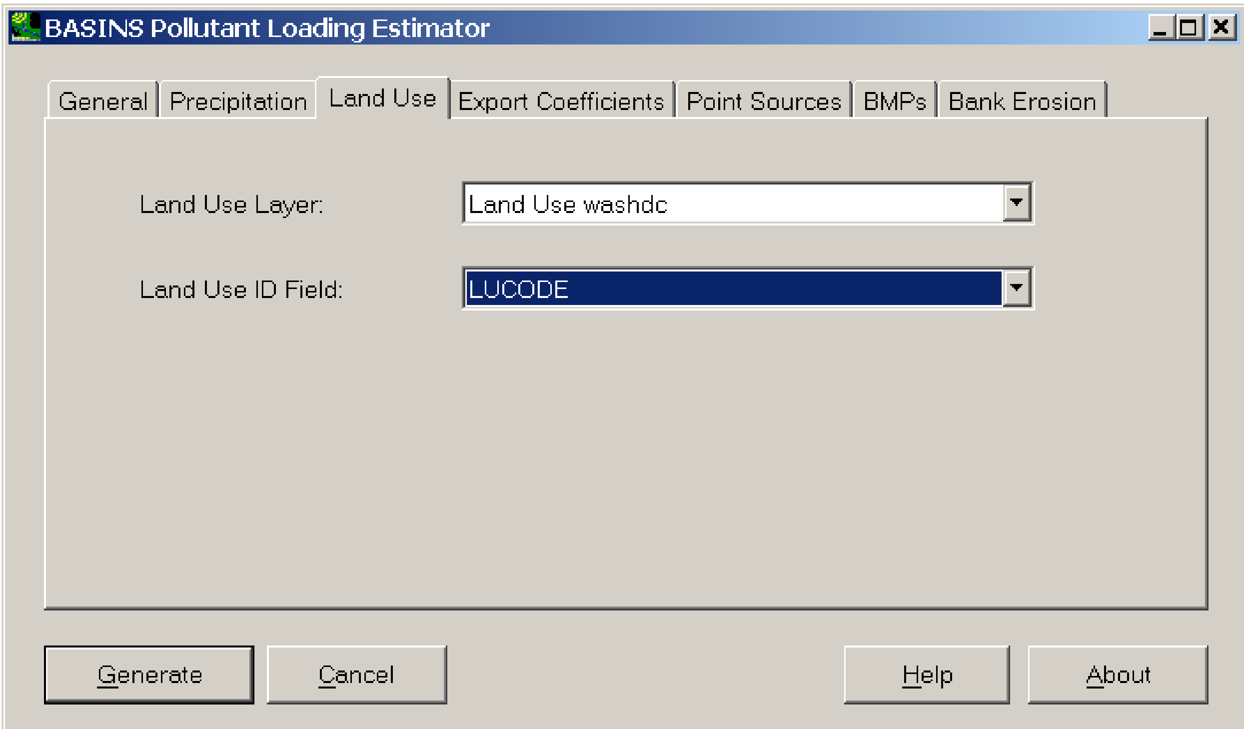
If the user wishes to enter a different value for each subbasin, the user enters the ratio of storms producing runoff as a single value, but then enters the annual precipitation for each subbasin in the grid. The **Subbasin ID Field** is used to specify which field of the subbasins layer is the unique identifier, to be used in the grid below (the name of the field may be different from the 'ID' shown here, depending upon the source of the subbasins layer). The **Change** button may be used to load a DBF file containing the annual precipitation for each subbasin, and the **Save** button is used to save the grid of annual precipitation values to a DBF file.



The file '\BASINS\etc\pload\precload_example.dbf' is provided as an example of an annual precipitation file. The user may produce a file such as this either in this interface or in any spreadsheet application that supports DBF files. Land Use Tab The **Land Use** tab is used to specify the input land use layer needed for *PLOAD*. If using the **USGS GIRAS Land Use** option, this tab includes only a message indicating that there is nothing to specify. *PLOAD* knows to load the necessary GIRAS land use tiles from BASINS.

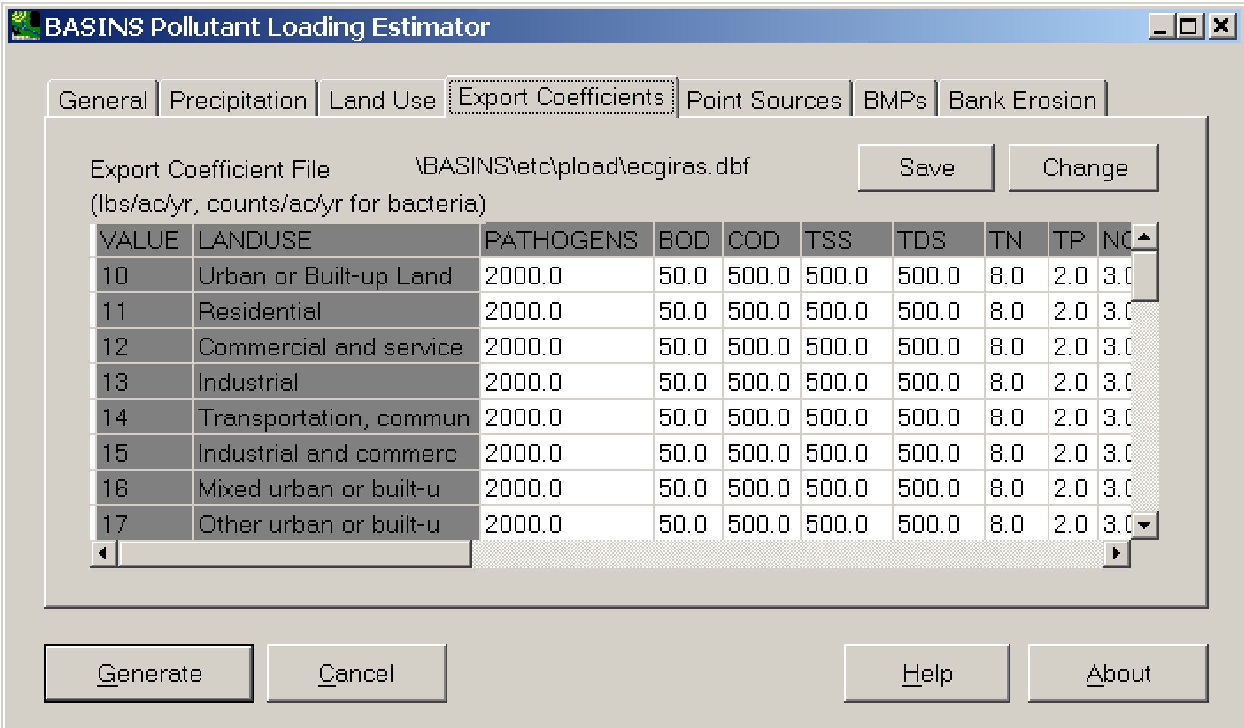


If the user chooses the **NLCD Grid**, **Other Grid**, or **Other Shapefile** option, the Land Use tab is used to specify which map layer to use containing the corresponding type of data. After the layer is specified the user must specify the field of that layer containing a unique land use identifier. The values of this identifier must correspond with the land use codes in the **Export Coefficient** or **Event Mean Concentration** tab.

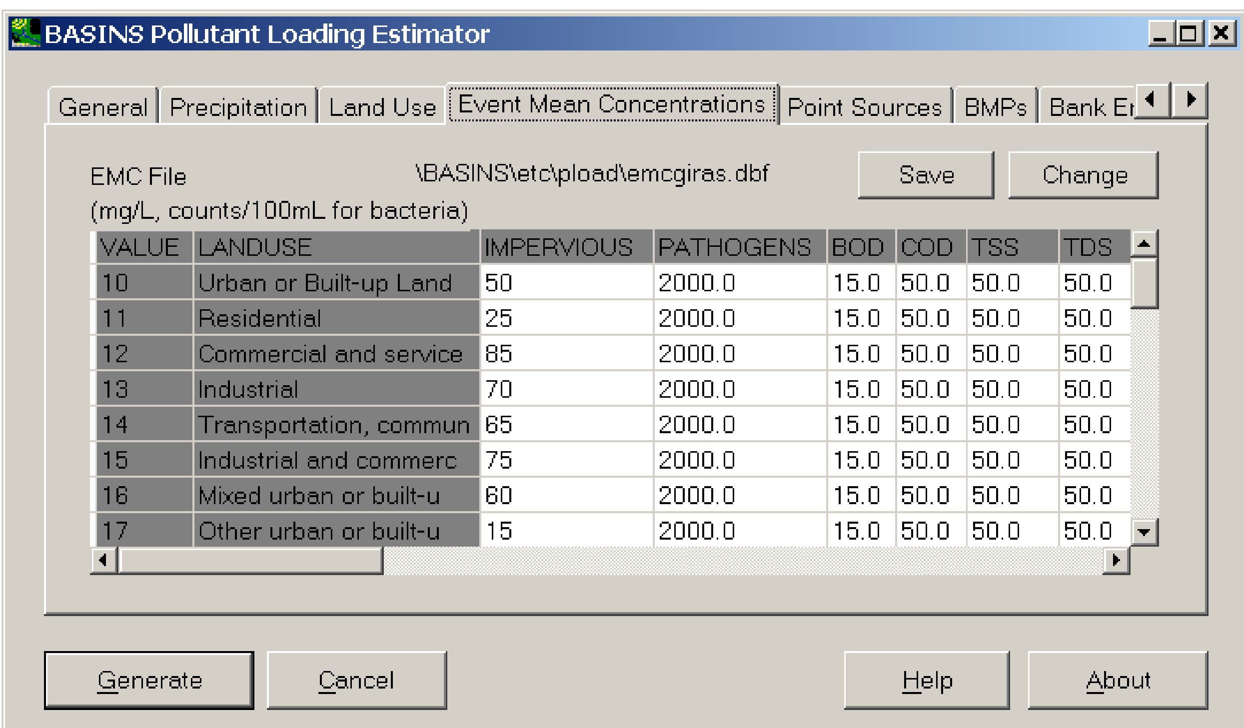


Export Coefficient or Event Mean Concentrations Tab The **Export Coefficient** or **Event Mean Concentrations** tab is used to specify the Export Coefficients for the Export Coefficient Method or the Event Mean Concentrations for the Simple Method. If using the Simple Method this tab is also used to enter the impervious percentage for each land use category.

Whichever option is used the tab contains a grid of values to be used in the *PLOAD* calculations for each land use category for each pollutant. The pollutants in the columns of this grid determine the set of pollutants that will be available in *PLOAD*. The user may import another DBF of values if desired using the **Change** button, and once modified the user can save the grid using the **Save** button.



If entering Event Mean Concentrations there is an additional column required, entitled **Impervious**. This column is used to enter the impervious percentage for each land use type.

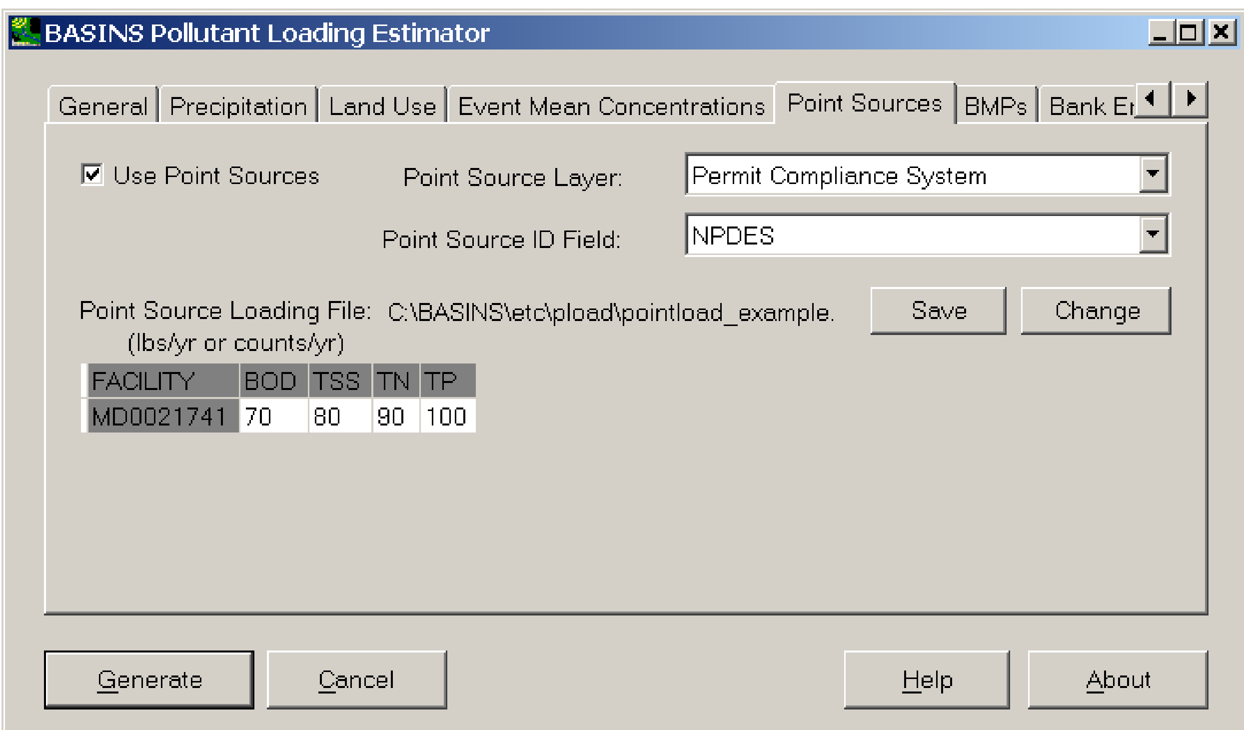


Starting tables of Export Coefficients and Event Mean Concentrations are provided in the \BASINS\etc\pload folder for GIRAS and NLCD land use categories.

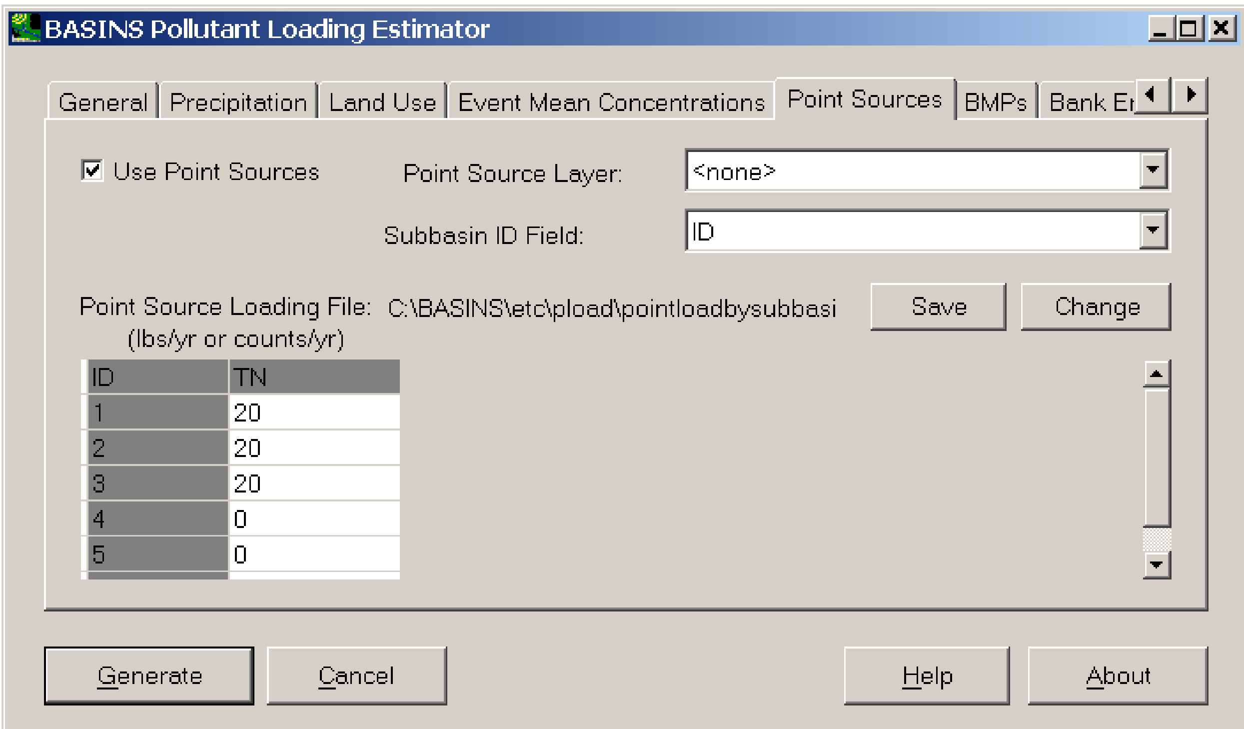
Note: The Export Coefficient and Event Mean Concentration tables provided with BASINS contain "representative" values as presented in the PLOAD v3 Users Manual distributed with BASINS 3.1 (available in the *BASINS/docs* folder in the file *PLOAD_v3.pdf*). These values represent a starting point and are based on data from a number of published sources, however they are specific to particular geographic regions. It is important that the user obtain appropriate values from studies in the corresponding geographic region.

Point Sources Tab The **Point Sources** Tab is used to specify the *PLOAD* linkage to point source loads. The tab includes a checkbox to specify whether point sources will be considered.

A point source layer may be identified, and if so this tab will require the user to specify a field within that layer's attribute table to indicate a unique identifier for each point source facility (such as NPDES number). With a point source layer identified, the user should reference an existing DBF file of point source loads using the **Change** button. This file will be loaded into the point source tab as a grid, with the facility identifiers in the first column followed by annual loads of each pollutant for each facility. The **Save** button may be used to save a modified point source loading file to disk.

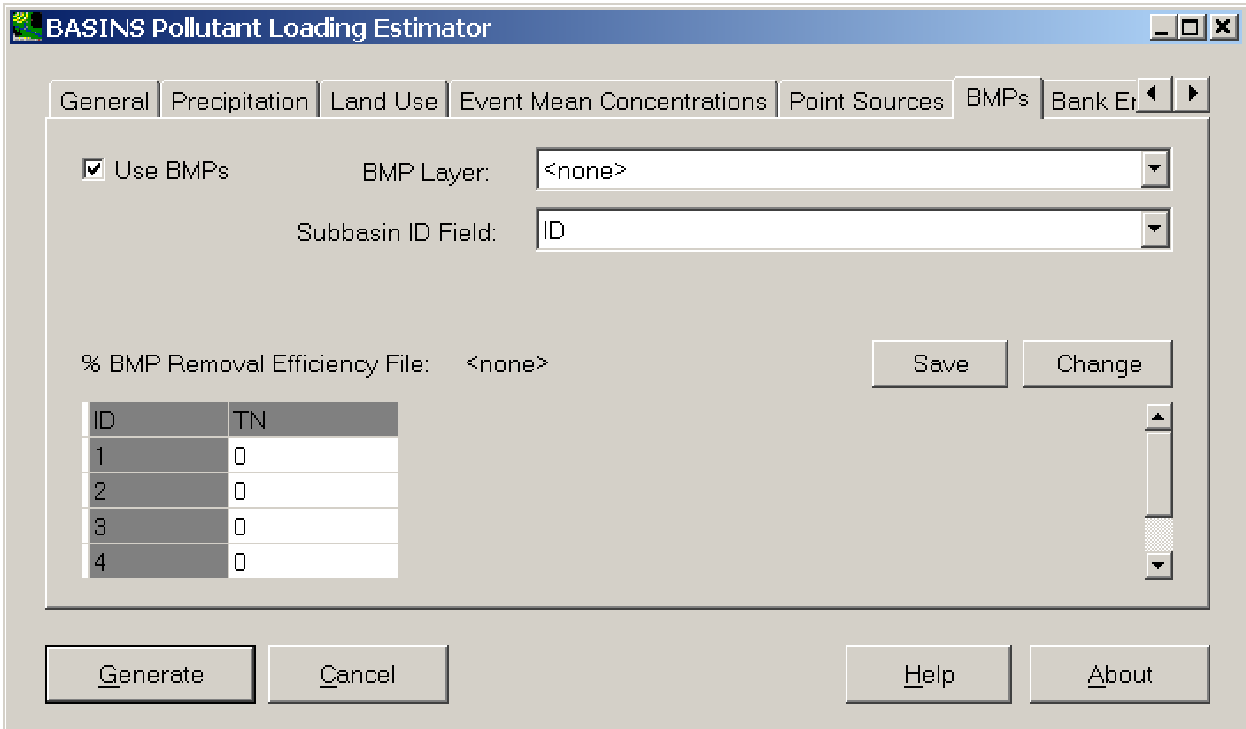


The user may alternatively choose to enter point source loads not from a map layer but as a simple table of loads for each pollutant and subbasin. If the Point Source Layer is set to 'none', the user must specify a unique subbasin identifier field (the name of the field may be different from that shown here, depending upon the source of the subbasins layer), and a grid will be displayed showing the point source load for each subbasin and pollutant. The **Change** button may be used to load an existing DBF file of point source loads by subbasin. The **Save** button may be used to save a modified point source loading file to disk.

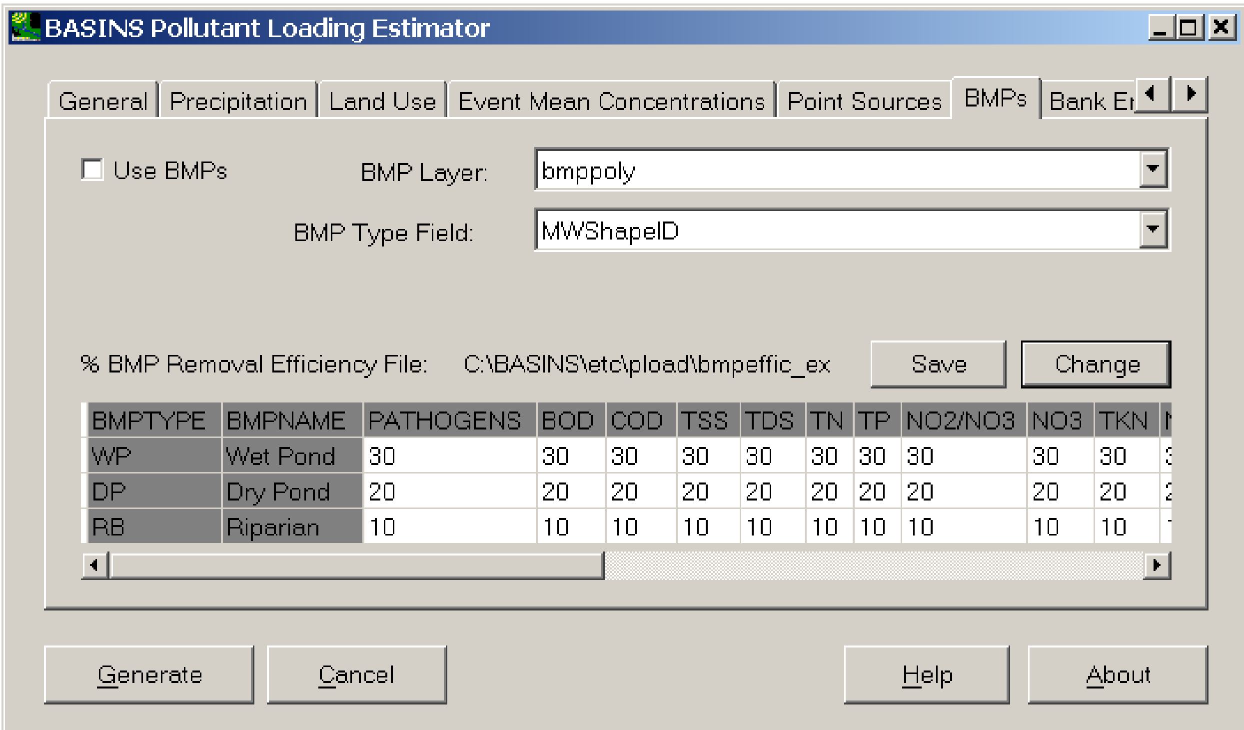


The file '\BASINS\etc\pload\pointload_example.dbf" is provided as an example of a point source loading file corresponding to a map layer. The file '\BASINS\etc\pload\pointloadbysubbasin_example.dbf" is provided as an example of a point source loading file by subbasin. The user may produce files such as these either in this interface or in any spreadsheet application that supports DBF files. BMPs Tab
The **BMPs** Tab is used to specify the pollutant removal percentages due to BMPs in *PLOAD*. The tab includes a checkbox to specify whether BMPs will be considered.

The user may choose to enter BMPs through a map layer or simply as a table of removal percentages for each pollutant and subbasin. If the BMP Layer is set to 'none', the user must specify a unique subbasin identifier field, and a grid will be displayed showing the BMP removal percentages for each subbasin and pollutant. The **Change** button may be used to load an existing DBF file of BMP removals by subbasin. The **Save** button may be used to save a modified BMP removal file to disk.

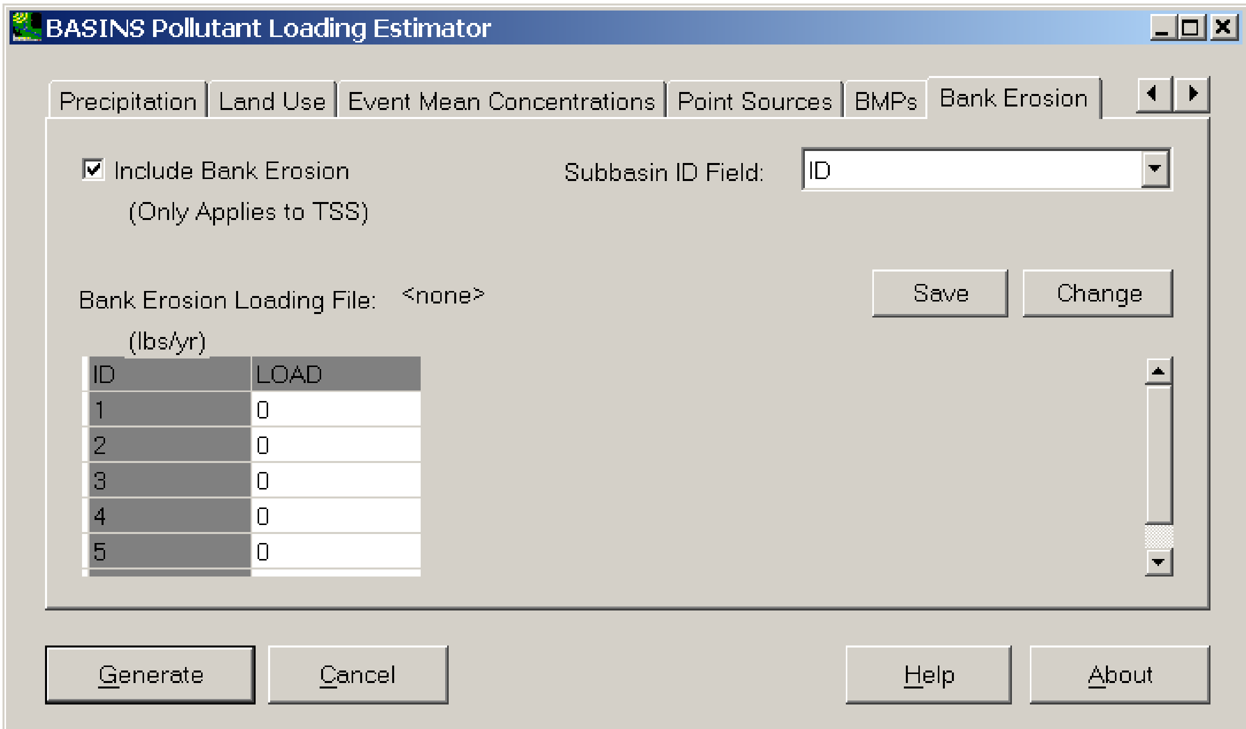


Alternately, a BMP map layer may be identified, and if so this tab will require the user to specify additional fields. The user must specify a field within that layer's attribute table to indicate a unique identifier for each type of BMP. If the BMP layer is a point layer, the user must also specify a field in that layer's attribute table indicating the area (in acres) to which that BMP applies. (If the BMP layer is a polygon layer the area will be calculated from the shapefile.) With a BMP layer identified, the user should reference an existing DBF file of BMP removal efficiencies using the **Change** button. This file will be loaded into the BMPs tab as a grid, with the BMP type identifiers in the first column, and a BMP name in the second column, followed by percent removal efficiencies for each pollutant for each BMP type. The **Save** button may be used to save a modified BMP efficiency file to disk. Note that no BMP map layer is provided with BASINS; it is up to the user to create this layer if desired.



The file '\BASINS\etc\pload\bmpeffic_example.dbf' is provided as an example of a BMP removal efficiency file. The user may produce a file such as this either in this interface or in any spreadsheet application that supports DBF files. Bank Erosion Tab The **Bank Erosion** Tab is used to specify loads from Bank Erosion contributing to TSS pollution. This tab includes a checkbox to specify whether bank erosion loads will be considered. The only pollutant to which the Bank Erosion feature applies is TSS.

Through this option the user may choose to enter loads from bank erosion as a simple table of loads for each subbasin. The user must specify a unique subbasin identifier field, and a grid will be displayed showing the load for each subbasin. The **Change** button may be used to load an existing DBF file of streambank loads by subbasin. The **Save** button may be used to save a modified streambank erosion loading file to disk.



The file '\BASINS\etc\pload\bankload_example.dbf' is provided as an example of a streambank erosion loading file. The user may produce a file such as these either in this interface or in any spreadsheet application that supports DBF files. Selected Literature References for Export Coefficients and Event Mean Concentrations

Novotny, V., and H. Olem, Water Quality: Prevention, Identification and Management of Diffuse Pollution, John Wiley Publishers, New York, NY, 1997.

CH2M HILL. Urban Stormwater Pollutant Event Mean Concentrations (EMCs) and Annual Runoff Coefficients for Calculation of Annual Pollutant Loads - Task F1 - "Pollutant Loadings", DERM Stormwater Management Master Plan, Phase I (C-9 East Basin Study). Prepared for the Metropolitan Dade County Department of Environmental Resources Management, Miami, FL. December 1, 1993.

CH2M HILL, 2000. Technical Memorandum 1, Urban Stormwater Pollution Assessment, prepared for North Carolina Department of Environment and Natural Resources, Division of Water Quality, August, 2000.

Northeast Florida Water Management District, 1994. St. Marks and Wakulla Rivers Resource Assessment and Greenway Protection Plan, September 1994. Appendix 4.

Novotny, Vladimir and Harvey Olem, 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution, Van Nostrand Reinhold, New York, 1994.

Panuska, John C. and Richard A. Lillie, 1995. Phosphorus Loadings from Wisconsin Watersheds: Recommended Phosphorus Export Coefficients for Agricultural and Forested Watersheds. Research

Management Findings, Bureau of Research, Wisconsin Department of Natural Resources, Number 38, April 1995.

Polls, Irwin and Richard Lanyon, 1980. Pollutant Concentrations from Homogeneous Land Uses. Journal of the Environmental Engineering Division, February 1980.

Raird, Charles, Marshall Jennings, David Ockerman, and Tim Dybale, 1996. Characterization of Nonpoint Sources and Loadings to Corpus Christi Bay National Estuary Program Study Area, Corpus Christi Bay National Estuary Program/USGS/NRCS, CCBNEP-05, January 1996, Table IV.9. http://tarpon.tamucc.edu/Library/FinalReports/pdf/CCB05.pdf.pdf

Schueler, Thomas R., 1997 Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments, July 1997.

U.S. EPA, 1983. Results of the Nationwide Urban Runoff Program, Volume 1 - Final Report. U.S. Environmental Protection Agency, PB84-185552, December 1983.

Washington State Department of Ecology, 2000. Stormwater Management Manual for Western Washington: Volume I Minimum Technical Requirements. Publication No. 99-11, August, 2000.

SWMM

The EPA **Storm Water Management Model (SWMM)** is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each subcatchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

SWMM is widely used throughout the world for planning, analysis and design related to storm water runoff, combined sewers, sanitary sewers, and other drainage systems in urban areas, with many applications in non-urban areas as well. In addition to modeling the generation and transport of runoff flows, SWMM can also estimate the production of pollutant loads associated with this runoff.

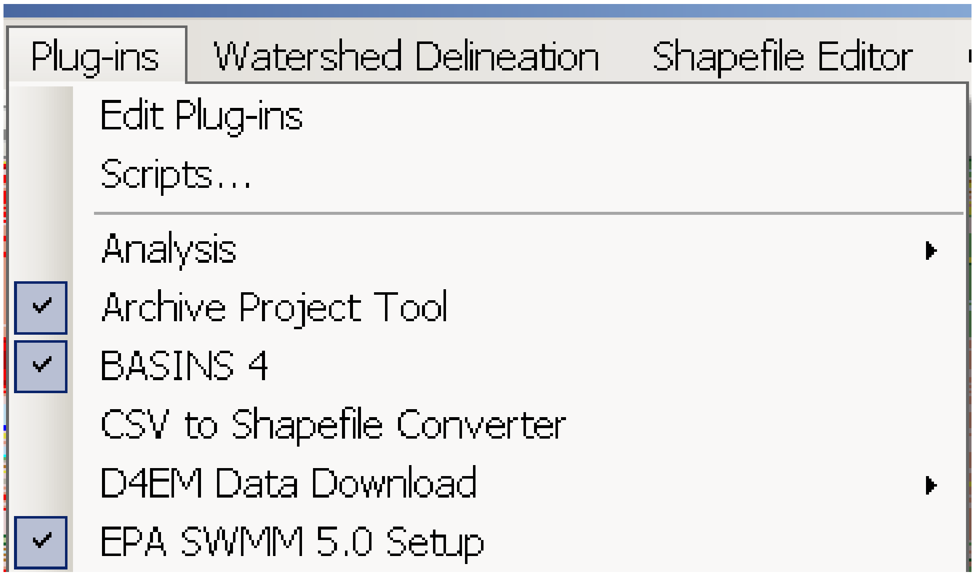
BASINS allows the user to build a new project and open SWMM directly from the BASINS user interface. The following sections provide more details on using *SWMM* through BASINS:

- Data Requirements for Setting up SWMM through BASINS
- Preparing GIS Data for use in the BASINS/SWMM Plug-in
- Creating a New SWMM Project
- Opening an Existing SWMM Project

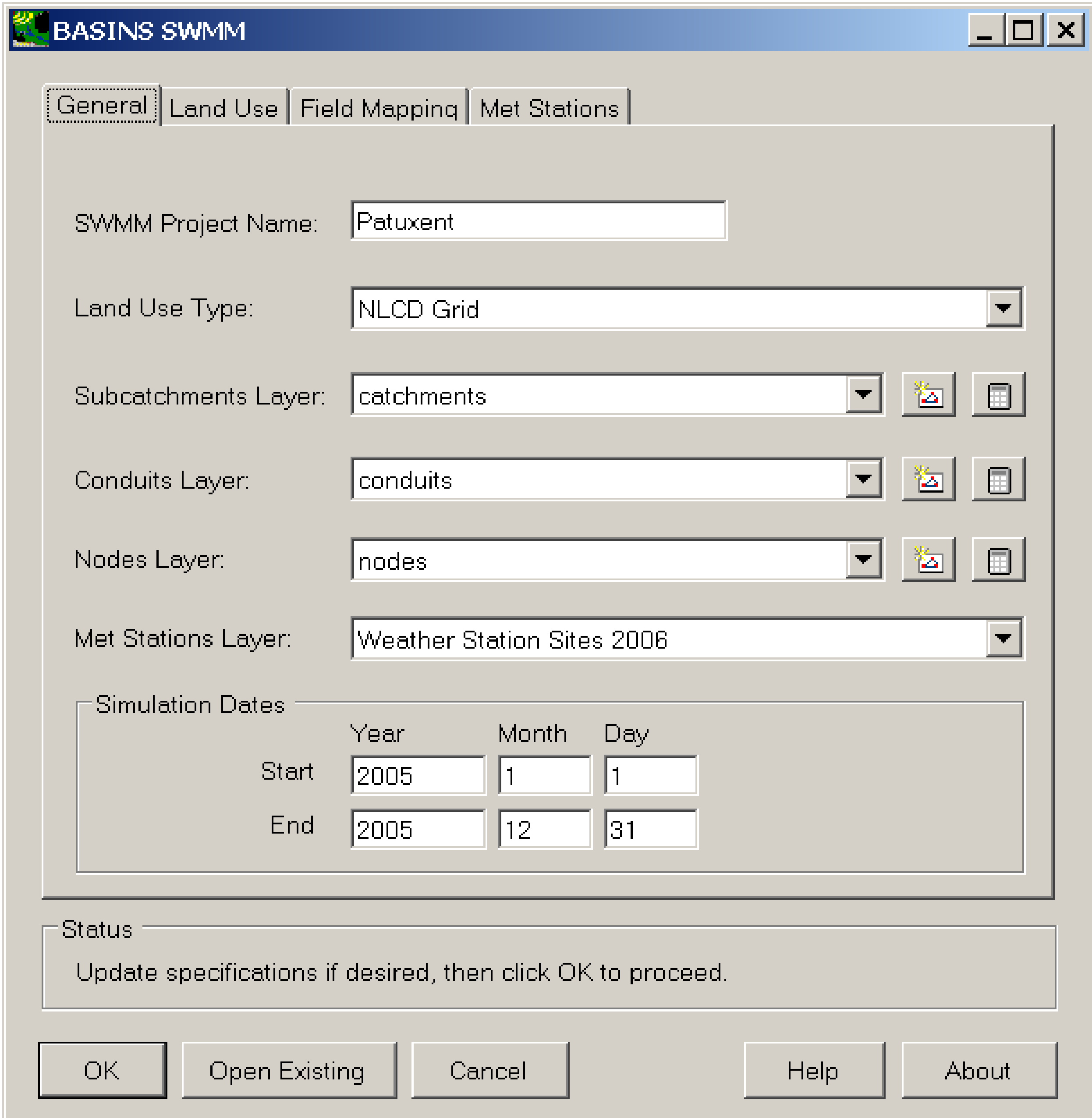
Note: SWMM 5.0 is not included with this package. It may be downloaded from http://www.epa.gov/ednnrmrl/models/swmm/

Key Procedures

1. Select **EPA SWMM 5.0 Setup** from the **Plug-ins** menu so that it is active. This will add **SWMM** to the Models menu on the main form.

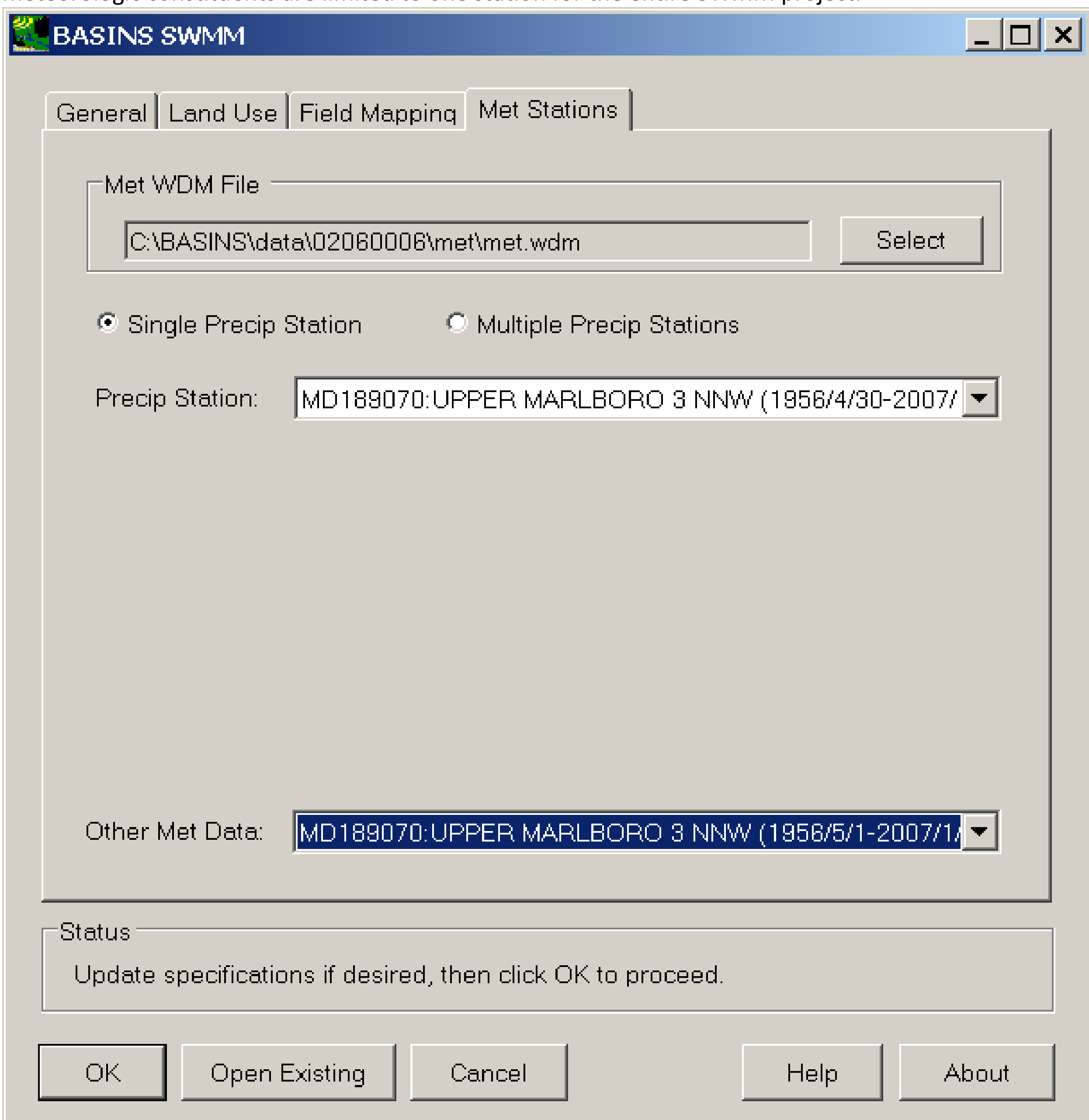


2. Select **Models:SWMM** from the main menu, and the *BASINS SWMM* form appears. The interface loads with the **General** tab active. This tab includes fields for the user to specify the SWMM project name (which defaults to the name of the BASINS project), the land use type (NLCD Grid and USGS GIRAS shapefile are 2 types available in BASINS depending upon the data downloaded for the project, or a user may choose to specify another grid or shapefile), map layers for subcatchments, conduits, and nodes (nodes layer is optional), the BASINS met stations layer (usually called Weather Station Sites 2009 in BASINS), and start and end dates for the simulation. The Met Stations Layer field will default to the Weather Station Sites if they have been downloaded for this project.



As the BASINS/SWMM PlugIn loads, the meteorological data is scanned to build the lists of available met data. This process may take a minute or two, depending upon how much met data is included in the BASINS project. The start and end dates for the simulation default to the most recent calendar year of data for the selected met stations (specified on the Met Stations tab). The simulation dates can be changed to any period within the span of the selected met stations, but be aware that using many years of hourly met data will result in a very large SWMM project file.

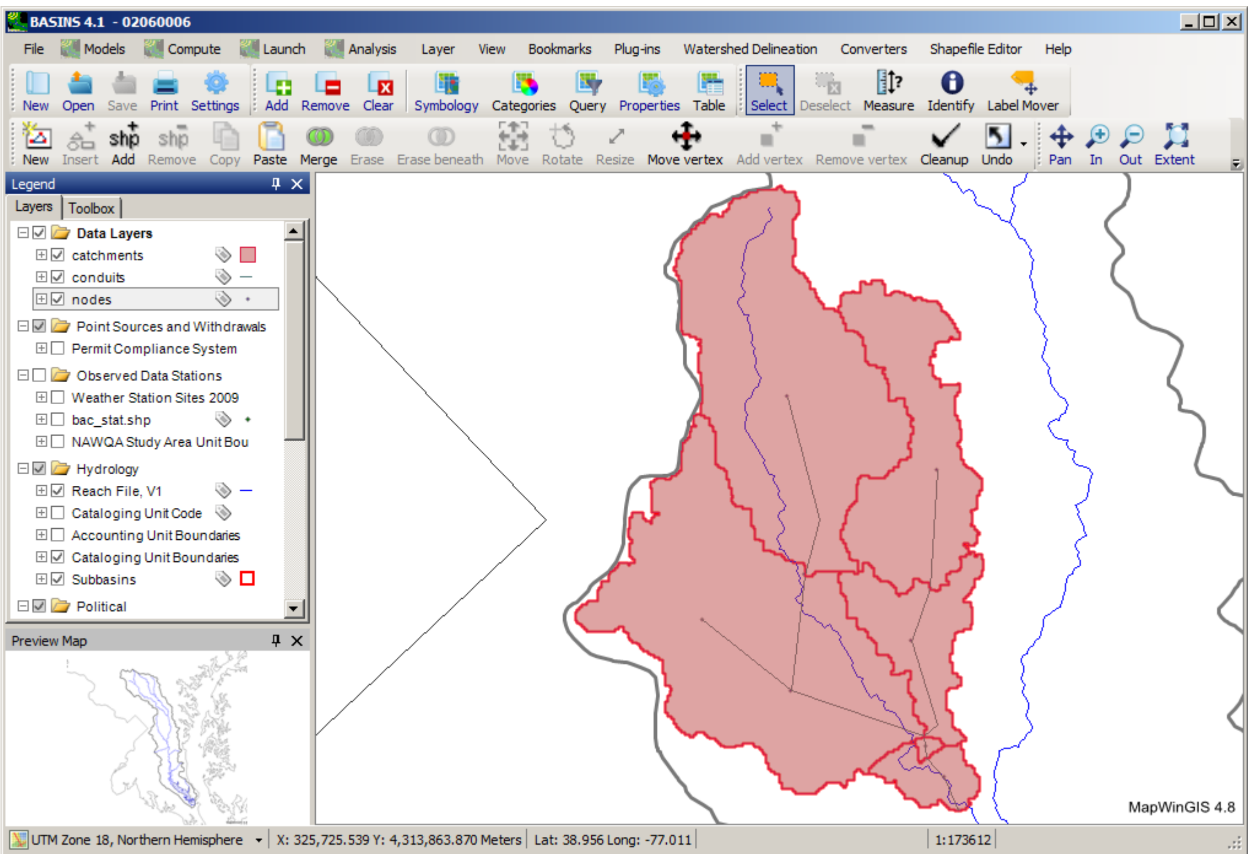
3. Click the Met Stations tab to specify the meteorologic data to use in the new SWMM project. A Met WDM File will already be specified if one has already been downloaded and the Met Stations Layer field has been set appropriately; if not the user must browse to the intended WDM file. The BASINS/SWMM interface allows a user to specify a single precipitation station for the entire SWMM study area, or a precipitation station for each SWMM catchment. The other meteorologic constituents are limited to one station for the entire SWMM project.



4. Once all of the specifications are set as desired, click OK to create the SWMM project. After processing, the SWMM 5.0 interface will open with the newly created project.

Data Requirements for Setting up SWMM through BASINS The BASINS/SWMM Setup Plug-in allows a user to set up a SWMM project using the GIS and meteorologic timeseries data available within BASINS. This plug-in is normally used in conjunction with existing shapefiles of subcatchments, conduits, and nodes, as might be available for an existing storm or sanitary sewer system.

When using BASINS/SWMM to build an initial *SWMM* Project File, the subcatchments, conduits, and nodes layers must exist on the map. If no nodes layer is provided, the plug-in will attempt to build SWMM nodes at either end of each conduit segment. The 'subbasins' and 'streams' outputs from the BASINS watershed delineation tools may be used as the subcatchments and conduits layers if desired, or these layers may be built using the BASINS shapefile editing tools (see Preparing GIS Data for use in the BASINS/SWMM Plug-in for more details). Since the 'streams' layer from a BASINS delineation contains connectivity information, do not specify a 'nodes' layer when using 'subbasins' and 'streams' outputs from the BASINS watershed delineation tools.



Besides the Subcatchments, Conduits, and Nodes layers, there are two other GIS layers that may be used in building the SWMM project file. A land use layer may be specified, and this layer will be used in computing the area of each land use within each subcatchment. A met data layer may also be specified, from which the user may select particular stations to use to supply timeseries of precipitation, air temperature, and evaporation. Land use and meteorological data layers may be downloaded using the BASINS Download Data tool.

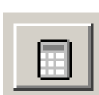
BASINS/SWMM is designed to be flexible in its handling of GIS layers. While typically a BASINS user will use the USGS GIRAS or NLCD land use layers, BASINS SWMM supports use of other vector or raster land use layers. The Land Use Index layer from BASINS is also required when using the USGS GIRAS land use data. While the BASINS met data is typically used to provide input meteorological data, other WDM files of meteorological data may be used.

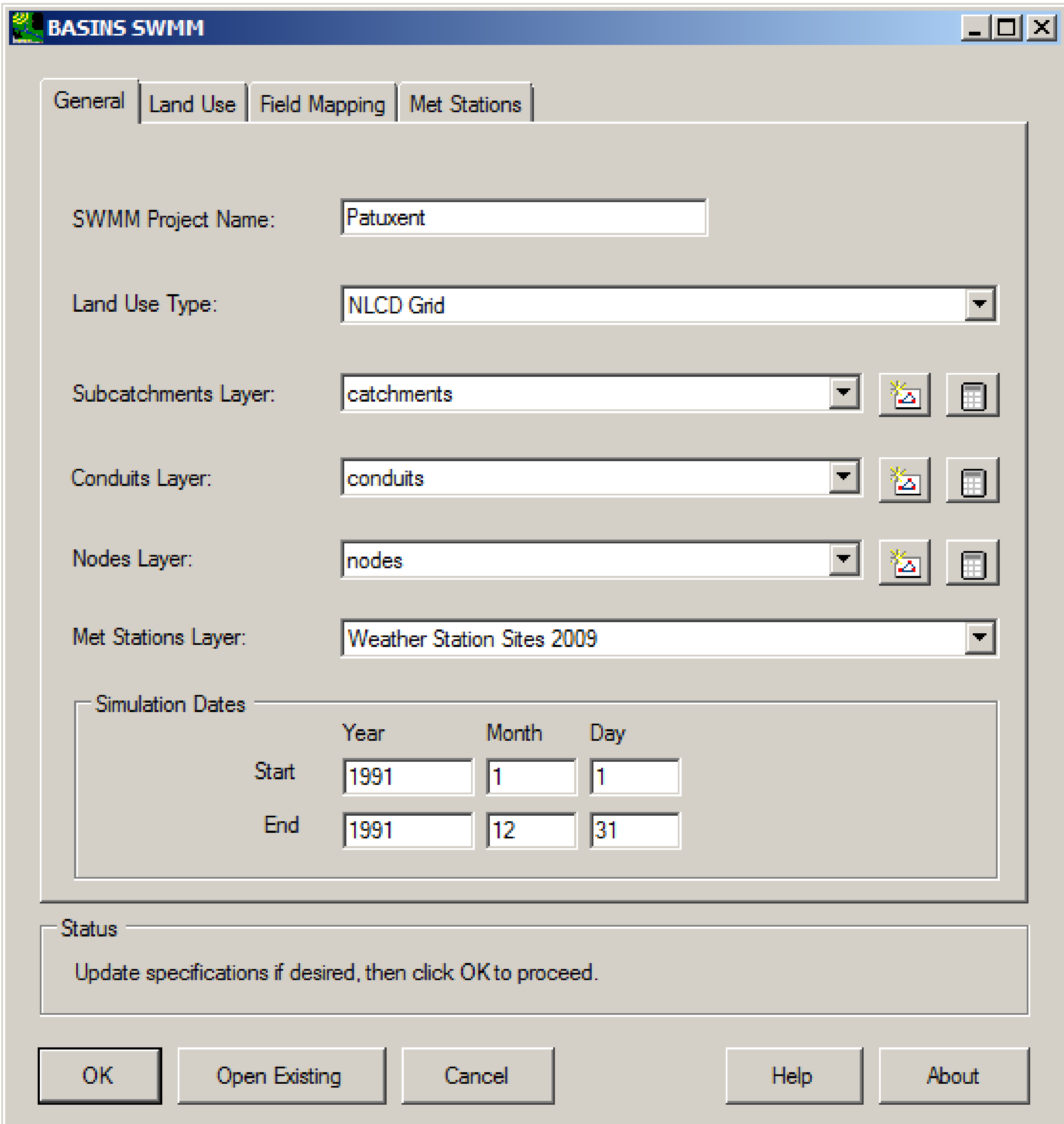
The BASINS/SWMM plug-in may also be used to enter *SWMM* with an existing *SWMM* project. In this case no other GIS or timeseries data are required.   Preparing GIS Data for use in the BASINS/SWMM Plug-in The BASINS/SWMM plug-in is normally used in conjunction with existing shapefiles of subcatchments, conduits, and nodes, as might be available for an existing storm or sanitary sewer system. If available these layers should be used in building the new SWMM project. See the Field Mapping Tab section for details about mapping the fields of existing shapefiles to the necessary variables of the SWMM data structure.

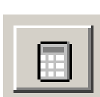
The GIS layers of subcatchments, conduits, and nodes may also be created using the BASINS watershed delineation and/or shapefile editing tools. The following pages provide an overview of how the BASINS delineation and shapefile editing tools can be used to create the shapefiles of subcatchments, conduits, and nodes, expected by the BASINS/SWMM plug-in.

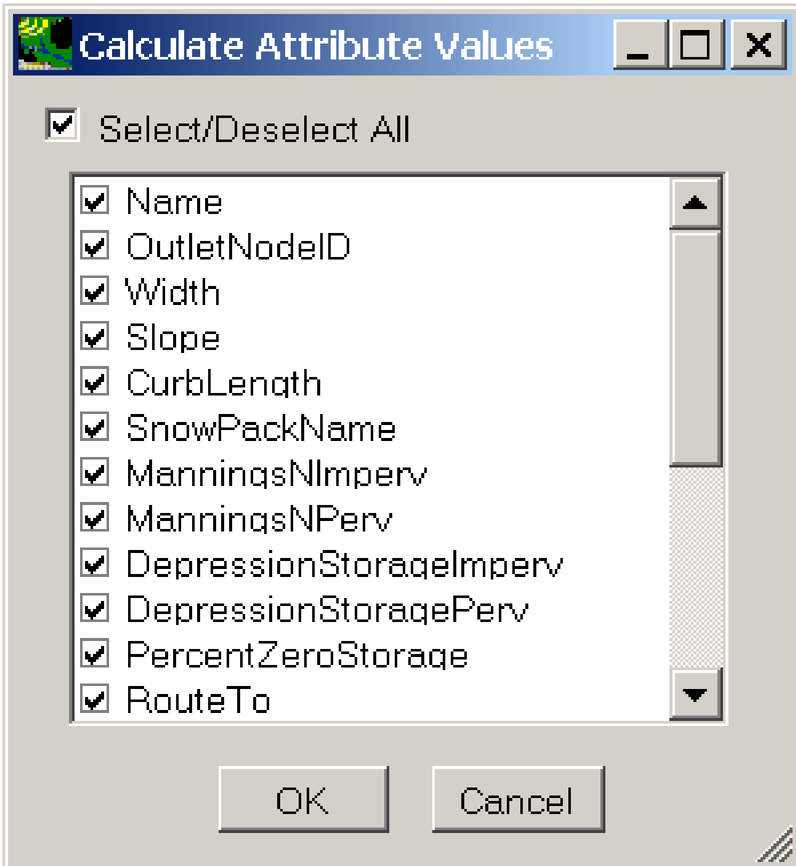
- Using the Automatic Watershed Delineation Tools
- Using the Manual Watershed Delineation Tools
- Using the BASINS Shapefile Editor Tools

Once the subcatchments, conduits, and nodes features have been created using one of the above methods, shapefile attributes may be added to these GIS layers. This section provides details of how those attributes may be added, along with additional details of how those attributes are populated and their default values.

The  buttons within the BASINS/SWMM interface are designed to help with adding the desired shapefile attributes.

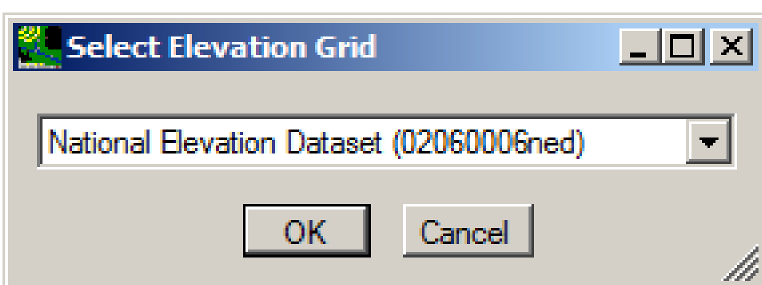


The  icon appears next to each type of layer in the BASINS/SWMM user interface, corresponding to subcatchments, conduits or nodes. When the icon is clicked, a window will appear showing the fields that may be populated automatically for the corresponding layer.

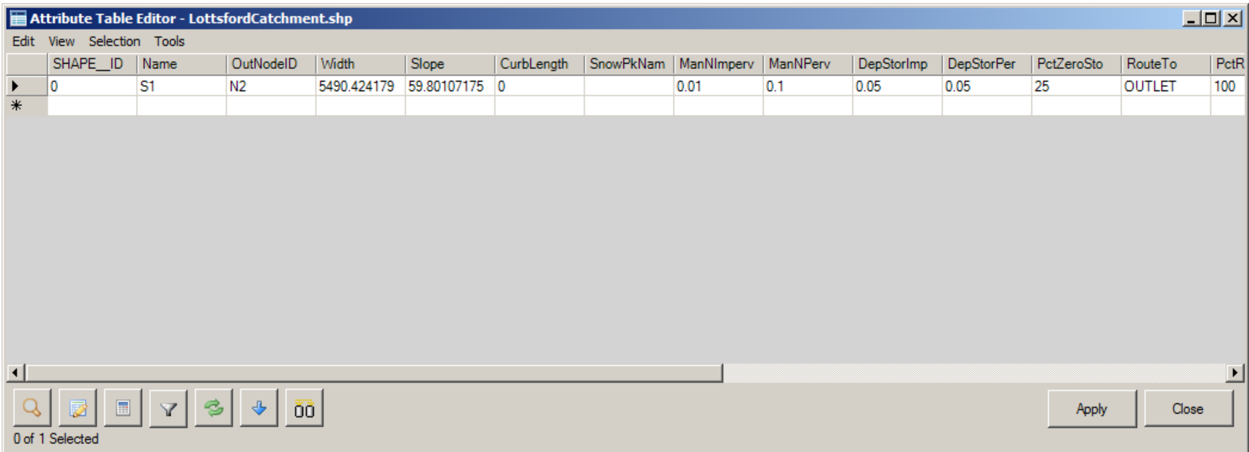


The user may choose any or all of the possible attribute values that may be added for each feature. Clicking 'OK' on this form will populate the selected values for each feature, in many cases using the default value. If a value for an attribute already exists on the shapefile, it will be recalculated if that field is checked. If the field does not exist, it will be added.

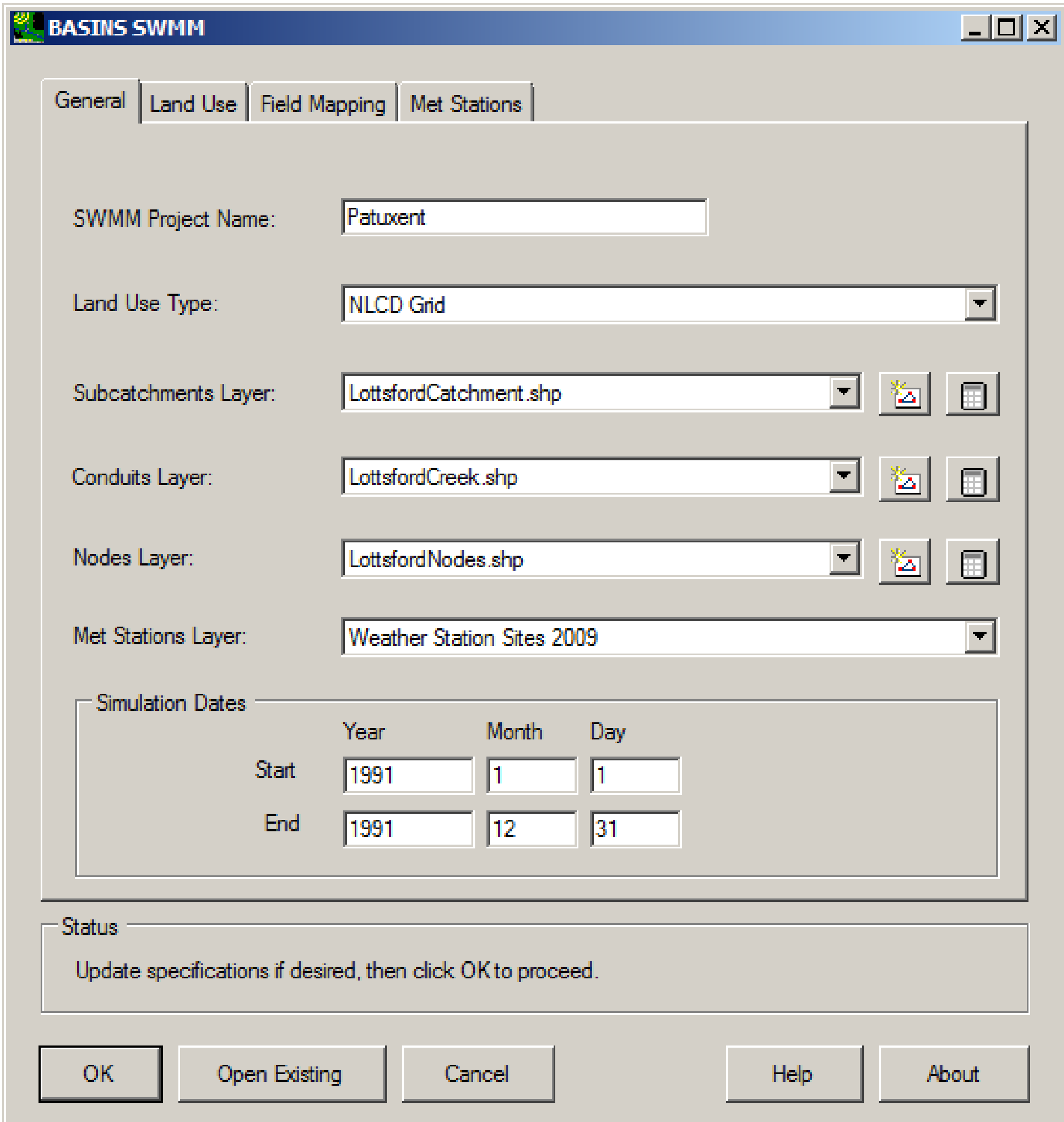
The average slope of a subcatchment is one special case. If this attribute is selected to populate, the interface will prompt for an elevation layer to use in the calculation.



After calculating the attributes, the user may use the Table Editor icon  to view the attributes that have been added.



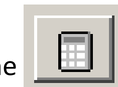
Once the desired attributes have been populated for the Subcatchments, Conduits, and Nodes layers, the user may proceed with the BASINS/SWMM plug-in using these layers.



A complete example of using the BASINS tools to create the GIS layers for SWMM Subcatchments, Conduits, and Nodes is provided in the tutorial section entitled Tutorial: Preparing GIS Data for use in the BASINS/SWMM Plug-in.

Attributes and Default Values

The following tables list the attributes of the subcatchment, conduit, and node shapefiles that may be added using the features described above. For each attribute the table includes a default value, a type (character string, integer, or real number), and a field length. The Long Field Name is the name used in the BASINS/SWMM plug-in data structure, and will correspond with the shapefile attribute name unless the name is longer than 10 characters, in which case the corresponding name will be the Short Field Name on the attribute table.

The default values in these tables are used whenever attributes are populated using the  icon. These default values are also used whenever a SWMM project is built from a shapefile where any of these fields are not present. While the values in these tables are provided within the BASINS/SWMM plug-in, the values may be overridden by values in a comma-delimited text file named ‘SWMMFields.txt’ located in the BASINS\etc folder.

Subcatchment Attributes

Long Field Name	Short Field Name	Default Value	Type	Length
Name	*none*	*‘S’ plus the feature index*	String	10
OutletNodeID	OutNodeID	*nearest node to the subcatchment centroid*	String	10
Width	*none*	*square root of the subcatchment area*	Real	10
Slope	*none*	*computed from elevation grid*	Real	10
CurbLength	*none*	0.0	Real	10
SnowPackName	SnowPkName	*blank*	String	10
ManningsNImperv	ManNImperv	0.01	Real	10
ManningsNPerv	ManNPerv	0.1	Real	10
DepressionStorageImperv	DepStorImp	0.05	Real	10
DepressionStoragePerv	DepStorPer	0.05	Real	10
PercentZeroStorage	PctZeroSto	25.0	Real	10
RouteTo	*none*	OUTLET	String	10
PercentRouted	PctRouted	100.0	Real	10
MaxInfiltRate	MaxInfiltR	3.0	Real	10
MinInfiltRate	MinInfiltR	0.5	Real	10
DecayRateConstant	DecayRate	4	Real	10

DryTime	*none*	7	Real	10
MaxInfiltVolume	MaxInfiltV	0	Real	10
Suction	*none*	3.0	Real	10
Conductivity	Conductiv	0.5	Real	10
InitialDeficit	InitDefcit	4.0	Real	10
CurveNumber	CurveNum	3.0	Real	10

Conduit Attributes

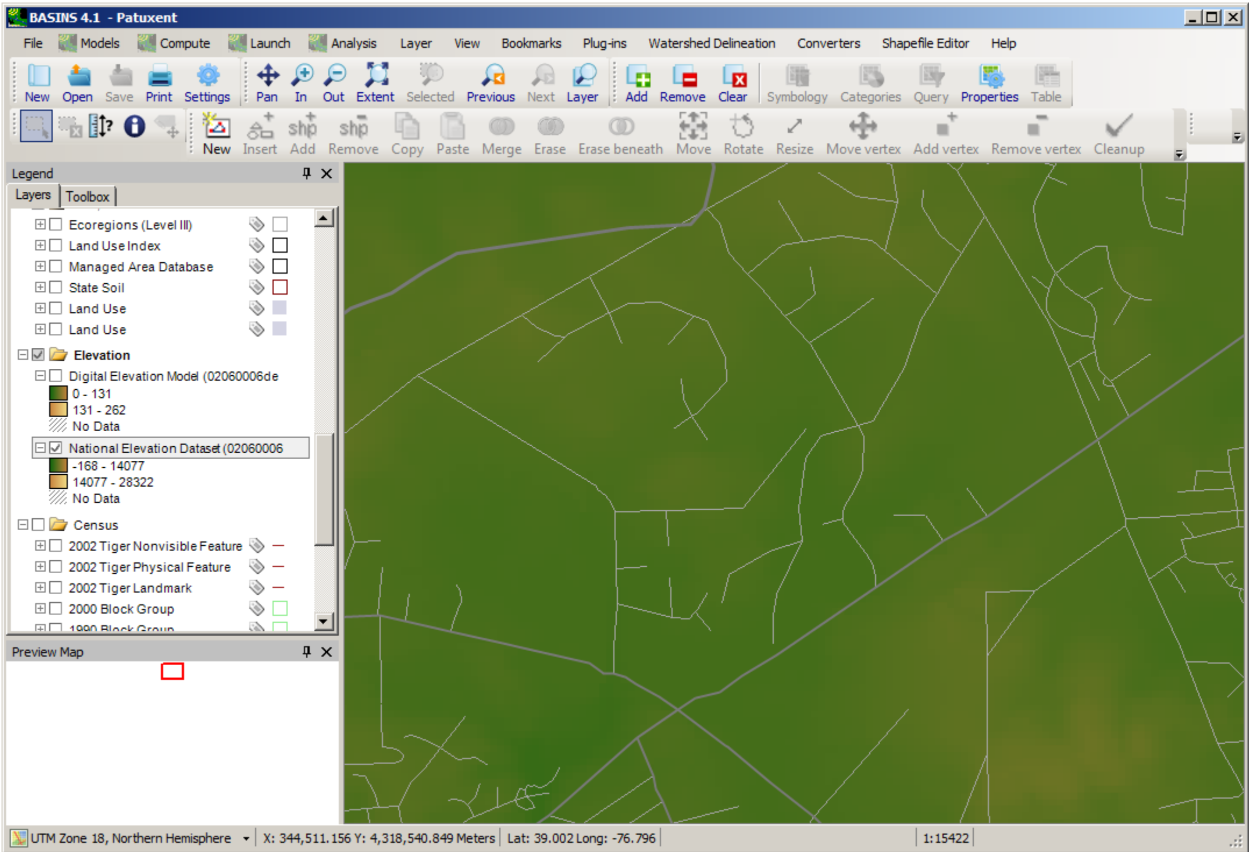
Long Field Name	Short Field Name	Default Value	Type	Length
Name	*none*	*'C' plus the feature index*	String	10
InletNodeName	InletNode	*nearest node*	String	10
OutletNodeName	OutletNode	*nearest node*	String	10
ManningsN	*none*	0.05	Real	10
InletOffset	InOffset	0.0	Real	10
OutletOffset	OutOffset	0.0	Real	10
InitialFlow	InitFlow	0.0	Real	10
MaxFlow	*none*	0.0	Real	10
Shape	*none*	TRAPEZOIDAL	String	12
Geometry1	*none*	10.0	Real	10
Geometry2	*none*	10.0	Real	10
Geometry3	*none*	1	Real	10
Geometry4	*none*	1	Real	10
NumBarrels	*none*	1	Integer	10

Node Attributes

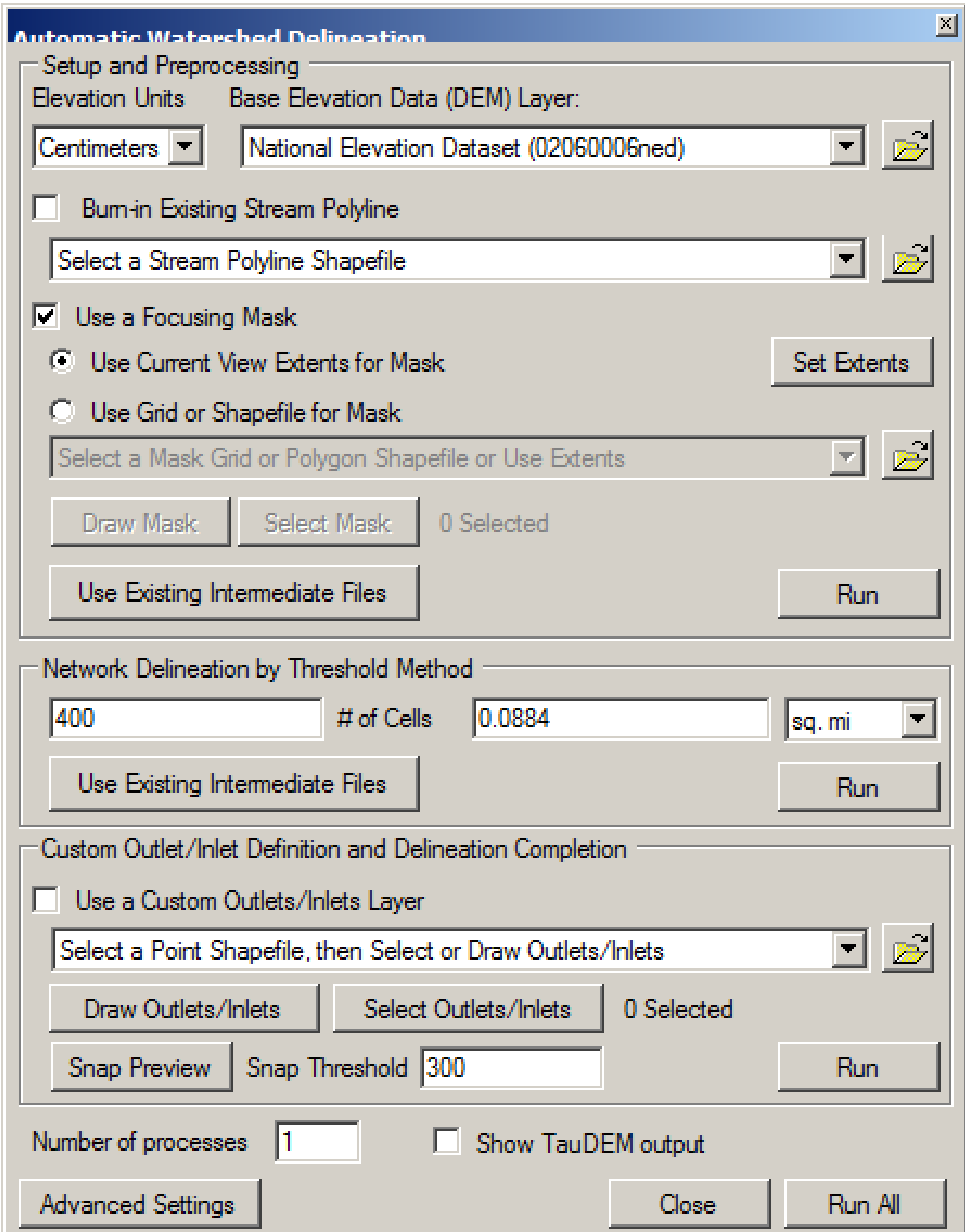
Long Field Name	Short Field Name	Default Value	Type	Length
Name	*none*	*'N' plus the feature index*	String	10
Type	*none*	JUNCTION	String	10
InvertElevation	InvertElev	0.0	Real	10
MaxDepth	*none*	0.0	Real	10
InitDepth	*none*	0.0	Real	10
SurchargeDepth	SurchargeD	0.0	Real	10
PondedArea	*none*	0.0	Real	10
OutfallType	OutfallTyp	FREE	String	10
StageTable	*none*	*blank*	String	10
TideGate	*none*	NO	String	10

Note: The units of the values in the table above are the units required in SWMM.
Using the BASINS Automatic Watershed Delineation Tools to Set Up BASINS/SWMM

The BASINS *Automatic Watershed Delineation* tools may be used to create subcatchment and conduit shapefiles for use in SWMM modeling. The delineation process requires a Digital Elevation Model (DEM) in grid format. Two forms of DEM grids are available through the BASINS Download Data menu. The BASINS DEM Grid (DEMG) has a 100 m resolution while the National Elevation Dataset (NED) has a 30 m resolution. The following image shows a BASINS project with an NED grid loaded, zoomed in to the approximate area to be modeled in the SWMM project.

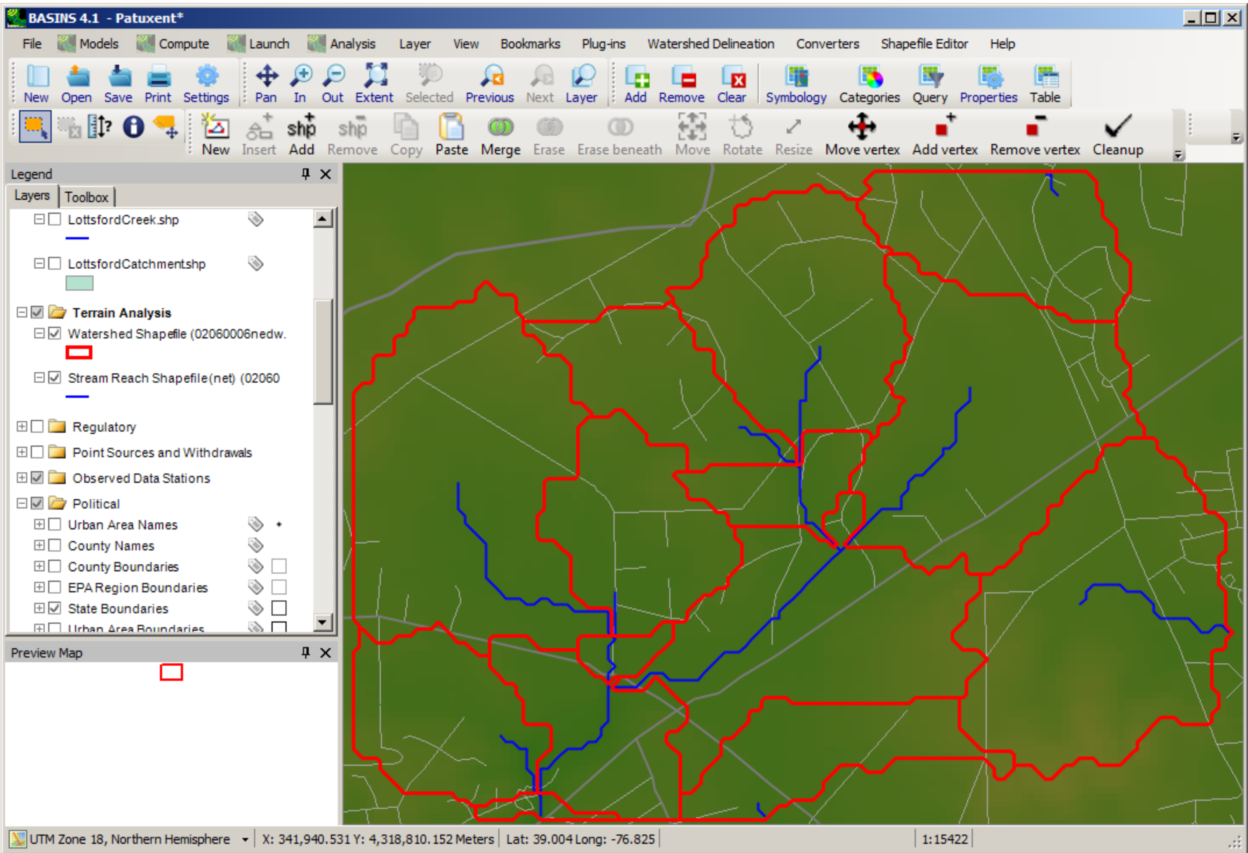


The Automatic Watershed Delineator may be added to a project by selecting the **Plug-ins:Watershed Delineation** menu item, which will make the automatic delineation tool available under the **Watershed Delineation:Automatic** menu item. Selecting the **Watershed Delineation:Automatic** menu item opens the **Automatic Watershed Delineation** form.

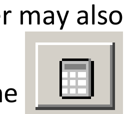

Automatic Watershed Delineation
Setup and Preprocessing
Elevation Units
Base Elevation Data (DEM) Layer:
Centimeters
National Elevation Dataset (02060006ned)
Burn-in Existing Stream Polyline
Select a Stream Polyline Shapefile
Use a Focusing Mask
Use Current View Extents for Mask
Set Extents
Use Grid or Shapefile for Mask
Select a Mask Grid or Polygon Shapefile or Use Extents
Draw Mask
Select Mask
0 Selected
Use Existing Intermediate Files
Run
Network Delineation by Threshold Method
400
# of Cells
0.0884
sq. mi
Use Existing Intermediate Files
Run
Custom Outlet/Inlet Definition and Delineation Completion
Use a Custom Outlets/Inlets Layer
Select a Point Shapefile, then Select or Draw Outlets/Inlets
Draw Outlets/Inlets
Select Outlets/Inlets
0 Selected
Snap Preview
Snap Threshold
300
Run
Number of processes
1
Show TauDEM output
Advanced Settings
Close
Run All

Within the Automatic Delineator form the user must select the DEM grid to provide topographic data for the delineation process. The **Use a Focusing Mask** box is used to delineate subbasins in only a portion of the specified input DEM grid, such as within the current view extents.

The Automatic Watershed Delineator provides a user input capability representing the minimum number of cells to be used as the threshold for delineation. The stream network and subwatersheds will be computed based upon the input threshold level.



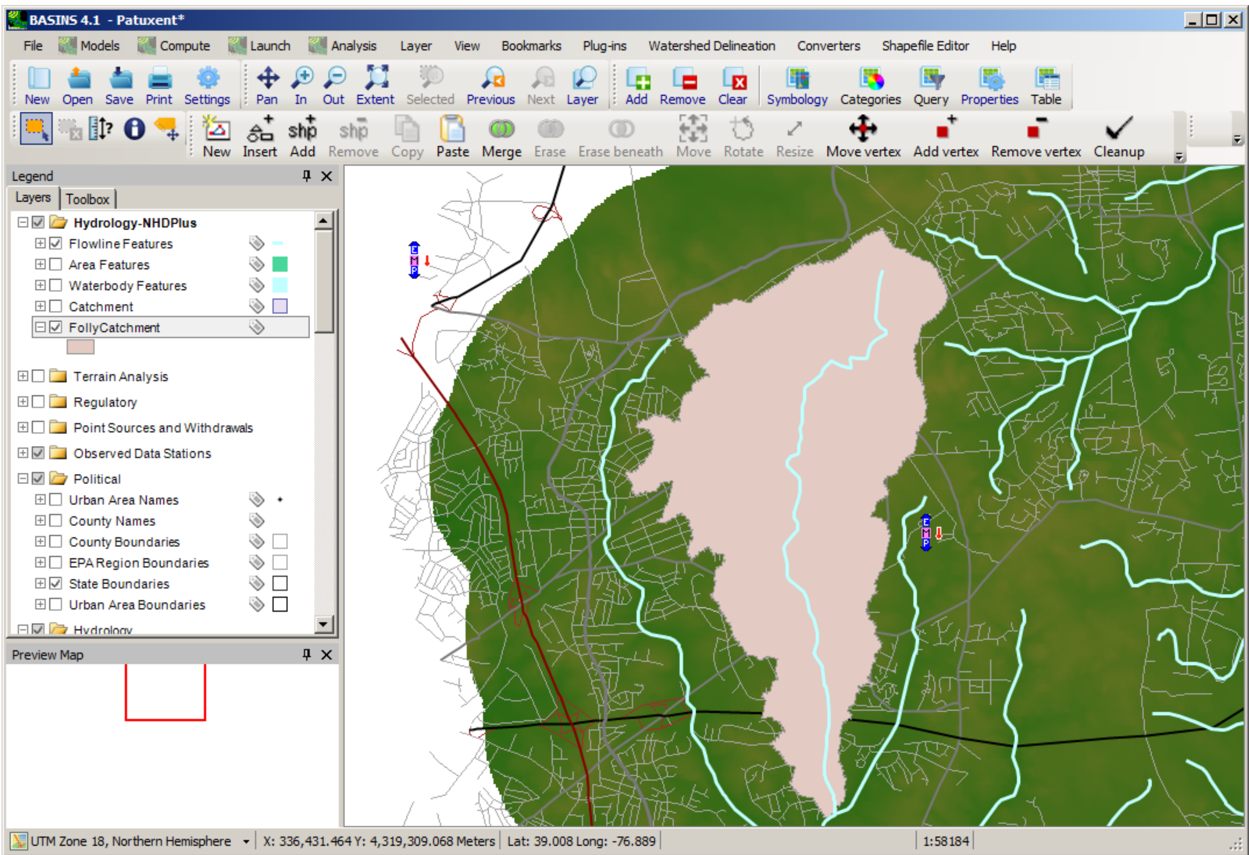
The *Watershed* and *Stream Reach* Shapefiles that are added to the map may be used as the Subcatchment and Conduit layers in the BASINS/SWMM plug-in. Complete instructions for using the BASINS Automatic Watershed Delineator can be found in the Automatic Watershed Delineation section.

When the user adds the *Watershed* and *Stream Reach* shapefiles to the map for use as the Subcatchment and Conduit layers in the BASINS/SWMM plug-in, the user may also wish to add some attributes to these shapefiles. Attributes may be added by clicking on the  buttons within the BASINS/SWMM interface. See the section entitled Preparing GIS Data for use in the BASINS/SWMM Plug-in for more details.

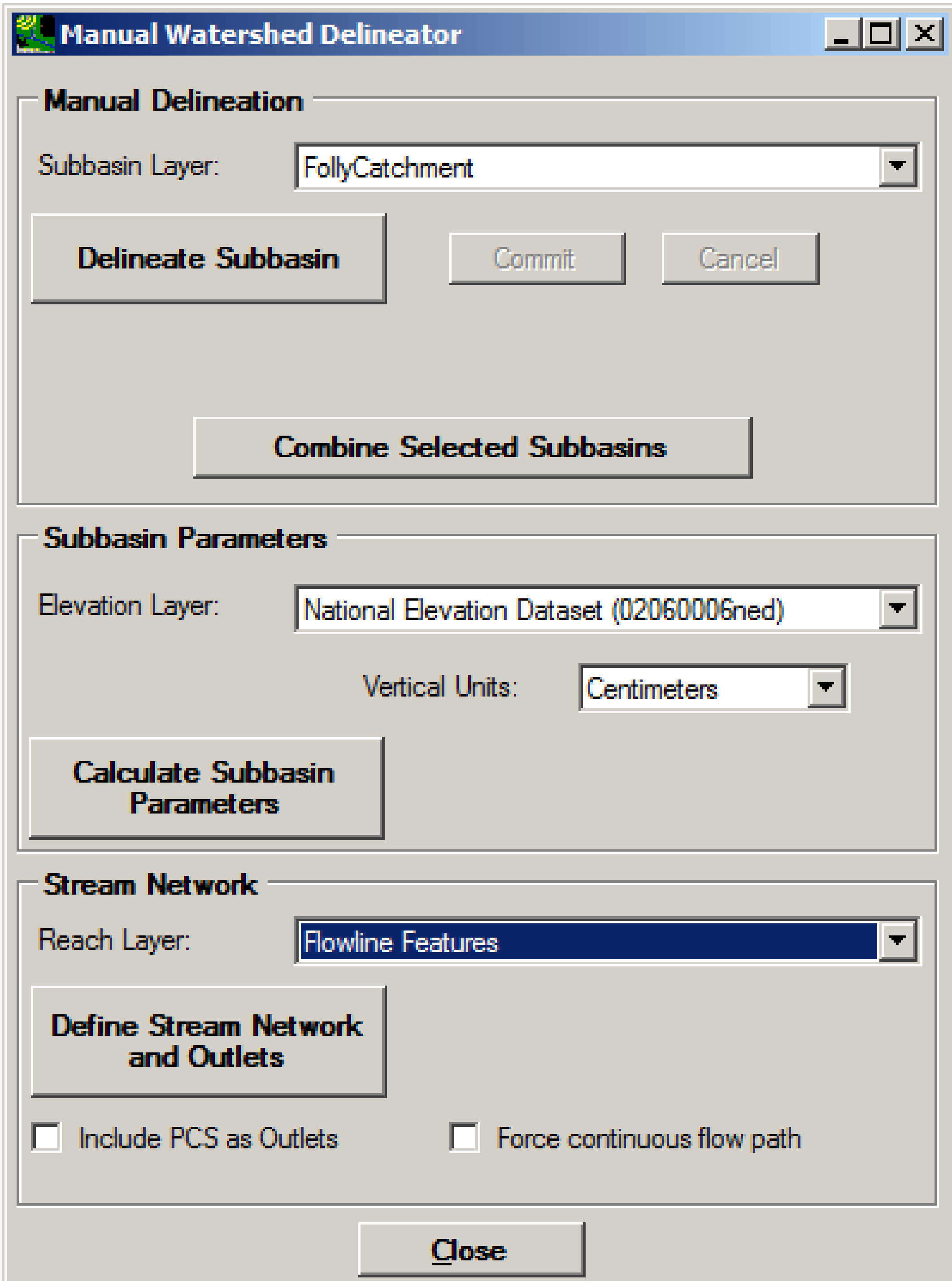
Using the BASINS Manual Watershed Delineation Tools to Set Up BASINS/SWMM

The BASINS 4 *Manual Watershed Delineation* tool may also be used to create subcatchment and conduit shapefiles for use in SWMM modeling. This tool allows the user to manually subdivide a watershed into several smaller hydrologically connected watersheds.

The BASINS Manual Watershed Delineator requires an existing polygon shapefile which is then divided into smaller subwatersheds. Any polygon shapefile may be used, but normally the user subdivides an existing Cataloging Unit Boundary, NHDPlus catchment, or any other user-supplied drainage boundary. This tool also uses a DEM grid for calculating average subwatershed slope, and a stream polyline layer. The BASINS NHDPlus catchment and flowline layers have a high resolution that works well for detailed analyses, such as a SWMM study.

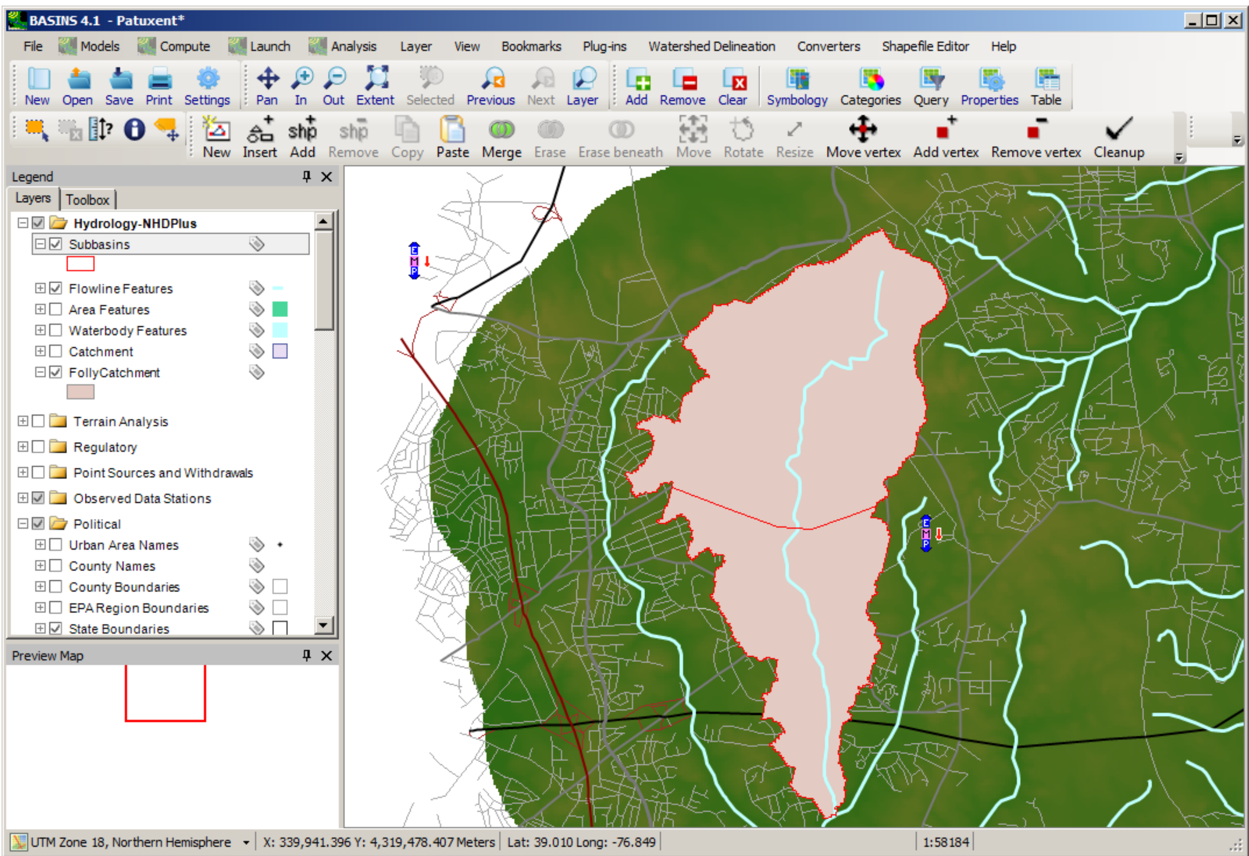


The Manual Watershed Delineator may be added to a project by selecting the **Plug-ins:Manual Delineation** menu item, which will make the manual delineation tool available under the **Watershed Delineation:Manual** menu item. Selecting the **Watershed Delineation:Manual** menu item opens the **Manual Watershed Delineator** window.



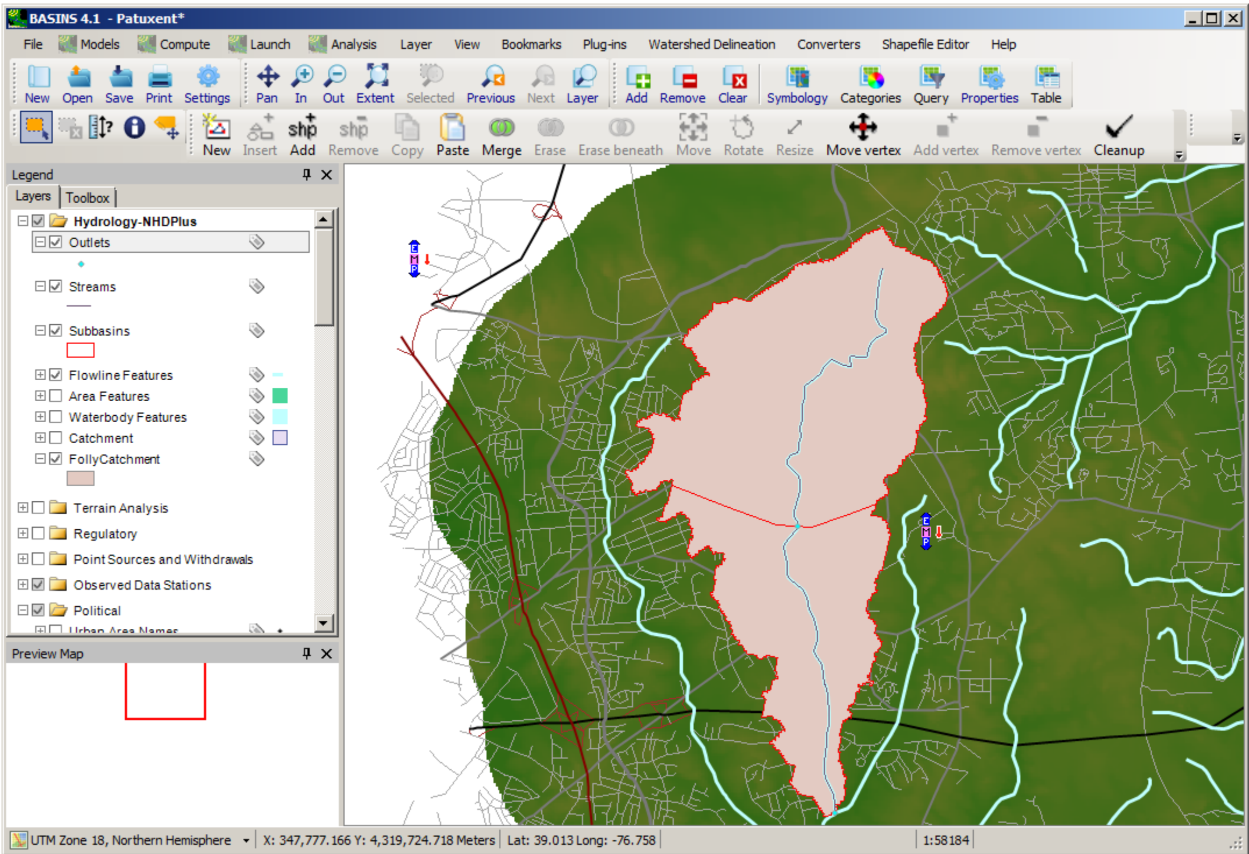
The **Subbasin Layer** pull-down menu is used to select the watershed boundary layer. The user delineates the subwatersheds (or subbasins or catchments) by clicking on the **Delineate Subbasin** button, changing the focus to the main BASINS window, and then drawing a new interior boundary to subdivide the watershed. The boundary is drawn by clicking on the beginning and end point, as well as any intermediate vertices, of the new boundary line.

To finish the watershed outline, the user makes a final mouse-click at a point outside the existing watershed boundary and right-clicks; or the user may return to the **Manual Watershed Delineator** form and click the **Commit** button. It is not necessary to delineate the portion of the watershed that coincides with the existing watershed boundary. The delineation tool automatically clips the subwatershed at the existing watershed boundary.



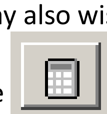
The **Delineate Subbasin** step may be performed as many times as desired to break a single catchment into multiple catchments.

To demarcate the stream segments in the newly delineated watershed, the user selects the polyline stream layer from the **Reach Layer** pull-down menu, and then clicks the **Define Stream Network and Outlets** button. The new stream segment parameters will be stored in the DBF file associated with the stream layer.



The *Subbasins* and *Streams* Shapefiles that are added to the map may be used as the Subcatchment and Conduit layers in the BASINS/SWMM plug-in. Complete instructions for using the BASINS Manual Watershed Delineator can be found in the Manual Watershed Delineation section.

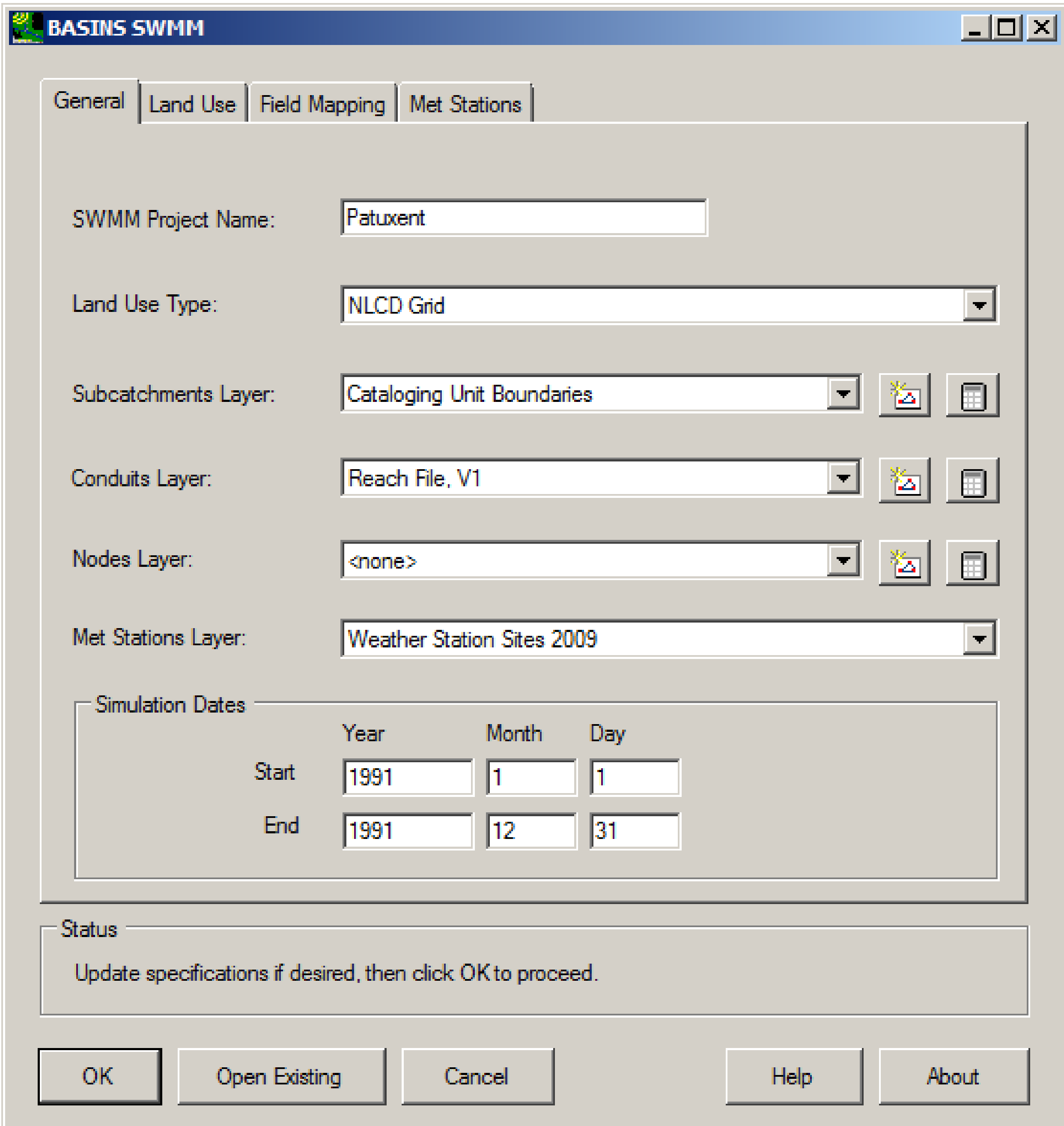
When the user specifies the *Subbasins* and *Streams* shapefiles as the Subcatchment and Conduit layers in the BASINS/SWMM plug-in, the user may also wish to add some attributes to these shapefiles.

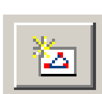
Attributes may be added by clicking on the  buttons within the BASINS/SWMM interface. See the section entitled Preparing GIS Data for use in the BASINS/SWMM Plug-in for more details.

Using the BASINS Shapefile Editor to Set Up BASINS/SWMM

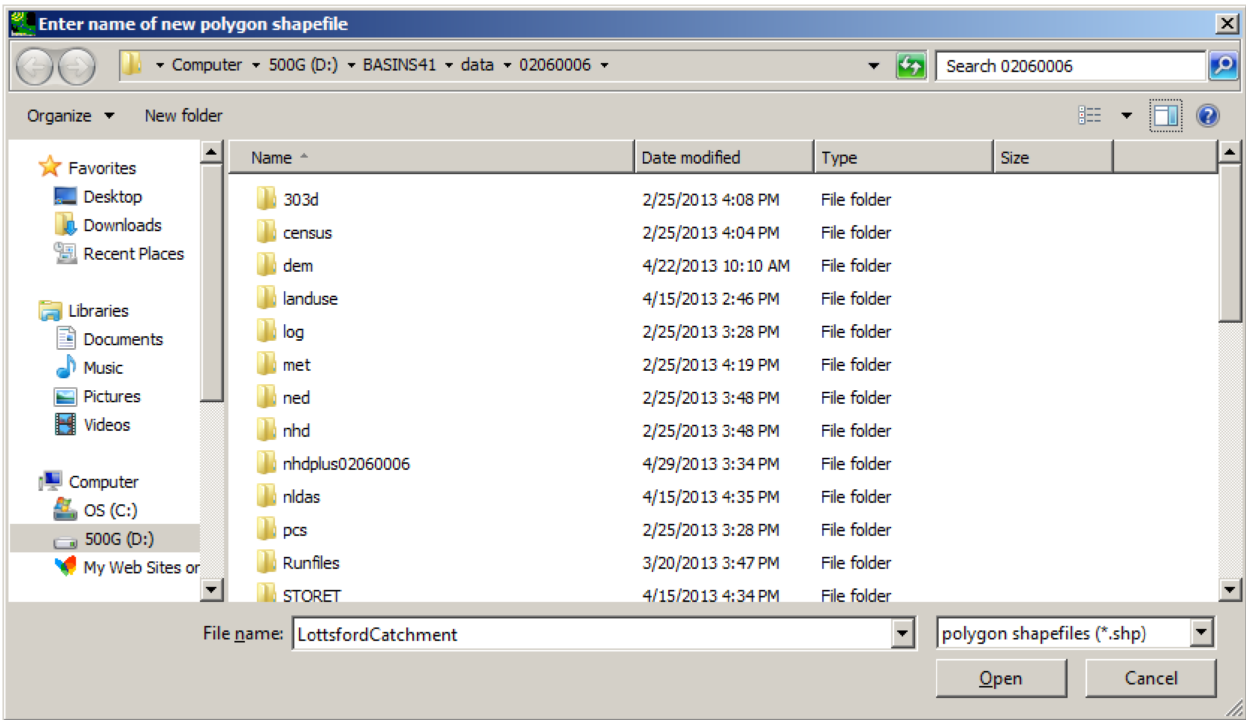
The BASINS Shapefile Editing tools may be used to create subcatchment and conduit shapefiles for use in SWMM modeling. These tools allow a user to create these shapefiles by digitizing the features directly. The BASINS/SWMM plug-in provides convenient tools for creating empty shapefiles for subcatchments, conduits, and nodes, and for calculating the attributes of these features. These tools require no data other than a Digital Elevation Model (DEM) in grid format for calculating the average slope of a subcatchment.

Within the BASINS/SWMM plug-in user interface, icons are available for creating new shapefiles of subcatchments, conduits, and nodes, as well as icons for populating the attribute values of these shapefiles. This section is focused on using the available tools to create the new shapefiles. See the section entitled Preparing GIS Data for use in the BASINS/SWMM Plug-in for more details on populating the attribute values of these shapefiles.

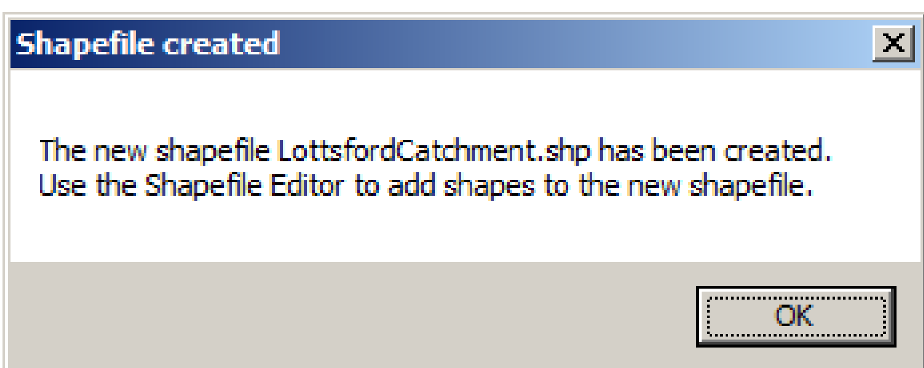


The  icon is used to create a new shapefile of subcatchments, conduits or nodes. This icon appears next to each type of layer in the BASINS/SWMM user interface, corresponding to subcatchments, conduits or nodes.

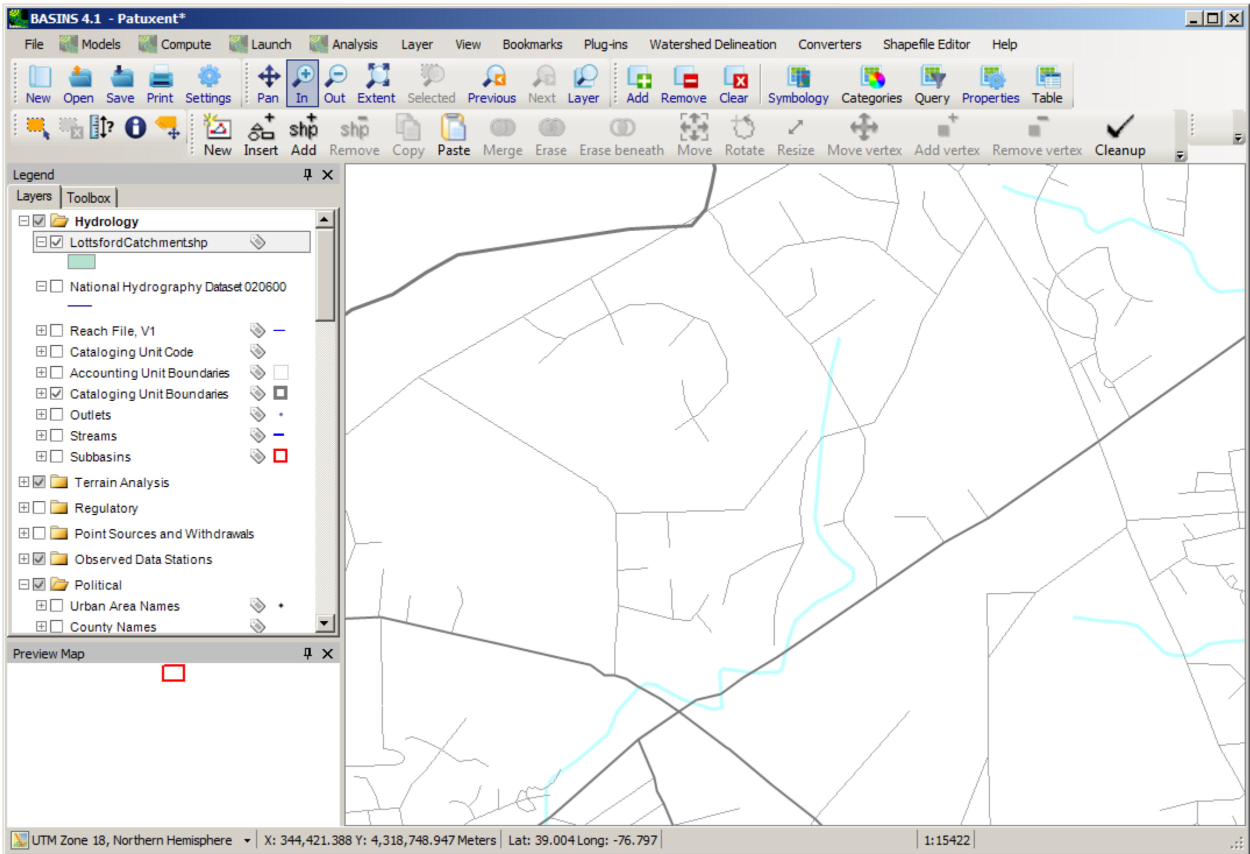
When the user clicks on any of these three icons, a dialog appears for the user to enter the corresponding name of the new shapefile.



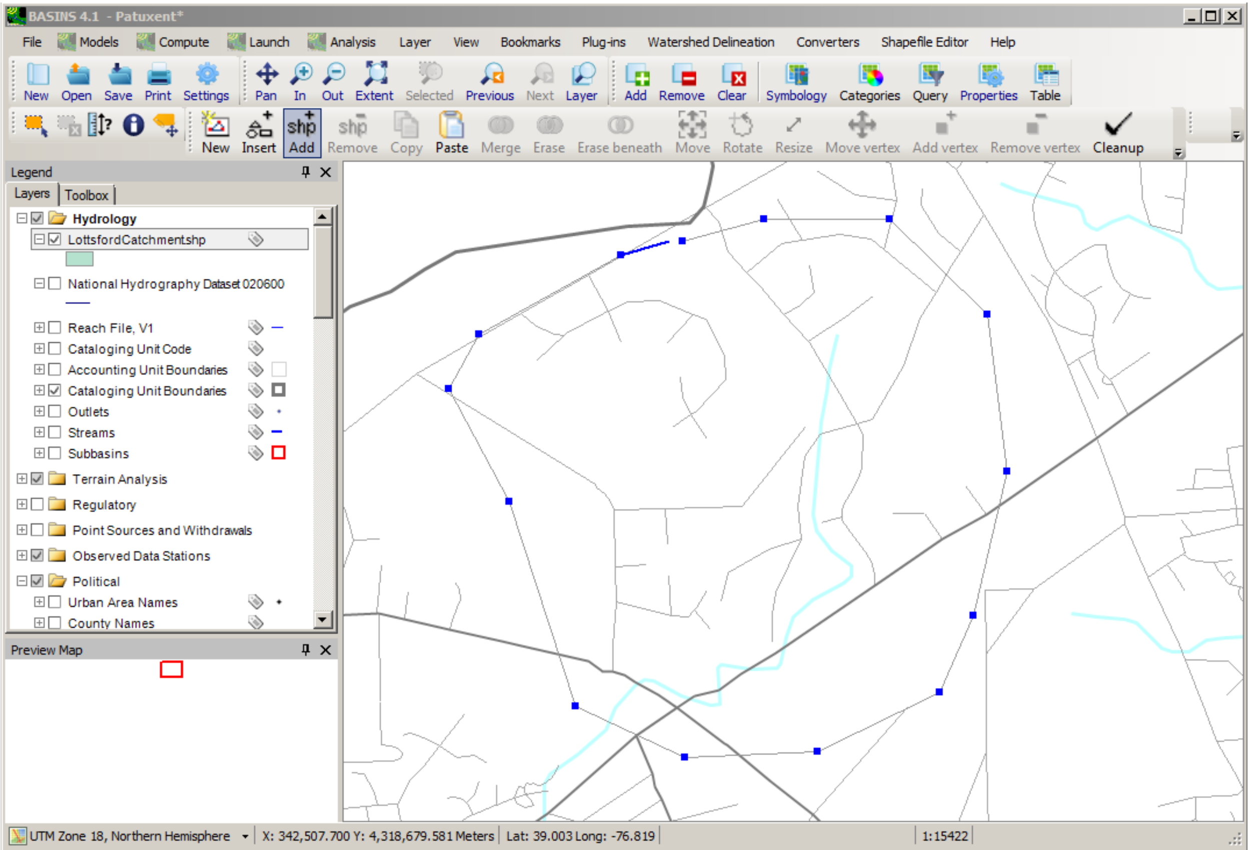
After clicking 'Open', a message appears to indicate that features can be added to this layer using the Shapefile Editor.



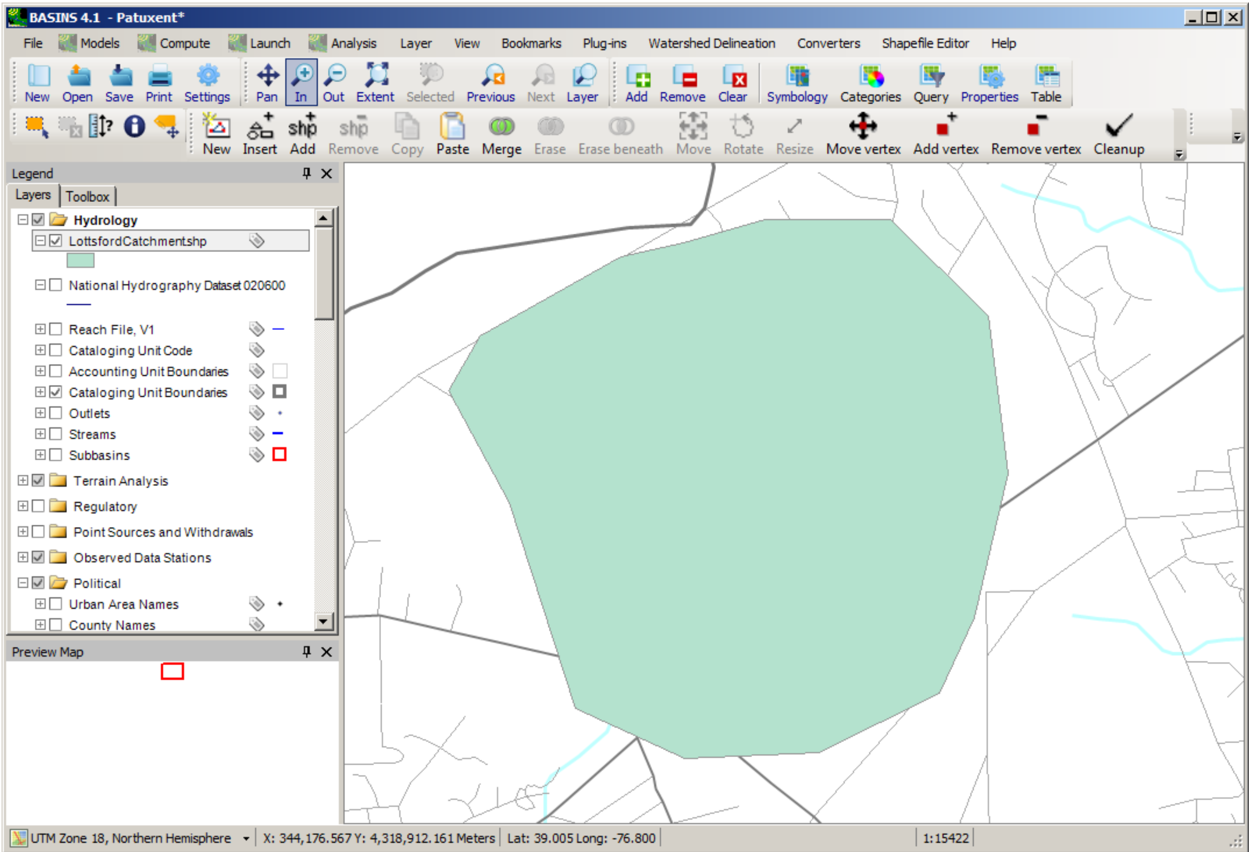
Note that at this point a blank shapefile will be created using the specified name. There will be no features within the shapefile at this point.



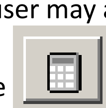
Within the Shapefile Editor toolbar, the user may click on the  icon to add a shape to the new shapefile. The shape is added by clicking a series of points on the map representing the polygon vertices.



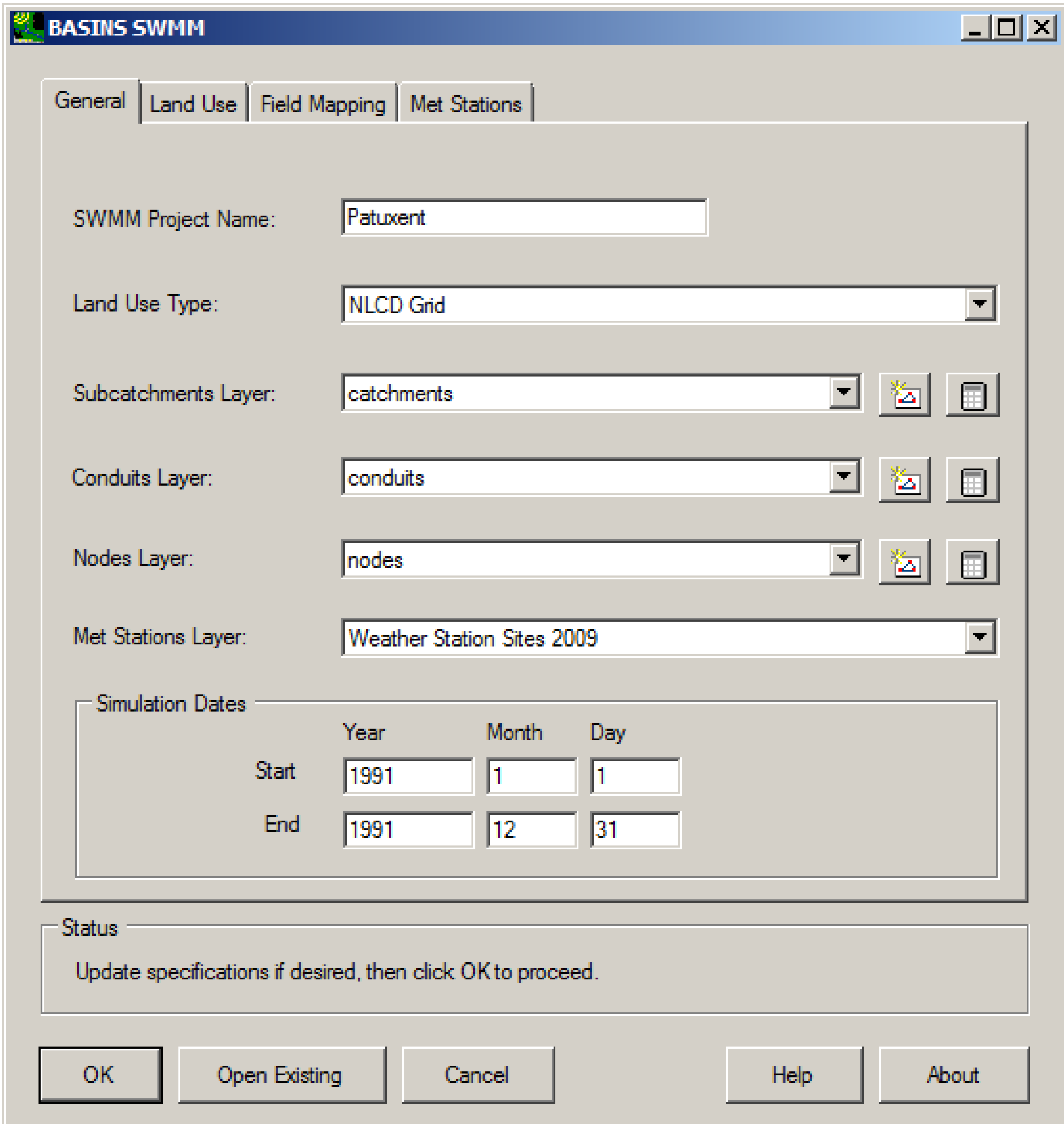
When finished drawing the vertices, the user double clicks on the first vertex and the figure will be completed. This process can be repeated as many times as desired.



The same process can be used to create a shapefile of conduits, as well as a shapefile of nodes. In the case of nodes, after specifying the file name and clicking ‘Open’, a message appears indicating that nodes may be added either automatically at the ends of the conduits or by point-and-click using the Shapefile Editor.

After the user creates the Subcatchment, Conduit, and Node layers, the user may also wish to add some attributes to these shapefiles. Attributes may be added by clicking on the  buttons within the BASINS/SWMM interface. See the section entitled Preparing GIS Data for use in the BASINS/SWMM Plug-in for more details. Creating a New SWMM Project The BASINS/SWMM Plug-In creates a new *SWMM* project using the GIS layers on the map and available meteorologic time-series data. Map layers used by this plug-in include **Subcatchments**, **Conduits**, and optionally **Nodes**. Depending upon the options chosen, the **Land Use Index** and corresponding land use layers may also be used. A met stations layer, such as that created by the Data Download tool when downloading meteorologic data, is useful for locating possible met stations for the SWMM model.

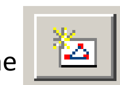
The BASINS/SWMM window opens with the interface populated according to the layers available on the map. The dominant portion of the BASINS/SWMM window is a tabbed dialog. Below the tabbed dialog is a small status frame and a row of command buttons.



The tabbed dialog contains a **General** tab for specifying general information about the *SWMM* project to be created, along with the map layers to be used in creating the *SWMM* project. The other tabs are used for specifying more details about the Land Use, Field Mapping, and the Met Stations to be used in the model setup.

The **General** tab is used to specify the name of the *SWMM* project (the base name of the SWMM INP file), the Land Use Type (USGS GIRAS Shapefile, Other Shapefile, NLCD Grid, or Other Grid), the Subcatchments layer, the Conduits layer, the Nodes layer, and the Met Stations Layer. By default the

SWMM Project name will be the base name of the BASINS project. The nodes layer is optional, and should only be provided if connectivity information is available as layer attributes. (Since the 'streams' layer from a BASINS delineation contains connectivity information, do not specify a 'nodes' layer when using 'subbasins' and 'streams' outputs from the BASINS watershed delineation tools.) If no nodes layer is provided, the plug-in will attempt to build SWMM nodes at either end of each conduit segment. The Met Stations Layer is optional as well, but it is useful for locating the WDM files containing meteorologic data for use in the model. This tab also includes fields for the user to specify start and end dates for the simulation.

If existing GIS layers of subcatchments, conduits, and nodes are not available, the BASINS watershed delineation tools can be used to create these layers, or the  and  icons can be used to create these layers through the BASINS shapefile editing tools. See Preparing GIS Data for use in the BASINS/SWMM Plug-in for more details on creating the GIS data layers of subcatchments, conduits, and nodes.

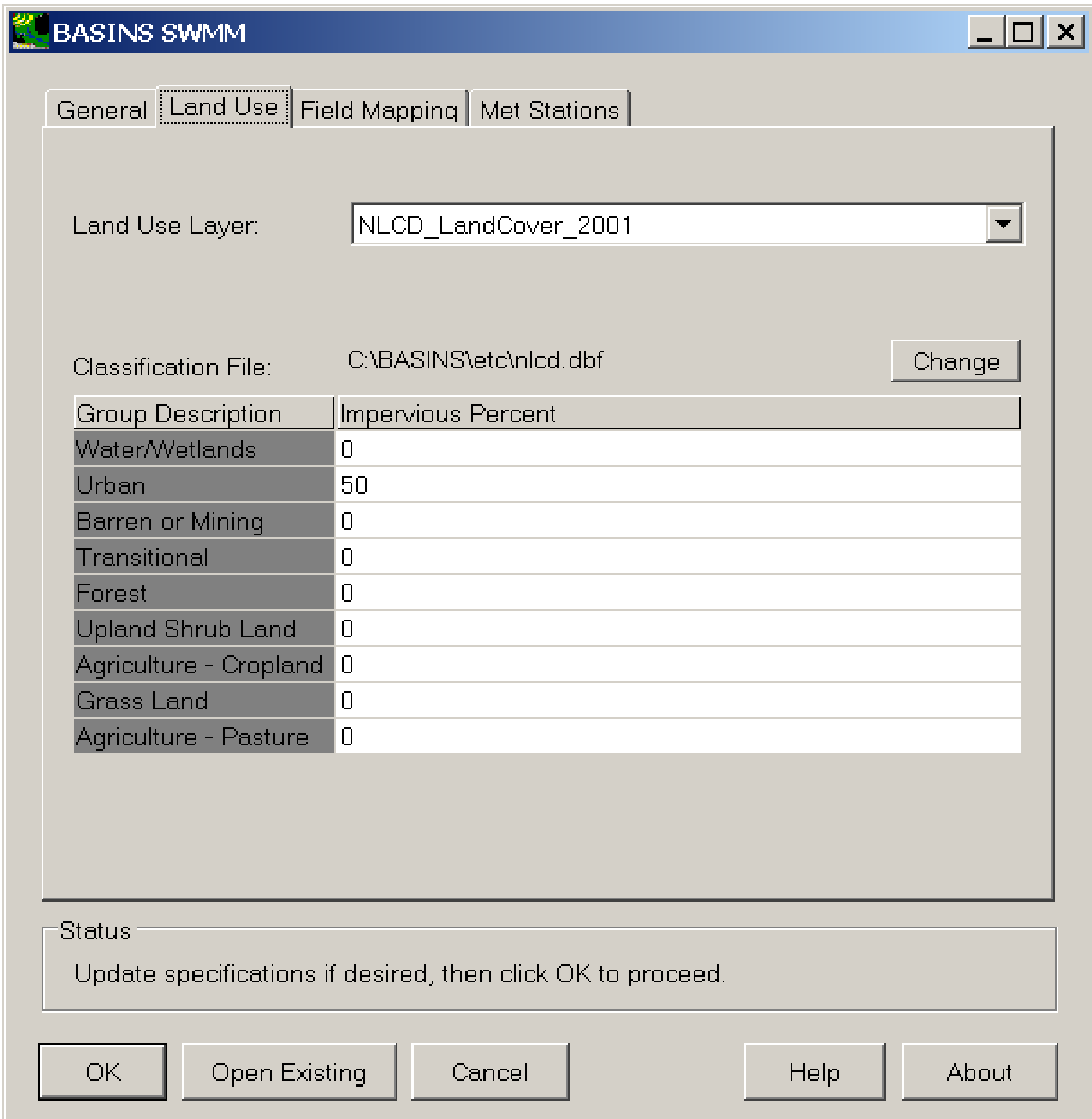
When entering BASINS/SWMM from a BASINS project containing the typical BASINS project layers, including land use and meteorologic data, all fields in the interface will be populated. In this case the user may update any of the specifications in the interface if desired. The met stations to be used in the model are specified through the Met Stations tab, and when ready the user may click **OK** to begin the calculations to produce the new *SWMM* project.

Clicking **OK** produces the new SWMM INP file. Messages in the **Status** frame give updates on the progress. The new SWMM INP file is written to the BASINS\modelout directory. After this file has been created, SWMM is automatically opened displaying the new project. Land Use Tab The **Land Use** tab is used to specify details of how land use data is to be extracted for each subcatchment. The interface on this form changes depending upon the **Land Use Type** specified in the **General** tab.

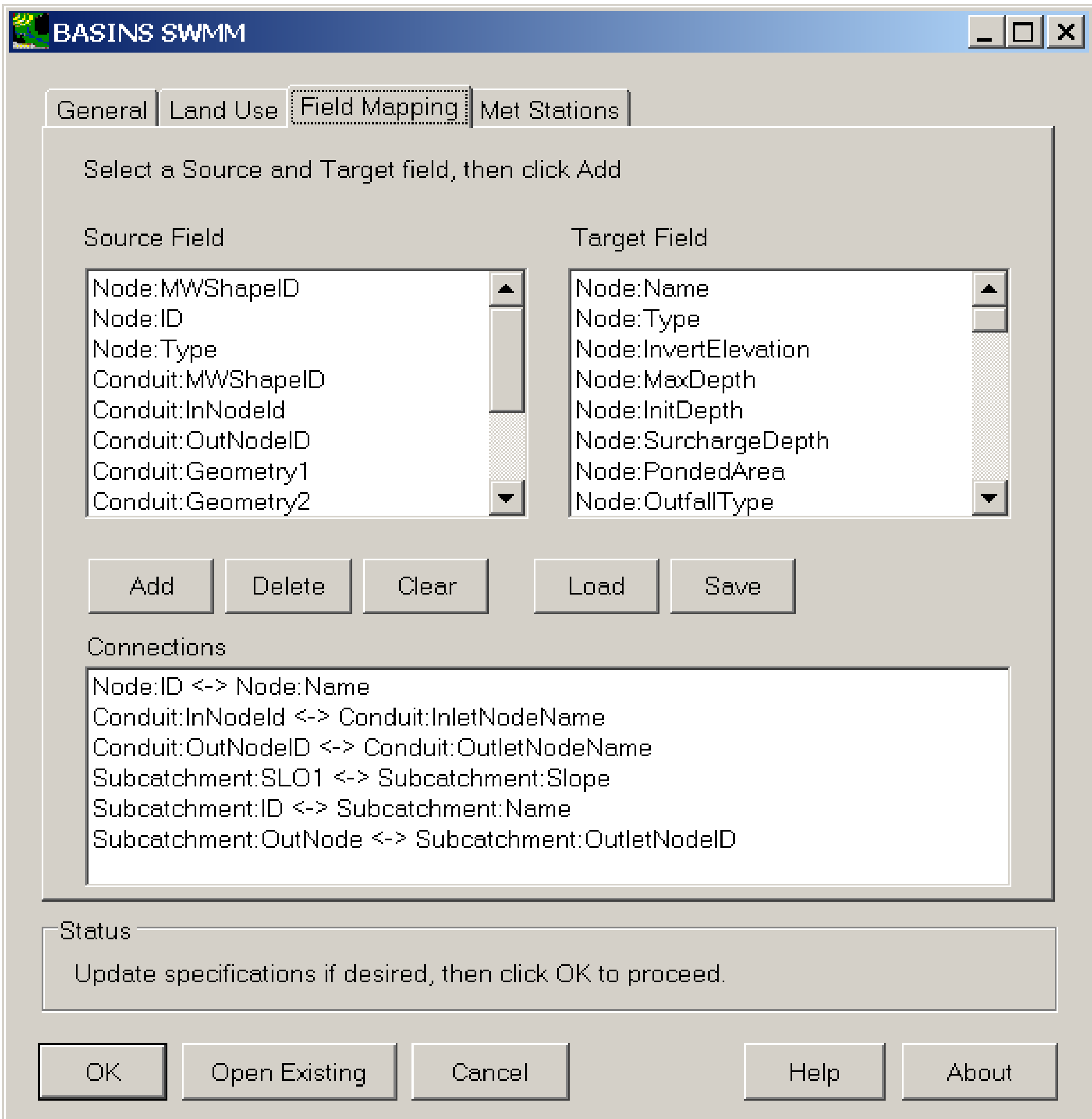
If the **Land Use Type** on the **General** tab is set to 'USGS GIRAS Shapefile', this tab will include a **Classification File** selection tool and a grid for specifying the impervious percentage of each land use type. When using the USGS GIRAS land use data with the default classification file, the land use types will be reclassified into six categories (forest, agricultural, urban, range land, barren, and wetlands/water).

If the 'Other Shapefile', 'NLCD Grid' or 'Other Grid' is specified as the **Land Use Type**, this tab will also include a drop-down list to specify the land use layer to be used. If 'Other Shapefile' is chosen, the **Classification Field** is used to specify the descriptive field in the attribute table of the land use layer that will be used as the land use type in *SWMM*, as reflected in the Impervious Percent grid. The Impervious Percent column of the grid is used to specify the percentage of each land use category that is to be considered impervious.

The **Land Use** tab contains a dialog for specifying a classification file and a table for specifying the impervious percent for each land use category. The land use classification file is a simple dbf file that contains a list of land use codes and a corresponding group description, for use in grouping land use codes into categories. A very similar interface is available in BASINS/HSPF PlugIn. For instance, the land use classification file might indicate that codes 21 through 24 should all be grouped together into one 'Urban' category. The user may create or modify this file as desired.



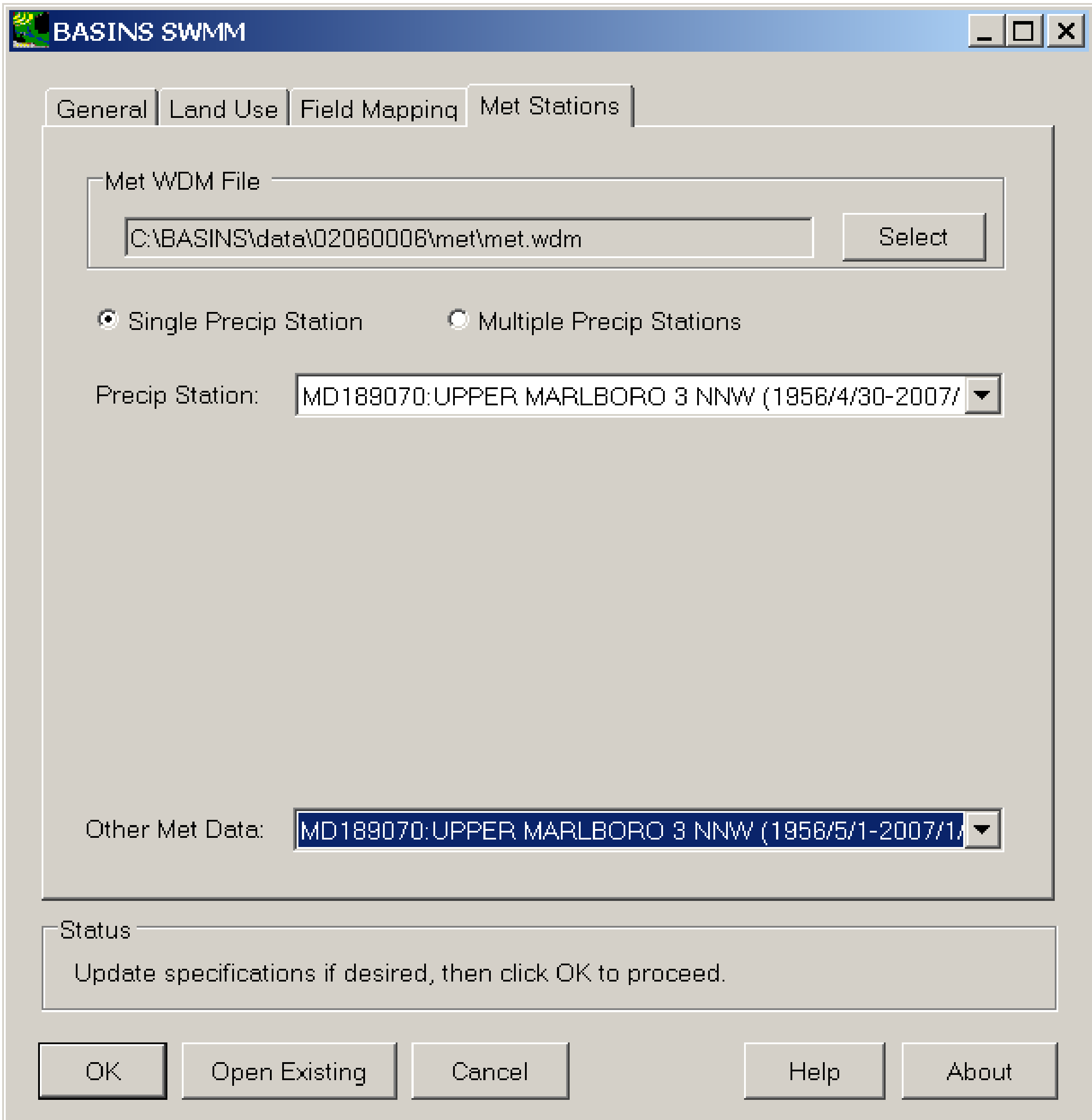
If no classification file is set, each individual land use category will be represented separately in *SWMM*. The Reclassify Land Use tool in BASINS can be used to build other classification files.   Field Mapping Tab The **Field Mapping** tab is used to map fields from the subcatchment, conduit, and node shapefile attribute tables specified on the 'General' tab to the variables in the BASINS/SWMM PlugIn data structure where that data will be used. This field mapping will default appropriately if using the output from a BASINS watershed delineation as the subcatchments and conduits, but it is needed if the user has obtained this data from a source other than BASINS.



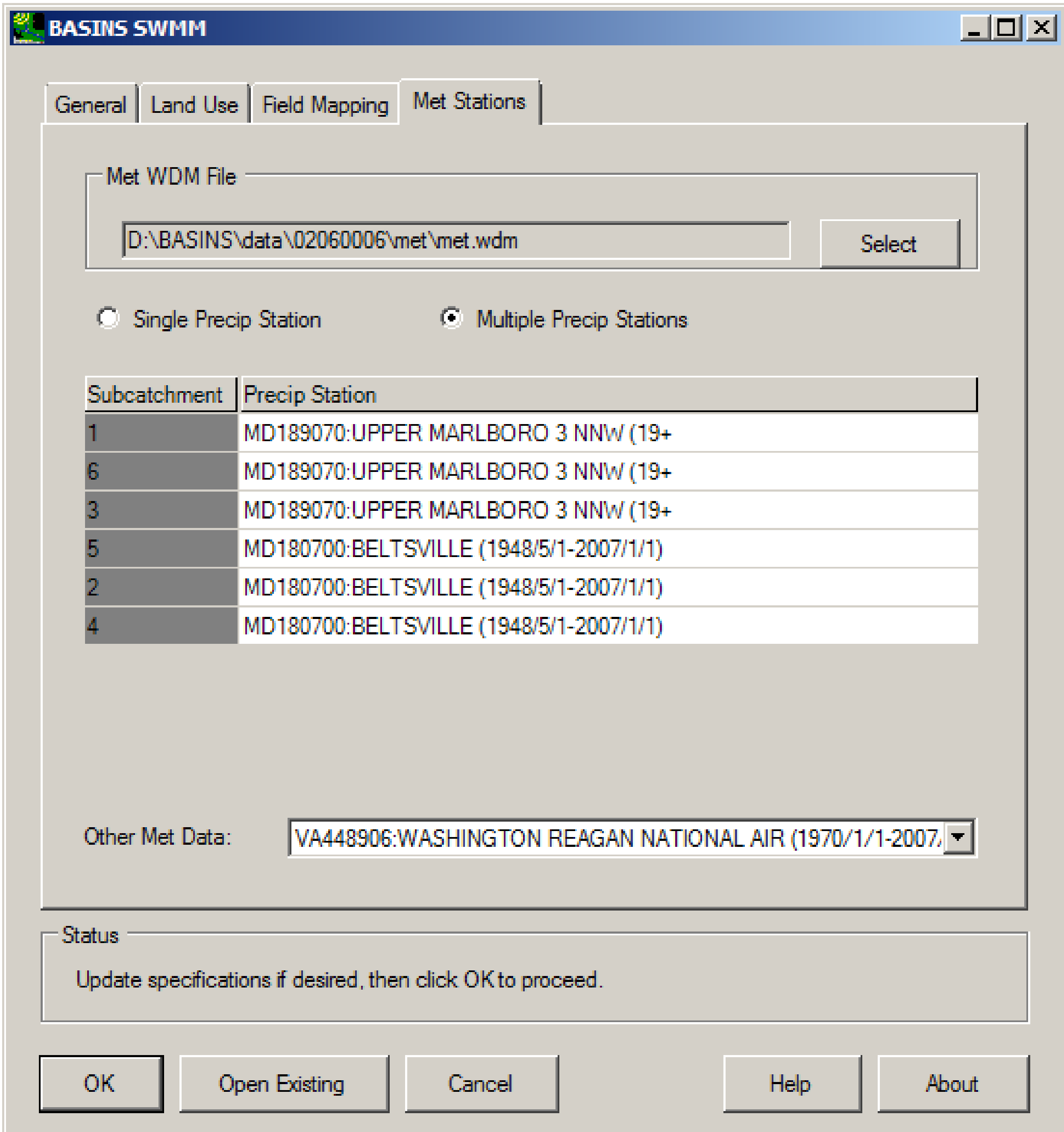
The list entitled 'Source Field' includes all of the fields of each attribute table associated with the specified subcatchment, conduit, and node shapefiles. The 'Target Field' list includes all of the information the BASINS/SWMM PlugIn can populate given corresponding information from a shapefile attribute. The user adds to the list of connections below by selecting a source field, and target field, and then clicking 'Add'. For instance, a user might have a field on the nodes shapefile attribute table named 'InvertElev' containing invert elevations. The user could map this field to the Invert Elevations of the nodes in SWMM by selecting Node:InvertElev on the source field list, selecting Node:InvertElevation in the target field list, and then clicking the ‘Add’ button to add it to the list of field connections.

The Delete button is used to delete a connection from the connections list, while the Clear button is used to clear all the connections from the connections list. The Load and Save buttons are used to read in and write out the list of connections for use in a later application of the BASINS/SWMM PlugIn, if desired.

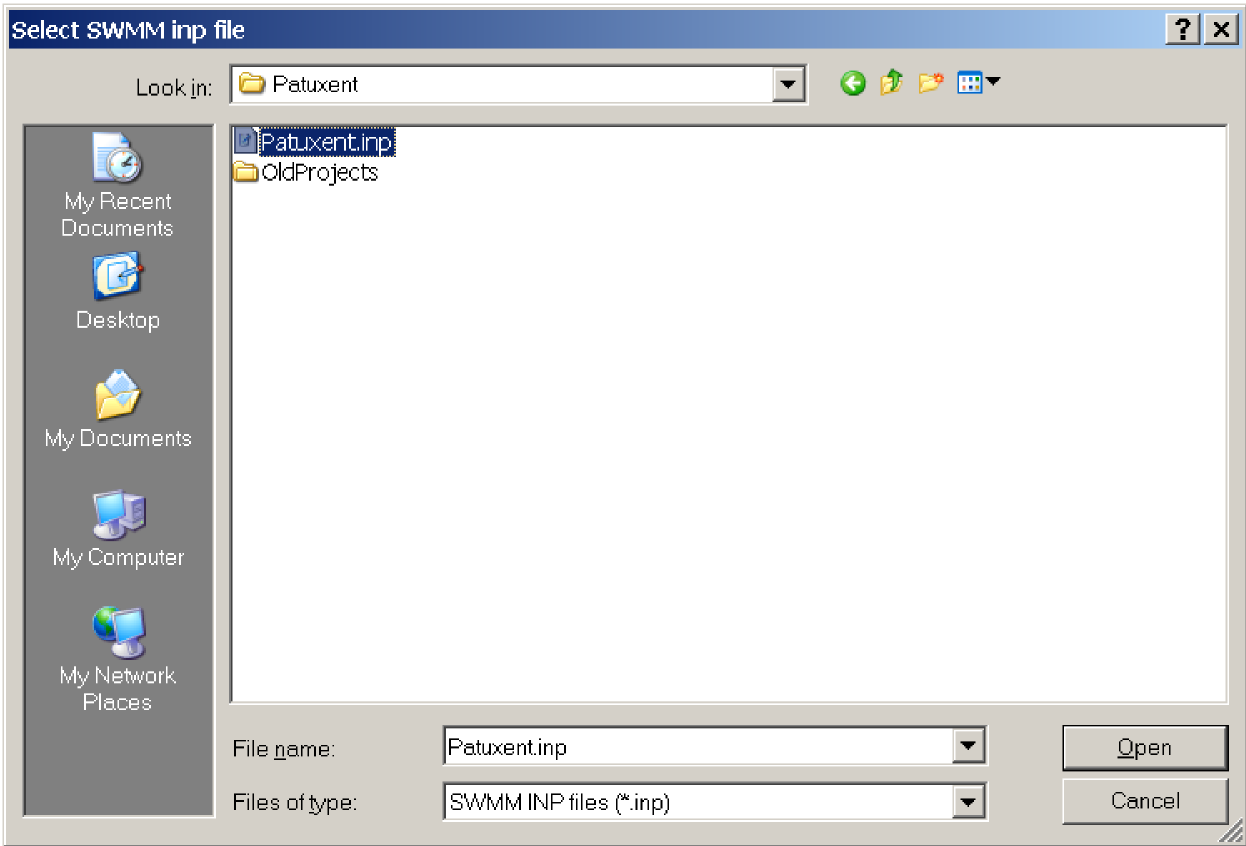
A field from one type of map layer can only be associated with a target field of the same type. In other words, a field from the ‘Nodes’ layer can only be associated with a ‘Nodes’ target in the data structure. Also, in cases where the source and target names are identical a connection does not have to be mapped. In other words, by default, the Conduit:Geometry1 in the source column will be mapped to Conduit:Geometry1 in the target column, and thus does not need to be explicitly specified as a connection. Met Stations Tab The **Met Stations** tab is used to specify which meteorological stations will be used to provide meteorological input for the model. In normal BASINS use, the met WDM file will be set to the name of the WDM that corresponds to the met stations layer specified on the General tab. Any other WDM file containing met data can be used through this interface by choosing that file through the Select button. The meteorological data files must be in Watershed Data Management (WDM) format.



The precipitation station is specified through a single drop down list, as is the station for obtaining all other meteorological constituents. The BASINS/SWMM interface allows a user to specify a single precipitation station for the entire SWMM study area, or a precipitation station for each SWMM subcatchment. To specify a precipitation station for each subcatchment, chose the 'multiple precip stations' option. With this option selected, a precipitation stations may be assigned by subcatchment.



Opening an Existing SWMM Project The **Open Existing** button is used to open an existing *SWMM* project (INP file) in *SWMM*. To open an existing SWMM Project, use the **Select INP** dialog to select the existing SWMM INP file that you would like to open.



Clicking **Open** will start *SWMM*.

EPA WASP Model Builder

The EPA **Water Quality Analysis Simulation Program (WASP)** is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. This model helps users interpret and predict water quality responses to natural phenomena and manmade pollution for various pollution management decisions. WASP allows the user to investigate 1, 2, and 3 dimensional systems, and a variety of pollutant types. The time varying processes of advection, dispersion, point and diffuse mass loading and boundary exchange are represented in the model. WASP also can be linked with hydrodynamic and sediment transport models that can provide flows, depths velocities, temperature, salinity and sediment fluxes.

WASP has been used to examine eutrophication of Tampa Bay, FL; phosphorus loading to Lake Okeechobee, FL; eutrophication of the Neuse River Estuary, NC; eutrophication Coosa River and Reservoirs, AL; PCB pollution of the Great Lakes; eutrophication of the Potomac Estuary; kepone pollution of the James River Estuary; volatile organic pollution of the Delaware Estuary; heavy metal pollution of the Deep River, NC; and mercury in the Savannah River, GA.

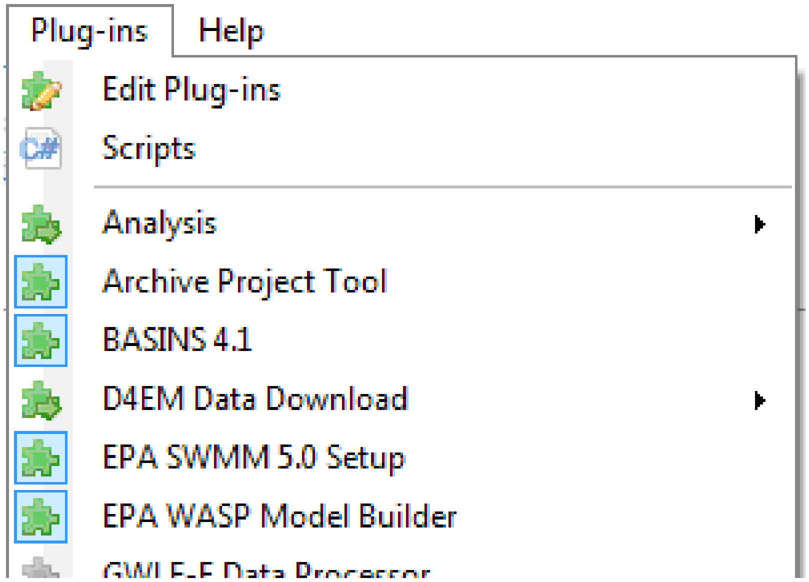
BASINS allows the user to build a new project and open WASP directly from the BASINS user interface. The following sections provide more details on using *WASP* through BASINS:

- Data Requirements for Setting up WASP through BASINS
- Creating a New WASP Project

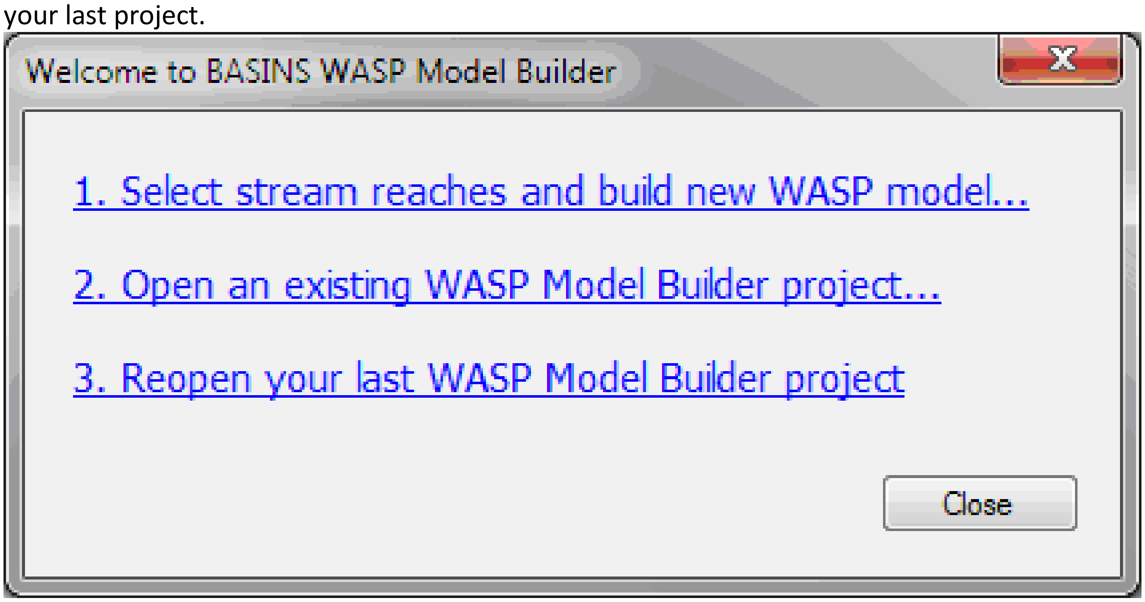
Note: The WASP model is not included with this package. It may be downloaded from http://www.epa.gov/athens/wwqtsc/html/wasp.html

Key Procedures

1. Select **EPA WASP Model Builder** from the **Plug-ins** menu so that it is active. This will add **WASP** to the Models menu on the main form.

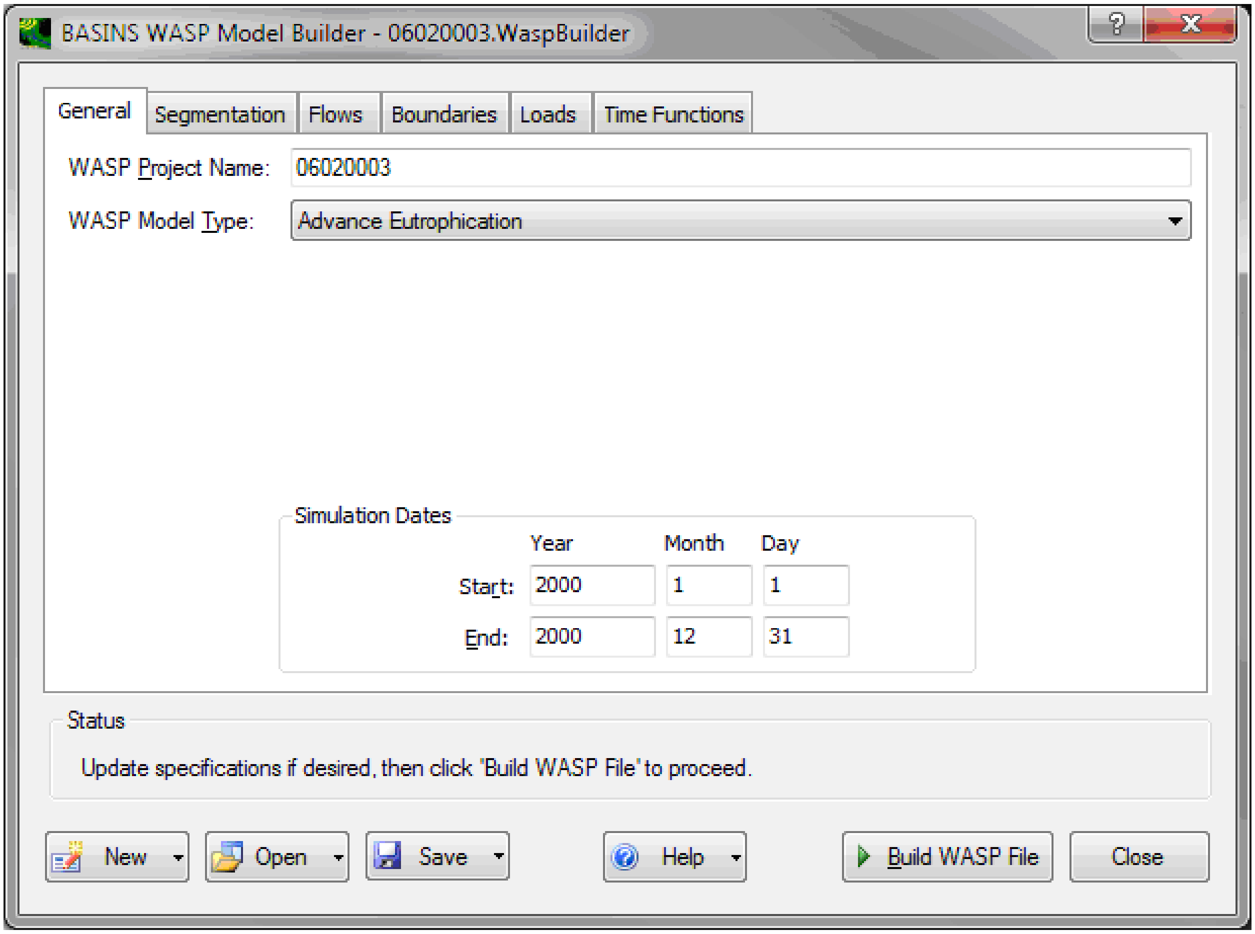


2. Select **Models:WASP** from the main menu, and the *Welcome to BASINS WASP Model Builder* form appears. Use this form to create a new WASP Builder project by selecting stream reaches from which you will build your model, open a previously saved WASP Builder project, or reopen your last project.



3. When the desired segments are selected or project file loaded, the *BASINS WASP Model Builder* form appears. This interface consists of six tabs: General, Segmentation, Flows, Boundaries, Loads, and Time Functions. The **General** tab includes fields for the user to specify the WASP project name (which defaults to the name of the BASINS project), the WASP Model type, and

start and end dates for the simulation.



4. The user may proceed through each tab, setting the input specifications as desired. Once all of the specifications are set as desired, click **Build WASP File** to create the WASP project. After processing, the WASP interface will open with the newly created project.

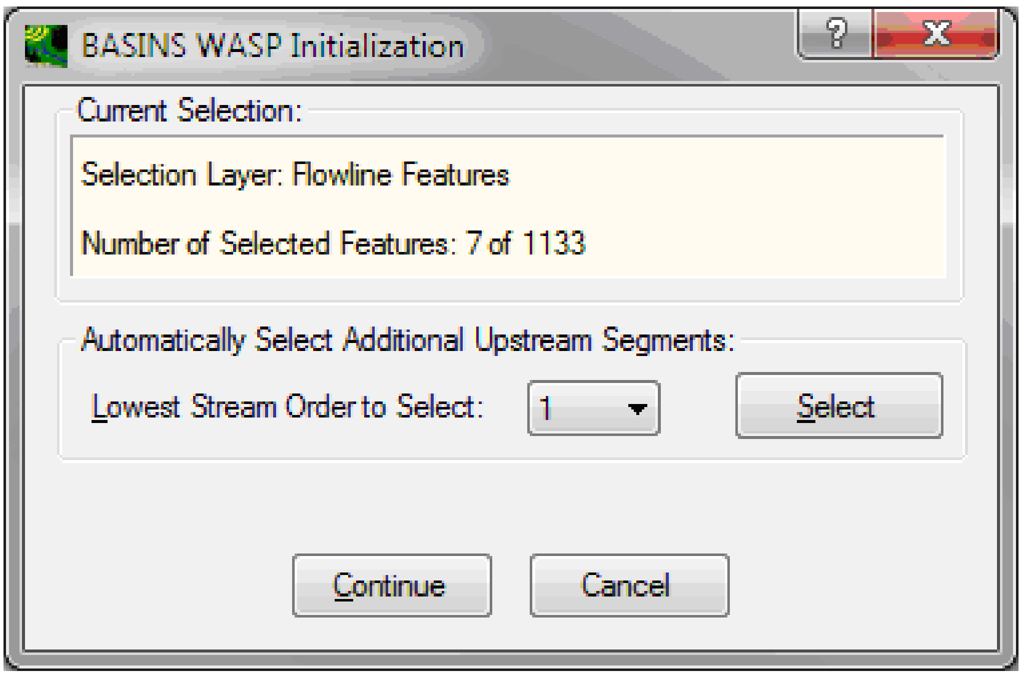
Note that the Model Builder form includes a "?" button in the upper-right corner. Click on this button and then any form field or button to get pop-up context-sensitive help. Data Requirements for Setting up WASP through BASINS The BASINS/WASP Setup Plug-in allows a user to set up a WASP project using the GIS and timeseries data available within BASINS. This plug-in is normally used in conjunction with the Flowline Features from NHDPlus.

When using BASINS/WASP to build an initial *WASP* Project File, the streams layer must exist on the map. In addition to the streams layer, a met data layer may also be specified, from which the user may select particular stations to use to supply timeseries of wind speed, solar radiation, and air temperature. The NHDPlus Flowlines and BASINS Meteorological Data layers may be downloaded using the BASINS Download Data tool.

BASINS/WASP is designed to be flexible in its handling of GIS layers. While typically a BASINS user will use the NHDPlus Flowlines, BASINS WASP supports use of other vector stream layers. See the Field Mapping section on the Segmentation tab for details about mapping the fields of existing shapefiles to the necessary variables of the WASP data structure. While the BASINS met data is typically used to provide input meteorological data, other WDM files of meteorological data may be used.

The BASINS/WASP plug-in may also be used to enter *WASP* with an existing *WASP* project. In this case no other GIS or timeseries data are required. Creating a New WASP Project The BASINS/WASP Plug-In creates a new *WASP* project using the GIS layers on the map and available time-series data. The NHDPlus Flowline Features are used by this plug-in.

To create a new project, select the first option, **Select stream reaches and build new WASP model**, and the *BASINS WASP Initialization* form appears.



This form is interactively used with BASINS; at this time, the previously selected flowline features will be identified or you can select one or more stream segments from a previously loaded NHDPlus flowline features layer. The tool examines the attribute table of the selected layer to confirm that it is compatible with NHDPlus; otherwise a warning will appear.

This form also has the ability to select segments upstream of a particular segment, using the connectivity information of NHDPlus. With any stream segment(s) selected, clicking the 'Select Upstream' button with begin a process of identifying upstream segments and selecting those as well up to a specified minimum stream order. The updated features will be selected on the map and will be indicated on this form.

Once the desired features are selected, the user clicks 'Continue'. The BASINS/WASP window opens with the interface populated according to the layers available on the map. The dominant portion of the

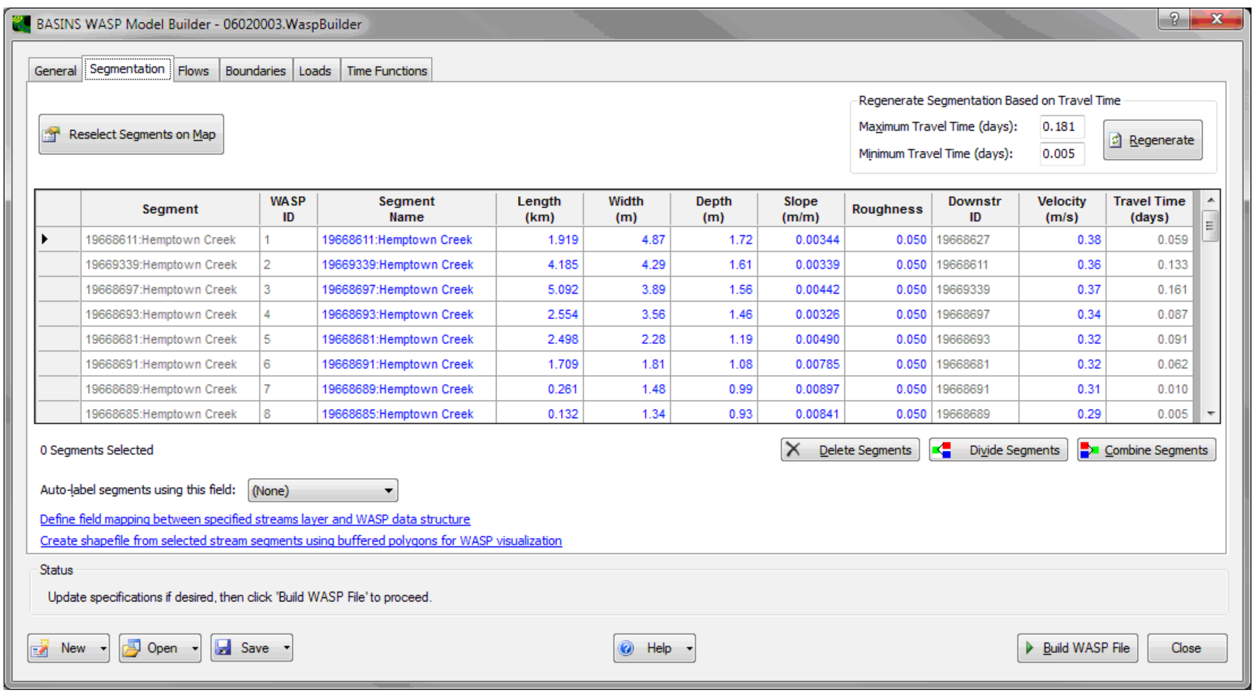
BASINS/WASP window is a tabbed dialog. Below the tabbed dialog are a small status frame and a row of command buttons.

The tabbed dialog contains a **General** tab for specifying general information about the *WASP* project to be created. The other tabs are used for specifying more details about the Segmentation, Flows, Boundaries, Loads, and Time Functions to be used in the model setup.

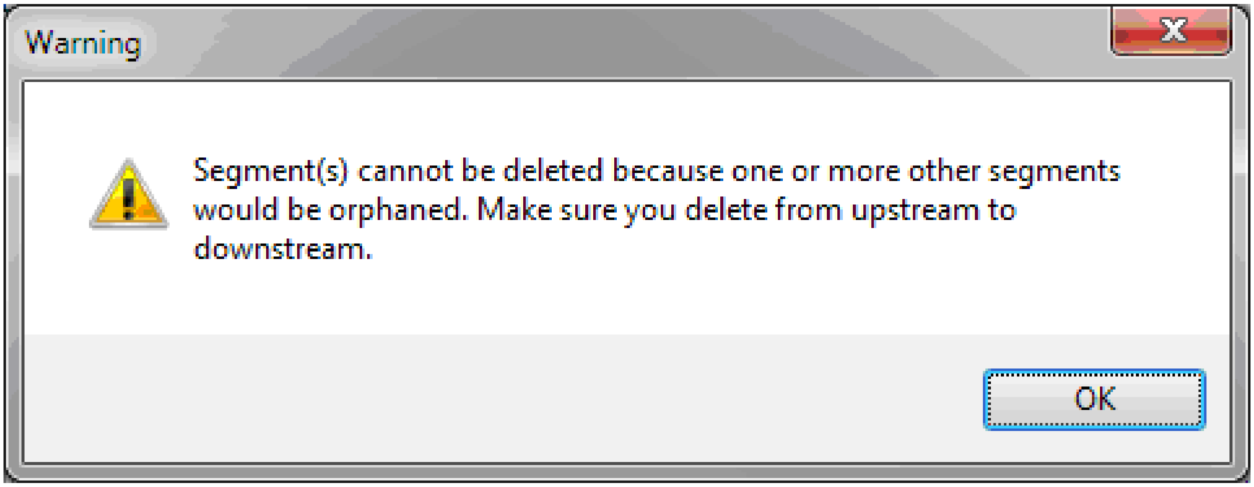
The **General** tab is used to specify the name of the *WASP* project (the base name of the BASINS project), the WASP model type, and the start and end dates for the simulation.

When entering BASINS/WASP from a BASINS project containing the typical BASINS project layers, including NHDPlus Flowline Features, all fields in the interface will be populated. In this case the user may update any of the specifications in the interface if desired.

The **Segmentation** tab is used to specify the properties of the WASP segments to be modeled. Only stream segments selected on the map will be shown here. A travel time is estimated for each stream segment, and the user has the option to combine or divide segments as desired based on travel time. To do so, the user enters the maximum or minimum allowable travel time, and clicks the 'Regenerate' button. After the new segments have been computed, the grid on the Segmentation tab will be refreshed. Note that the GIS map highlights selected segments as you move among the rows in the grid.



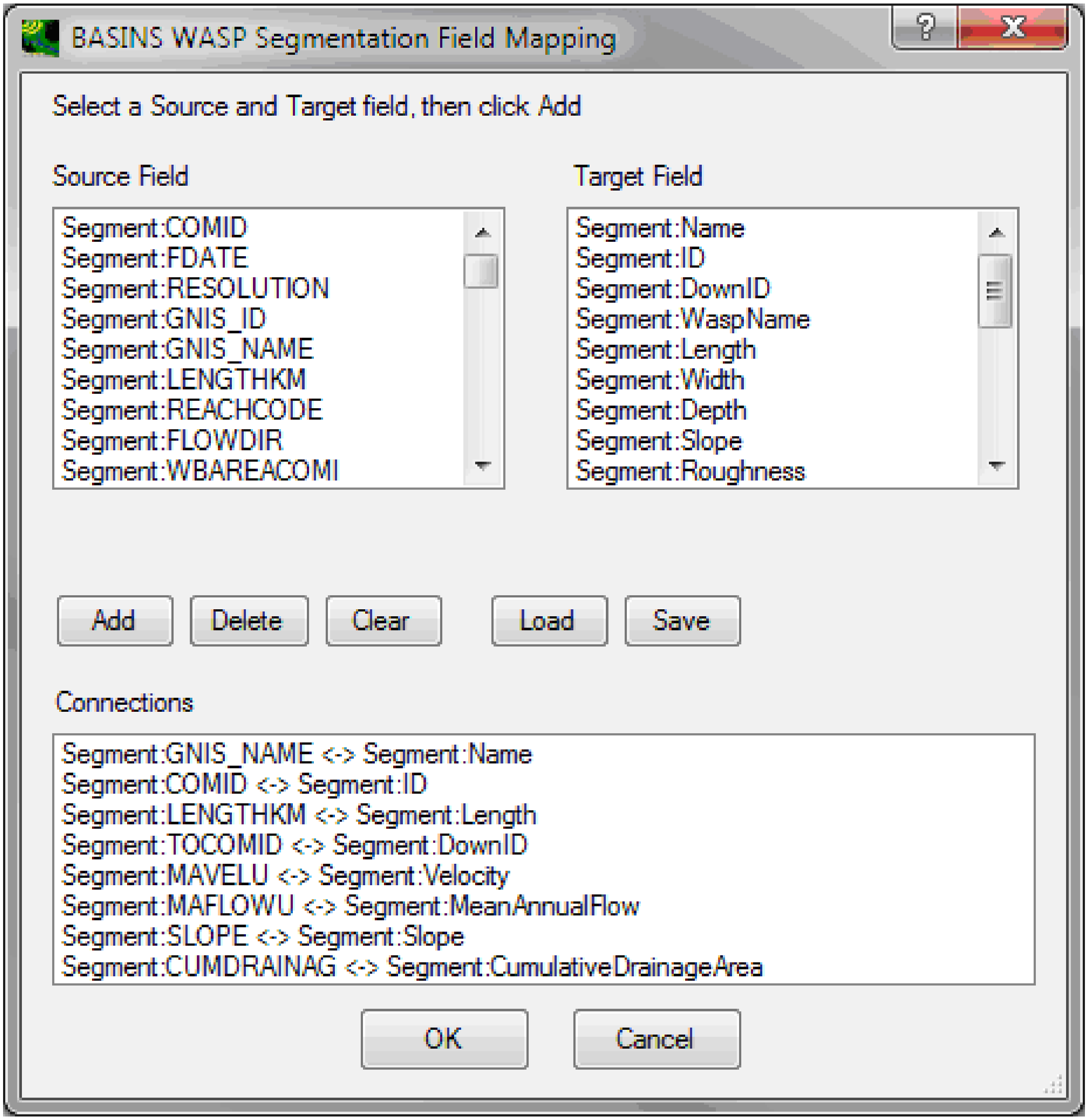
The **Delete Segments** button is used to delete a segment from the segment grid. . If you try to delete a segment inappropriately, the following error appears:



The **Divide Segments** button is similar to the **Regenerate** button except that it acts on only the selected segments. You are prompted to enter a minimum travel time and the segments are subdivided as many times as necessary to meet that criterion.

Combine Segments is used to combine multiple connected segments into a single one. First, select all segments on a tributary either on the map of by selecting one or more cells in the grid. Click this button and the segments will immediately be joined.

Clicking on the link **Define field mapping between specified streams layer and WASP data structure** produces a form showing how fields from the specified streams layer attribute table will be mapped to the required segment data items needed in the WASP data structure. This field mapping will default appropriately if using the NHDPlus Flowlines as the streams layer, but it is needed if the user wishes to use streams data from another source:

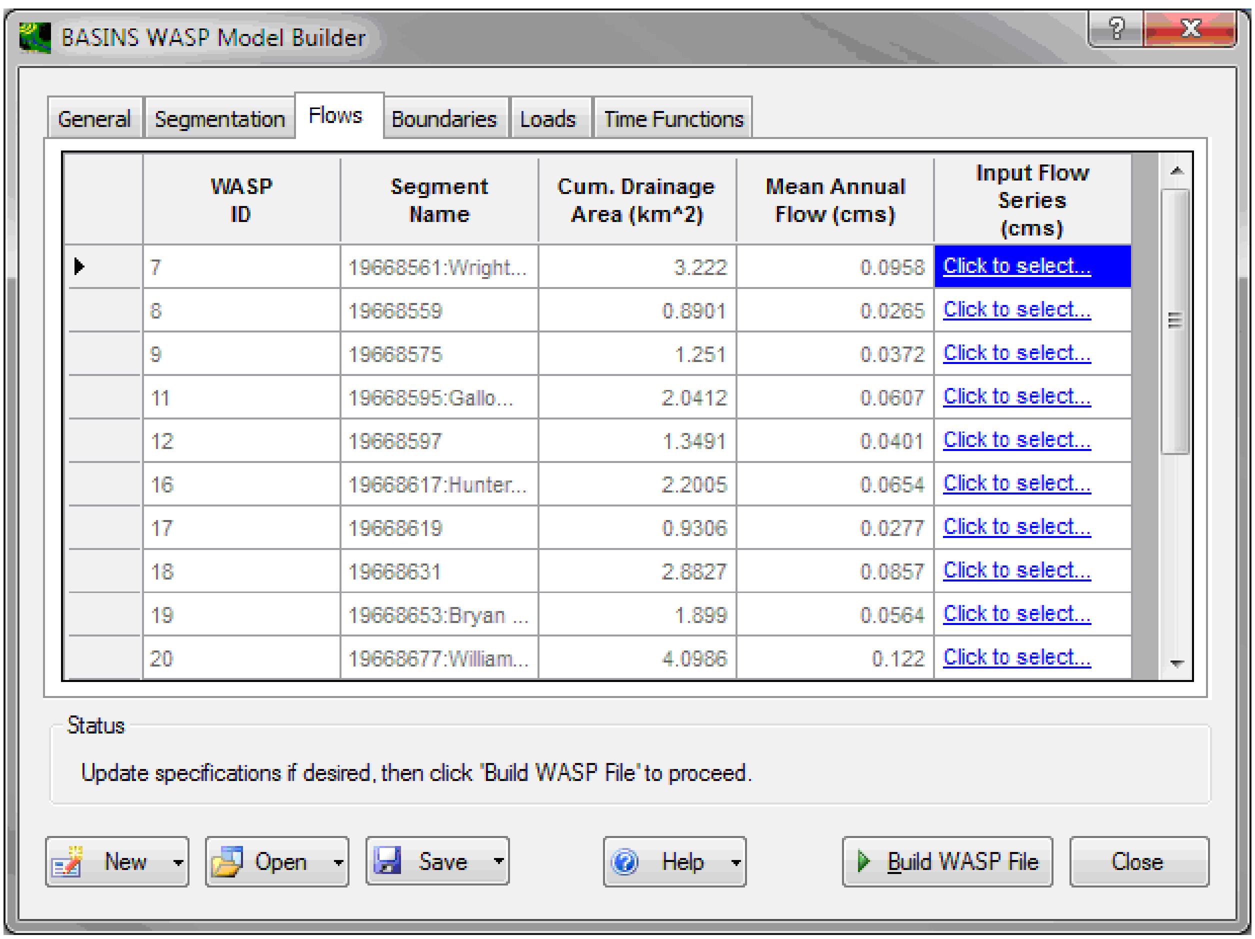


The list entitled 'Source Field' includes all of the fields of the streams attribute table. The 'Target Field' list includes all of the information the BASINS/WASP PlugIn can populate given corresponding information from a shapefile attribute. The user adds to the list of connections below by selecting a source field, and target field, and then clicking 'Add'. For instance, a user might have a field on the streams shapefile attribute table named 'Len' containing the length of the stream segments. The user could map this field to the Length property of the segments in WASP by selecting Segment:Len on the source field list, selecting Segment:Length in the target field list, and then clicking the 'Add' button to add it to the list of field connections. The Clear button is used to clear all the connections from the connections list. The Load and Save buttons are used to read in and write out the list of connections for use in a later application of the BASINS/WASP PlugIn, if desired.

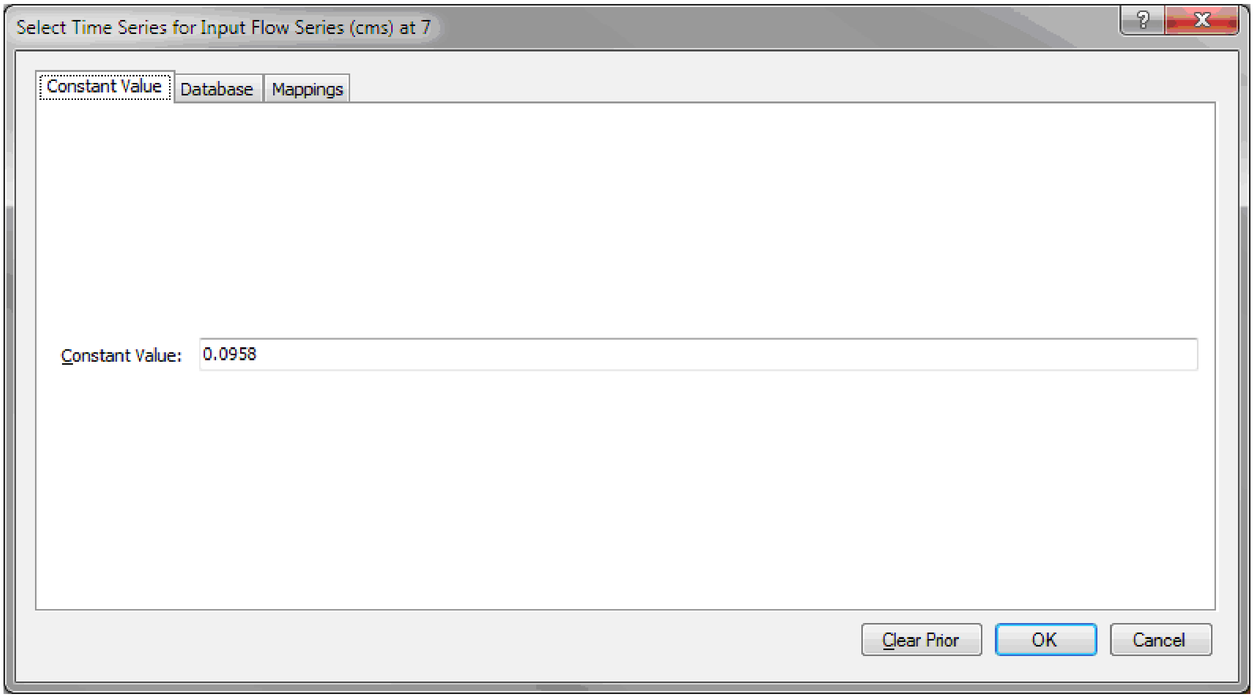
In cases where the source and target names are identical a connection does not have to be mapped. In other words, by default, the Segment:Length in the source column will be mapped to Segment:Length in the target column, and thus does not need to be explicitly specified as a connection.

The link **Create shapefile from selected stream segments using buffered polygons for WASP visualization** is used to create a shapefile of the selected stream segments, as they will be modeled by WASP. The stream lines will be converted to buffered polygons, so that they can be used as WASP postprocessing for animation. Each stream segment will be displayed with its assigned WASP ID on the map.

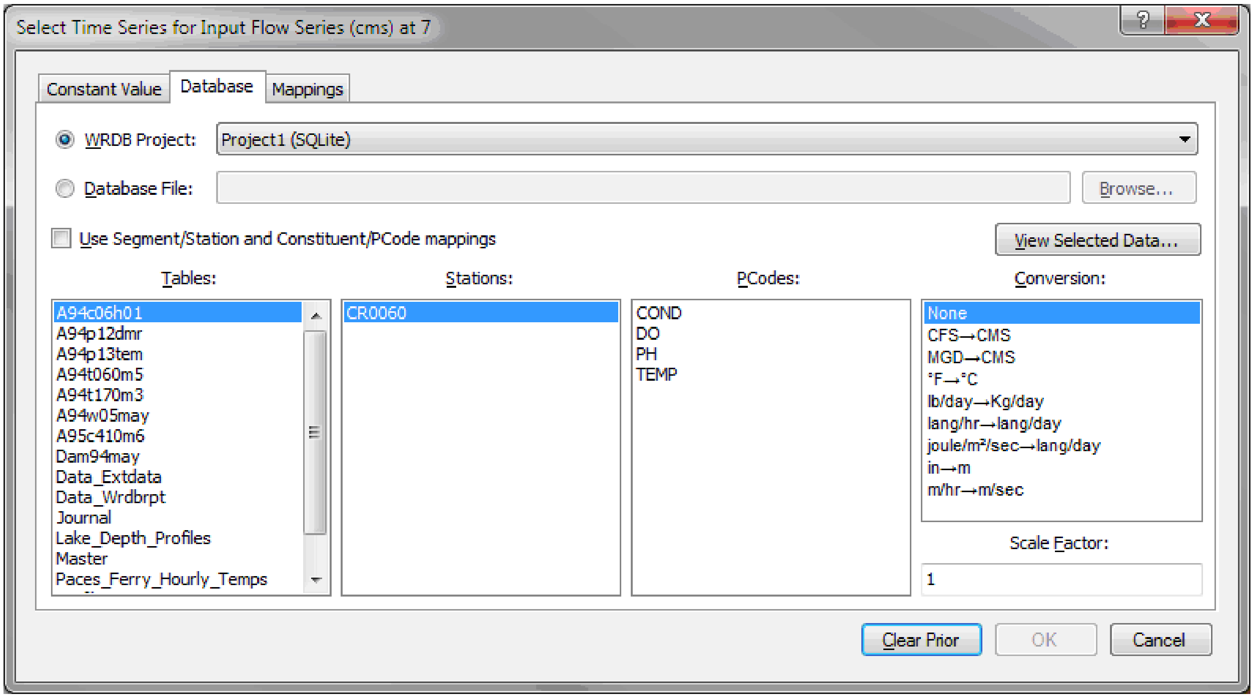
The **Flows** tab is used to specify the timeseries of input flows into each WASP boundary segment. The grid on this tab displays the cumulative drainage area and mean annual flow from the NHDPlus Flowline attributes. The user may specify any available timeseries to be used to supply the input flow in the 'Input Flow Series' column.



Input series are selected or modified by clicking the link **Click to select�** to display the Select Time Series form which consists of three tabs. The Constant Value tab allows entry of a constant value; be default it is the mean annual flow value from NHDPlus but can be changed to anything:

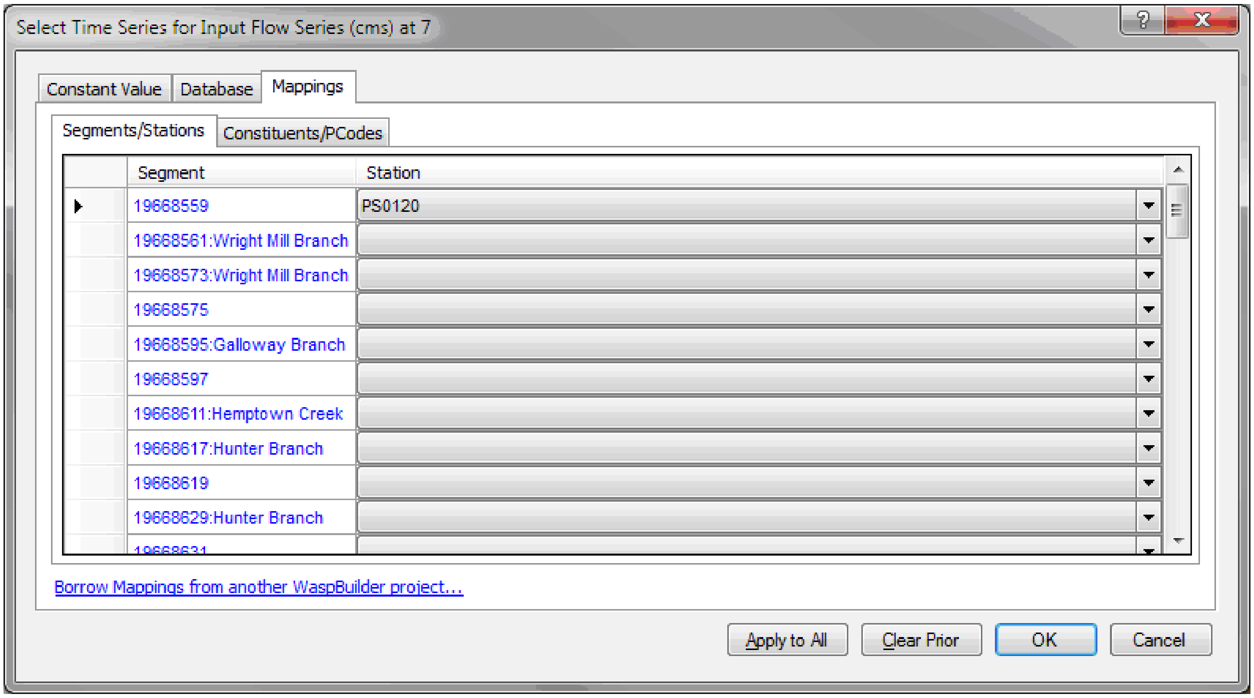


The Database tab allows selection from data contained in either standard WRDB 5.x databases or database files containing time series information with the following standard field names: Date_Time, Station_ID, PCode and Result. WRDB projects are selected from a list of existing WRDB 5.x projects referenced on your computer:

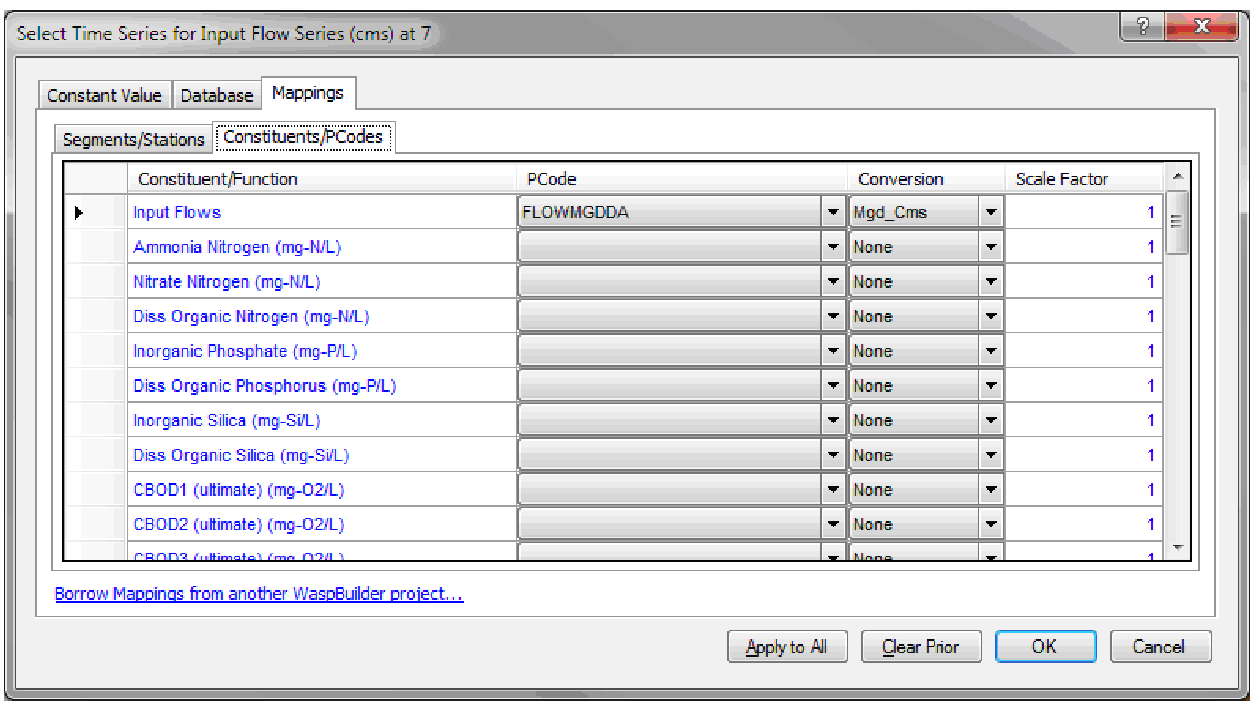


When you select a WRDB project or database file, a list of available tables is displayed. Click **View Selected Data** to display a form containing all the data in the selected table. Select the table and the list of stations is displayed, and then the list of parameters for each station. You can apply predefined conversion factors and/or scale factors.

Using these steps, you can individually assign time series data to each WASP segment. If all or most of your data are contained in a single database table, you can define segment/station and constituent/PCode mappings that will apply to all your data using the Mappings tab, which itself contains two subtabs. The Segment/Stations tab allows you to assign Station IDs from the database table to WASP segments:



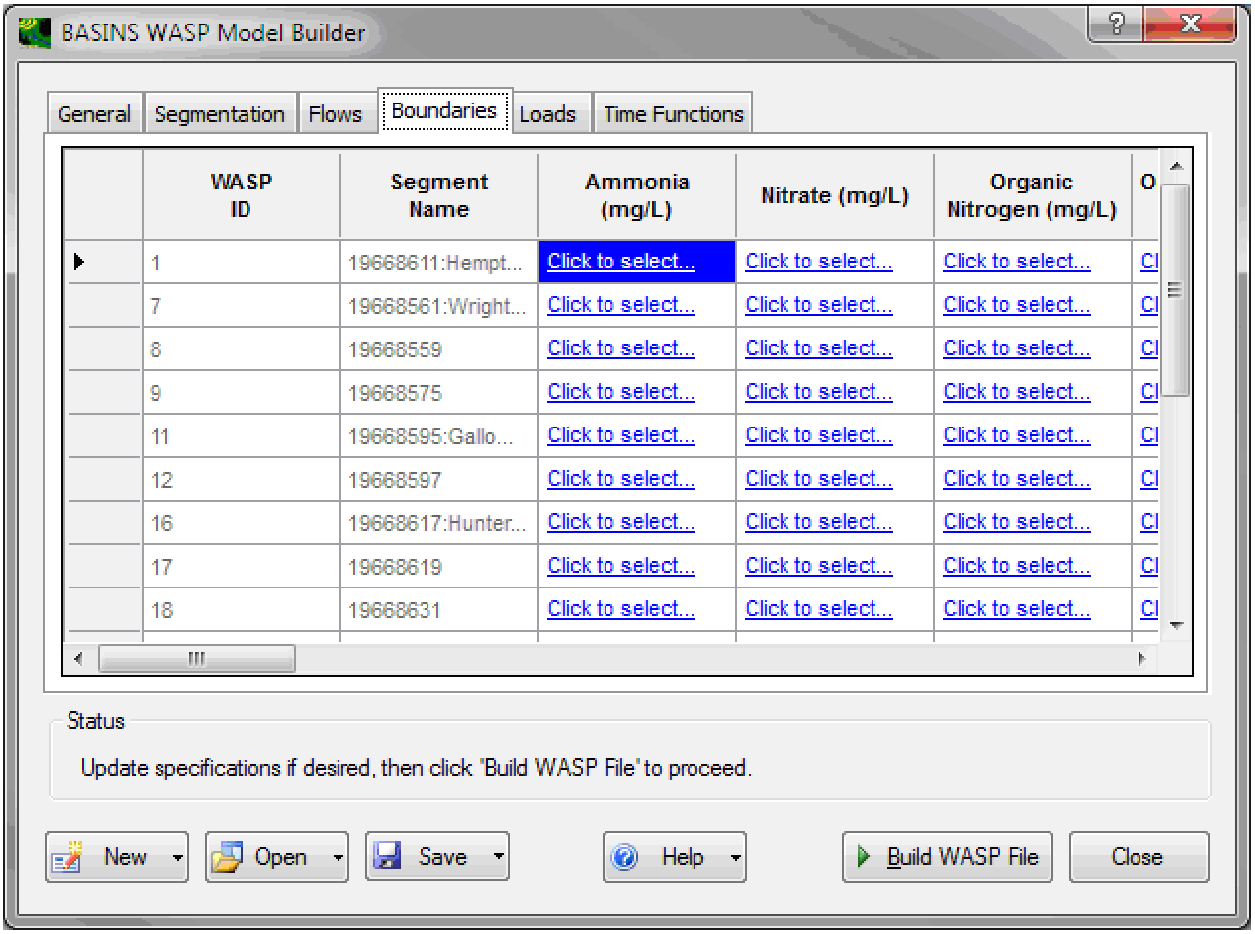
The Constituents/PCodes tab allows you to assign database PCode to WASP constituents (as well as conversion and scale factors:



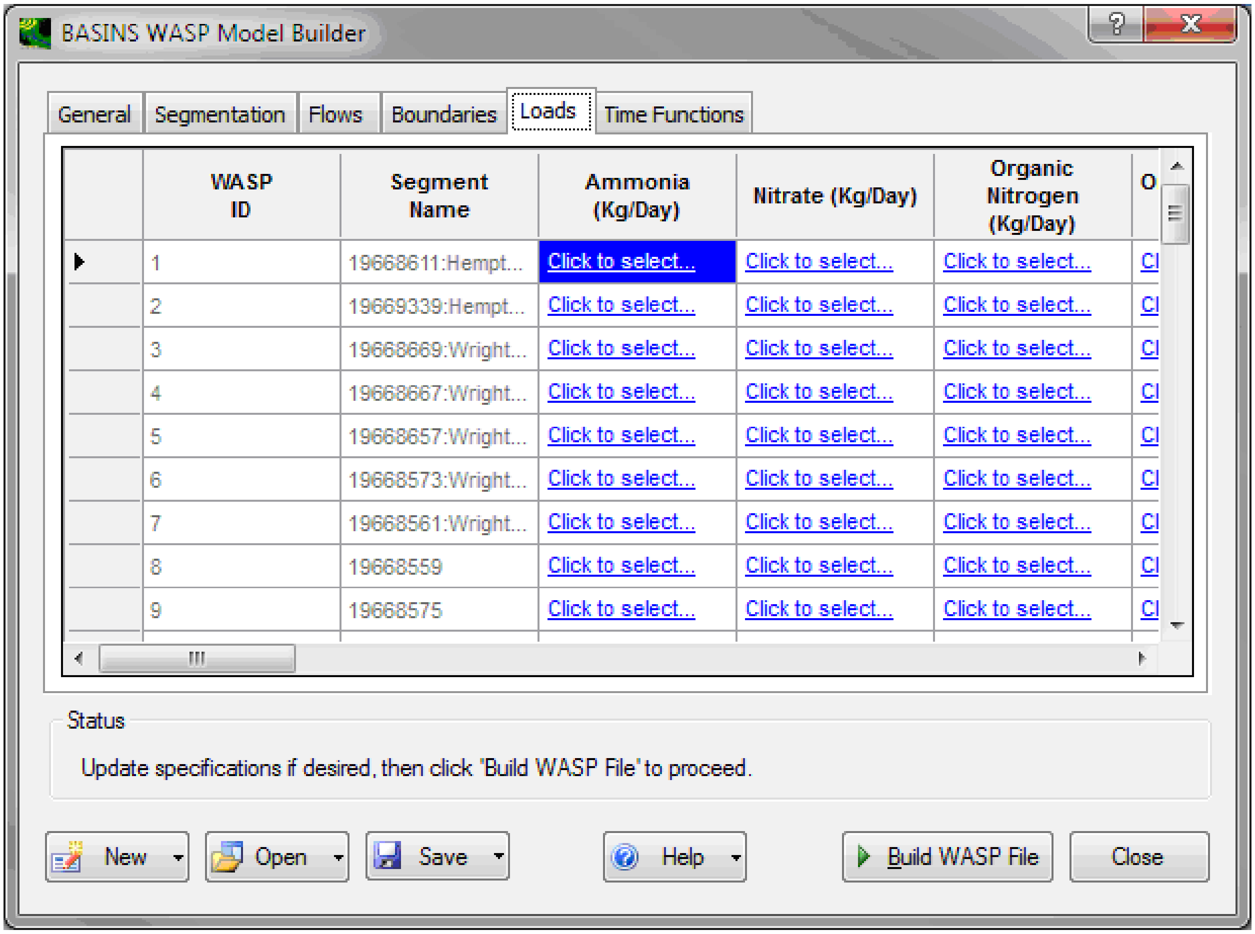
Once the mappings are defined, you can check the �Use Segment/Station and Constituent/PCode mapping checkbox of the Select Time series form. The Stations, Parameters, Conversion, and Scale

Factor controls are disabled, indicating that these all will be derived from the mappings you have defined. You can also adopt these settings for all Input Time Series by clicking the **Apply to All** button.

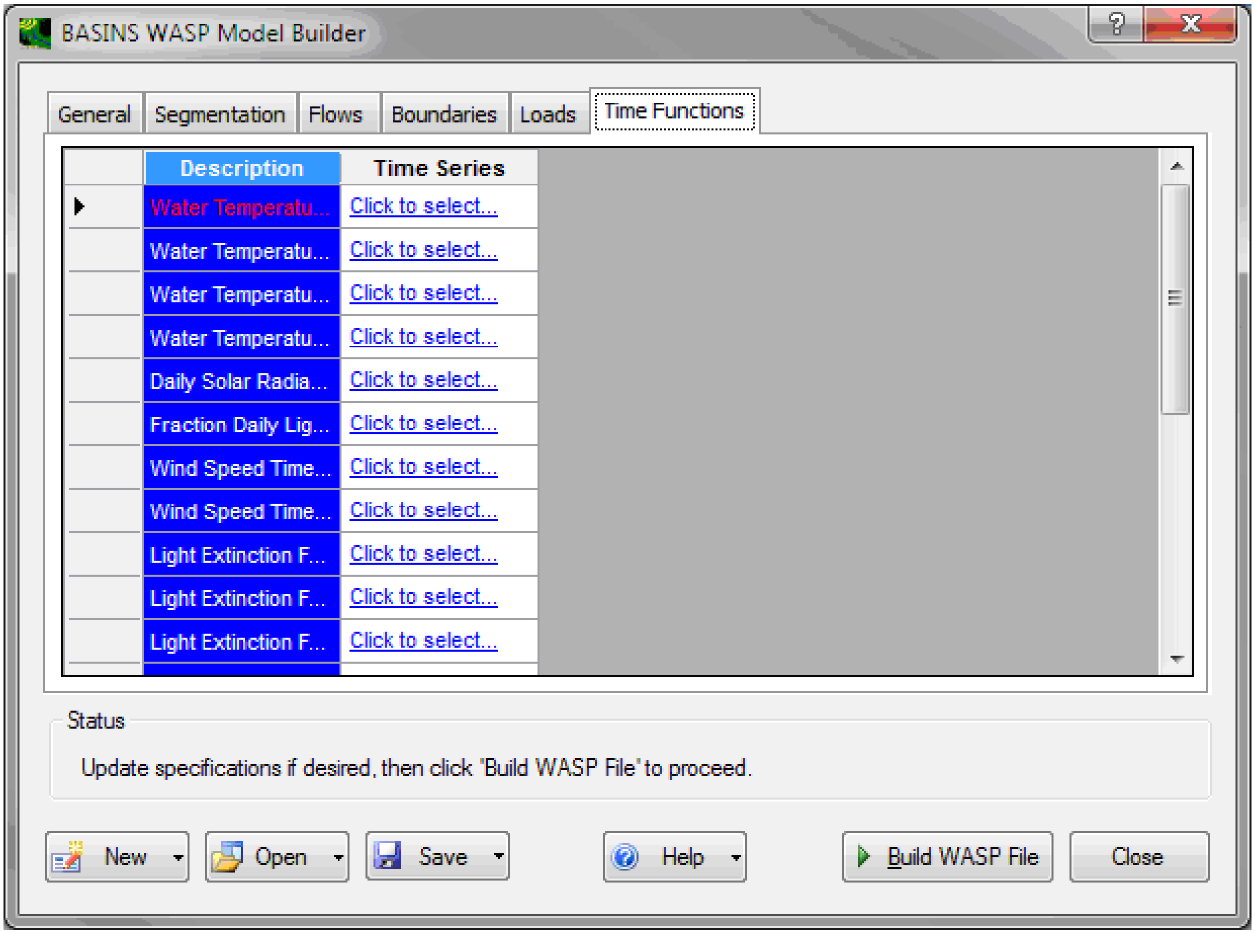
The **Boundaries** tab is used to specify the timeseries of boundaries for each WASP boundary segment. The columns of the grid represent each possible constituent for which a user might supply a boundary, and they are controlled through the 'WASP Model' selection on the 'General' tab. All timeseries in the BASINS project will be available for all user-specified Boundaries.



The **Loads** tab is used to specify the timeseries of loads for each WASP segment. The columns of the grid represent each possible constituent for which a user might supply a load, and they are controlled through the 'WASP Model' selection on the 'General' tab. All timeseries in the BASINS project will be available for all user-specified loads.



The **Time Functions** tab is used to specify which time series will be used to provide each time function for the model.



When all the specifications on each tab have been set as desired, the user may click **Build WASP File** to produce the new *WASP* INP file. Messages in the **Status** frame give updates on the progress. After this file has been created, WASP is automatically opened displaying the new project.

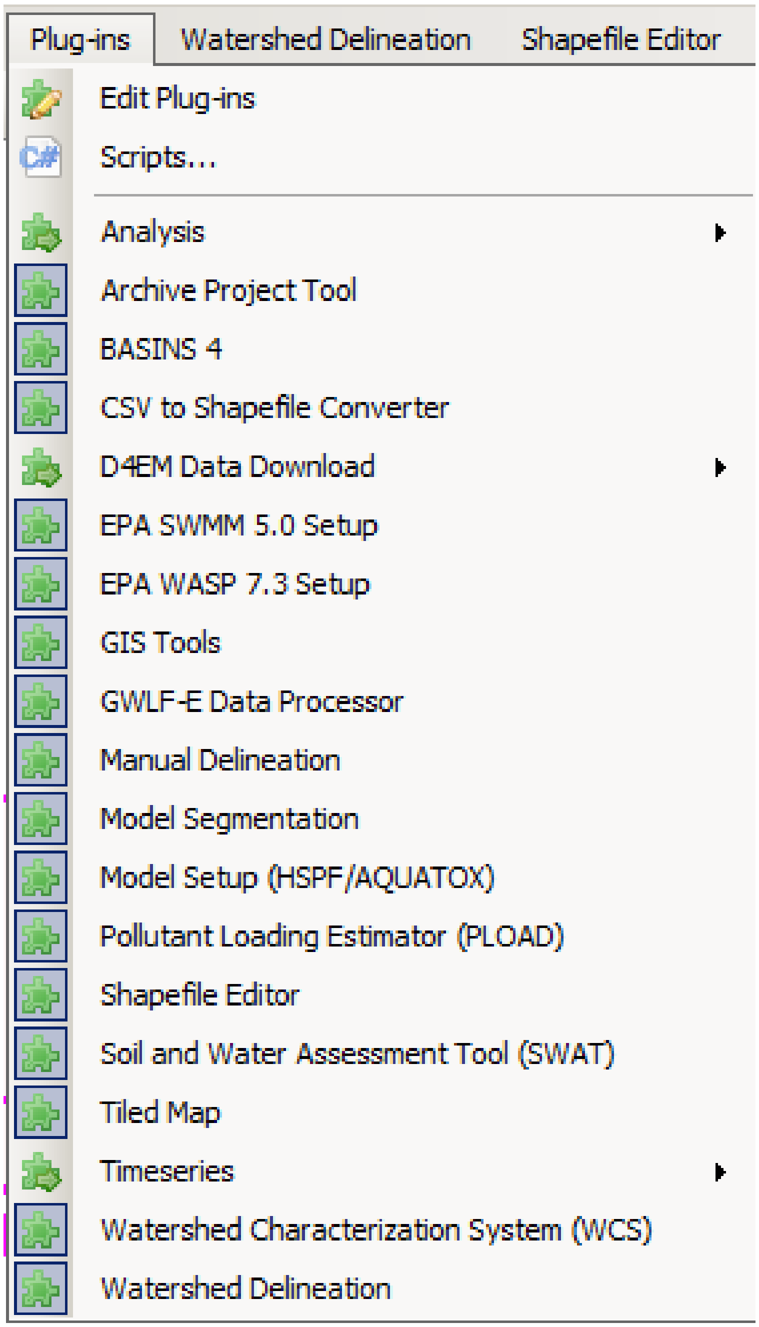
GWLF-E

The **GWLF-E** Plug-in included with BASINS is a GIS-based watershed modeling tool created by the Penn State Institutes of Energy and the Environment (PSIEE). GWLF-E is a 'mid-level' model that estimates monthly nutrient and sediment loads within a watershed. This plug-in provides a link between BASINS and PSIEE's newest version of the GWLF watershed model (now called GWLF-E). The core watershed simulation model used in the GWLF-E plug-in is based on the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker (1987). An advantage of GWLF is the ease of use and reliance on input datasets less complex than those required by other watershed-oriented water quality models such as SWAT, SWMM and HSPF.

The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loads from a watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads based on the daily water balance accumulated to monthly values.

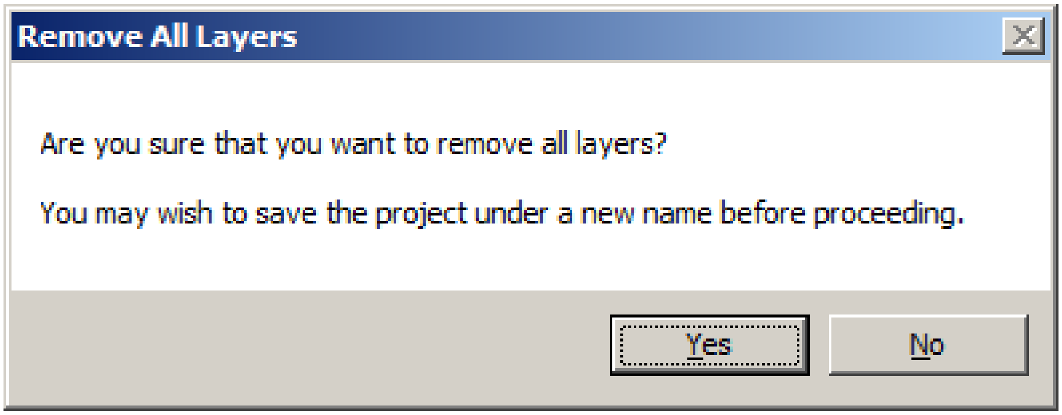
Full details of the GWLF-E BASINS plug-in are available in the *BASINS/docs* folder in the file *GWLFE_BASINS_PlugIn_Manual_V1.pdf*. Full details of the core GWLF model are documented in the file *GWLFManual.pdf* in the same folder.

Key Procedures Select **GWLF-E Data Processor** from the **Plug-ins** menu so that it is active. This will add the **GWLF-E Tools** menu and toolbar to the main BASINS form.

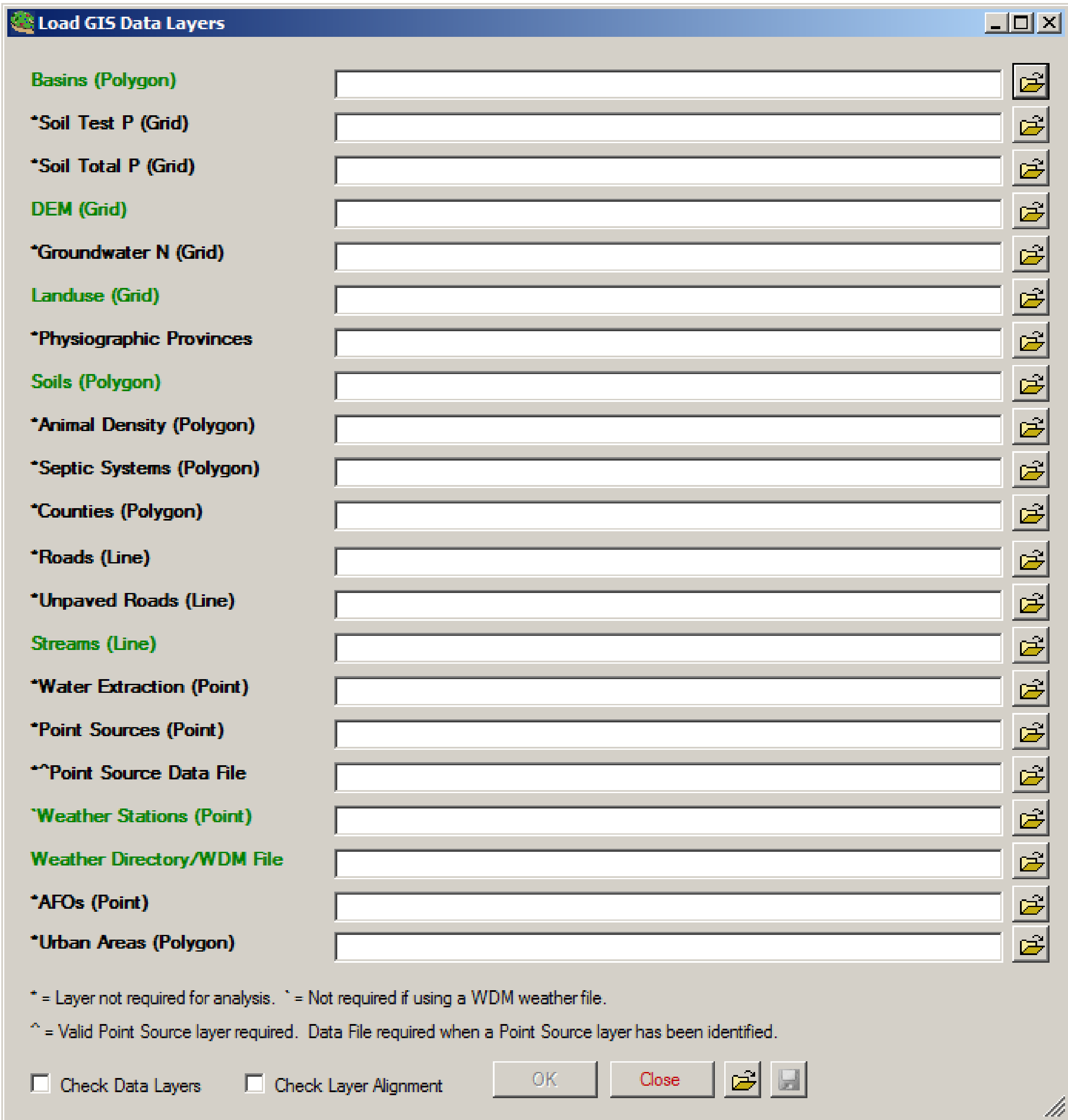


The GWLF plug-in behaves slightly differently from other BASINS model setup plug-ins. To begin, all GIS layers must be removed from the map. Before doing this, save the current project, and then use 'File:Save As' to save the project under a new name. Doing so will allow the user to return to either the original BASINS project or the GWLF project at a later time.

Select **GWLF-E Tools:Remove GIS Layers** from the main menu, or click on the Remove GIS Layers button on the GWLF-E toolbar. You will be reminded that all the layers will be removed from the map.



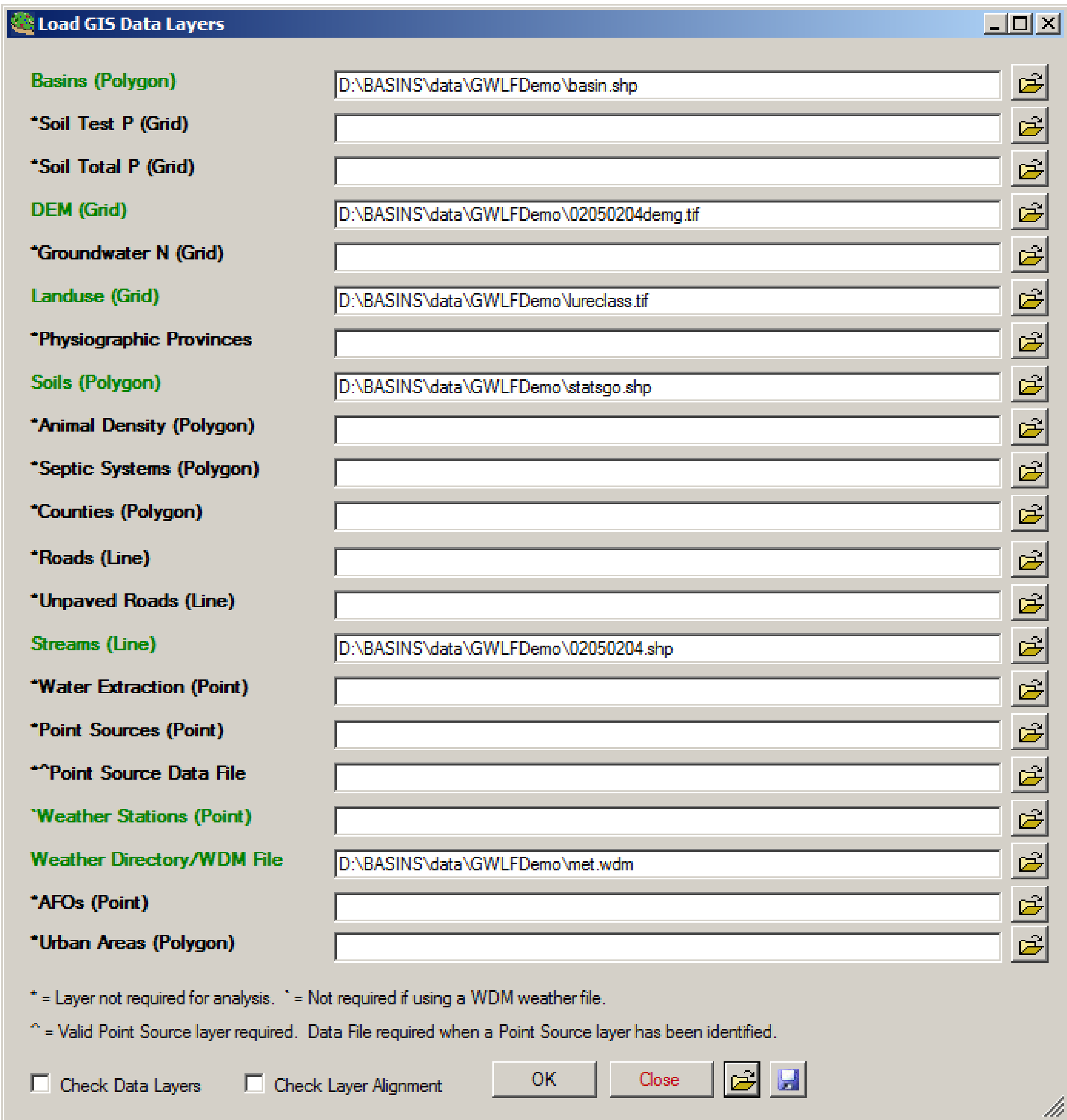
Select **GWLF-E Tools:Load Data Layers** from the main menu, or click on the Load Data Layers button on the GWLF-E toolbar. The following form will appear.



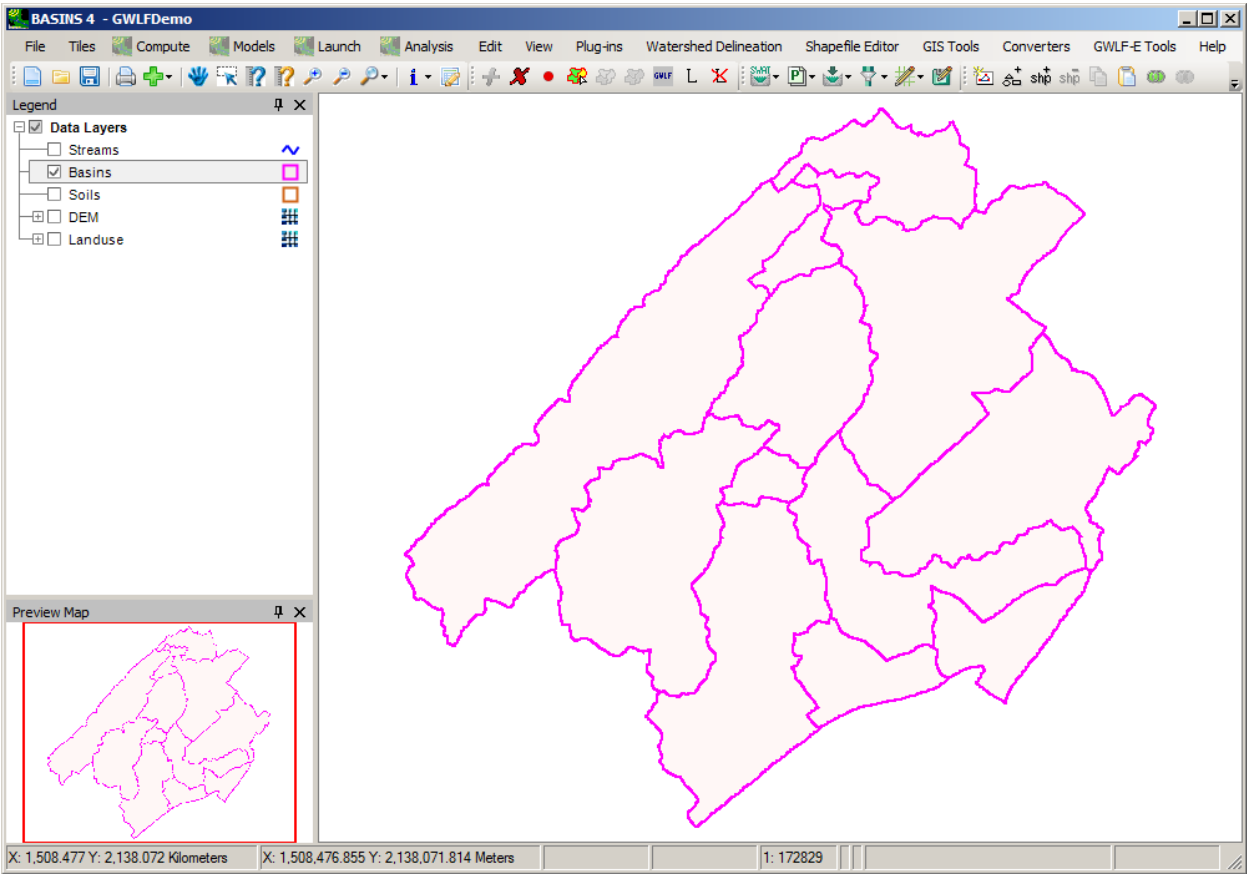
At this point, you must identify each layer that corresponds to those listed in the form. This is accomplished by clicking on the "browse to location" button at the end of each input line. When data layers created outside of BASINS are used for the first time, it is always a good idea to click on the "Check Data Layers" and "Check Data Alignment" options located at the bottom of the form to ensure that the files identified will work (i.e., that they have been created properly). If layers have been checked at least once with no errors being identified, it is not necessary to check them in subsequent data processing runs.

Note that some data set labels are green and others are black. The ones colored green indicate data sets that are absolutely required to create model input files, whereas those in black indicate "optional" data sets. Once all of the input files have been specified, they can be loaded by clicking on the OK button at the bottom of the form.

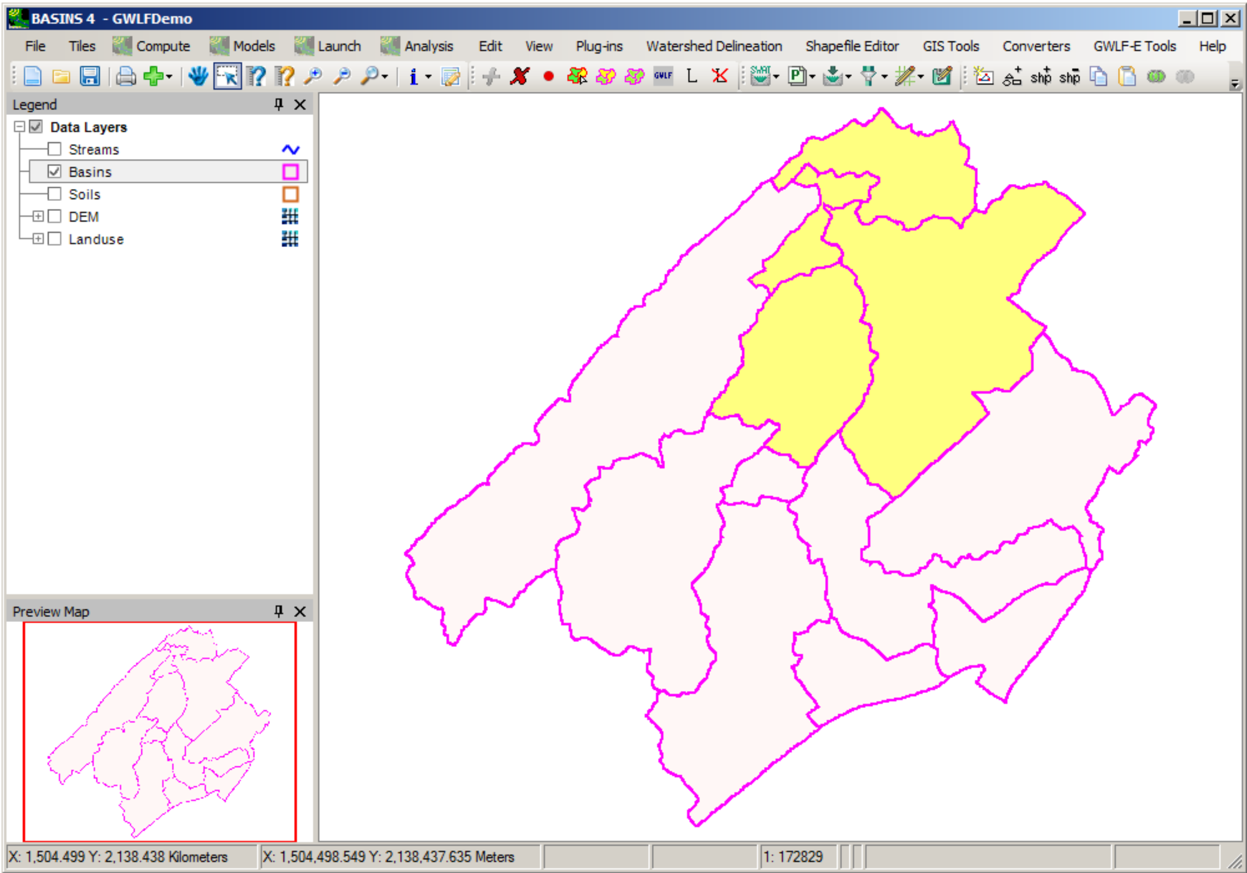
Note: Depending upon the map projection of the original project, the user might see messages about projection mis-matches. If these messages appear, for the sake of this demo, click 'Ignore' to proceed without re-projecting those layers.



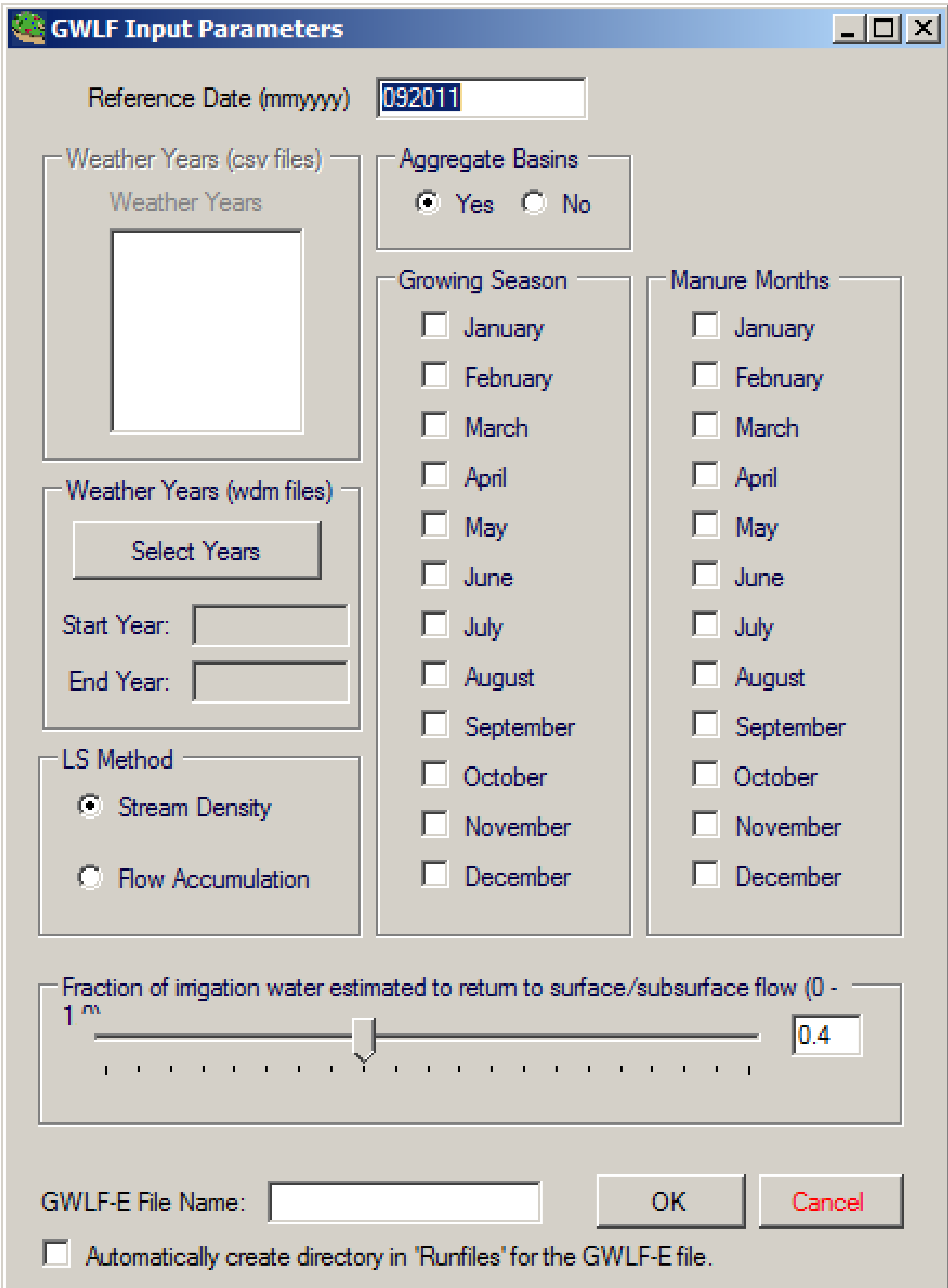
The specified layers will automatically load onto the map. An example is shown below.



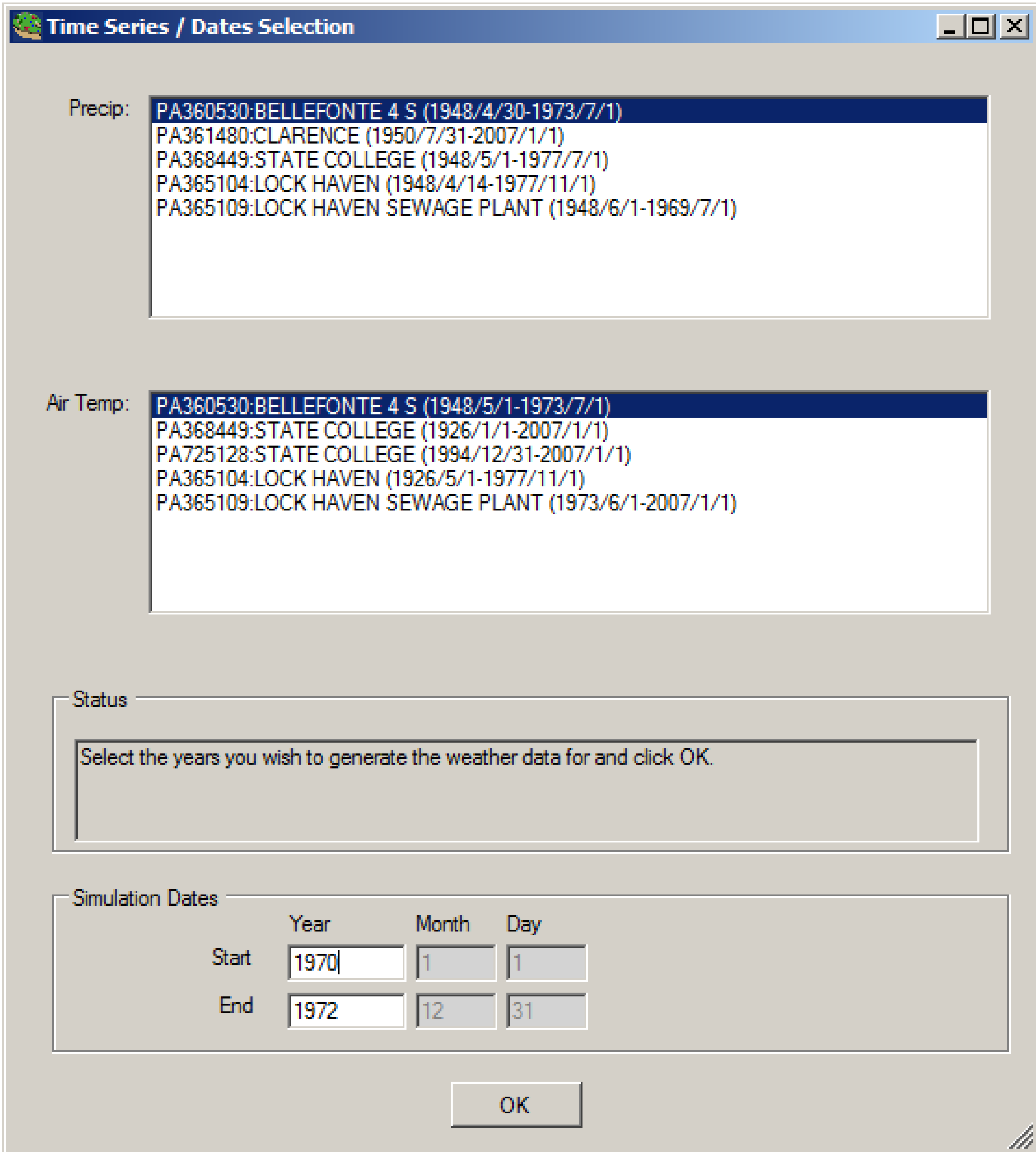
With the “Basins” theme active, select one or more watersheds that you wish to use in the analysis using the BASINS selection tool.



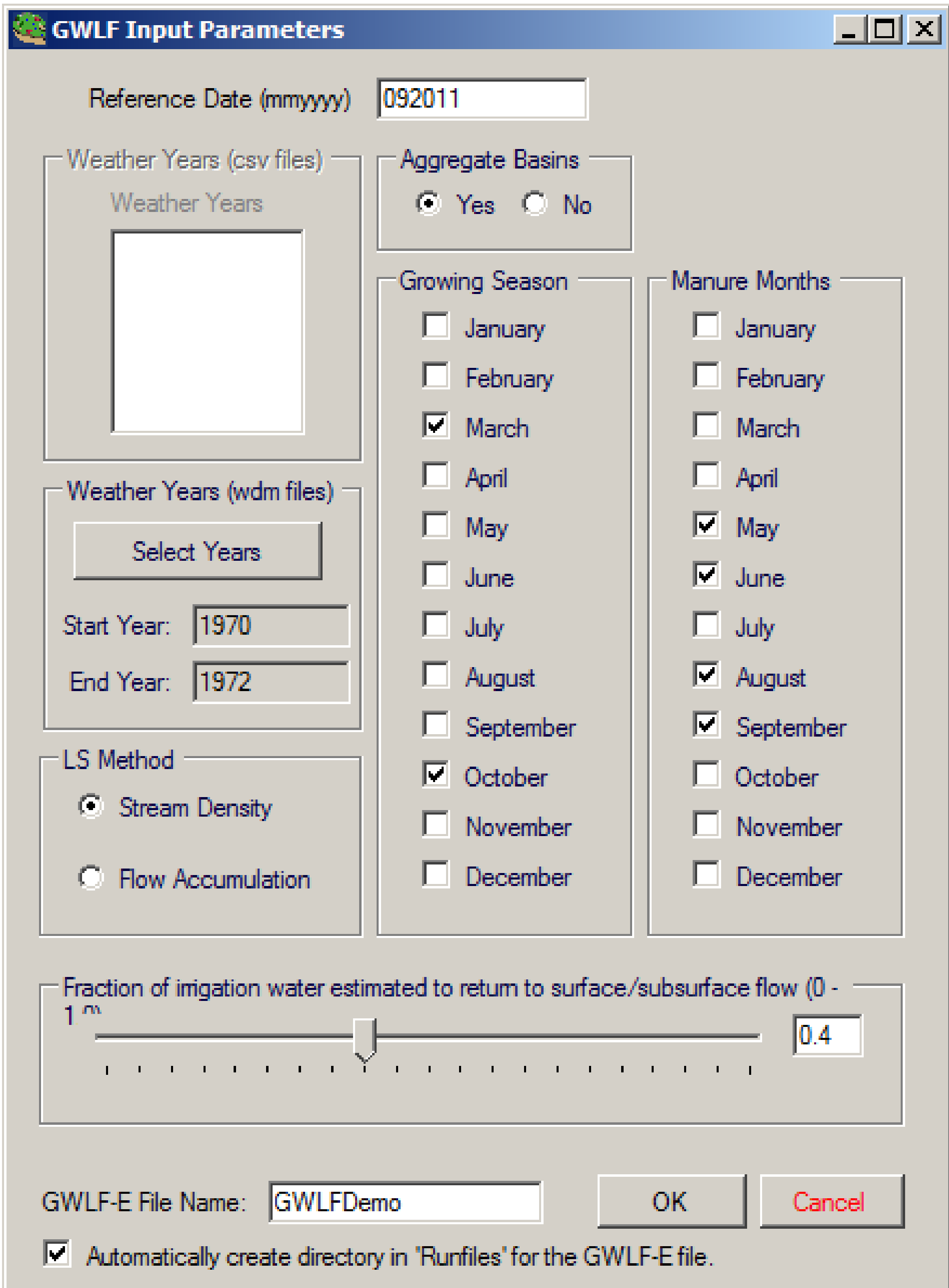
Select **GWLF-E Tools:Create GWLF Input** from the main menu, or click on the Create GWLF Input button on the GWLF-E toolbar. The following form will appear.


GWLF Input Parameters
Reference Date (mmyyyy)
092011
Weather Years (csv files)
Weather Years
Aggregate Basins
Yes
No
Growing Season
Manure Months
January
February
March
April
May
June
July
August
September
October
November
December
Weather Years (wdm files)
Select Years
Start Year:
End Year:
LS Method
Stream Density
Flow Accumulation
Fraction of irrigation water estimated to return to surface/subsurface flow (0 - 1.0)
0.4
GWLF-E File Name:
OK
Cancel
Automatically create directory in 'Runfiles' for the GWLF-E file.

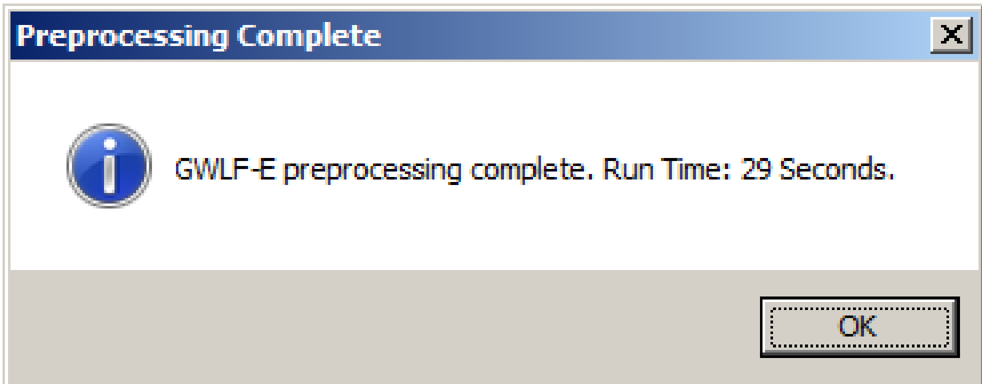
Click the 'Select Years' button, and the following form will appear for setting the start and end dates of the run based on the data available in the meteorological WDM file. Set the dates and then click 'OK'.



Specify the season (beginning and end) during which vegetation typically grows. Specify two periods during which manure is spread on agricultural fields. Specify a name for the GWLF-E file and the checkbox for automatically creating a directory for the GWLF-E input file. Then click 'OK'.


GWLF Input Parameters
Reference Date (mmyyyy)
092011
Weather Years (csv files)
Weather Years
Aggregate Basins
Yes
No
Growing Season
Manure Months
January
February
March
April
May
June
July
August
September
October
November
December
Weather Years (wdm files)
Select Years
Start Year:
1970
End Year:
1972
LS Method
Stream Density
Flow Accumulation
Fraction of irrigation water estimated to return to surface/subsurface flow (0 - 1.0)
0.4
GWLF-E File Name:
GWLFDemo
OK
Cancel
Automatically create directory in 'Runfiles' for the GWLF-E file.

Processing at this point will take several minutes. Upon completion, a message box will appear indicating that data processing has been completed.



Upon completion of the data processing steps, all of the necessary input data for the GWLF-E model have been created and included in a single input (*.gms) file. Run the model by either selecting the **Run GWLF-E** option from the GWLF Tools pull-down menu, or by clicking the **Run GWLF-E** button. The main GWLF-E window will appear as shown below.

Note that the GWLF-E input file will be written to the folder *BASINS**models**GWLF-E**Runfiles*\\.

Notes for using BASINS data in GWLF-E

Most of the data sets that are used to create input data for the GWLF-E plug-in can be compiled using the data download functions included with BASINS. Appendix F of the Guide to Utilizing the GWLF-E Plug-in within the BASINS 4.x Environment, provided in the *BASINS/docs* folder in the file

GWLFE_BASINS_PlugIn_Manual_V1.pdf, provides explicit details of the data layers needed and specific characteristics of those layers.

Hints for resolving frequently encountered limitations:

- The streams shapefile must have a field named 'STRMID' containing an integer stream ID that is unique for each stream segment. This field can be added and populated using the MapWindow Table Editor.
- The soils shapefile must have fields named 'MU_AWC', 'MU_KF', and 'MUHSG_DOM'. 'MU_AWC' must be a real number and should represent the available water-holding capacity in cm. 'MU_KF' must be a real number representing the soil erodibility (K) factor (typical range of 0.1 - 0.5). 'MUHSG_DOM' must be a text string representing the dominant hydrologic soil group (values of A, B, C, or D). These fields can be added using the MapWindow Table Editor. Appropriate values for populating the fields can be found in the USDA Web Soil Survey interface (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm).
- Land use must be provided as a grid, with specific codes for each land use category. Land use reclassification can be performed using the tool found in the menu selection 'GWLF-E Tools:Edit/Data Check Tools:Reclassify Landuse', using the codes from Table G13 of the *GWLFE Plug-in Manual*.

For complete details see the *GWLFE Plug-in Manual*.

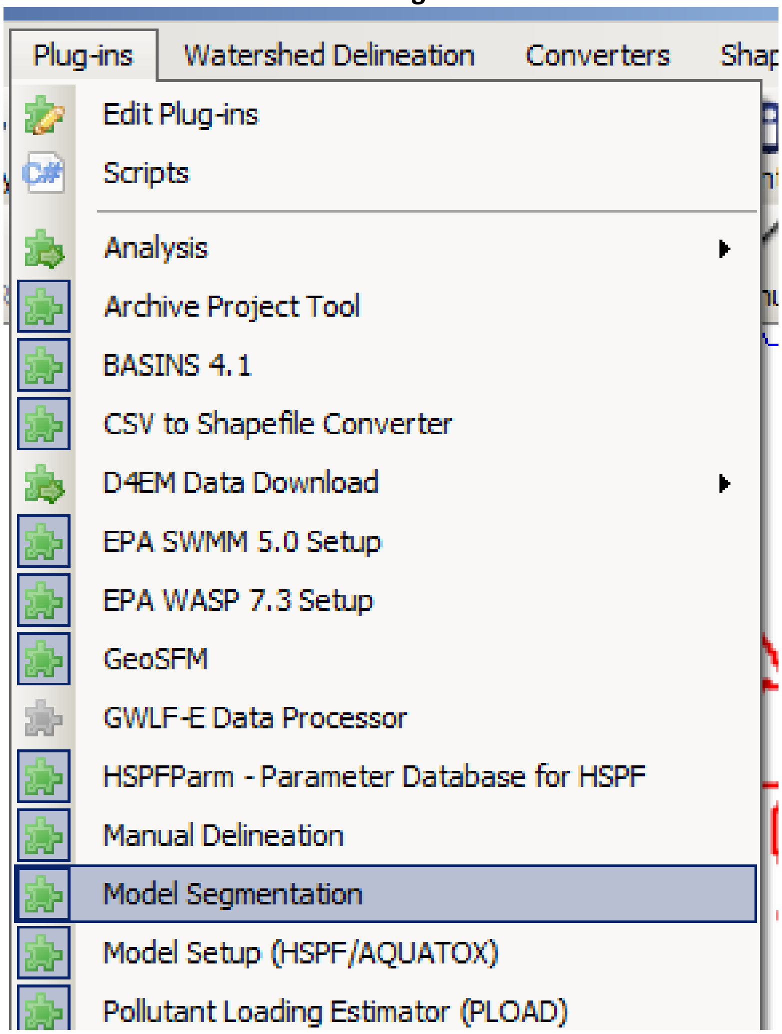
Model Segmentation Specifier

The BASINS Model Segmentation Specifier is not itself a model, but a tool for use in specifying the model segmentation for setting up a model. This tool has been designed especially for HSPF, but it may be useful for other models where subbasins should be grouped in some fashion, often by the nearest or most appropriate meteorologic data.

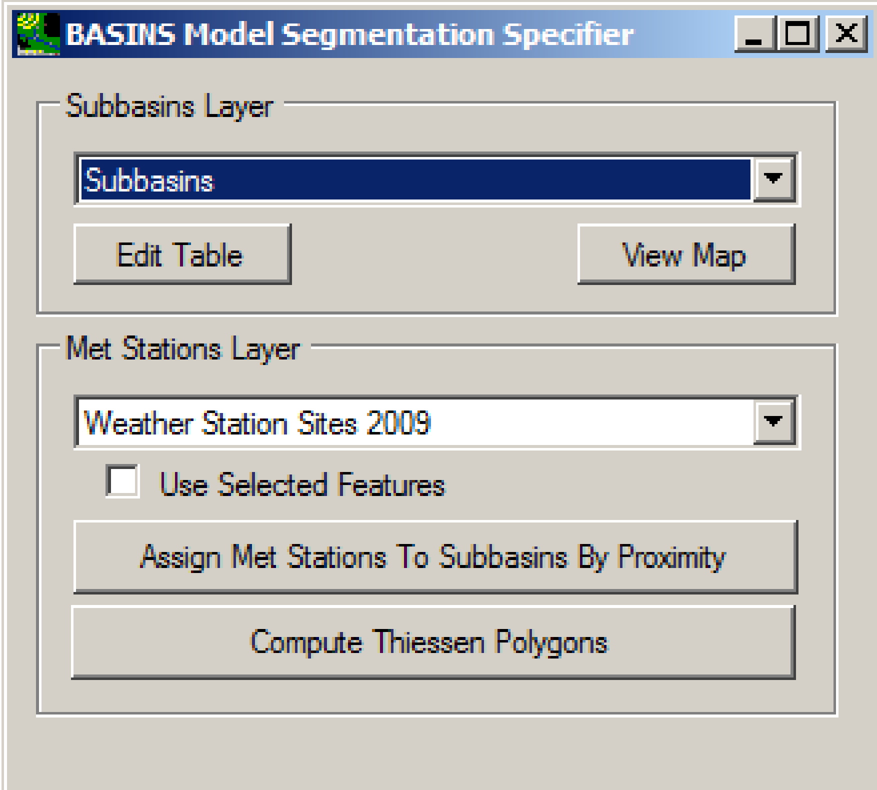
The Model Segmentation Specifier provides the user with a simple interface for adding a field to the Subbasins Layer attribute table containing a model segment identifier. This model segment identifier can be used with the HSPF setup tool to indicate subbasins that will be modeled as a common model segment, most often due to common meteorlogical input data. The Model Segmentation Specifier also provides a direct means to edit the model segment identifier and to create a thematic map of subbasins rendered by common model segment identifier.

Key Procedures

1. From on the main BASINS window, select **Model Segmentation** from the **Plug-ins** menu so that it is active. This will add **Model Segmentation** to the 'Models' menu on the main form.



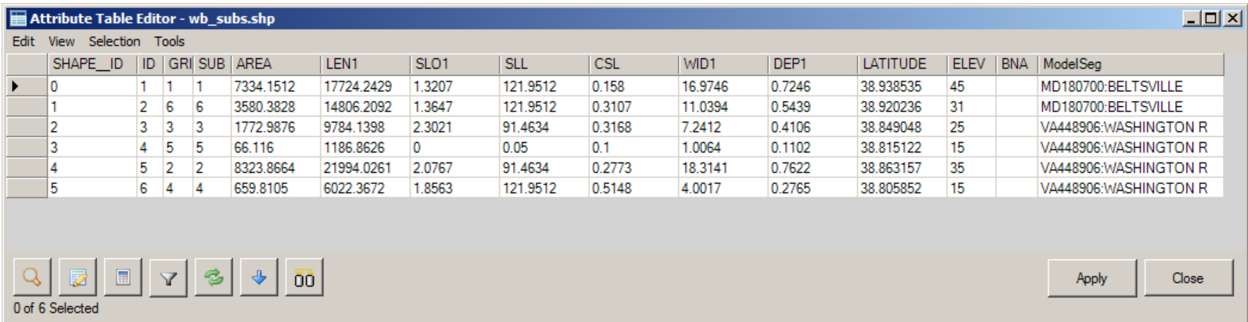
2. Select **Models:Model Segmentation** from the main menu to invoke the **Model Segmentation** specifier form.



3. Specify the Subbasins Layer and the Met Stations Layer, and then click **Edit Table**, **View Map**, **Assign Met Stations to Subbasins By Proximity**, or **Compute Thiessen Polygons**.

With a Subbasins Layer and a Met Stations Layer selected, clicking **Assign Met Stations to Subbasins By Proximity** will result in each of the subbasins being assigned the nearest of the selected met stations. After using this option, the resulting model segment identifier can be displayed and edited using the **Edit Table** button, and it may be thematically displayed on the map using the **View Map** button.

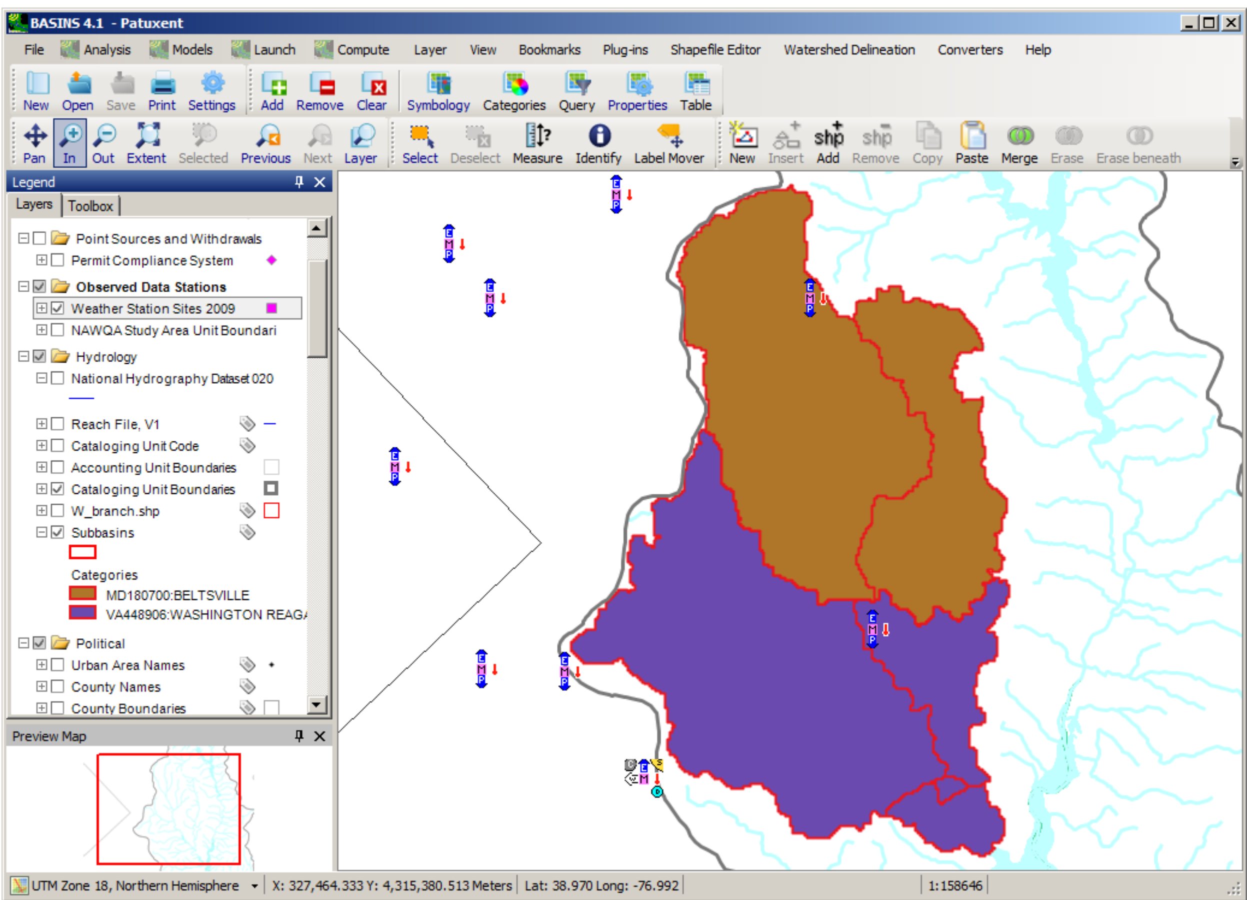
The new field in the attribute table is named 'ModelSeg'. When using the 'assign' function, each subbasin will be assigned the identifier and station name of the closest station in the specified met station layer. The 'ModelSeg' attributes may be edited as desired. Any unique 'ModelSeg' attribute value indicates a separate model segment to the Model Setup plugin for HSPF.



Attribute Table Editor - wb_subs.shp

SHAPE__ID	ID	GRI	SUB	AREA	LEN1	SLO1	SLL	CSL	WID1	DEP1	LATITUDE	ELEV	BNA	ModelSeg
0	1	1	1	7334.1512	17724.2429	1.3207	121.9512	0.158	16.9746	0.7246	38.938535	45		MD180700:BELTSVILLE
1	2	6	6	3580.3828	14806.2092	1.3647	121.9512	0.3107	11.0394	0.5439	38.920236	31		MD180700:BELTSVILLE
2	3	3	3	1772.9876	9784.1398	2.3021	91.4634	0.3168	7.2412	0.4106	38.849048	25		VA448906:WASHINGTON R
3	4	5	5	66.116	1186.8626	0	0.05	0.1	1.0064	0.1102	38.815122	15		VA448906:WASHINGTON R
4	5	2	2	8323.8664	21994.0261	2.0767	91.4634	0.2773	18.3141	0.7622	38.863157	35		VA448906:WASHINGTON R
5	6	4	4	659.8105	6022.3672	1.8563	121.9512	0.5148	4.0017	0.2765	38.805852	15		VA448906:WASHINGTON R

The **View Map** button creates a thematic map of the 'ModelSeg' attribute as shown below. Subbasins rendered in the same fill color will be created as a unique model segment in the HSPF when the 'ModelSeg' field is specified as the 'Model Segment ID Field' in the 'Subbasins' tab of the BASINS/HSPF Setup plugin.



The **Compute Thiessen Polygons** button creates a map layer of Thiessen Polygons around the points of the specified Met Stations layer. Thiessen polygons may be defined as polygons whose boundaries define the area that is closest to each point of the input layer, relative to all other points. They are mathematically defined by the perpendicular bisectors of the lines between all points. The new map layer will automatically be added to the map and assigned the name 'Thiessen Polygons for' followed by the name of the Met Stations layer. This new Thiessen Polygon layer can be used for reference in assigning met stations to subbasins.

HSPFParm

Successful application of HSPF requires modelers to evaluate parameters for a large number of process-based algorithms. One of the most pressing needs to support the expanding community of HSPF modelers is for a readily available source of model parameter values that can provide the best possible starting point for developing new watershed applications. To meet this need, EPA has funded the collection of HSPF parameter values from previous applications across North America, assimilation of the parameter values into a single database, and development of an interface that enables modelers to access and utilize the database.

The U. S. Environmental Protection Agency under Purchase Order 7W-1220-NASX to AQUA TERRA Consultants dated September 22, 1997 funded the original development of the HSPFParm database and supporting software. The pilot HSPFParm database contained parameter values for model applications in over 40 watersheds in 14 states.

The Minnesota Pollution Control Agency (MPCA) funded an update to HSPFParm in 2012. Under contract to the MPCA, AQUA TERRA Consultants ported the original stand-alone HSPFParm software to this BASINS plug-in. As part of that project, many recent Minnesota HSPF applications were added to the HSPFParm database.

The parameter values that are contained in the database characterize a broad variety of physical settings, land use practices and water quality constituents. The database has been provided with a simplified interactive interface that enables modelers to access and utilize HSPF parameter values developed and calibrated in various watersheds across the United States. It is anticipated that the HSPFParm database will be expanded as current and future model applications are completed.

Introduction Successful application of HSPF requires modelers to evaluate parameters for a large number of process-based algorithms. By doing so, modelers ‘fine tune’ the model to represent site-specific physical, chemical and biological conditions that determine the fate and transport of pollutants. Typical applications of HSPF require the development of parameter values numbering in the hundreds. As a result, one of the most pressing needs to support the expanding community of HSPF modelers is for a readily available source of model parameter values that can provide the best possible starting point for developing new watershed applications.

To meet this need, EPA has funded the collection of HSPF parameter values from previous applications across North America, assimilation of the parameter values into a single database, and development of an interface that enables modelers to access and utilize the database.

The basic goal of developing a water quality parameter database for HSPF applications is to provide model users with one of the tools they need to develop realistic input sequences to run the model at other sites. At some point in the future it will likely be possible to tie environment-dependent water quality parameter values directly to modeling units (e.g., USGS hydrologic units) across large areas of North America. (Efforts to do the same for HSPF’s hydrology parameters have already been accomplished in some areas such as the Puget Sound Region.) Users’ needs to refine these baseline values and to develop values for additional water quality parameters will likely be met by use of decision support and/or expert systems that utilize additional databases, estimation techniques and rules in order to generate the needed values. By providing an archive of HSPF parameter values from across North America, HSPFParm is a first step in developing these future capabilities.

The current version of HSPFParm was developed by porting the original stand-alone version into the BASINS software in the form of a plug-in. This development updates the programming code base of the original software, and the new plug-in can take advantage of the BASINS's modern GIS mapping capabilities.

Purpose

The purpose of developing the model parameter database is to provide BASINS and HSPF users with the best possible starting point for evaluating HSPF parameter values for calibration efforts on new watershed applications, or additional studies on watersheds that have already been modeled. Nearly two decades of HSPF applications provide a valuable resource for expediting and improving the parameter evaluation process for future model applications. The collection of available parameter values into a single database with straightforward user interaction capabilities enables modelers to efficiently identify and access calibrated parameter values for modeling studies performed on watersheds that may have similar characteristics/settings to the watersheds which they intend to model.

This pilot effort to collect and unify the collective body of HSPF parameter values for model applications in North America set the groundwork for archiving the data that will be made available from a growing number of ongoing and future applications. It is anticipated that the HSPFParm database will be expanded as current and future model applications are completed.

Scope

The scope of the original database was defined to include study sites that meet all the following requirements:

- Sites at any scale, anywhere in North America, where HSPF water quality simulation has been performed
- Modeling studies that include both hydrology and water quality calibration parameters; water quality simulations may include one or more water quality constituents (i.e., water temperature, sediment, conventional pollutants, pesticides, etc.)
- Calibrated model parameters are available as of September 1998

The Minnesota Pollution Control Agency (MPCA) funded an update to HSPFParm in 2012, through a contract to AQUA TERRA Consultants. This project ported the original stand-alone HSPFParm software to a BASINS plug-in. As part of that project, many recent Minnesota HSPF applications were added to the HSPFParm database.

Limitations

Limitations to the database product resulting from this pilot effort include those related to (1) the type of assistance made available to modelers for evaluation of model parameters, and (2) the completeness of the database of parameter values. Each of these categories of limitations is addressed below.

Limitations to nature of parameter evaluation assistance

The basic goal of developing a water quality parameter database for HSPF applications is to provide model users with one of the tools they need to develop realistic input sequences to run the model at other sites. In defining and limiting the scope of this product, we recognize that additional tools are needed by model users in order to ensure the opportunity to develop the best possible values for the parameters that determine water quality simulation results. Other useful tools include the following:

- Parameter definitions
- Summary information relating parameter values to key environmental factors and/or management practices
- When available, parameter estimation techniques
- Decision support and/or expert system capabilities that recognize interdependence of parameters and provide a directed sequence for developing full input sequences and guiding calibration efforts

Capabilities listed above are not included in the HSPFParm database product.

The usefulness of the data contained in the HSPFParm database is wholly dependent on the users' ability to evaluate whether or not the values are appropriate, and hence transferable, to the site that they are modeling. To make this determination, users need to evaluate supplemental data (e.g., hydrology, soils, weather, topography, land use, chemical properties) that characterize their own modeling site and the modeling sites/scenarios contained in the database; further, users must be able to discern the relevance of the characterization data to specific water quality parameters.

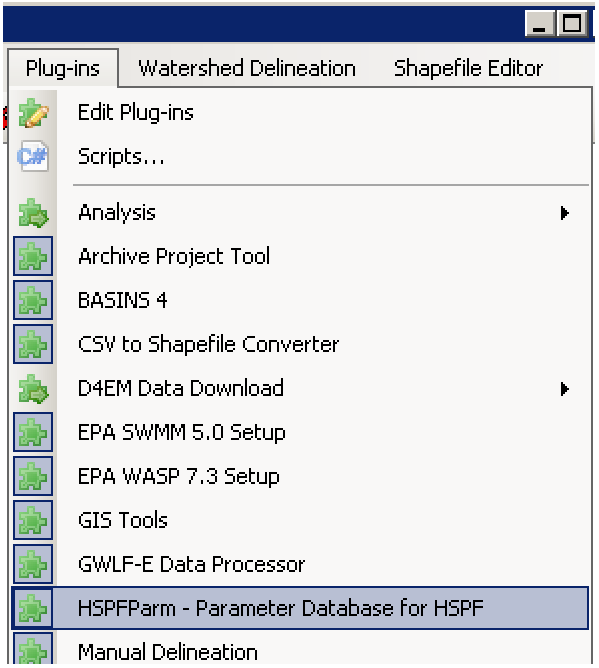
The database product does not provide a sophisticated mechanism or specific guidance that allows users to identify the list of water quality parameter values that need to be adjusted to reflect basic differences between a site/scenario contained in the database and a similar site that needs to be modeled. The database does, however, provide a 'coarse characterization' of important factors influencing parameter transferability; the characterization includes such relevant information as a modeling site's physiographic setting (e.g., coastal piedmont), the climate regime, the baseline land use types that are represented in model segments, and the relative scale (i.e., drainage area) of the model segments.

Limitations to completeness of HSPF applications database

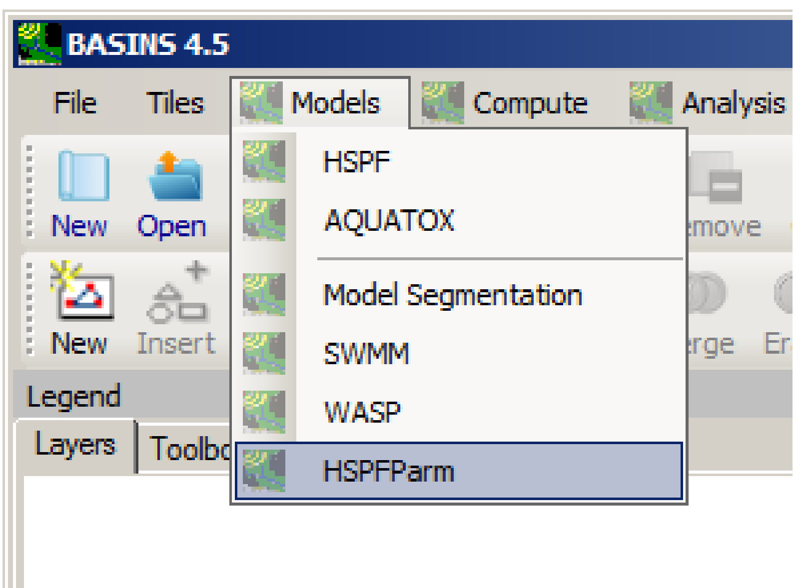
Acquisition of parameter data sets for past HSPF applications can be a difficult process. As a result, the breadth of data that are currently contained in the database is not comprehensive. There is an opportunity to include data for a number of additional applications, some already completed and others nearing completion in the near future.

Certain types of data included in the User Control Input for some HSPF model applications are not included in the current version of HSPFParm. In particular, changes to parameter values implemented using HSPF Special Actions capabilities are not stored and made available in the HSPFParm database. Approach The approach used to develop the original parameter database featured seven steps: Identify HSPF applications. A thorough search for HSPF applications in North America that included hydrologic and water quality calibration was performed. Those responsible for the model applications were contacted and needed data (HSPF User Control Input (UCIs), study reports) were requested. Develop a characterization strategy. A list of 'coarse characterization' attributes (predominantly information not contained in the HSPF User's Control Input) was established. Compilation of these attributes was deemed necessary in order for a user to assess whether the application might yield information relevant to the watershed he or she intends to model. A strategy was also developed to extract information from the application UCIs and enter it into the parameter database. (UCIs contain an additional level of modeling detail greater than that currently accommodated in the parameter database.) Identify database requirements. A data model was developed to define the contents of fields and parameter tables, the structure within tables, and the relationship between tables. Parameter values were organized first by watershed, and second by modeling scenario. Produce database user interface. Requirements for a simple user interface were identified, and the interface was implemented using Visual Basic and MapObjects LT. In addition, an interface to the native data in the UCIs was developed. The interface provides the capability to erase, rebuild and add data for additional applications. This simplifies the activities of the HSPFParm database maintainer. Evaluate model applications. This task entailed implementing the characterization strategy. Study reports and supplemental information sources were reviewed to compile coarse characterization data for each model application. UCIs were evaluated manually and electronically to assess completeness of data. UCIs that were only available in paper format were converted to electronic format. Produce database. A batch processor was developed and used to populate the parameter database; the processor extracted data from a 'master' flat file containing coarse characterization and UCI file data. Iterative use of the batch processor identified the need to accommodate additional input options. In response, the user interface and the data model were adjusted to accommodate the additional data options. Quality assurance was performed to check the ability of the processor to correctly transfer parameter values into the database. Report results. Documentation was developed to explain the project approach, the database, and the user interface embodied in the final product. Operational Instructions The new BASINS-HSPFParm plugin helps users to query the HSPFParm database by organizing the querying through a natural "narrowing down" process. Users first choose watersheds using location or other characteristics, followed by choosing particular scenarios within those watersheds, then followed by choosing segments or reaches from within those scenarios, and finally particular parameter values from those selections can be displayed, saved to a file, or sent to a printer.

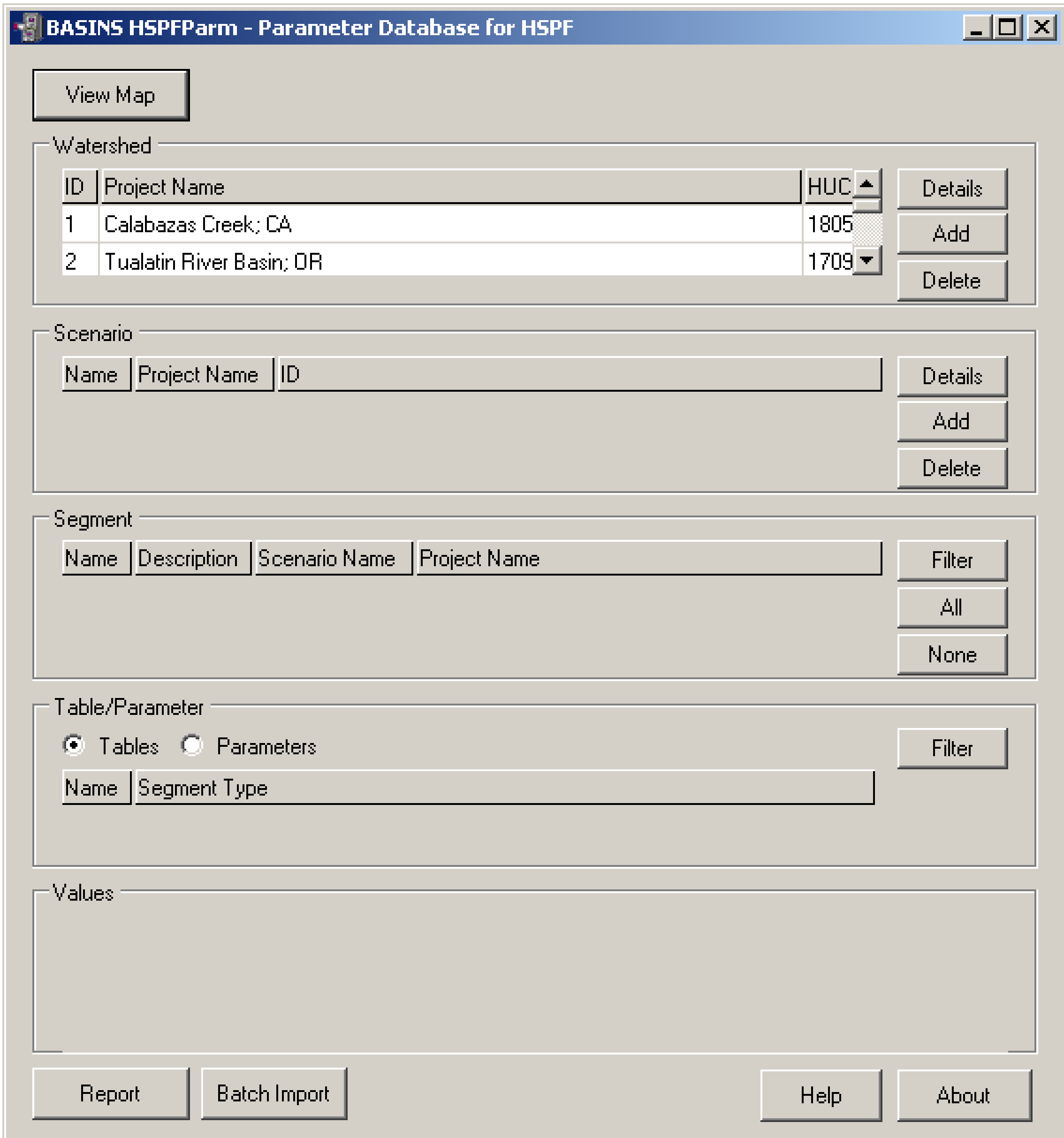
This part of the guide assume users have already downloaded and installed the BASINS software. To use HSPFParm in BASINS, users need to first turn on the HSPFParm plugin from the 'Plug-ins' dropdown menu as shown below.



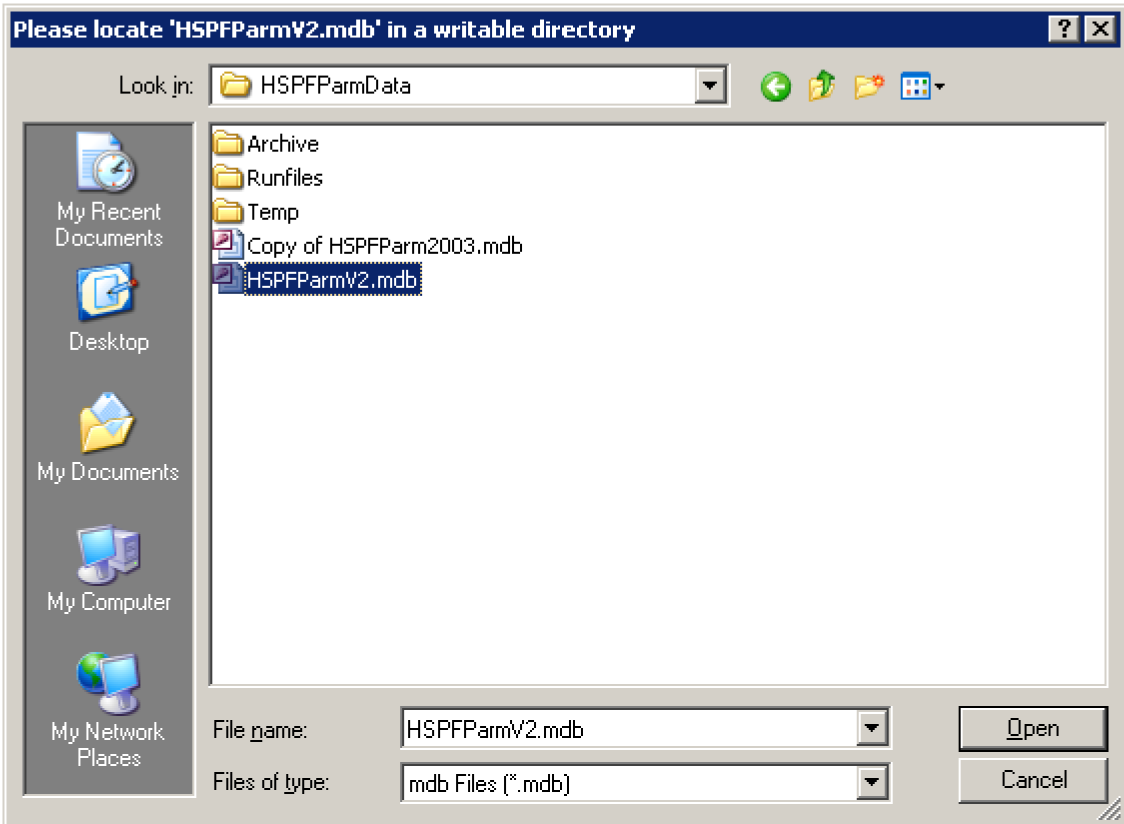
Then, HSPFParm main window can be accessed from the 'Models' menu as shown below.



Upon selection of the 'HSPFParm' option under the 'Models' menu, the main window will appear as shown below.



If users run it for the first time, the software will ask user for the location of the HSPFParm Access database file as shown below.

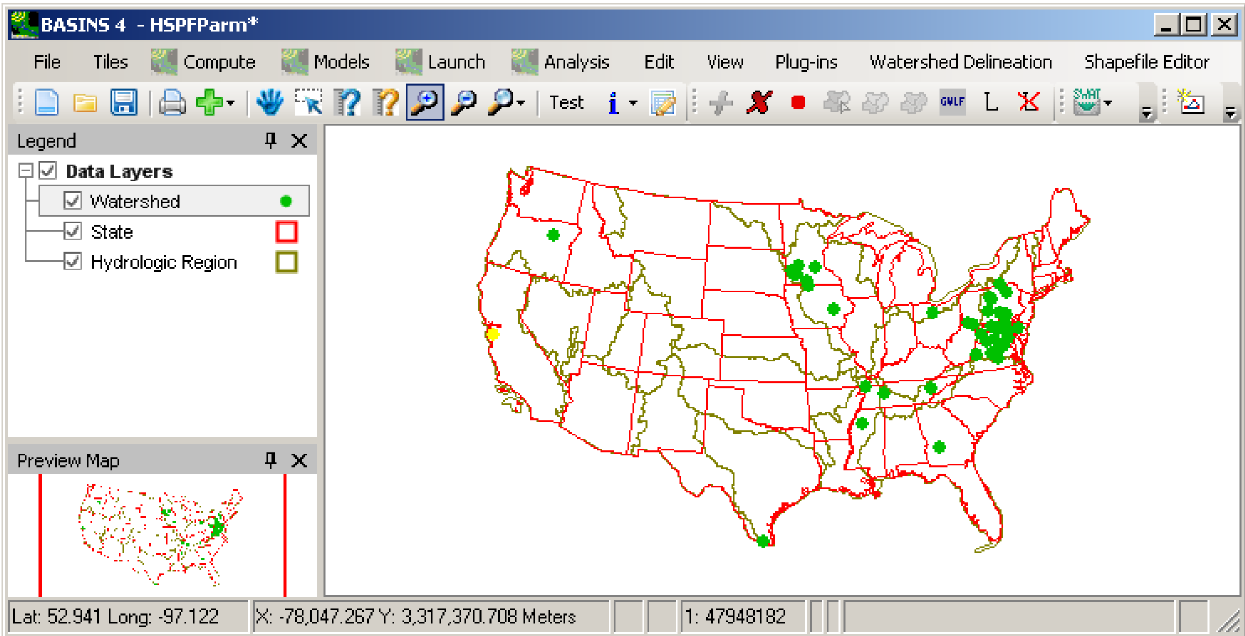


This MS Access MDB file comes with the BASINS software installation, it is usually installed by default here:

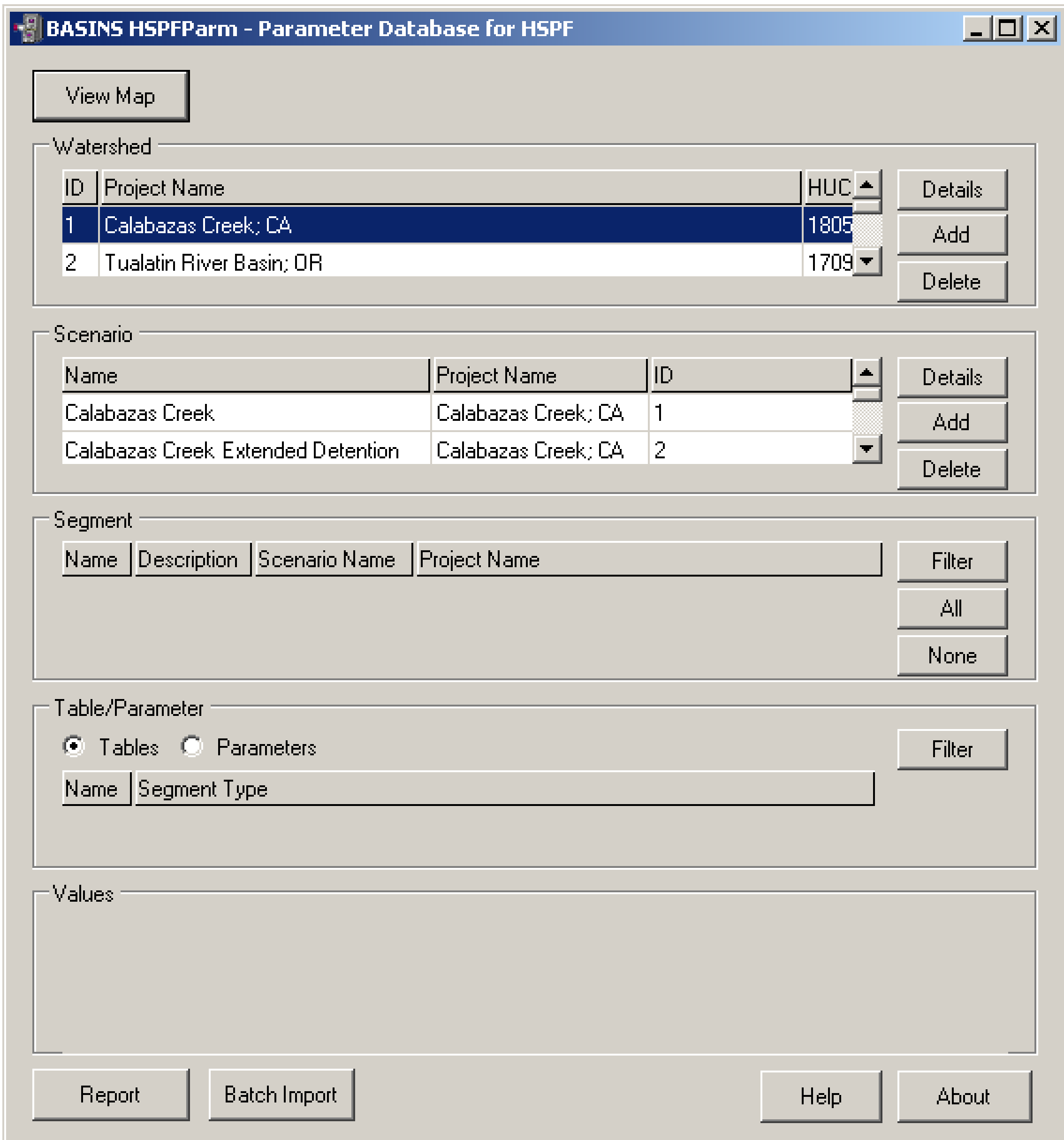
C:\Basins\models\HSPF\HSPFParmData\HSPFParmV2.mdb

The software will remember this default location such that it will try to find it automatically the next time users run the software.

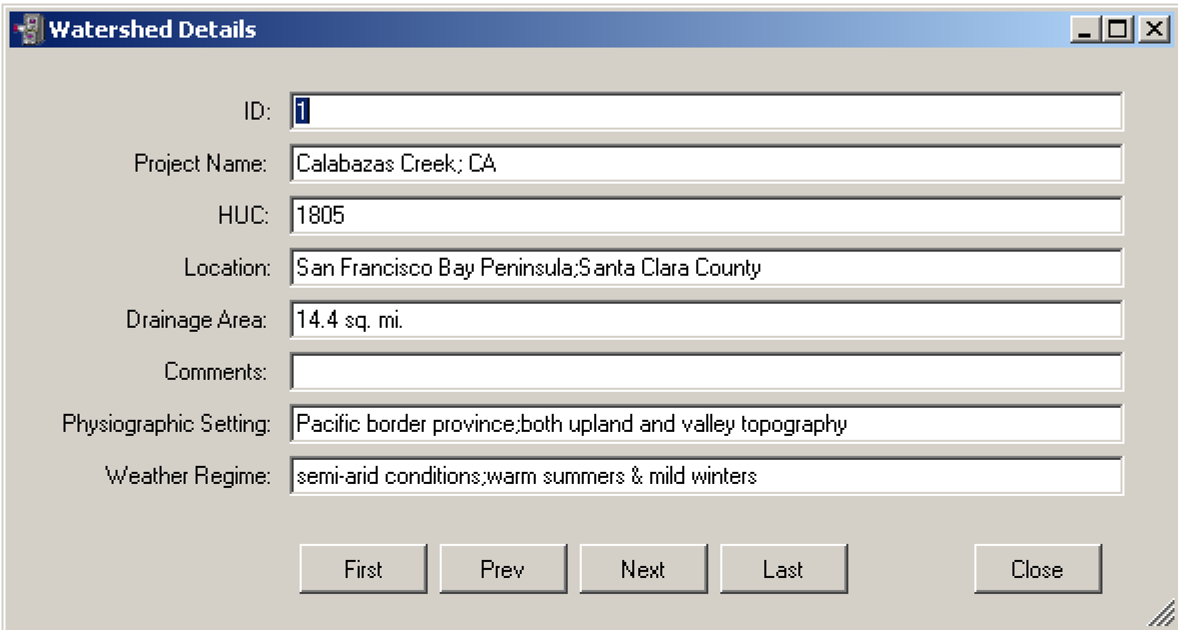
Scenarios To aid users' selection of a watershed, the HSPFParm plugin provides a map of all of the recorded sites. Clicking the 'View Map' button will launch the map and display it in the main map window as shown below.



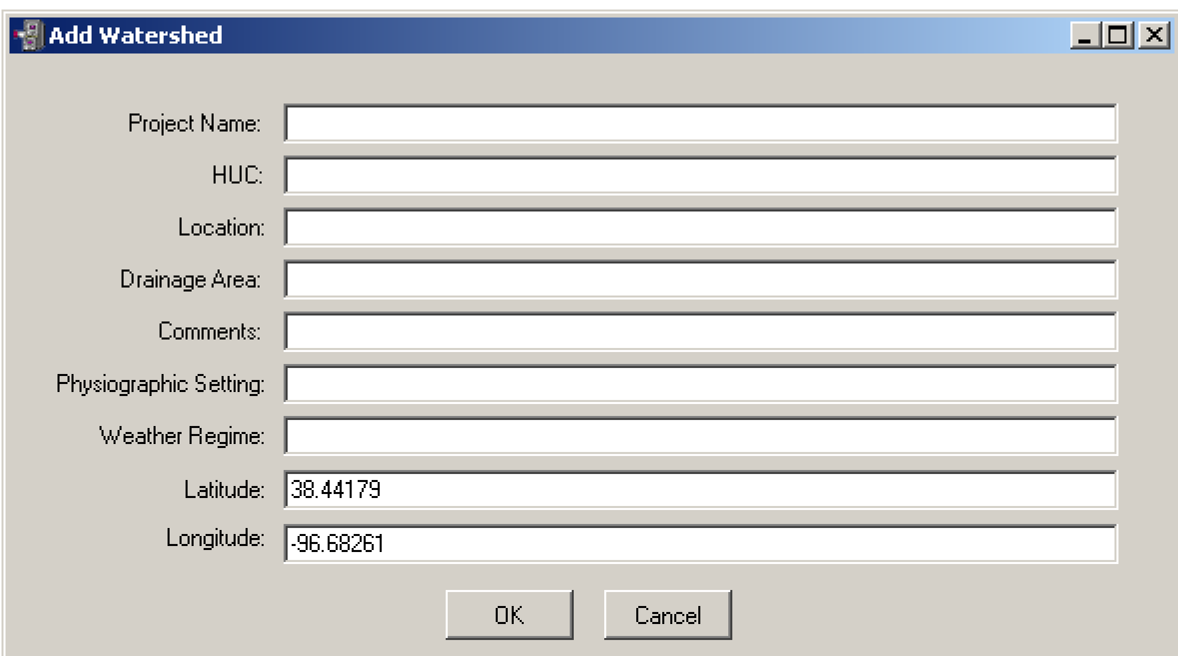
On the map, one or multiple watersheds may be selected at once. The selection of watershed(s) on the map will trigger the selection of corresponding watershed(s) entries on the main form's 'Watershed' list. Also, the simulation scenarios within those watersheds are also listed in the 'Scenario' list as shown below.



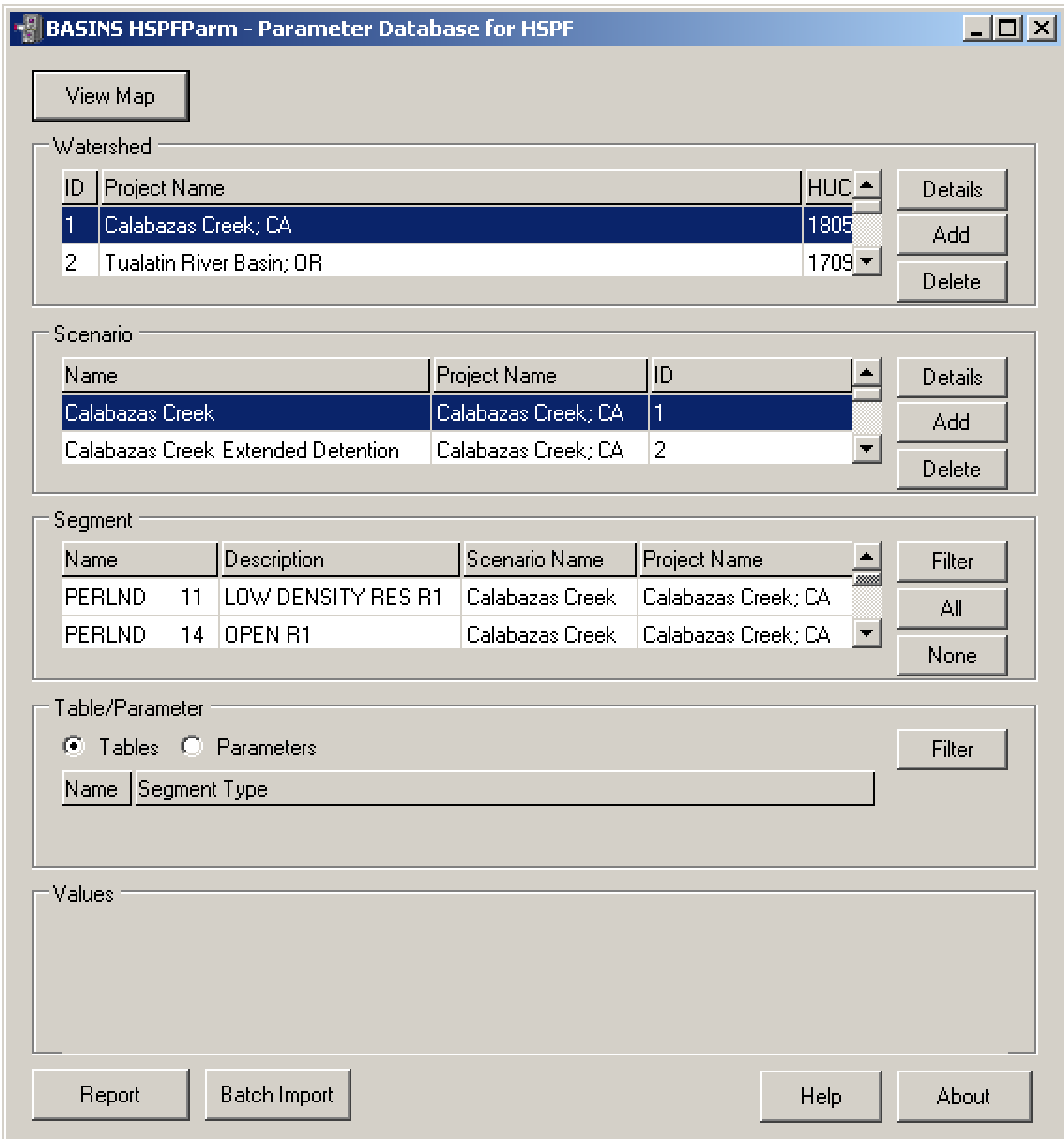
Clicking the 'Details' button next to the selected watershed will show the detailed description of the chosen watershed as shown below.



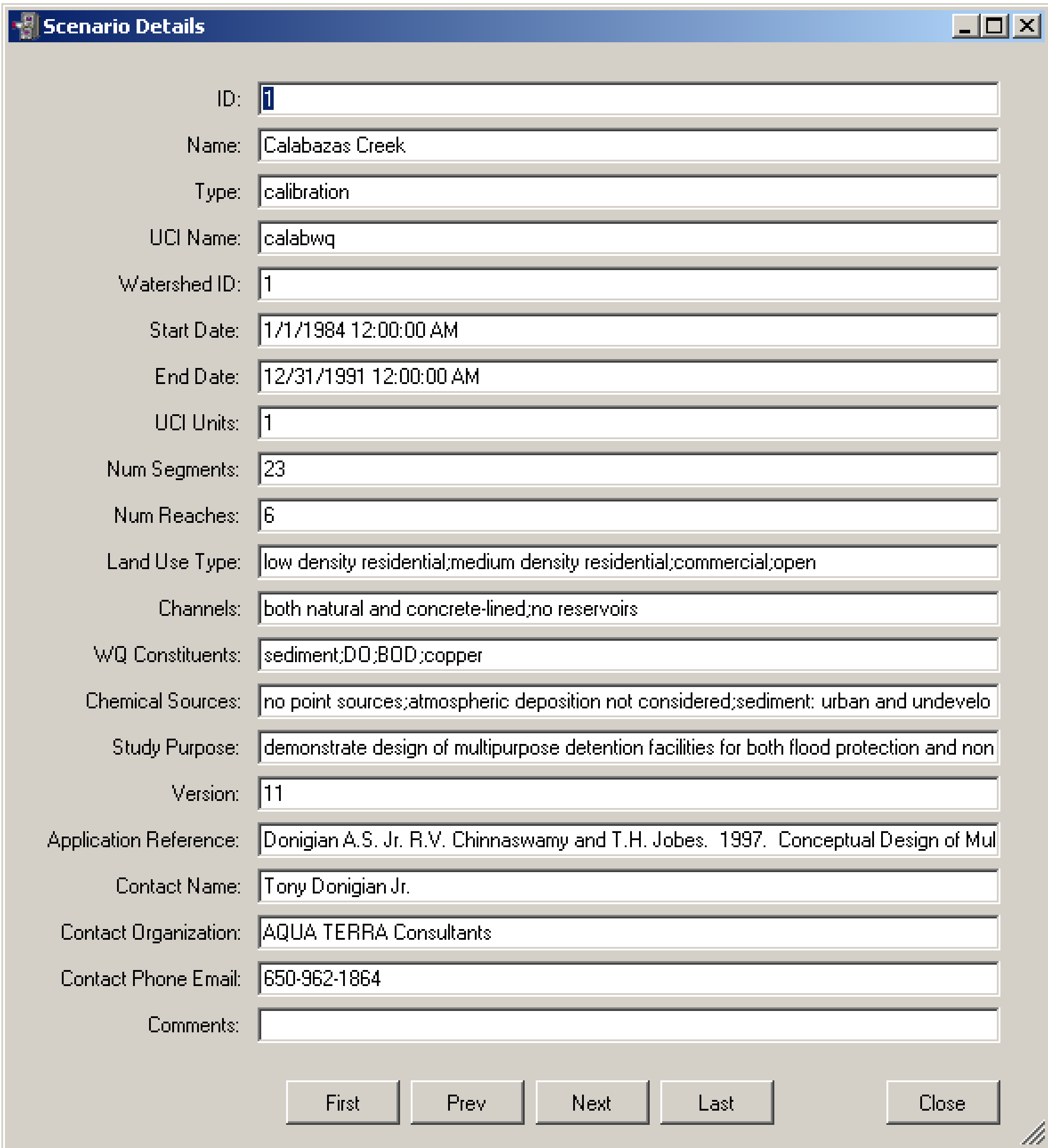
Clicking on the ‘Add’ button next to the watershed list will show an blank form for adding a new watershed as shown below.



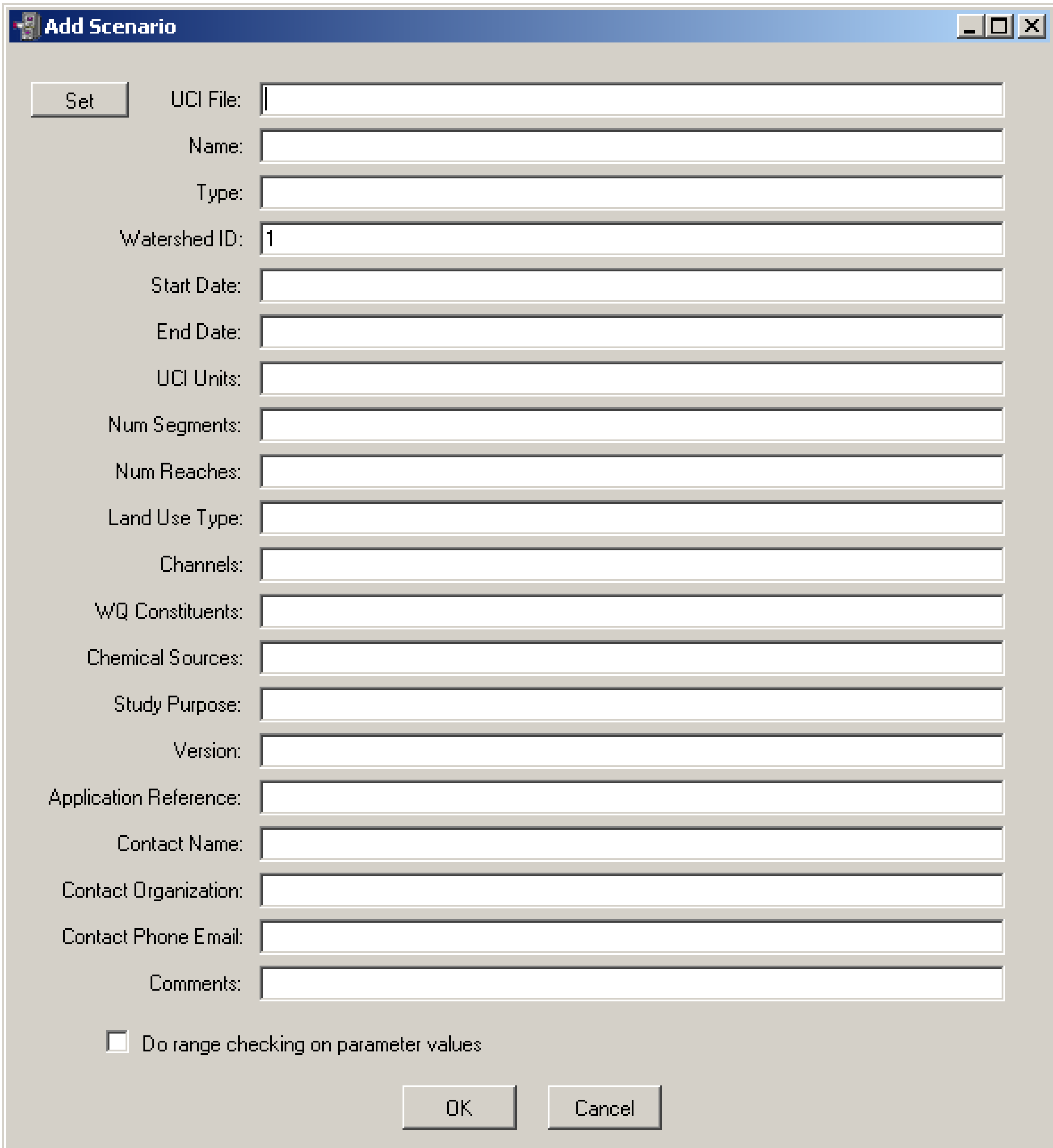
Selecting a scenario from the ‘Scenario’ list (e.g. Calabazas Creek; CA, ID 1) will trigger the retrieval of all segments in that chosen scenario.



Clicking the 'Details' button next to the selected scenario will produce a window showing the details of the selected scenario as shown below. The buttons at the bottom of the window allow the user to move through the available scenarios.



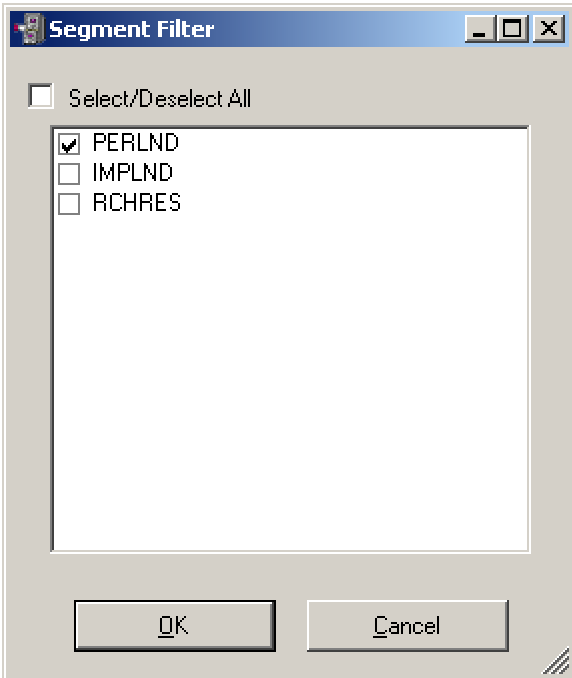
Clicking on the ‘Add’ button next to the scenario list will show a blank form for adding a new scenario as shown below.



Click on the 'Set' button to navigate to an existing HSPF UCI file, i.e. a new scenario, to be associated with the selected watershed in the 'Watershed' list on the main form.

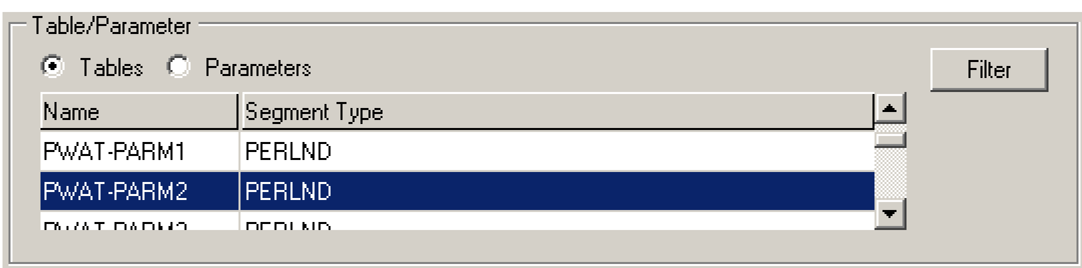
Selecting one or more scenario(s) by click on entries in the scenario list will result in the segment list being populated. The segment listing contains all of the PERLND, IMPLND, or RCHRES segments within that selected scenario(s). Note: Within the HSPFParm database interface, and throughout this documentation, the term 'segment' refers to a modeling segment and is inclusive of both land surface segments and surface water reaches.

The ‘Filter’ button next to the ‘Segment’ listing allows users to select which HSPF operations (PERLND, IMPLND, or RCHRES) to display in the Segment list as shown below.

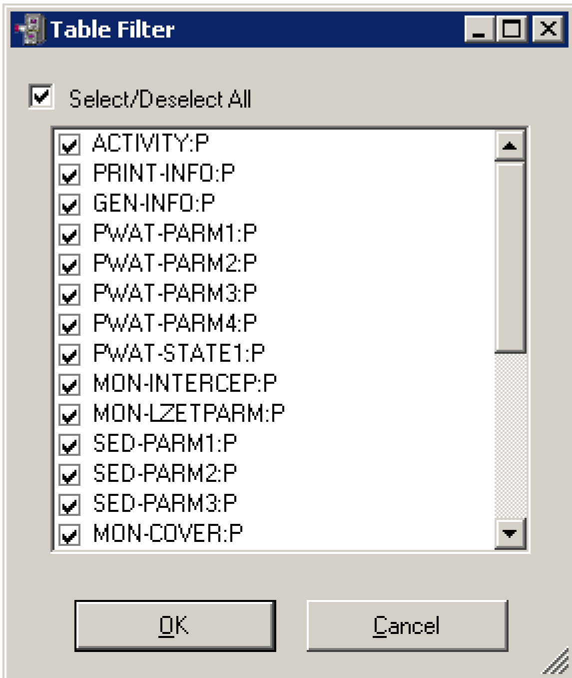


Users can choose to check (include)/uncheck (exclude) the checkboxes in front of the names of the HSPF operations, then the segment listing will be refreshed to only list those chosen HSPF operations.

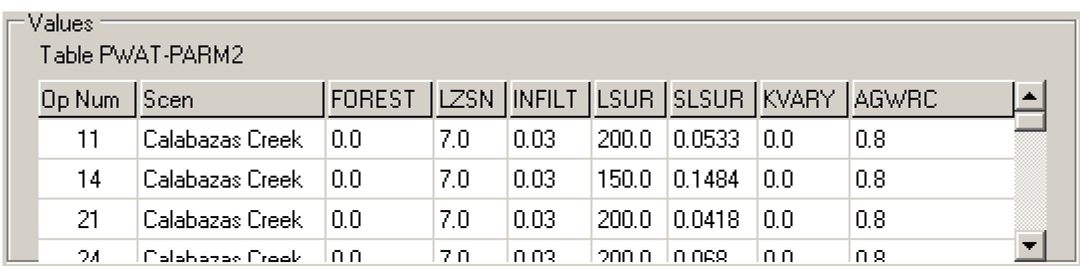
The ‘All’ button will select all entries in the segment list. The ‘None’ button will deselect all entries. Values Clicking on one or more segments in the Segment frame results in the Table/Parameter frame being populated. If the ‘Table’ radio button is selected, the user may scroll through a list of all of the tables which apply to the selected segments.



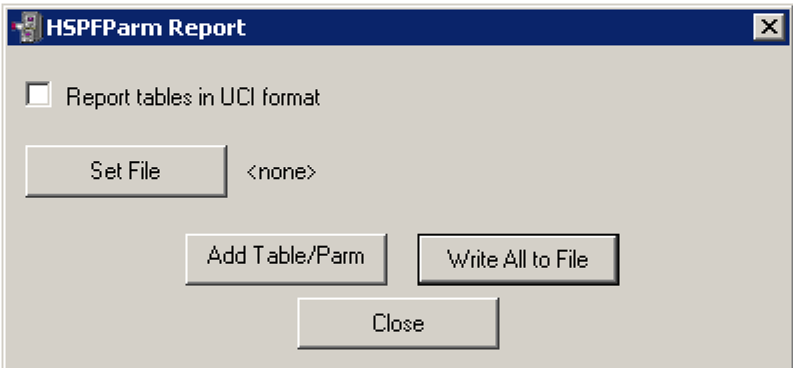
Clicking the ‘Filter’ button in the Table/Parameter frame produces a window with which the user may select/unselect tables to appear in the list.



Clicking a table name will result in values being displayed for all parameters in that table for the selected segments in the values frame below the Table/Parameter frame. If the Parameter tab is active within this frame, the user may scroll through a list of all of the parameters which apply to the selected segments. Clicking a parameter name will result in values being displayed in the values frame for that parameter for the selected segments.



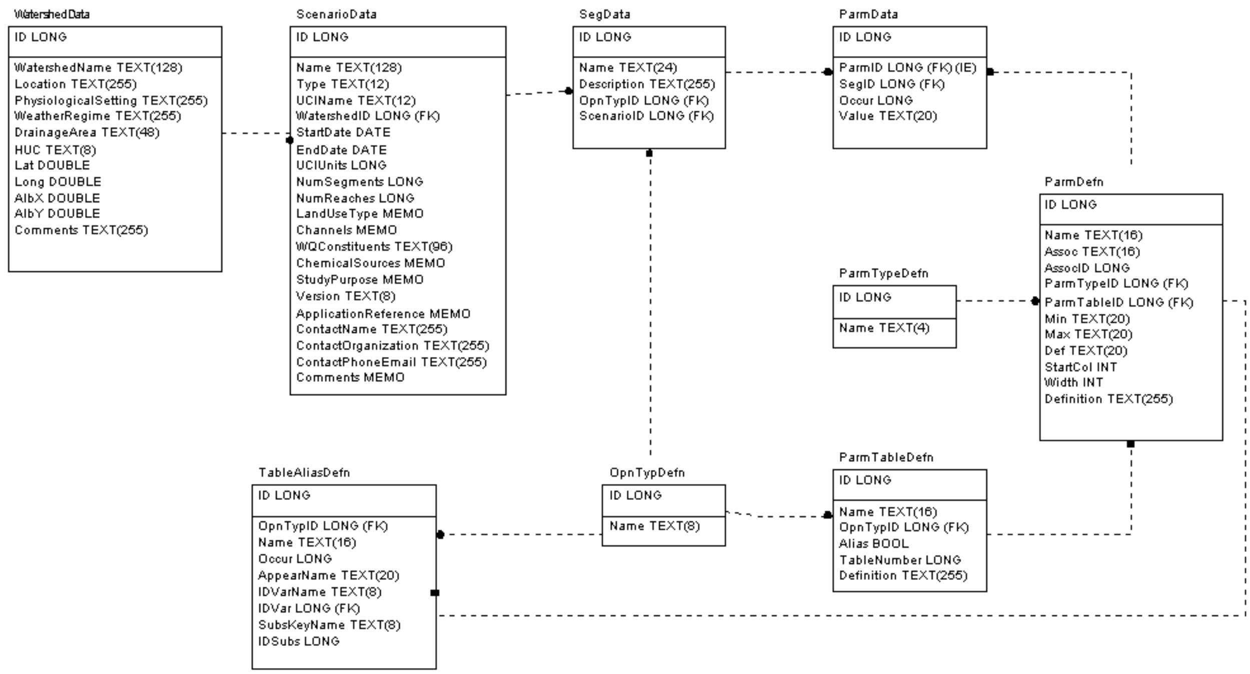
Reports The HSPFParm software contains a report feature for building text output summaries. Click on the ‘Report’ button to open the report dialog window.



Clicking the ‘Set File’ button allows the user to select an output file for reports. Once the output file is set, the user may click on the ‘Add Table/Parm’ button to add the contents of the Values frame to the output file. Users can opt to output the content of the ‘Values’ frame in two formats, either in the tabular format as shown in the Values frame or in the form of a properly formatted UCI file table. To achieve the latter, check the ‘Report Tables in UCI Form’ check box and the report will be written out in HSPF UCI table format such that users may directly extract these tables from the output file to use in their own UCI file.

The ‘Write All to File’ button writes all tables from the current scenario to the output file.   Data Model The following sections provide technical details of the HSPFParm database. The database contains ten tables with ten relationships between them. Seven queries are used to update or extract data from the database. Three reports can be produced by the HSPFParm interface software.

Further details of the HSPFParm database can be obtained by reviewing it with Microsoft Access (version 2003 or later).   Tables The chart below shows the structure of the tables within the HSPFParm database.



HSPFParm		Edit Date: 12/2/98 9:36:15 AM
Parameter Database Tables		
Microsoft Access	Rev: 0	Creator: JLKittle
Filename: DBDocX.vsd		Aqua Terra Consultants

Records in the WatershedData table contain information about each watershed in the database. In the HSPFParm interface, the location of these watersheds are shown on the map and described in the Watershed table below the map in the main window. The following are the fields, data types, and associated information in this table:

- ID - LONG - assigned automatically at record creation
- WatershedName - TEXT
- Location - TEXT
- PhysiographicSetting - TEXT
- WeatherRegime - TEXT
- DrainageArea - TEXT
- Hydrologic Unit Code - TEXT - 2 to 8 digits depending on watershed size
- Latitude - DOUBLE

- Longitude - DOUBLE
- Albers X Coordinate - DOUBLE - calculated from Latitude/Longitude
- Albers Y Coordinate - DOUBLE - calculated from Latitude/Longitude
- Comments - TEXT

The ScenarioData table contains information about each scenario or UCI file in the database. Each scenario is associated with one watershed; one watershed may have multiple scenarios associated with it. The following are the fields in this table:

- ID - LONG - assigned automatically at record creation
- Name - TEXT
- Type - TEXT - valid values are ‘calibration’, ‘management’ or ‘baseline’
- UCIName - TEXT - file with UCIName and suffix ‘.uci’ must exist to create database
- WatershedID - LONG - see WatershedData for valid values
- StartDate - DATE - obtained from UCI
- EndDate - DATA - obtained from UCI
- UCIUnits - LONG - English:1, obtained from UCI
- NumSegments - LONG - obtained from UCI
- NumReaches - LONG - obtained from UCI
- LandUseType - MEMO
- Channels - MEMO
- WQConstituents - TEXT
- ChemicalSources - MEMO
- StudyPurpose - MEMO
- Version - TEXT
- ApplicationReference - MEMO
- ContactName - TEXT

- ContactOrganization - TEXT
- ContactPhoneEmail - TEXT
- Comments - MEMO

The SegData table contains information about each segment in each scenario. Each segment is associated with one scenario; one scenario likely has multiple segments associated with it. The following are the fields in this table:

- ID - LONG - assigned automatically at record creation
- Name - TEXT - from UCI
- Description - TEXT - from UCI
- OpnTypID - LONG - see OpnTypDefn for valid values
- ScenarioID - LONG - see ScenarioData for valid values

The ParmData table contains information about each parameter in each segment, including the parameter value. Each parameter is associated with one segment; one segment will have multiple parameters associated with it. Some parameters may occur multiple times, hence each parameter has an occurrence field. The following are the fields in this table:

- ID - LONG - assigned automatically at record creation
- ParmID - LONG - see ParmDefn for valid values
- SegID - LONG - see SegData for valid values
- Occur - LONG
- Value - TEXT

The ParmDefn table contains information about each parameter, such as its minimum, maximum, default value, and definition. This table also associates each parameter with the UCI parameter table in which it is contained. Each parameter in the parameter data table is associated with one parameter definition. The following are the fields in this table:

- ID - LONG - assigned automatically at record creation
- Name - TEXT

- Assoc - TEXT - associated parameter name (ties monthly parameters to their constant cousin)
- AssocID - LONG - associated parameter ID
- ParmTypeID - LONG - see ParmTypeDefn for valid values
- ParmTableID - LONG - see ParmTableDefn for valid values
- Min - TEXT - minimum allowed value
- Max - TEXT - maximum allowed value
- Def - TEXT - default Value
- StartCol - INT - starting column in UCI file
- Width - INT - width of field in UCI File
- Definition - TEXT - not currently in use

The ParmTableDefn table contains information which describes each UCI parameter table. Each parameter table is associated with one parameter table definition. The following are the fields in this table:

- ID - LONG - assigned automatically at record creation
- Name - TEXT
- OpnTypID - LONG - see OpnTypDefn for valid values
- Alias - BOOL - indicates if an alias exists in TableAliasDefn
- TableNumber - LONG
- Definition - TEXT - not currently in use

The OpnTypDefn table associates an operation type ID with an operation type name. The following are the fields in this simple table:

- ID - LONG - valid are ‘1’,’2’,’3’
- Name - TEXT - valid are ‘PERLND’, ‘IMPLND’, ‘RCHRES’

The ParmTypeDefn table associates a parameter type ID with a parameter type name, such as character, long integer, real, or double precision. The following are the fields in this simple table:

- ID - LONG - valid are '1','2','3','4'
- Name - TEXT - valid are 'Char','Long','Real','Dble'

The TableAliasDefn table contains information about each table alias. The following are the fields in this table:

- ID - LONG - assigned automatically at record creation
- OpnTypID - LONG - - see OpnTypDefn for valid values
- Name - TEXT - parameter table name, see ParmTableDefn for valid values
- Occur - LONG - occurence of table
- AppearName - TEXT - occurence name (such as 'FIRST CROP' for occurance 1 of CROP-STAGES)
- IDVarName - TEXT - name of variable containing alias (such as QUALID for QUAL-PROPS)
- IDVar - LONG - ID in ParmDefn for IDVarName
- SubsKeyName - TEXT - name of supplemental variable
- IDSubs - LONG - ID in ParmDefn for SubsKeyName

The ParmRange table contains the typical and possible range of parameter values that are garnered from EPA HSPF techical note 6 and 8. This table is used when users add a new scenario to a watershed. The newly imported parameter values are checked against the ranges in this table to give users warnings about range violations. The following are the fields in this table:

- Name - TEXT - Parameter Name
- Unit - TEXT - Unit
- TMin - TEXT - Typical minimum
- TMax - TEXT - Typical maximum
- PMin - TEXT - Possible minimum
- PMax - TEXT - Possible maximum
- HSPFOPN - TEXT - HSPF operation ie PERLND, IMPLND, RCHES

- HSPFTable - TEXT - HSPF parameter table name as in a UCI File
- Source - TEXT - Where it comes from, eg tech notes 6 and 8
- Definition - Memo - Short description
- Description - Memo - Long description including influencing factors and comments

Queries Queries are used in the HSPFParm database to populate fields in tables in the interface and update fields when the HSPFParm database is being created. In the following sections the structured query language (SQL) for each query is shown along with a brief description of the purpose of the query.

Query: ParmTableAliasAvailable

This query changes the Alias value in the ParmTableDefn table to true where appropriate. It runs when the database is created.

```
SQL: UPDATE DISTINCTROW TableAliasDefn INNER JOIN ParmTableDefn ON
       (TableAliasDefn.OpnTypID = ParmTableDefn.OpnTypID)
       AND (TableAliasDefn.Name = ParmTableDefn.Name)
     SET ParmTableDefn.Alias = Yes;
```

Query: ParmTableData

This query builds a result set containing all parameter values in the database. It is used with various criteria to populate the values frame in the interface

```
SQL: SELECT DISTINCTROW SegData.ID AS SegID, ParmDefn.Name, ParmData.Value,
ParmDefn.ID AS
       ParmID, ParmDefn.AssocID AS AssocID, ParmDefn.ParmTableID AS TabID,
ParmTableDefn.Name AS [Table]
     FROM (ScenarioData INNER JOIN SegData ON ScenarioData.ID =
SegData.ScenarioID) INNER JOIN
       ((ParmTableDefn INNER JOIN ParmDefn ON ParmTableDefn.ID =
ParmDefn.ParmTableID) INNER JOIN
       ParmData ON ParmDefn.ID = ParmData.ParmID) ON SegData.ID = ParmData.SegID;
```

Query: ParmTableList

This query builds a result set containing information about all parameter tables in the database. It is used with a table id to get information about parameters in a particular table.

```
SQL: SELECT DISTINCTROW ParmDefn.Name, ParmDefn.ID, ParmTableDefn.ID AS TabID,
       ParmTableDefn.Name AS TabName, ParmTableDefn.OpnTypID, ParmTypeDefn.Name AS
ParmType,
       ParmDefn.Def, ParmDefn.Min, ParmDefn.Max, ParmDefn.StartCol, ParmDefn.Width
     FROM ParmTypeDefn INNER JOIN (ParmTableDefn INNER JOIN ParmDefn ON
ParmTableDefn.ID =
       ParmDefn.ParmTableID) ON ParmTypeDefn.ID = ParmDefn.ParmTypeID
     ORDER BY ParmDefn.ID, ParmTableDefn.ID;
```

Query: ScenTableList

This query builds a result set containing information about available tables for scenarios which meet a id criteria.

```
SQL: SELECT DISTINCTROW SegData.ID AS SegID, ParmTableDefn.Name, ParmTableDefn.ID
AS TabID,
       ParmTableDefn.OpnTypID
     FROM (ScenarioData INNER JOIN SegData ON ScenarioData.ID =
SegData.ScenarioID) INNER JOIN
       ((ParmTableDefn INNER JOIN ParmDefn ON ParmTableDefn.ID =
ParmDefn.ParmTableID) INNER JOIN
       ParmData ON ParmDefn.ID = ParmData.ParmID) ON SegData.ID = ParmData.SegID;
```

Query: UniqueName

This query builds a result set containing the different names found in parameters ‘PESTID’, ‘QUALID’ and ‘GQID’.

```
SQL: SELECT DISTINCTROW OpnTypDefn.Name AS OpnType, ParmDefn.Name AS ParmName,
       ParmData.Value
     FROM (ParmDefn INNER JOIN (OpnTypDefn INNER JOIN TableAliasDefn ON
       OpnTypDefn.ID = TableAliasDefn.OpnTypID) ON ParmDefn.ID =
TableAliasDefn.IDVar)
       INNER JOIN ParmData ON ParmDefn.ID = ParmData.ParmID
     GROUP BY OpnTypDefn.Name, ParmDefn.Name, ParmData.Value,
TableAliasDefn.OpnTypID,
       TableAliasDefn.IDVar
     ORDER BY TableAliasDefn.OpnTypID, ParmDefn.Name, ParmData.Value;
```

Query: ParmListAll

This query lists all parameters in the database along with related text information like watershed name, scenario name, segment name, etc. Don’t run it unless you have lots of ram and disk space.

```
SQL: SELECT DISTINCTROW OpnTypDefn.Name AS OpnType,
       ParmTableDefn.Name AS [Table],
       ParmDefn.Name AS Parm,
       WatershedData.WatershedName AS Watershed,
       ScenarioData.Name AS Scenario,
       SegData.Name AS Segment,
       ParmData.Occur,
       ParmData.Value
     FROM ((WatershedData INNER JOIN ScenarioData ON WatershedData.ID =
ScenarioData.WatershedID)
       INNER JOIN SegData ON ScenarioData.ID = SegData.ScenarioID)
       INNER JOIN (OpnTypDefn
       INNER JOIN ((ParmTableDefn
       INNER JOIN ParmDefn ON ParmTableDefn.ID = ParmDefn.ParmTableID)
       INNER JOIN ParmData ON ParmDefn.ID = ParmData.ParmID) ON OpnTypDefn.ID =
ParmTableDefn.OpnTypID) ON SegData.ID = ParmData.SegID
     ORDER BY ParmDefn.ParmTableID, ParmData.ParmID, ParmData.Occur,
WatershedData.WatershedName, ScenarioData.Name, SegData.Name;
```

Relationships Tables in the HSPFParm database have ten defined relationships. Each relationship in this database has many values in a field in the first table relating to one value in a field in the second table. A relationship is defined by a relationship name, first table name and field, and second table name and field. The relationships are as follows:

- OperationName: SegData!OpnTypID - OpnTypDefn!ID

- OpnTypDefnTableAliasDefn: TableAliasDefn!OpnTypID - OpnTypDefn!ID
- ParmDefnTableAliasDefn: TableAliasDefn!IDVar - ParmDefn!ID
- ScenarioName: SegData!ScenarioID - ScenarioData!ID
- ProjectName: ScenarioData!WatershedID - WatershedData!ID
- ParameterTypeName: ParmDefn!ParmTypeID - ParmDefn!ID
- ParameterTableName: ParmDefn!ParmTableID - ParmTableDefn!ID
- ParmName: ParmData!ParmID - ParmDefn!ID
- SegmentName: ParmData!SegID - SegData!ID
- ParmOperationName: ParmTableDefn!OpntypID - OpnTypDefn!ID

The parameter range table (ParmRange) is a stand-alone table. Report Formats The HSPFParm interface can write files containing parameter values in either a text format which includes scenario name and associated header information or a UCI format which has just the information needed for the requested UCI table.

Example: Parameter Table With Associated Information

```
    Table PWAT-PARM2
  Op Type PERLND
```

Op Num	Scenario	FOREST	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
11	Calabazas	0.0	7.0	0.03	200.0	0.0533	0.0	0.8
14	Calabazas	0.0	7.0	0.03	150.0	0.1484	0.0	0.8
21	Calabazas	0.0	7.0	0.03	200.0	0.0418	0.0	0.8
24	Calabazas	0.0	7.0	0.03	200.0	0.068	0.0	0.8
31	Calabazas	0.0	7.0	0.03	200.0	0.0222	0.0	0.95
32	Calabazas	0.0	7.0	0.03	200.0	0.0307	0.0	0.95
34	Calabazas	0.0	7.0	0.03	150.0	0.28	0.0	0.95
42	Calabazas	0.0	7.0	0.03	225.0	0.0141	0.0	0.95
43	Calabazas	0.0	7.0	0.03	225.0	0.0141	0.0	0.95
51	Calabazas	0.0	7.0	0.03	250.0	0.0083	0.0	0.95
52	Calabazas	0.0	7.0	0.03	250.0	0.0083	0.0	0.95
53	Calabazas	0.0	7.0	0.03	250.0	0.0083	0.0	0.95

62	Calabazas	0.0	7.0	0.03	250.0	0.0065	0.0	0.95
1	Tualatin R	0.98	7.82	0.210	17225.	0.250	1.0	0.988
2	Tualatin R	0.56	7.82	0.210	9186.8	0.190	1.0	0.988
1	West Sandy	0	6.0	0.05	350.	0.020	0.50	0.98
2	West Sandy	0	6.0	0.05	350.	0.020	0.50	0.98
3	West Sandy	0	6.0	0.05	350.	0.020	0.50	0.98
4	West Sandy	0	6.0	0.05	350.	0.020	0.50	0.98
5	West Sandy	0	6.0	0.05	350.	0.020	0.50	0.98
Min		0	6	.03	150	.0065	0	.8
Max		.98	7.82	.21	17225	.28	1	.988
Mean		.077	6.832	.053	1545.59	.0622	.225	.9312999

Example: Parameter Table in UCI Format

```
PWAT-PARM2
PERLND ***FOREST    LZSN      INFILT    LSUR      SLSUR     KVARY     AGWRC
11        0.0       7.0       0.03      200.0     0.0533    0.0       0.8
14        0.0       7.0       0.03      150.0     0.1484    0.0       0.8
21        0.0       7.0       0.03      200.0     0.0418    0.0       0.8
24        0.0       7.0       0.03      200.0     0.068     0.0       0.8
31        0.0       7.0       0.03      200.0     0.0222    0.0       0.95
32        0.0       7.0       0.03      200.0     0.0307    0.0       0.95
34        0.0       7.0       0.03      150.0     0.28      0.0       0.95
42        0.0       7.0       0.03      225.0     0.0141    0.0       0.95
43        0.0       7.0       0.03      225.0     0.0141    0.0       0.95
51        0.0       7.0       0.03      250.0     0.0083    0.0       0.95
52        0.0       7.0       0.03      250.0     0.0083    0.0       0.95
53        0.0       7.0       0.03      250.0     0.0083    0.0       0.95
62        0.0       7.0       0.03      250.0     0.0065    0.0       0.95
1         0.98      7.82      0.210     17225.    0.250     1.0       0.988
2         0.56      7.82      0.210     9186.8    0.190     1.0       0.988
1         0         6.0       0.05      350.      0.020     0.50      0.98
2         0         6.0       0.05      350.      0.020     0.50      0.98
3         0         6.0       0.05      350.      0.020     0.50      0.98
4         0         6.0       0.05      350.      0.020     0.50      0.98
5         0         6.0       0.05      350.      0.020     0.50      0.98
END PWAT-PARM2
```

Example: Parameter Values With Associated Information

Parameter LZSN

Name	Value	Segment		Scenario
LZSN	7.0	PERLND	11	Calabazas Creek Final Detention

LZSN	7.0	PERLND	14	Calabazas Creek Final Detention
LZSN	7.0	PERLND	21	Calabazas Creek Final Detention
LZSN	7.0	PERLND	24	Calabazas Creek Final Detention
LZSN	7.0	PERLND	31	Calabazas Creek Final Detention
LZSN	7.0	PERLND	32	Calabazas Creek Final Detention
LZSN	7.0	PERLND	34	Calabazas Creek Final Detention
LZSN	7.0	PERLND	42	Calabazas Creek Final Detention
LZSN	7.0	PERLND	43	Calabazas Creek Final Detention
LZSN	7.0	PERLND	51	Calabazas Creek Final Detention
LZSN	7.0	PERLND	52	Calabazas Creek Final Detention
LZSN	7.0	PERLND	53	Calabazas Creek Final Detention
LZSN	7.0	PERLND	62	Calabazas Creek Final Detention
LZSN	7.82	PERLND	1	Tualatin River
LZSN	7.82	PERLND	2	Tualatin River
LZSN	6.0	PERLND	1	West Sandy Creek
LZSN	6.0	PERLND	2	West Sandy Creek
LZSN	6.0	PERLND	3	West Sandy Creek
LZSN	6.0	PERLND	4	West Sandy Creek
LZSN	6.0	PERLND	5	West Sandy Creek

HSPF Application References

The following are the application references from the original (circa 1998) HSPFParm database/software:

Bicknell, B.R., A.S. Donigian, Jr., T.H. Jobes, and R.V. Chinnaswamy. 1996. Modeling Nitrogen Cycling and Export in Forested Watersheds Using HSPF. Final Report. Prepared for U.S. Geological Survey, Reston, VA, and U.S. EPA, NERL, Ecosystems Research Division, Athens, GA. 144 p.

Chen, Y.D. 1996. Hydrologic and Water Quality Modeling for Aquatic Ecosystem Protection and Restoration in Forest Watersheds: A Case Study of Stream Temperature in the Upper Grande Ronde River, Oregon. Ph.D. Dissertation, University of Georgia, Athens, GA. 267 p.

Chen, Y.D., R.F. Carsel, and S.C. McCutcheon. 1996. Stream Temperature Simulation of Forest Watersheds: Part 1. Enhancement of HSPF Modeling System, and Part 2. Application Study in the Upper Grande Ronde River, Oregon. Water Resources Bulletin (submitted for publication).

Chew, C.Y. L.W. Moore, and R.H. Smith. 1991. Hydrological Simulation of Tennessee's North Reelfoot Creek Watershed. Res. J. WPCF 63(1):10-16.

Dean, J.D., D.W. Meier, B.R. Bicknell and A.S. Donigian, Jr. 1984. Simulation of DDT Transport and Fate in the Arroyo Colorado Watershed, Texas, Draft Report, prepared for U.S. EPA, Environmental Research Laboratory, Athens, GA.

Donigian, A.S., Jr., D.W. Meier and P.P. Jowise. 1986. Stream Transport and Agricultural Runoff for Exposure Assessment: A Methodology. EPA/600/3-86-011, Environmental Research Laboratory, U.S. EPA, Athens, GA. 30613.

Donigian, A.S. Jr., B.R. Bicknell and J.L. Kittle Jr. 1986. Conversion of the Chesapeake Bay Basin Model to HSPF Operation. Prepared by AQUA TERRA Consultants for the Computer Sciences Corporation, Annapolis, MD and U.S. EPA Chesapeake Bay Program, Annapolis, MD.

Donigian, A.S., Jr., B.R. Bicknell, L.C. Linker, J. Hannawald, C. Chang, and R. Reynolds. 1990. Chesapeake Bay Program Watershed Model Application to Calculate Bay Nutrient Loadings: Preliminary Phase I Findings and Recommendations. Prepared by AQUA TERRA Consultants for U.S. EPA Chesapeake Bay Program, Annapolis, MD.

Donigian, A.S. Jr., B.R. Bicknell, A.S. Patwardhan, L.C. Linker, D.Y. Alegre, C.H. Chang and R. Reynolds. 1991. Chesapeake Bay Program Watershed Model Application to Calculate Bay Nutrient Loadings. Prepared by AQUA TERRA Consultants for U.S. EPA Chesapeake Bay Program , Annapolis, MD.

Donigian, A.S., Jr. R.V. Chinnaswamy, and D.C. Beyerlein. 1993. Surface Water Exposure Assessment: Preliminary Application of the U.S. EPA HSPF Model to Assess Agrichemical Contributions and Impacts. EPA Contract No. 68-C0-0019, W.A. No. 18. Prepared for U.S. EPA, Environmental Research Laboratory, Athens, GA. 200 p.

Donigian, A.S. Jr., B.R. Bicknell, A.S. Patwardhan, L.C. Linker, C.H. Chang, and R. Reynolds. 1994. Chesapeake Bay Program - Watershed Model Application to Calculate Bay Nutrient Loadings: Final Findings and Recommendations (FINAL REPORT). Prepared for U.S. EPA Chesapeake Bay Program, Annapolis, Maryland.

Donigian, A.S. Jr., R.V. Chinnaswamy, A.S. Patwardhan, and R.M. Jacobson. 1996. Watershed Modeling of Pollutant Contributions and Water Quality in the LeSueur Basin of Southern Minnesota. In: WATERSHED '96 - Moving Ahead Together. Conference Proceedings, June 8-12, 1996. pp. 109-111.

Donigian, A.S., Jr., R.V. Chinnaswamy and T.H. Jobes. 1997. Conceptual Design of Multipurpose Detention Facilities for Both Flood protection and Nonpoint Source Pollution Control (Draft Final Report). Prepared for: Santa Clara Valley Water District, San Jose, CA.

Fontaine, T.A. and V.M.F. Jacomino. 1997. "Sensitivity Analysis of Simulated Contaminated Sediment Transport," J. Am. Water Res. Assoc., Vol. 33, No. 2., pp 313-?

Imhoff, J.C., B.R. Bicknell, and A.S. Donigian, Jr. 1983. Preliminary Application of HSPF to the Iowa River Basin to Model Water Quality and the Effects of Agricultural Best Management Practices, Office of Research and Development, U.S. Environmental Protection Agency, Contract No. 68-03-2895, (PB-83-250399).

Maryland Dept. of the Environment. 1996. Patuxent Watershed Model: Final Report. Baltimore, MD.

Moore, L.W. and S.J. Klaine. 1987. Nonpoint Agricultural Pollution Processes in West Tennessee. Memphis State University, Memphis, TN.

Moore, L.W., H. Matheny, T. Tyree, D. Sabatini, and S.J. Klaine. 1988. Agricultural Runoff Modeling in a Small West Tennessee Watershed. J. Water Pollution Control Federation 60(2):242-249.

Moore, L.W. et al. 1992. Feasibility of an Integrated Geographic Information/Nonpoint Modeling System. Memphis State University, Memphis, TN.

Moore, L.W. C.Y. Chew, R.H. Smith and S.Sahoo. 1992. Modeling of Best Management Practices on North Reelfoot Creek, Tennessee. Water Env. Res. 64(3):241-247.

Patwardhan, A.S., R.M. Jacobson, W.P. Anderson, and A.S. Donigian, Jr. 1996. Modeling Nutrients From the Minnesota River Watershed. In: WATERSHED '96 - Moving Ahead Together. Conference Proceedings, June 8-12, 1996. pp. 439-442.

Sams, J.I. III and E.C. Witt III. 1992. Simulation of Streamflow and Sediment Transport in Two Surface-Coal-Mined Basins in Fayette County, PA. U.S. Geological Survey Water Resources Investigation Report 92-4093, 52p.

Tang, F. 1993. Calibration and Verification of HSPF Model for Tualatin River Basin Water Quality. Technical Report EWR-003-93, Dept. Civil Eng., Portalnd State University, Portland, OR.

Production of HSPFParm Database

The BASINS HSPFParm plug-in allows users to import HSPF parameters from existing UCI files in a batch mode.

Users need to construct a batch import control file named 'HSPFParmBat.inp'. The control file is a comma-delimited ASCII text file containing information about the watersheds and UCIs to be included in the database.

At the beginning of the control file, users can include as many lines of comments as they wish. Comment lines should begin with '#' character. However, there should not be any comment lines in the body of the file.

For each watershed to be included in the database, a line beginning with 'PRJ' must be added to the control file. The 'PRJ' designator must be followed by the fields below, in single quotes, with commas separating fields. Note that a comma must not be used within a field's contents.

- Watershed Name
- Hydrologic Unit Code
- Location
- Drainage Area
- Comments
- Physiographic Setting
- Weather Regime
- Latitude
- Longitude

Following each ‘PRJ’ record should be a series of ‘SCN’ records representing each scenario (or UCI file) to be included in that watershed. The ‘SCN’ designator must be followed by the fields below, in single quotes, with commas separating fields. Like the ‘PRJ’ lines, a comma must not be used within a field’s contents.

- UCI FileName, full path (this is required)
- Land Use Types
- Channel Types
- Water Quality Constituents
- Chemical Sources
- Study Purpose
- Version
- Application Reference
- Contact Name
- Contact Organization
- Contact Phone/Email

- Comments

An example ‘HSPFParmBat.inp’ file is shown below.

```
#PRJ,PRJName,HUC,Loc,DA,Comments,PhysiographicSetting,Weather,Lat,Long
#SCN,UCIFilename,LandUseType,Channels,WQConst,ChemSrc,Purpose,Version,Ref,ContactN
ame,ContactOrg,ContactNumber,Comments
PRJ,'TZWatershed','03070101','North East Georgia','2920','100% GA','Atlantic
slope','Humid subtropical','34.009412','-84.235954'
SCN,'C:\Basins\modelout\scen\scen.uci'
```

To utilize the import function, launch the HSPFParm plugin in BASINS, then load the map by clicking the ‘View Map’ button. Then, click on the ‘Batch Import’ button to start the process. Upon conclusion of the import process, the software will refresh the watershed grid and the map to reflect newly added projects.

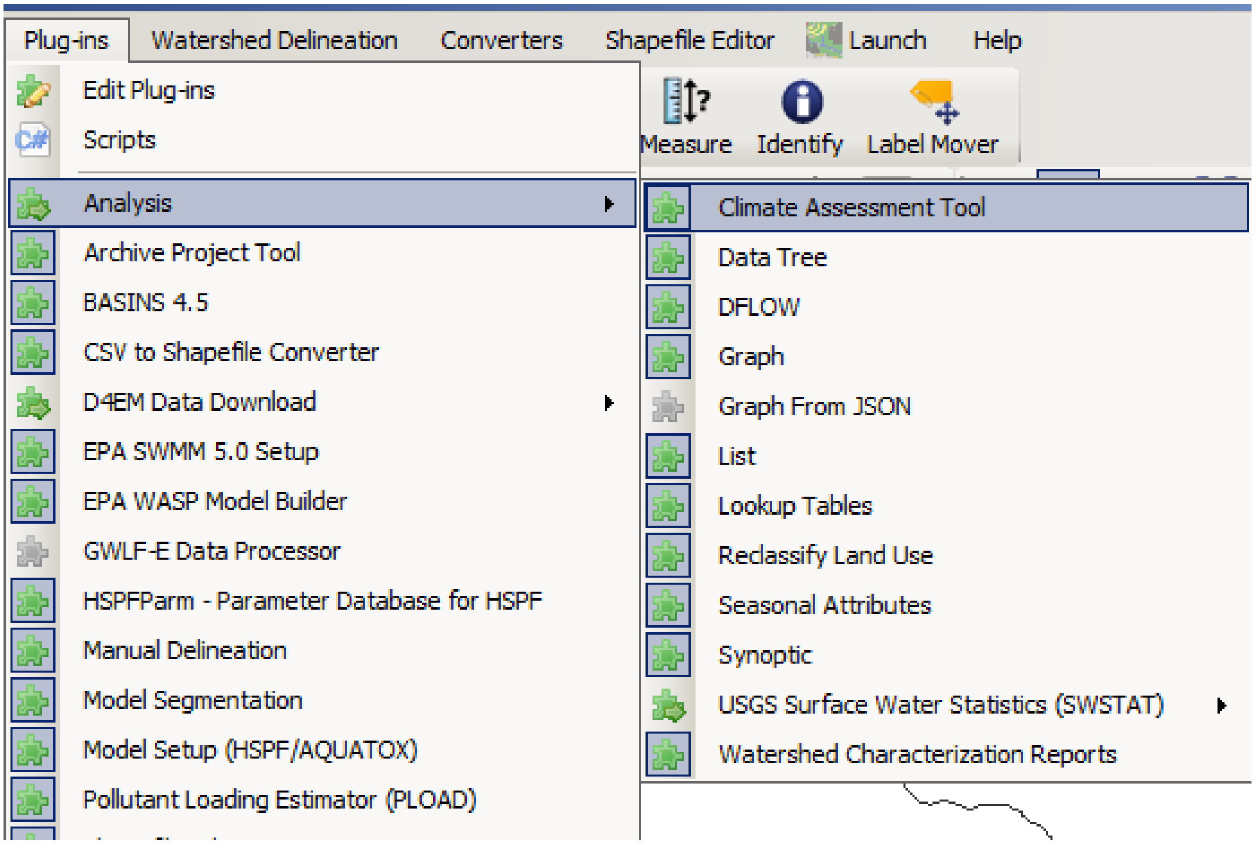
Climate Assessment Tool

The BASINS **Climate Assessment Tool** (**CAT**) provides a flexible set of capabilities for representing and exploring climate change and its relationship to watershed science. Tools have been integrated into the BASINS system allowing users to create climate change scenarios by modifying historical weather data, and to use these data as the meteorological input to several BASINS watershed models (HSPF, SWAT, SWMM). A capability is also provided to calculate specific hydrologic and water quality endpoints important to watershed management based on model output (e.g. the 100-year flood or 7Q10 low flow event). Finally, the CAT can be used to assess the outcomes of a single climate change scenario, or to automate multiple model runs to determine the sensitivity or general pattern of watershed response to different types and amounts of climate change.

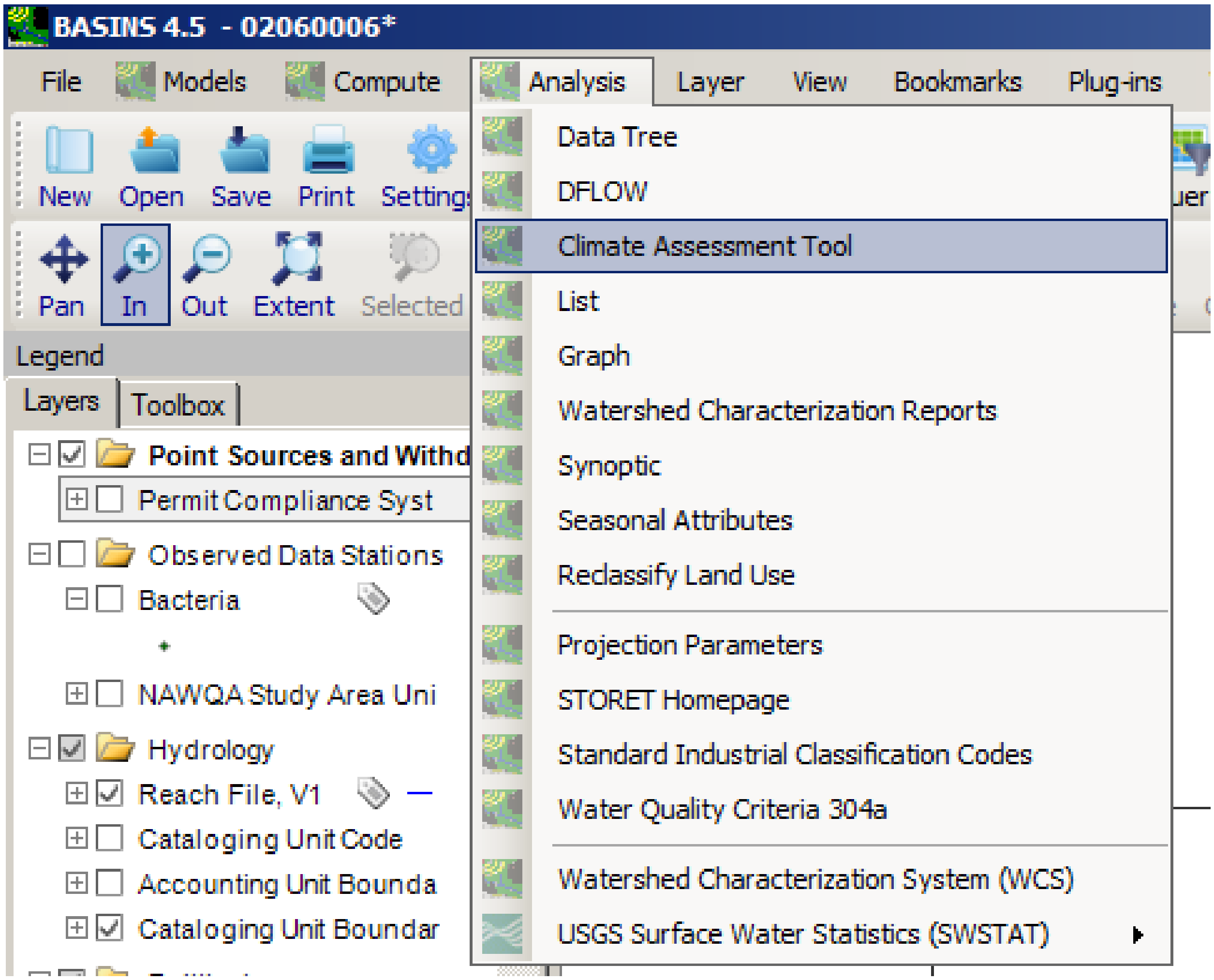
Users can modify historical climate data using standard arithmetic operators applied monthly, seasonally or over any other increment of time. Increases or decreases in a climate variable (precipitation, air temperature) can be applied uniformly, or they can be selectively imposed on only those historical events that exceed (or fall below) a specified magnitude. This capability allows changes to be imposed only on events within user-defined size classes, and can be used to represent the projected effects of 'intensification' of the hydrologic cycle, whereby larger precipitation events intensify, instead of events becoming more frequent. In addition, users are able to create time series that contain more frequent precipitation events. These capabilities provide users with an ability to represent and assess the impacts of a wide range of potential future climatic conditions and events.

BASINS CAT does not provide climate change scenario data. Rather, the tool provides a capability for quickly creating and running climate change scenarios within the BASINS system. Diverse sources of information such as records of historical and paleo-extreme events, observed trends, and projections based on global or regional scale climate models can be used to guide scenario development. Data requirements will vary depending on assessment goals. BASINS CAT provides capabilities to support a range of assessment goals, e.g. simple screening analysis, systematic sensitivity analysis, or implementing more detailed scenarios based on climate model projections. Other resources are available to support users with scenario development and climate change impact assessment.

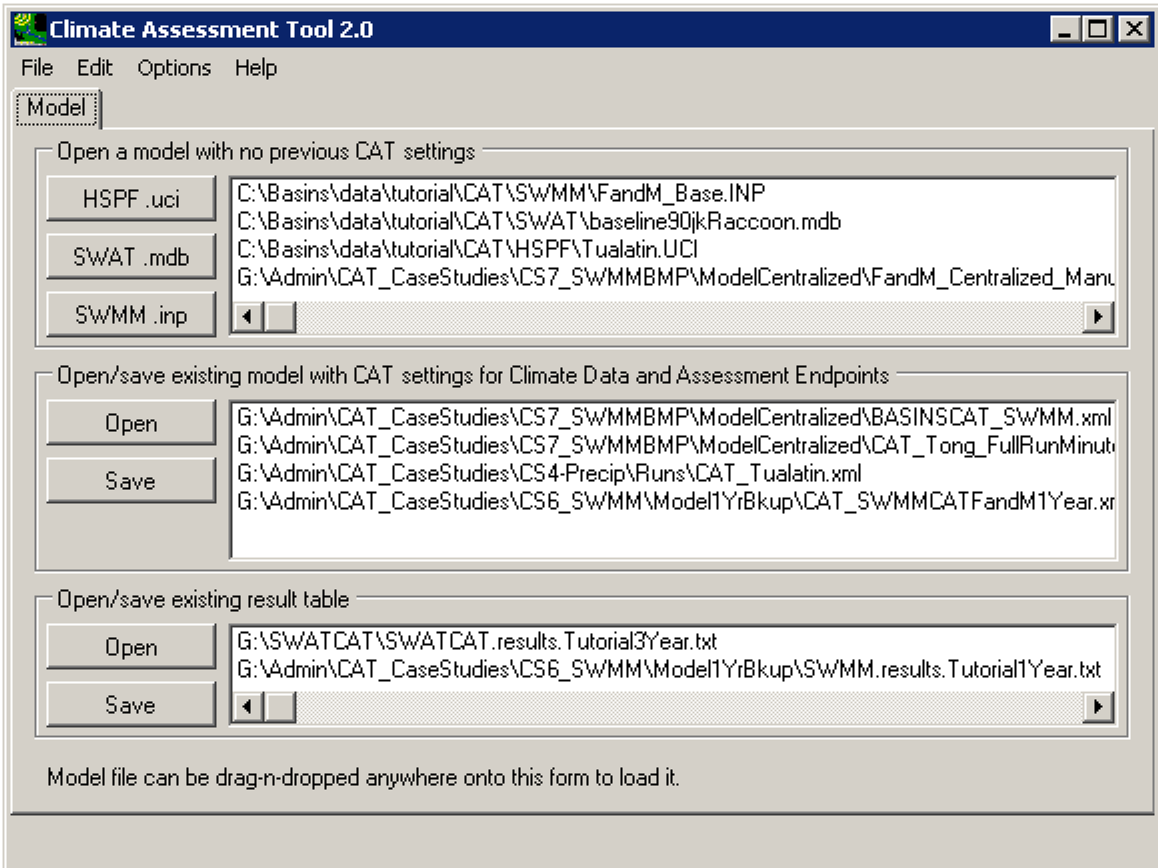
To activate CAT, first confirm that the Climate Assessment Tool is active on the **Plug-ins:Analysis** menu on the main BASINS window.



From the main BASINS window, CAT is opened by first clicking **Analysis** on the BASINS menu bar, then **Climate Assessment Tool** on the submenu (or typing **ALT-AC**).



The main CAT window opens. It contains a menu bar and a tab for scenario organization as shown below.

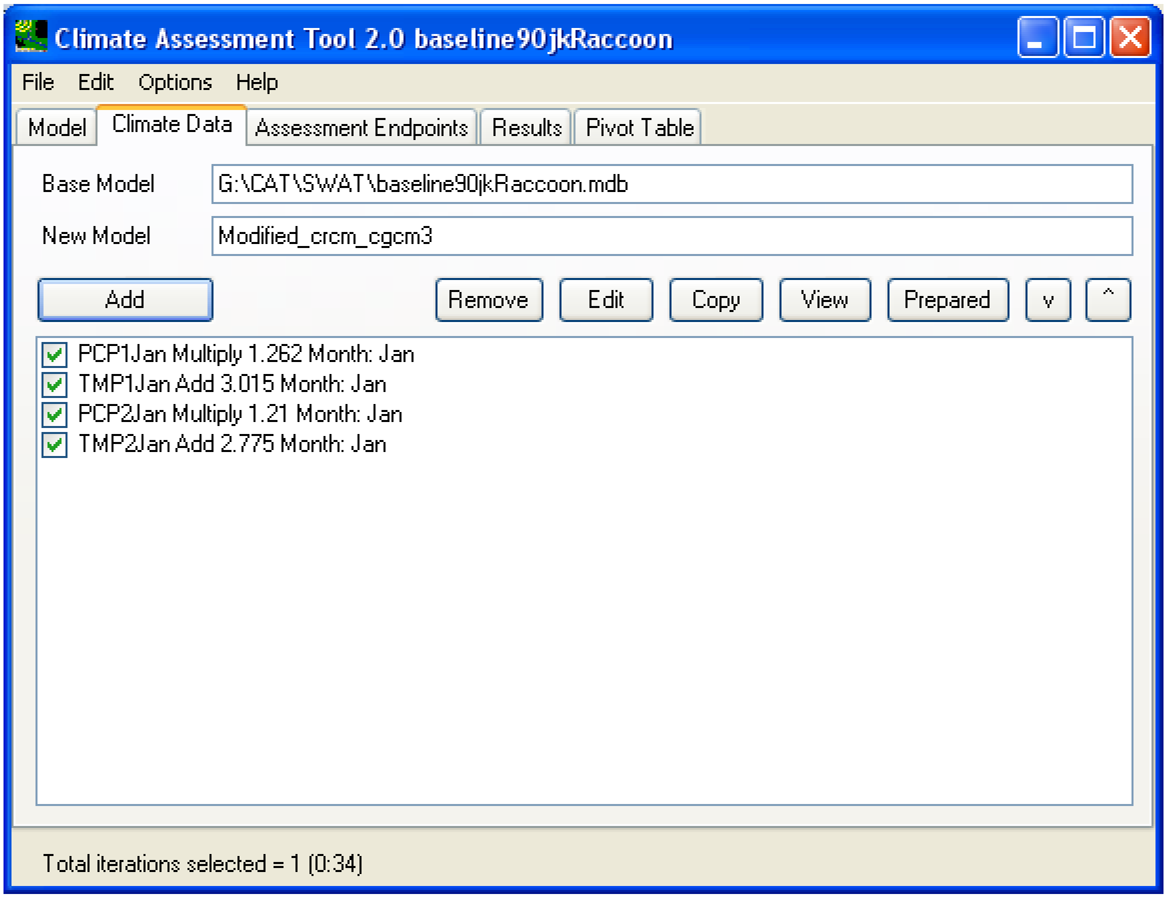


Options

On the initial tab of **CAT** interface, users can initiate a new CAT session with the three models, open/save existing CAT models, and open/save results from previously run CAT sessions.

Tabs

After the user selects an existing CAT session or starts a new session, more tabs will appear in the CAT interface to help define climate data, select endpoints of interest, and examine results as shown below.



The **Climate Data** tab allows the user to create climate change scenarios by defining and combining adjustments to existing weather time series to be used as input to the hydrologic model. The **Assessment Endpoints** tab allows the user to specify the hydrologic and water quality endpoints to be calculated from model output. The **Results** and **Pivot Table** tabs are for viewing model output including hydrologic and water quality endpoints computed by the model.

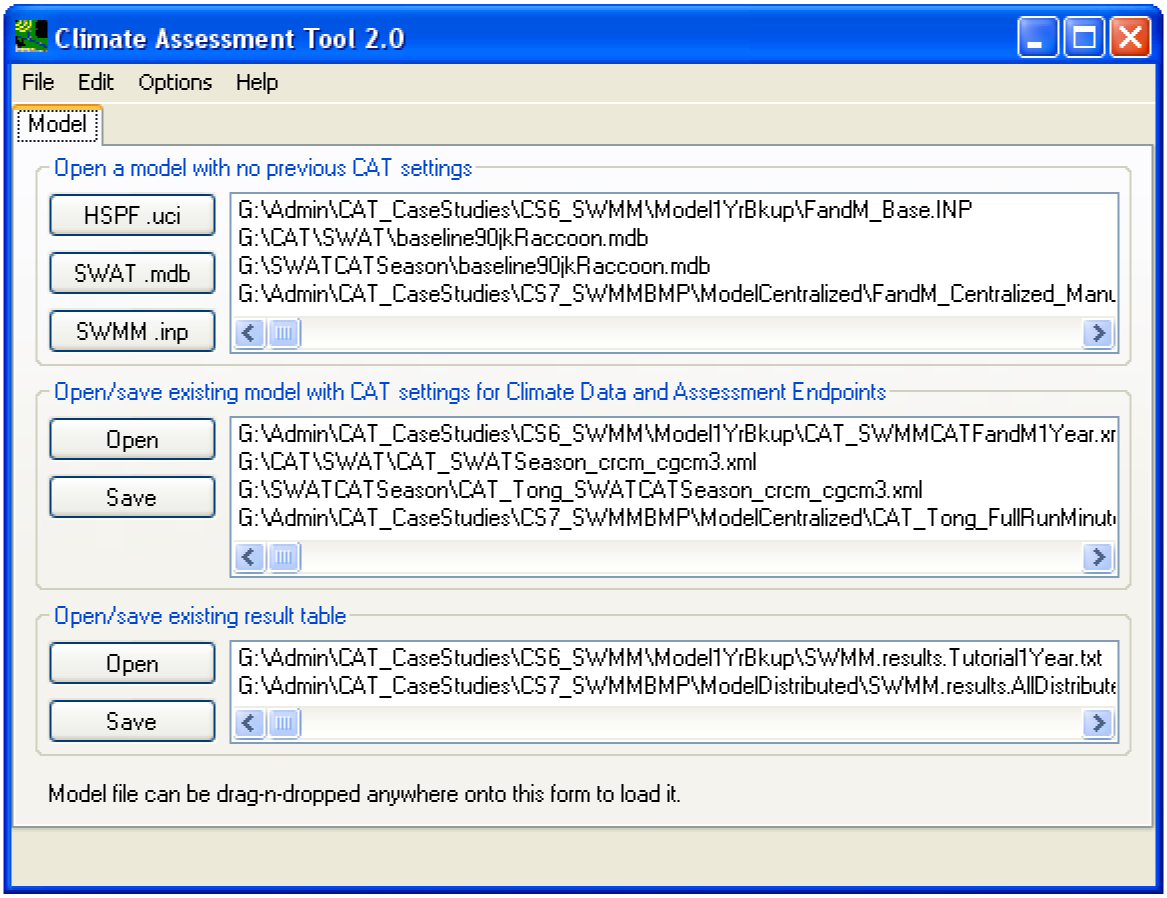
Total Iterations Selected

Once the desired climate modifications have been specified, the **Total Iterations Selected** shown at the bottom of the window indicates the number of model runs to complete the task. This number can range from 1 when running a single scenario, to greater than 1 when automating multiple runs to determine sensitivity to a range of different scenarios of change.

The Climate Assessment Tool makes a separate model run for each distinct combination of input data specified by the user. After the model runs, critical model output endpoints for each run are displayed so that the user may analyze the impacts of varying input data. Optionally, the user may save the model output for further analysis.

A series of tutorials are available for the Climate Assessment Tool.

Model Selection



The **Model** tab is the only one showing when a user launches CAT. This window helps initiate a brand new CAT analysis session and manage existing and saved analysis sessions. There are three blocks in this window:

1. Open a model with no previous CAT settings
2. Open/save existing model with CAT settings for Climate Data and Assessment Endpoints
3. Open/save existing result table
4.

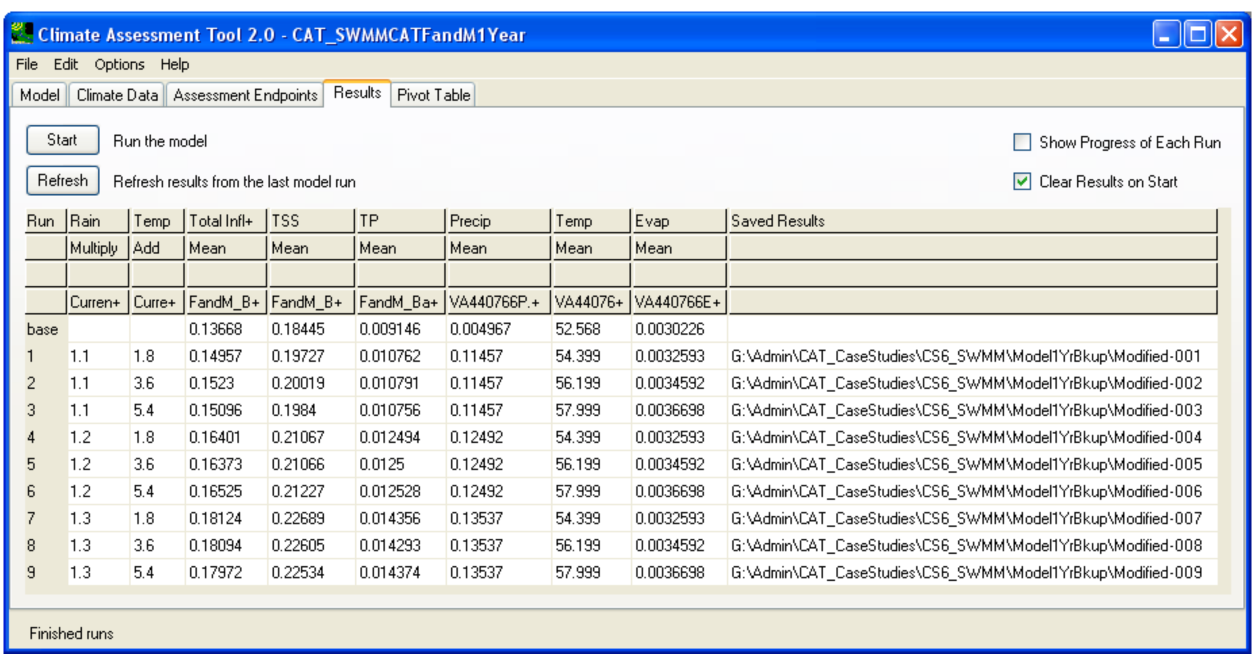
These same functionalities are also accessible through the options under the 'File' menu.

The first block helps initiate a new CAT session. Currently, CAT can be used to conduct analysis using HSPF, SWAT, and SWMM models, which correspond to the 'HSPF.uci', 'SWAT.mdb' and 'SWMM.inp' buttons, respectively. Clicking on these namesake buttons will open a file dialog window to locate the first base model input file/data to be loaded into the application. Alternately, a user may ‘drag-n-drop’ a .uci, .inp, or .mdb file directly from a Windows Explorer onto it to be loaded automatically.

The base scenario files for HSPF and SWMM models are their native main text input files with the .uci and .inp file extensions respectively. The SWAT model requires the model Access mdb database file and the general SWAT model Access mdb database files. Once the user specifies the base scenario data file, CAT will attempt to locate all related input and output files.

The second block allows a user to select an existing CAT session (saved in XML file format) that contains climate data modification and endpoint selection specifications. If CAT is successful in loading the chosen CAT definition file, it will automatically populate the climate data and endpoint lists on their corresponding tabs.

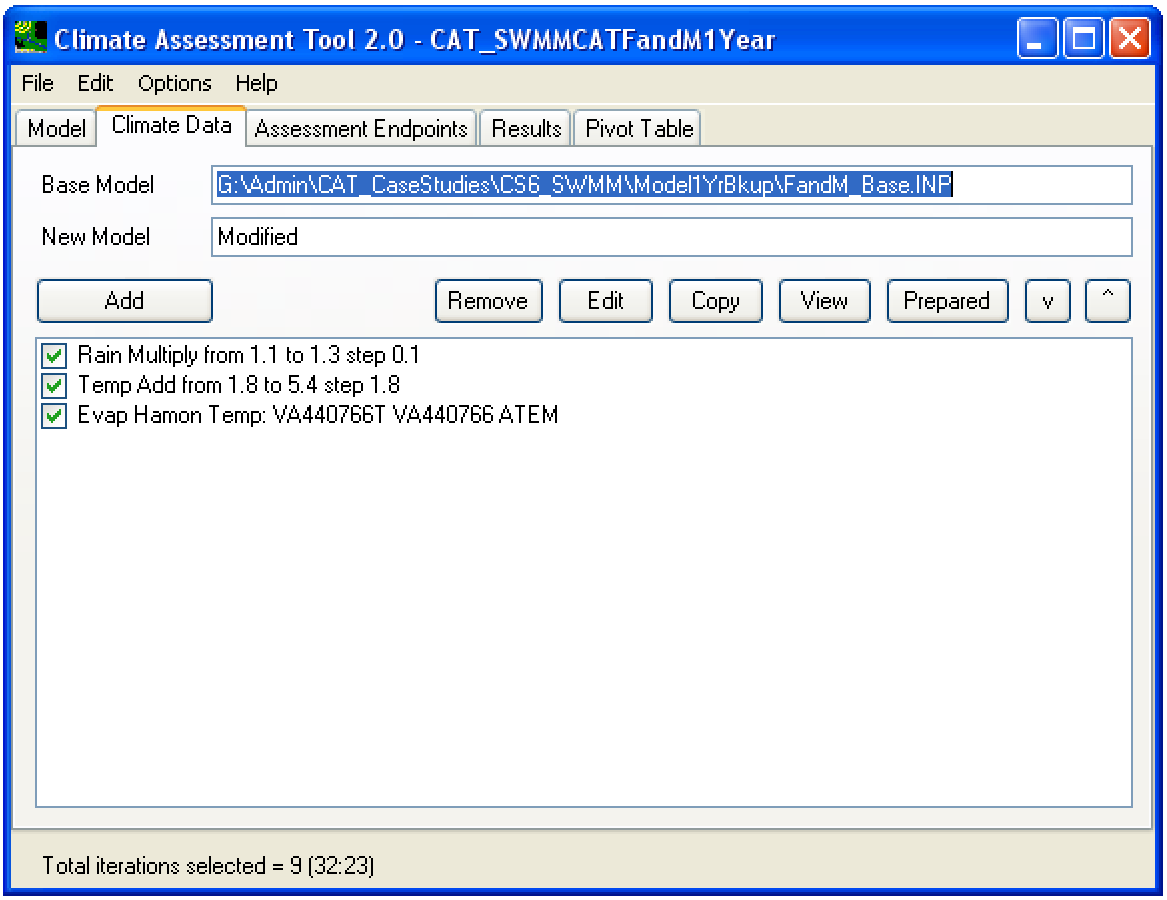
The third block allows a user to select an existing result file (saved in tab delimited text file format) to be opened in the Result tab. This is to allow a quick examination of results from a previously run CAT session without going through the loading of input data, climate data change and endpoint selection steps. If CAT is successful in its loading of the result file, it will display the results in grid format on the **Results** tab (as shown below) and also allow user to explore the results on the **Pivot Table** tab.



Run	Rain	Temp	Total Infl+	TSS	TP	Precip	Temp	Evap	Saved Results
	Multiply	Add	Mean	Mean	Mean	Mean	Mean	Mean	
	Curren+	Curre+	FandM_B+	FandM_B+	FandM_Ba+	VA440766P.+	VA44076+	VA440766E+	
base			0.13668	0.18445	0.009146	0.004967	52.568	0.0030226	
1	1.1	1.8	0.14957	0.19727	0.010762	0.11457	54.399	0.0032593	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-001
2	1.1	3.6	0.1523	0.20019	0.010791	0.11457	56.199	0.0034592	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-002
3	1.1	5.4	0.15096	0.1984	0.010756	0.11457	57.999	0.0036698	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-003
4	1.2	1.8	0.16401	0.21067	0.012494	0.12492	54.399	0.0032593	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-004
5	1.2	3.6	0.16373	0.21066	0.0125	0.12492	56.199	0.0034592	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-005
6	1.2	5.4	0.16525	0.21227	0.012528	0.12492	57.999	0.0036698	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-006
7	1.3	1.8	0.18124	0.22689	0.014356	0.13537	54.399	0.0032593	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-007
8	1.3	3.6	0.18094	0.22605	0.014293	0.13537	56.199	0.0034592	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-008
9	1.3	5.4	0.17972	0.22534	0.014374	0.13537	57.999	0.0036698	G:\Admin\CAT_CaseStudies\CS6_SWMM\Model1YrBkup\Modified-009

Climate Data

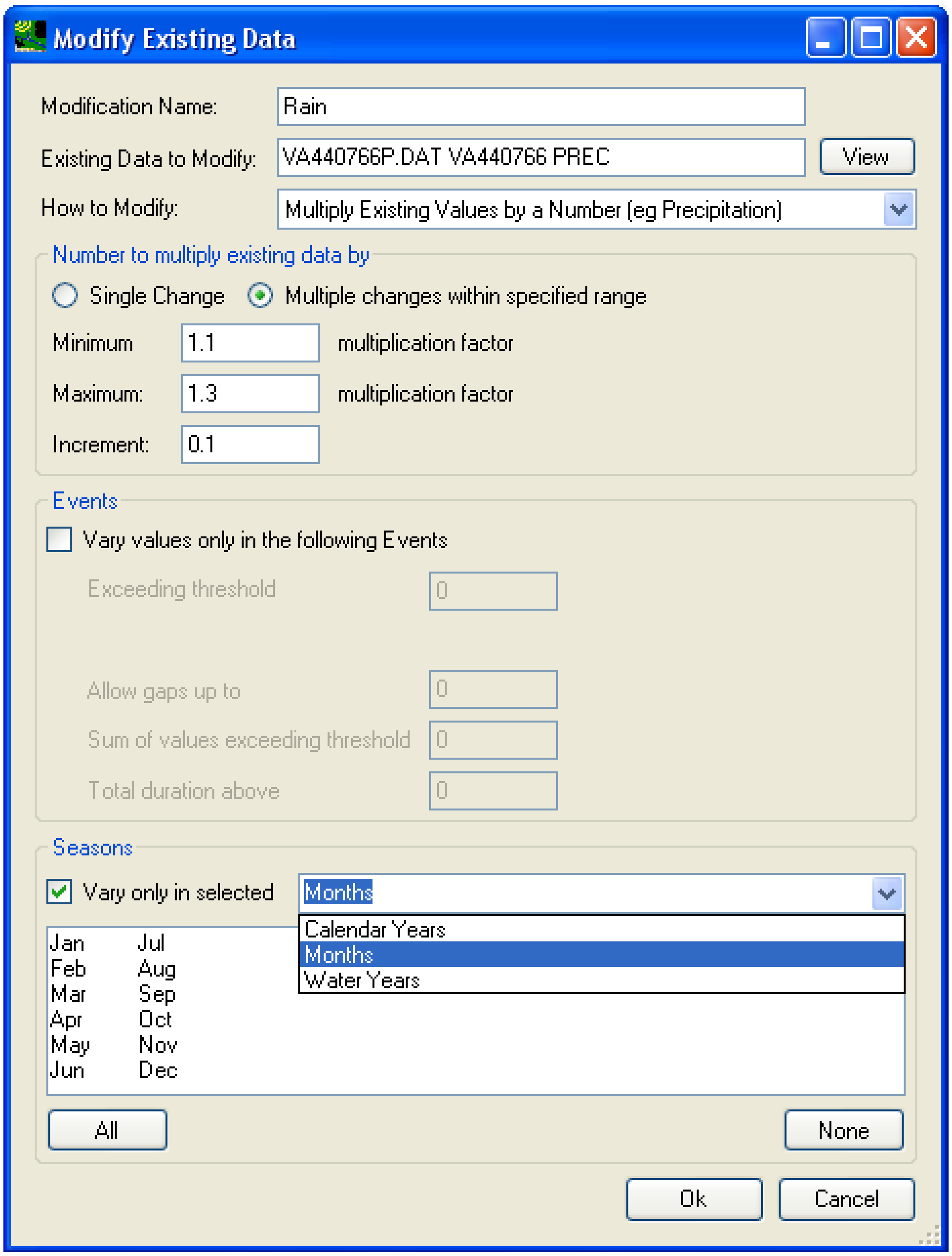
The **Climate Data** tab is the main window for managing changes to input time series data (i.e. weather data). Through this tab users are able to create climate change scenarios by selecting existing input time series to be modified, and selectively implementing one or more changes to create different climate scenario(s).



The **Base Model** text field shows the base case input data source file per relevent model (HSPF (.uci), SWMM (.inp), or SWAT (.mdb)). Running the **Climate Assessment Tool** will create a set of modified model input files that are saved in a separate folder with the name specified in the **New Model** text field. As shown later on the **Assessment Endpoints** tab, if the 'Save Complete Copy of All Model Inputs and Outputs for Every Run' radio button is checked, then each scenario run will be saved in a separate folder.

Add Button

To add input time series to be modified, click **Add**, the **Modify Existing Data** dialog box will be brought up as shown below:



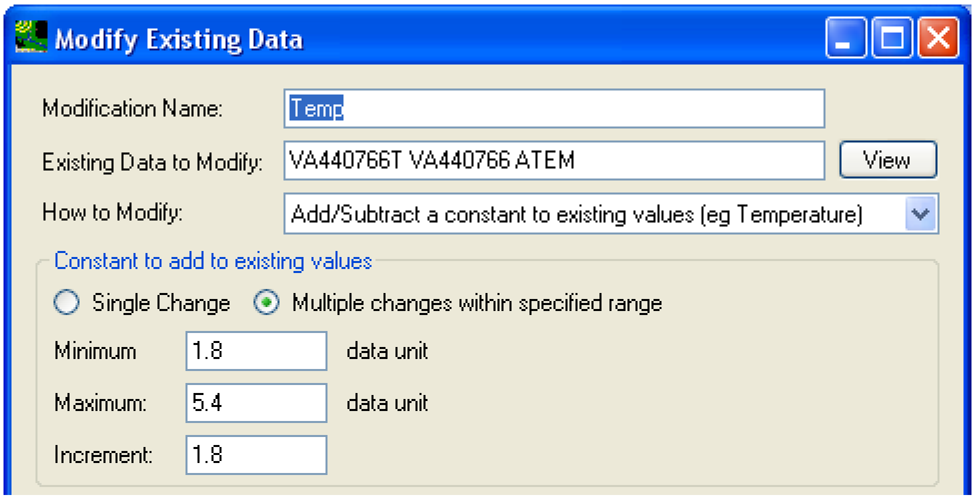
In this window, modify existing time series data as directed in the tutorial. A user is to specify a **Modification Name**, the **Existing Data to Modify**, and **How to Modify** those data. Several modification options are available, including:

- Add/Subtract a constant to existing values (eg Temperature)
- Multiply Existing Values by a Number (eg Precipitation)
- Multiply large/small events by a number
- Add/Remove Storm Events

CAT can also be used to calculate evaporation per modified input weather data using Hamon or Penman-Monteith methods.

There are three main blocks under the 'How to Modify' choice-box. When user selects a modification method, the interface will change accordingly to present pertinent choices for that method. In the topmost block, user chooses to apply change with a single value or by a series of automated changes within a range. For automated multiple changes, the user needs to specify starting and ending values and step size. For example, a user can specify an increase in average annual temperature from 1 to 3 degrees C at a step interval of 1 degree C (or 1.8 degree F).

In the middle block, users can choose to enforce change on specific precipitation events based on storm intensity, volume, gap, and duration. In the bottom block, users can further specify changes to be applied in chosen months, calendar years, or water years.



Running CAT would then automate the creation and processing of 3 input time series (i.e. reflecting average annual temperature increases of 1, 2, and 3 degrees C). When 2 or more sets of multiple changes are specified, CAT will systematically create scenarios and assess each possible combination of specified values. For example, if the above temperature change were specified together with changes in annual precipitation from 0 to 20 percent with a step interval of 5 percent (i.e. changes of 0, 5, 10, 15, 20%), CAT would automate the creation and processing of 3 * 5 = 15 climate change scenarios reflecting each possible combination of values. To create and process a single scenario, the maximum and minimum values in the range can be entered as the same value.

An input time series can receive a series of changes. By combining these modifications, a wide range of climate change scenarios of varying complexity can be created. After adding a change, it will appear as a line item in the text box on the **Climate Data** tab. Checking the box will apply the change to the input timeseries when running the CAT. Unchecking the box will cause the change to be ignored when running CAT. When multiple changes are applied to an input time series, the changes are implemented in the same order the changes were added, i.e. line by line from top to bottom as listed in the text box.

Remove Button

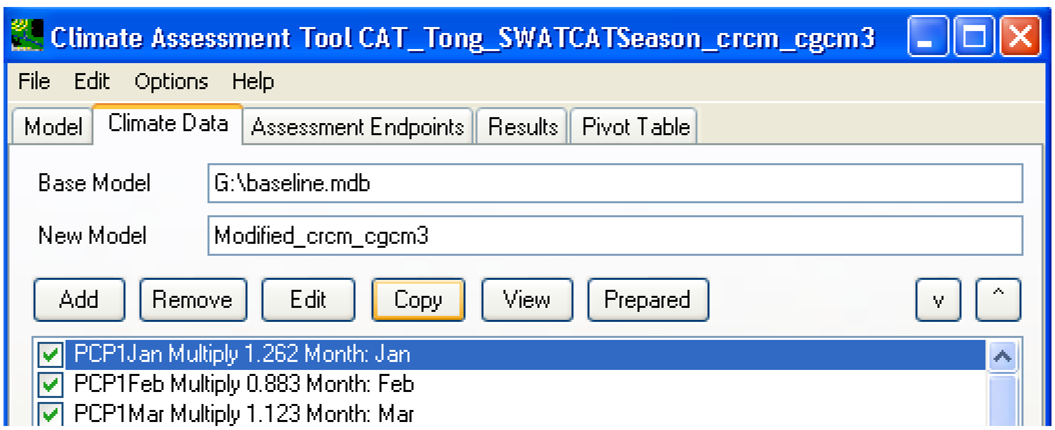
To remove a weather data modification scenario, highlight the entry and click **Remove** button.

Edit Button

To edit a weather data modification scenario, highlight the entry and click **Edit**.

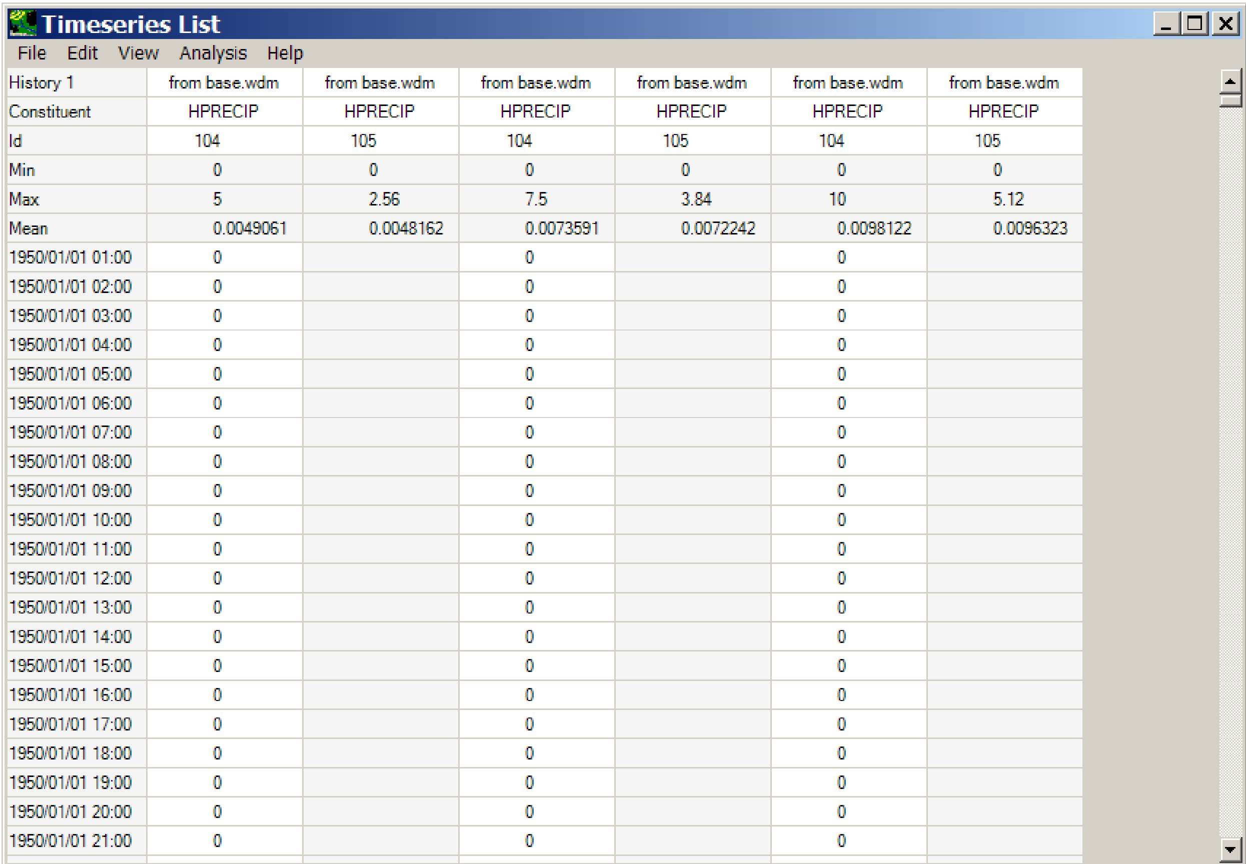
Copy Button

The copy button allows user to quickly create a new weather change scenario by making small changes on another similar scenario.



View Button

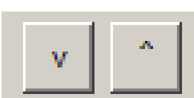
Click **View** to see the actual data in tabular form. The **Time Series List** window will pop up. This may take a minute to load. To change the layout, use the **Analysis** menu option.



History 1	from base.wdm	from base.wdm	from base.wdm	from base.wdm	from base.wdm	from base.wdm
Constituent	HPRECIP	HPRECIP	HPRECIP	HPRECIP	HPRECIP	HPRECIP
Id	104	105	104	105	104	105
Min	0	0	0	0	0	0
Max	5	2.56	7.5	3.84	10	5.12
Mean	0.0049061	0.0048162	0.0073591	0.0072242	0.0098122	0.0096323
1950/01/01 01:00	0		0		0	
1950/01/01 02:00	0		0		0	
1950/01/01 03:00	0		0		0	
1950/01/01 04:00	0		0		0	
1950/01/01 05:00	0		0		0	
1950/01/01 06:00	0		0		0	
1950/01/01 07:00	0		0		0	
1950/01/01 08:00	0		0		0	
1950/01/01 09:00	0		0		0	
1950/01/01 10:00	0		0		0	
1950/01/01 11:00	0		0		0	
1950/01/01 12:00	0		0		0	
1950/01/01 13:00	0		0		0	
1950/01/01 14:00	0		0		0	
1950/01/01 15:00	0		0		0	
1950/01/01 16:00	0		0		0	
1950/01/01 17:00	0		0		0	
1950/01/01 18:00	0		0		0	
1950/01/01 19:00	0		0		0	
1950/01/01 20:00	0		0		0	
1950/01/01 21:00	0		0		0	

Arrow Buttons

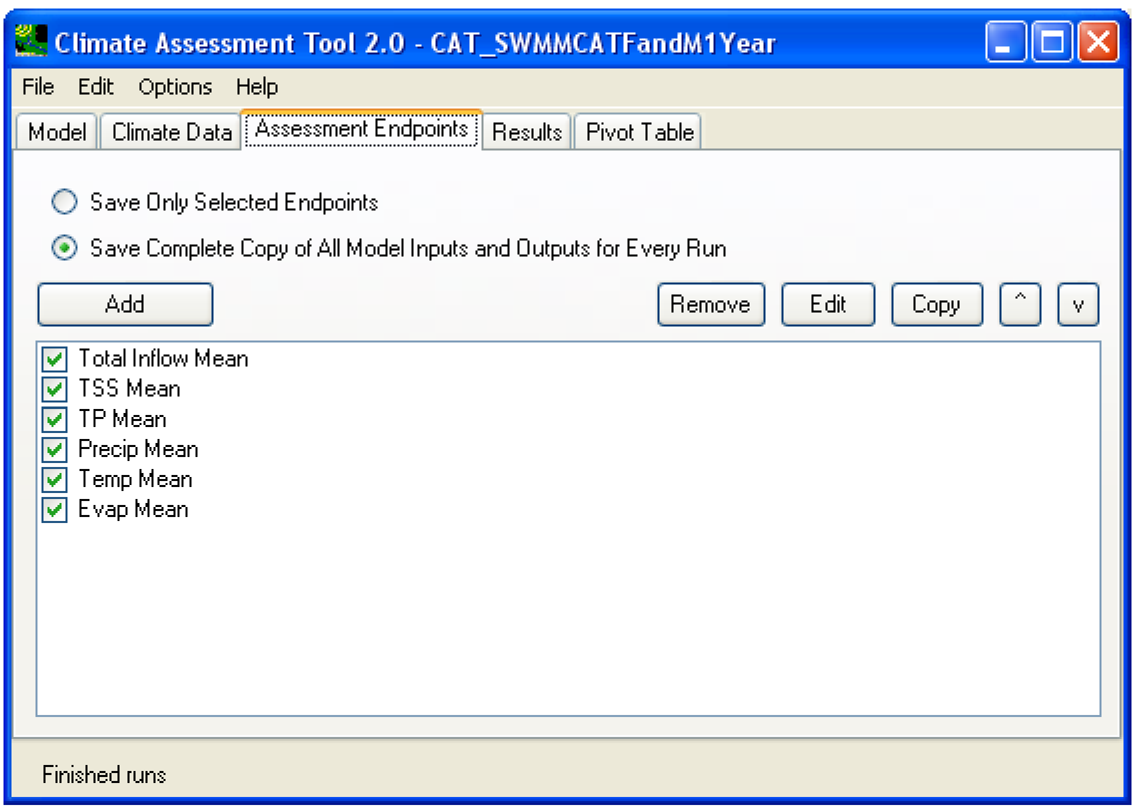
The arrows on the right side of the window are used to move the list of scenario entries up and down for organization.



Assessment Endpoints

EPA's Guidelines to Ecological Risk Assessment define an assessment endpoint as an explicit expression of an environmental value that is to be protected. More generally, any ecological attribute of relevance or concern to those conducting an assessment can be considered an endpoint. Examples include a particular duration-frequency flow event (e.g. the 100-year flood, 7Q10 low flow event), the annual water yield from a watershed, or the annual nutrient loading to a stream.

BASINS CAT provides a flexible capability to calculate and display assessment endpoints based on model output data. Endpoints are calculated as a post-processing step using model output data. This capability allows users to quickly generate data for assessing the influence of climate change on hydrologic and water quality endpoints of concern.



The **Assessment Endpoints** tab contains a list of the Endpoints which the user has created. To run the model, at least one input and one output are necessary.

Check Boxes.

At the top of the tab window, there are two checkboxes for options when the model is run. The user can choose to:

- Save Only Selected Endpoints
- Save Complete Copy of All Model Inputs and Outputs for Every Run
-

If the **Save Complete Copy** box is checked, CAT will save each scenario run (all related input and output files) into its own separate folder. The naming convention is by appending the weather change scenarios' ordinal number to the **New Model** name (specified on the **Climate Data** tab). For example, if the new model name is 'Modified', then each run's sequential number is appended to this name to form corresponding folder for each CAT scenario run, i.e. Modifield-1, Modified-2, Modified-3 etc.

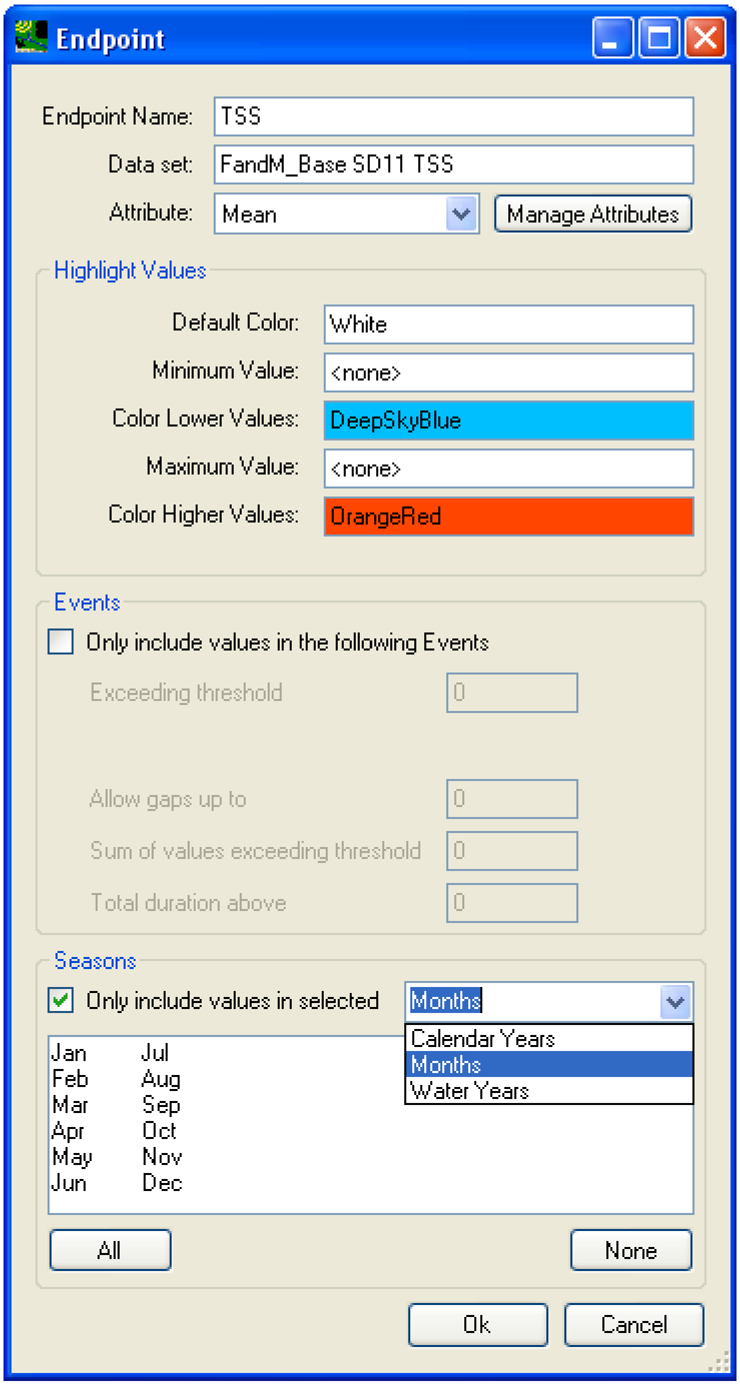
If the **Save Only Selected Endpoints** box is checked, CAT will save each scenario run (all related input and output files) into a single folder, whose name is the **New Model** name (specified on the **Climate Data** tab). Subsequent runs' input/output files will overwrite previous runs' files. So, continuing on with the example above, instead of having multiple folders, there will be only one folder called 'Modified'

Add Button

To generate a new endpoint, click the **Add** button, and select a dataset as

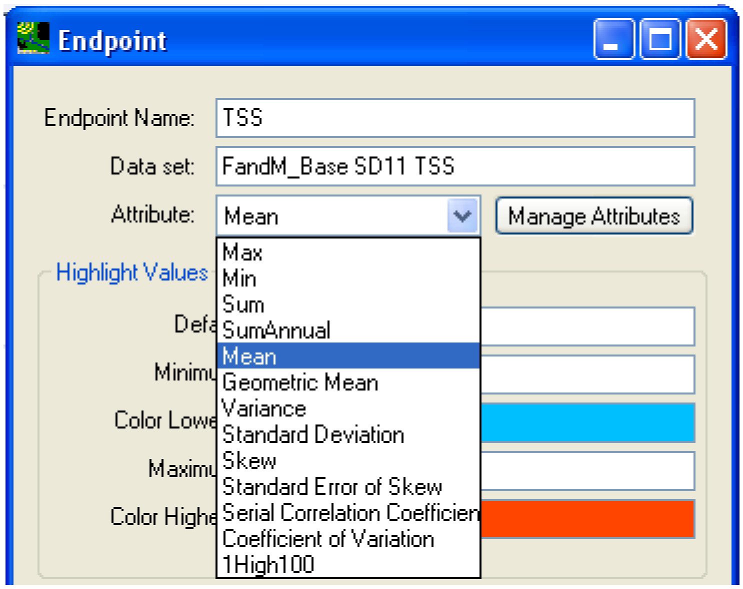
directed in the tutorial.

Click the 'Add' button will bring up the endpoint definition window as shown below.



The above endpoint definition window has a similar layout as the climate data modification window introduced in the 'Climate Data' section. User is to choose a model output as target endpoint, provide a label for the chosen endpoint, and select the desired statistics.

The common statistics are shown below:



CAT also allows more user-defined advanced statistics such as the duration-frequency statistics or percentile values. Click on the **Manage Attribute** button next to the 'Attribute' dropdown list, it will bring up the extended endpoint statistic definition window as shown below:

In the above window, user can specify N-Day parameters for desired duration and frequency. Once the OK button is clicked, the newly created statistics will be added to the existing list until user chooses to delete it from the list using the window above.

The 'Highlight Values' block in the endpoint definition window allows user to specify minimal and maximal threshold values for the chosen endpoint to be colored accordingly in the resulting grid.

The ‘Events’ block allows user to specify whether the endpoint statistics is to be calculated on an event basis by checking/unchecking the ‘Only include values in the following Events’ checkbox. If it is checked, then user is to specify the threshold values and/or duration or gap to define what constitutes an event.

The ‘Seasons’ block allows user to specify whether the endpoint statistics is to be calculated on a seasonal basis by checking/unchecking the ‘Only include values in selected’ checkbox. If it is checked, then user is to further specify the type of season, i.e. Months, Calendar Years, or Water Years using the drop down box. Lastly, user can select which seasons are to be included in the statistic.

Remove Button

Click on an endpoint to highlight it, then click **Remove** to delete the endpoint.

Edit Button

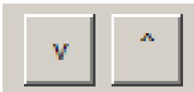
Highlight an endpoint and click **Edit** to open the main **Endpoint** window to modify the endpoint.

Copy Button

If you would like to use a similar endpoint, but make a small change (for example, change which months are selected), click the **Copy** button to create a new, identical endpoint that can be edited more easily than starting over.

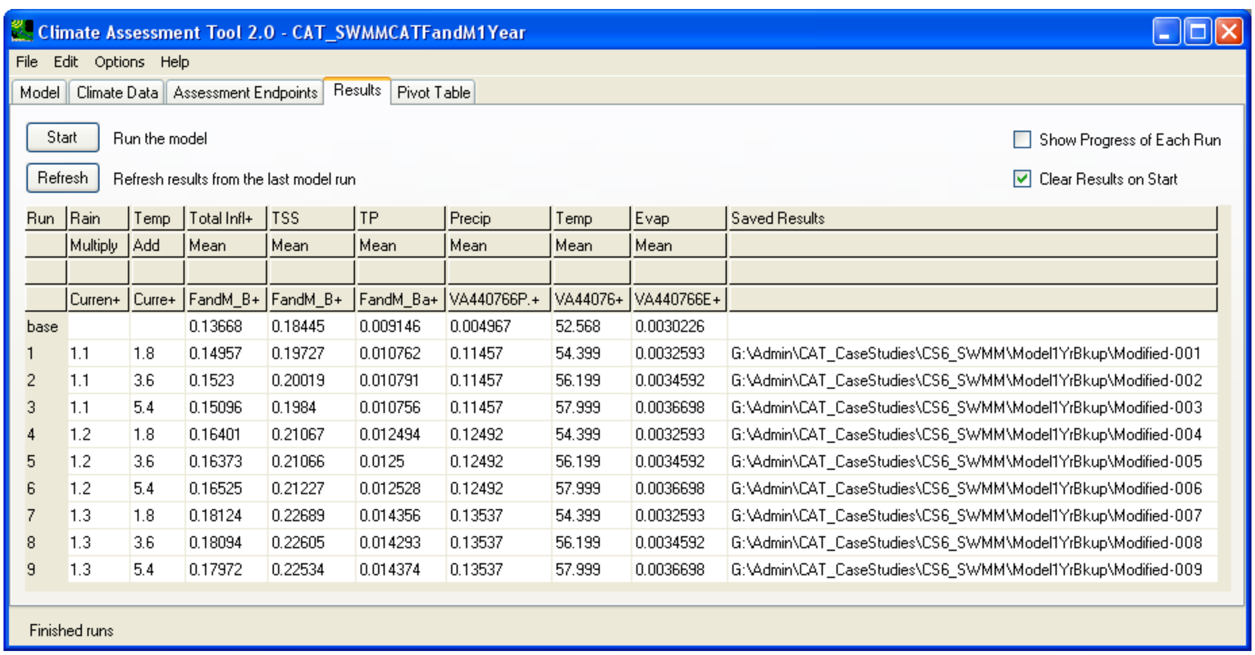
Arrow Buttons

The arrow buttons on the right side of the window are used to move the list of endpoints up and down one rank at a time for organization.



Results

The **Results** tab manages running the chosen CAT scenarios and displays the CAT model run results in a grid format.



There are two buttons on this tab, i.e. **Start** and **Refresh**. The **Start** button will initiate the scenarios simulations. This implies that input/output files from previous runs will be overwritten and created anew if the current run uses the same folder naming convention as the previous run. In contrast, the **Refresh** button will only retrieve the endpoint results as defined in the saved configuration file without re-running all the scenarios, which could be time consuming.

There are two checkboxes on this tab, i.e. **Show Progress of Each Run** and **Clear Results on Start**. These are quite straightforward as to their functions.

The simulation results are shown in a grid format.

All chosen scenarios are labeled with a sequential value as the order in which they are defined on the **Climate Data** tab. The corresponding endpoint values of the base scenario are displayed in the first row of the result grid. This allows the user a quick appreciation of the impact of various scenarios. It is worth pointing out that climate data are also allowed to be defined as endpoints and hence displayed on the result grid. This is to provide all input/output information for all scenarios in one place for quick analysis. Lastly, the last (right-most) column of the result grid contains the full path of the result files for each scenario to allow easy organization.

Pivot Table

A pivot table is a data visualization and mining tool that allows users to reorganize selected columns and rows of data within a database. The term pivot refers to turning the data to view it from different perspectives. Pivot tables are especially useful for summarizing large amounts of data in a compact format, looking for patterns and relationships within a dataset, and organizing data into a format suitable for plotting data as a chart.

The **Pivot Table** tab allows users to view model output data (the same data listed in the results table) in a pivot table. The **Rows**, **Columns**, and **Cell** fields must be selected from the dropdown lists on this tab. In a classic example, user can choose precipitation changes to be the row and temperature changes to be the column, then a desired endpoint (such as runoff) to be the cell values.

Other Resources

Further information on Climate Change can be found at EPA's climate change web site. This site contains a wide range of information about climate change and climate change impacts.

The U.S. Climate Change Science Program (CCSP) web site discusses science issues.

Research topics are discussed at the U.S. Global Change Research Program web site.

More research topics are found at the NOAA Regional Integrated Sciences and Assessments (RISA) web site.

An international perspective is found at the Intergovernmental Panel on Climate Change (IPCC) web site.

Further information on Climate Scenarios can be found at the IPCC Climate Change 2001 - The Scientific Basis - Chapter 13 - Climate Scenario Development

The IPCC Task Group on Scenarios for Climate Impact Analysis gives guidance on developing scenarios and conducting climate change impact assessments at their guidelines web site.

The Consortium for Atlantic Regional Assessment has a useful Climate Change Primer along with some climate change scenarios for the Northeastern US.

Model Tutorials

In these tutorials, the user will setup and run the HSPF watershed model.

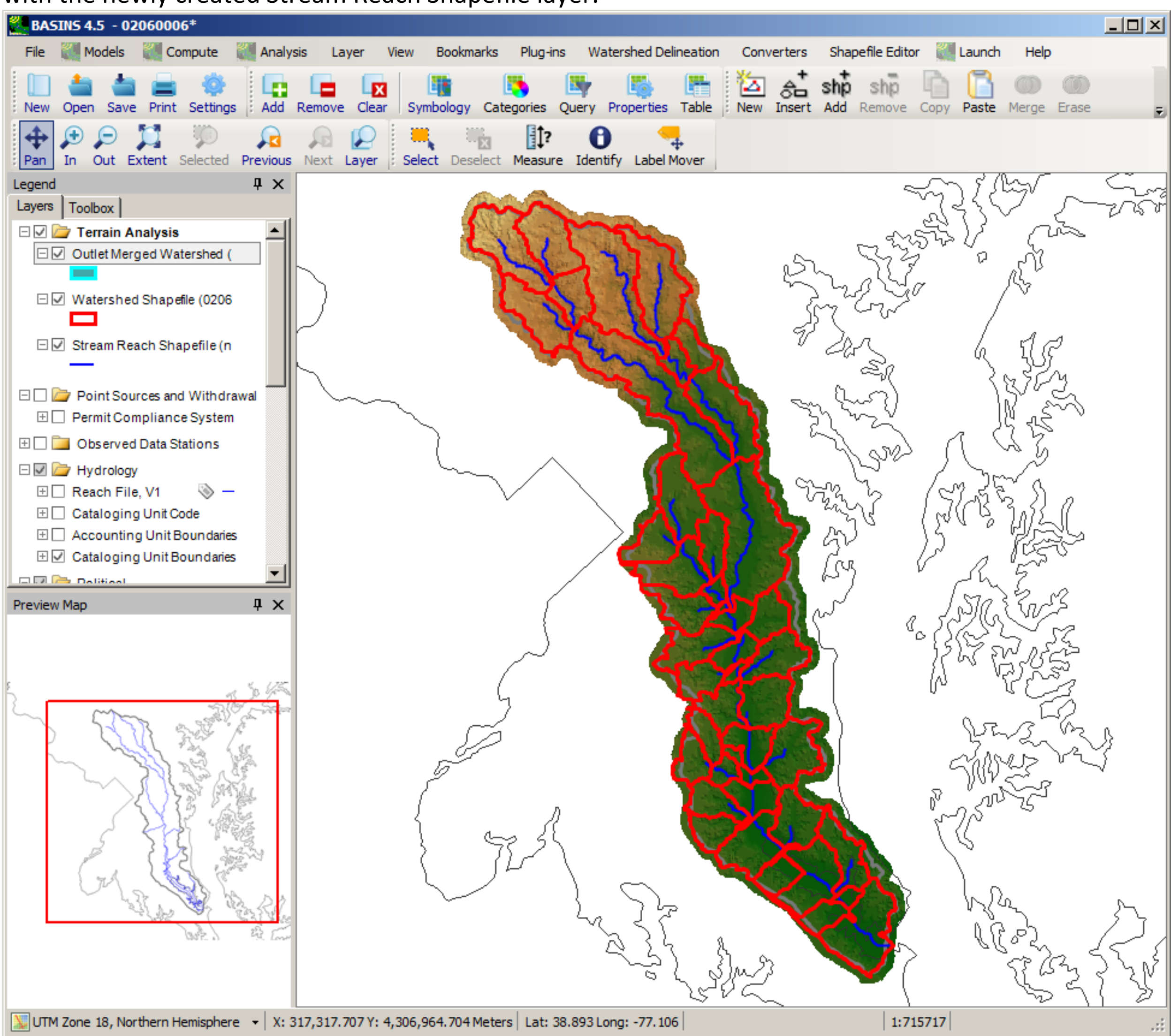
Next, input meteorological data will be varied to assess the impacts on critical model output parameters (e.g., streamflow).

Users may also be led through the process of creating a SWMM project through BASINS or creating a SWAT project through BASINS.

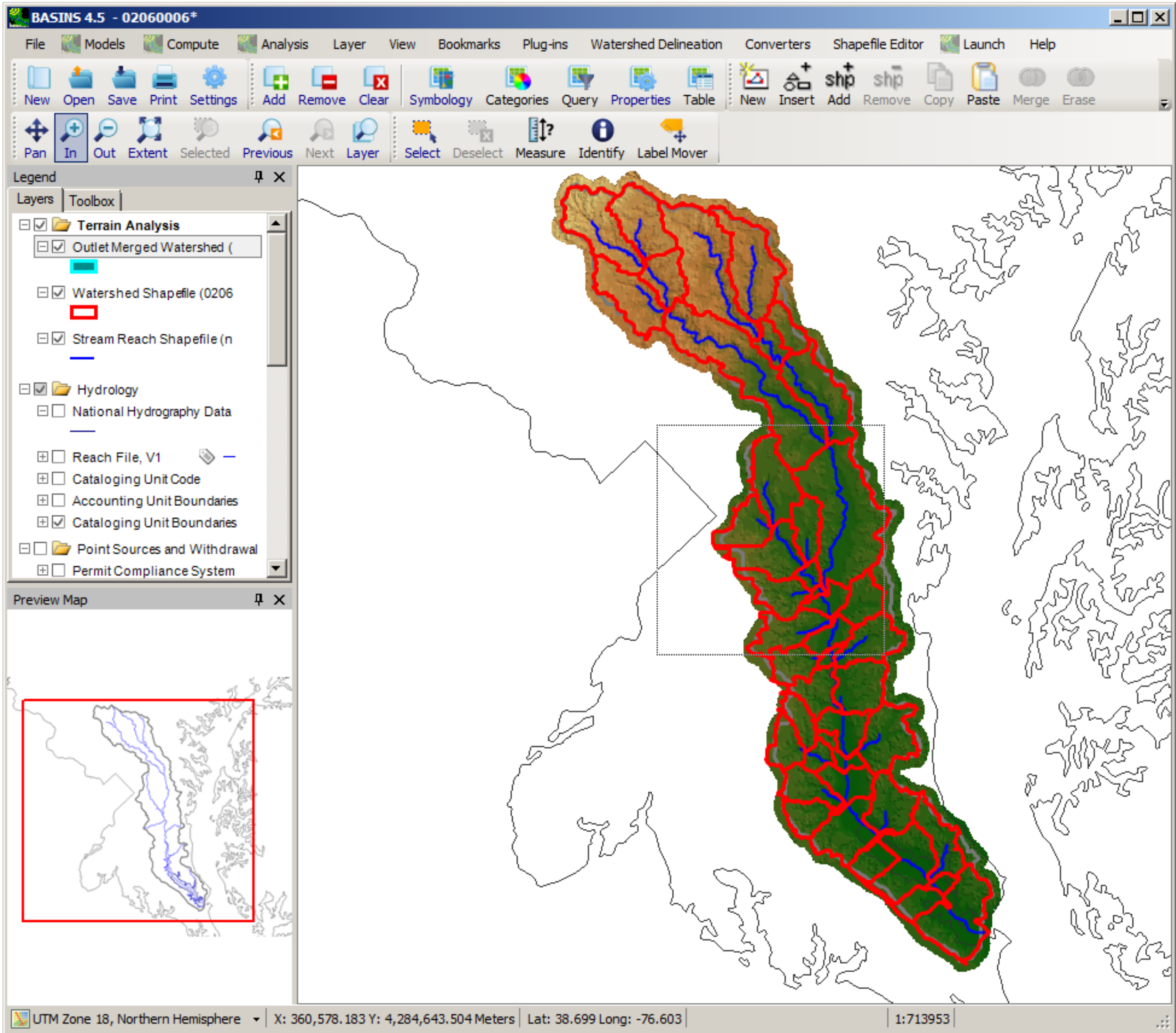
Starting HSPF

One of the most valuable applications of BASINS is the ability to construct an *HSPF* project from the information contained within a BASINS project. Execute the following steps to construct and run an *HSPF* model for a select area within the Patuxent watershed.

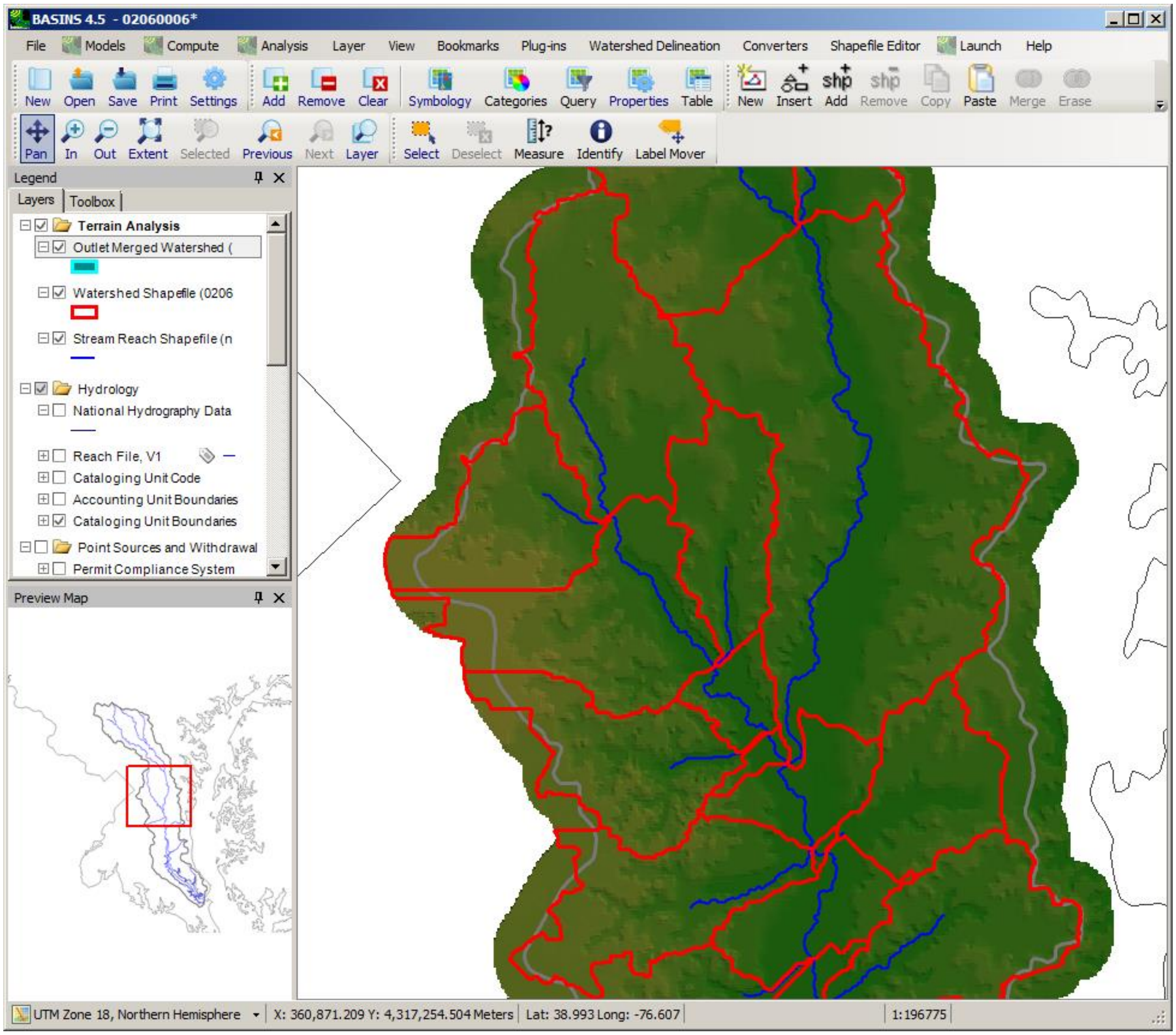
1. This section begins with a map of the entire Patuxent watershed, identical to the final product of the Basic Automatic Delineation tutorial. (A map layer entitled 'Outlet Merged Watershed' may have been produced by the automatic delineator based on some default settings. This layer is optional and it is not used in building an HSPF project. It does not appear in the images below.) Turn off the Reach Vile, V1 layer by clicking off the checkbox next to it. This will avoid confusion with the newly created Stream Reach Shapefile layer.



2. With the Watershed Shapefile active in the map window, zoom in on the Western Branch of the Patuxent near Washington DC as shown below:

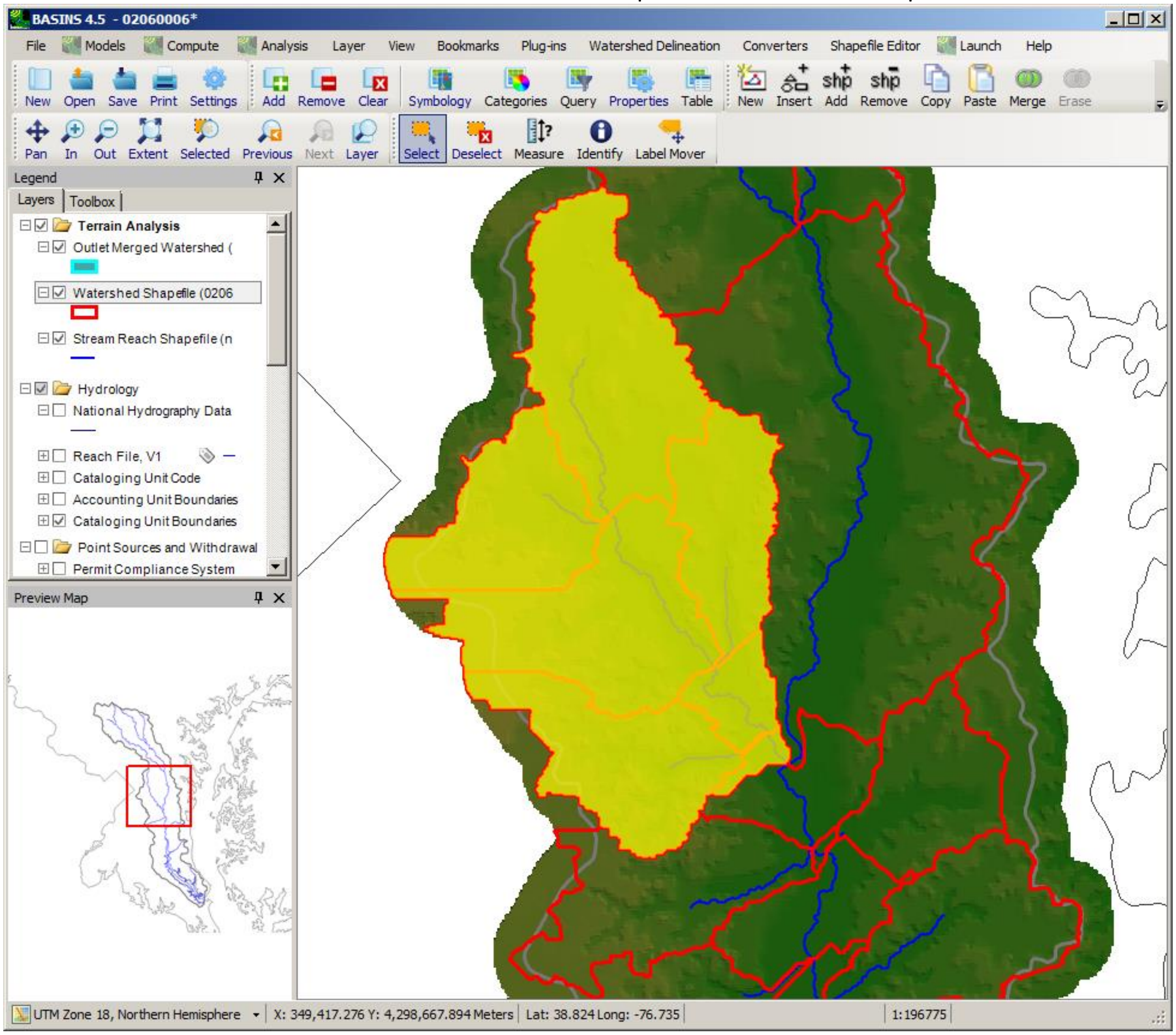


The zoomed view should like that shown below:

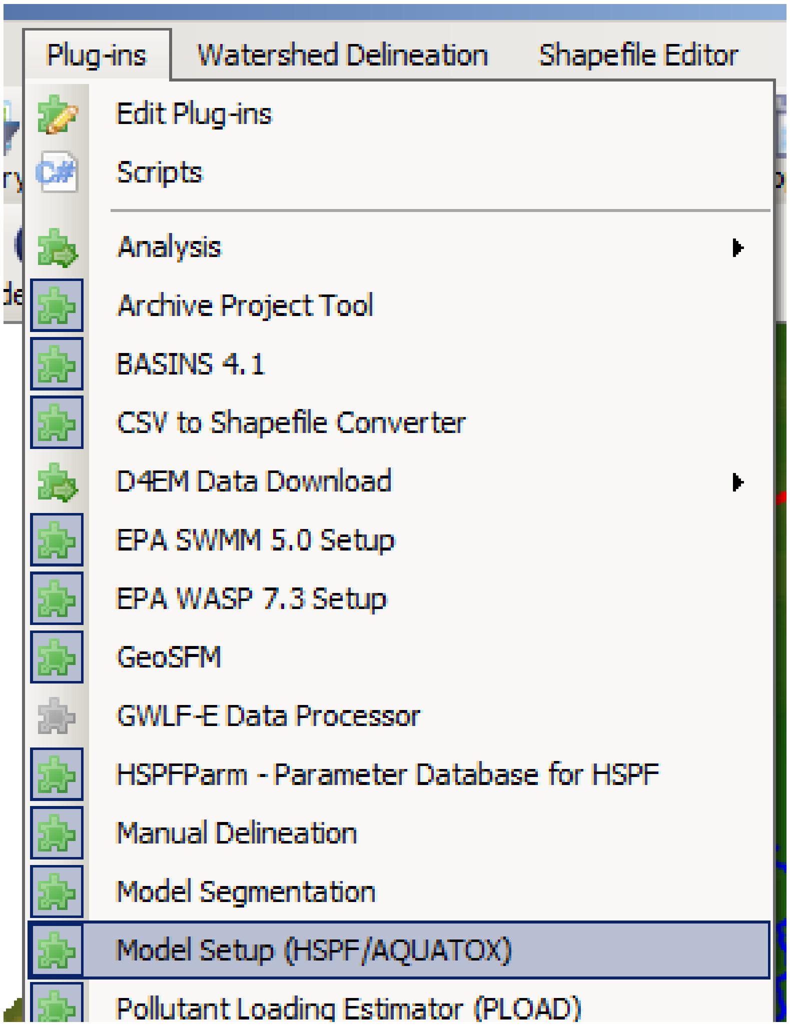


3. To identify the boundaries of the impending *HSPF* model, select by using the Select tool (an arrow on the toolbar) and holding down the **Ctrl** button while clicking on the seven subbasins of

the Western Branch. Make sure that the Watershed Shapefile is active in the map window.

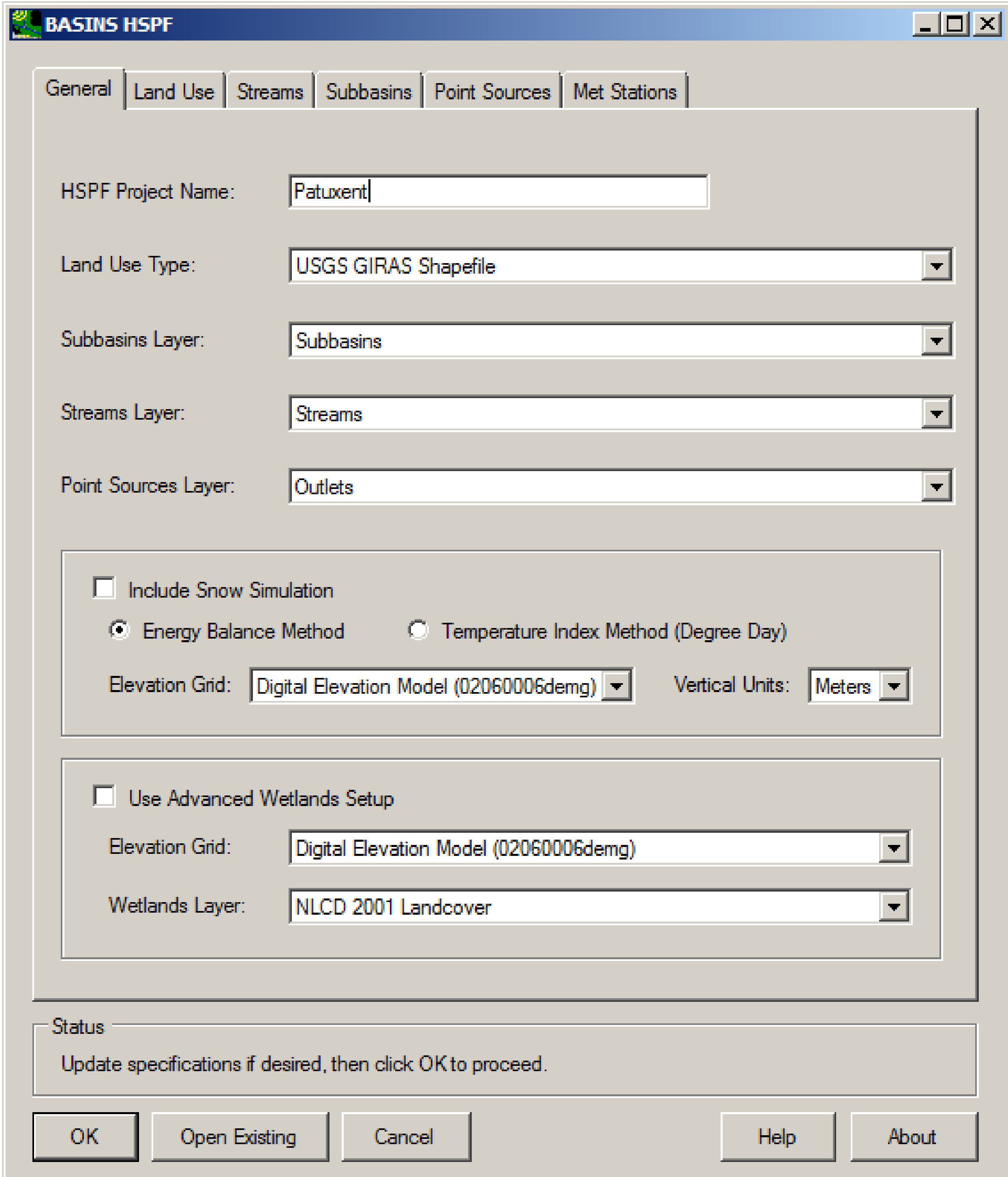


4. Select **Model Setup (HSPF/AQUATOX)** from the **Plug-ins** menu so that it is active. This will add **Models** to the menu on the main form.

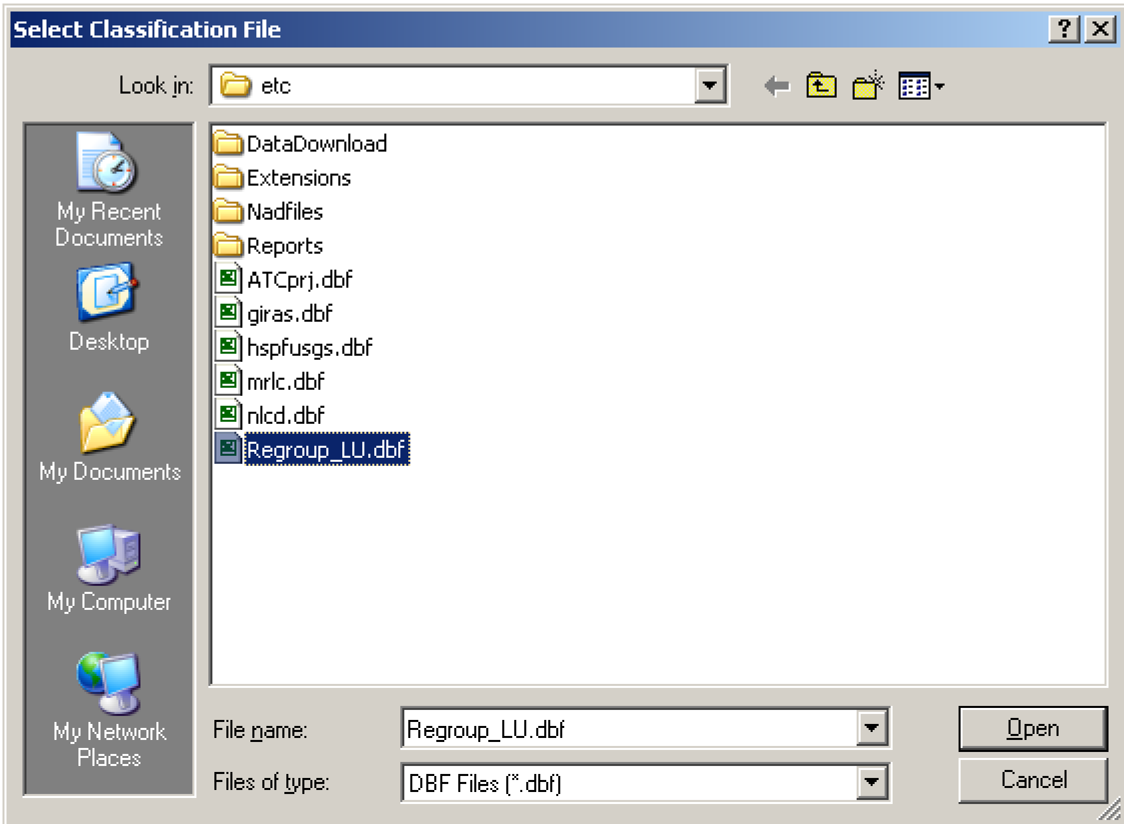


5. Select **Models:HSPF** from the main menu, and the BASINS *HSPF* form appears. Change the name of the HSPF project to 'Patuxent'. All of the other fields will be defaulted appropriately, specifying that the results of the Automatic Delineator will be used along with the GIRAS

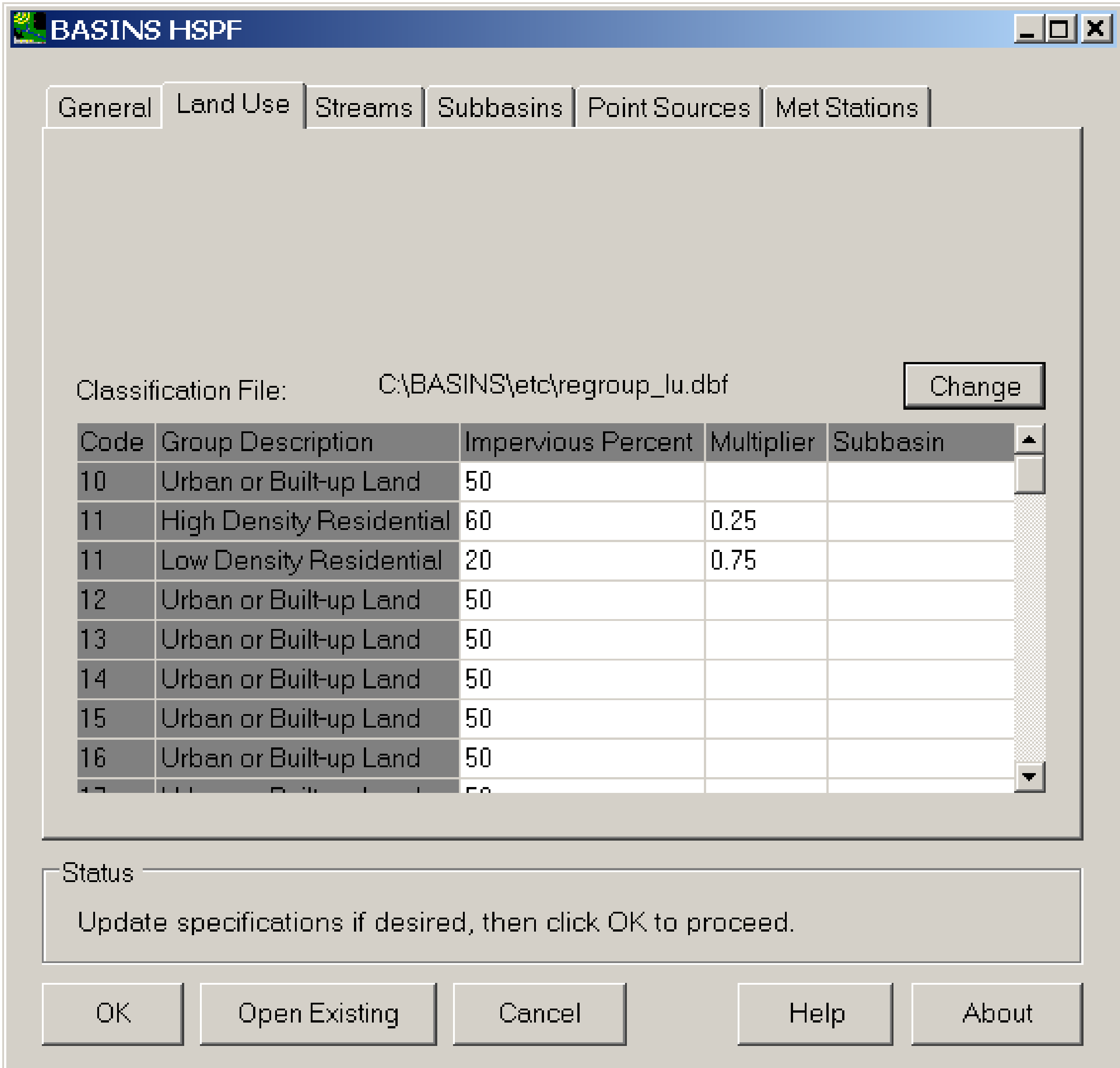
landuse data.



6. *Optional:* On the Land Use tab, click the **Change** button to load the classification file that was produced in the Reclassify Land Use lesson.

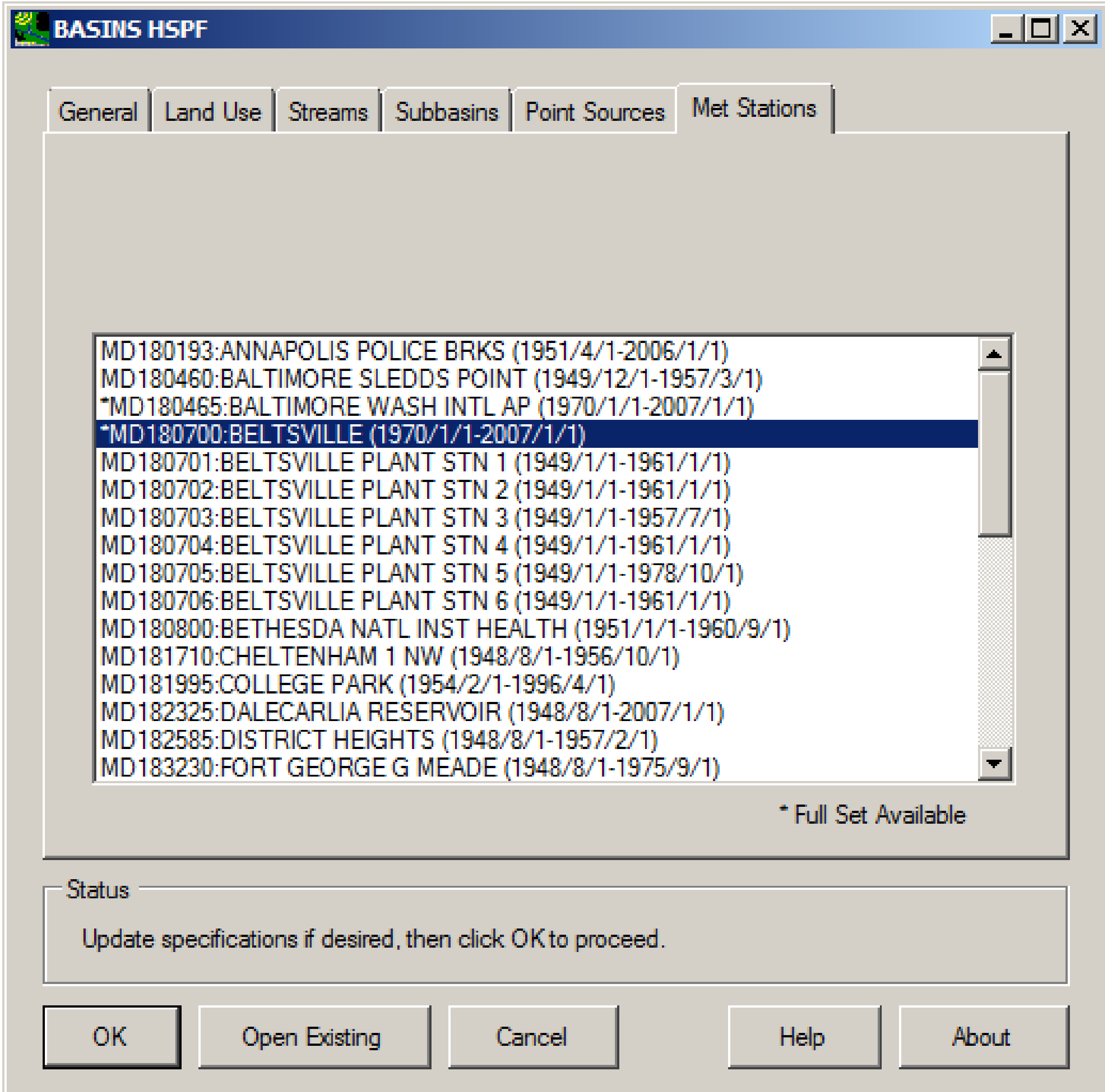


The Land Use tab will update to display the new classification scheme.



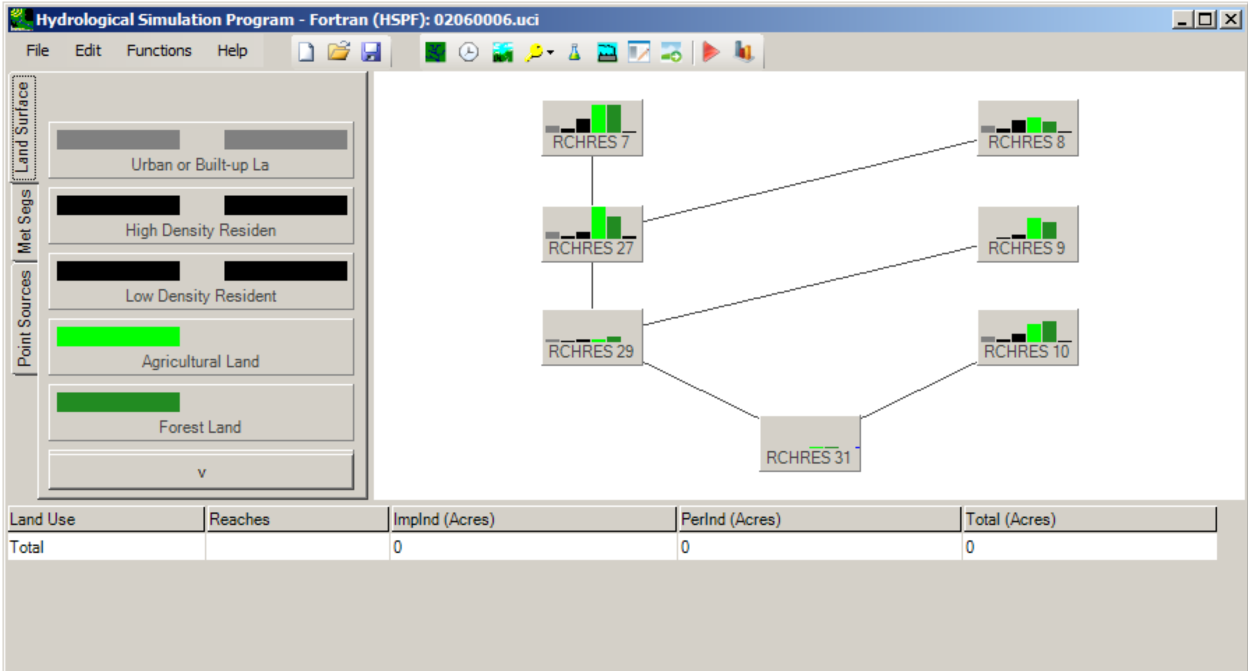
7. Click on the **Met Stations** tab to view the meteorological data available, based on the WDM files in the current BASINS project. The WDM file of met data was downloaded in the previous Downloading Additional Data lesson. The Beltsville, MD met station is a reasonable pick from

the Initial Met Station picklist.



8. Click **OK** to create the *HSPF* UCI file, which will be stored in the '\BASINS\modelout\02060006\' directory. After processing, the main window of *WinHSPF* will appear with the new *HSPF*

project.



9.

Note: You are now in the *WinHSPF* environment. Refer to that program's documentation from this point on to see how to further enhance your *HSPF* project (e.g., creating time series in 'Output.wdm' where model output can be written).

Climate Assessment Tool

Variations in the input meteorological data can have a significant effect on instream water quantity and quality. The **Climate Assessment Tool** (**CAT**) allows the user to vary certain input data sets across specified ranges and see the resulting impact on critical model output parameters (more information about CAT; other resources for climate change assessment).

BASINS-CAT version 2.0 allows for climate change assessment using three watershed models: HSPF, SWAT, and SWMM. A tutorial has been developed for CAT using each of these models. Besides showing CAT interfacing with the models, the tutorials also demonstrate a wide range of CAT capabilities. While the tutorials use actual real-world models and feasible ranges of climate change, the results presented in them are for demonstration purposes only.

Note that each of these CAT tutorials assumes the use starts with an empty BASINS project, i.e. a project with no map layers or timeseries data already loaded. If you have a BASINS project open, save the project, close BASINS, then reopen BASINS and select ‘Close’ from the ‘Welcome to BASINS 4.5’ window.

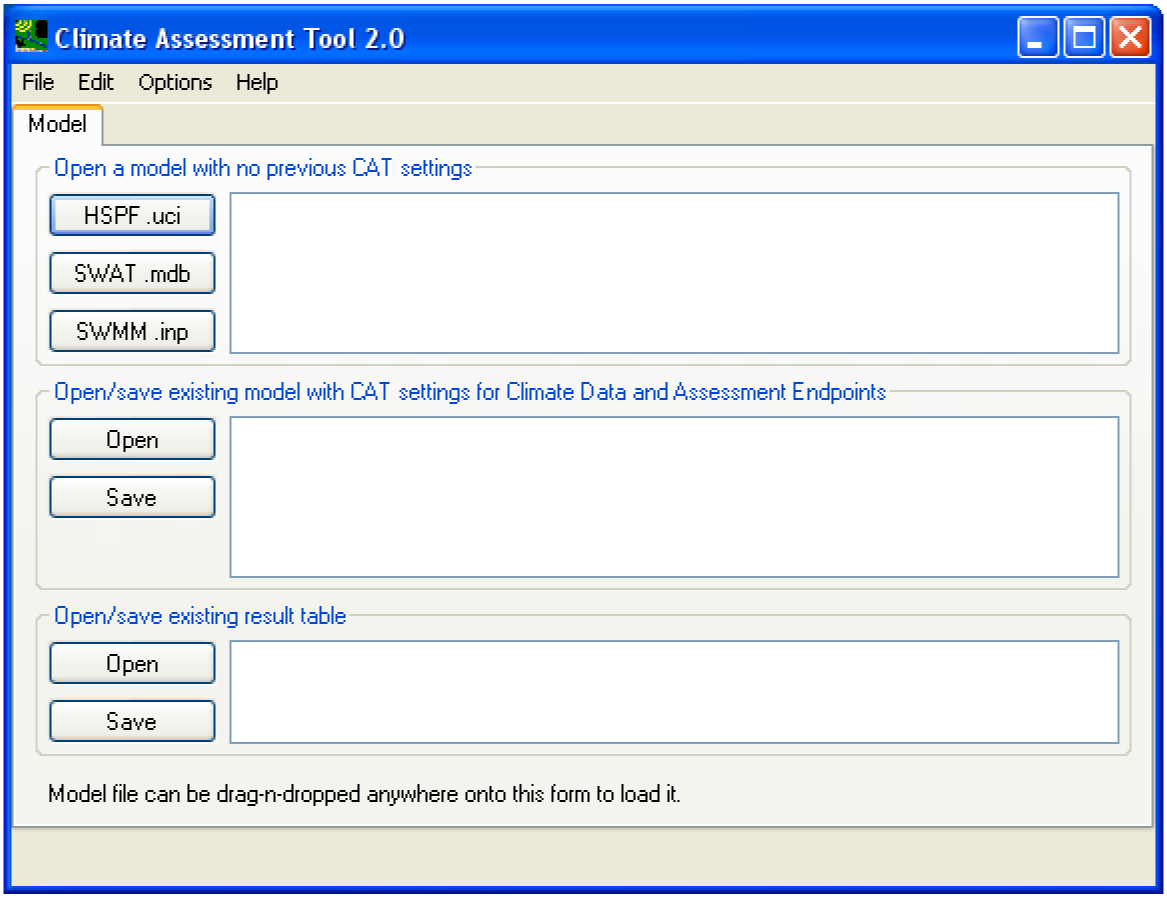
The three tutorials are:

- Climate Change Assessment using HSPF
- Climate Change Assessment using SWAT
- Climate Change Assessment using SWMM

Climate Change Assessment using HSPF

The BASINS **Climate Assessment Tool (CAT)** allows users to easily create climate change scenarios, run hydrologic models to quantify the impact on selected environmental endpoints. Users can refer to the introduction of CAT features and interface options under the general BASINS help section for CAT. In this exercise, we will demonstrate the use of CAT with the **Hydrological Simulation Program - FORTRAN (HSPF)**.

Users can activate the CAT plug-in in BASINS by clicking the Plug-ins->Analysis->Climate Assessment Tool menu option. To launch CAT after the plug-in is activated, click on the Analysis->Climate Assessment Tool menu option. This will bring up the CAT window as shown below.

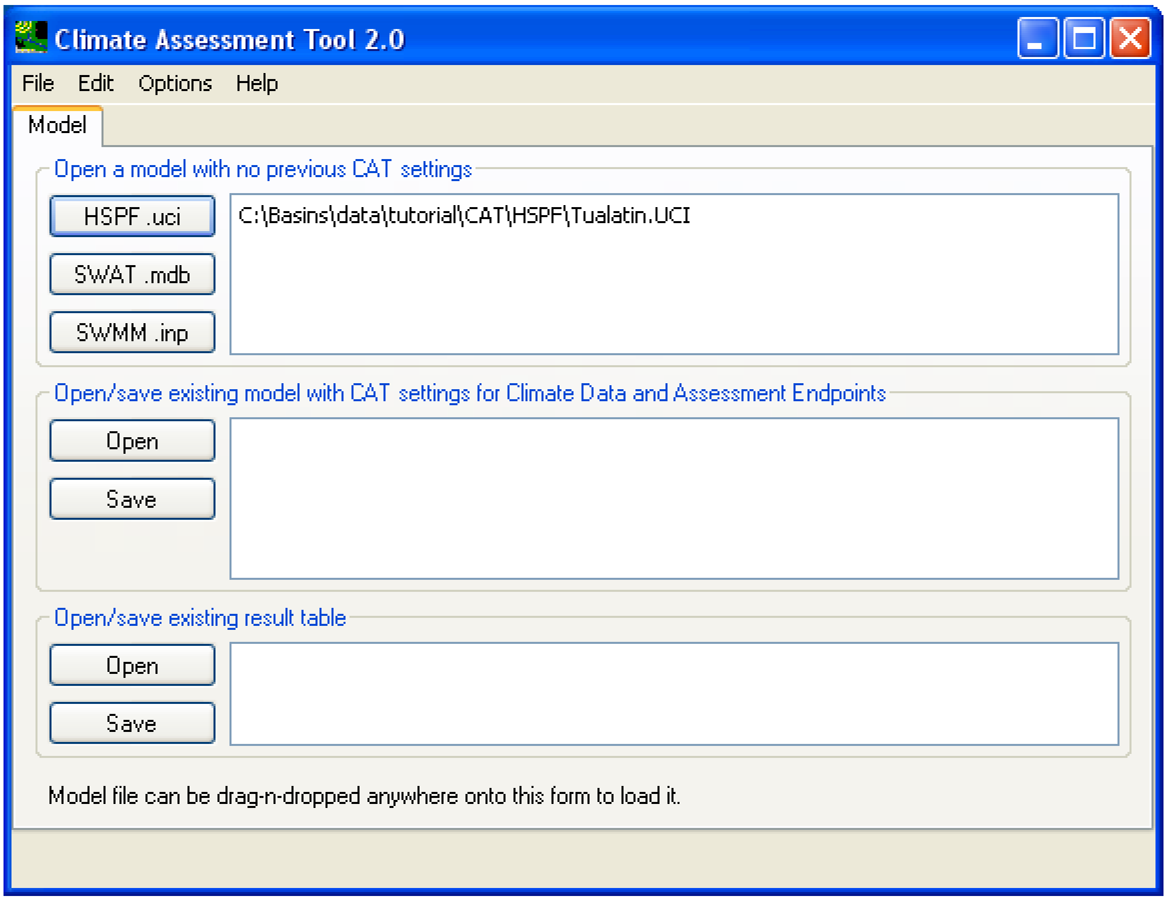


This first tab allows the user to start a brand new analysis, open an existing saved analysis, or simply re-examine the result table from a past analysis. In this exercise, we will create a new HSPF CAT analysis. The prerequisite files listed here for this exercise should be found under the \Basins\data\tutorial\CAT\HSPF folder:

- Tualatin.UCI (base case HSPF model input file)
- Tualatin.wdm (base case HSPF model data file)
- Tualmet.wdm (base case HSPF weather input data file)

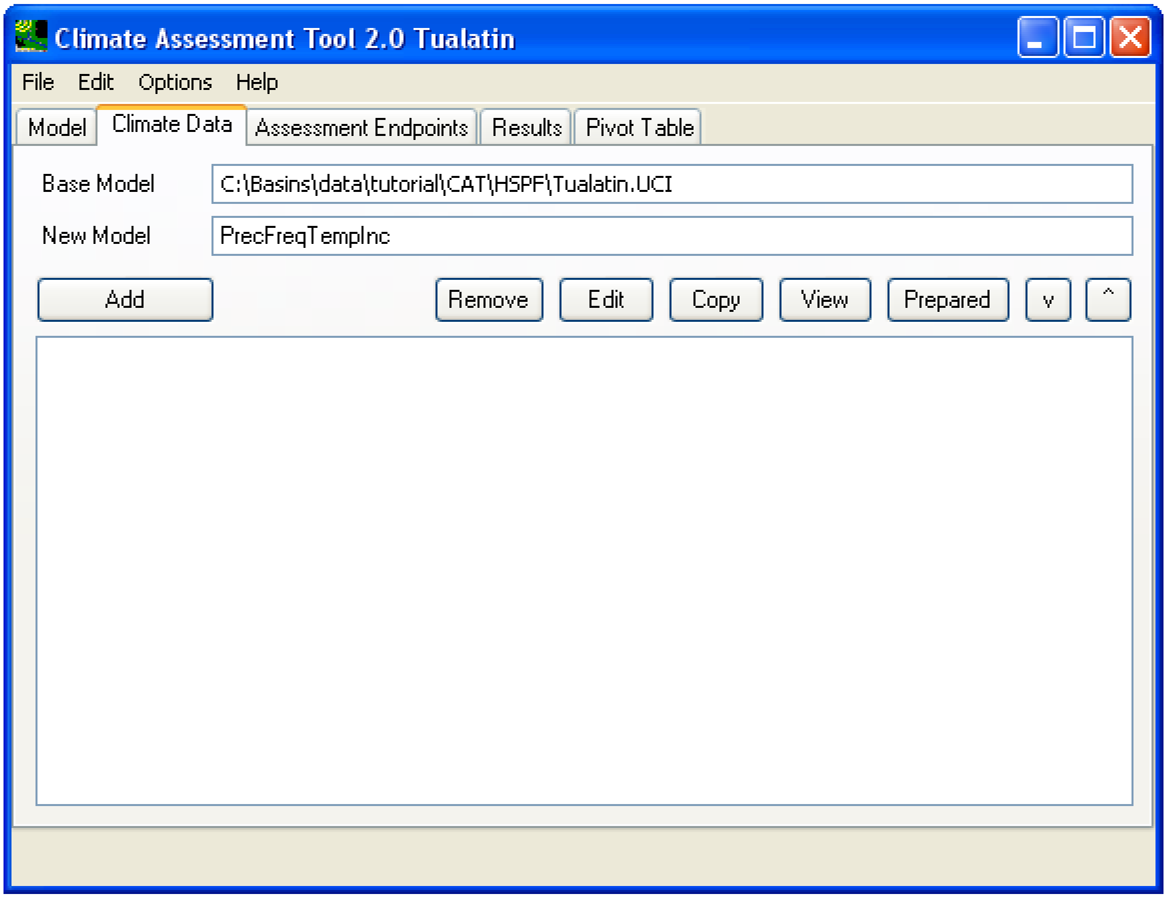
In this exercise, the weather data are hourly precipitation (inch), temperature (Fahrenheit), and potential evapotranspiration (inch) from October 1, 1972 to December 31, 2006.

From the **Model** Tab, click the **HSPF .uci** button. This will open the file dialog window to locate the Tualatin.UCI input file for the base case scenario, which is located under C:\BASINS\Data\tutorial\CAT\HSPF. Once this is done, the full directory path to this input file will be displayed as the first entry in the text box next to the **HSPF .uci** button as shown below.

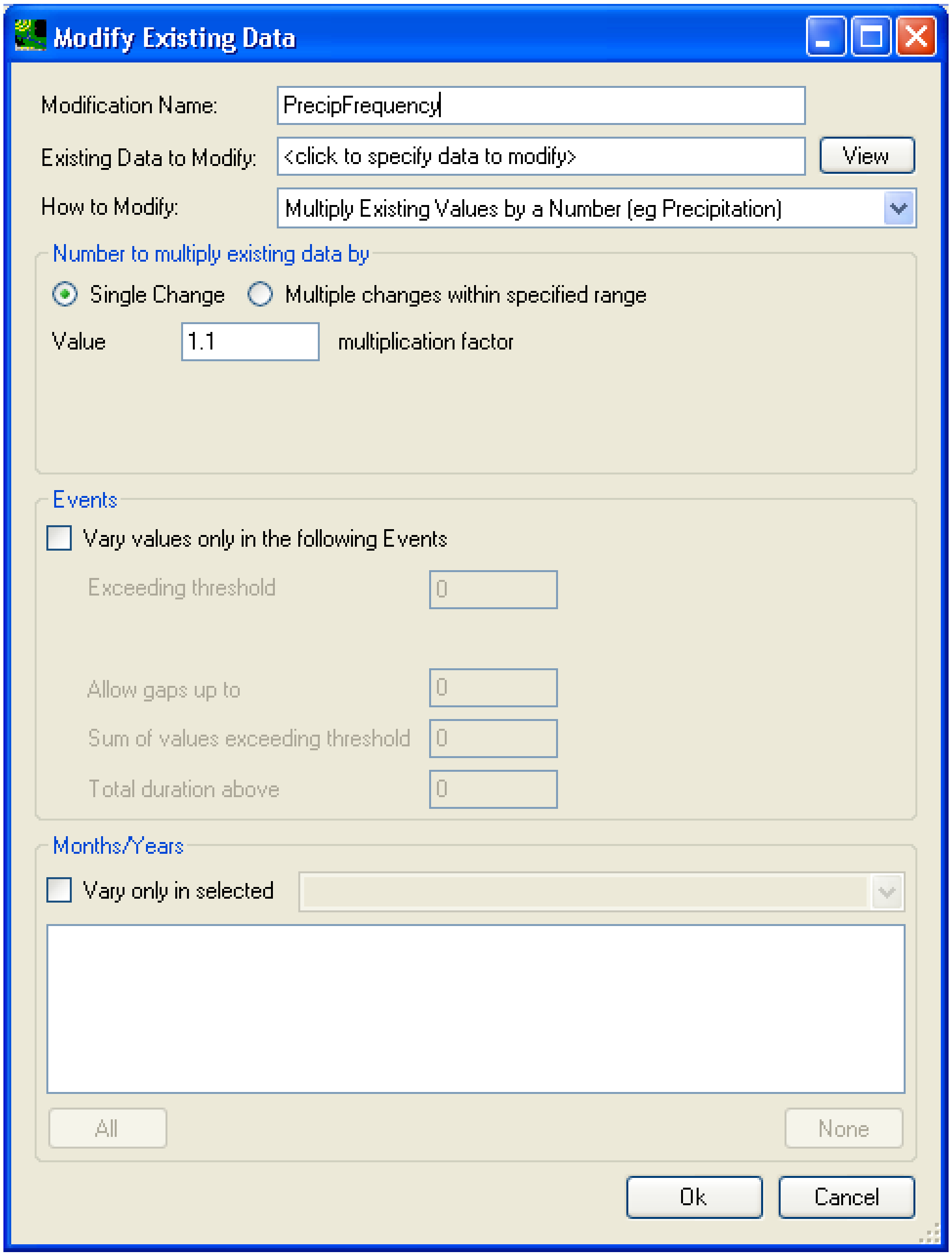


Click on the full path of the base input file in the text box. This will allow CAT to open it and retrieve related output and input data and make them available for user selection in subsequent steps. Once CAT successfully opens the base input file, it will automatically advance to the **Climate Data** tab.

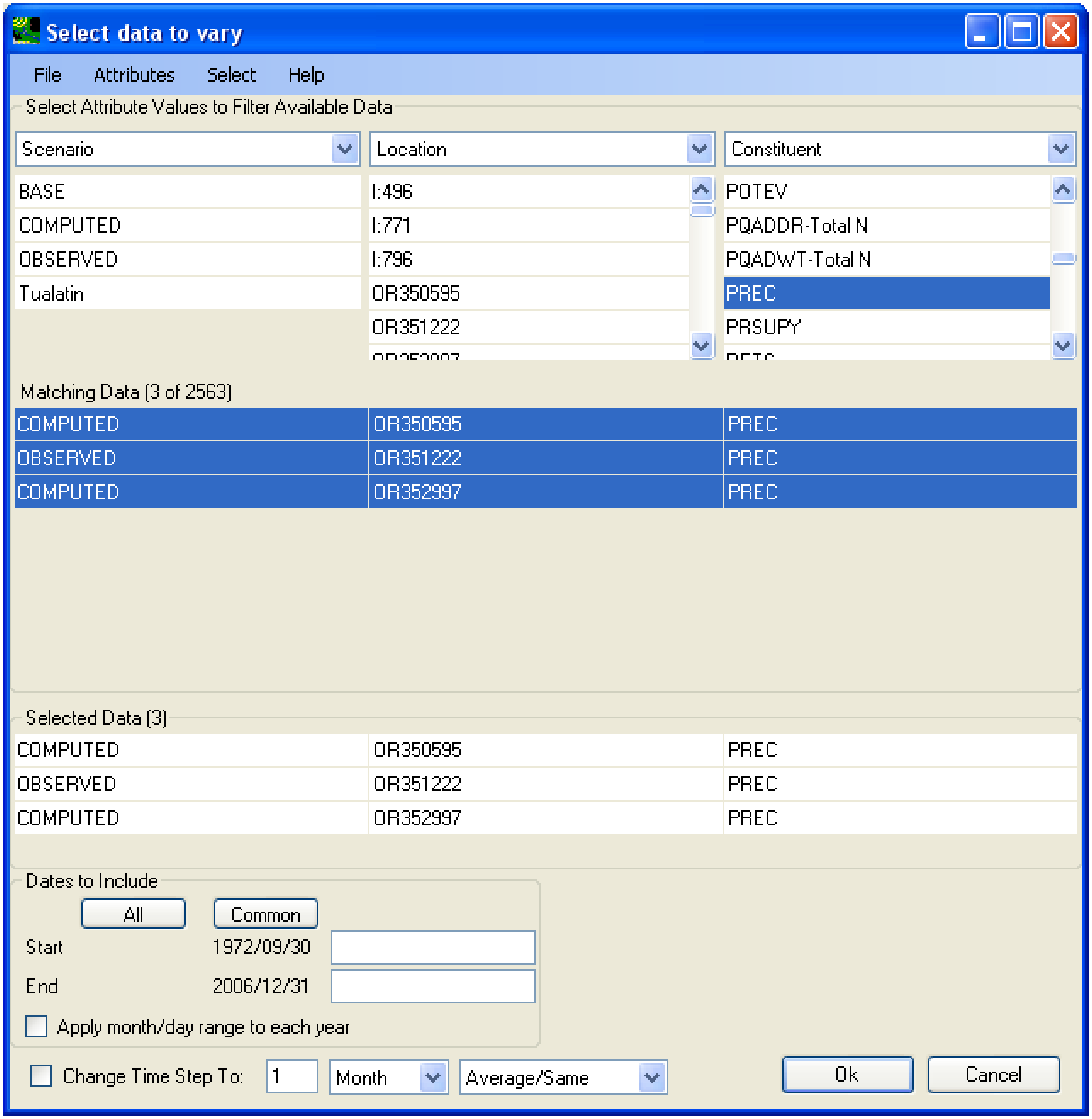
In this exercise, we will assess model sensitivity to varying adjustments to rainfall and temperature data. To begin, change the 'New Model' name to <u>PrecFreqTempInc</u> as shown below.



To initiate a climate adjustment, click the **Add** button to open the **Modify Existing Data** window. In this example, we will specify a series of increases to precipitation. Begin this process by setting the 'Modification Name' to <u>PrecipFrequency</u> as shown below.



Next, select the precipitation data records to be modified. A single left-click in the 'Existing Data to Modify:' text field will open the **Select data to vary** window. Proceed to select the three precipitation timeseries as shown below and then click the **OK** button.

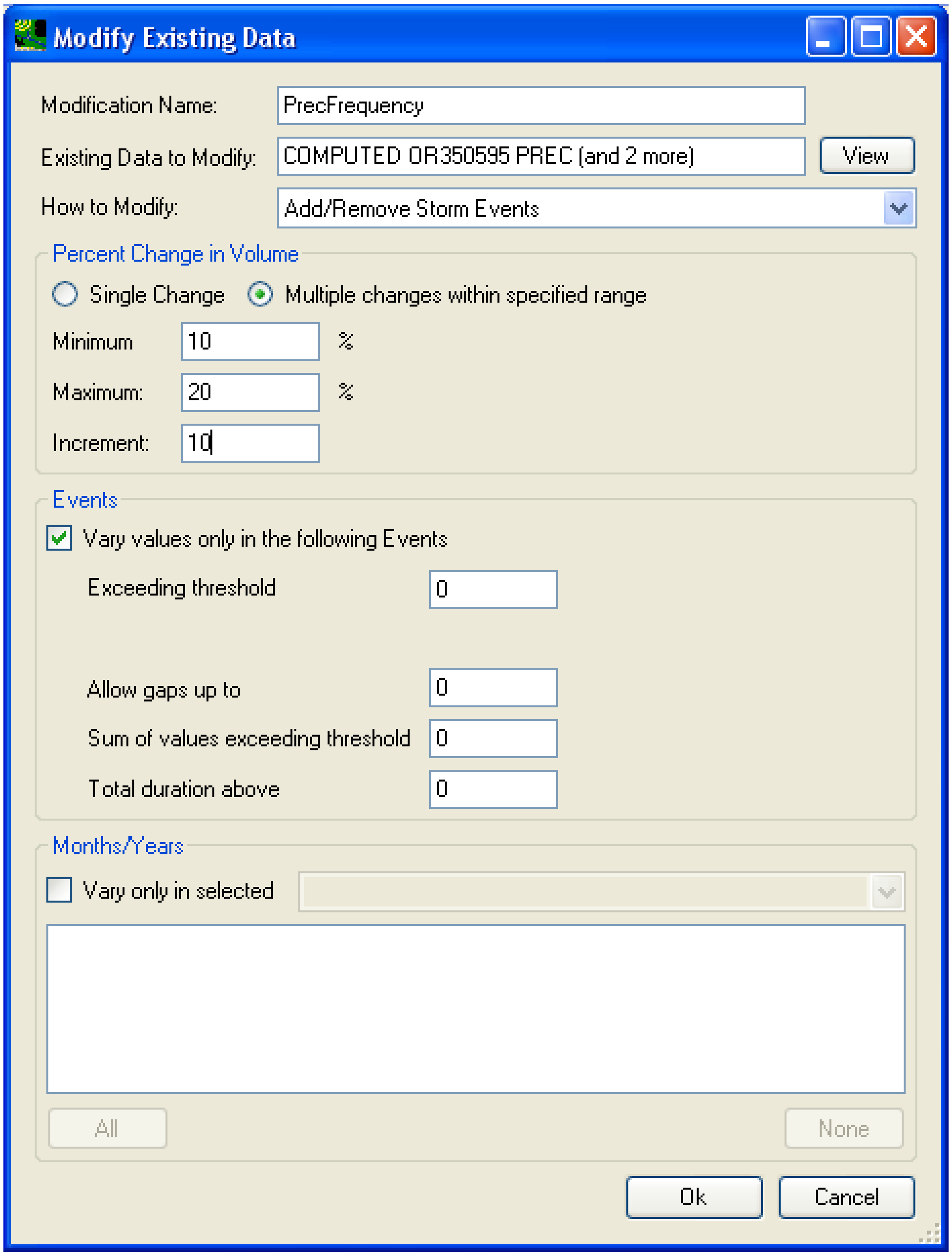


Next, we will specify the exact changes that will be made to the selected rainfall time series. From the 'How to Modify' dropdown box, one can pick different methods for timeseries adjustments. For precipitation, the three most common choices are:

- Multiply Existing Values by a Number (eg Precipitation): This method is used to apply blanket adjustments by simply multiplying every value in the target timeseries with a constant (e.g. 1.2).
- Multiply large/small events by a number: This method is used to apply selective adjustment to rainfall events above or below certain thresholds. Users should specify adjustments as a percentage (eg. 20 %) of the total rainfall volume. This method is used to intensify certain rainfall events. The **Events** frame is used in conjunction with this option to qualify what qualifies as an event.
- Add/Remove Storm Events: This method is used to apply adjustments to total rainfall volume by adding or removing events. Users should specify adjustments as a percentage (eg. 20 %). The **Events** frame is used in conjunction with this option to qualify what qualifies as an event.

For all three methods above, user can choose to apply either a single adjustment or a range of adjustments at a constant step size. This is done by the selection of either **Single Change** or **Multiple changes within specified range** radio buttons.

In this exercise, we will choose the 'Add/Remove Storm Events' adjustment method. We will choose to apply a range of adjustments by selecting the 'Multiple changes within specified range' radio button and by increasing the total precipitation event volume by 10% and 20% at a step size of 10 as shown below:



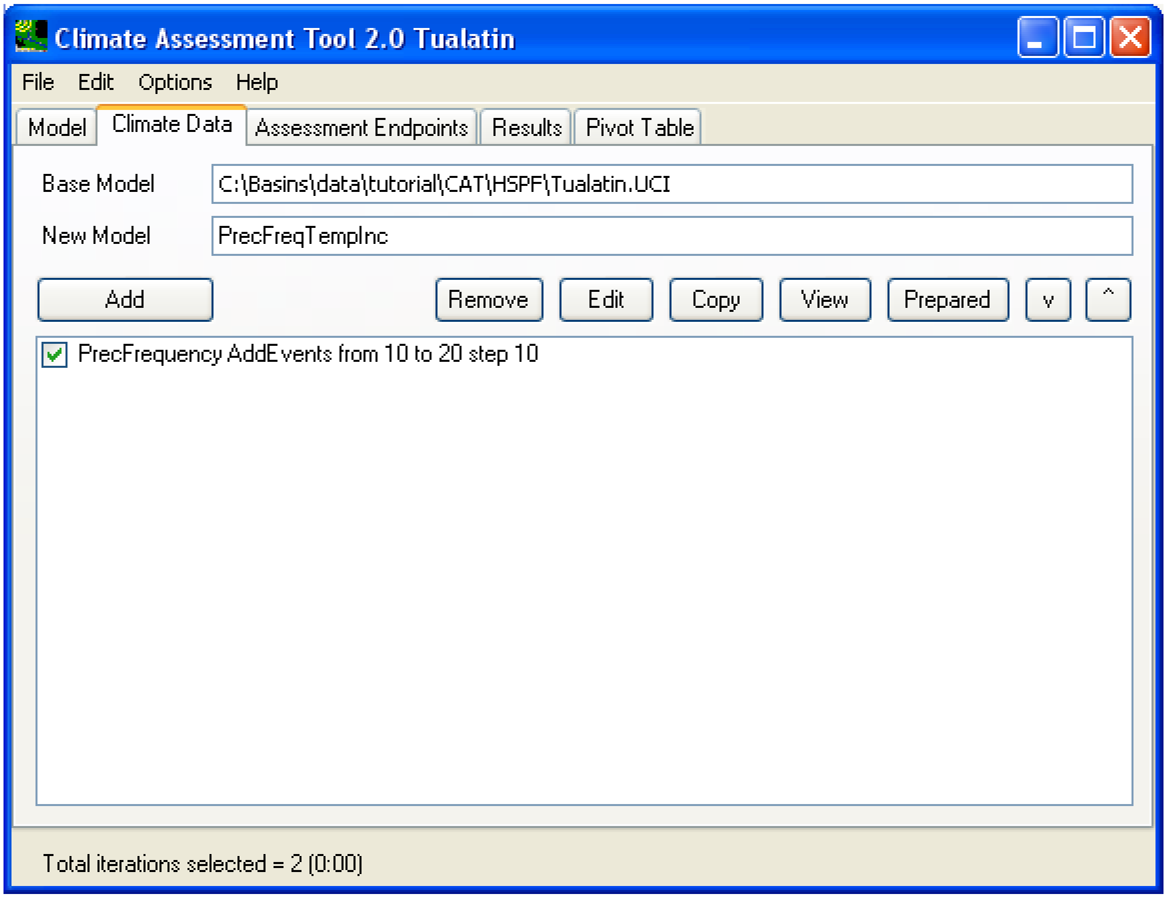
As shown above, the 'Vary values only in the following Events' check box (in the 'Events' frame) **needs to be checked**. The four elements in the 'Events' frame are used to define rainfall events to be adjusted to achieve the desired increase (or decrease) in the total rainfall volume.

Events are defined in terms of intensity, duration, volumes, and gaps, in the units of the data (for BASINS precipitation data these will be inches and hours). These are briefly described below:

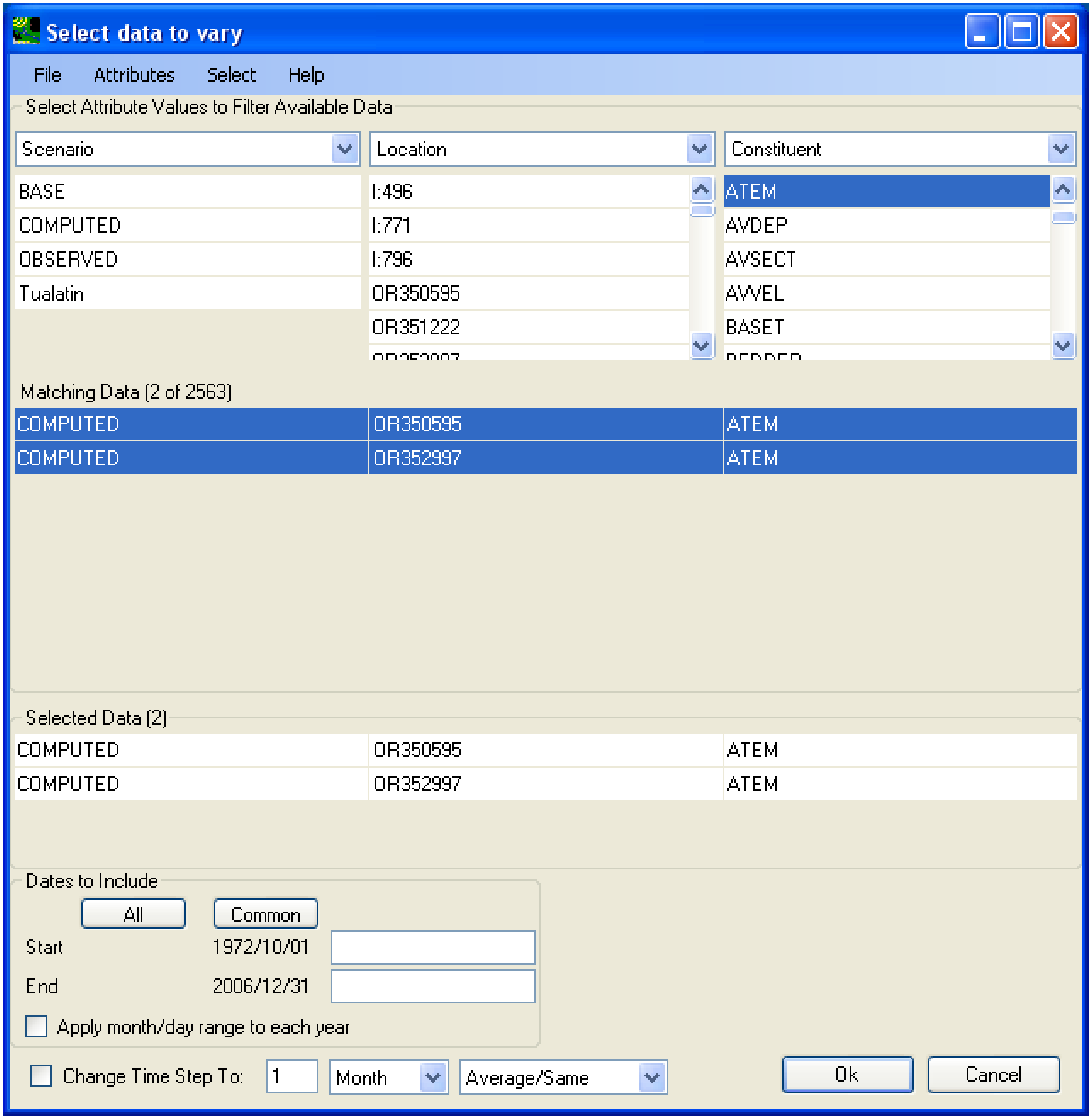
- Exceeding threshold: the minimum rainfall intensity (i.e. values equal to or greater) at which a rainfall value will be considered (default is zero, in inches/hour for BASINS data)
- Allow gaps up to: the longest gap in time between two otherwise consecutive rainfall values for them to be considered as within a single event (default is zero, in number of values)
- Sum of values exceeding threshold: the minimum total volume for an rainfall event to achieve to be included in the adjustment (default is zero, in inches for BASINS data)
- Total duration above: the minimum duration in time for a rainfall event to achieve to be included in the adjustment (default is zero, in hours for BASINS data)

The combined effect of the above four criteria could result in zero qualified events. Thus, users should be familiar with the data record and exercise caution when specifying these criteria. Otherwise, users can simply use the default 0 value for all four, which ensures all potential rainfall events be subject to consideration to achieve the desired total volume adjustment. In this exercise, use zero for all four criteria as shown in the screen shot above.

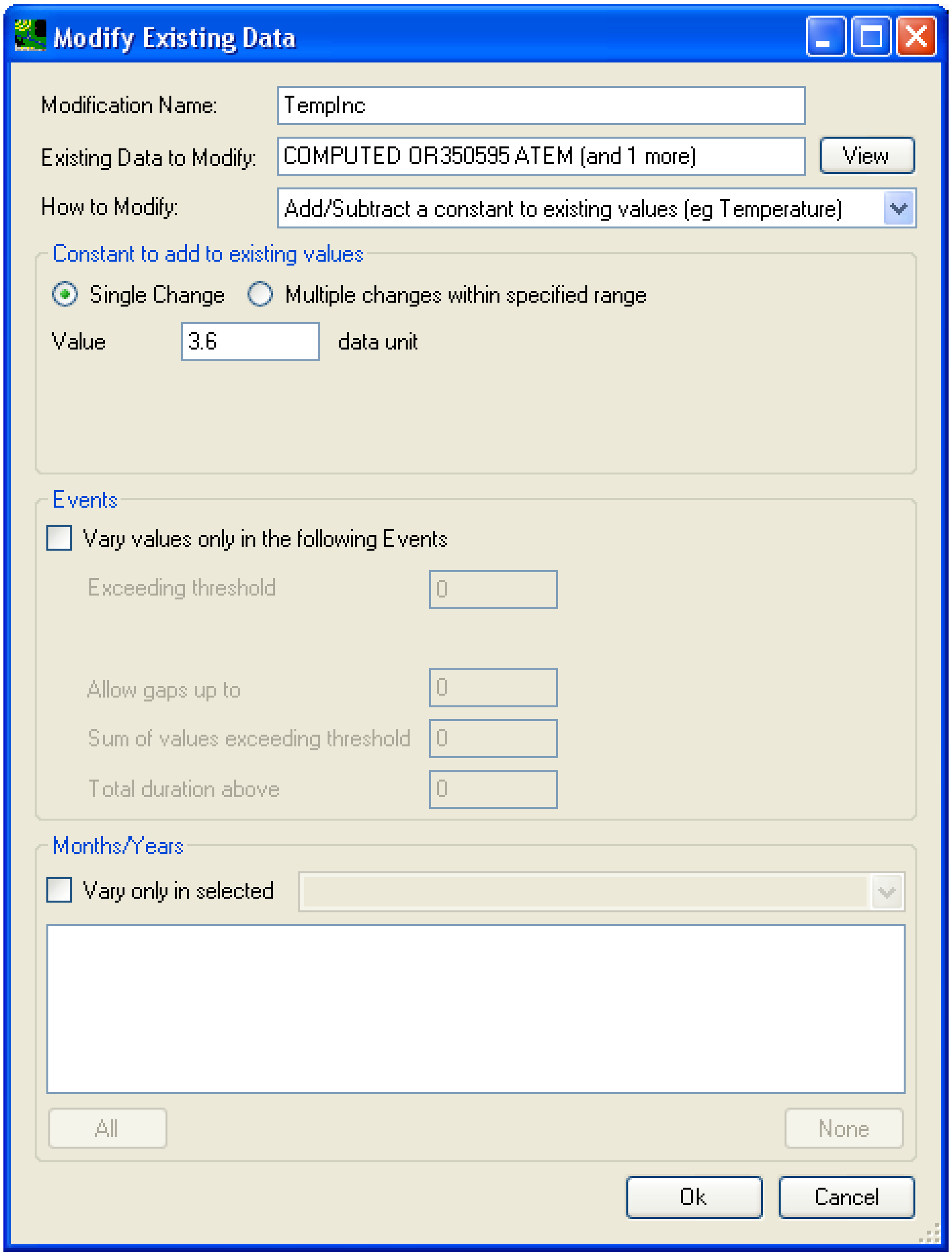
Click the **OK** button to finish the precipitation adjustment definition and close the window. The **Climate Data** tab on the main CAT form will show the newly defined climate data adjustment as below.



Next, we will define a temperature change to be applied to model input data. Begin by again clicking the **Add** button from the **Climate Data** tab. Similar to precipitation adjustment definition, begin by entering a 'Modification Name' (e.g. **TempInc**) and then clicking in the 'Existing Data to Modify:' text field. Select the temperature data to modify as shown below and then click the **OK** button:

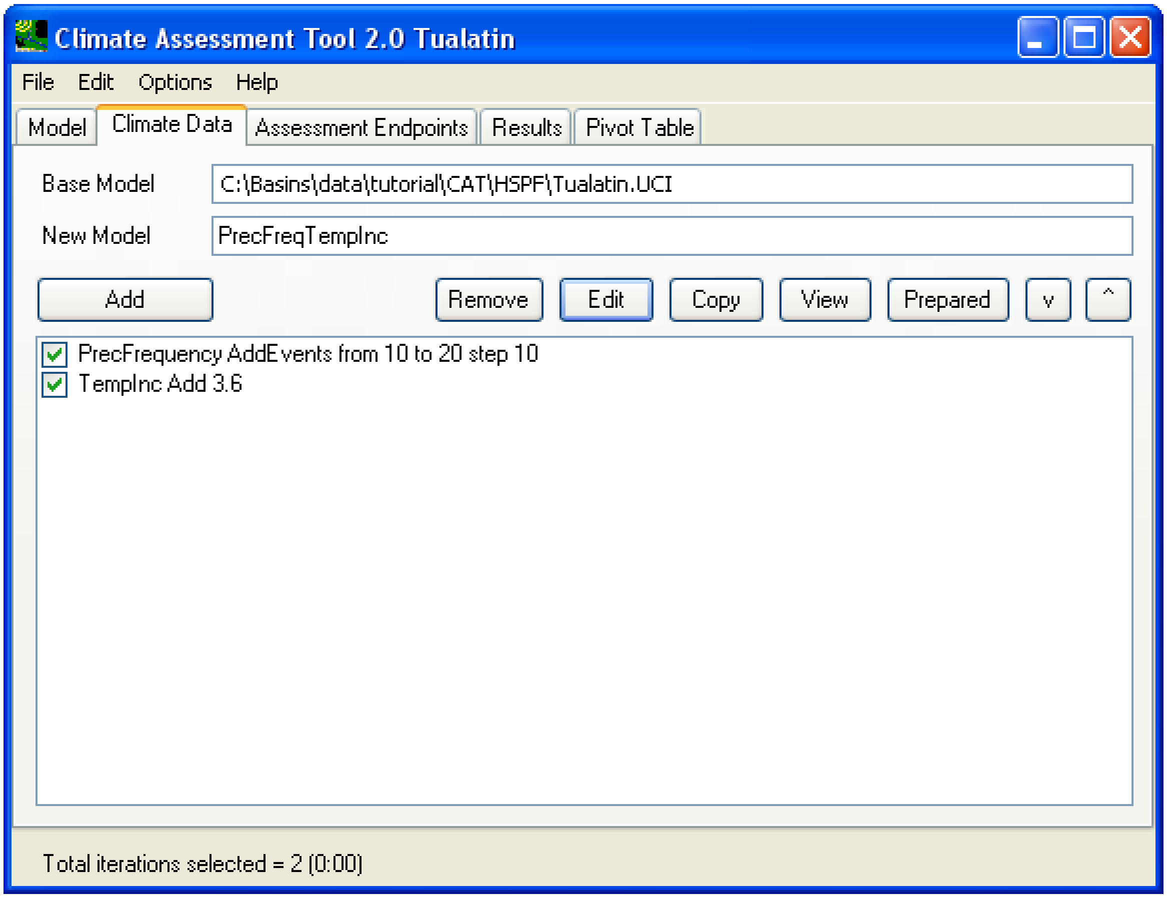


For this example we will apply a single temperature increase of 3.6 degree F as shown below:

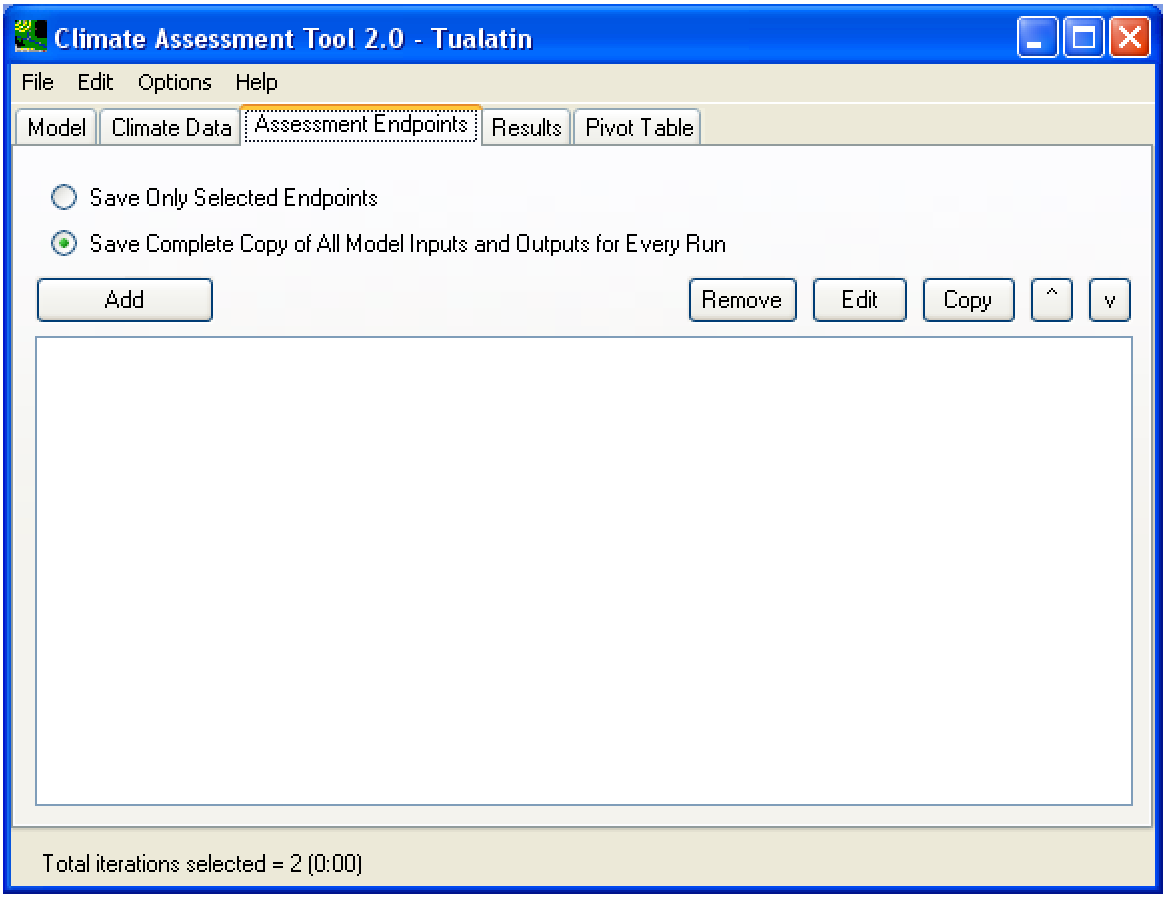


Click the **OK** button to finish the temperature adjustment definition and close the window.

The **Climate Data** tab should now appear as below. Note that each climate adjustment listed contains a check box, allowing it to be turned "on" or "off". This is especially useful when numerous adjustments are defined, and unique climate scenarios can be developed via different combinations of adjustments.

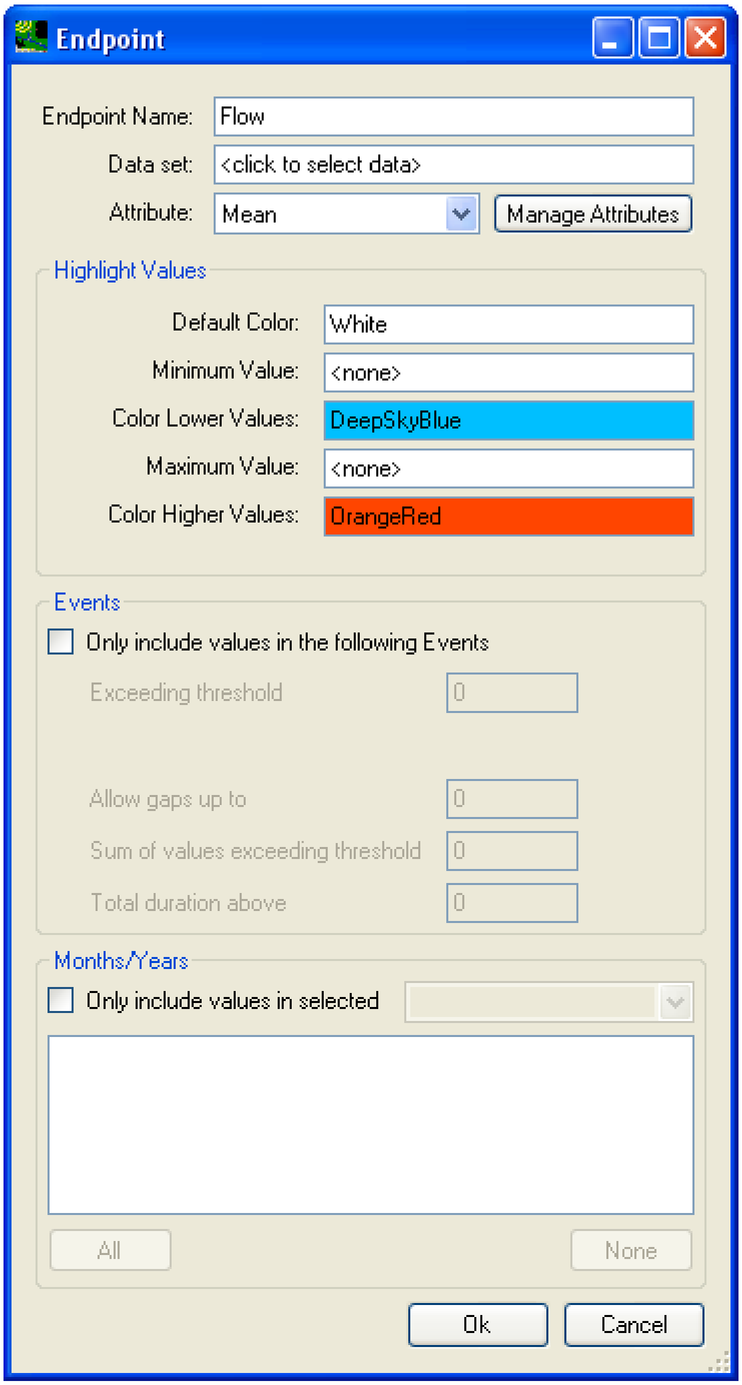


Now that you have defined the weather data adjustments on the **Climate Data** tab, move onto the **Assessment Endpoints** tab as shown below:

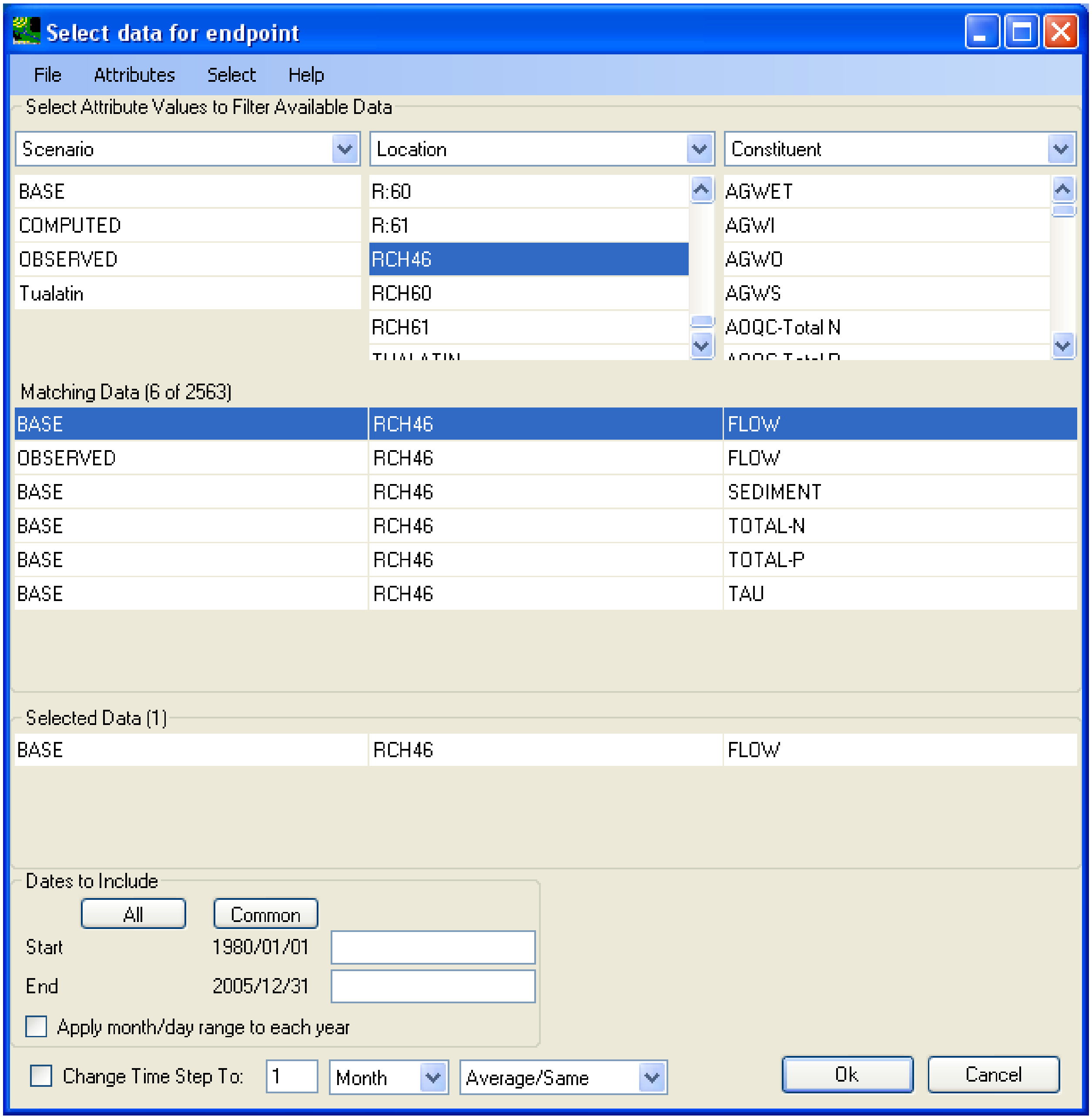


On the **Assessment Endpoints** tab, we will define three HSPF output items as endpoints and also add two precipitation statistics as endpoints. Click the **Add** button to initiate the definition of a new endpoint.

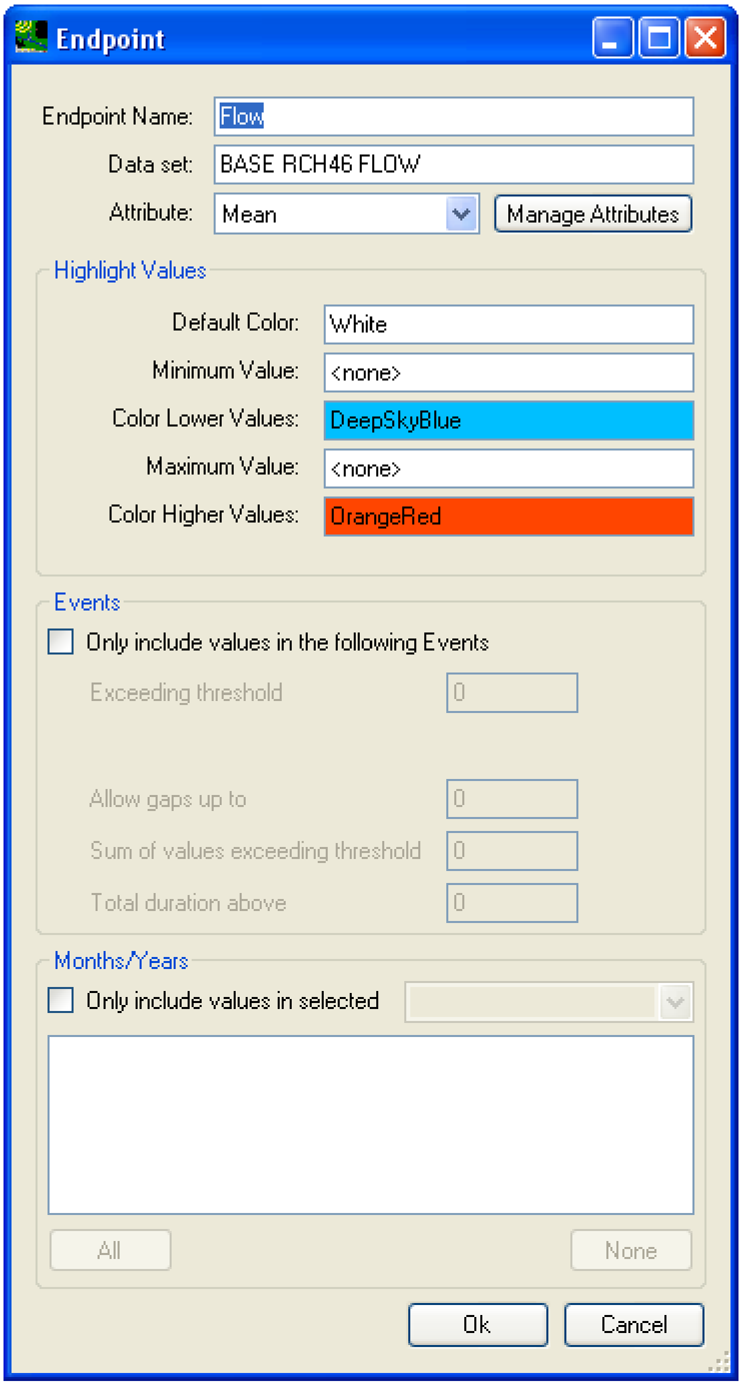
On the **Endpoint** form, begin definition of the flow endpoint by entering Flow in the 'Endpoint Name' text field as shown below:



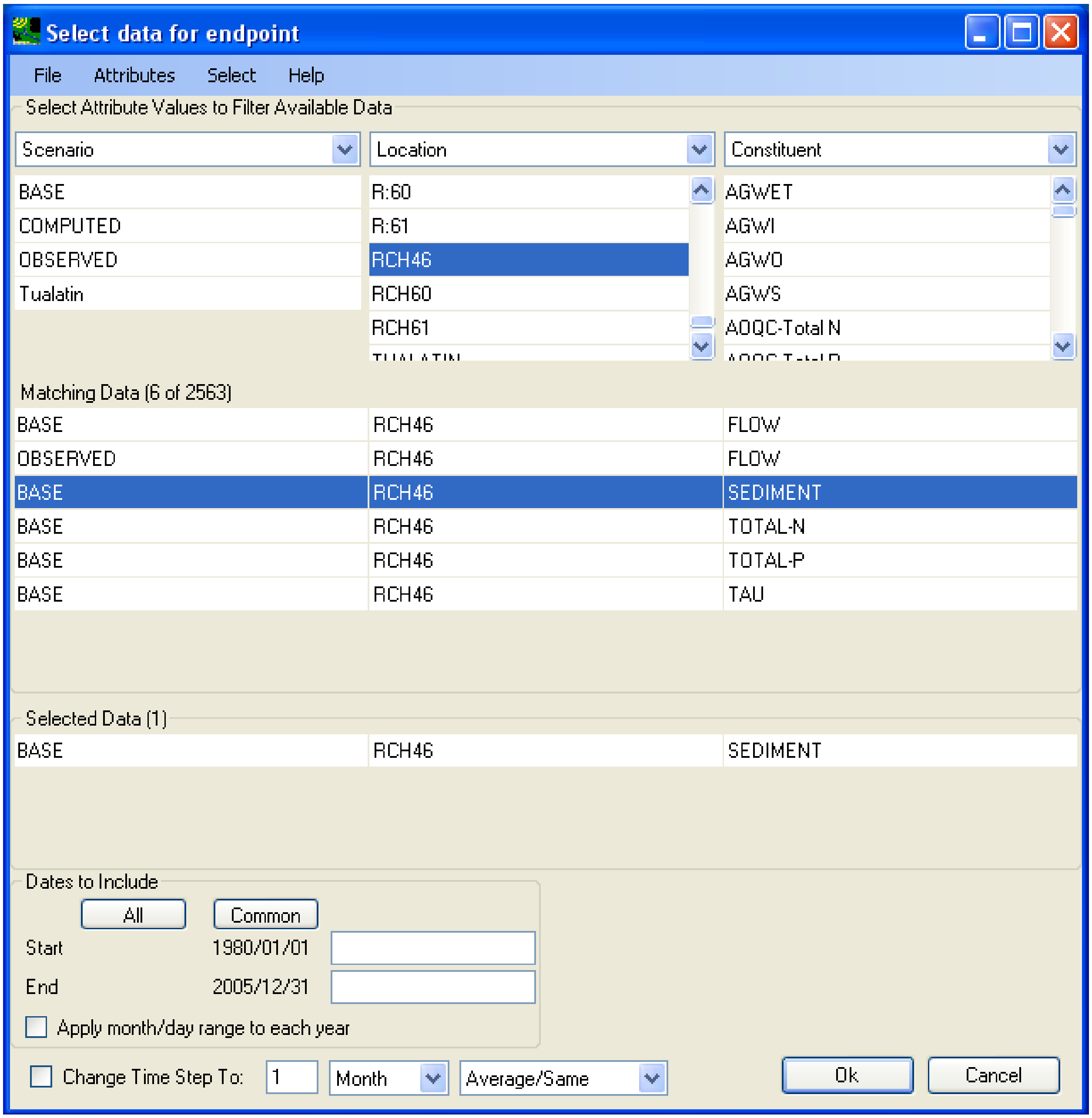
To select the time series containing the endpoint values, single click in the **Data set** text field. The **Select data for endpoint** form will be displayed. For this HSPF application, RCH46 is the outlet of the watershed and will thus be the location of our model output endpoints. Select the **Base** scenario **Flow** time series at **RCH46** as shown below and then click the **OK** button.


Select data for endpoint
File
Attributes
Select
Help
Select Attribute Values to Filter Available Data
Scenario
Location
Constituent
BASE
COMPUTED
OBSERVED
Tualatin
R:60
R:61
RCH46
RCH60
RCH61
AGWET
AGWI
AGWO
AGWS
AOQC-Total N
Matching Data (6 of 2563)
BASE RCH46 FLOW
OBSERVED RCH46 FLOW
BASE RCH46 SEDIMENT
BASE RCH46 TOTAL-N
BASE RCH46 TOTAL-P
BASE RCH46 TAU
Selected Data (1)
BASE RCH46 FLOW
Dates to Include
All
Common
Start 1980/01/01
End 2005/12/31
Apply month/day range to each year
Change Time Step To:
1
Month
Average/Same
Ok
Cancel

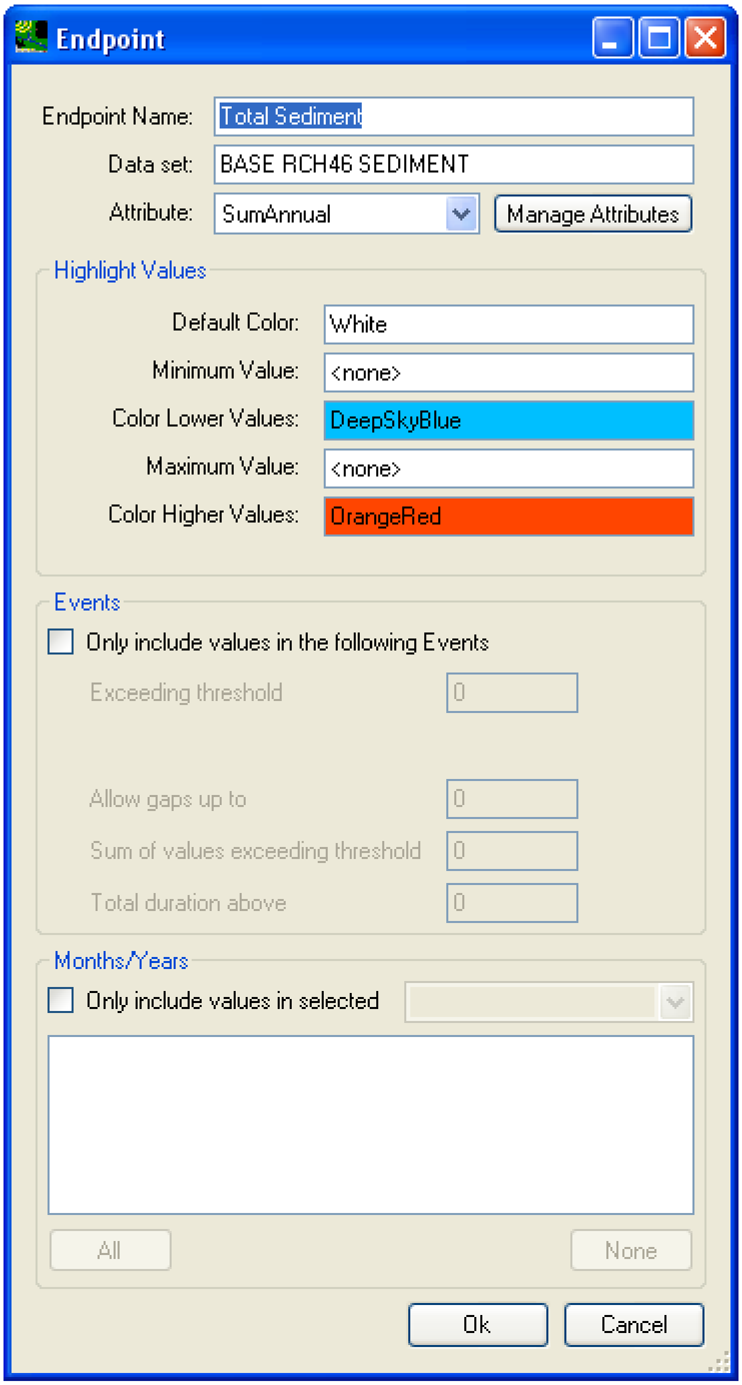
The **Endpoint** form now shows the selected time series in the **Data set** field. For this endpoint we will consider average flow values, so select the **Mean** option from the 'Attribute' pull-down list. Click the **OK** button to complete endpoint definition.



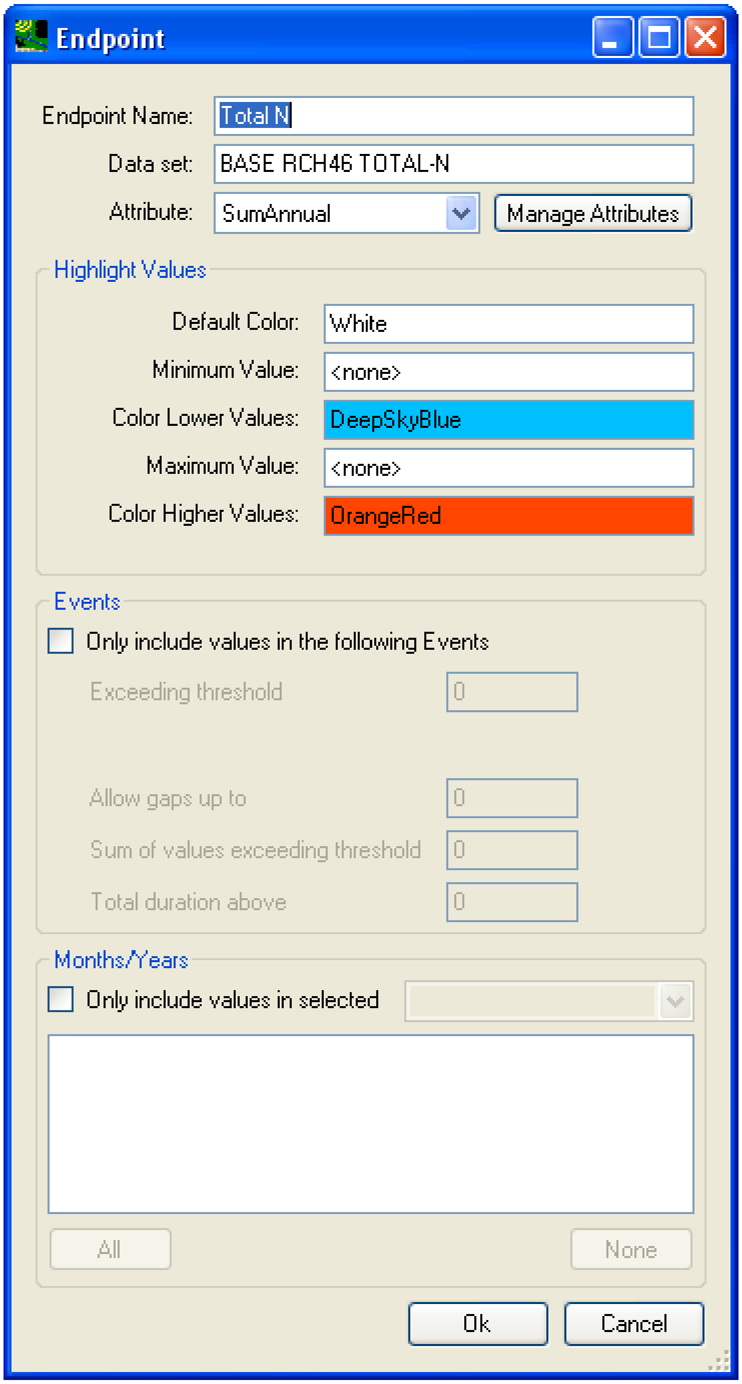
Additional endpoints for Total Sediment and Total N will now be defined as model output endpoints in the same manner as Flow. Click the **Add** button from the **Climate Data** tab to initialize the **Endpoint** form. Enter a description (e.g. Total Sediment or Total N) in the 'Endpoint Name' field and then click in the **Data set** field to bring up the **Select data for endpoint** form for selection of the appropriate output time series. As shown below for Total Sediment, select the time series at location **RCH46** for the constituent **Sediment**. Click the **OK** button when done.



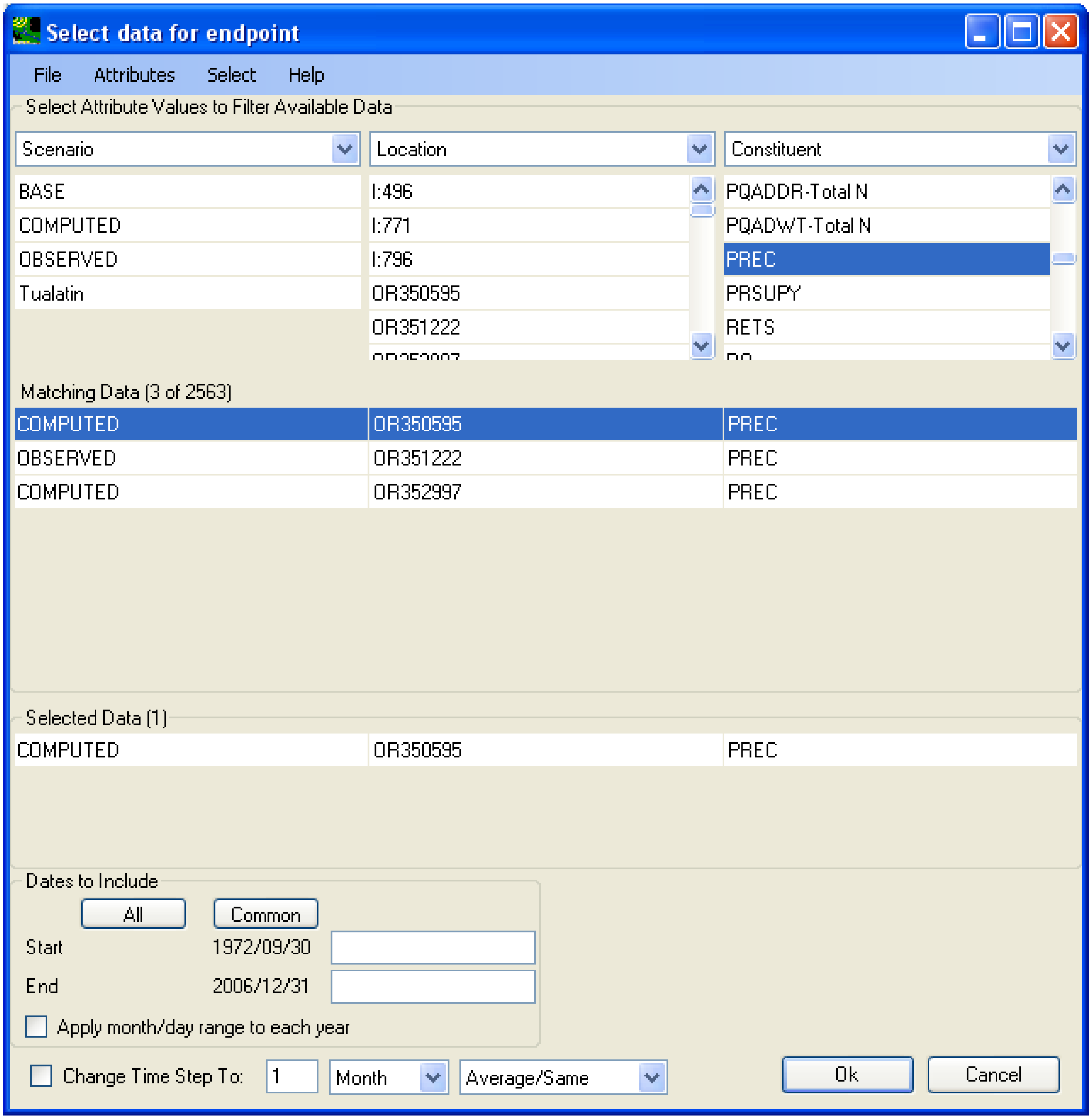
The **Endpoint** form now shows the selected time series in the **Data set** field. For Total Sediment we will consider average annual loads, so select the **SumAnnual** option from the 'Attribute' pull-down list. Click the **OK** button to complete endpoint definition.



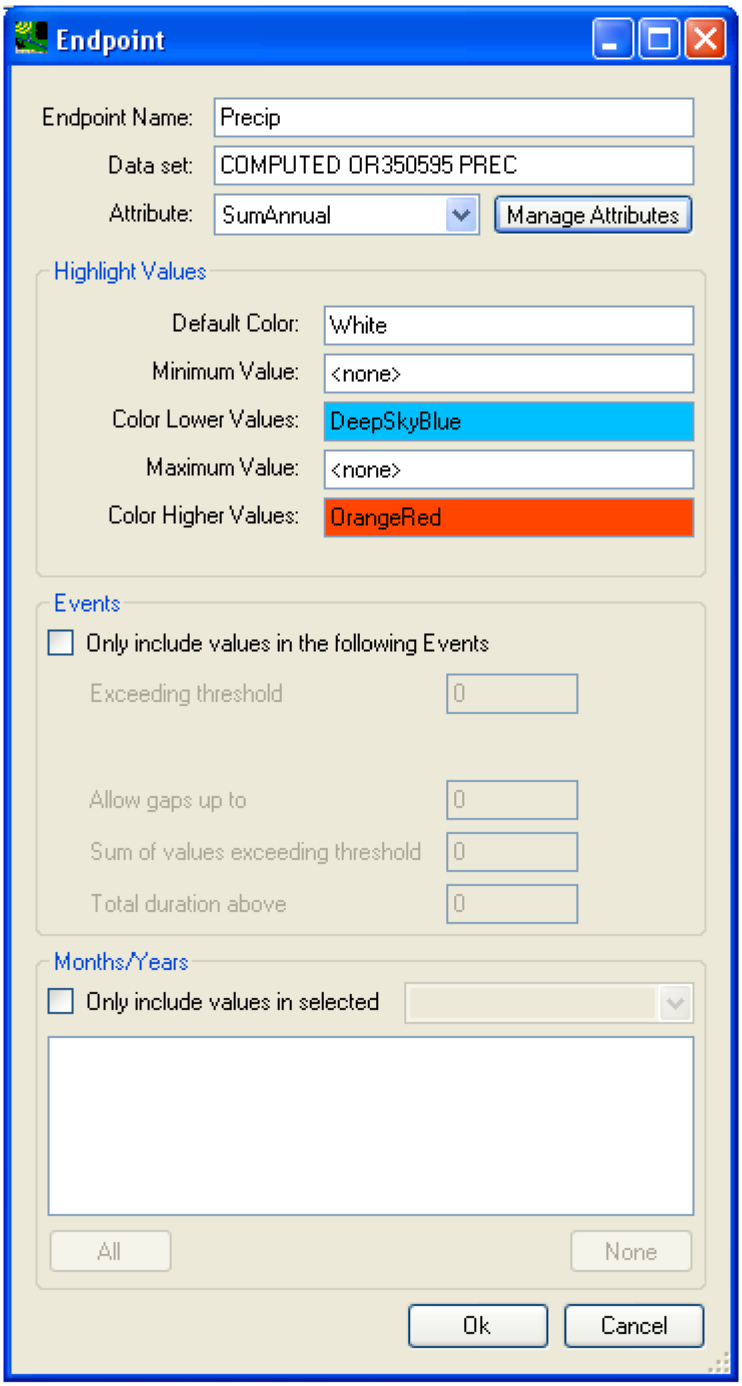
Repeat the process of Total Sediment endpoint definition, only this time define an endpoint for Total N. The resulting Endpoint form should appear as below. Click **OK** when complete.


Endpoint
Endpoint Name:
Total N
Data set:
BASE RCH46 TOTAL-N
Attribute:
SumAnnual
Manage Attributes
Highlight Values
Default Color:
White
Minimum Value:
<none>
Color Lower Values:
DeepSkyBlue
Maximum Value:
<none>
Color Higher Values:
OrangeRed
Events
Only include values in the following Events
Exceeding threshold
0
Allow gaps up to
0
Sum of values exceeding threshold
0
Total duration above
0
Months/Years
Only include values in selected
All
None
Ok
Cancel

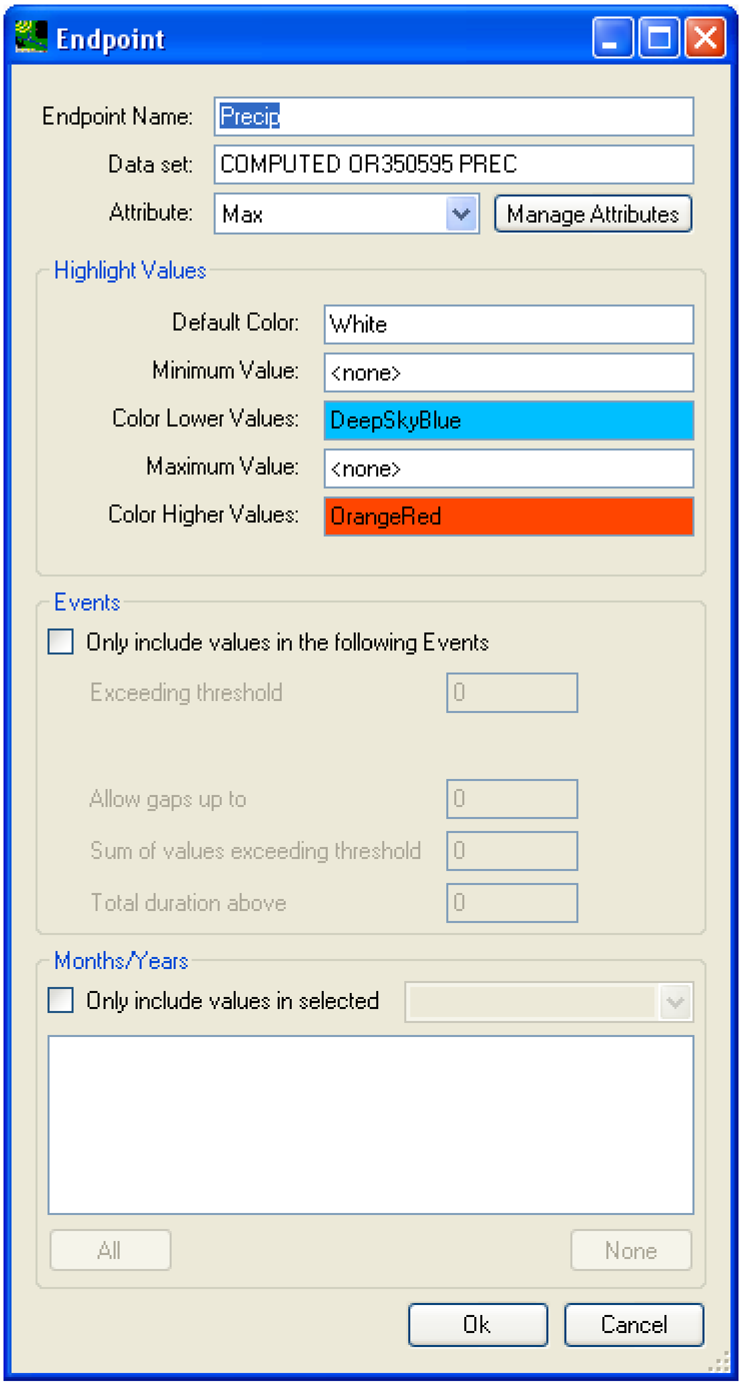
In the same manner as the output endpoints developed above, endpoints of input data may also be created; a feature that can be useful in presenting a CAT study's results. Two precipitation endpoints will be developed here. Begin the first by clicking the **Add** button from the **Assessment Endpoints** tab. Enter Precip for the 'Endpoint Name' and then click in the **Data set** field to select the precipitation time series as shown below. Click the **OK** button when complete.



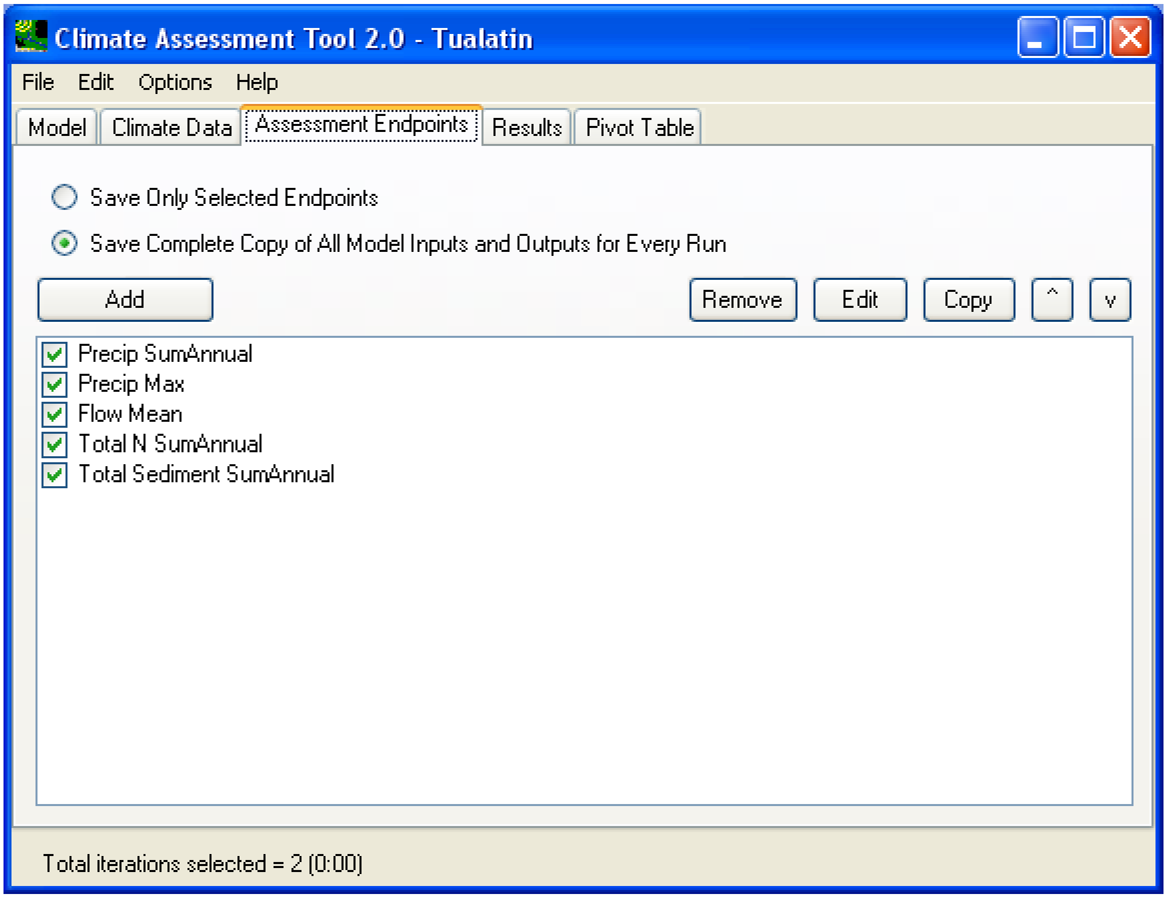
For the first precipitation endpoint, we want to assess average annual rainfall. Thus, select the **SumAnnual** option from the 'Attribute' pull-down list as shown below. Click the **OK** button to complete endpoint definition.


Endpoint
Endpoint Name:
Precip
Data set:
COMPUTED OR350595 PREC
Attribute:
SumAnnual
Manage Attributes
Highlight Values
Default Color:
White
Minimum Value:
<none>
Color Lower Values:
DeepSkyBlue
Maximum Value:
<none>
Color Higher Values:
OrangeRed
Events
Only include values in the following Events
Exceeding threshold
0
Allow gaps up to
0
Sum of values exceeding threshold
0
Total duration above
0
Months/Years
Only include values in selected
All
None
Ok
Cancel

Repeat these same steps, only this time we will assess maximum precipitation values. After selecting the same precipitation time series as before, select the **Max** option from the ‘Attribute’ pull-down list as shown below. Click the **OK** button to complete endpoint definition.



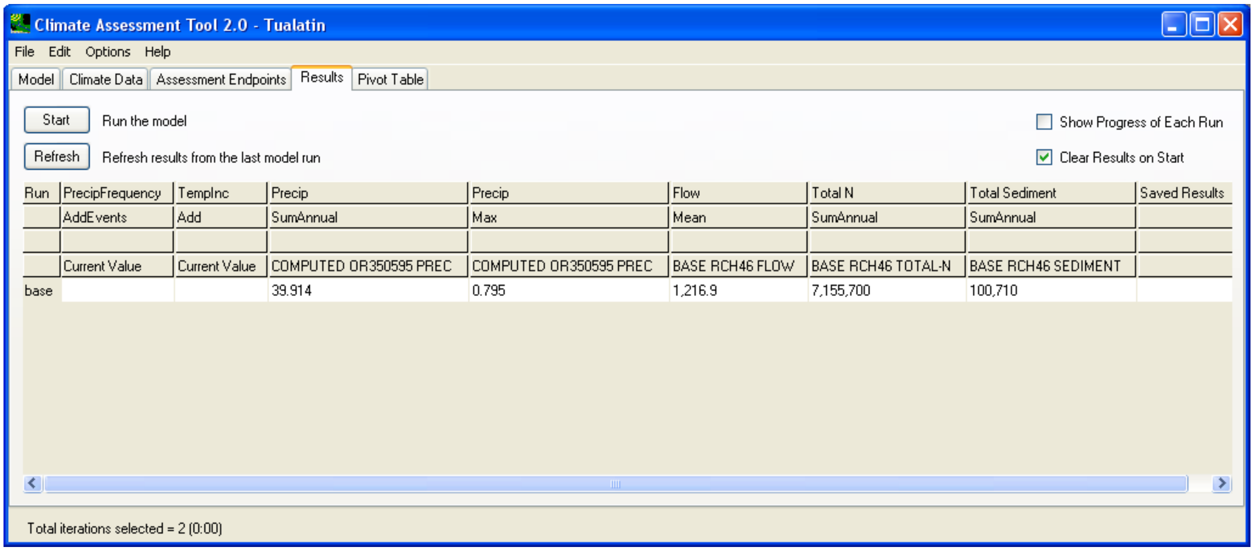
Now your **Assessment Endpoint** tab should look like below:



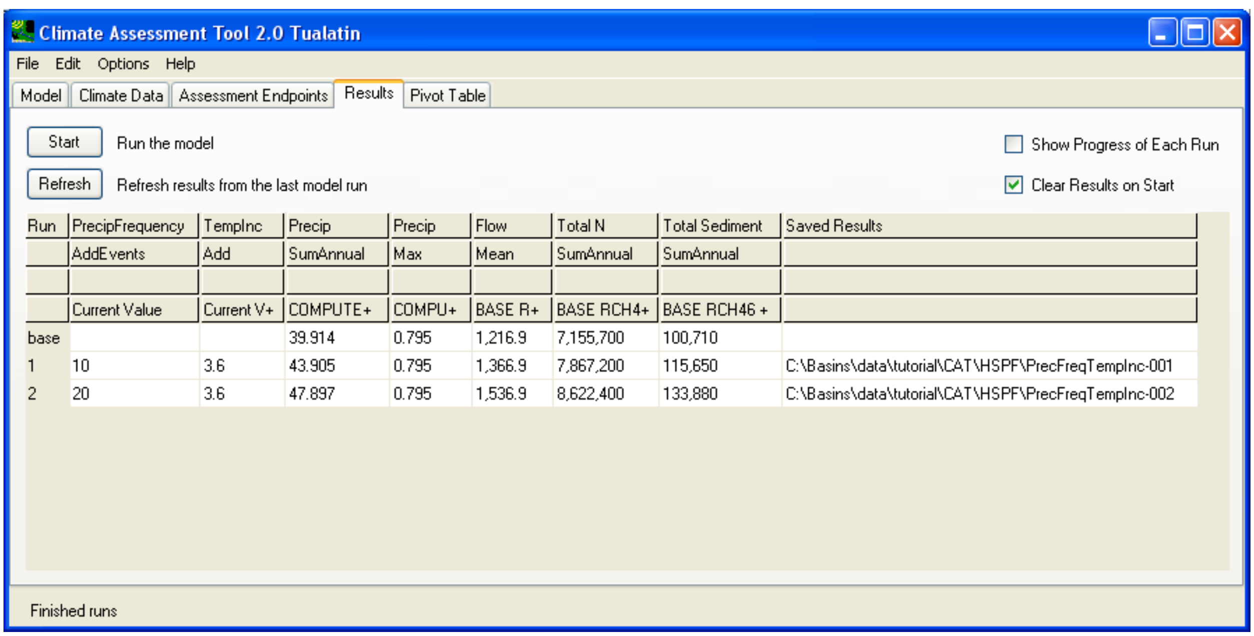
With both meteorological input adjustments and endpoints defined, you are ready to conduct the analysis by running the HSPF model for the defined combination of climate change scenarios. Make sure to check the radio button with the label **Save Complete Copy of All Model Inputs and Outputs for Every Run** on the **Assessment Endpoint** tab. This choice allows CAT to save all scenarios' run files (both input and output) into their own folders.

Click the **Results** tab and note that the result grid has already been populated with the endpoints' statistics from the base case scenario in the first row of the result grid as shown below.

Note also that since we defined 2 levels of change in precipitation and 1 level of increase in temperature, there will be 2 (2 x 1) HSPF simulations in total as shown below at the bottom of the form.

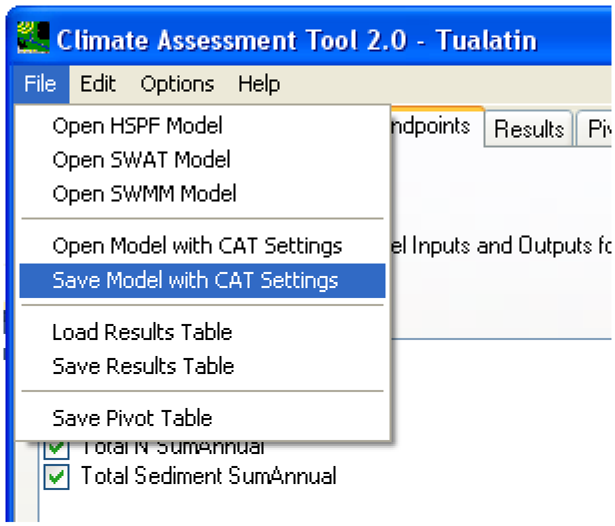


Since this is a new CAT analysis, click the **Start** button to initiate the simulations.



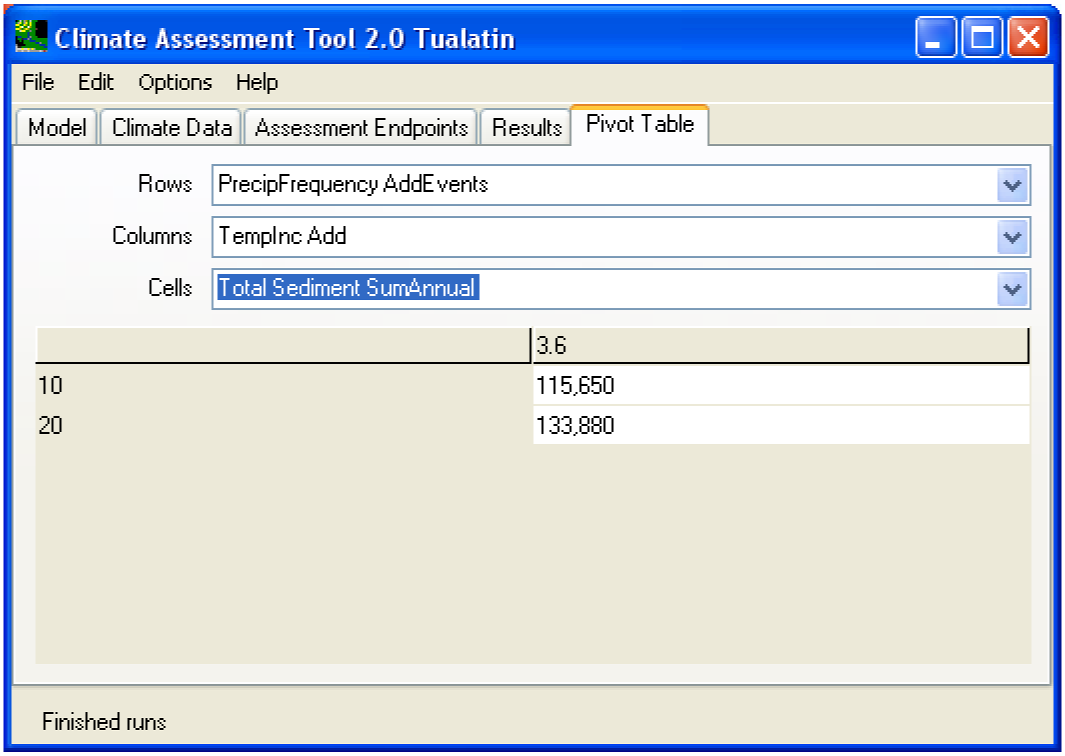
On the above **Results** tab, endpoints are listed on the top as column headers and the scenarios' ordinal number are listed as row numbers.

When the model runs have complete, we can save our work. From the ‘File’ menu on the top of the CAT window, select the “Save Model with CAT Settings” option to save all of our input modifications and endpoint definitions into a XML file as shown below:



From the ‘File’ menu, select “Save Results Table” option to save the result grid into a tab-delimited text file.

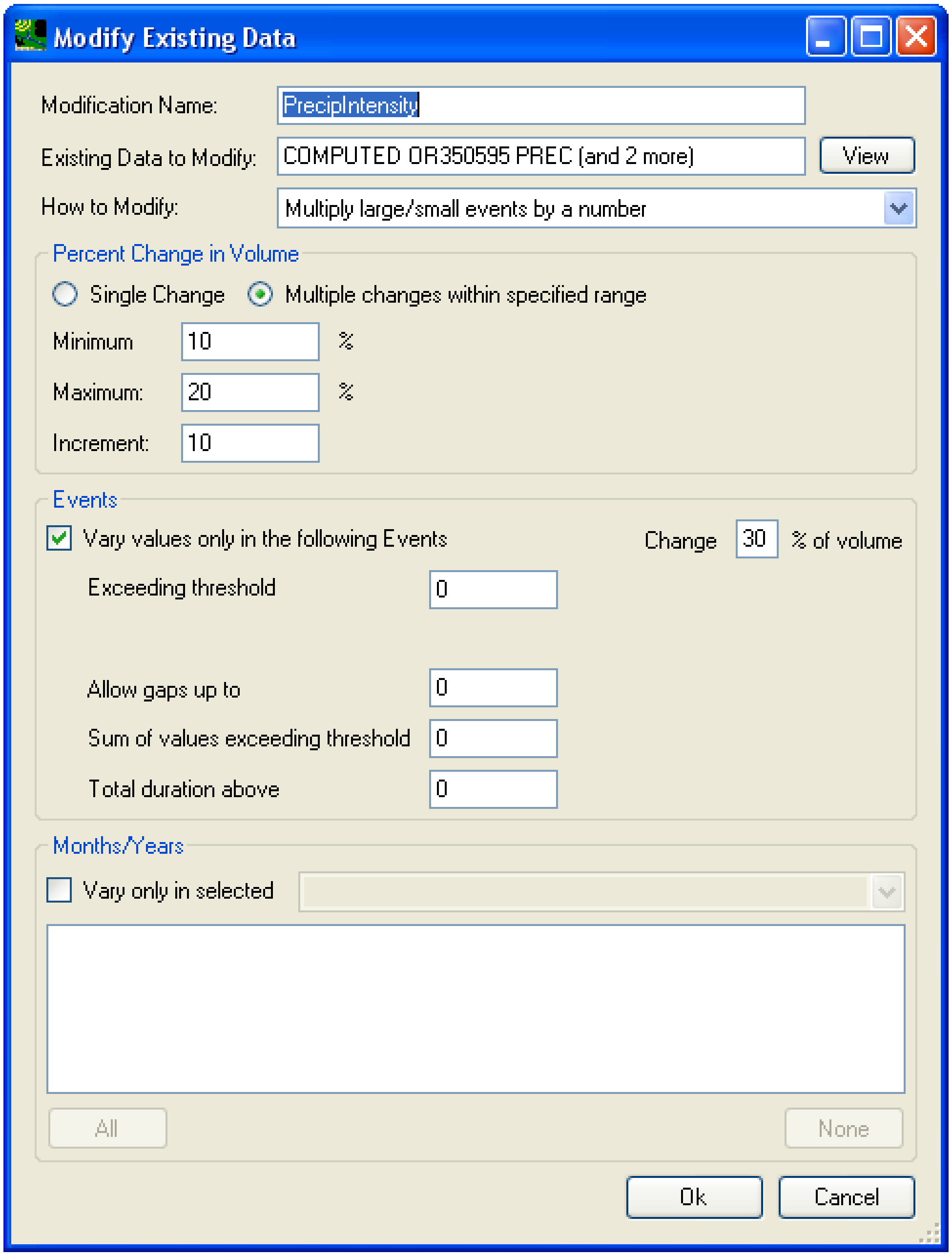
We can examine the results in a pivot table on the **Pivot Table** tab as shown below:



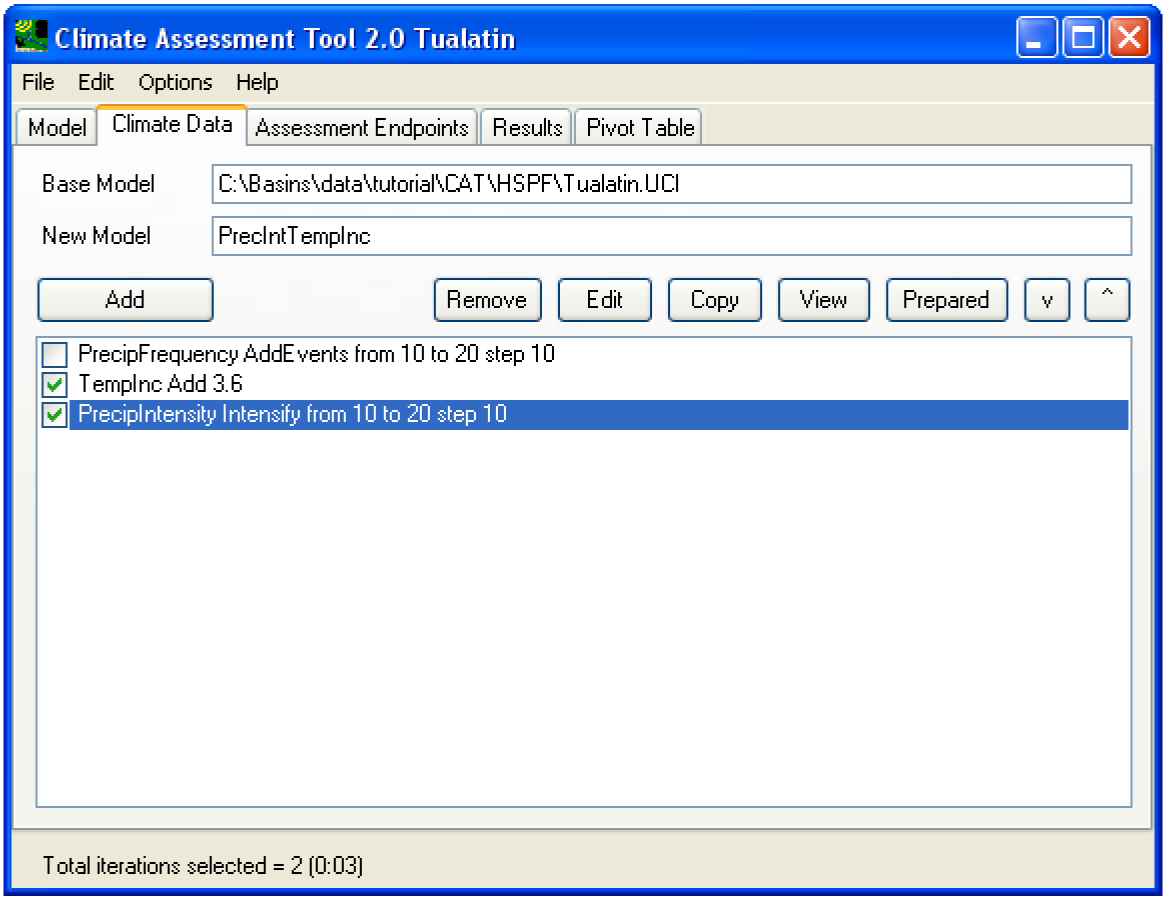
At this point, you have successfully completed a CAT analysis with HSPF. However, don't close the current CAT window just yet, we will try more climate change scenarios below.

Next, we will create another climate change scenario that involves increases in rainfall intensity. Click on the **Climate Data** tab and change the **New Model** name to <u>PrecIntTempInc</u> as our new adjustment name. Click the **Add** button to start the Modify Existing Data dialog window. Define the rainfall intensity increase scenario as shown below.

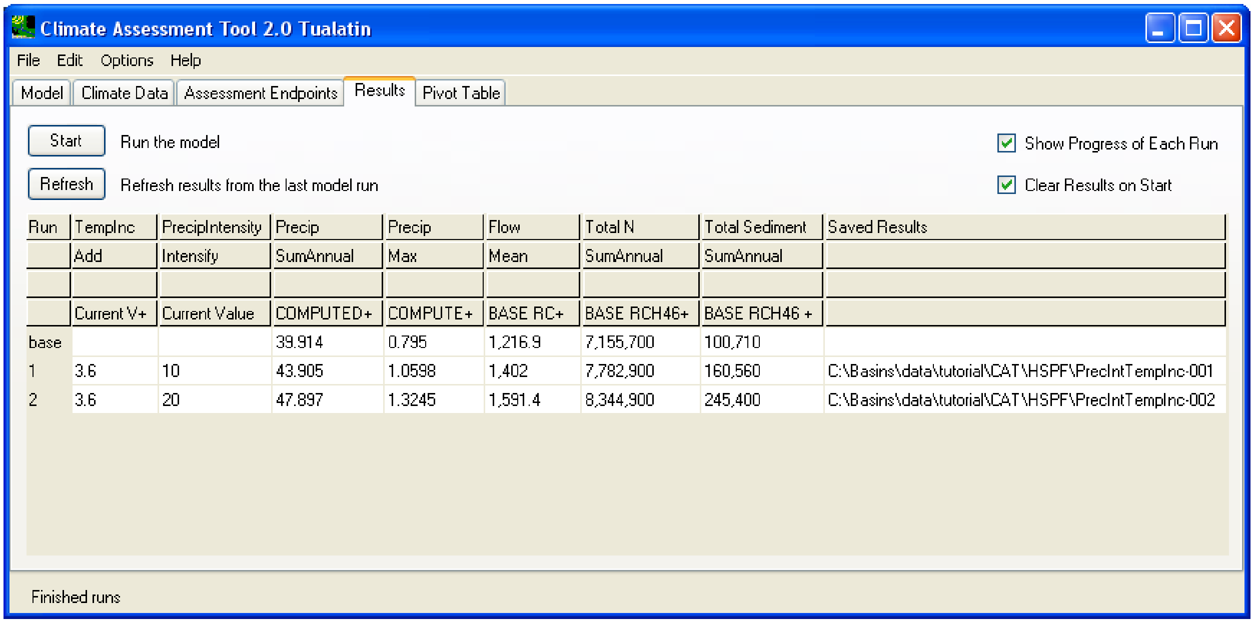
It is important to note the additional **Change 'n' % of volume** field available in the 'Events' frame when making this type of adjustment to precipitation. This field allows the user to specify a percentage of the events in which the volume increase (or decrease) will be applied. For this example, enter '30' in this field, which means the 10 and 20% increase will be applied to the largest events that constitute 30 percent of the volume in the original record.



Select the same three precipitation timeseries as shown earlier (above) for the rainfall frequency scenario. Click OK to finalize the data modification, then your **Climate Data** tab should look like below:

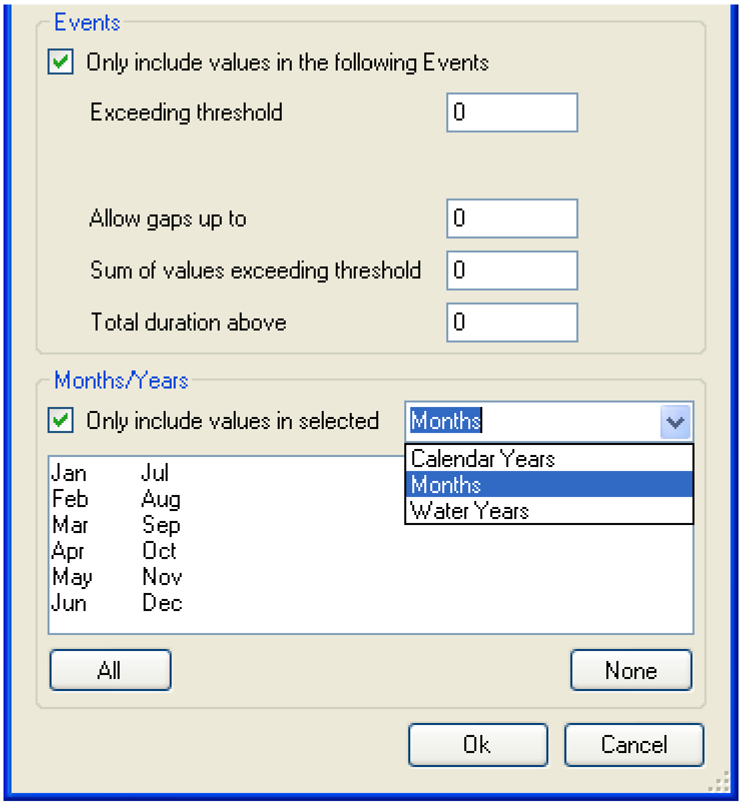


Moving on to **Results** tab, click the **Start** button to start the model simulations. After the HSPF model runs are finished, the Results tab will have the simulation results shown for all combinations of the two chosen scenarios as shown below:



Notice that by changing the **New Model** name (on the **Climate Data**) tab, CAT saves the new analysis into a different series of folders. By doing so, CAT allows clear file organization of multiple analyses within a single session.

Lastly, users can explore additional options offered in CAT for climate data modification and endpoint statistic definition. For example, rainfall data change can be specified to be applied only to certain events or months/years as shown below:



Lastly, changes in rainfall pattern can be represented by applying adjustments to selected calendar years, water years, or months within a year. The combined event- and selective duration-based changes offer tremendous flexibility in representing varying degree of changing climate patterns.

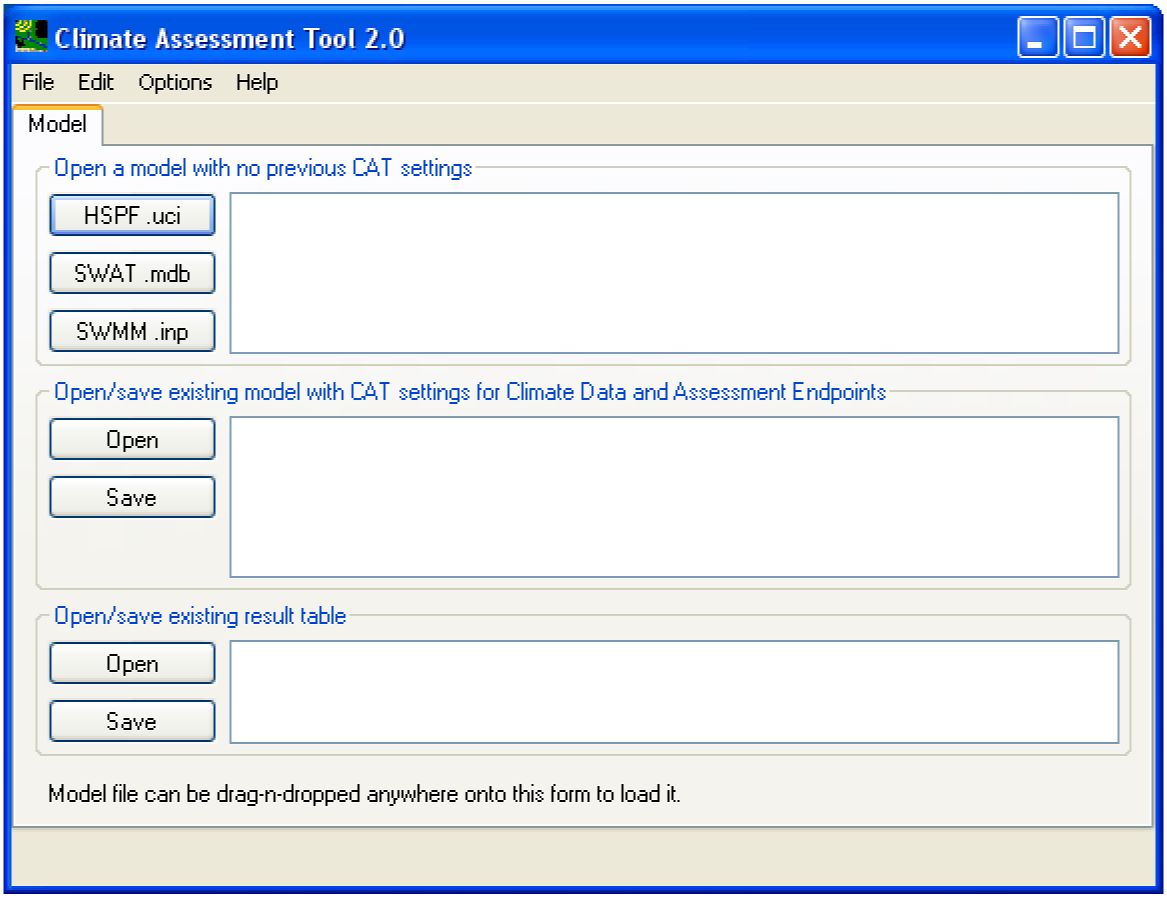
The same event- and duration-based logic applies to both climate data adjustment and endpoints' statistics, which gives user maximum control over the extraction of endpoints statistics.

Users are encouraged to try out different approach for setting up input climate data modification and endpoint statistic representations. This concludes this tutorial on climate assessment analysis using BASINS CAT with the HSPF model.

Climate Change Assessment using SWAT

The BASINS **Climate Assessment Tool (CAT)** allows users to easily create climate change scenarios, run hydrologic models to quantify the impact on selected environmental endpoints. Users can refer to the introduction of CAT features and interface options under the general BASINS help section for CAT. In this exercise, we will demonstrate the use of CAT with the **Soil Water Assessment Tool (SWAT)** model.

The user can activate the CAT plug-in by clicking the Plug-ins->Analysis->Climate Assessment Tool menu options. To launch CAT after the plug-in is activated, click on the Analysis->Climate Assessment Tool menu option, this will bring up the CAT window as shown below.

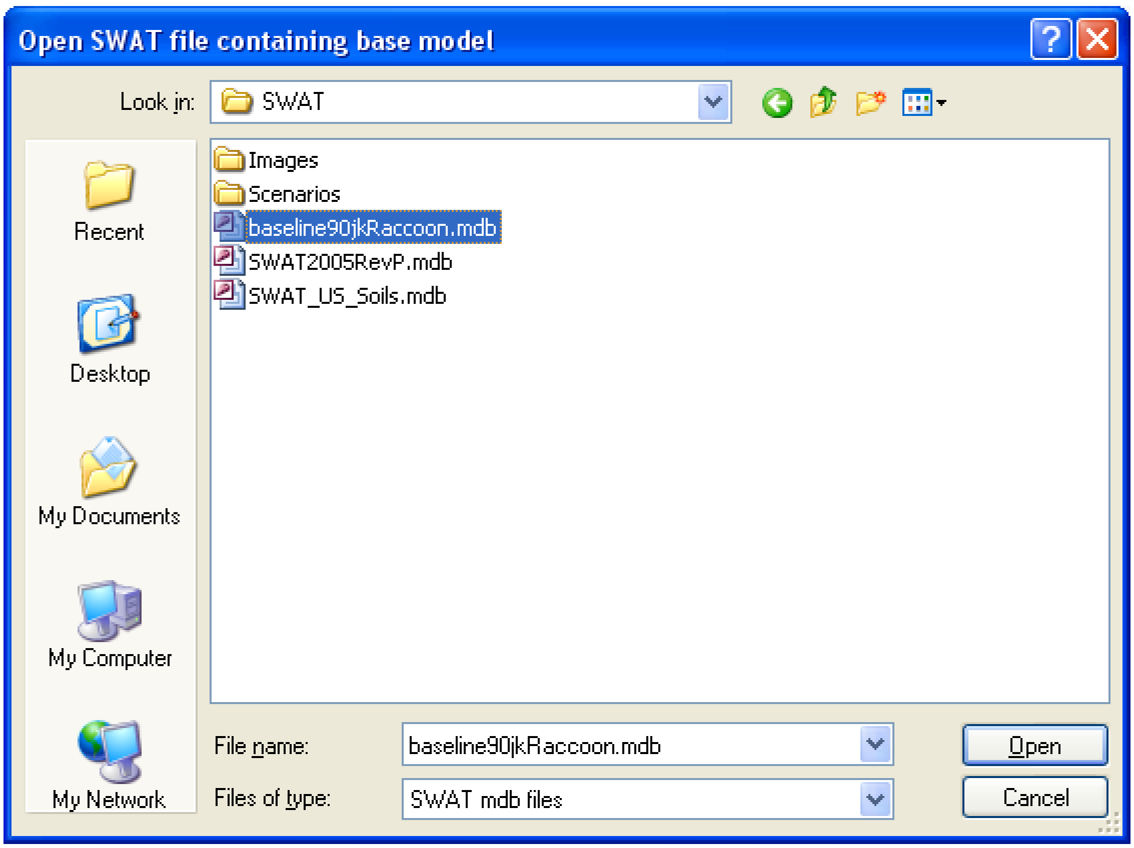


This first tab allows the user to start a brand new analysis, open an existing saved analysis, or simply re-examine the result table from a past analysis. In this exercise, we will create a new SWAT CAT analysis. The prerequisite files for this exercise are listed below and are provided at \Basins\data\tutorial\CAT\SWAT:

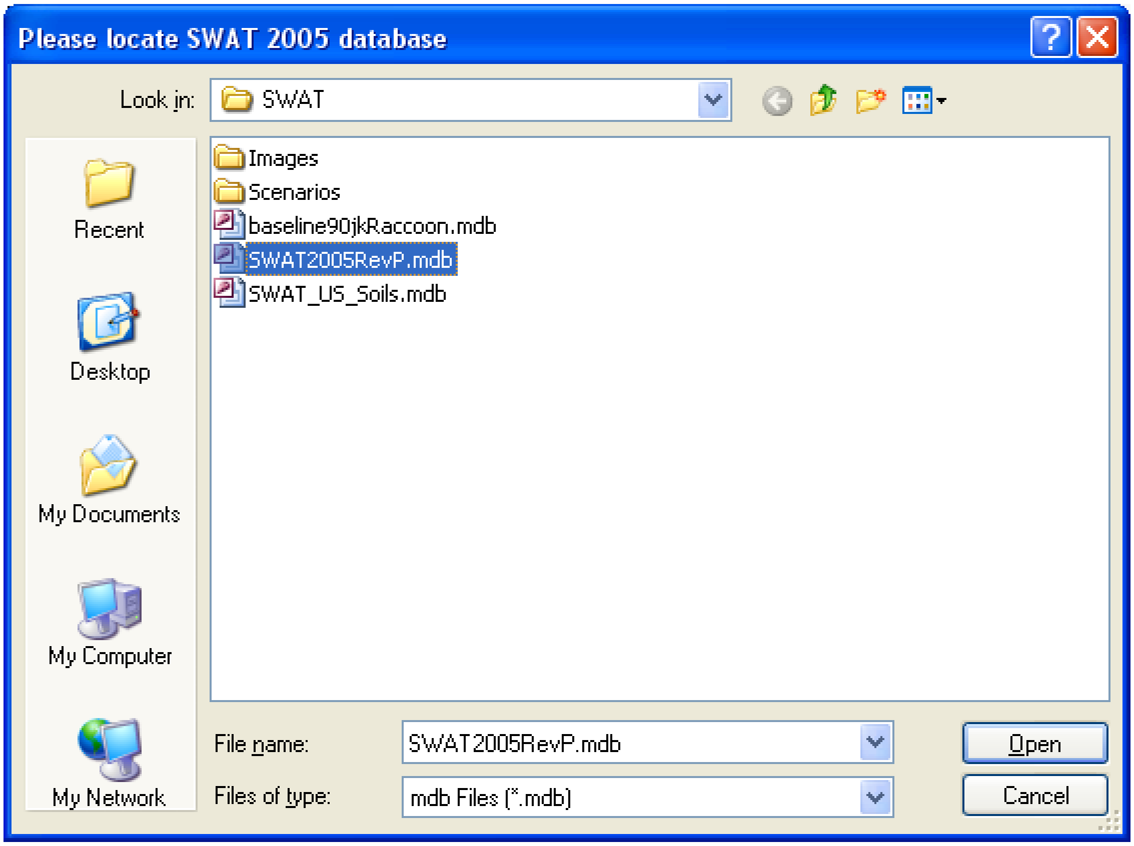
- base case SWAT model files (under \Scenarios\base\TxtInOut directory) - a working SWAT model that has already been run and has all of the input and output files ready
- baseline90jkRaccoon.mdb (base case SWAT model Microsoft Access database file)
- SWAT2005RevP.mdb (SWAT model general Microsoft Access database file)
- SWAT_US_Soils.mdb (SWAT model soil Microsoft Access database file)
- swat2005.exe (SWAT model executable program)
-

In this exercise, the weather data are daily precipitation (mm) and temperature (Celsius) data for two weather stations within the model watershed, duration is from January 1, 1960 to December 31, 2001.

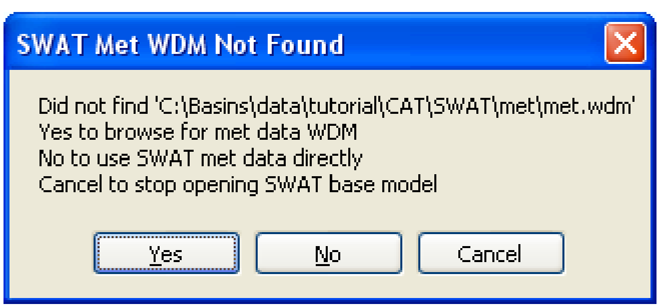
From the first CAT Model Tab, click button **SWAT.mdb**. This will open the file dialog window to locate the Access database file for the base case scenario as shown below.



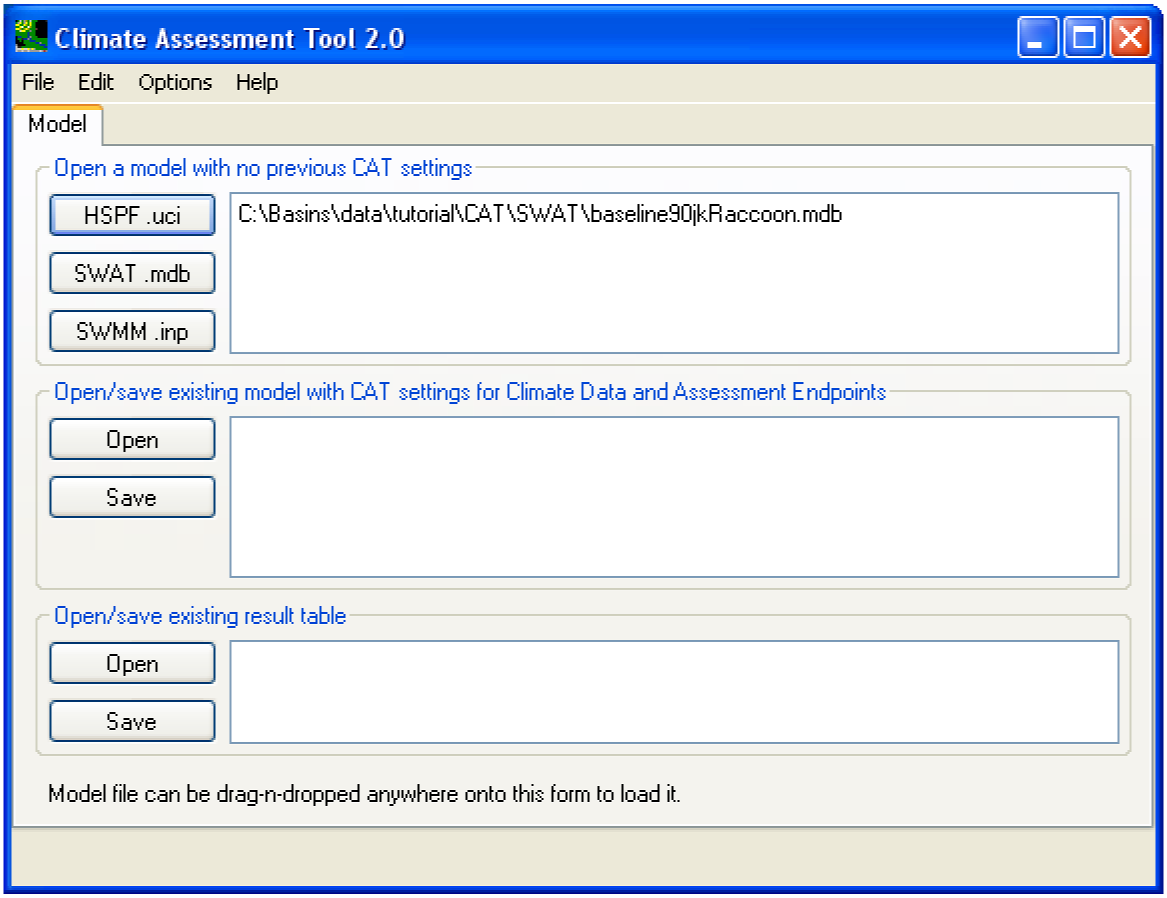
Once this is done, continue to locate the general SWAT Access database file when prompted, as shown below:



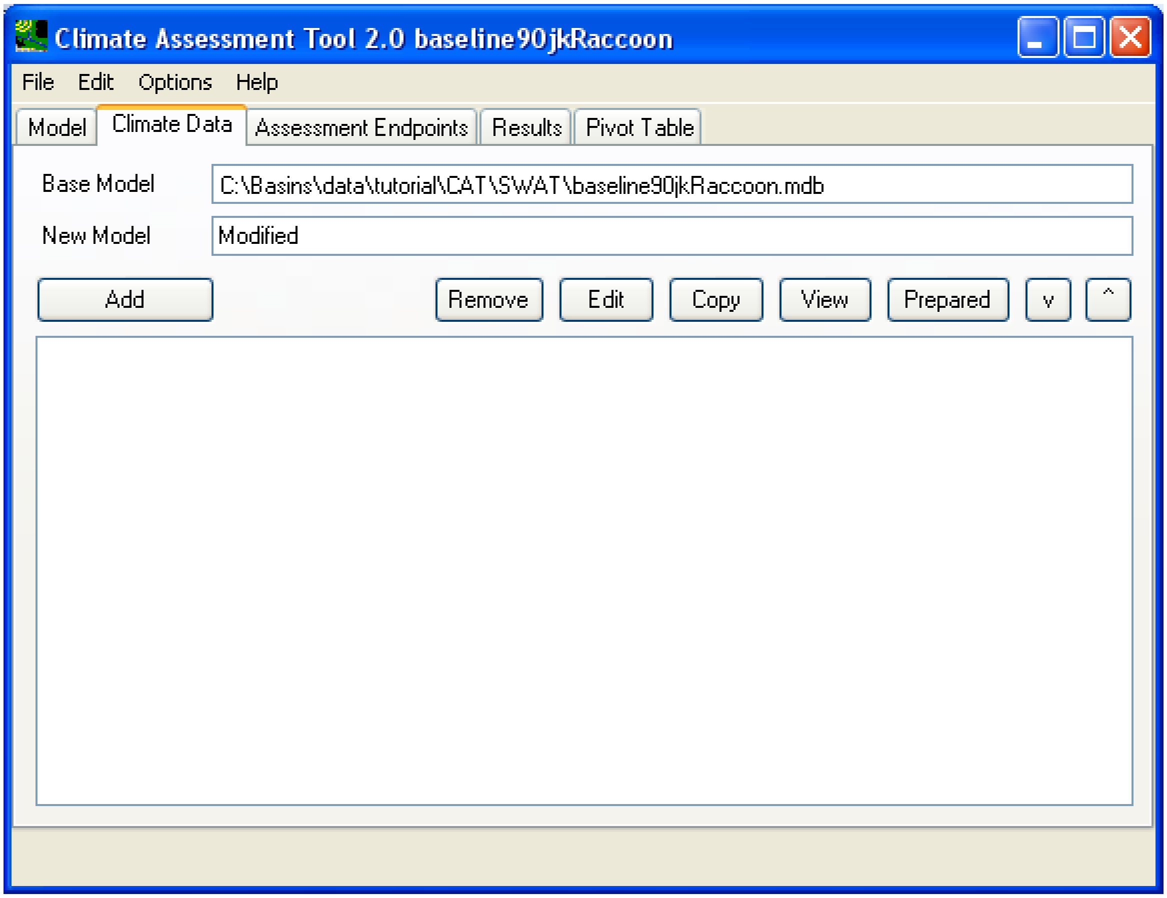
When prompted with a message about SWAT Met WDM as shown below, click 'No' to use SWAT weather input data in their native text file format that come with the base SWAT model.



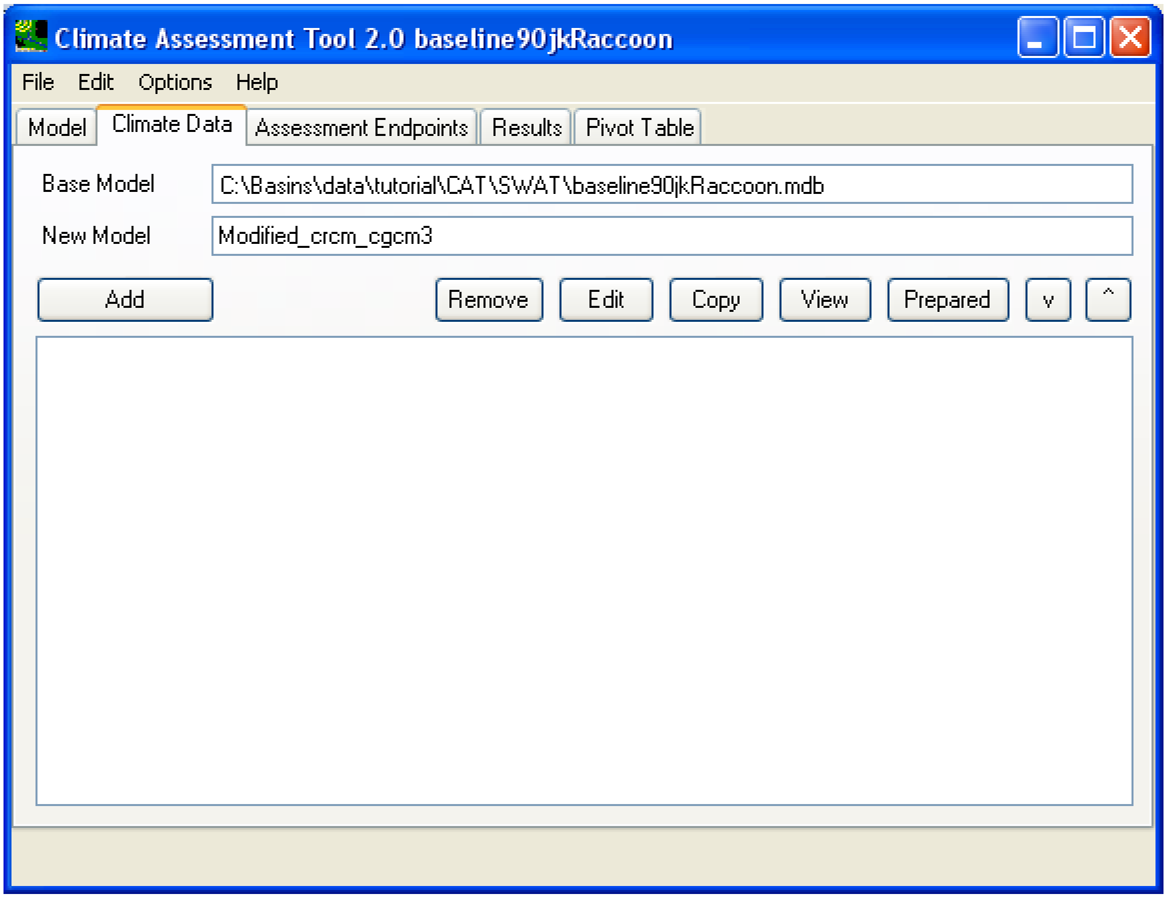
Now the full directory path to the base model MDB file is displayed as the first entry in the text box next to the **SWAT.mdb** on the **Model** tab as shown below:



Click on the full path of the base model MDB file in the text box, this will allow CAT to open it and retrieve related output and input data and make them available for user selection in subsequent steps. Once CAT successfully opens the base case model files, it will automatically advance to the **Climate Data** tab as shown below.

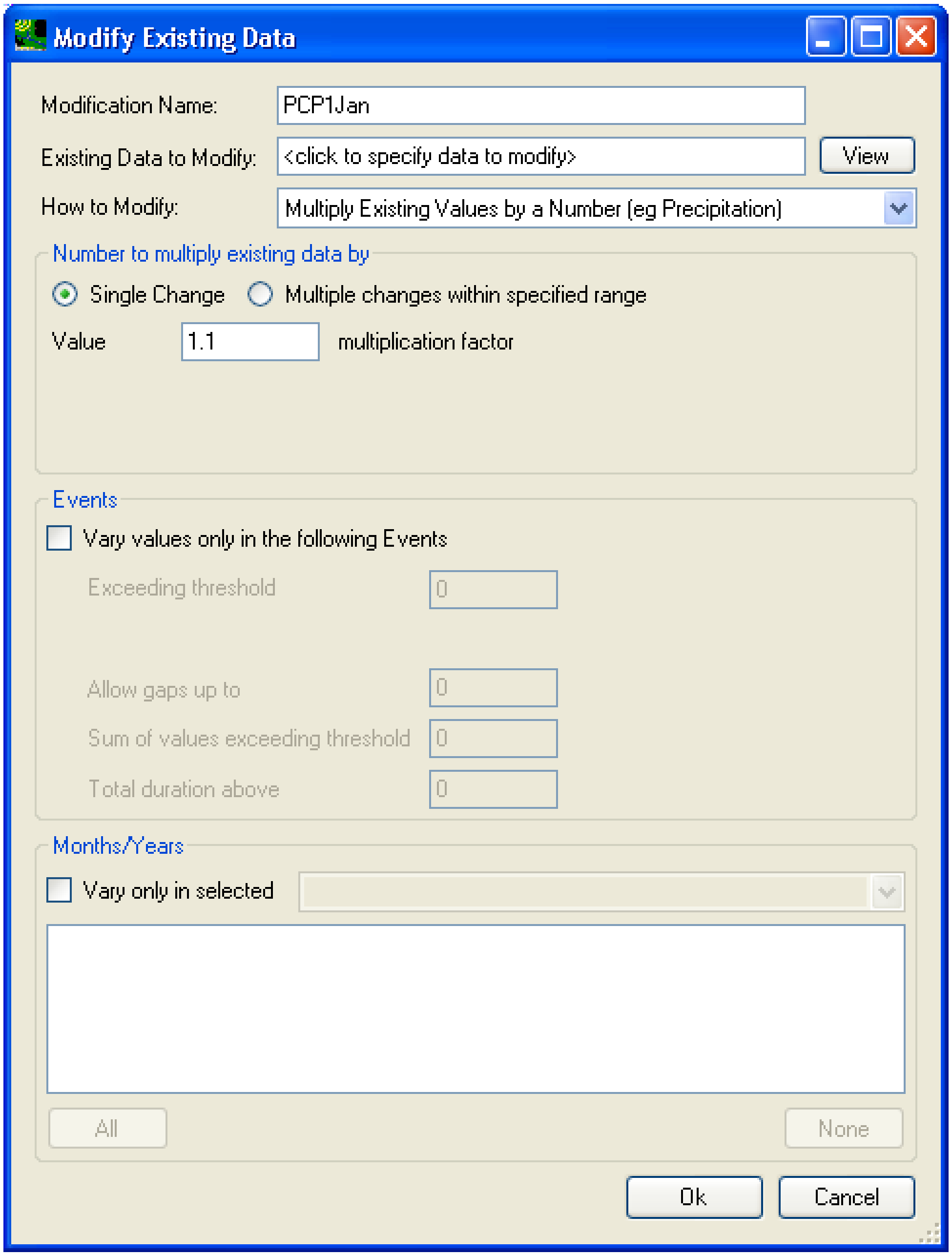


Change the **New Model** name on this tab to 'Modified_crcm_cgcm3' as shown below.

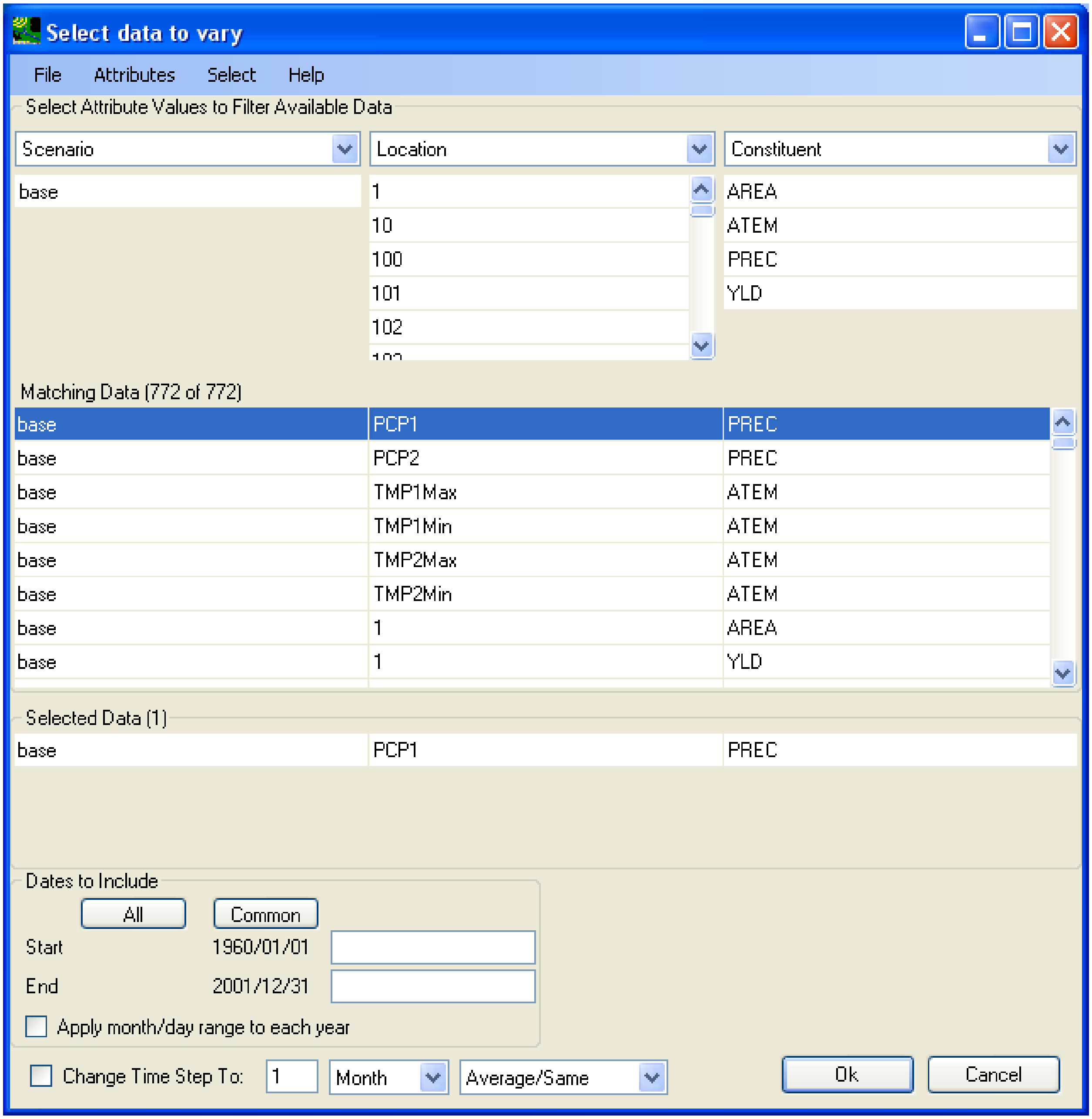


In this exercise, we will demonstrate CAT's ability to selectively adjust data of certain time periods within the input data. In this exercise's SWAT model, there are daily precipitation and temperature records (daily minimum and maximum) from two weather stations within the model watershed. They are labeled as PCP1, PCP2 for rainfall data and TMP1Max, TMP1Min, TMP2Max, TMP2Min for temperature data. We will apply a series of single modifications on all rainfall and temperature data for the month of January. To initiate each adjustment, click the **Add** button to open the **Modify Existing Data** window.

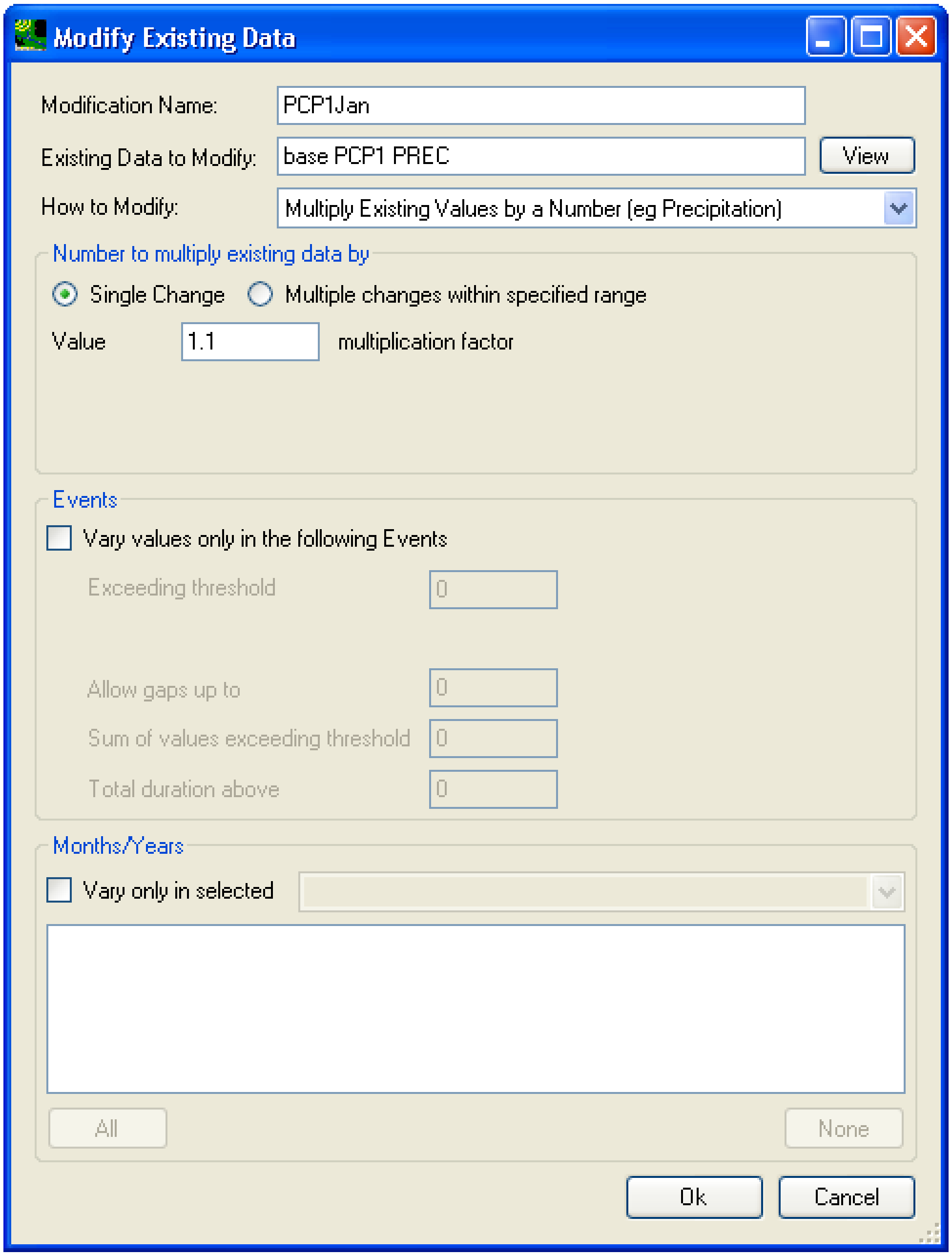
For the first adjustment, we will increase the daily rainfall in January from weather station 1 (PCP1) by 26.15%. First, type in the name for this adjustment, 'PCP1Jan', in the **Modification Name** field as shown below:



Then, select the rainfall data from weather station 1 for adjustment. A single click in the 'Existing Data to Modify:' text field will open the **Select data to vary** window. Proceed to choose the 'PCP1' timeseries as shown below:



Click **OK** to accept the selection, then the data modification window will look like below:

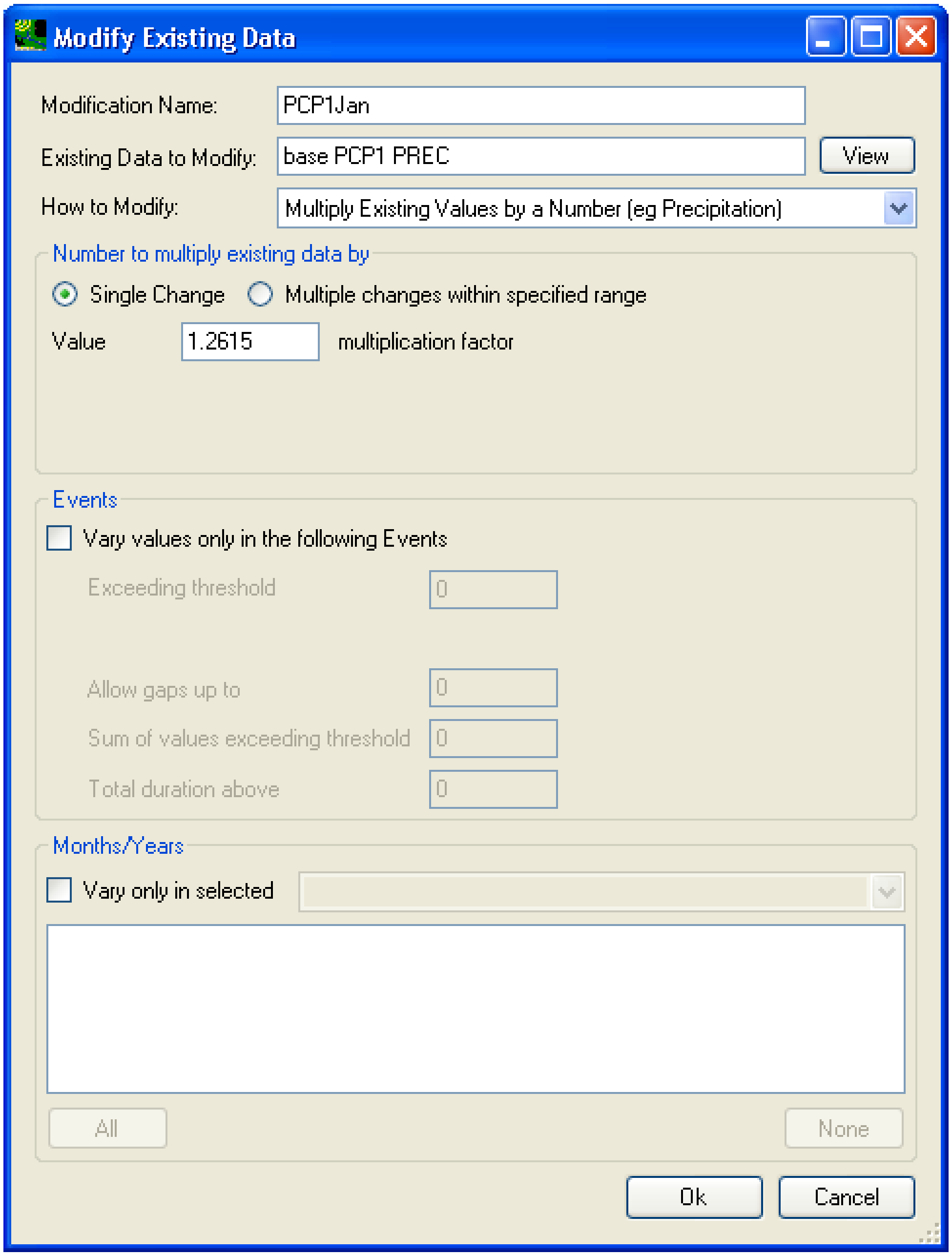


Next, we will specify the exact changes that will be made to the selected rainfall time series. From the ‘How to Modify’ dropdown box, one can pick different methods for timeseries adjustments. For precipitation, the three most common choices are:

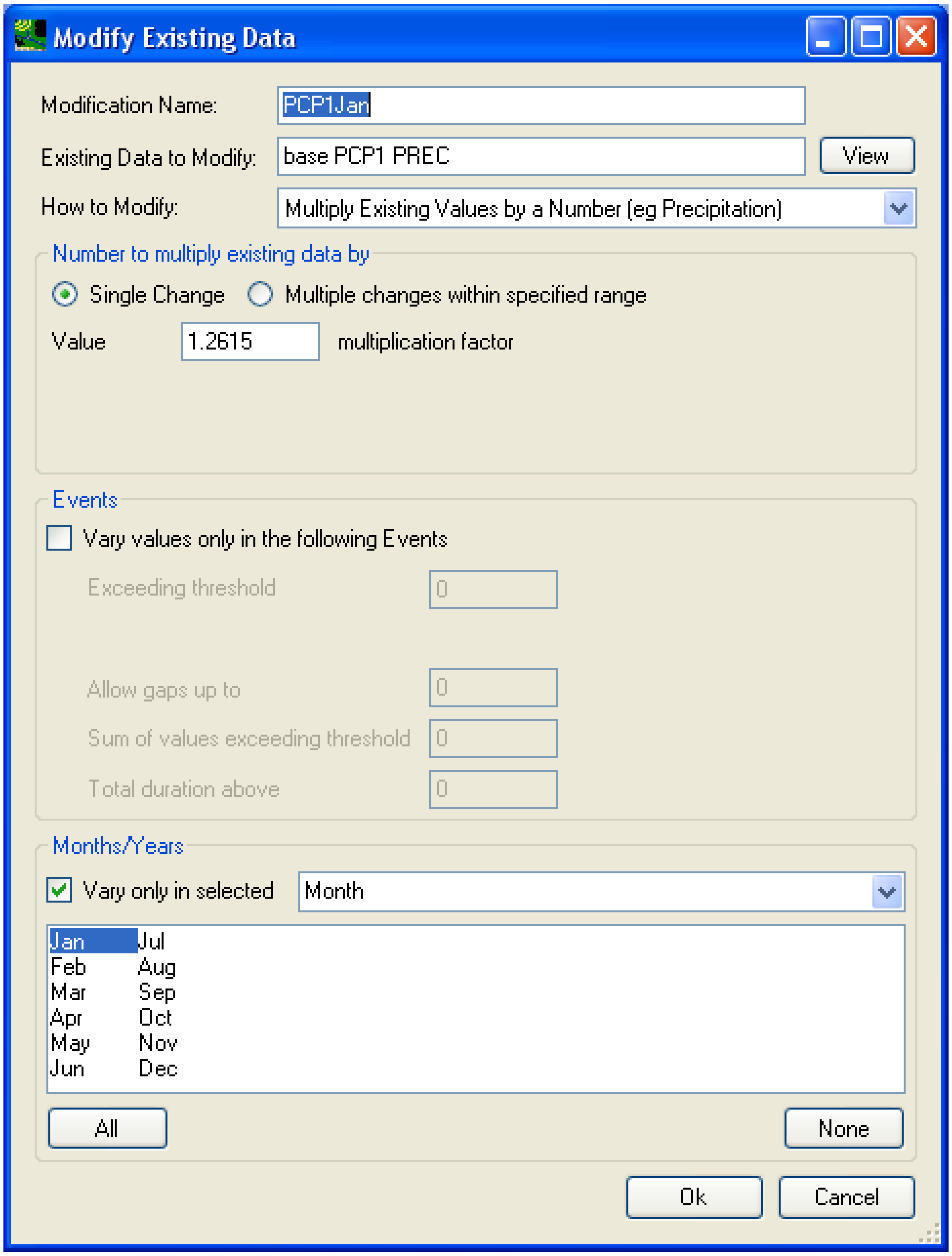
- Multiply Existing Values by a Number (eg Precipitation): This method is used to apply blanket adjustment by simply multiplying every value in the target timeseries with a constant (e.g. 1.2).
- Multiply large/small events by a number: This method is used to apply selective adjustment to rainfall events above or below certain thresholds. Users should specify adjustments as a percentage (eg. 20 %). This method is used to intensify certain rainfall events. The **Events** frame is used in conjunction with this option to qualify what qualifies as an event.
- Add/Remove Storm Events: This method is used to apply adjustment to total rainfall volume of the target timeseries. User should specify adjustment as percentage (eg. 20 %). The **Events** frame is used in conjunction with this option to qualify what qualifies as an event.
-

For all three methods above, user can choose to apply either a single adjustment or a range of adjustments at a constant step size. This is done by the selection of either 'Single Change' or 'Multiple changes within specified range' radio buttons.

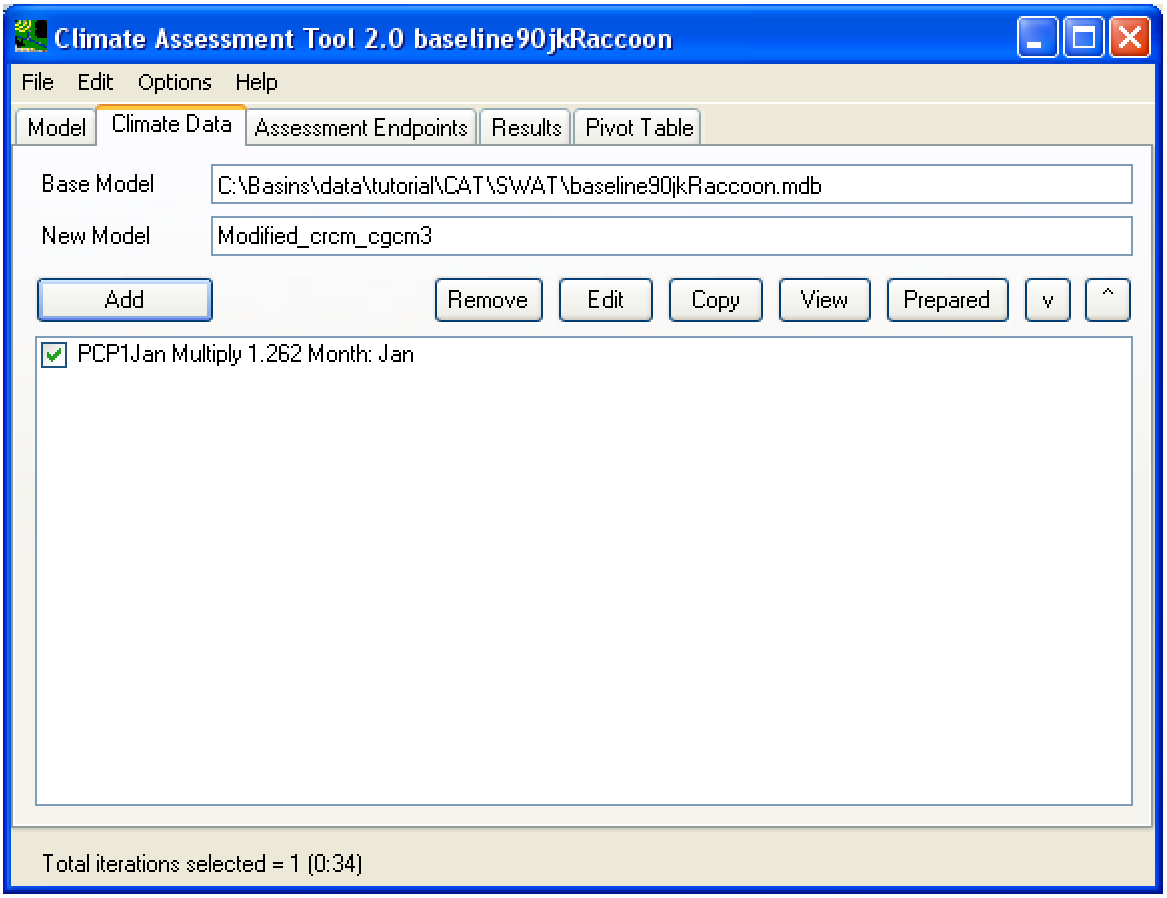
In this exercise, we will choose the 'Multiply Existing Values by a Number' adjustment method. We will choose to apply a Single adjustment by selecting the 'Single Change' radio button and specify 1.2615 as the multiplier factor as shown below:



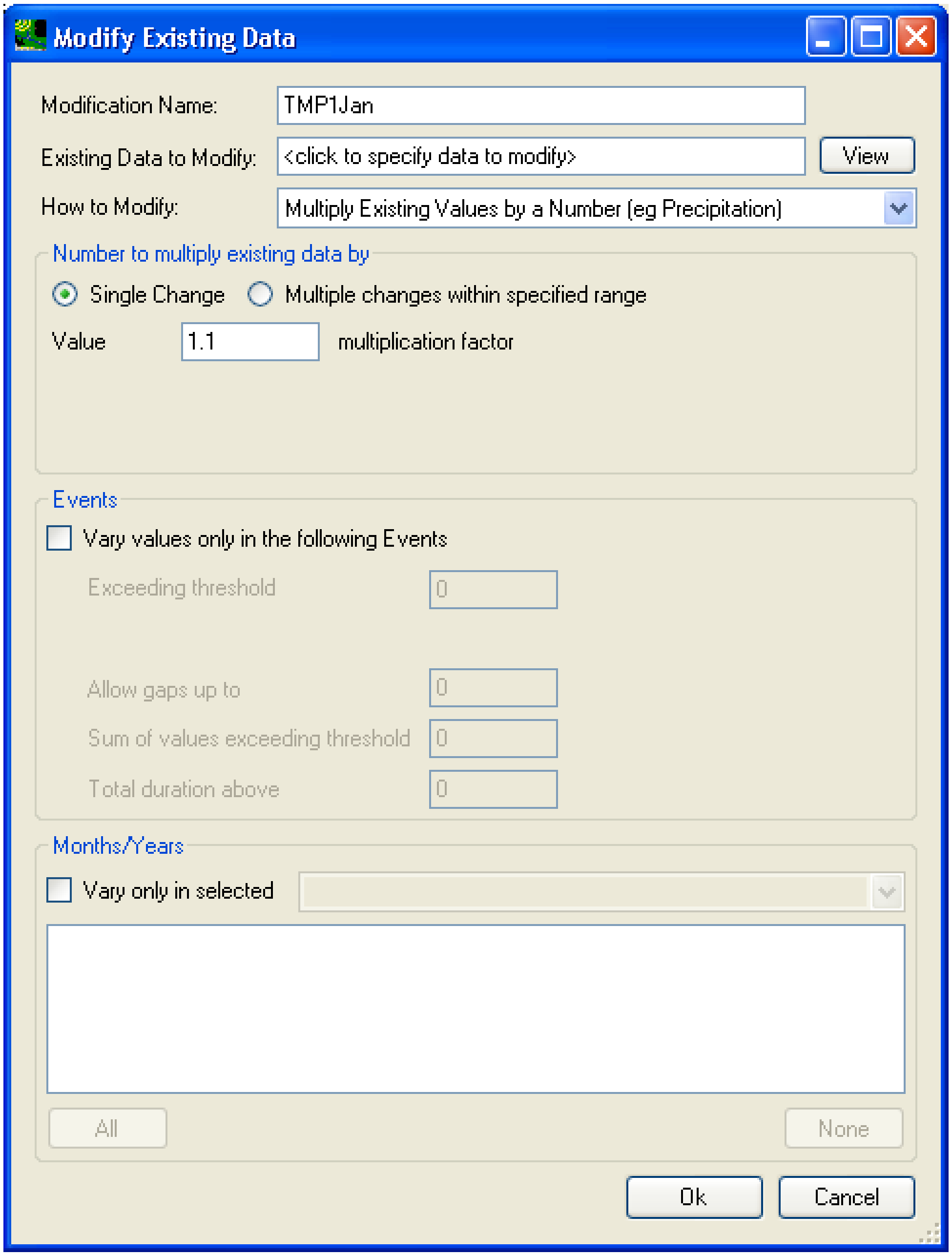
Next, we will specify to only apply the above adjustment to rainfall data within the month of January throughout the timeseries. First, check the 'Vary only in selected' checkbox. Then, from the dropdown list, select 'Month'. This will bring up the three-letter abbreviation of the twelve months of a year for selection. Click on 'Jan' to highlight it. At this point, you have completed the definition of the first climate data adjustment. Your climate data modification window should look like below:



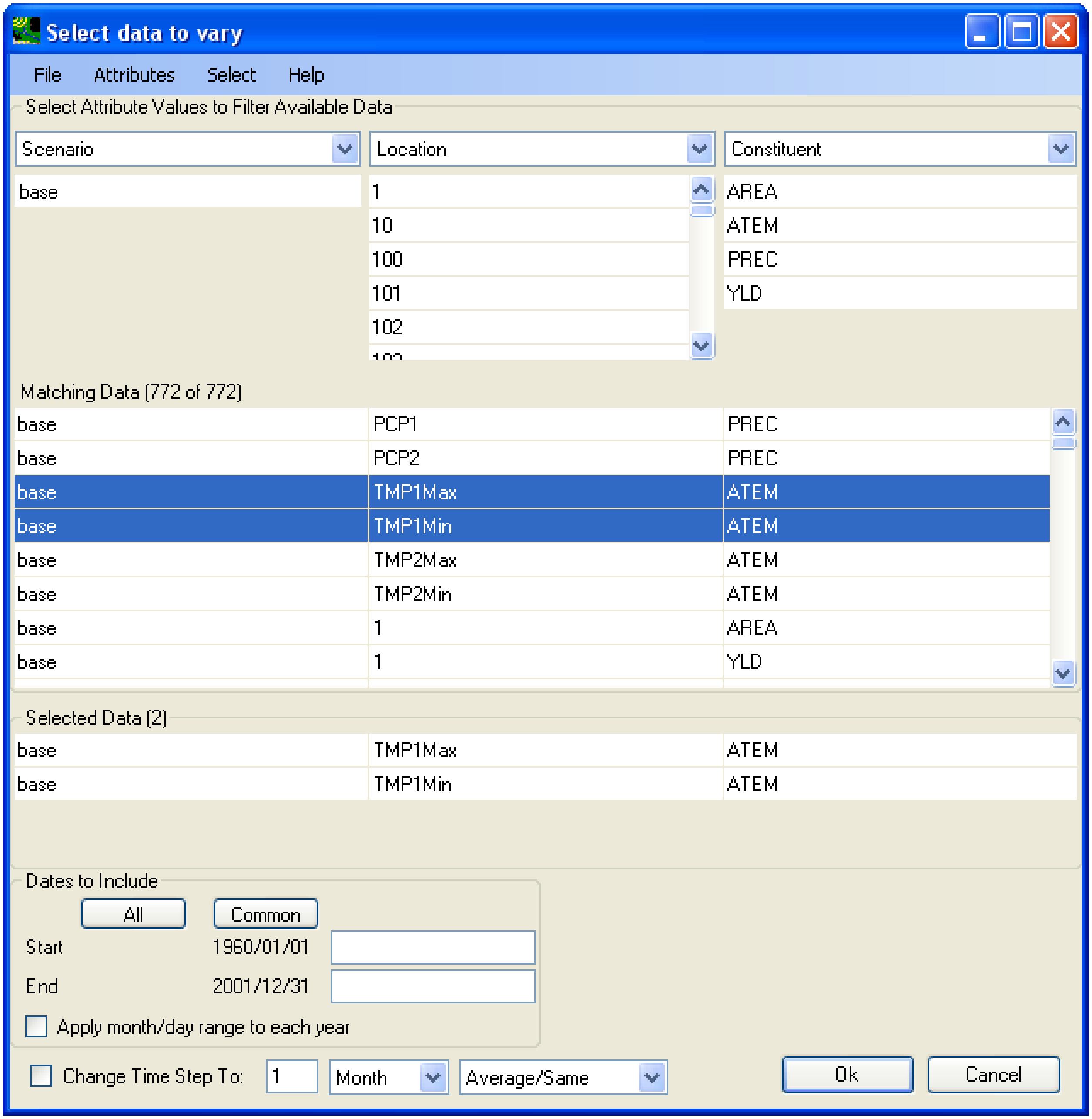
Click **OK** to accept the adjustment. Then the **Climate Data** tab will look like below:



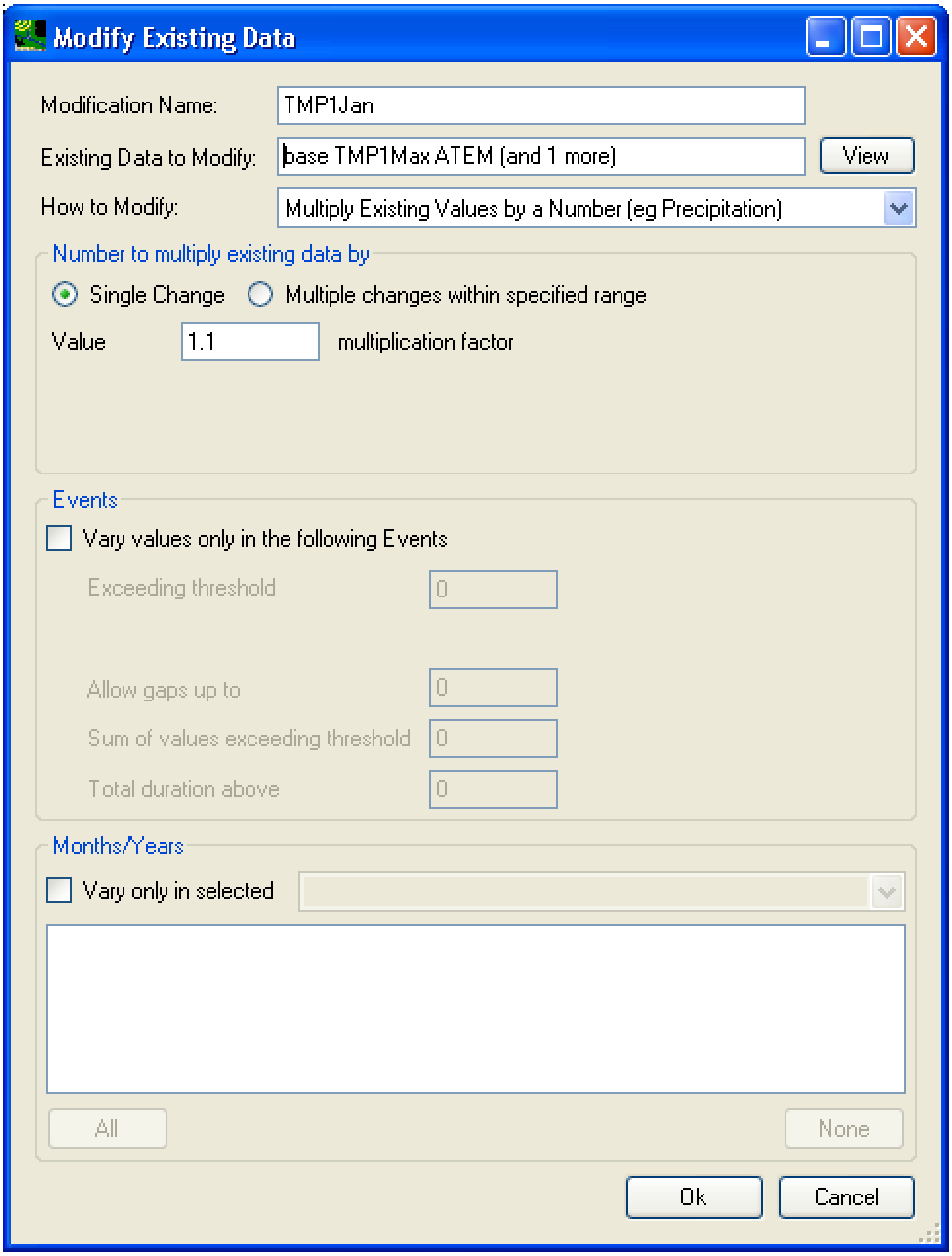
The next adjustment is to increase the daily temperature in January from weather station 1 (TMP1Max and TMP1Min) by 3.0147 degree C. The steps are the same as the rainfall data adjustment you just finished. Click on the **Add** button to bring up the **Modify Existing Data** window. Then, provide a name for this adjustment (TMP1Jan), as shown below:



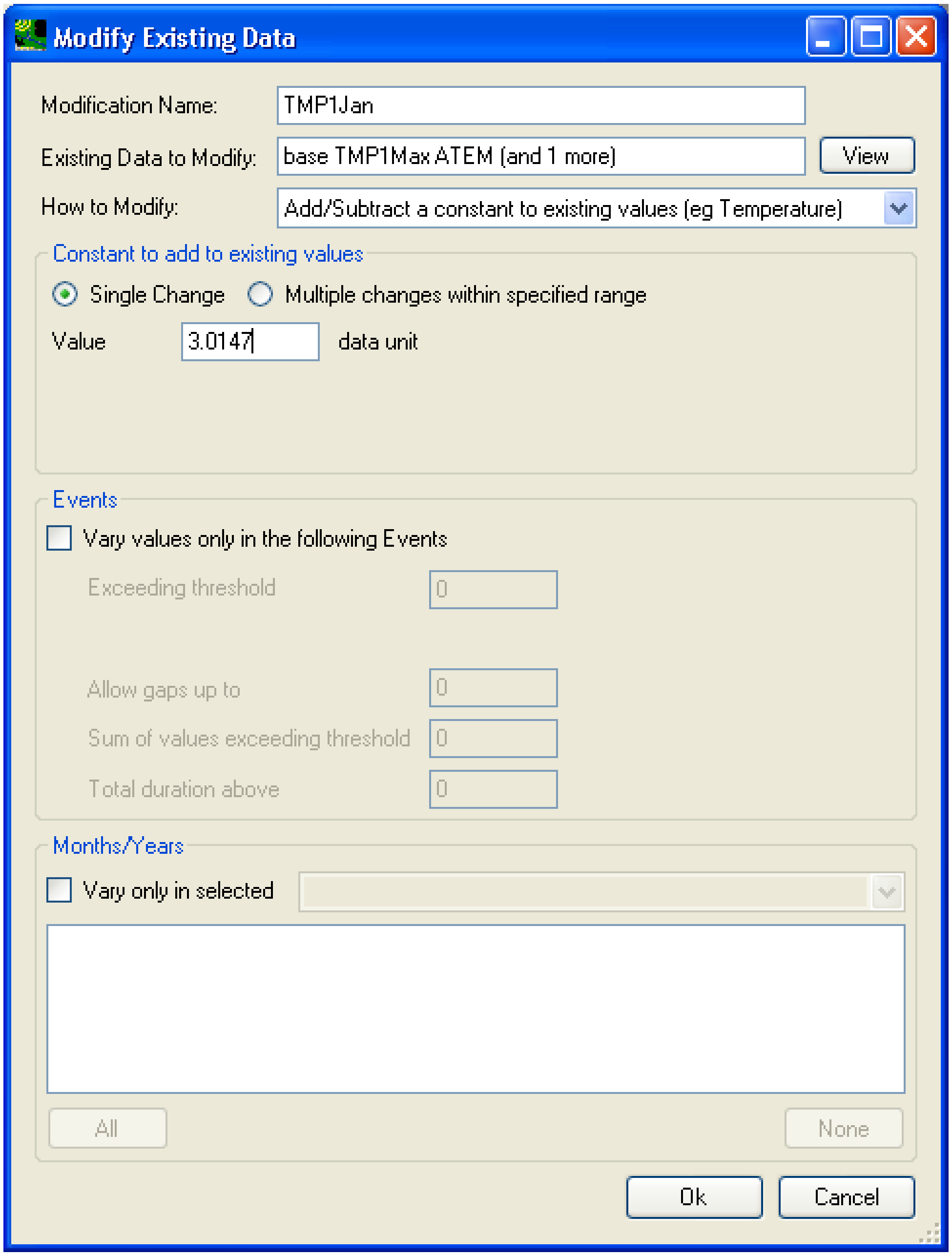
Similar to precipitation data selection, a single click in the 'Existing Data to Modify:' text field will open the **Select data to vary** window. Proceed to choose the temperature data by selecting both daily min and max timeseries from weather station 1 as shown below:



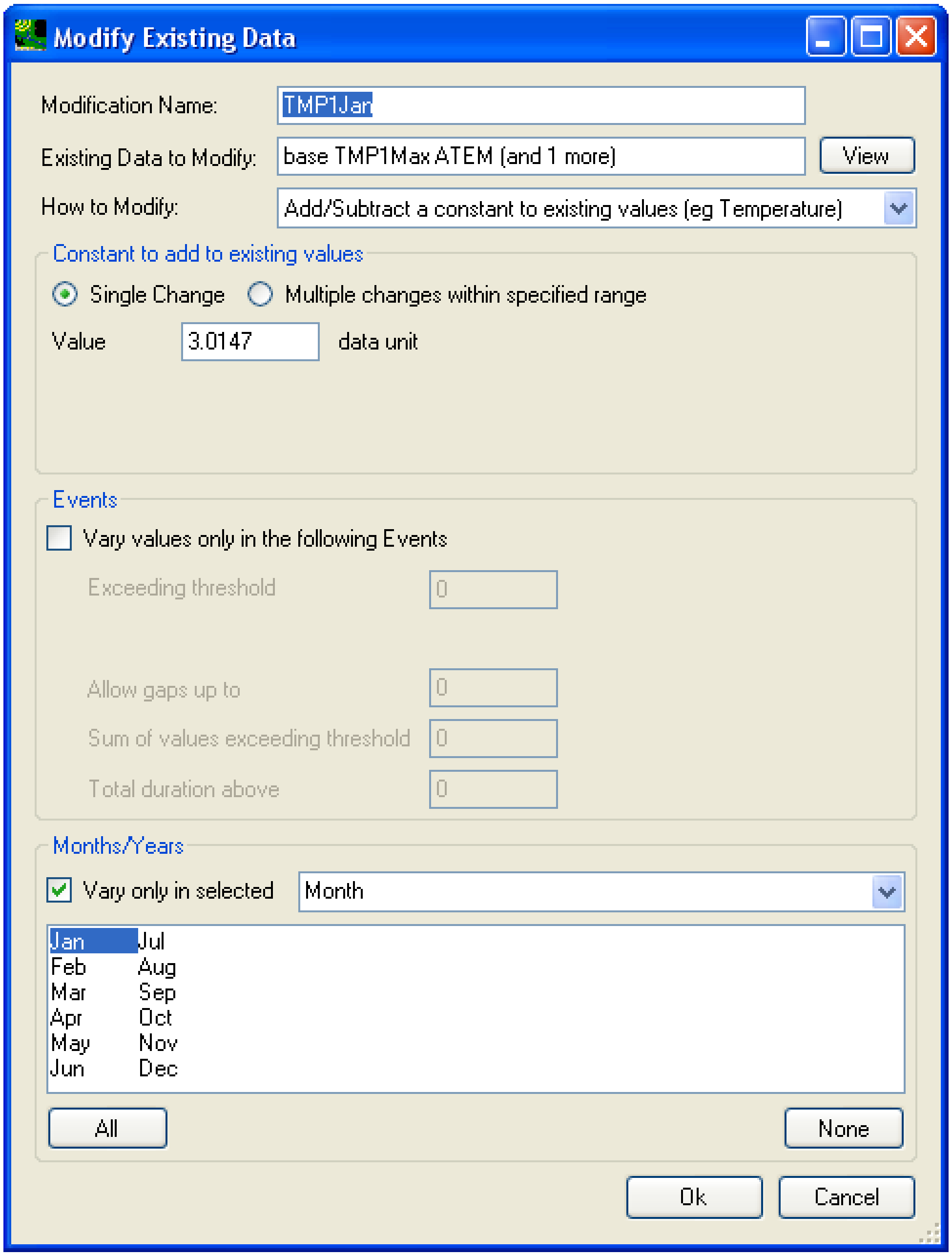
Then, the **Modify Existing Data** window will look like below:



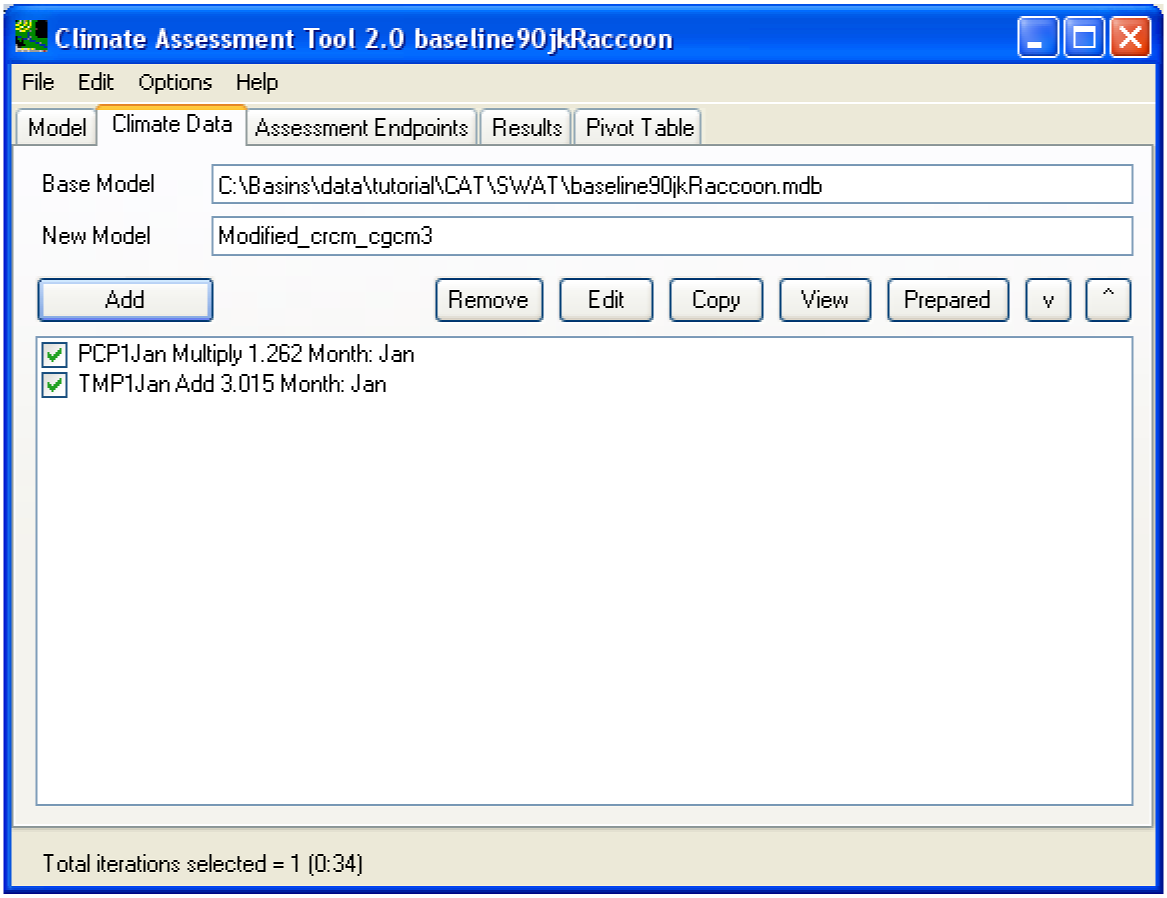
Then, from the **How to modify** dropdown list, choose 'Add/Subtract a constant to existing values' adjustment method. Then, specify a single change. Then, specify 3.0147 as the change constant in the 'Value' text field. The **Modify Existing Data** window will look like below:



Next, we will specify to only apply the above adjustment to temperature data within the month of January throughout the timeseries. First, check the 'Vary only in selected' checkbox. Then, from the dropdown list, select 'Month'. This will bring up the three-letter abbreviation of the twelve month of a year for selection. Click on 'Jan' to highlight it. At this point, you have completed the definition of the second climate data adjustment. Your **Modify Existing Data** window should look like below:

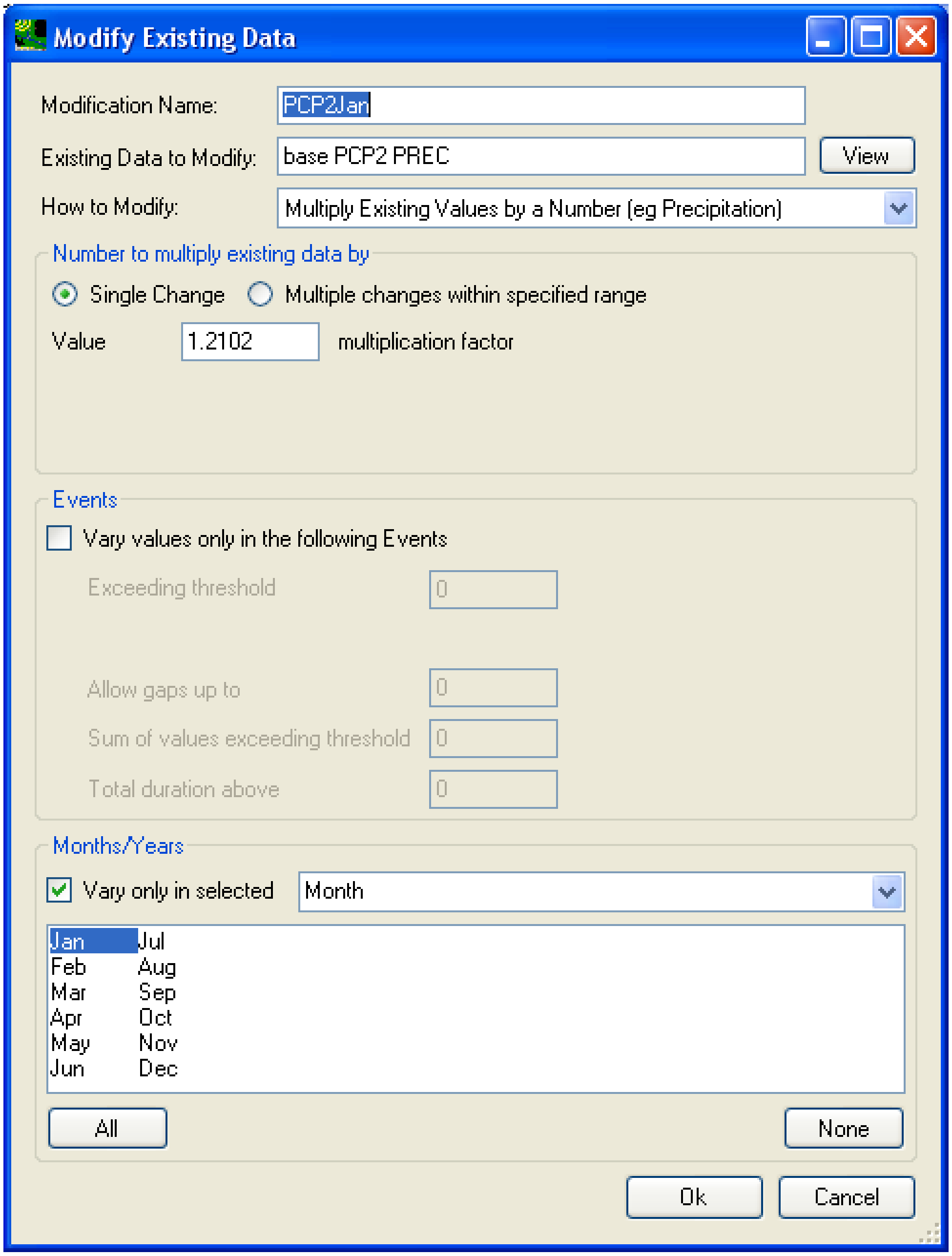


Click **OK** to accept the adjustment. Then, the '**Climate Data** ' tab will look like below:

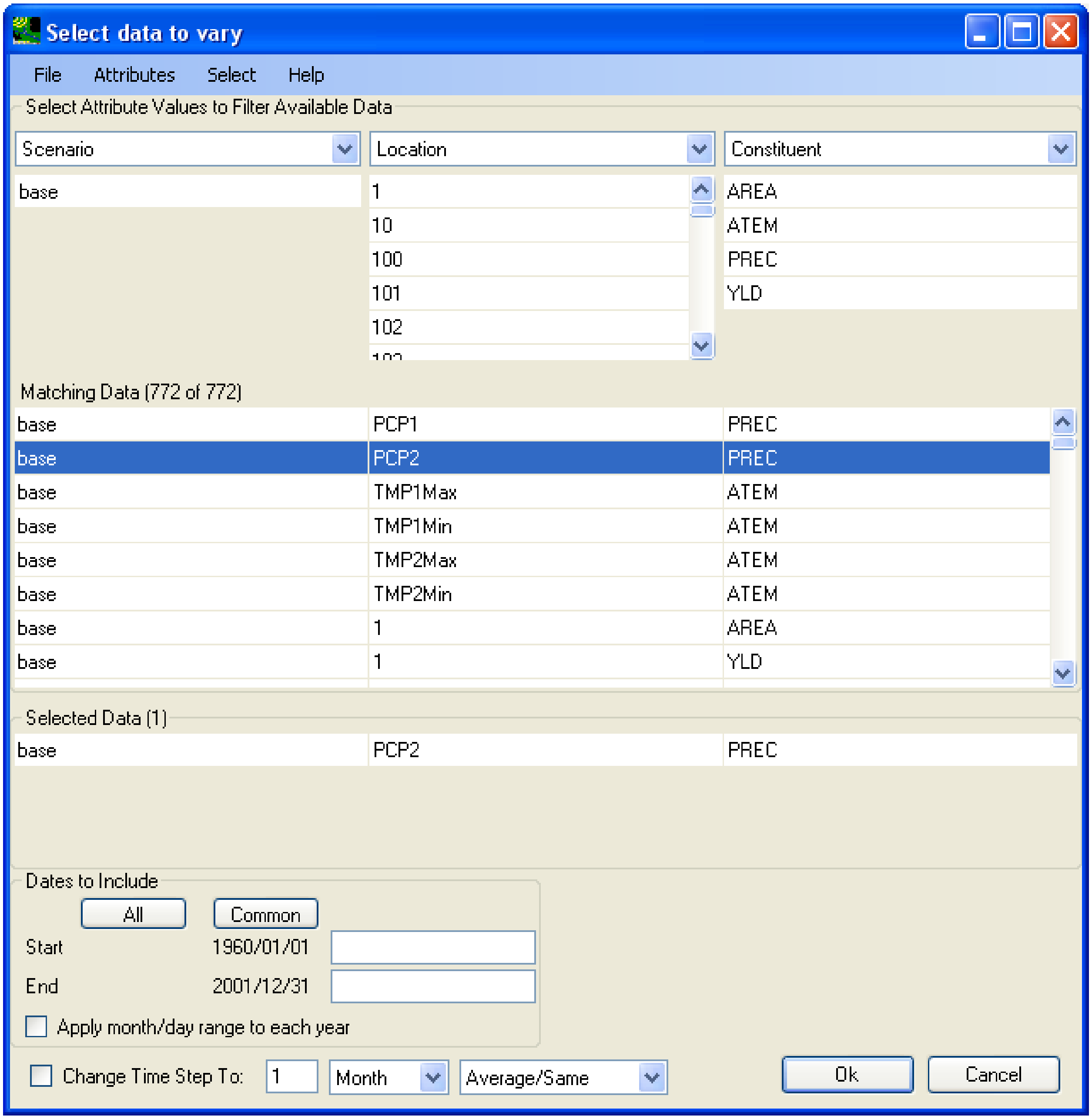


Below, we will apply similar adjustments to the rainfall and temperature data from weather station 2.

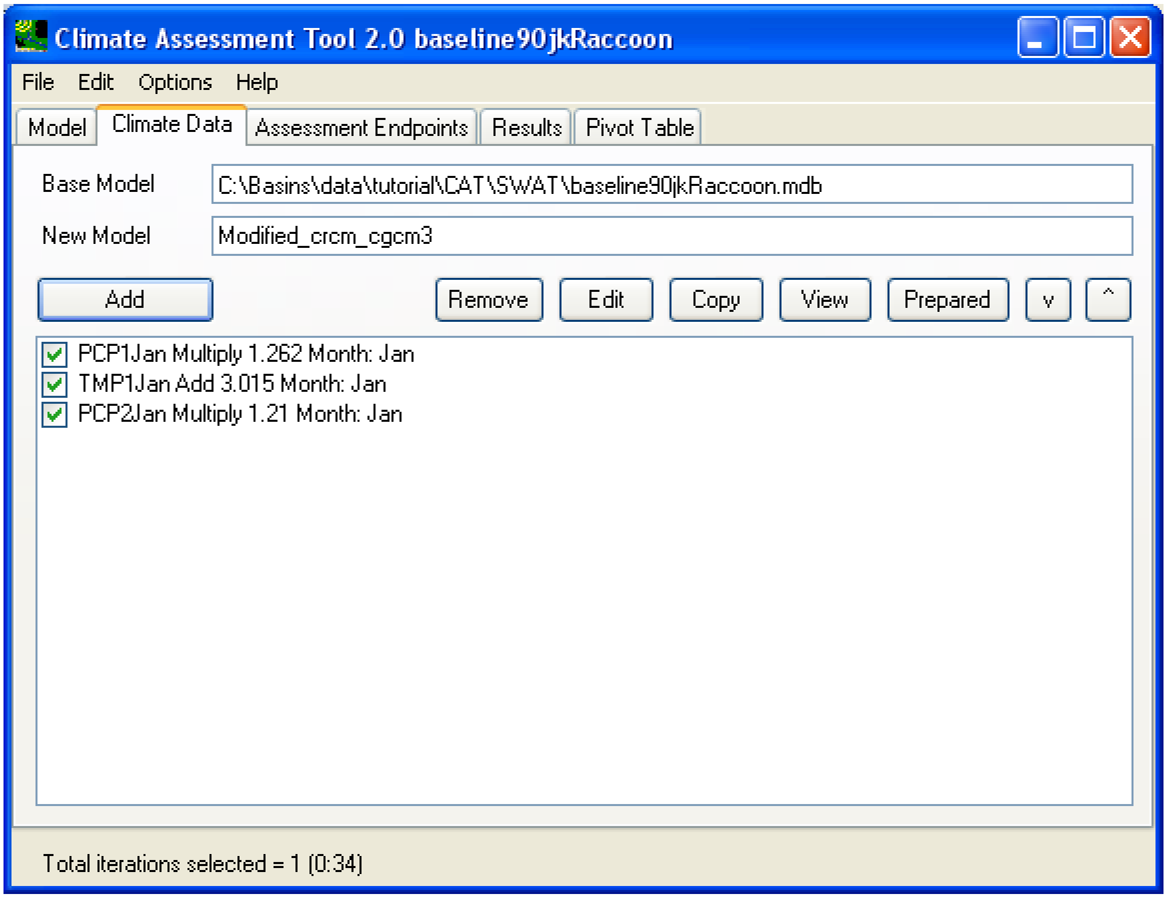
Follow the same steps as with the rainfall adjustment for weather station 1, increase the daily rainfall in January from weather station 2 (PCP2) by 21.02% as shown below:



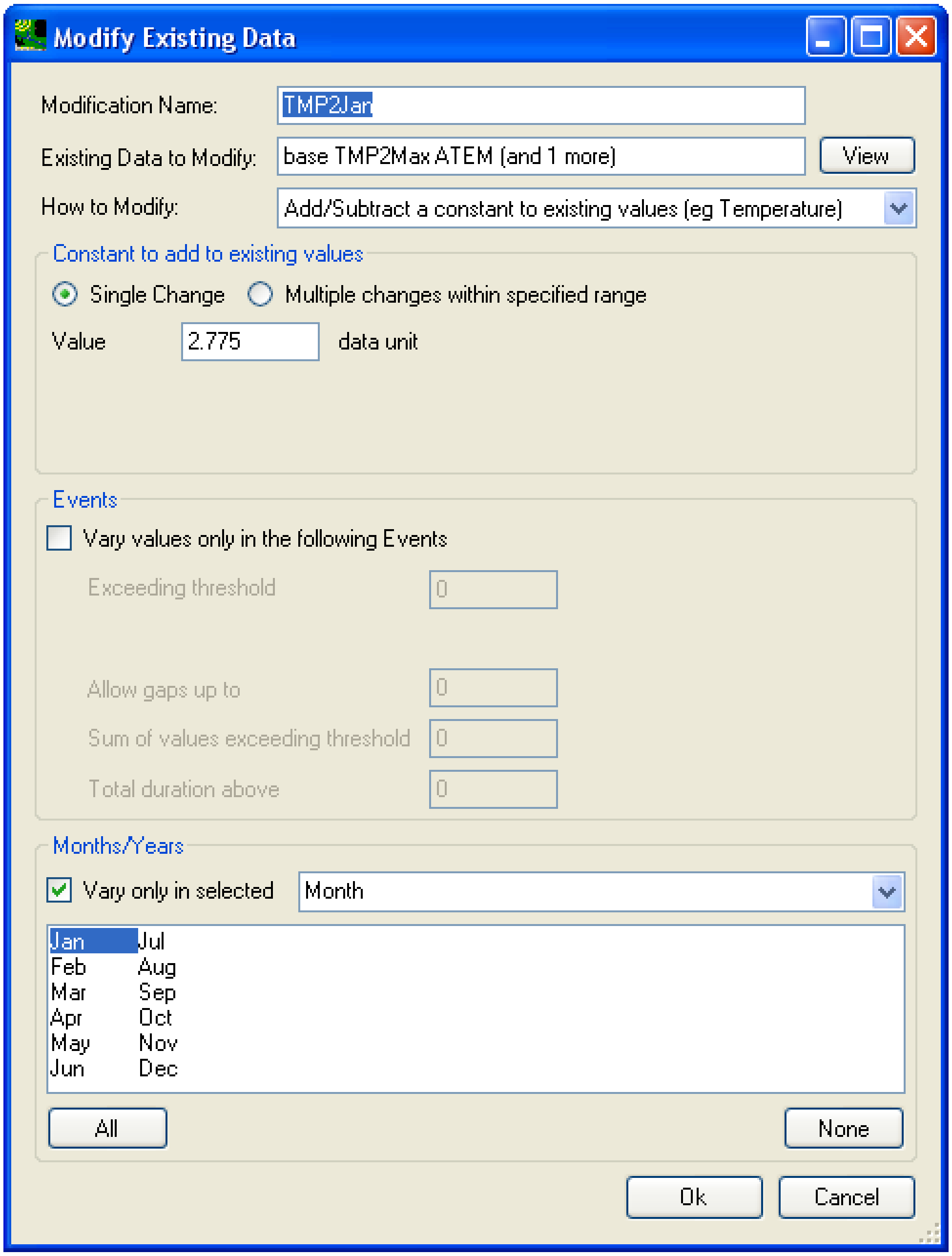
In the above window, to select rainfall data from weather station2 (PCP2), click in the 'Existing data to modify' textbox to bring up the data selection window and select PCP2 data as shown below:



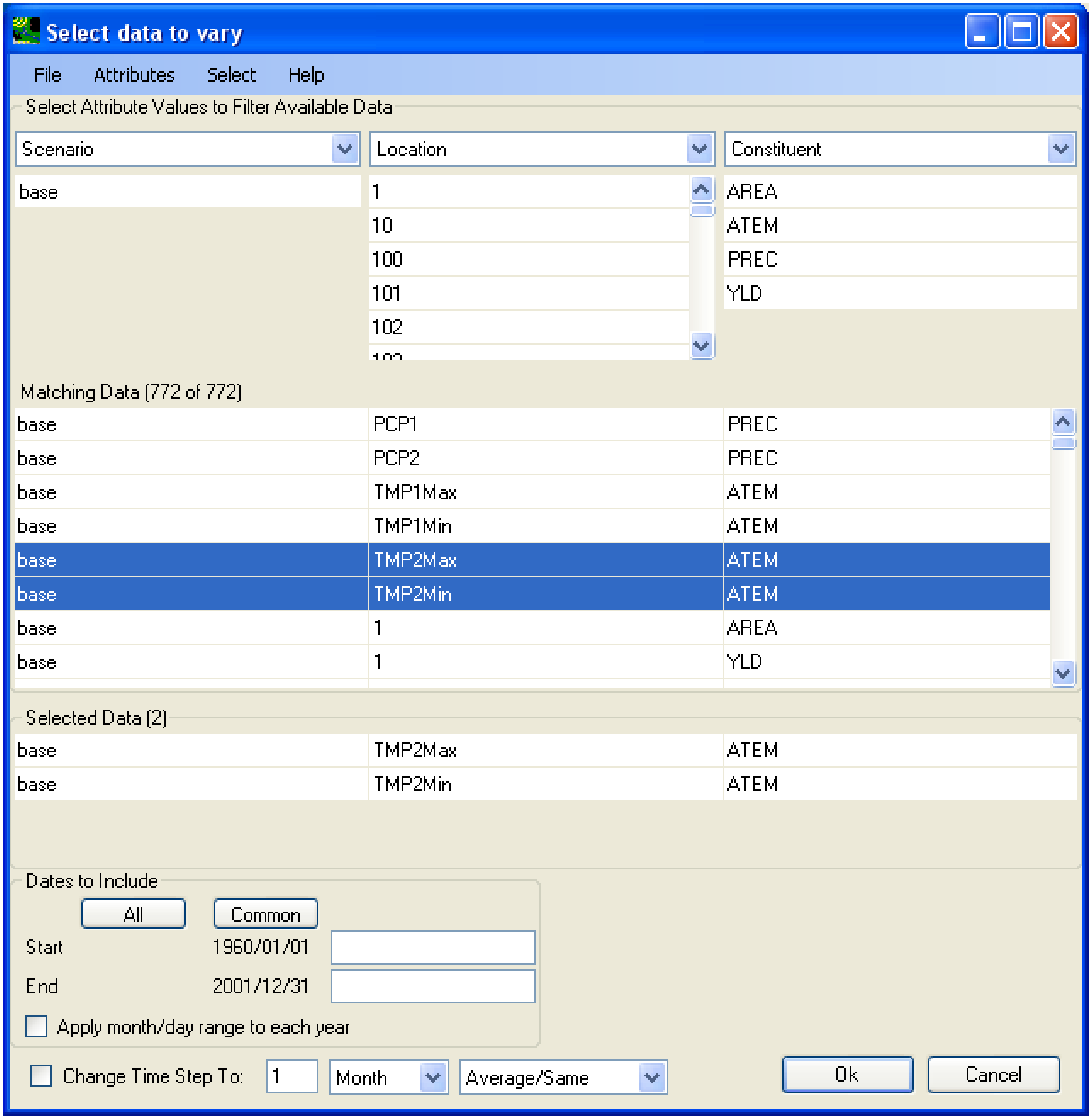
Click **OK** to accept the adjustment, now your '**Climate Data**' tab will look like below:



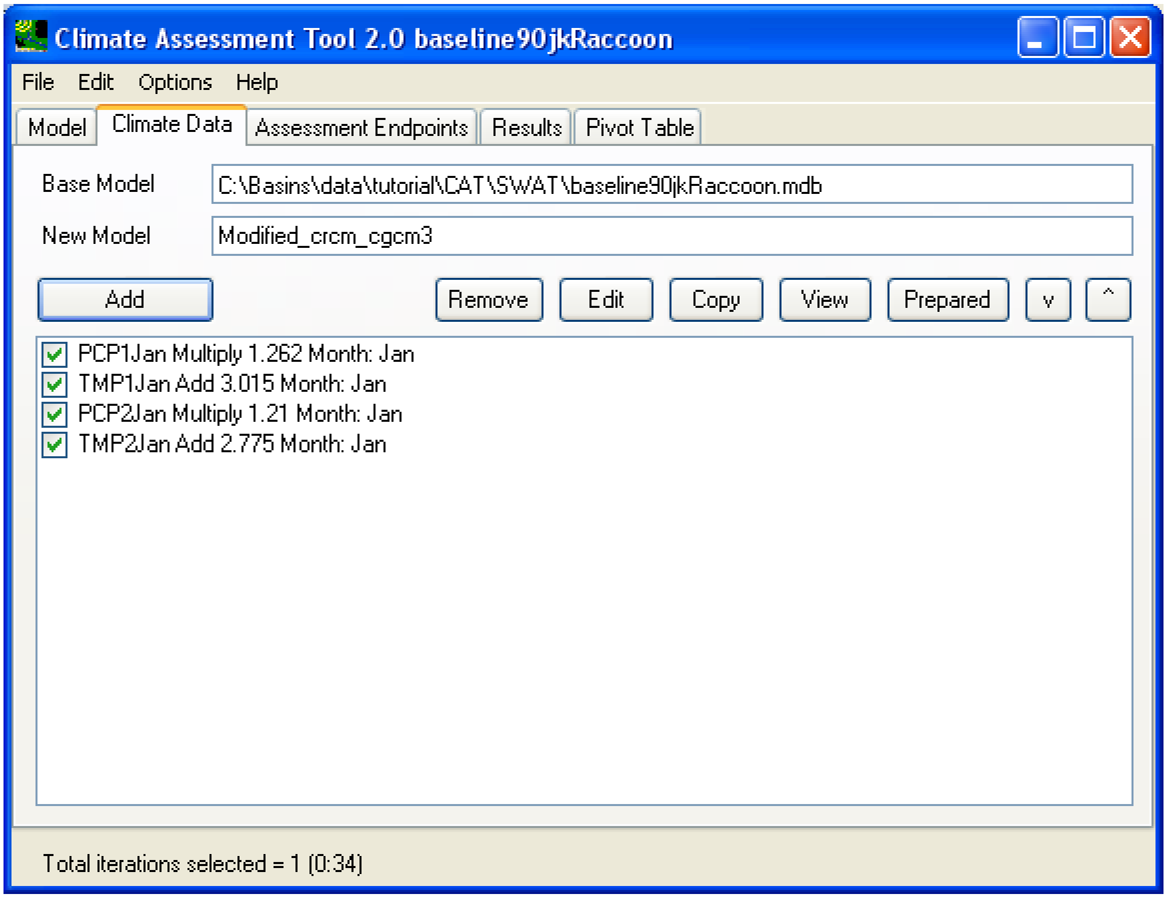
Lastly, follow the same steps as with the temperature adjustment for weather station 1, increase the daily temperature in January from weather station 2 (TMP2Max and TMP2Min) by 2.775 degree C as shown below:



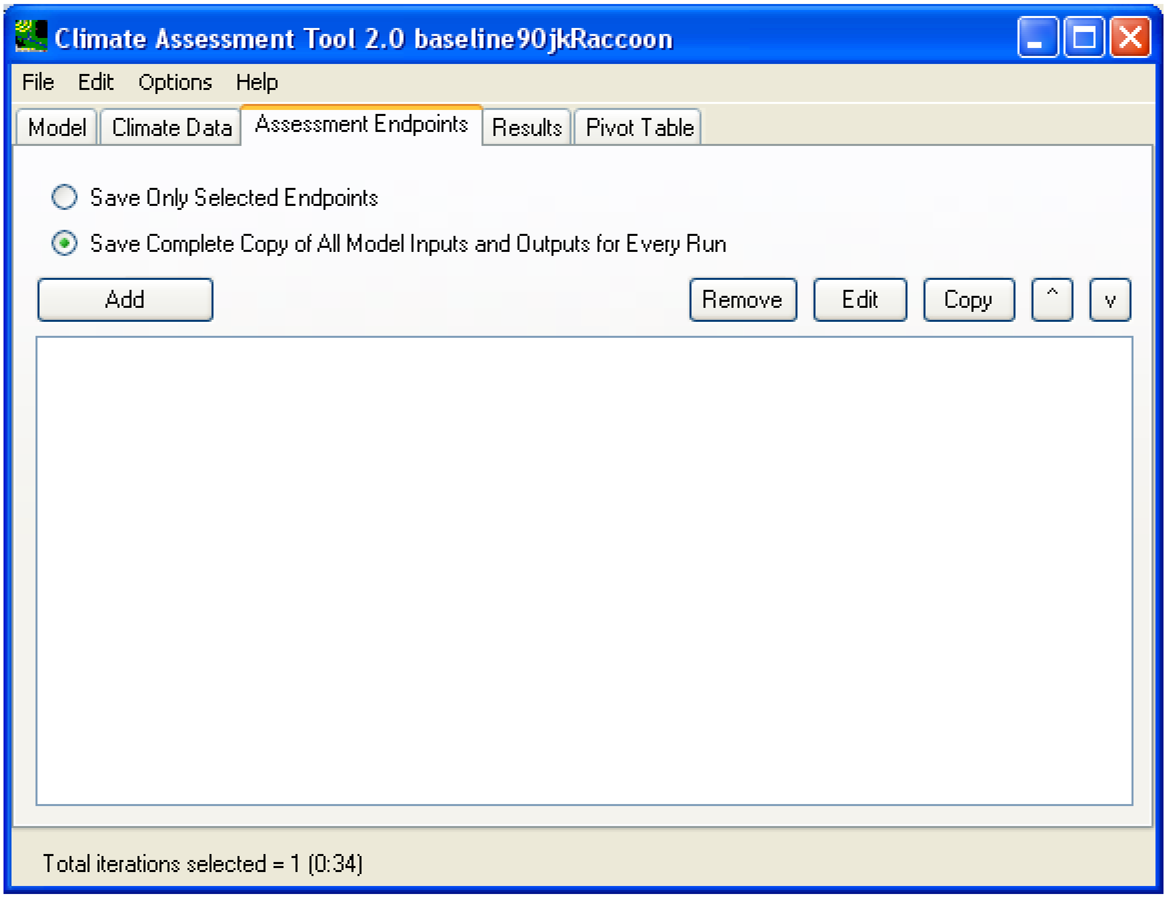
In the above window, to select temperature data from weather station2 (TMP2...), click in the 'Existing data to modify' textbox to bring up the data selection window and select both TMP2Max and TMP2Min temperature timeseries from weather station 2 as shown below:



Click **OK** to accept the adjustment, now, the **Climate Data** tab should look like below:



Now that you have defined the four modifications on the **Climate Data** tab, move onto the **Assessment Endpoints** tab as shown below:

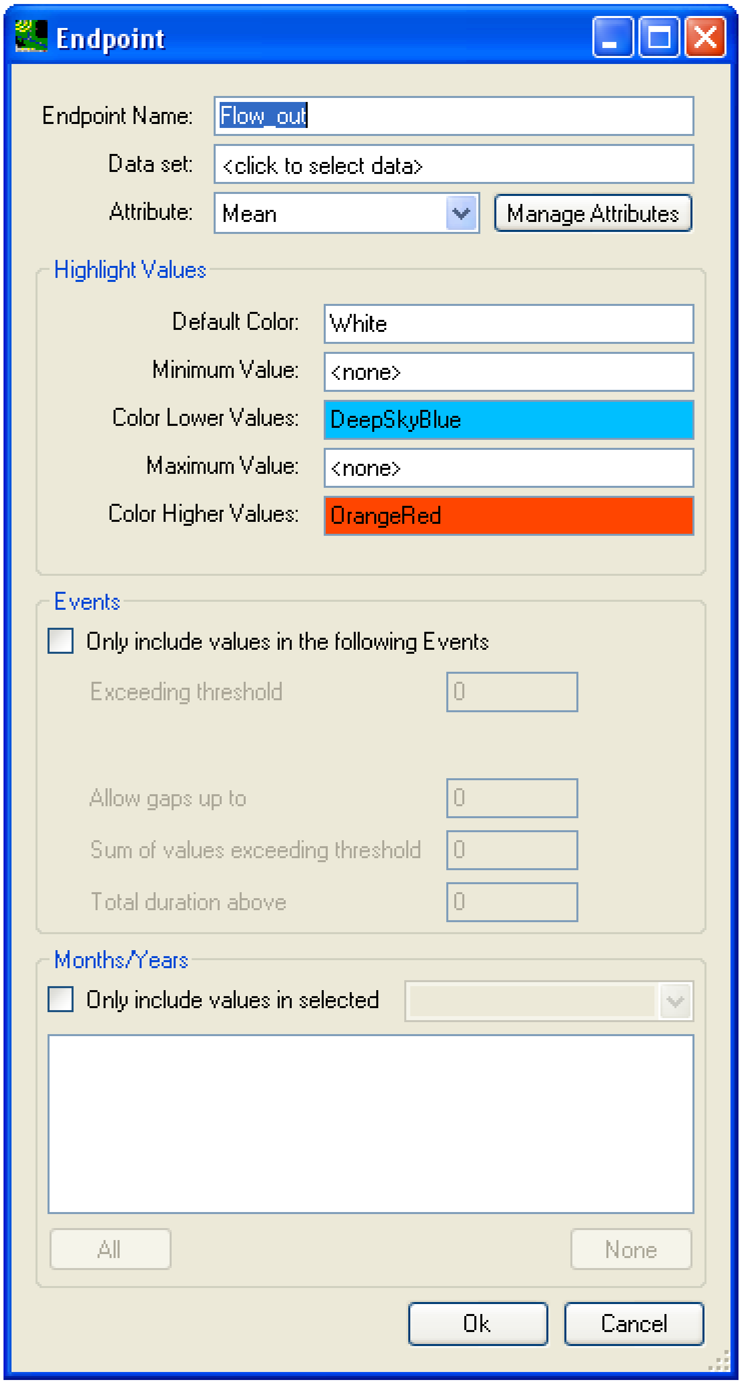


On the **Assessment Endpoints** tab, we will define three SWAT output items as endpoints and also add all weather input data from both weather stations as endpoints. This way, we will be able to see both input and output on the **Results** tab after running the model simulations.

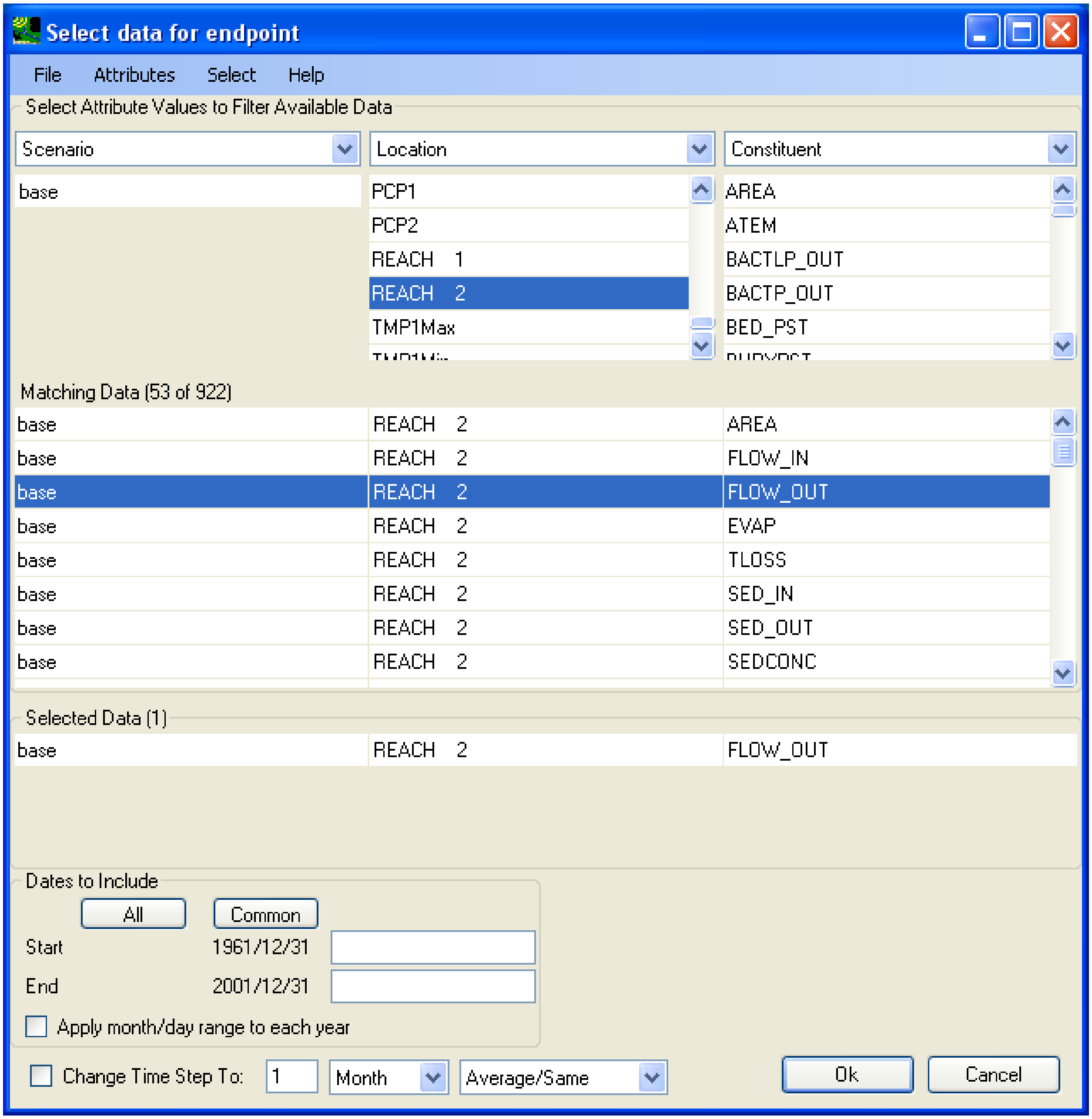
The SWAT outputs from **REACH 2**, which is the outlet of the model watershed, will be the focus. We will select the mean **Flow out** (cms), **Sediment (SED)** load (tonnes/year), and **Nitrate (NO3)** load (kg/year) as endpoints.

Click the **Add** button to initiate the definition of a new endpoint.

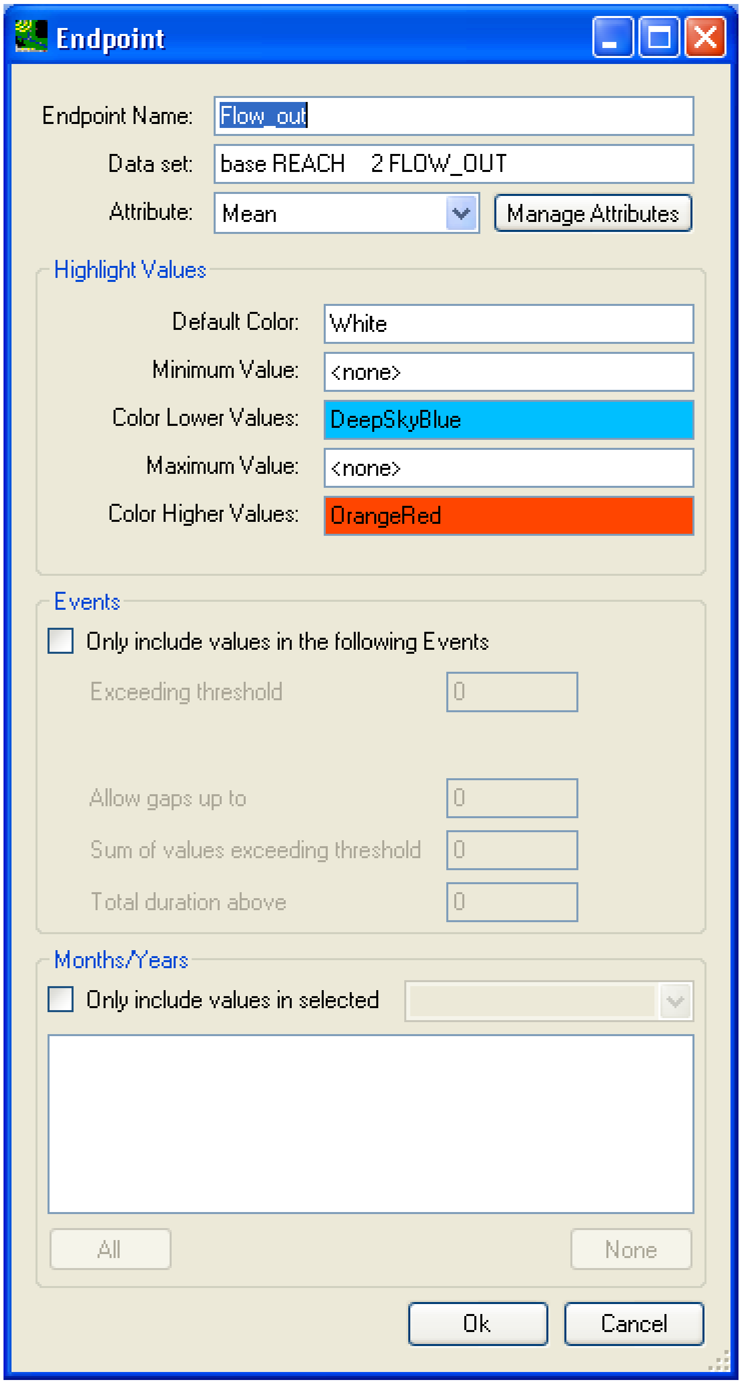
For the first endpoint, specify the **Endpoint Name** as 'Flow_out' and specify the endpoint **Attribute** to be 'Mean' as shown below:



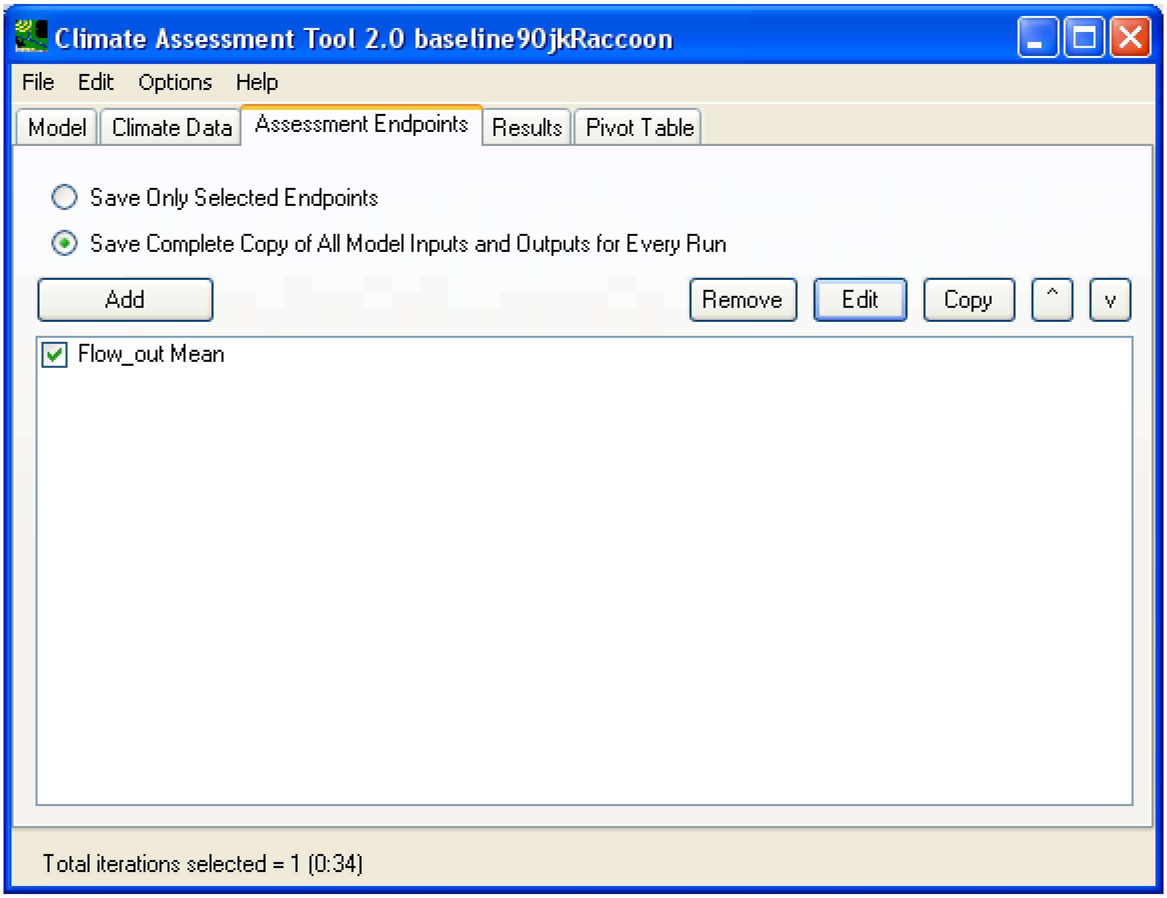
In the above window, click in the **Data set** text box to open the **Select data for endpoint** window to select the outflow output at REACH 2 as shown below:



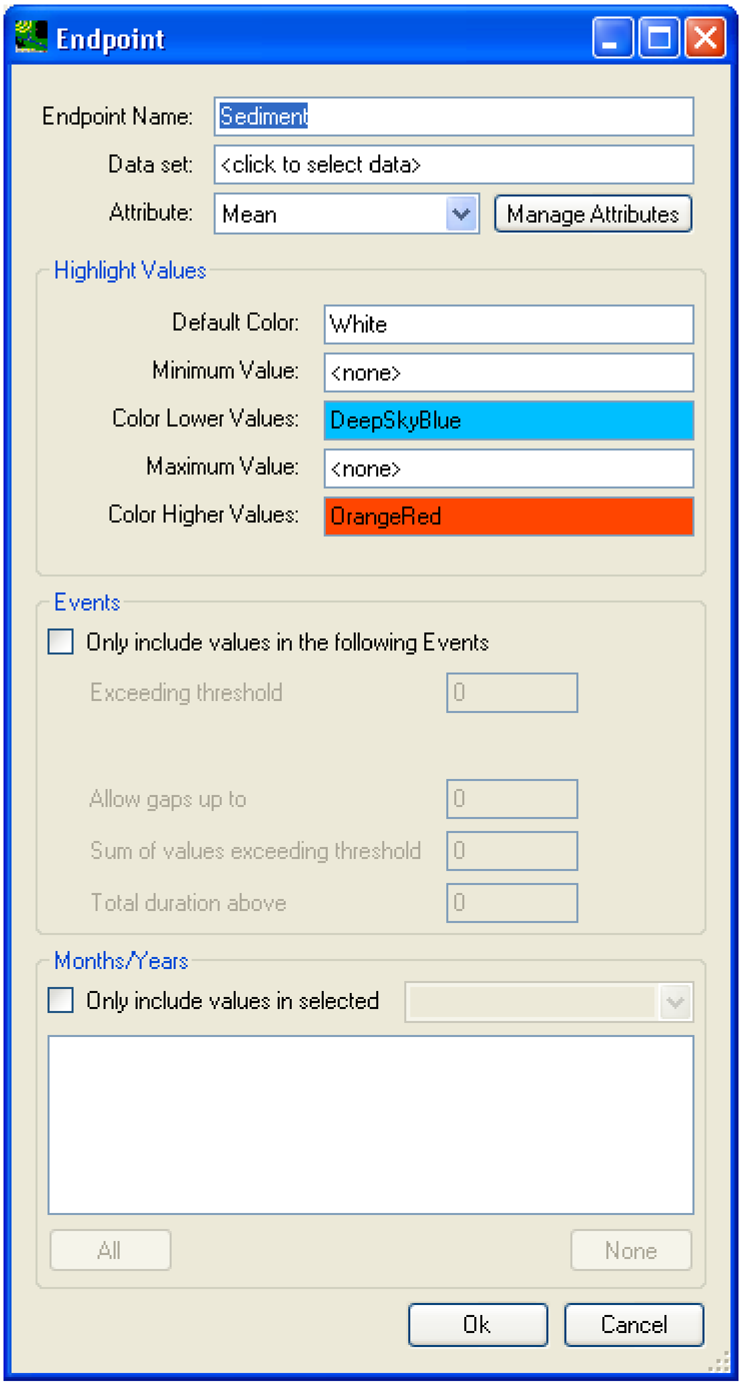
Click **OK** to accept data selection, then, the endpoint definition window will look like below:



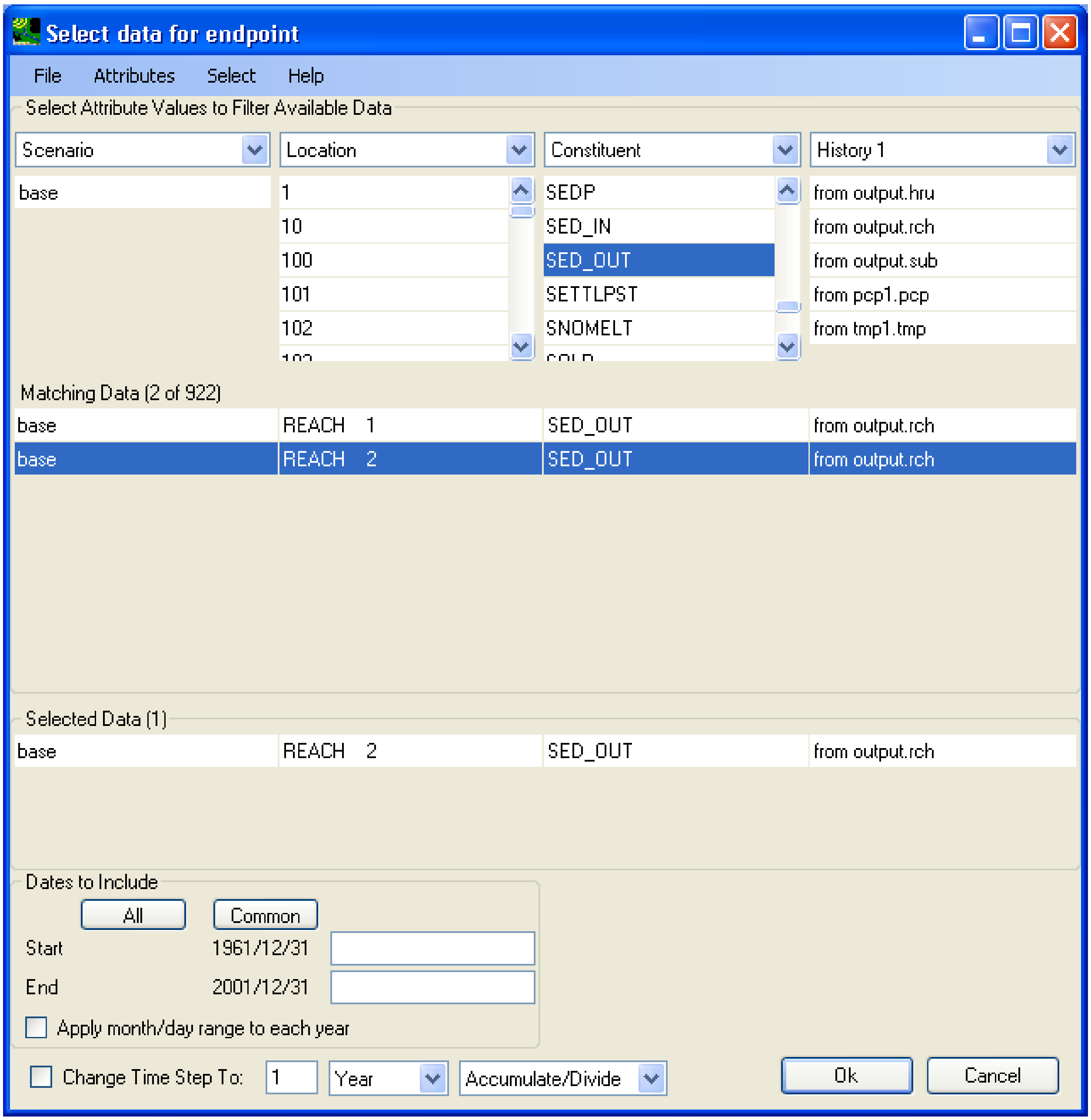
Click **OK** to accept the endpoint definition, then the **Assessment Endpoint** tab will look like below:



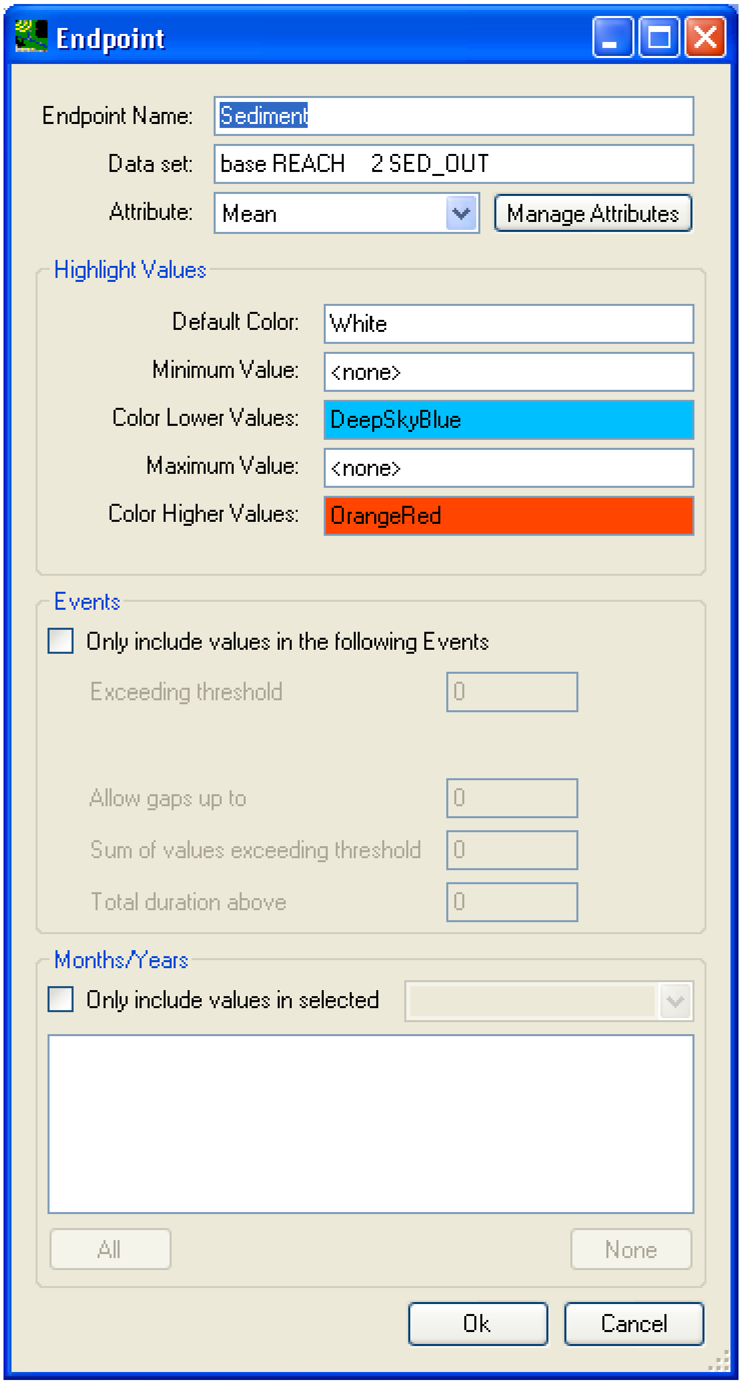
Click **Add** button to add a second endpoint. In the endpoint definition window, specify 'Sediment' as endpoint and use 'Mean' as the statistic attribute as shown below:



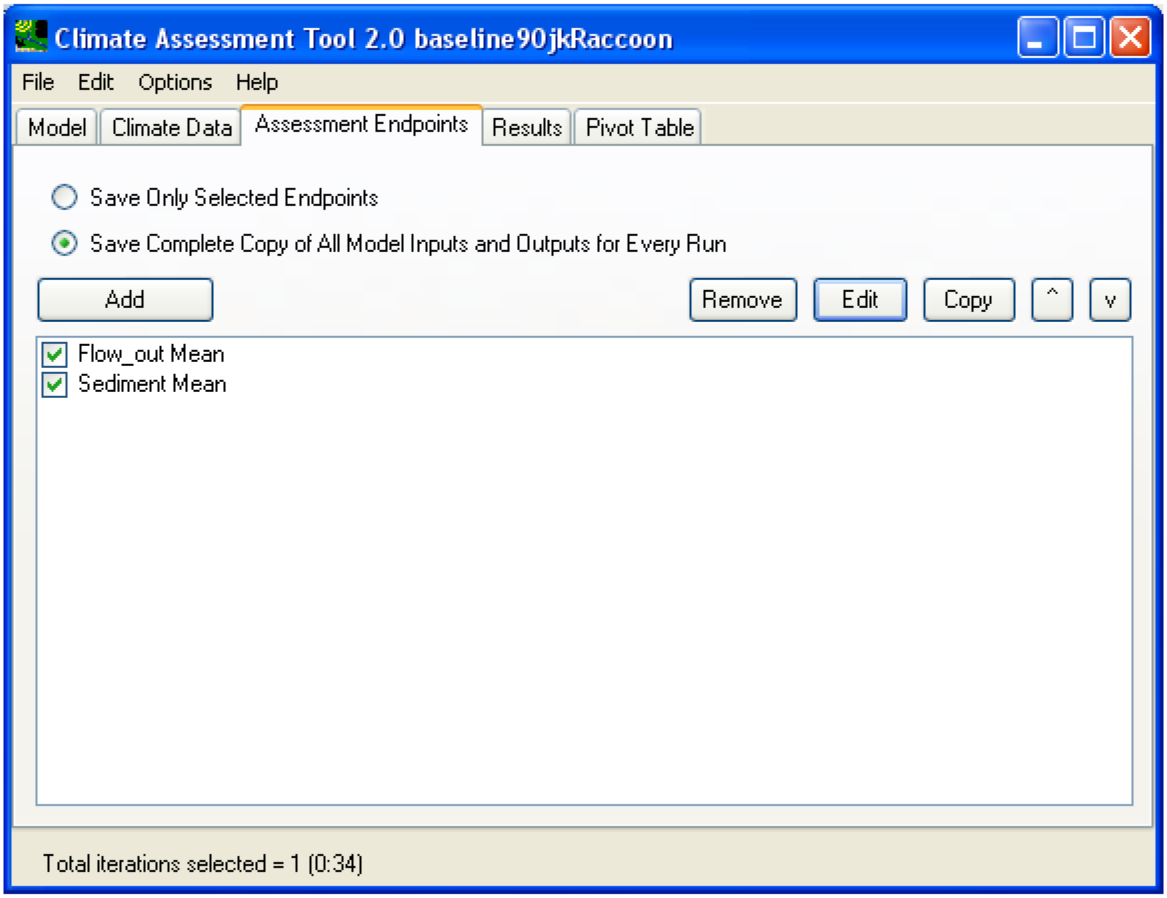
In the above window, click in the **Data set** text box to open the **Select data for endpoint** window to select the sediment output at REACH 2 as shown below. Note that the image below includes the 'History 1' attribute as well as the Scenario, Location, and Constituent attribute headers; the 'History 1' attribute was added by the user through the ‘Attributes:Add’ menu as another means of selecting timeseries, but it is optional.



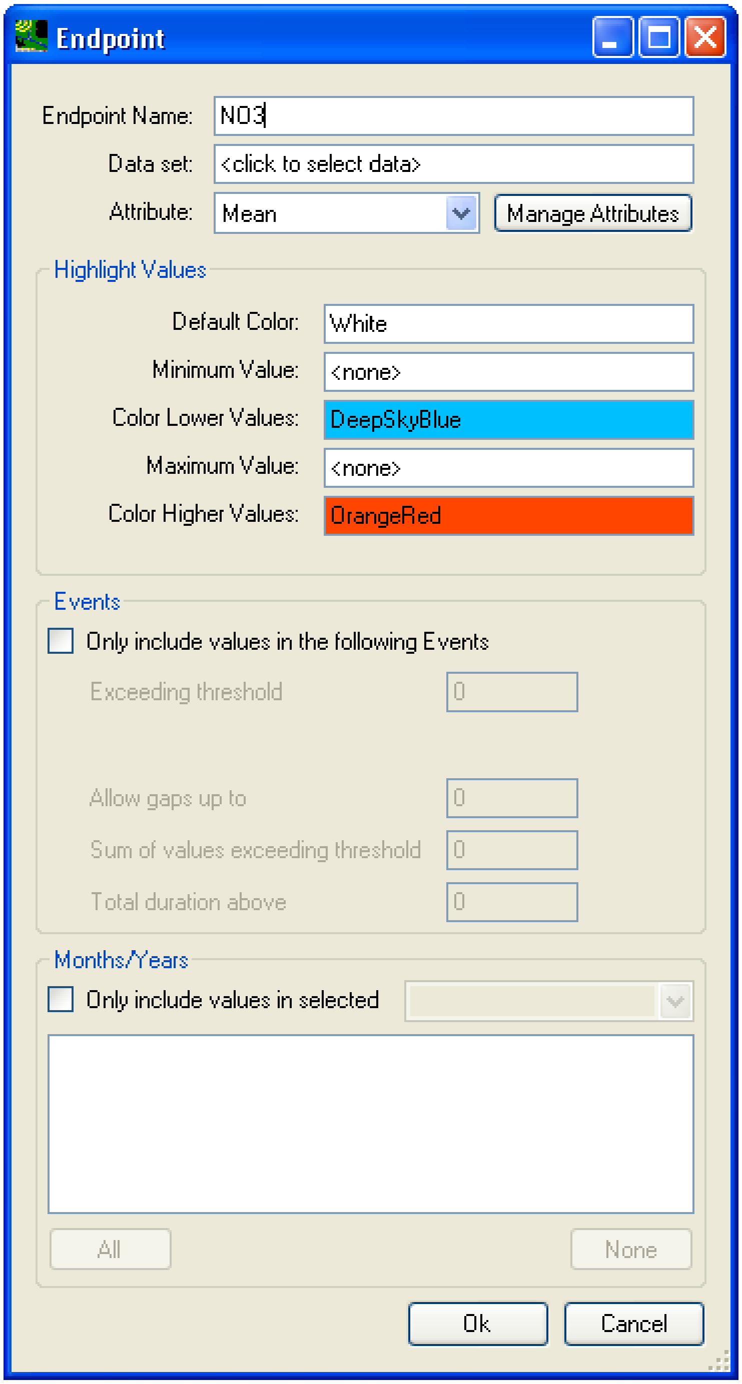
Click **OK** to accept data selection, then, the endpoint definition window will look like below:



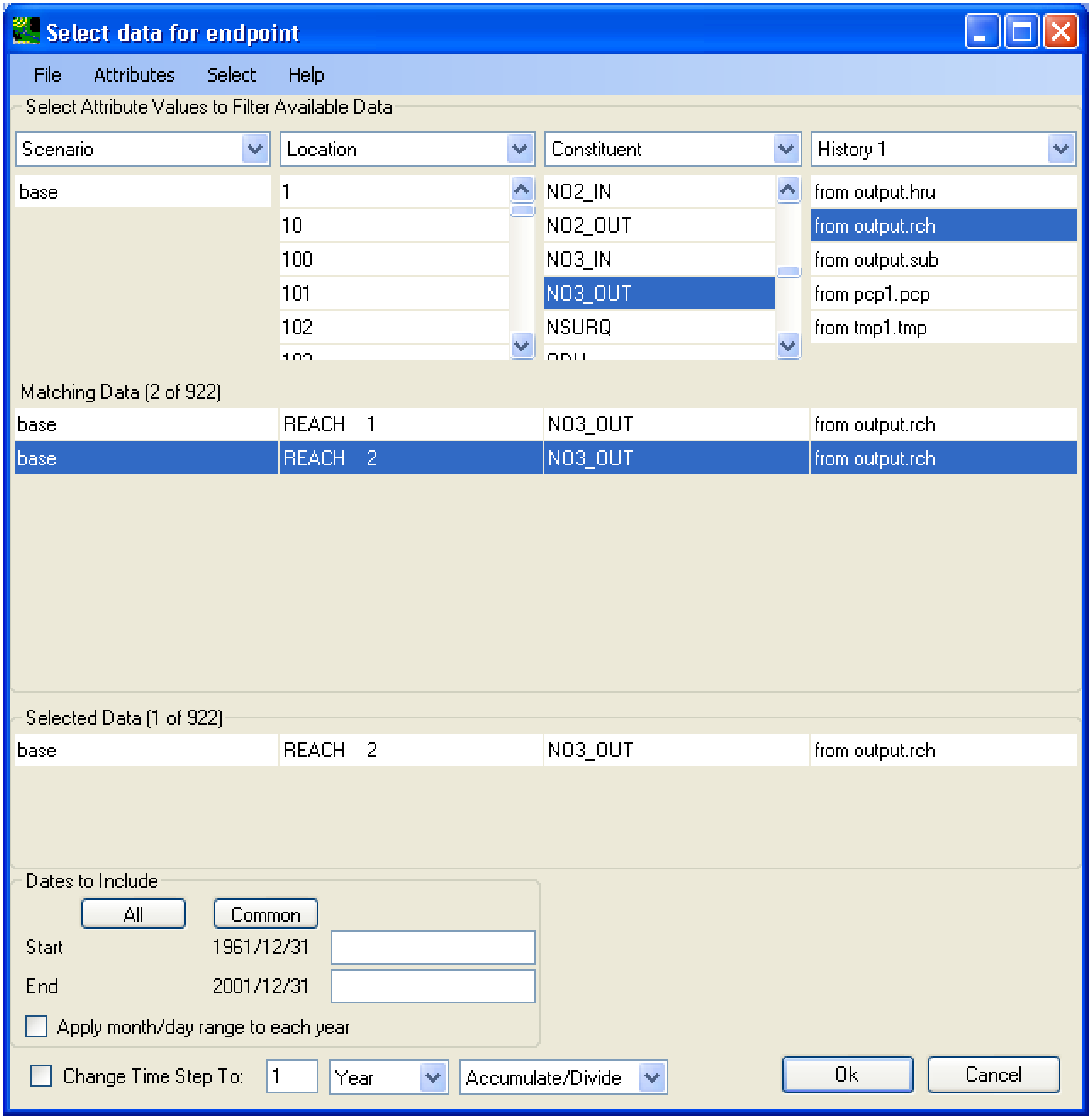
Click **OK** to accept the endpoint definition, then the **Assessment Endpoint** tab will look like below:



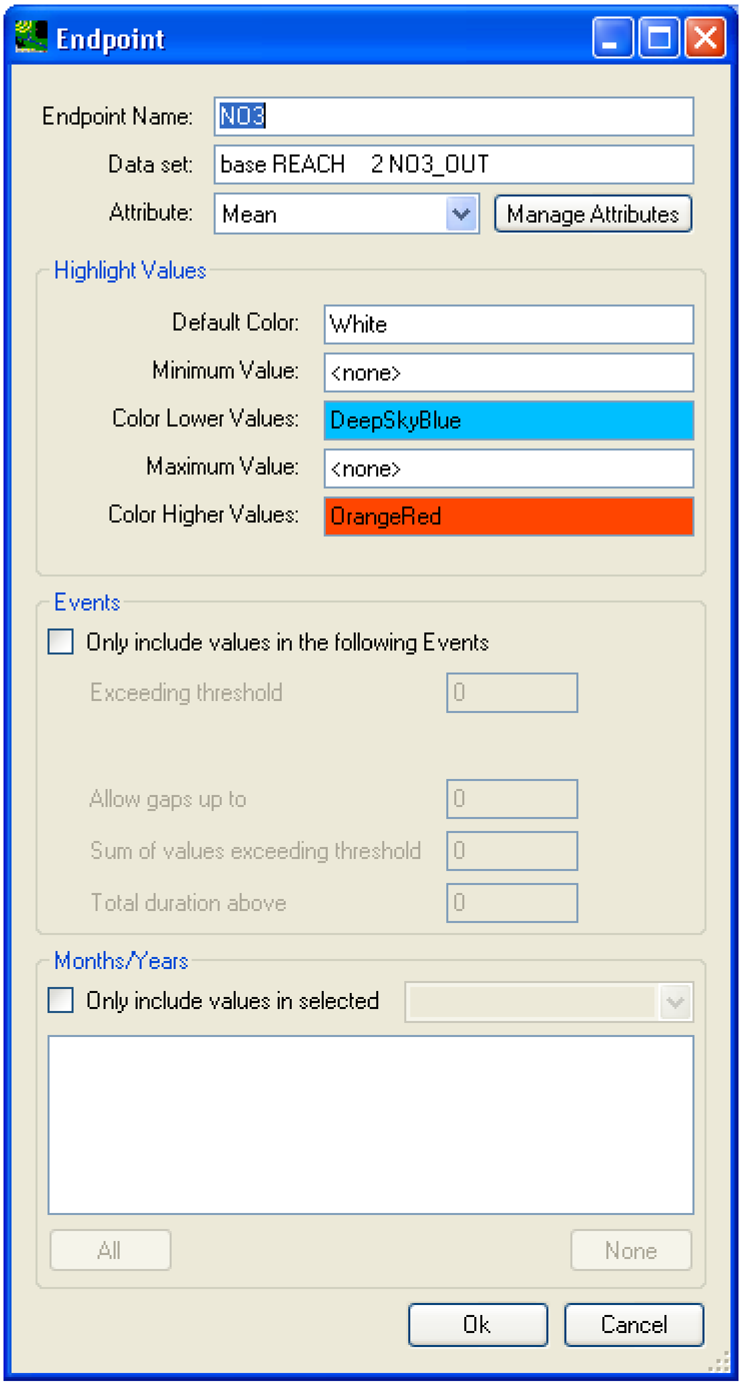
Click **Add** button to add a third endpoint. In the endpoint definition window, specify ‘NO3’ as endpoint and use ‘Mean’ as the statistic attribute as shown below:



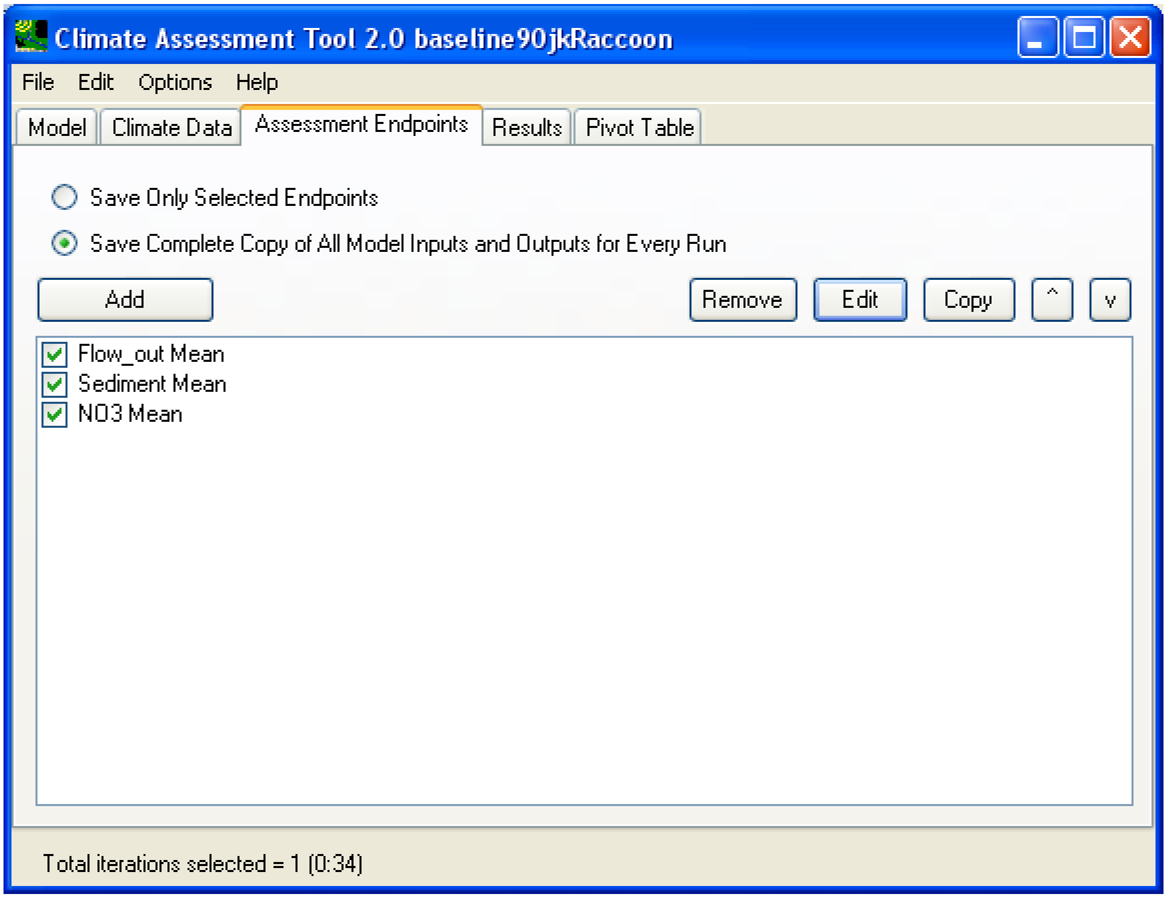
In the above window, click in the **Data set** text box to open the **Select data for endpoint** window to select the NO3 output at REACH 2 as shown below:



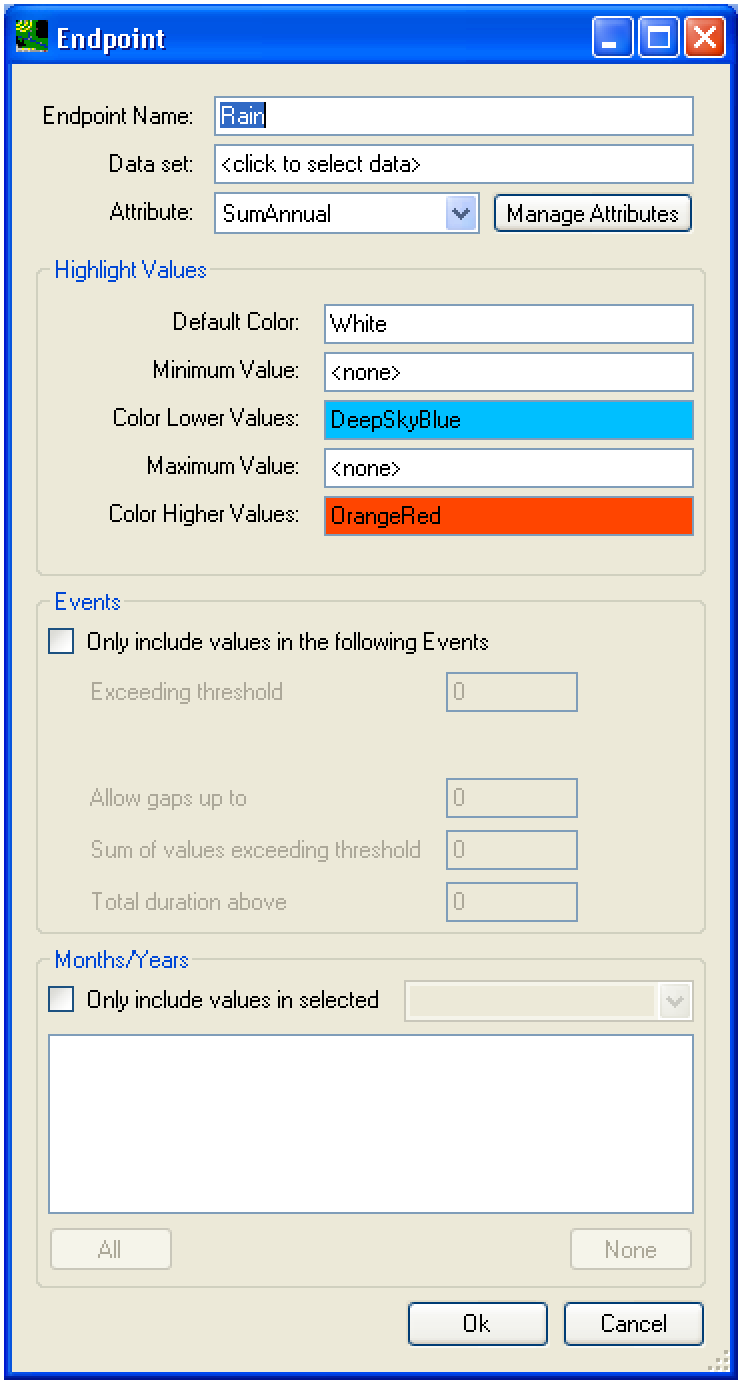
Click **OK** to accept data selection, then the endpoint definition window will look like below:



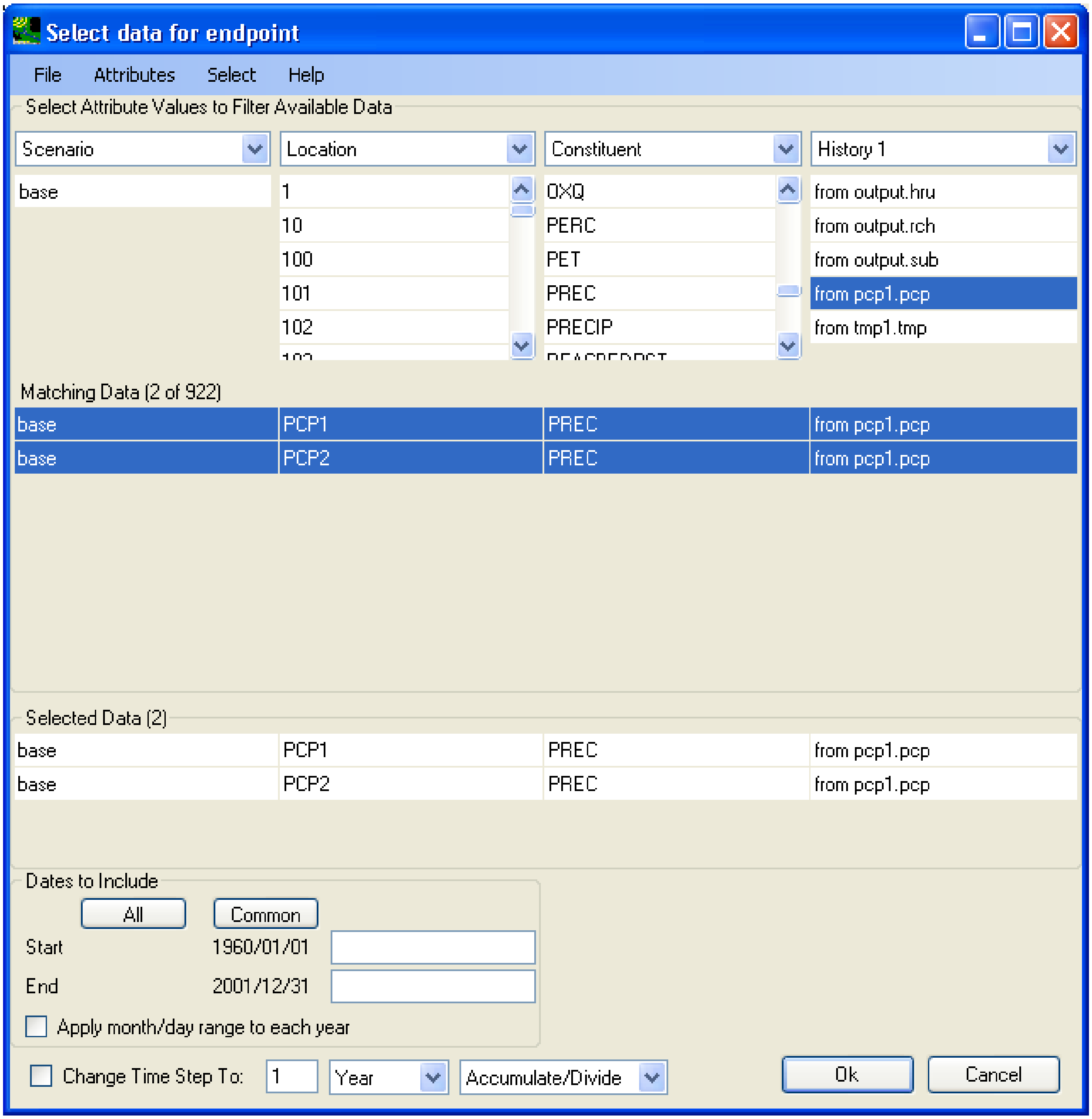
Click **OK** to accept the endpoint definition, then the **Assessment Endpoint** tab will look like below:



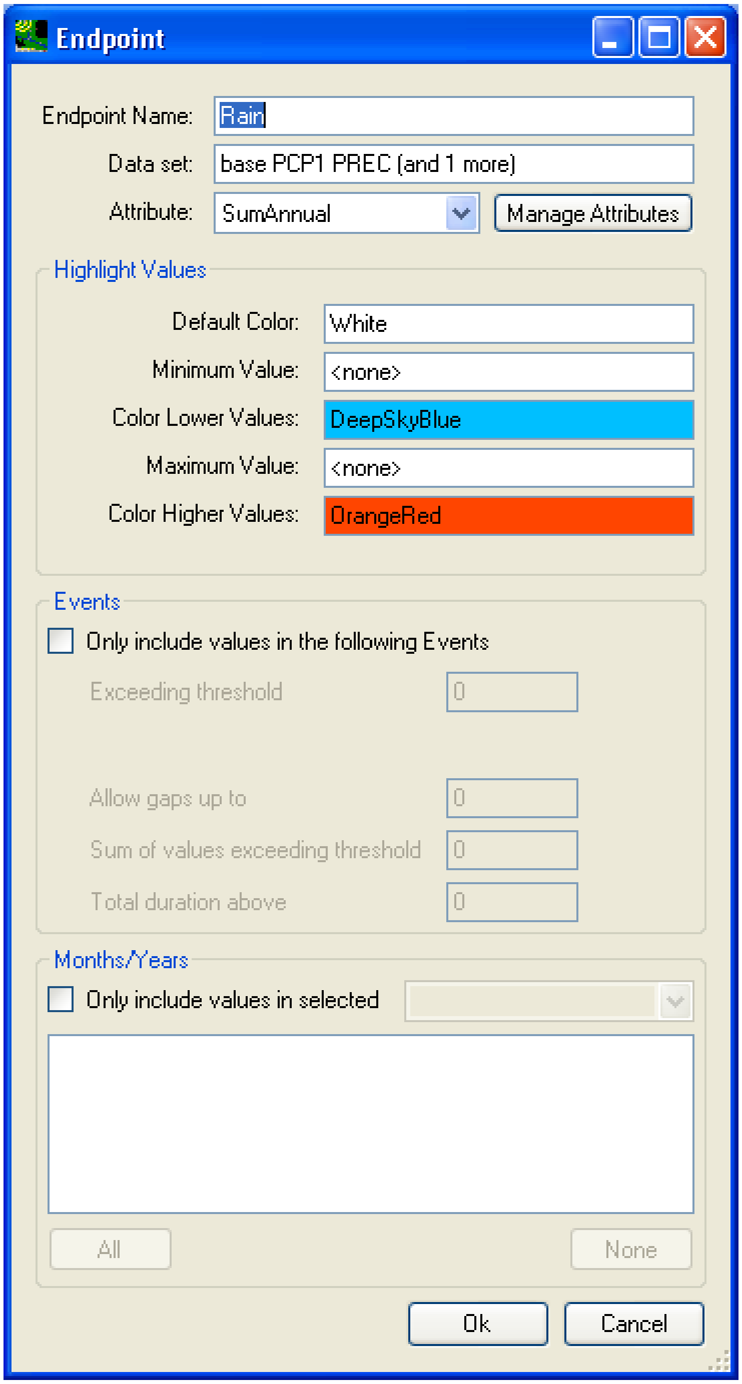
Click **Add** button to add a fourth endpoint. In the endpoint definition window, specify ‘Rain’ as endpoint and use ‘SumAnnual’ as the statistic attribute as shown below:



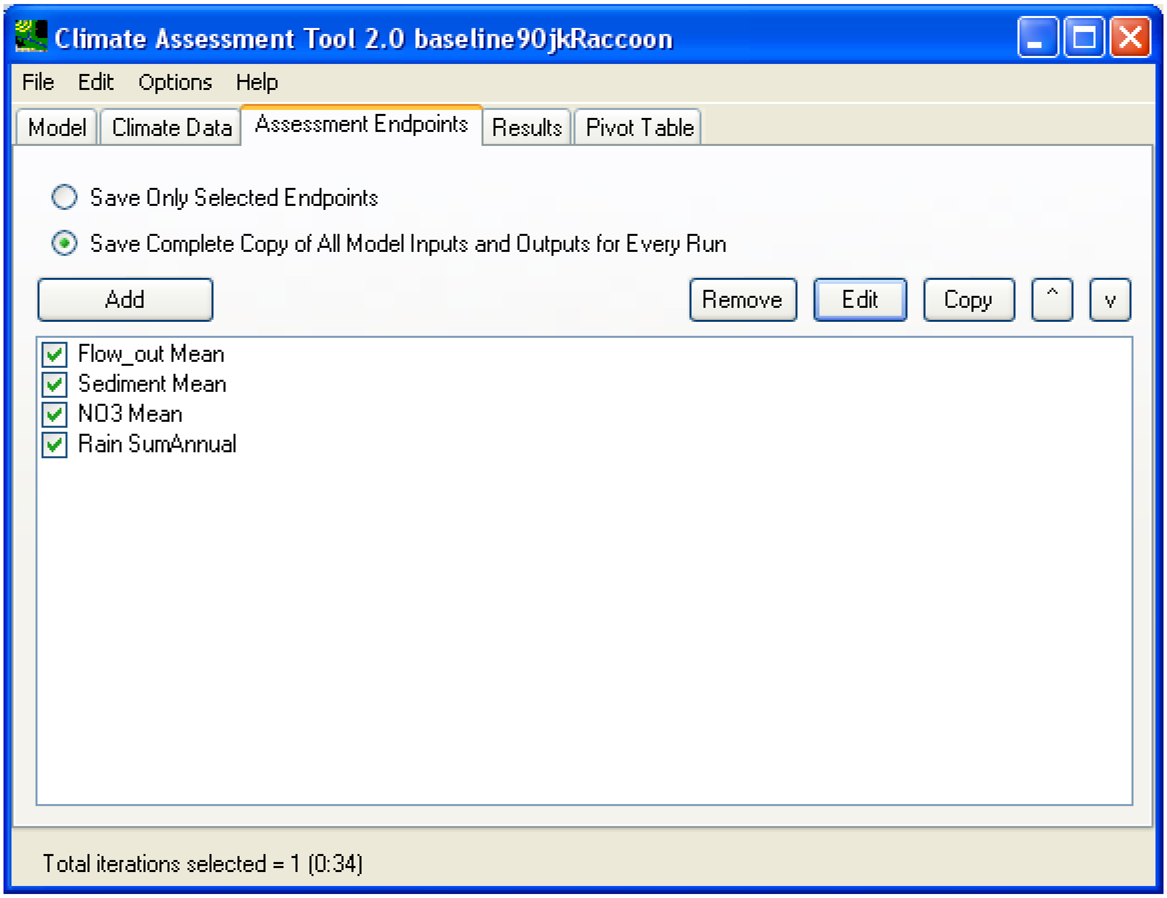
In the above window, click in the **Data set** text box to open the **Select data for endpoint** window to select the rainfall data at both weather stations as shown below:



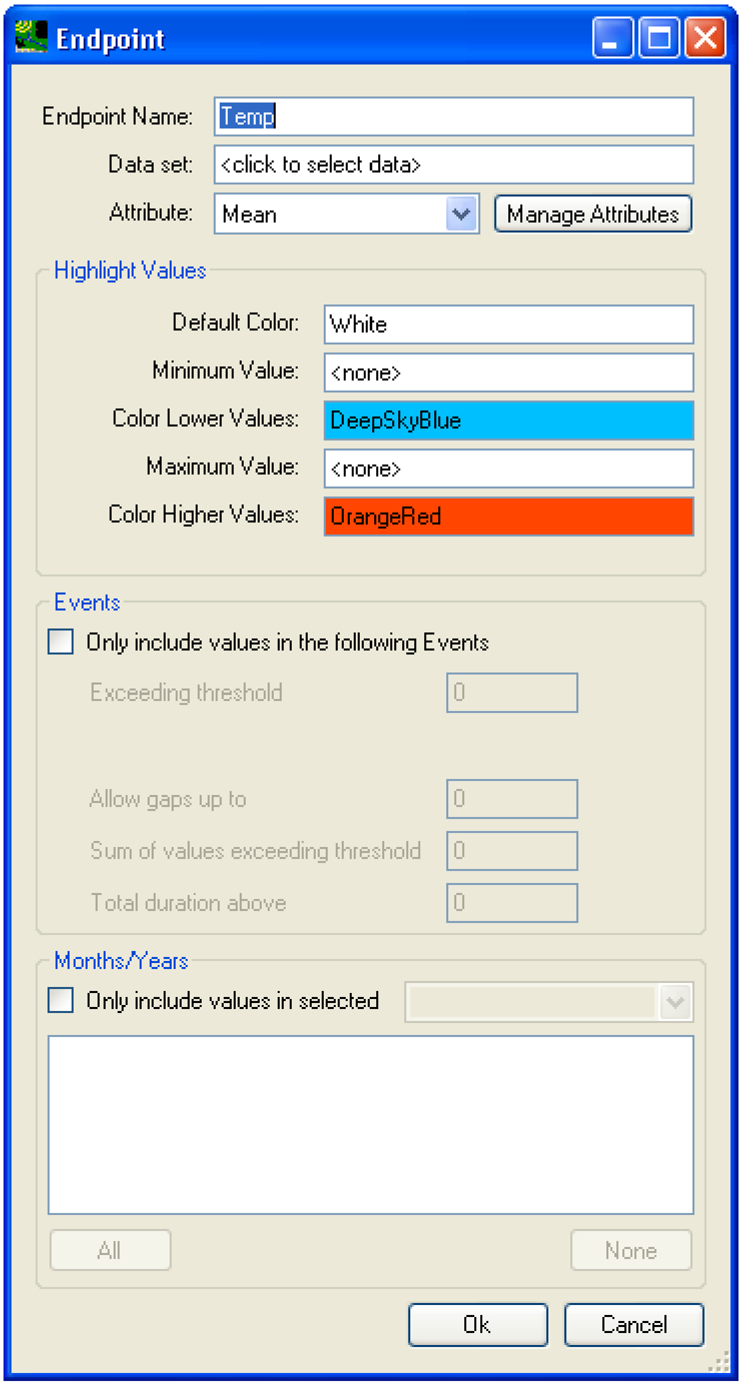
Click **OK** to accept the data selection, then the endpoint definition window will look like below:



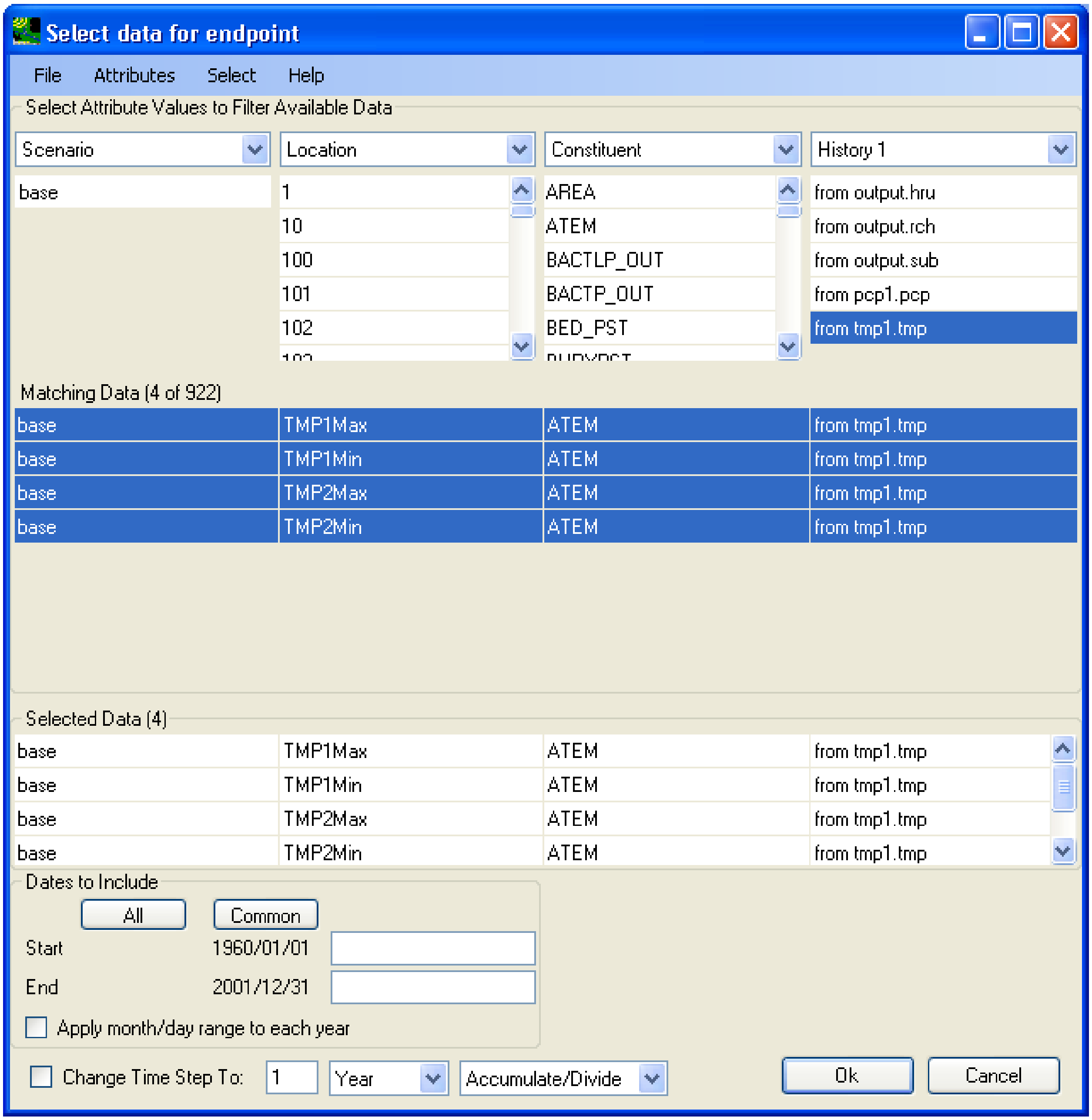
Click **OK** to accept the endpoint definition, then the **Assessment Endpoint** tab will look like below:



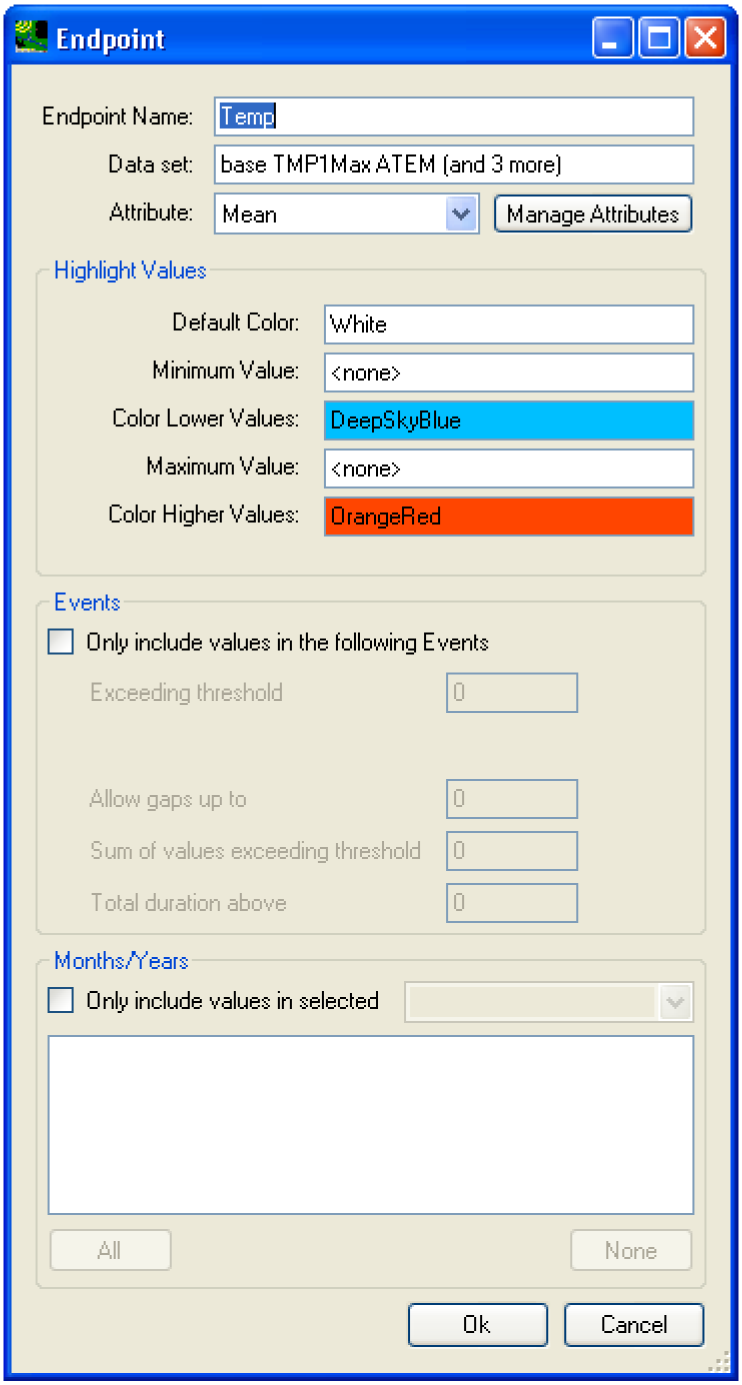
Click **Add** button to add the last endpoint, temperature. In the endpoint definition window, specify 'Temp' as endpoint and use 'Mean' as the statistic attribute as shown below:



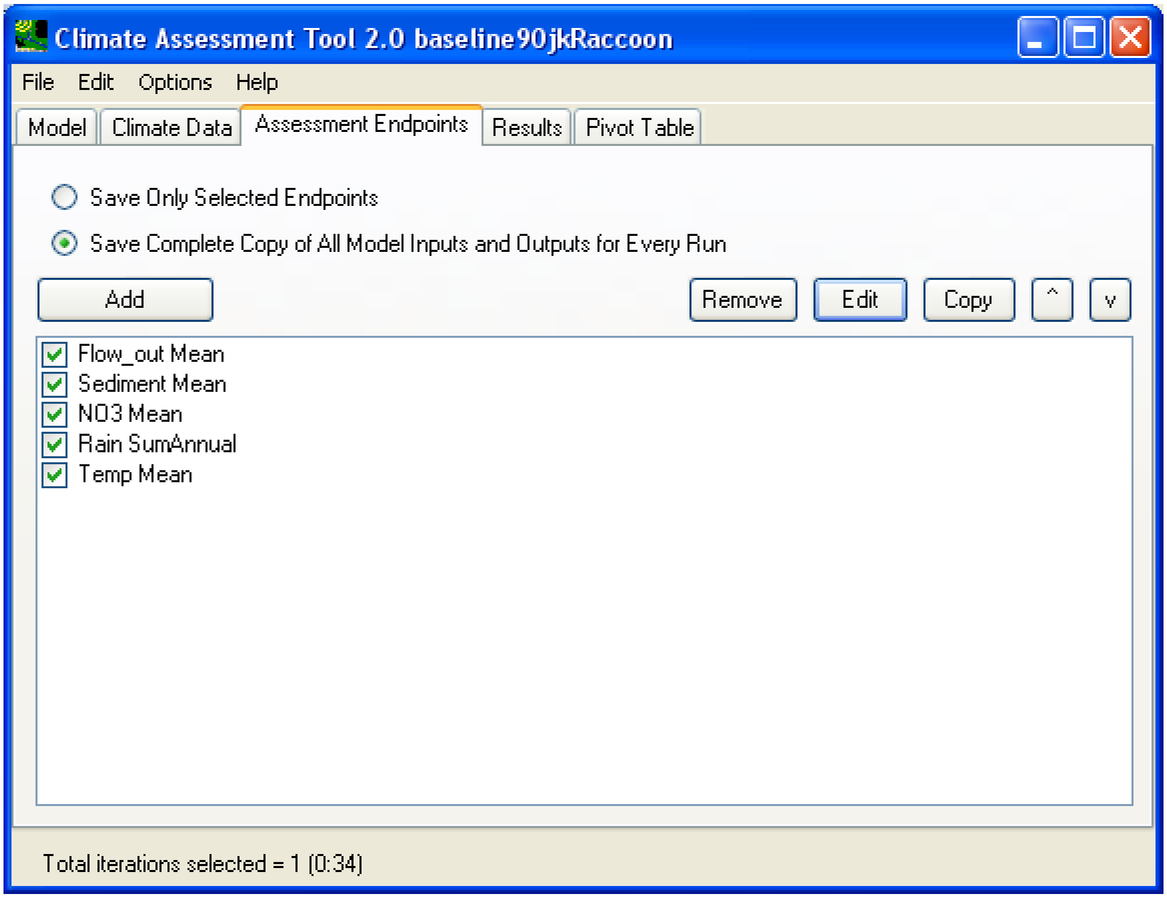
In the above window, click in the **Data set** text box to open the **Select data for endpoint** window to select the air temperature data at both weather stations as shown below:



Click **OK** to accept the data selection, then the endpoint definition window will look like below:



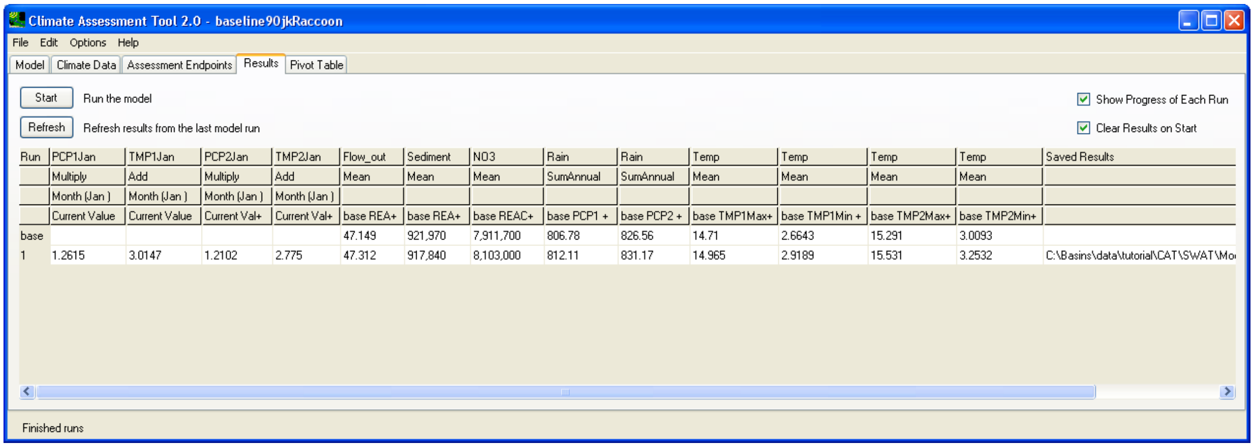
Click **OK** to accept the endpoint definition, then the **Assessment Endpoint** tab will look like below:



Now you have defined both input modification and endpoints to be inspected, you are ready to conduct the analysis by running the SWAT model for the combined climate change scenarios.

Click the **Results** tab and right away, you will see the result grid has already been populated with the endpoints' statistics from the base case scenario, it is in the first row of the result grid. Since this is a brand new CAT analysis, click the **Start** button to initiate the simulations.

Since we defined 4 single climate data modifications and they are applied as a combined change scenario, there will be only 1 SWAT simulation run in total as shown below on the **Results** tab:

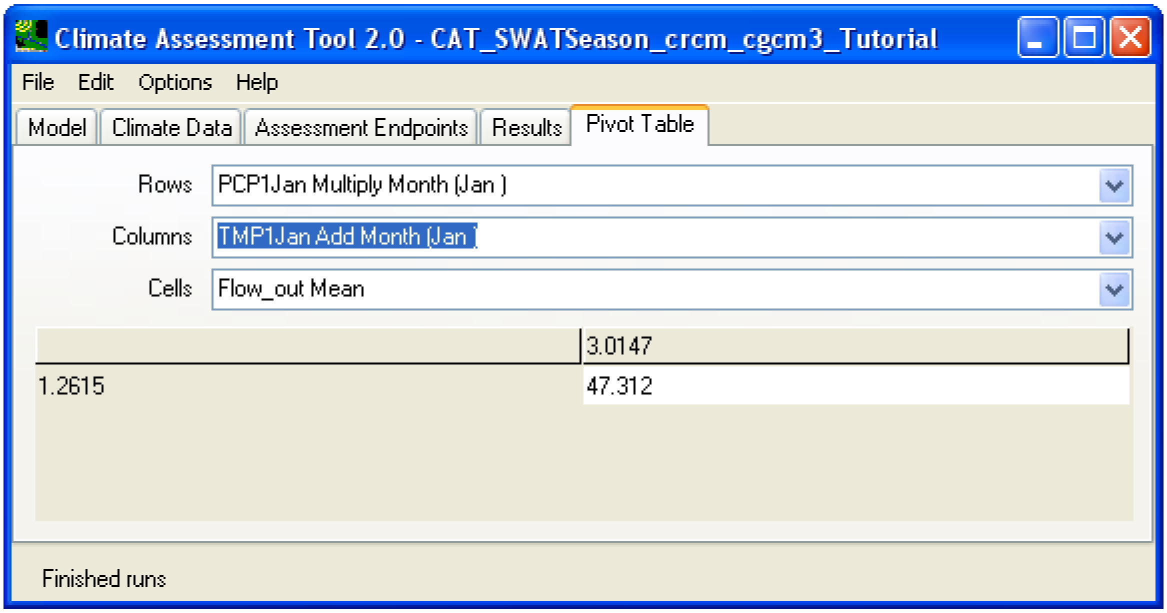


On the above **Results** tab, endpoints are listed on the top as column headers and the scenarios' ordinal number are listed as row numbers.

Now we can save our work. From the 'File' menu on the top of the CAT window, select "Save Model with CAT Settings" option to save all of our input modifications and output endpoint statistic choices into a XML file with a user-specified name. It is recommended to save the XML file in the folder that contains the 'Scenarios' folder.

From the 'File' menu, select "Save Results Table" option to save the result grid into a tab-delimited text file.

We can examine the results in a pivot table on the **Pivot Table** tab as shown below:



Lastly, users can explore additional options offered for CAT during climate data modification and endpoint statistic definition. For example, rainfall data change can be specified to be applied only to certain events or selected months or years in the climate data modification window.

Events are defined in terms of intensity, duration, volumes, and gaps. Changes in rainfall pattern are represented by applying changes to selected calendar years, water years, or months within a year. The combined event- and selective duration-based changes offer tremendous flexibility in representing varying degree of changing climate patterns.

The same event- and duration-based logic also applies to endpoints' statistics, which gives user maximum control over the extraction of endpoints statistics.

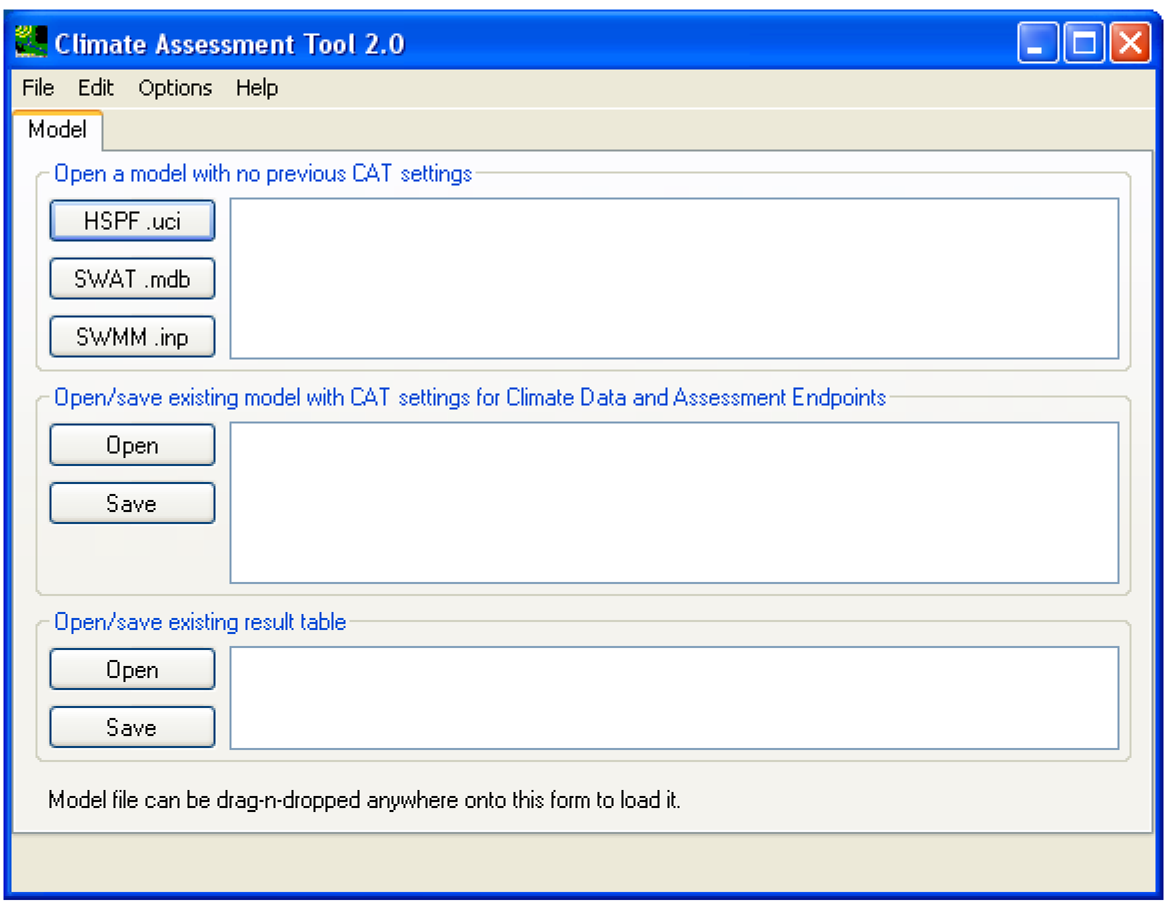
Users are encouraged to define more time specific climate data modifications and run CAT for different combinations of these changes.

In the example above, when user is to define many time-specific modifications, the **Copy** button provide a quick way of making new modification based on an existing one. This concludes this tutorial on climate assessment analysis using BASINS CAT with the SWAT model.

Climate Change Assessment using SWMM

The BASINS **Climate Assessment Tool (CAT)** allows users to easily create climate change scenarios, run hydrologic models to quantify the impact on selected environmental endpoints. Users can refer to the introduction of CAT features and interface options under the general BASINS help section for CAT. In this exercise, we will demonstrate the use of CAT with the **Storm Water Management Model (SWMM)**.

Users can activate the CAT plug-in by clicking the Plug-ins->Analysis->Climate Assessment Tool menu options. To launch CAT, click on the Analysis->Climate Assessment Tool menu option, this will bring up the CAT window as shown below.

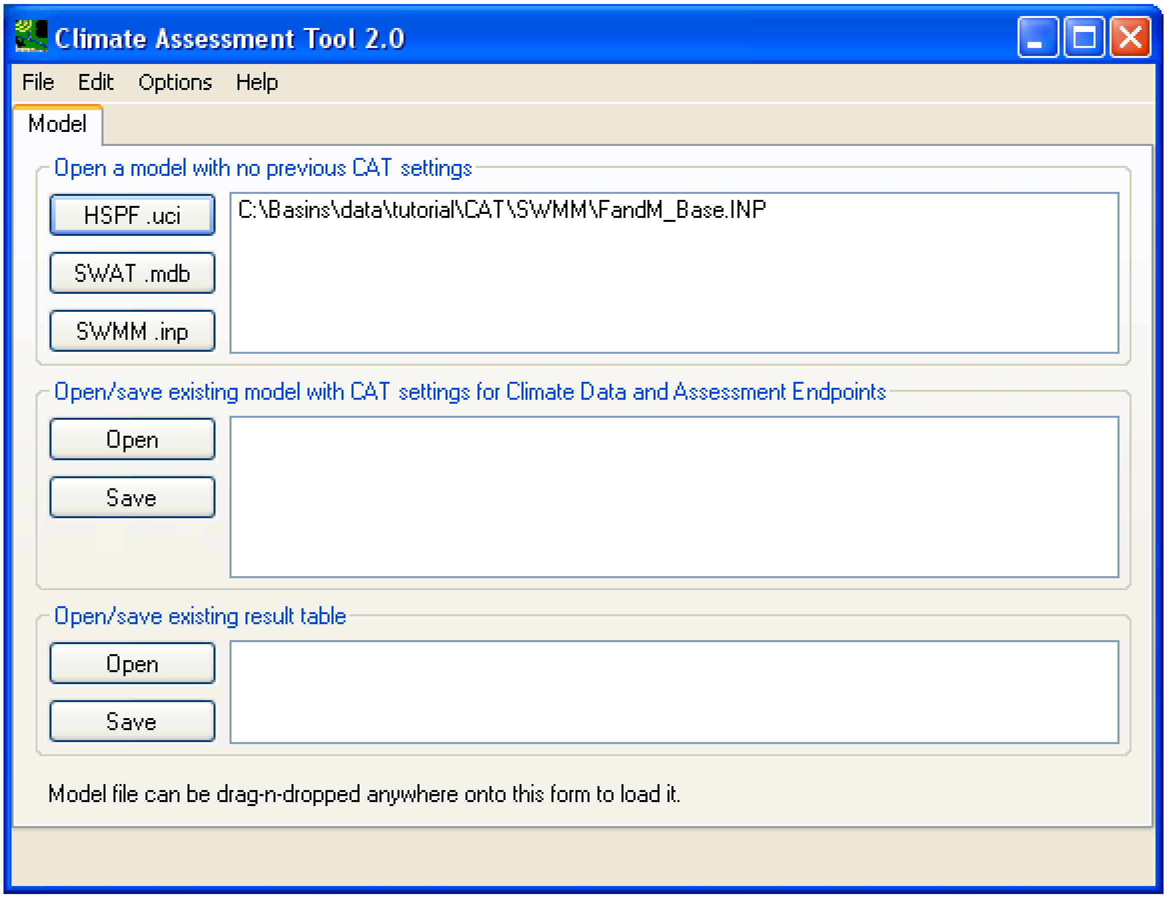


This first tab allows the user to start a brand new analysis, open an existing saved analysis, or simply re-examine the result table from a past analysis. In this exercise, we will create a new SWMM CAT analysis. The prerequisite files for this exercise are listed below and can be found at: \Basins\data\tutorial\CAT\SWMM:

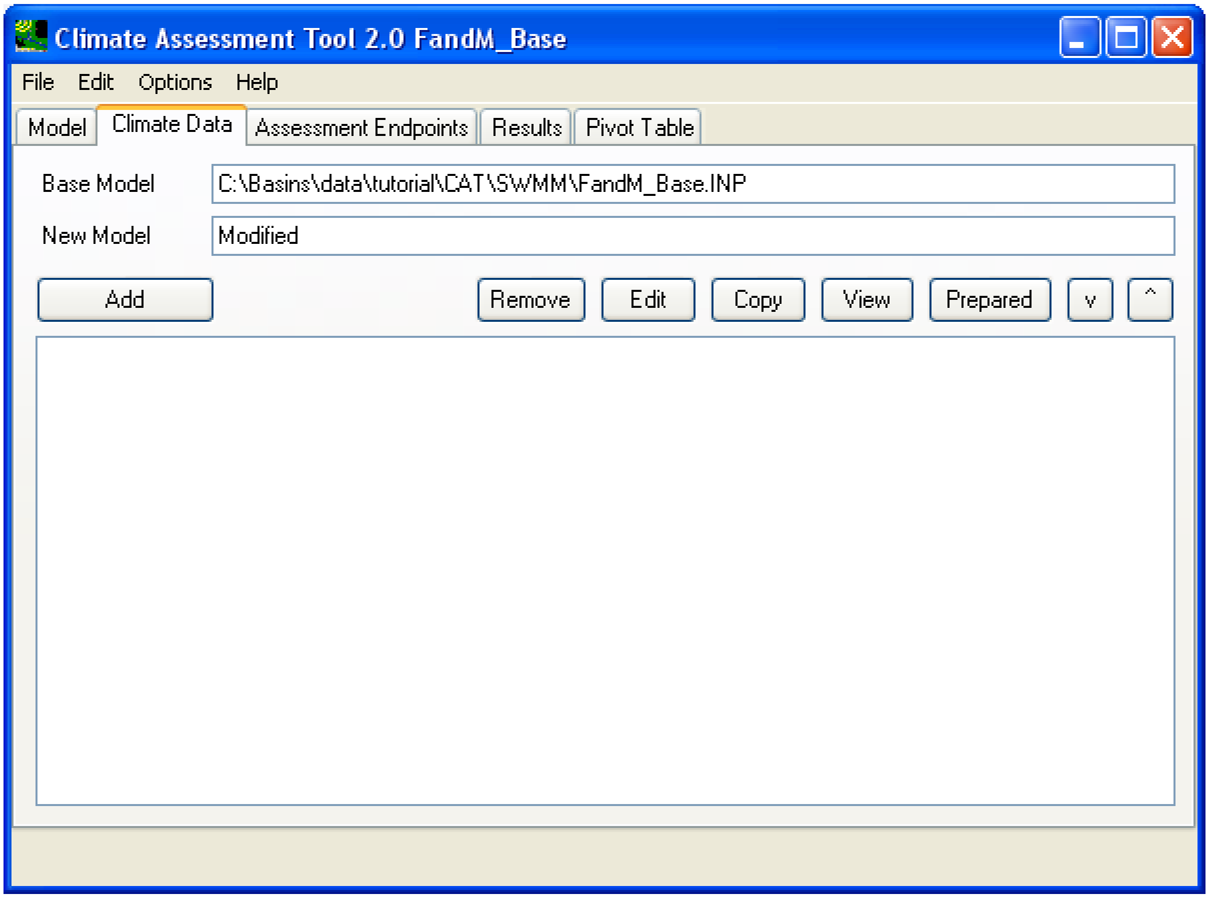
- FandM_Base.INP (base case SWMM input file)
- FandM_Base.out (base case SWMM output file, this means the base case has to be run first)
- VA440766P.DAT (base case rainfall data, inch)
- VA440766T.DAT (base case temperature data, Fahrenheit)
- VA440766E.DAT (base case evaporation data, inch)

In this exercise, the weather data are hourly data from January 1, 2006 to December 31, 2006.

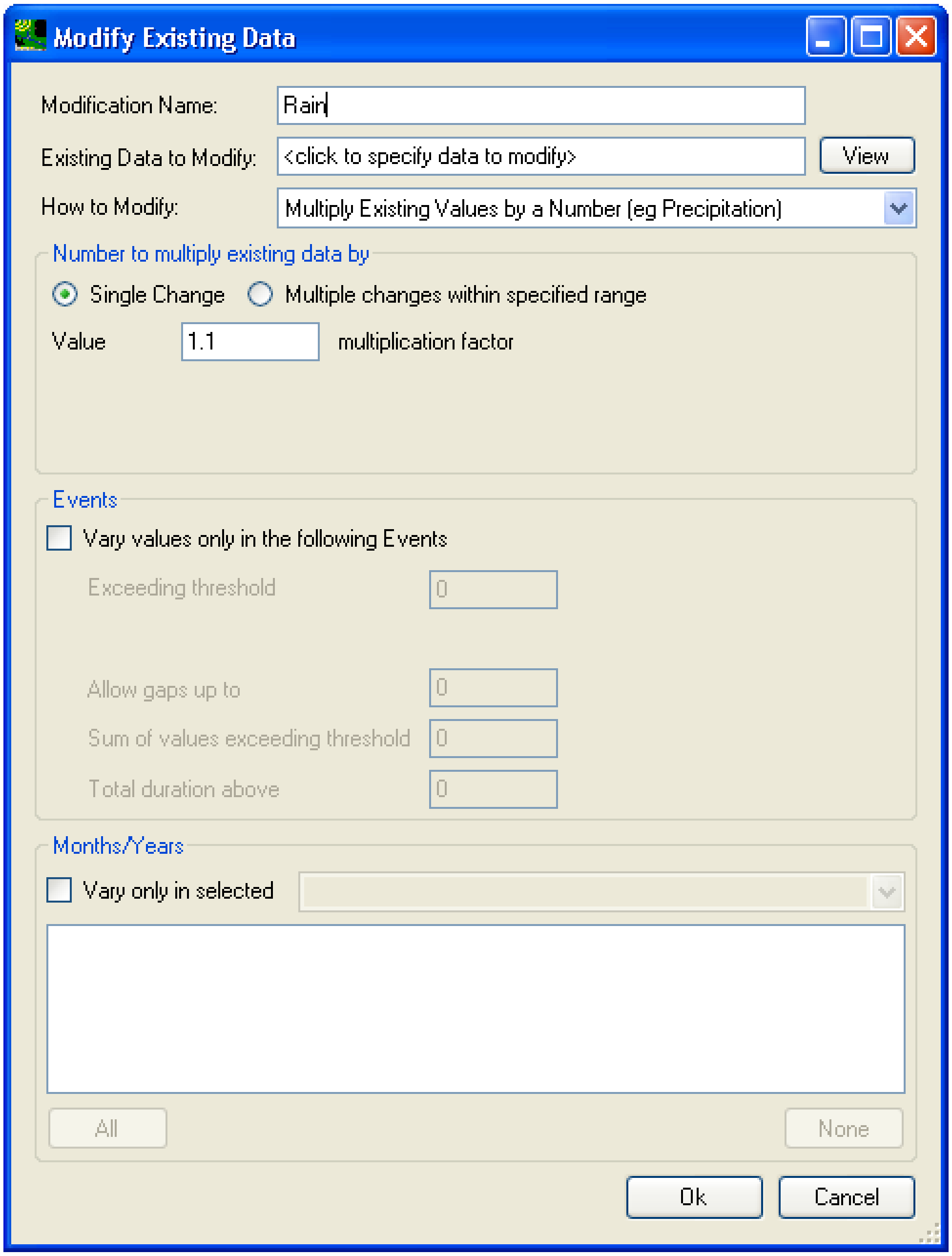
From the CAT **Model** Tab, click button **SWMM.inp**. This will open the file dialog window to locate the FandM_Base.INP input file for the base case scenario. Once this is done, the full directory path to this input file will be displayed as the first entry in the text box next to the **SWMM.inp** button as shown below.



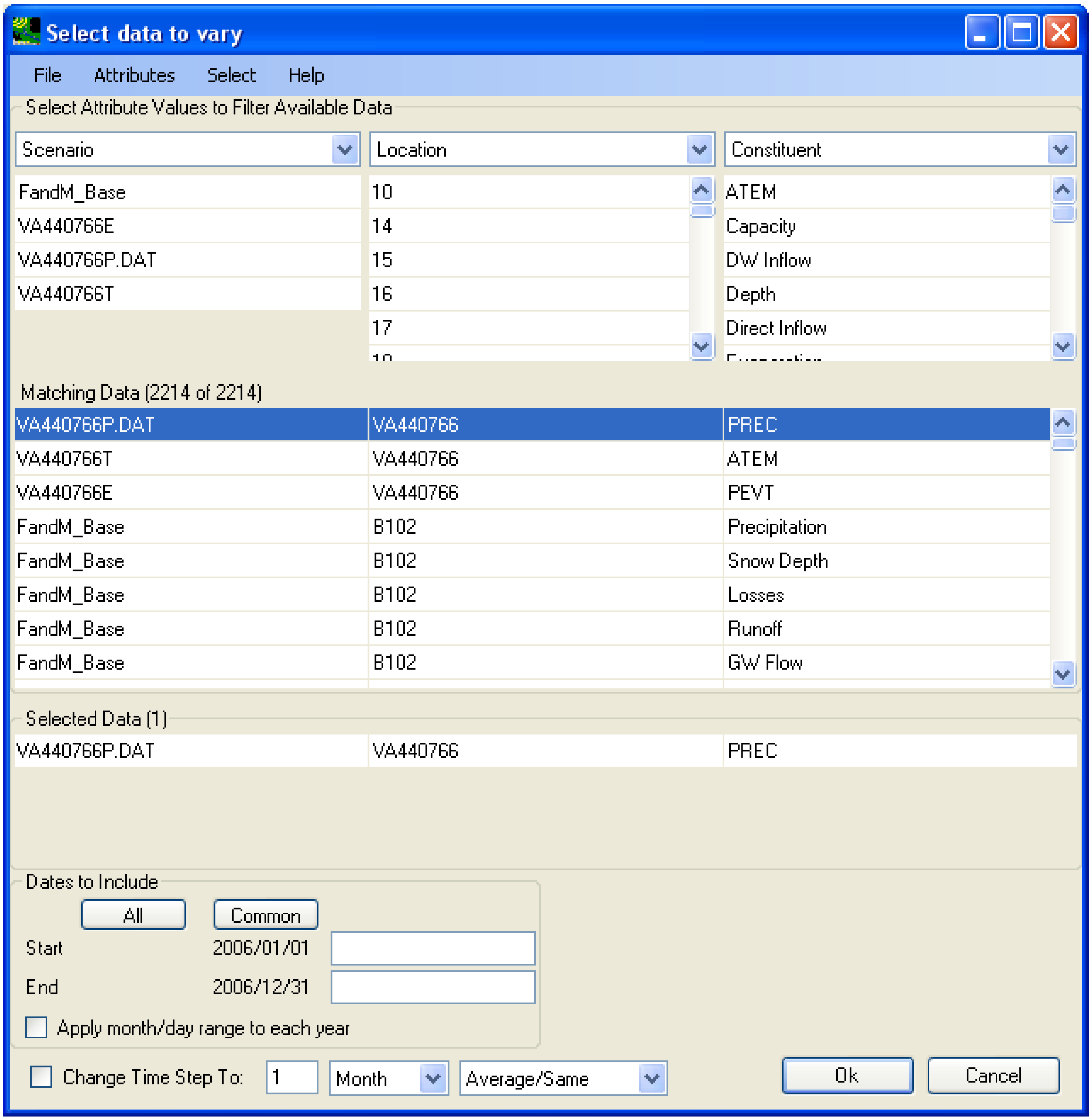
A single click on the full path of the base input file in the text box will allow CAT to open it and retrieve related output and input data and make them available for user selection in subsequent steps. Once CAT successfully open the base input file, it will automatically advance to the **Climate Data** tab as shown below.



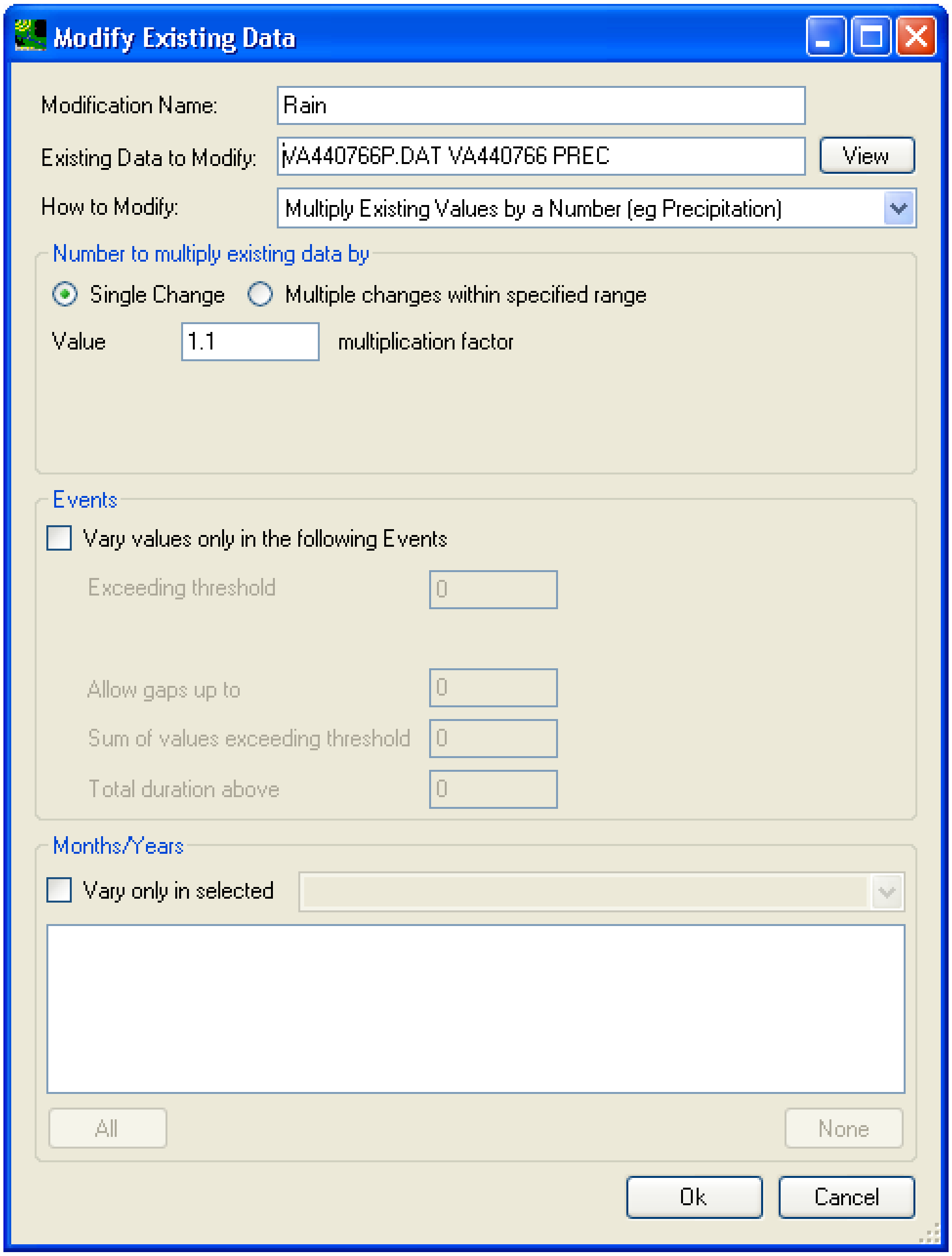
In this exercise, we will conduct modifications on rainfall and temperature data. The evaporation data will also be modified using the Hamon's method that uses temperature as the sole input. To initiate each modification, click the **Add** button to open the **Modify Existing Data** window. Begin defining this adjustment a name by entering 'Rain' in the **Modification Name** field as shown below:



Then, select the rainfall data for adjustment. A single click in the 'Existing Data to Modify:' text field will open the **Select data to vary** window. Proceed to choose the rainfall data timeseries as shown below:



Click **OK** to accept the selection, then the data modification window will look like below:

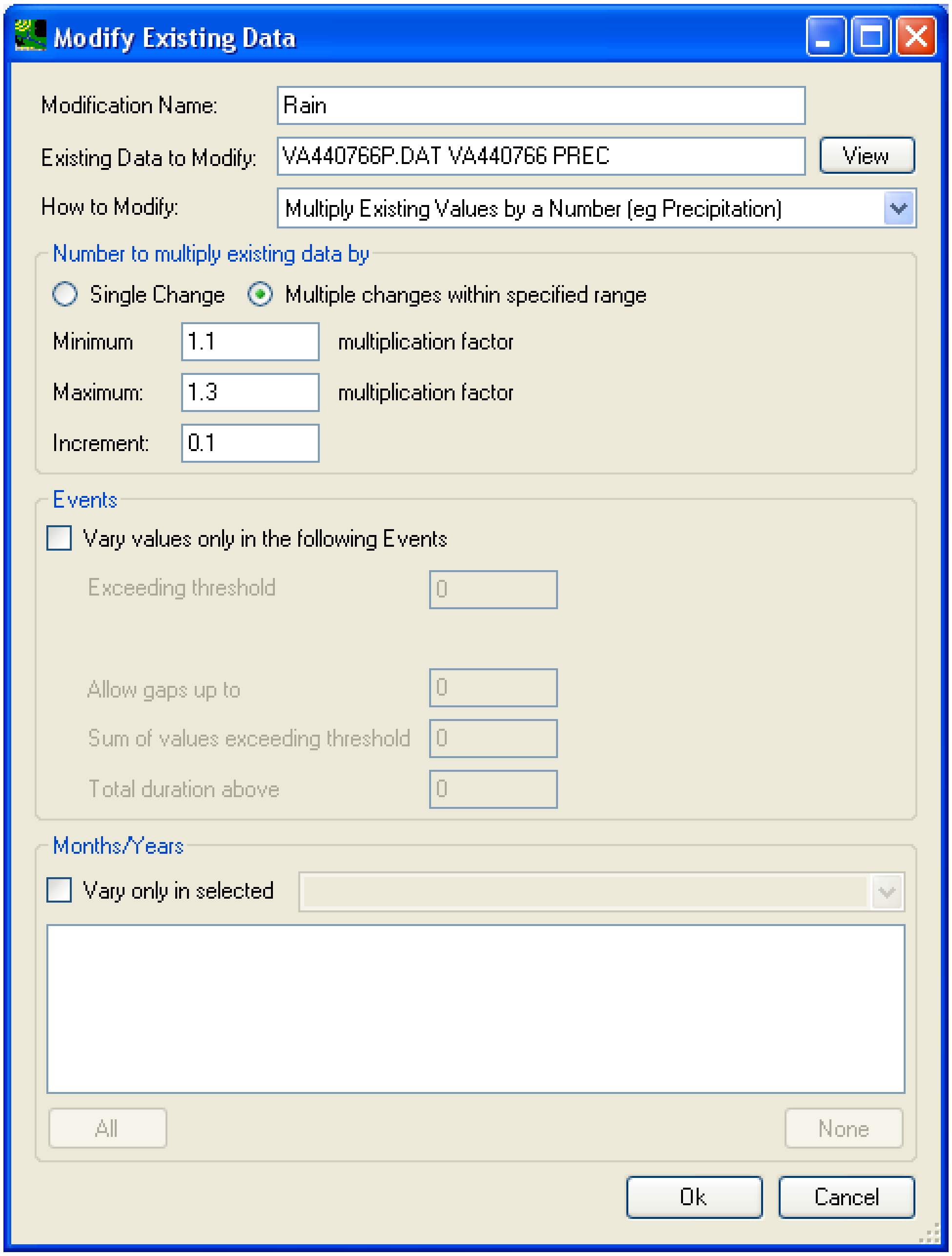


Next, we will specify the exact changes that will be made to the selected rainfall time series. From the 'How to Modify' dropdown box, one can pick different methods for timeseries adjustments. For precipitation, the three most common choices are:

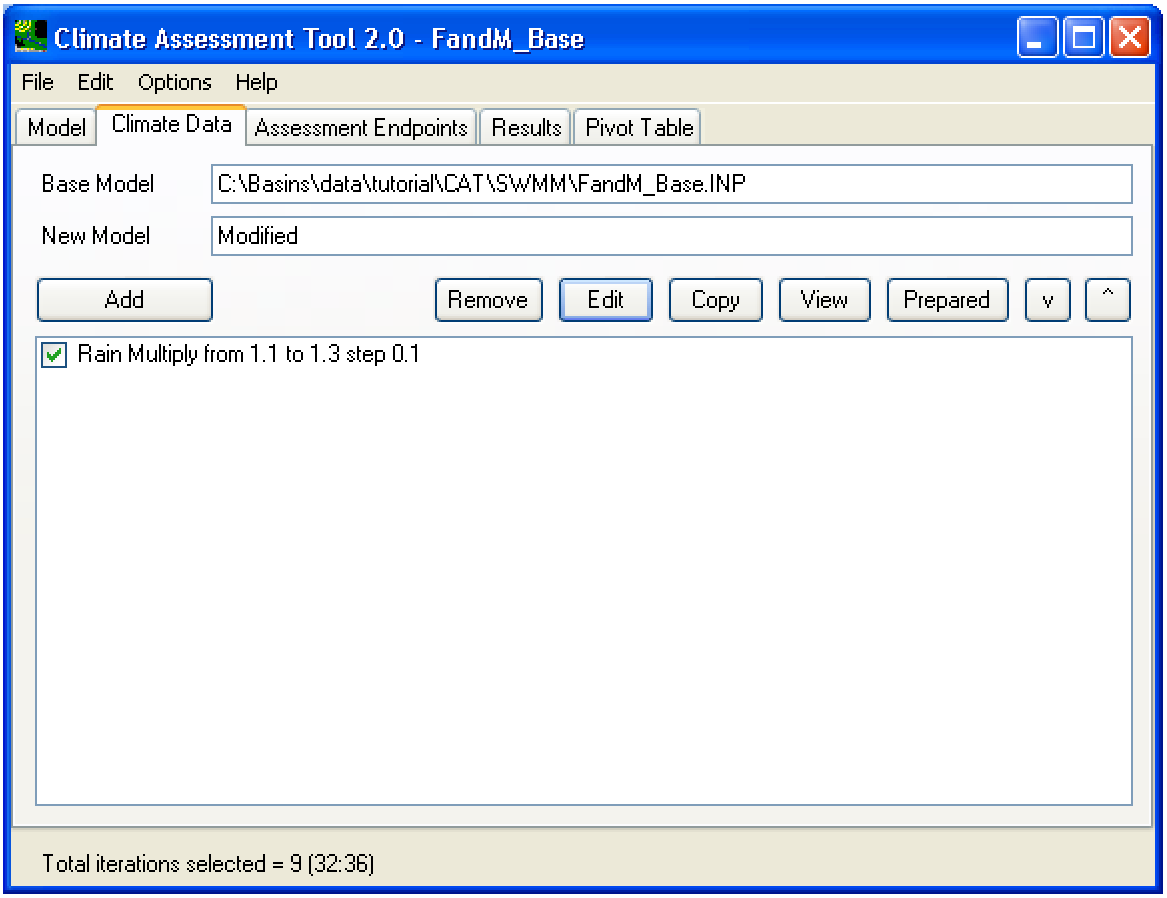
- Multiply Existing Values by a Number (eg Precipitation): This method is used to apply blanket adjustment by simply multiplying every value in the target timeseries with a constant (e.g. 1.2).
- Multiply large/small events by a number: This method is used to apply selective adjustment to rainfall events above or below certain thresholds. Users should specify adjustments as a percentage (eg. 20 %). This method is used to intensify certain rainfall events. The **Events** frame is used in conjunction with this option to qualify what qualifies as an event.
- Add/Remove Storm Events: This method is used to apply adjustment to total rainfall volume of the target timeseries. User should specify adjustment as percentage (eg. 20 %). The **Events** frame is used in conjunction with this option to qualify what qualifies as an event.
-

For all three methods above, user can choose to apply either a single adjustment or a range of adjustments at a constant step size. This is done by the selection of either 'Single Change' or 'Multiple changes within specified range' radio buttons.

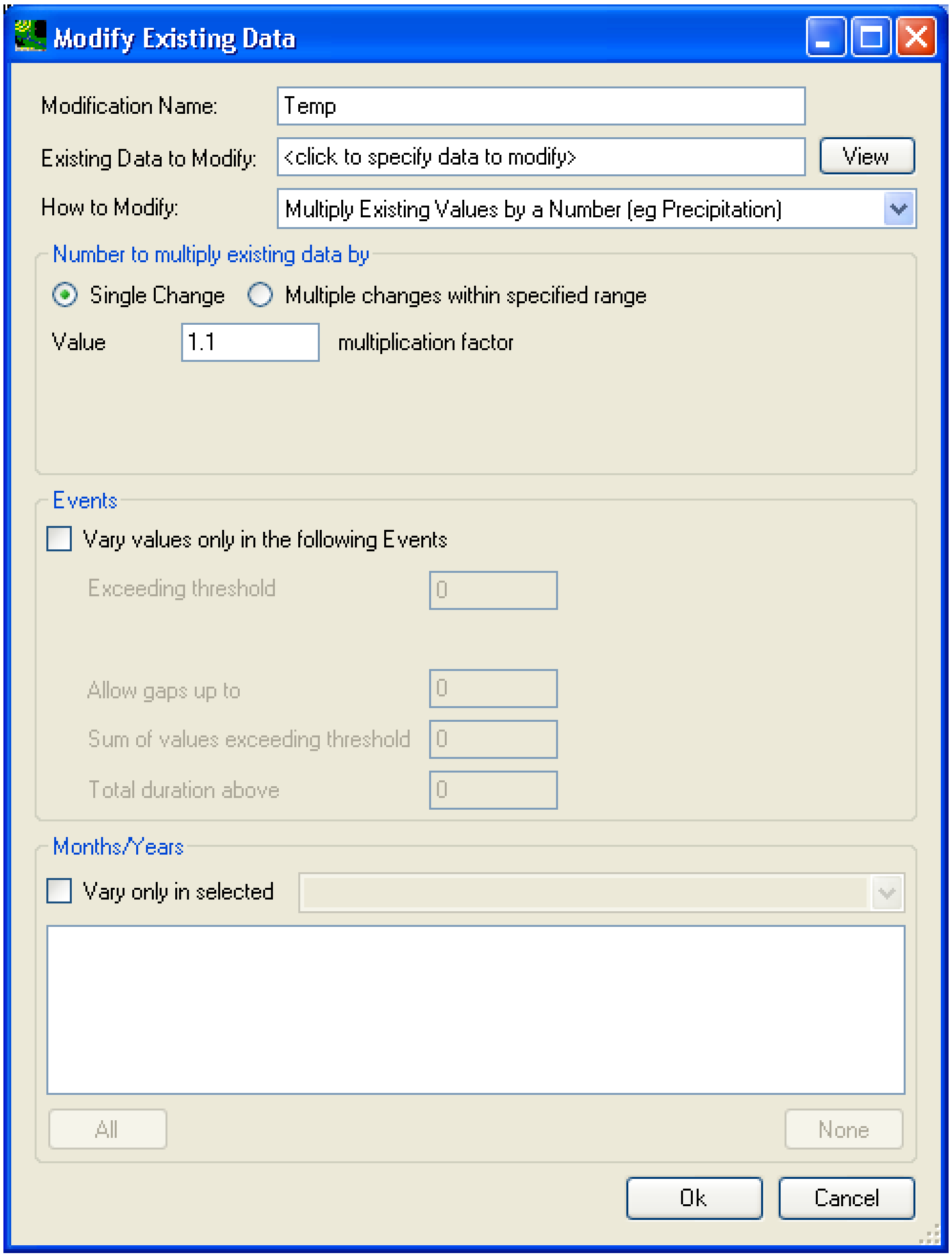
In this exercise, we will choose the 'Multiply Existing Values by a Number' adjustment method. We will choose to apply multiple adjustments by selecting the 'Multiple changes within a specified range' radio button and specify to increase the hourly rainfall input by 10%, 20%, and 30% as shown below:



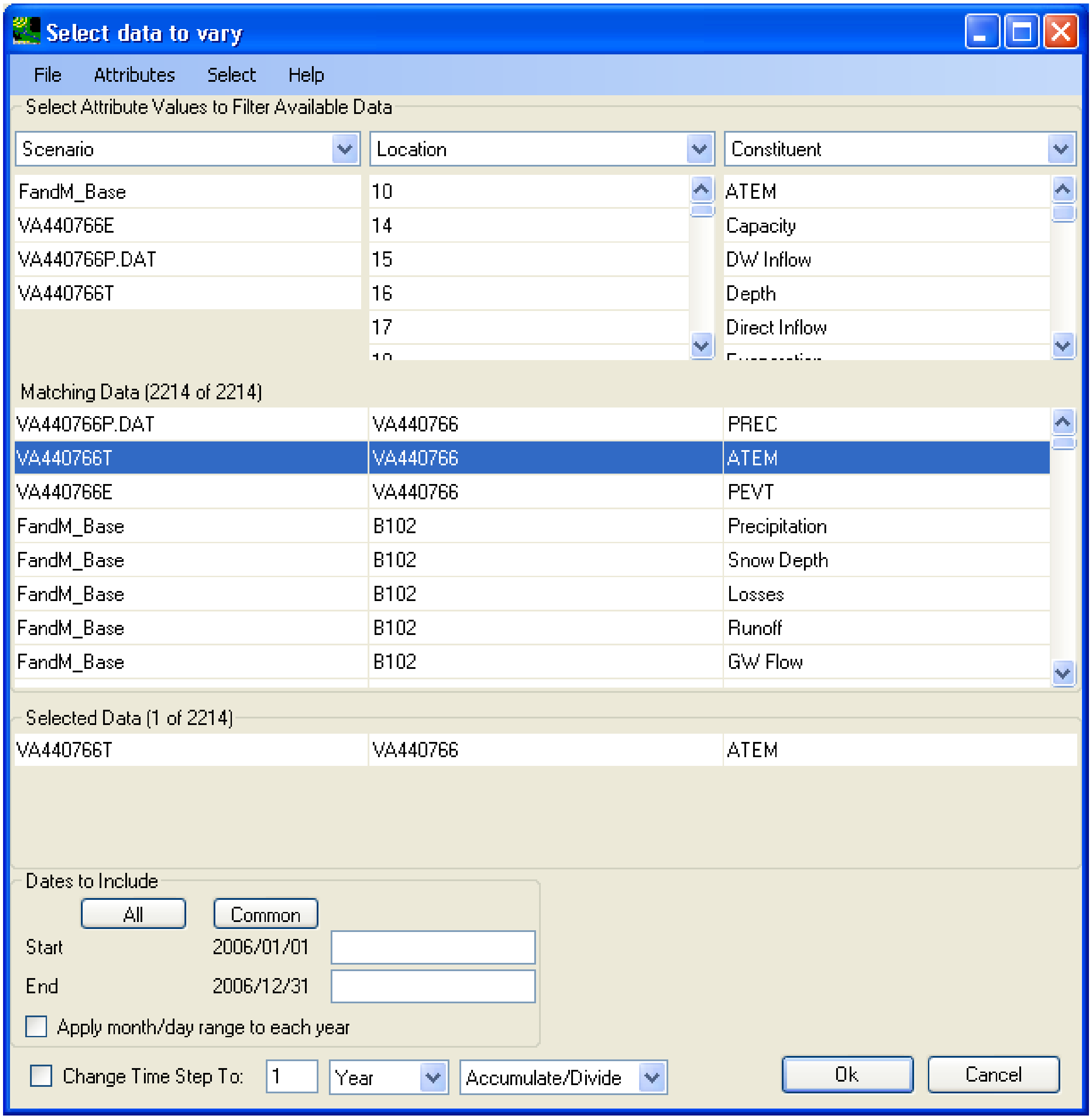
Click **OK** to accept the adjustment. Then the '**Climate Data**' tab will look like below:



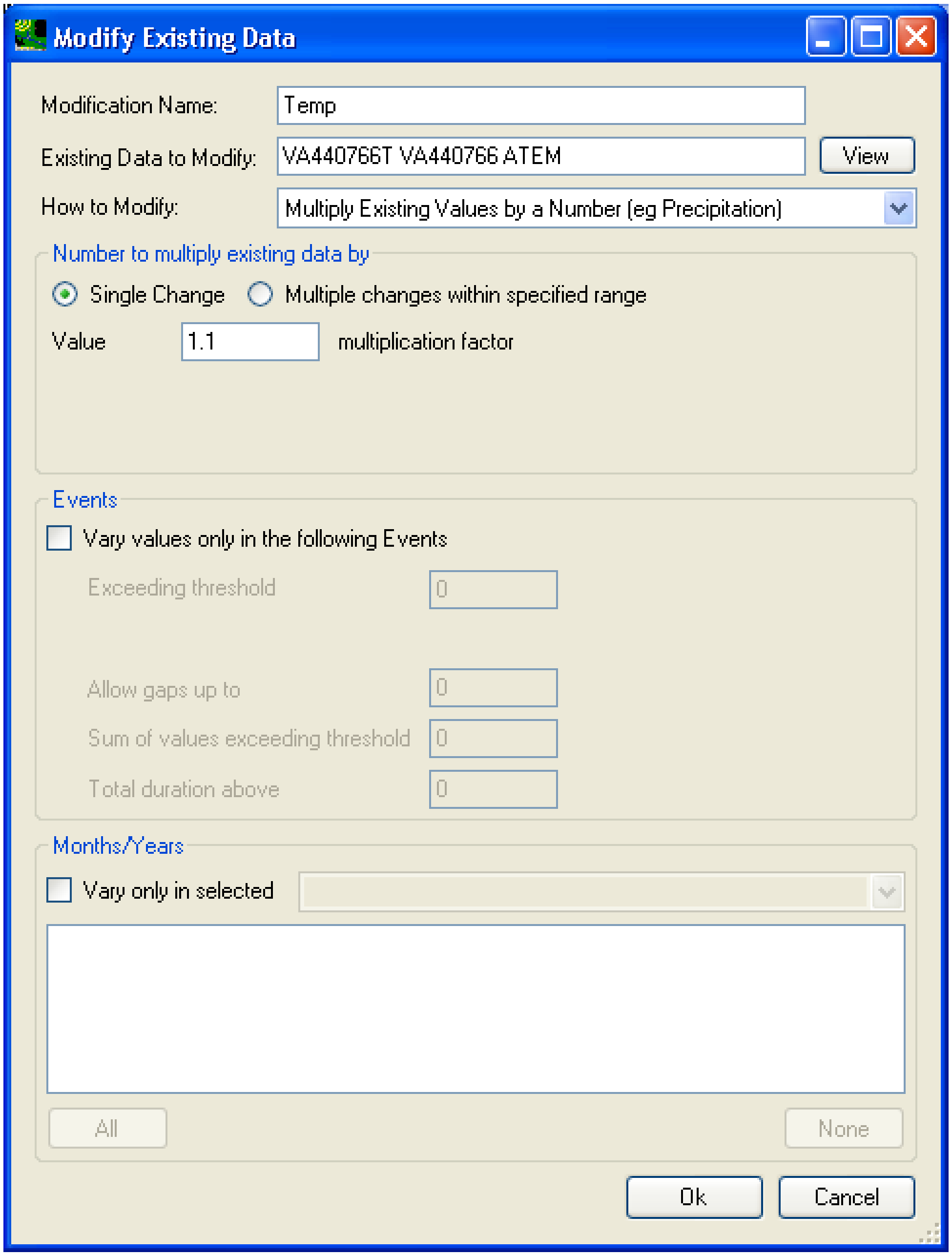
The next adjustment is to increase the daily temperature by 1.8, 3.6, and 5.4 degree F. The steps are the same as the rainfall data adjustment you just finished. Click on the **Add** button to bring up the climate data modification window. Then, provide a name for this adjustment (Temp), as shown below:



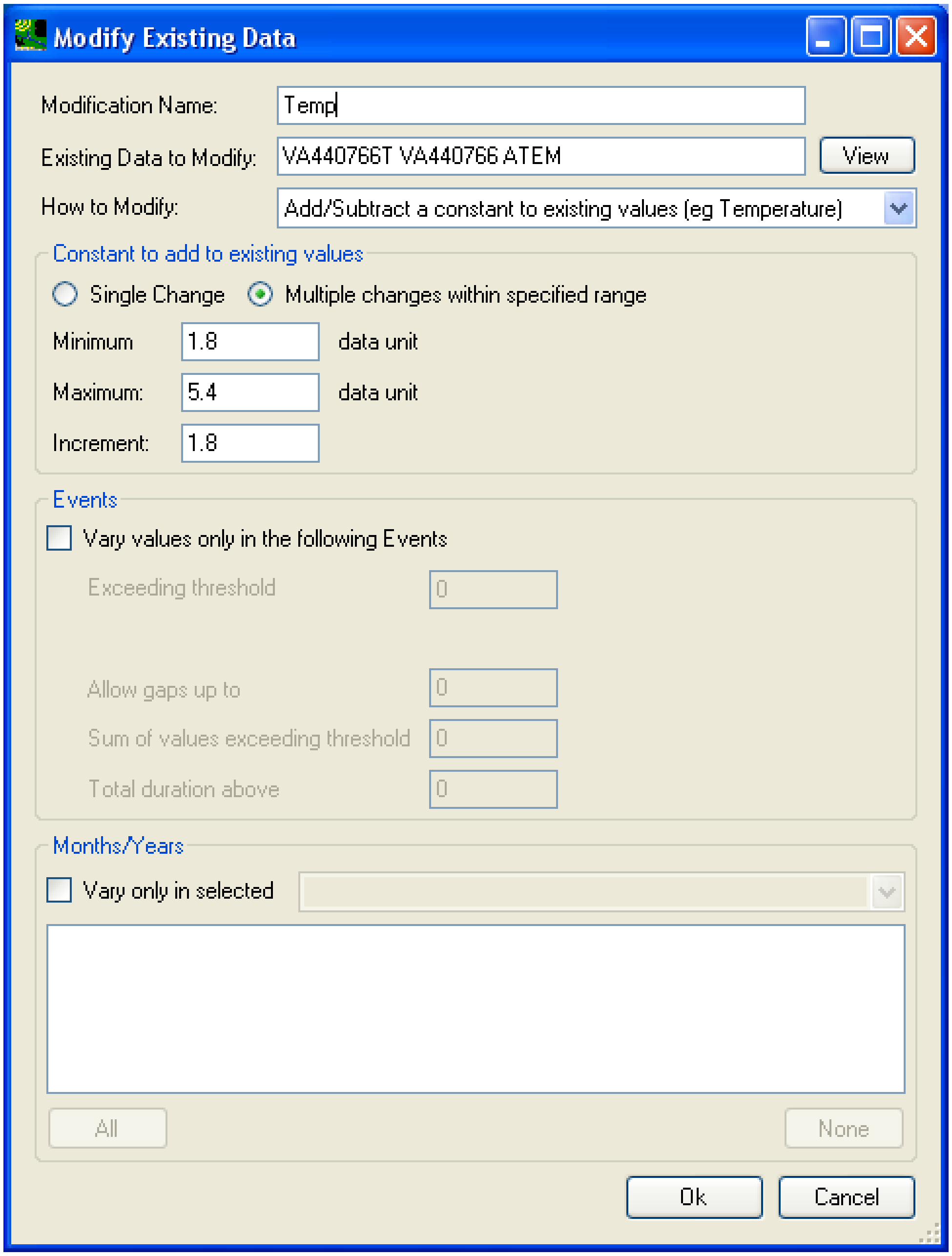
Similar to precipitation data selection, a single click in the 'Existing Data to Modify:' text field will open the **Select data to vary** window. Proceed to choose the temperature data by selecting both daily min and max timeseries from weather station 1 as shown below:



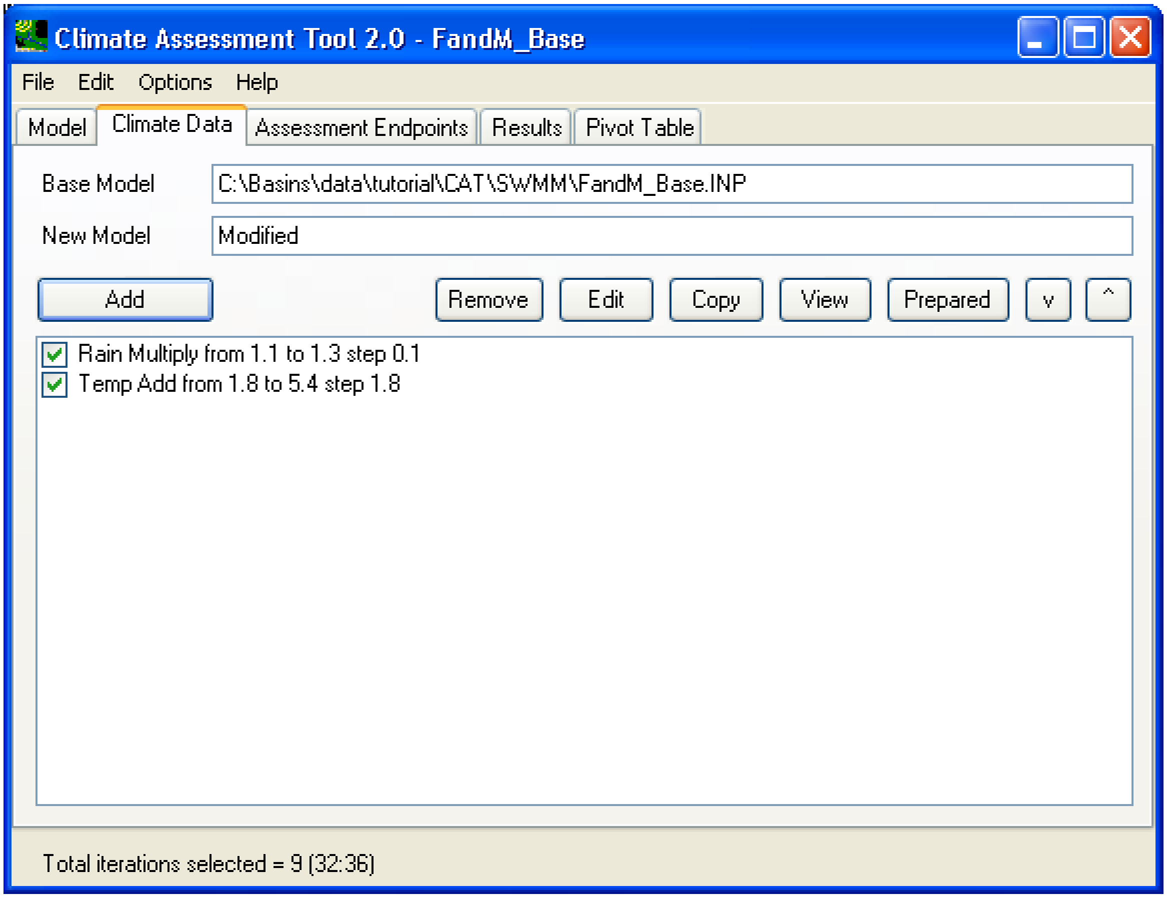
Then, the **Modify Existing Data** window will look like below:



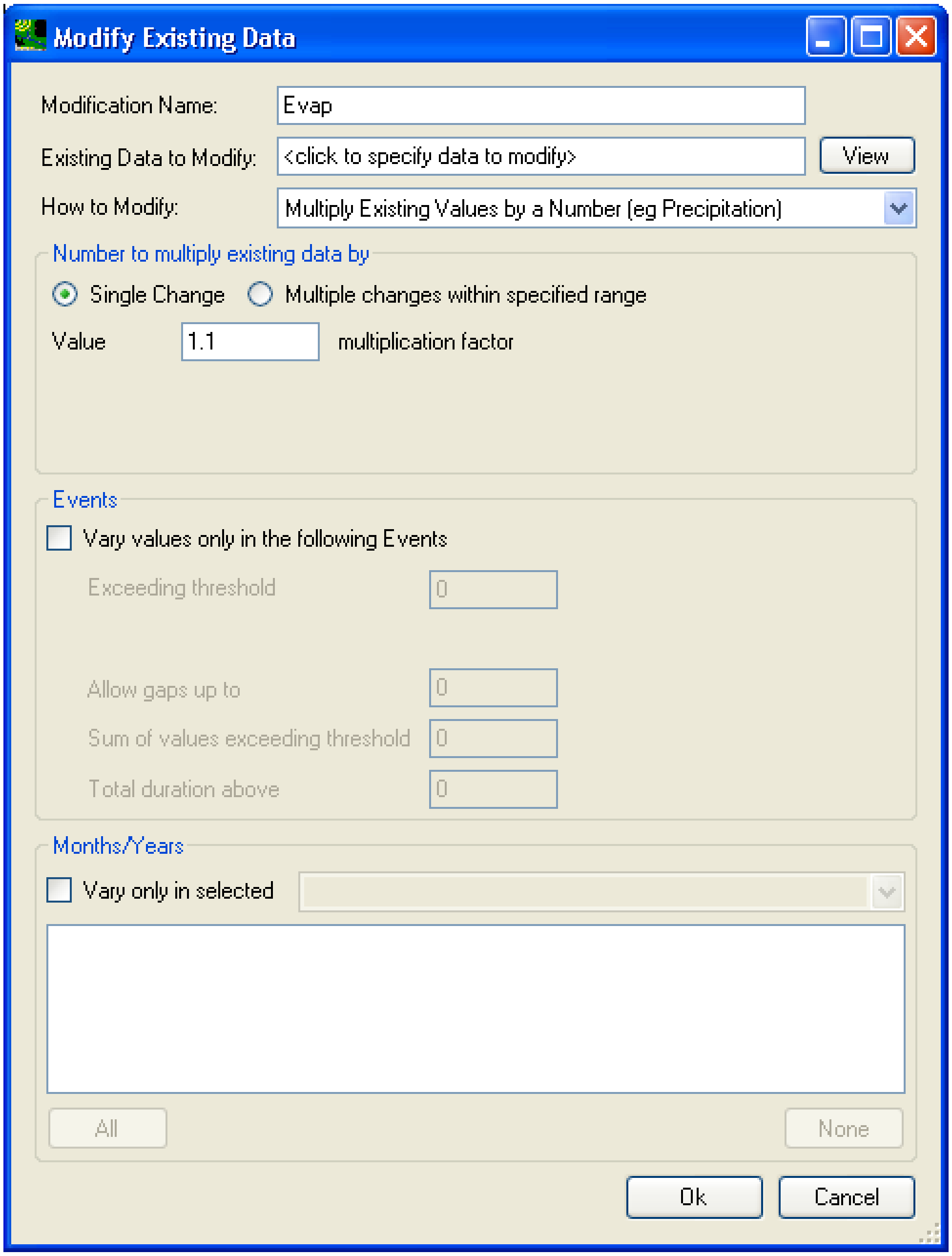
Then, from the 'How to modify' dropdown list, choose 'Add/Subtract a constant to existing values' adjustment method. Then, specify multiple changes within a range as shown below:



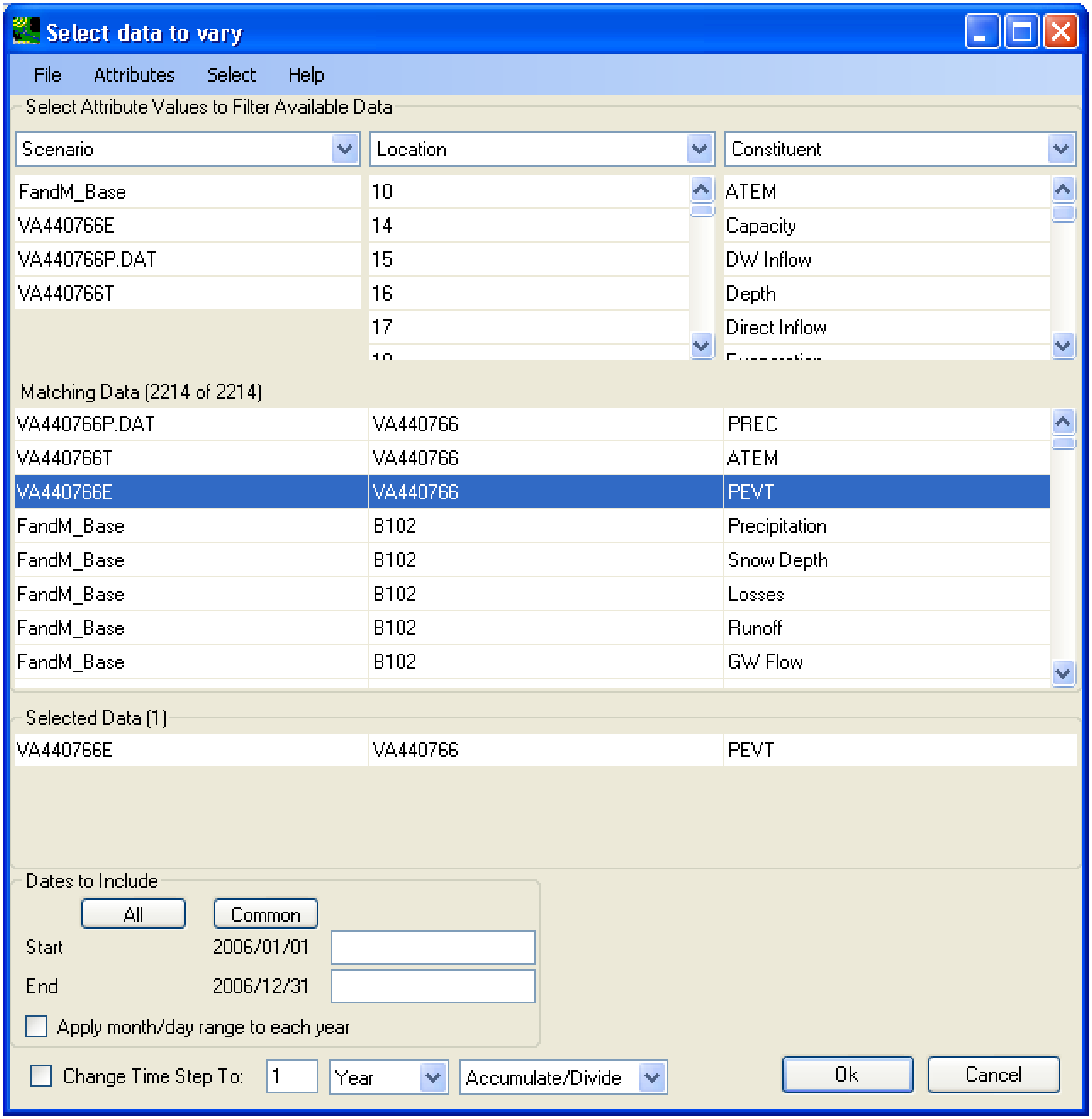
Click **OK** to accept the adjustment. Then, the '**Climate Data** ' tab will look like below:



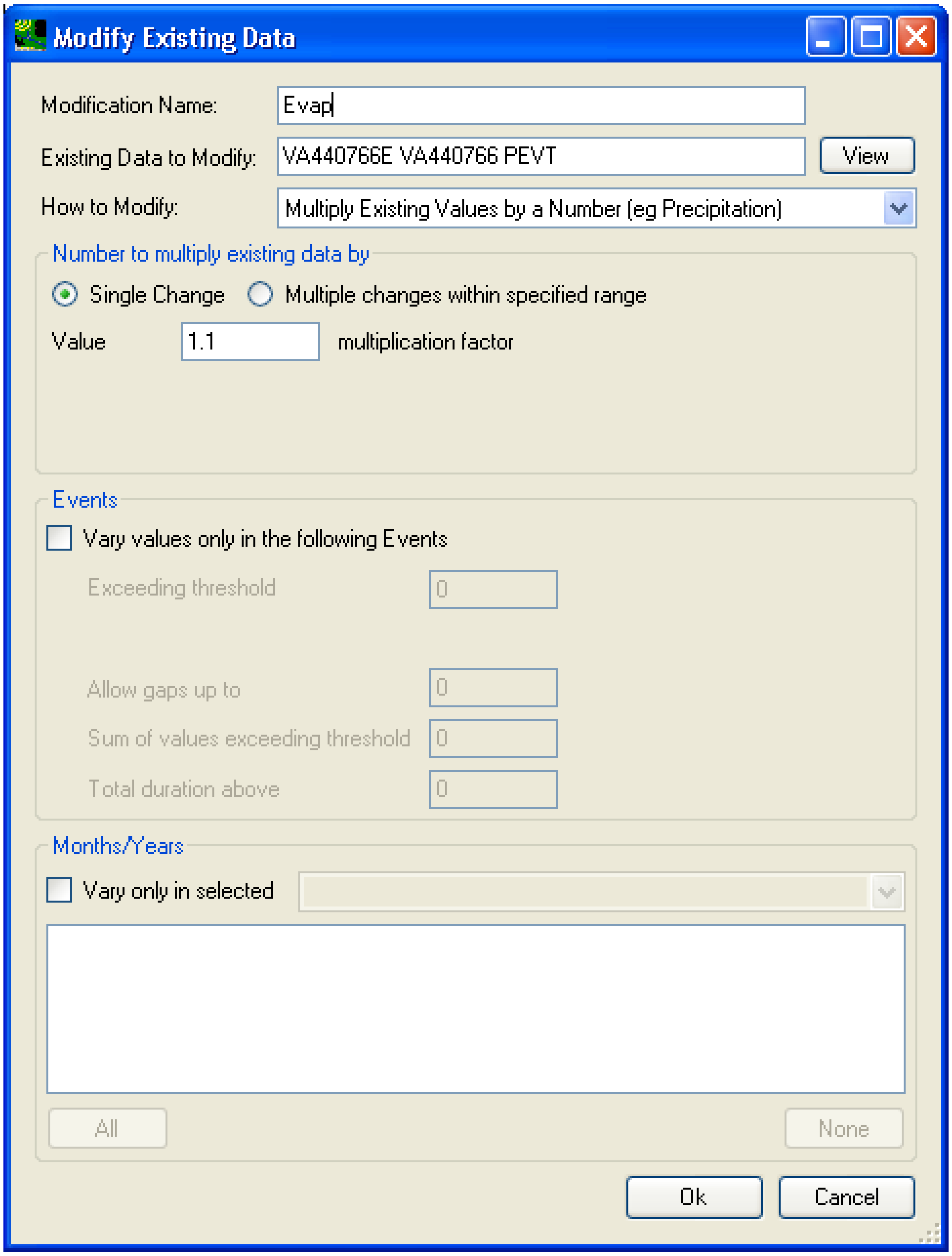
Lastly, specify to re-calculate evaporation using the Hamon's method. Click the **Add** button to bring up a new data modification window and specify the name for the adjustment to be "Evap" as shown below:



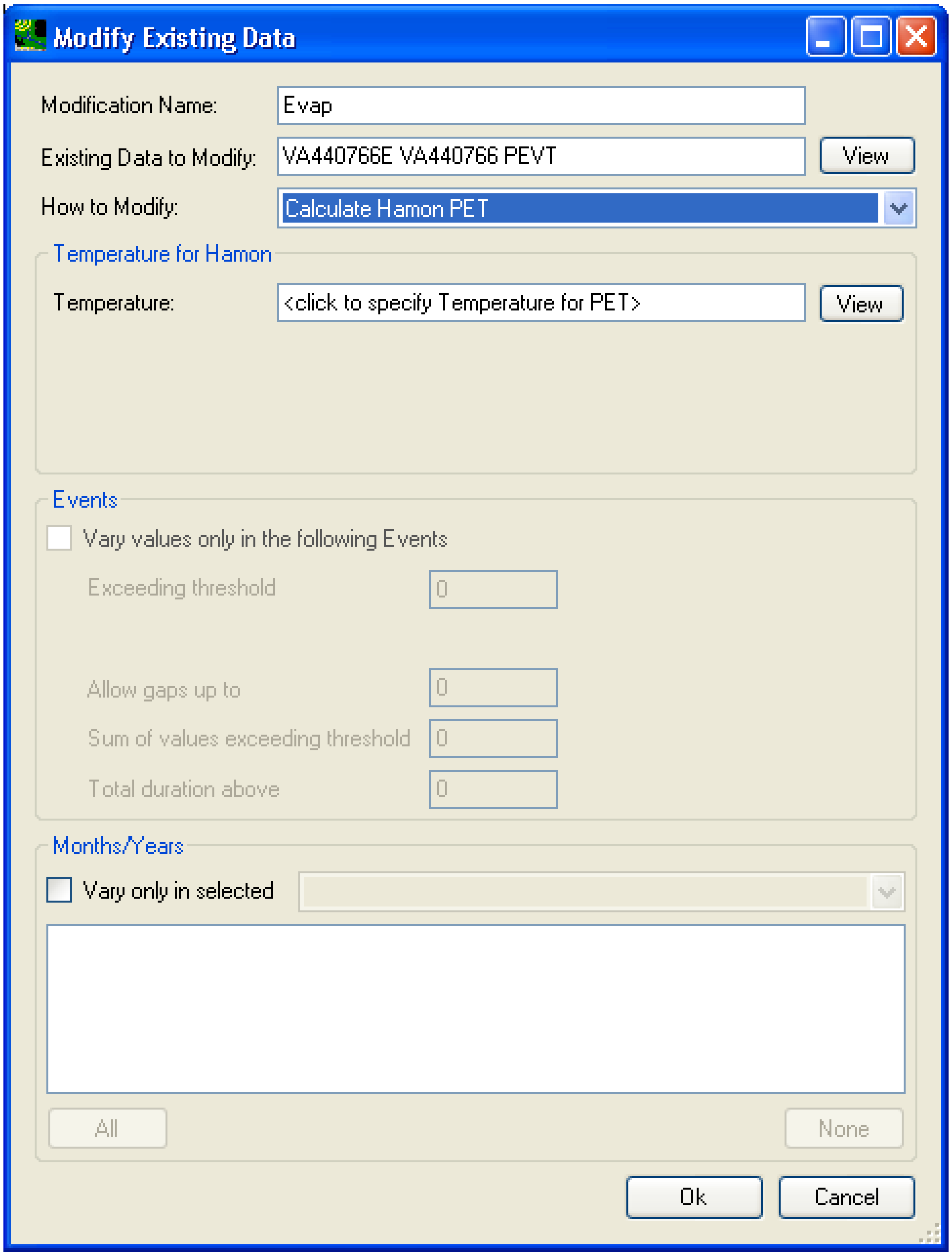
Next, click in the 'Existing Data to Modify' text box to bring up the data selection window and select the evaporation data as shown below:



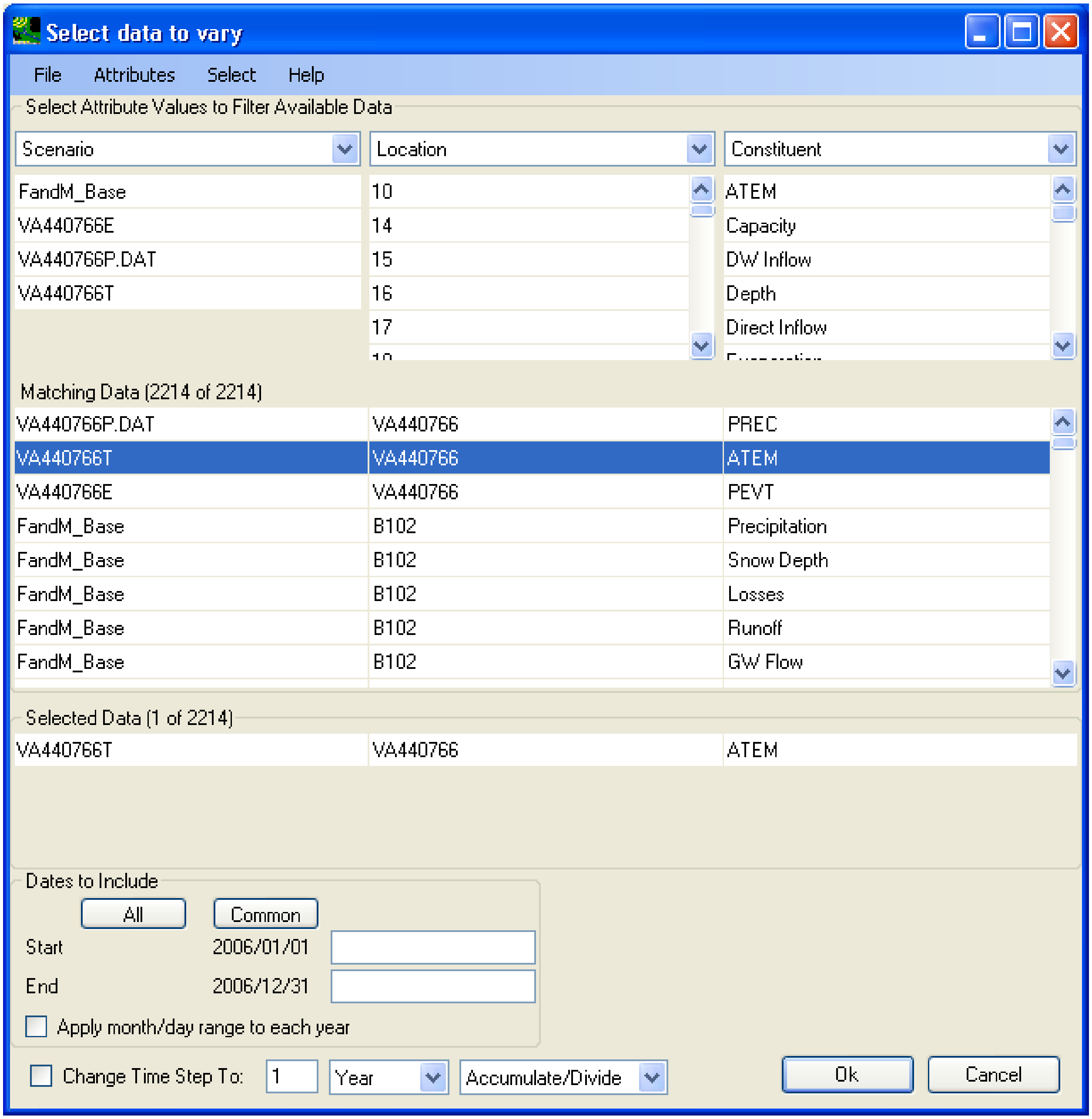
Click **OK** to accept data selection, now, the data modification window will look like below:



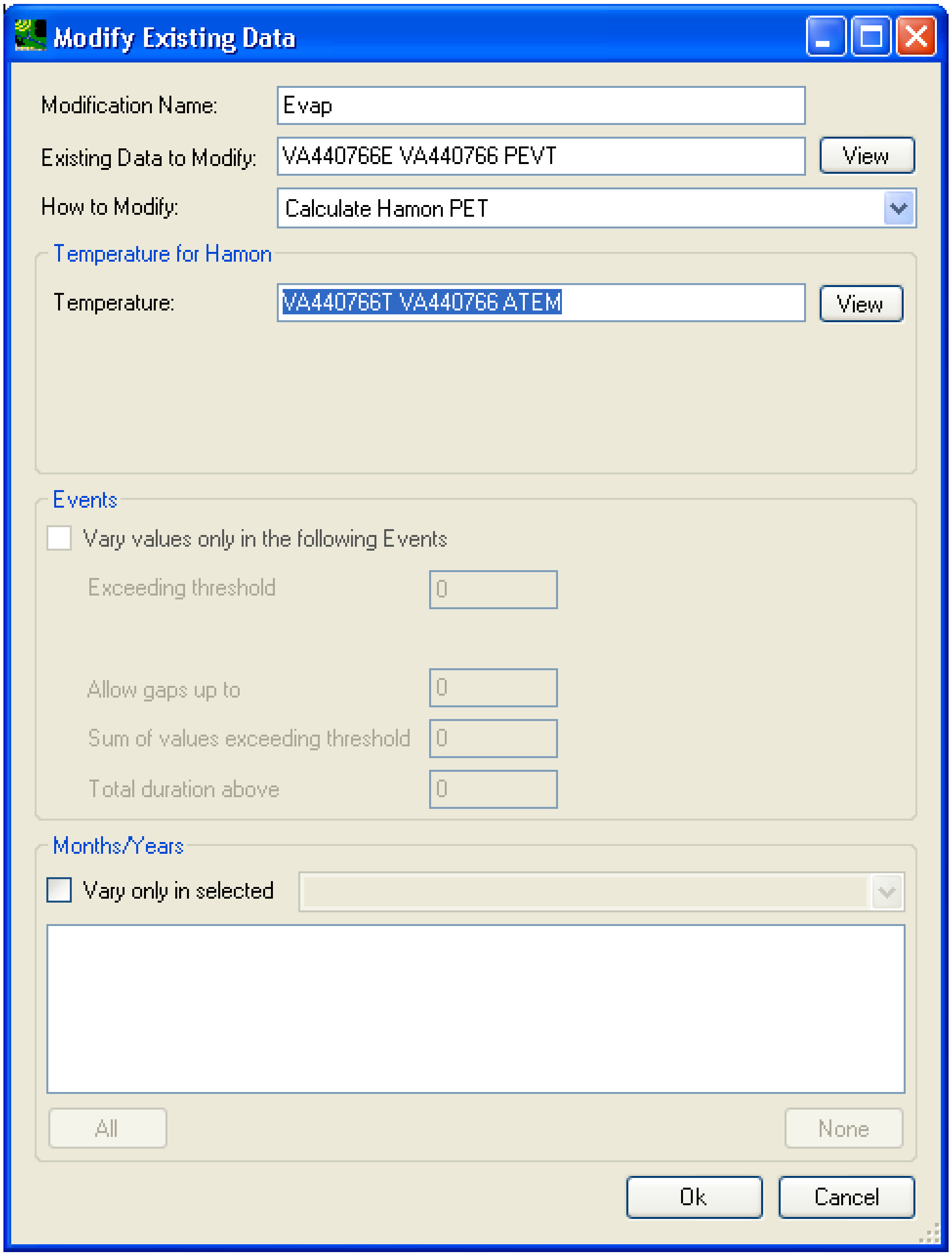
Next, from the 'How to modify' dropdown list, choose 'Calculate Hamon PET' as shown below:



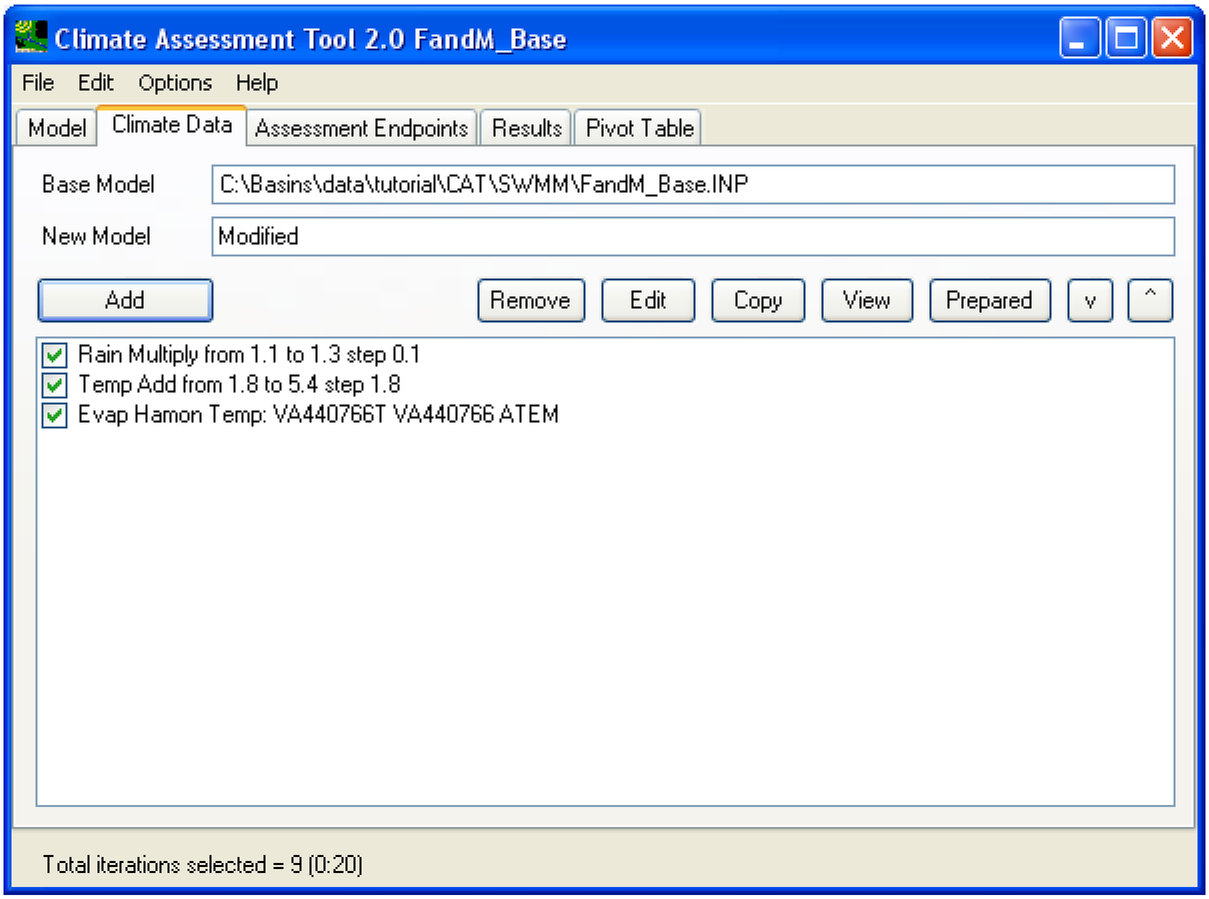
Next, click in the 'Temperature' textbox to select temperature input for the Hamon's method as shown below:



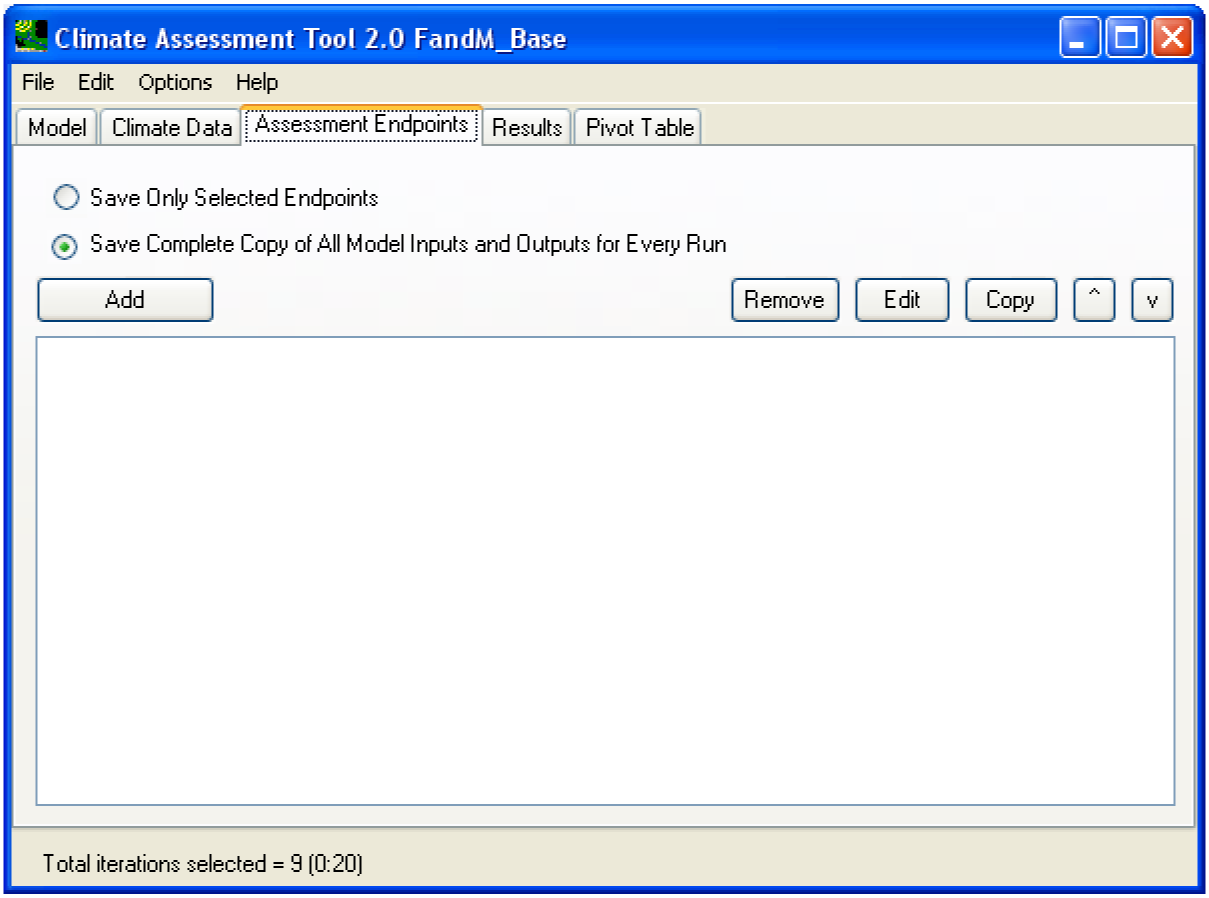
Click **OK** to accept data selection, then, the data modification window will look like below:



Click **OK** to accept the data modification, then, the **Climate Data** tab will look like below:



Now that you have defined the three modifications on the **Climate Data** tab, move onto the **Assessment Endpoints** tab as shown below:



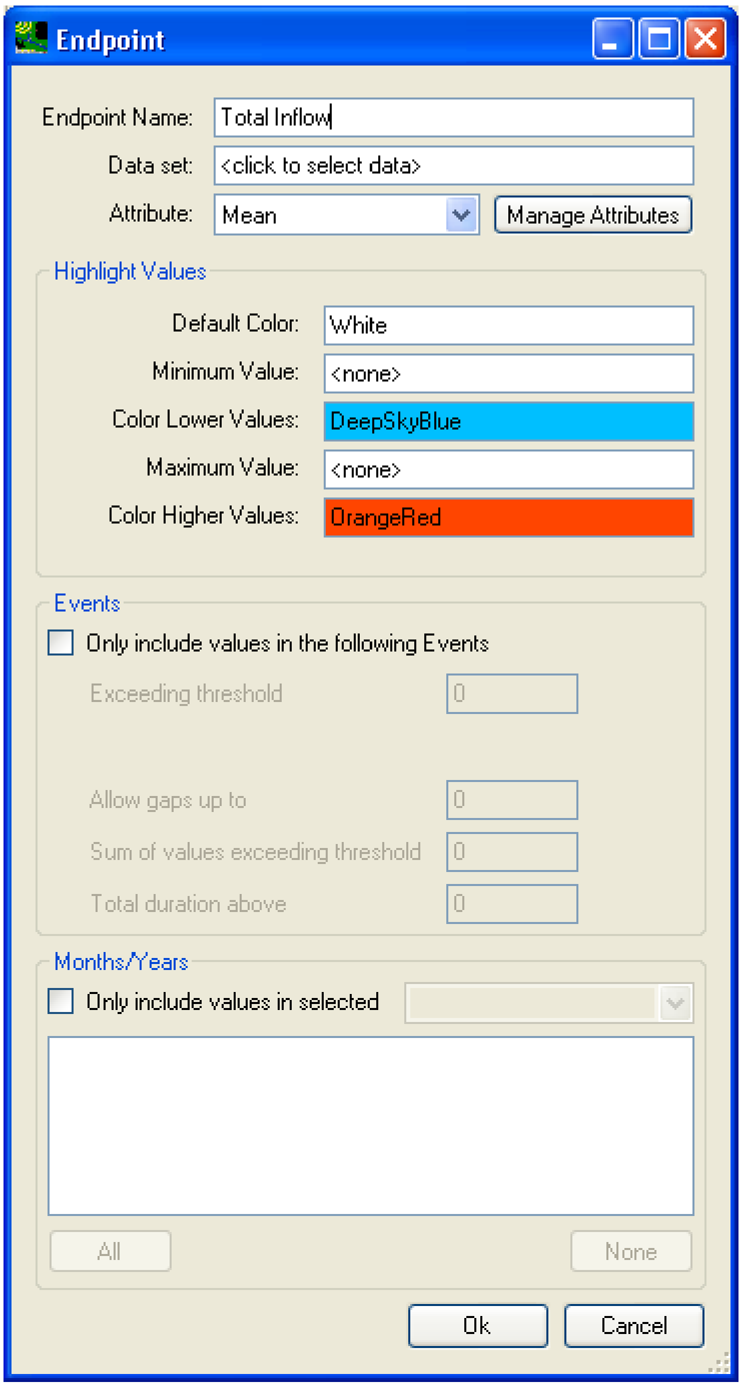
Click in the radio button that is labeled as "Save Complete Copy of All Model Inputs and Outputs for Every Run". This option will save each scenario run into its own directory, whereas the 'Save Only Selected Endpoints' option will save each scenario run into a same directory (hence overwrite input output files from previous runs).

On the **Assessment Endpoints** tab, we will define three SWMM output items as endpoints and also add the three input climate data items (defined on the **Climate Data** tab) as endpoints. This way, we will be able to see both input and output on the **Results** tab after running the model simulations. Click the **Add** button to initiate the definition of a new endpoint.

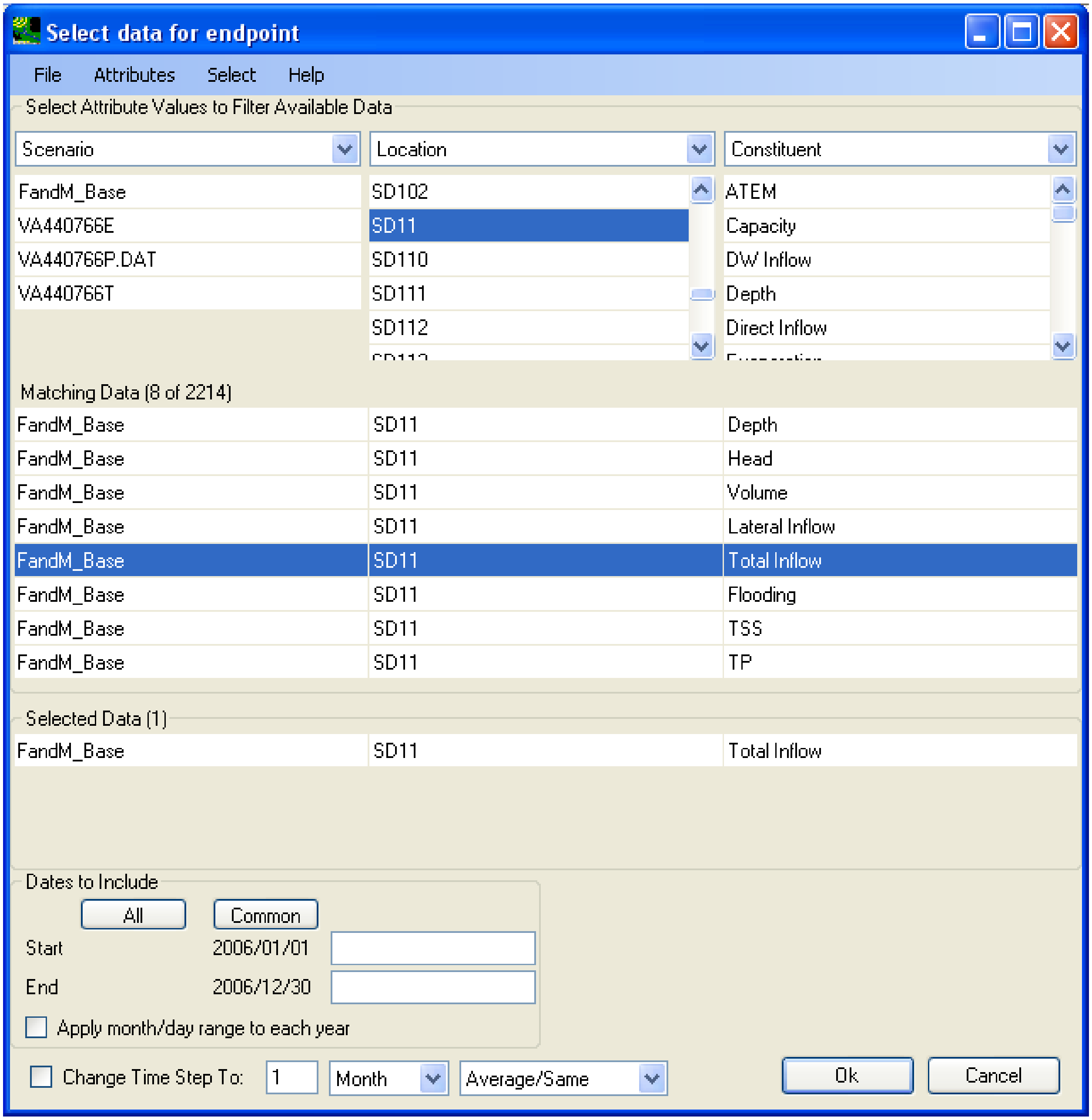
The SWMM outputs from the Node **SD11**, which is the outlet of the urban watershed, will be the focus. We will select the mean **Total Inflow** (cfs), **Total Suspended Sediment (TSS)** concentration (mg/l), and **Total Phosphorus (TP)** concentration (mg/l) at the node **SD11** as our endpoints.

Click the **Add** button to bring up the endpoint definition window.

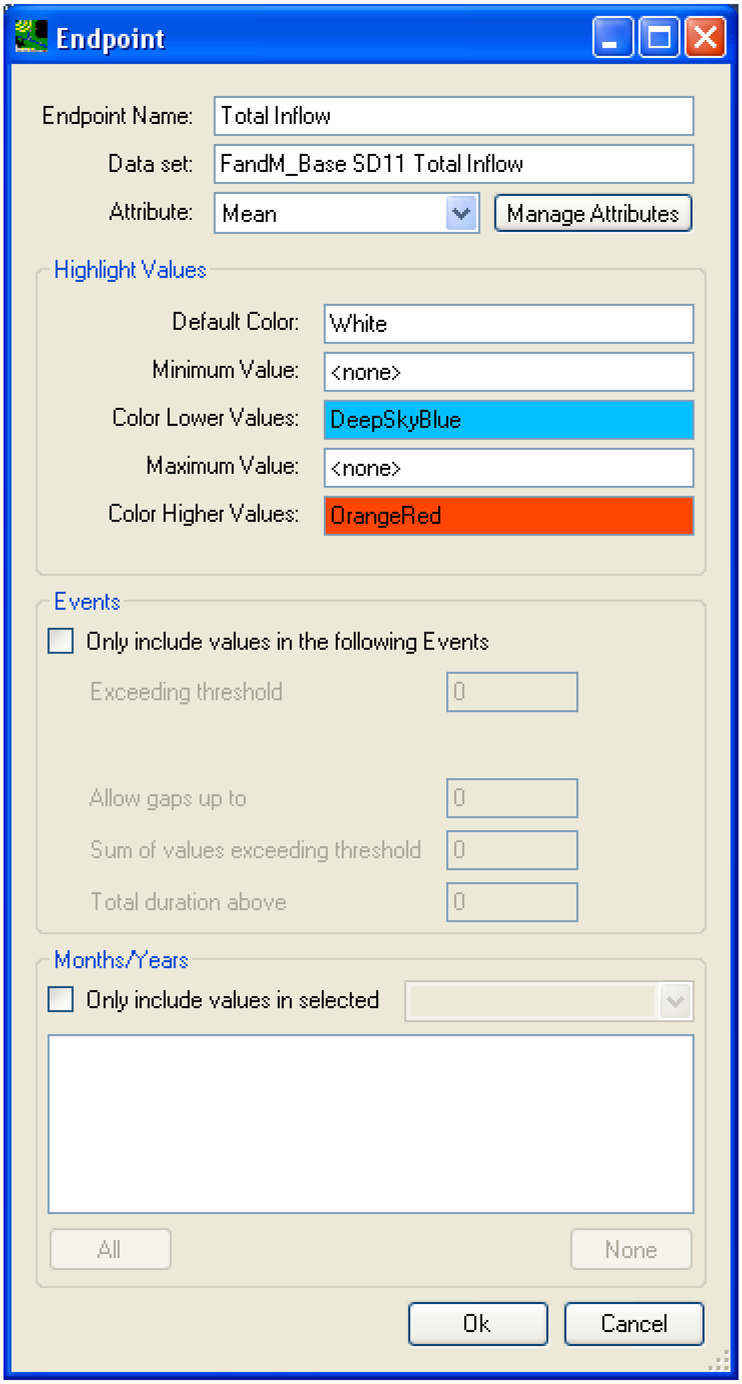
In the first endpoint definition window, specify the endpoint name as **Total Inflow** as shown below:



Click in the **Data set** field to open data selection window to select total inflow at SD11 node as below:

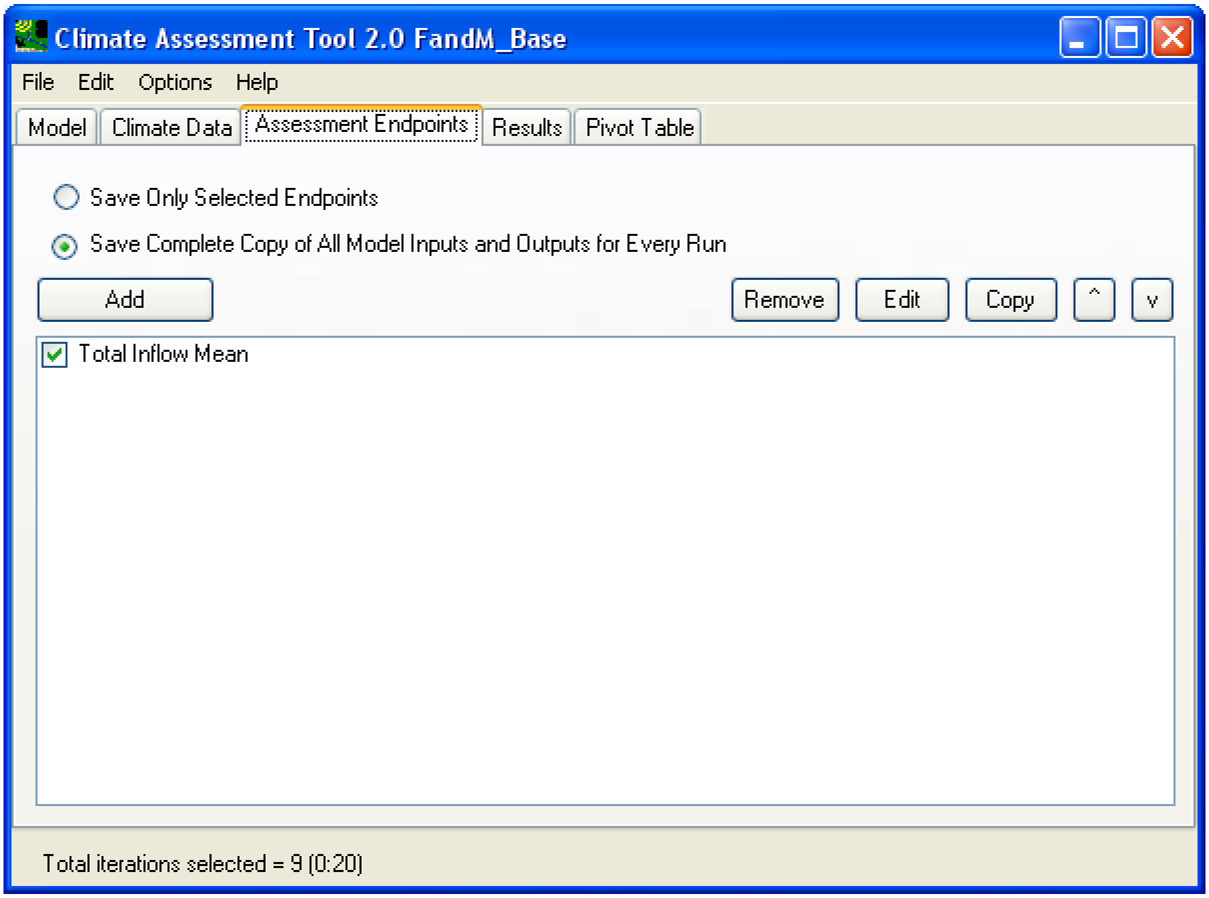


Click **OK** to accept data selection, then the endpoint definition window will look like below:



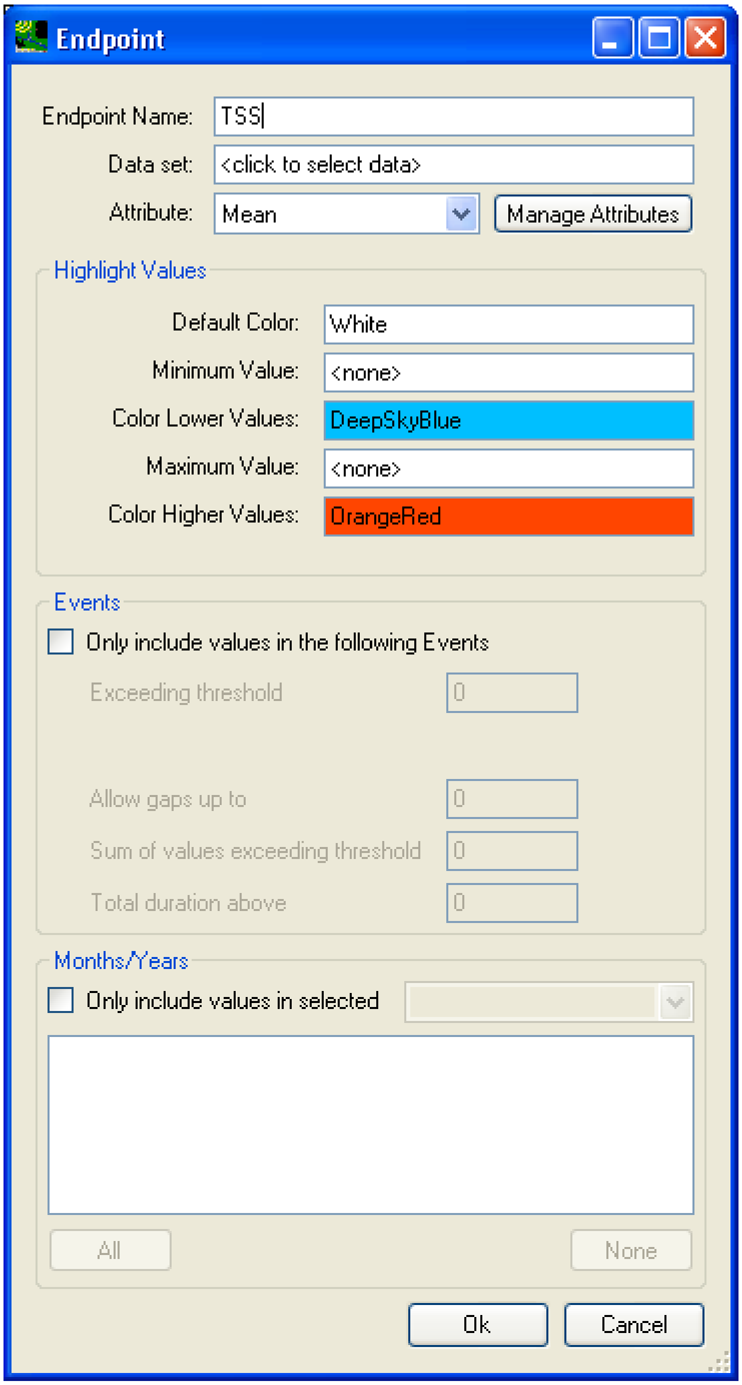
Be sure to use the default statistic attribute, i.e. "Mean".

Click **OK** to accept the endpoint definition, then, the **Endpoint Assessment** tab will look like below:

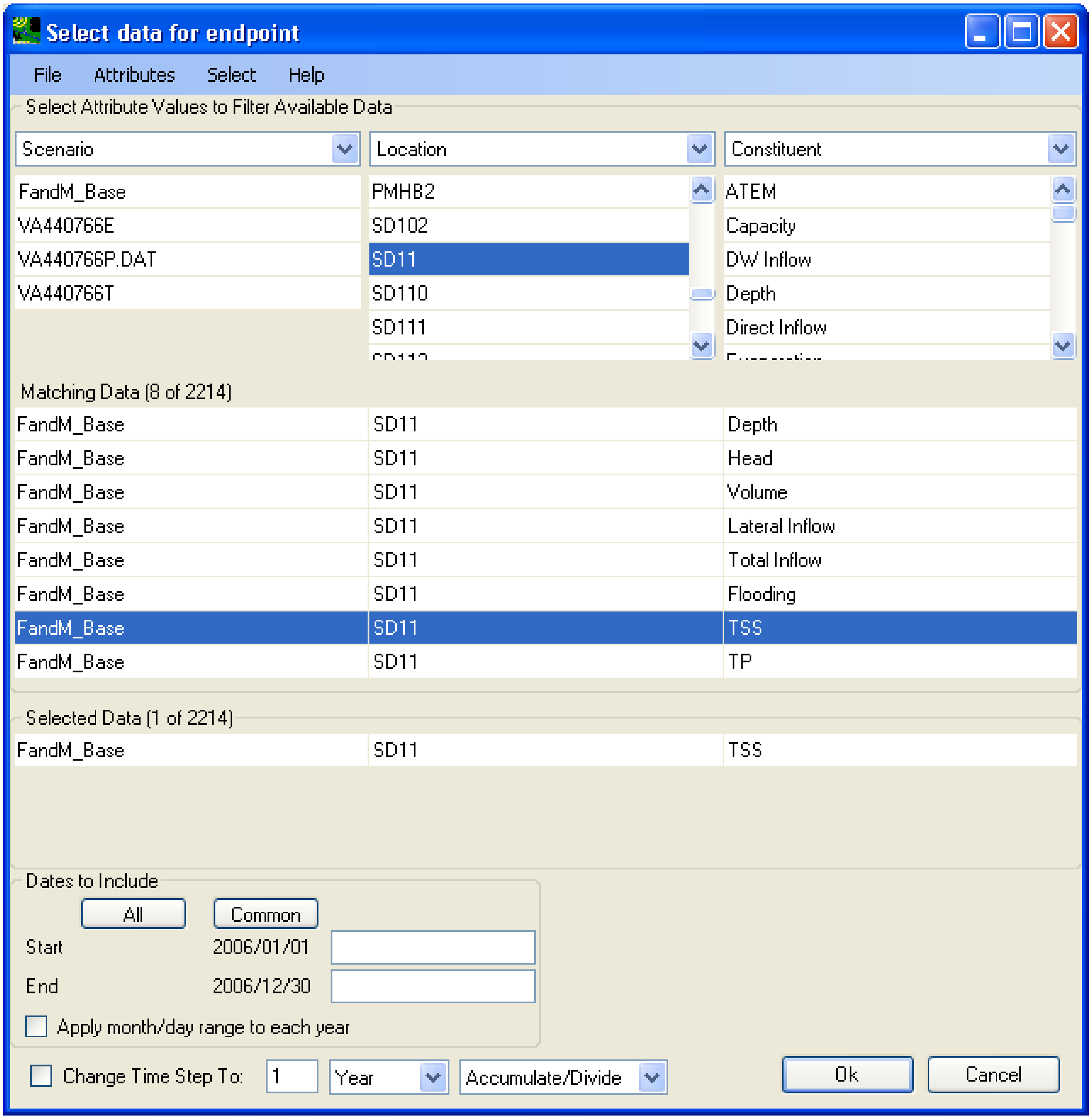


Again, click the **Add** button to bring up the endpoint definition window.

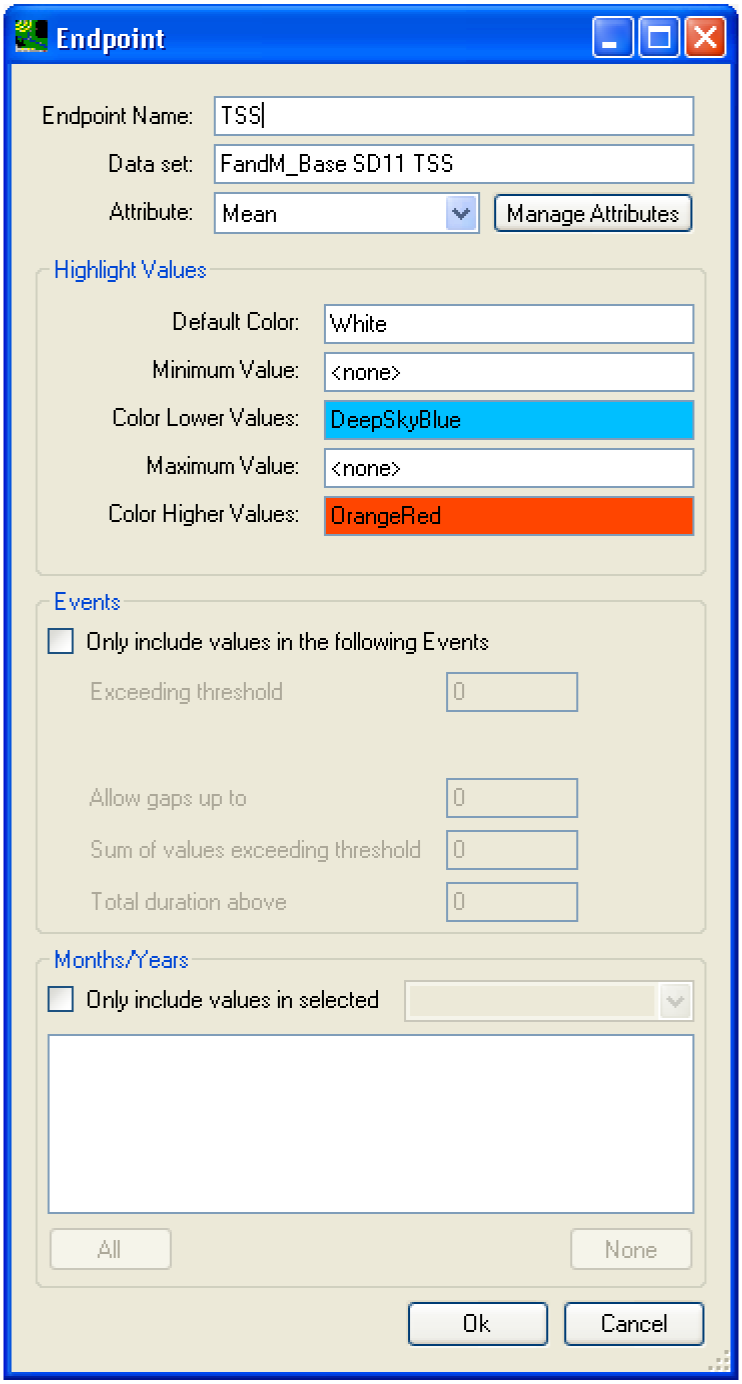
This time, specify the endpoint name as **TSS** as shown below:



Click in the **Data set** field to open data selection window to select TSS at SD11 node as below:

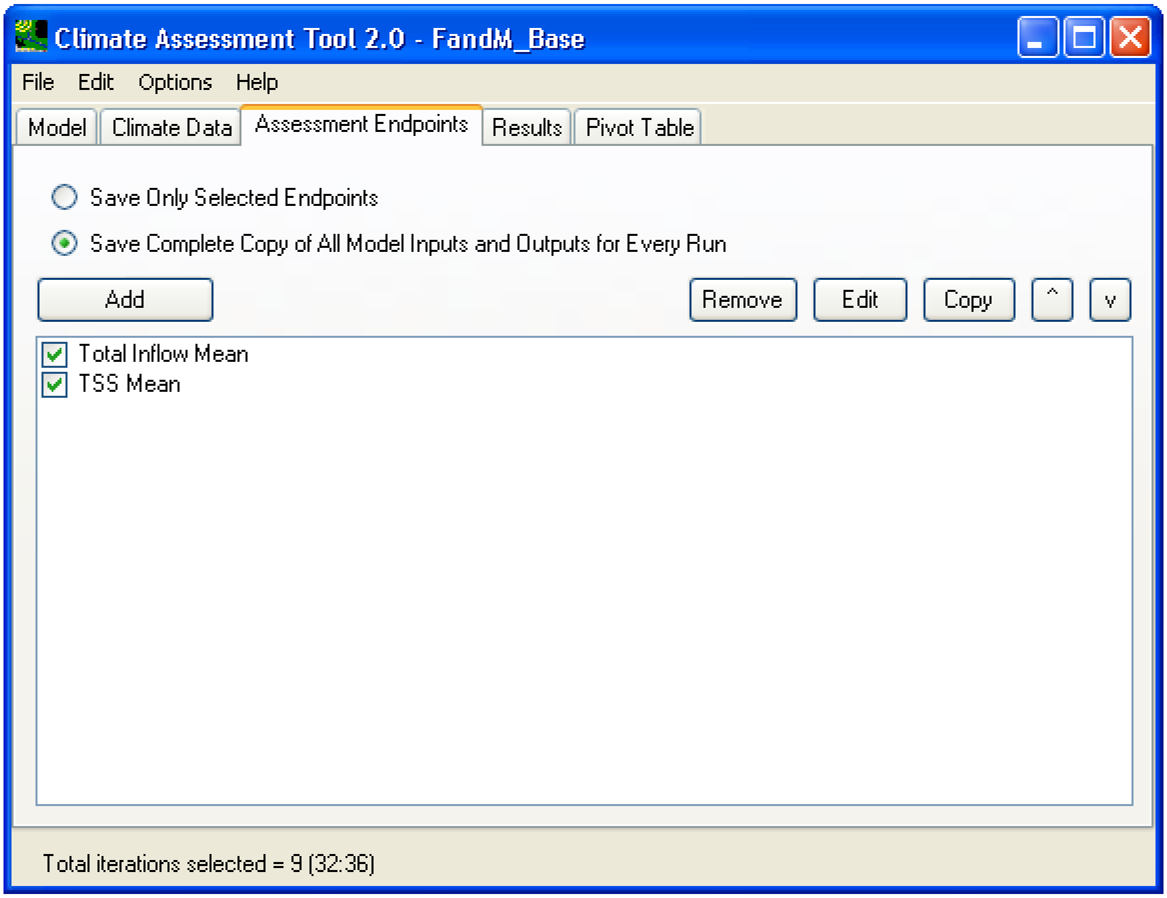


Click **OK** to accept data selection, then the endpoint definition window will look like below:



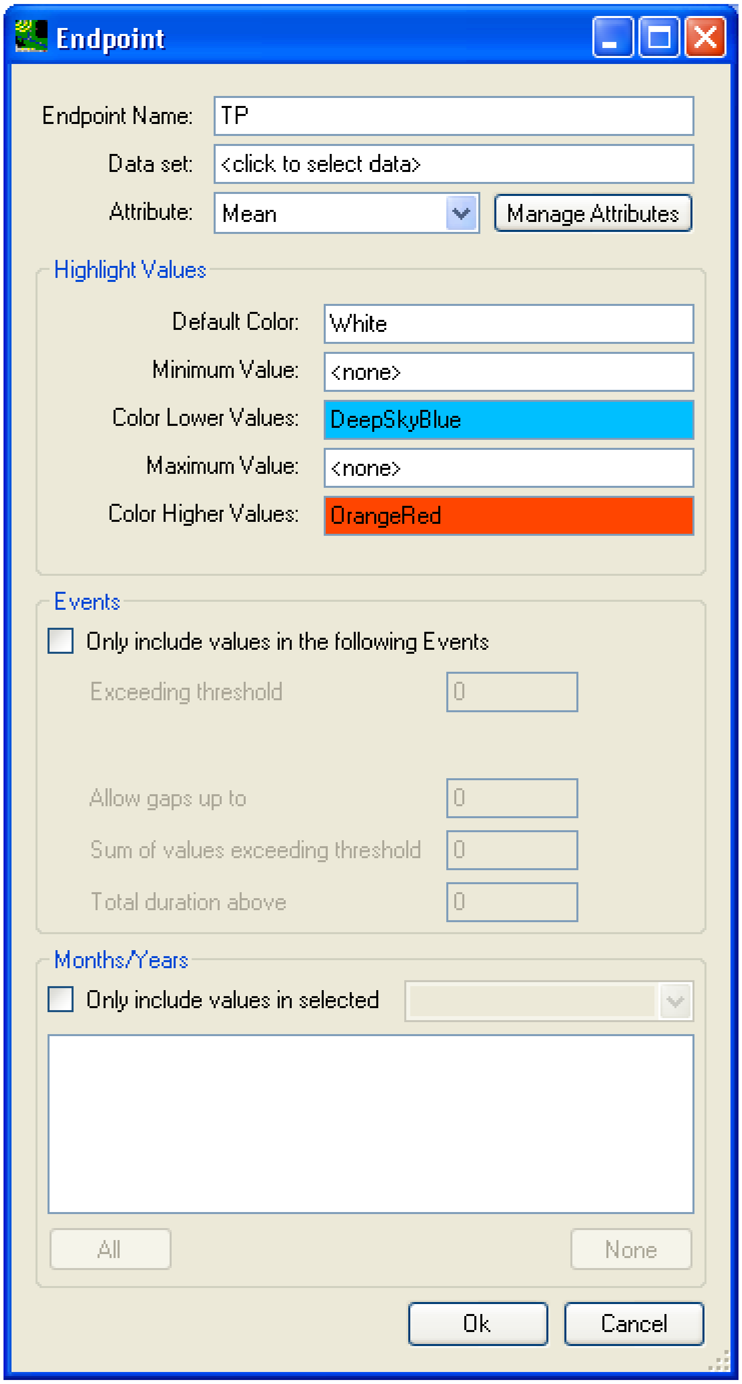
Be sure to use the default statistic attribute, i.e. “Mean”.

Click **OK** to accept the endpoint definition, then, the **Endpoint Assessment** tab will look like below:

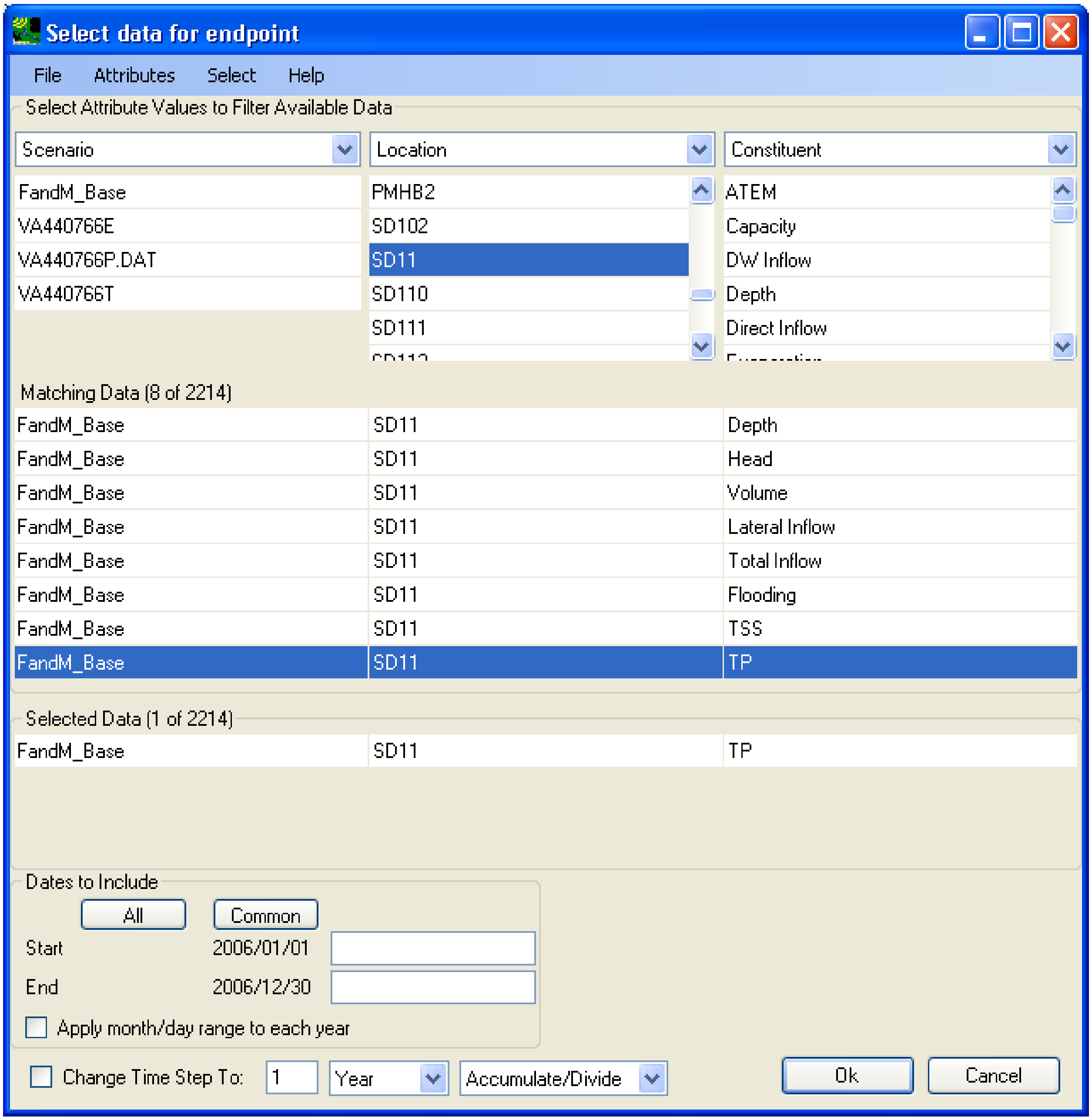


Click the **Add** button to bring up the endpoint definition window.

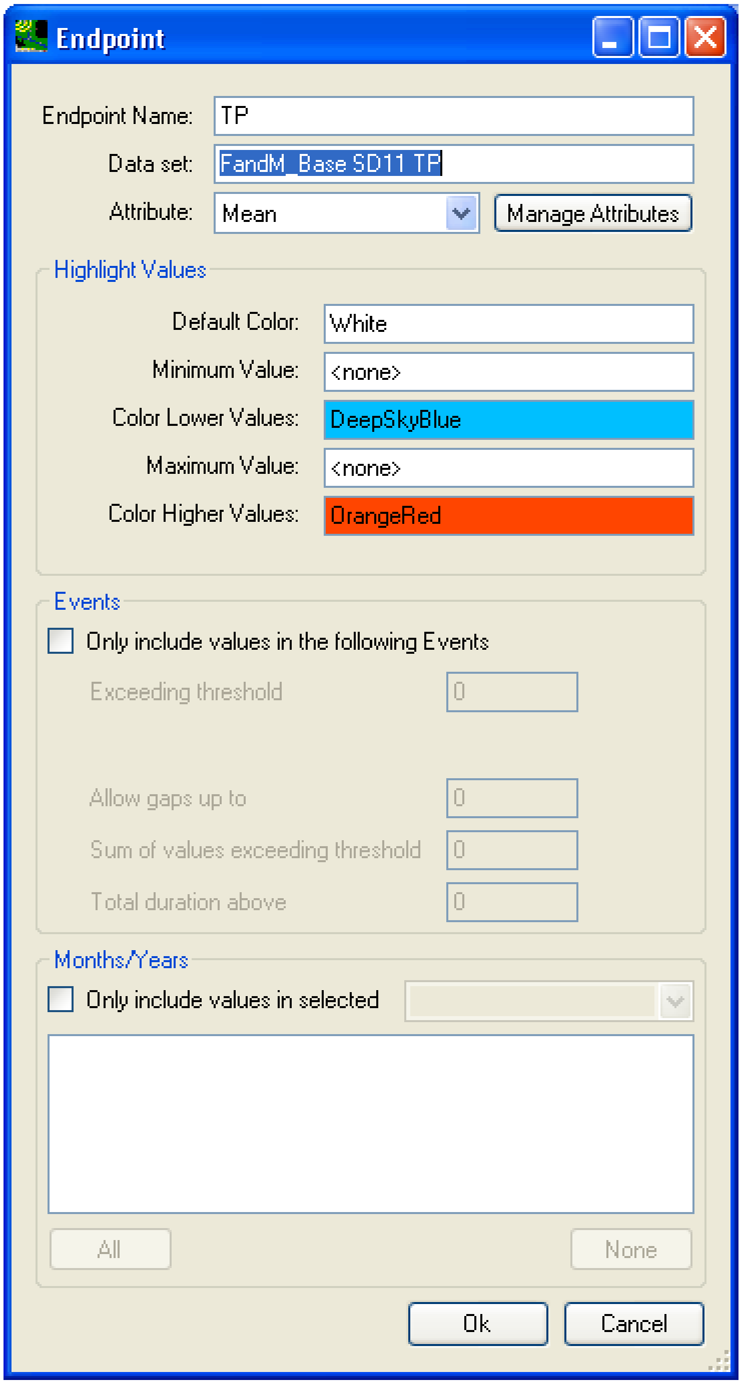
In this endpoint definition window, specify the endpoint name as **TP** as shown below:



Click in the **Data set** field to open data selection window to select TP at SD11 node as below:

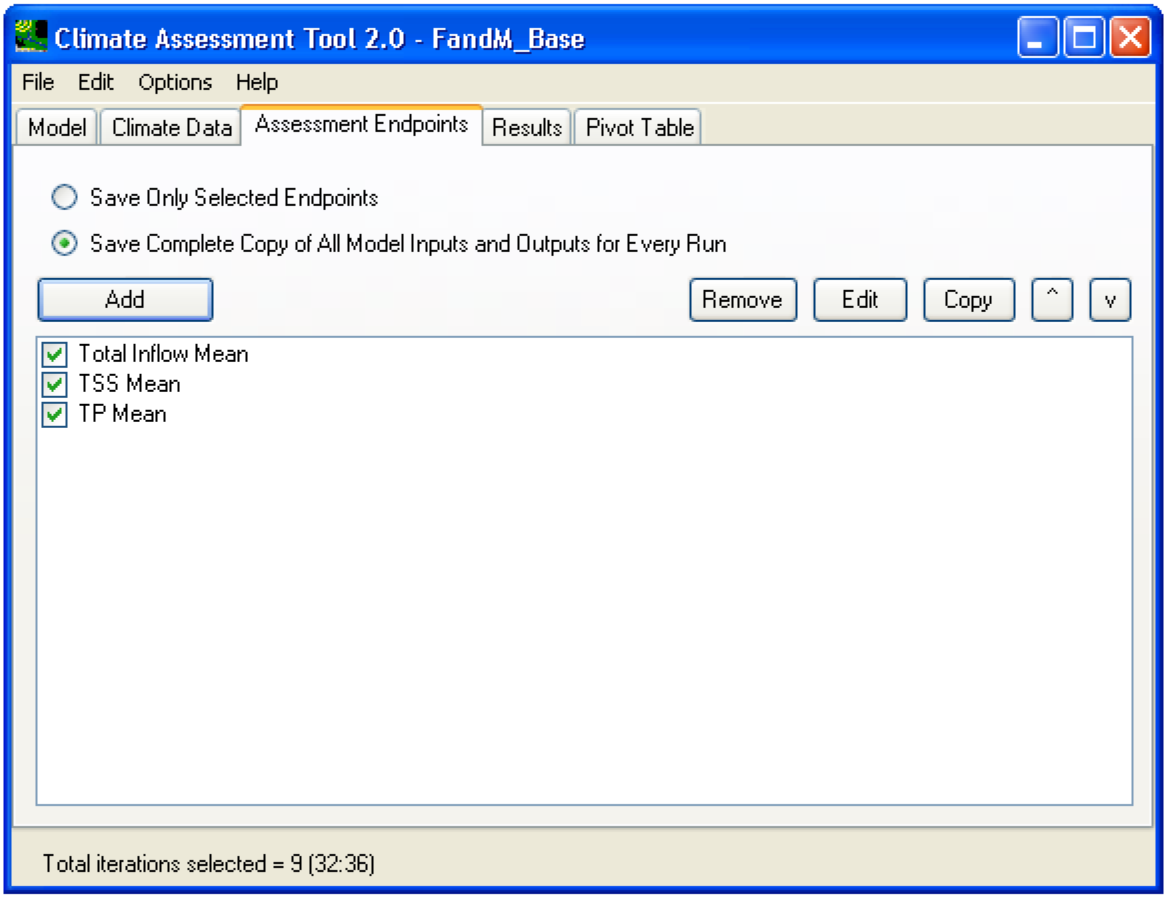


Click **OK** to accept data selection, then the endpoint definition window will look like below:



Be sure to use the default statistic attribute, i.e. "Mean".

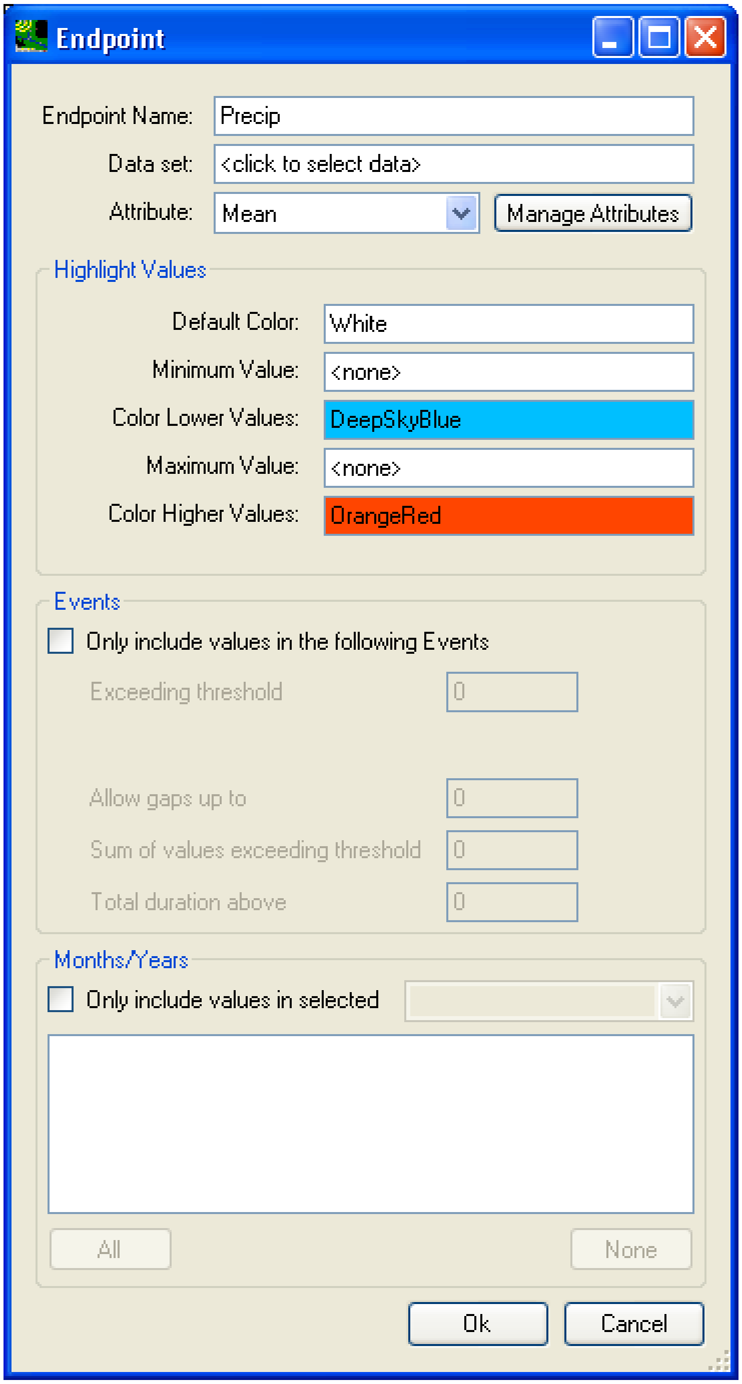
Click **OK** to accept the endpoint definition, then, the **Endpoint Assessment** tab will look like below:



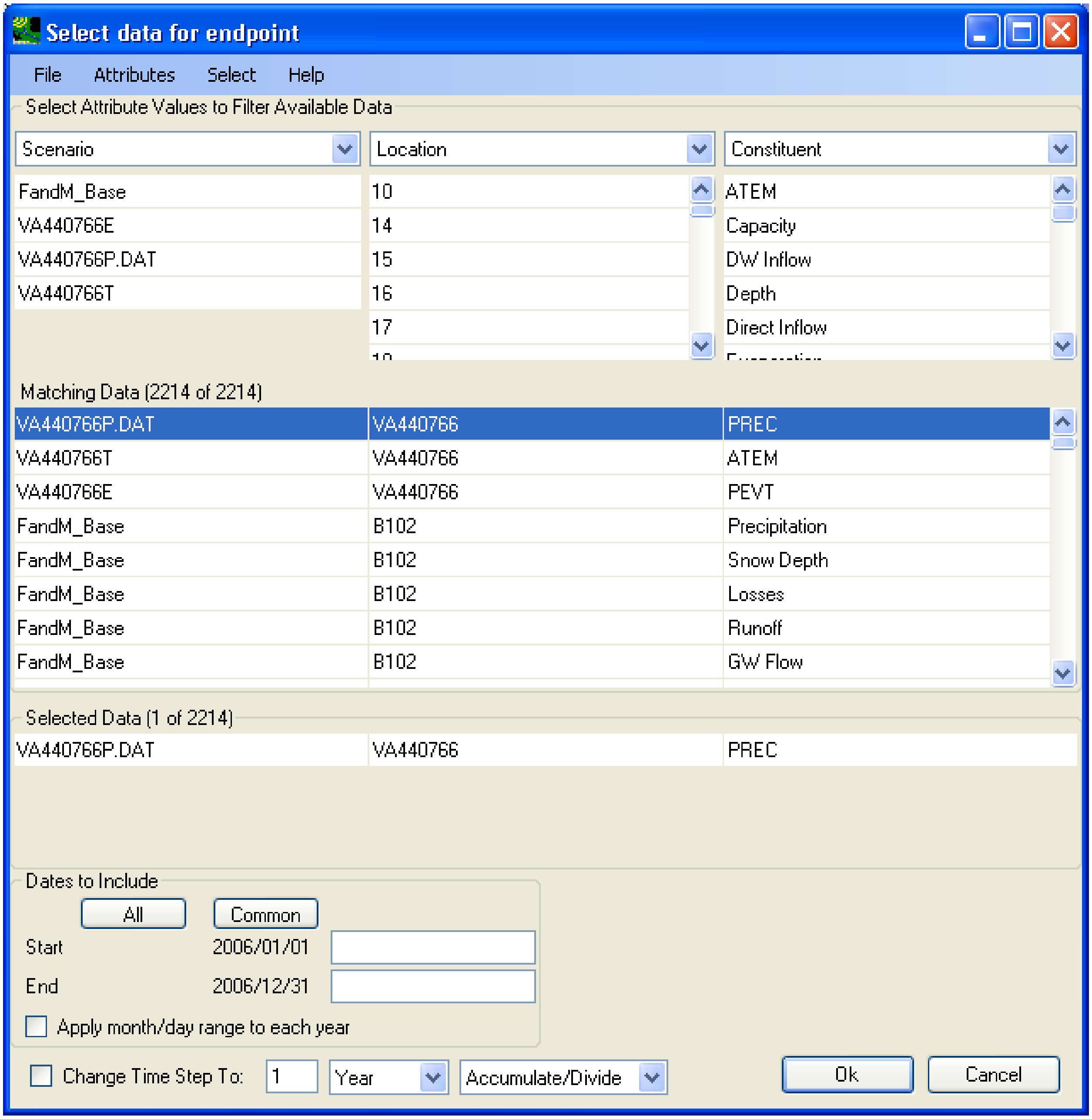
Similarly, we will add the rainfall, temperature, evaporation data as endpoint.

Click the **Add** button to bring up the endpoint definition window.

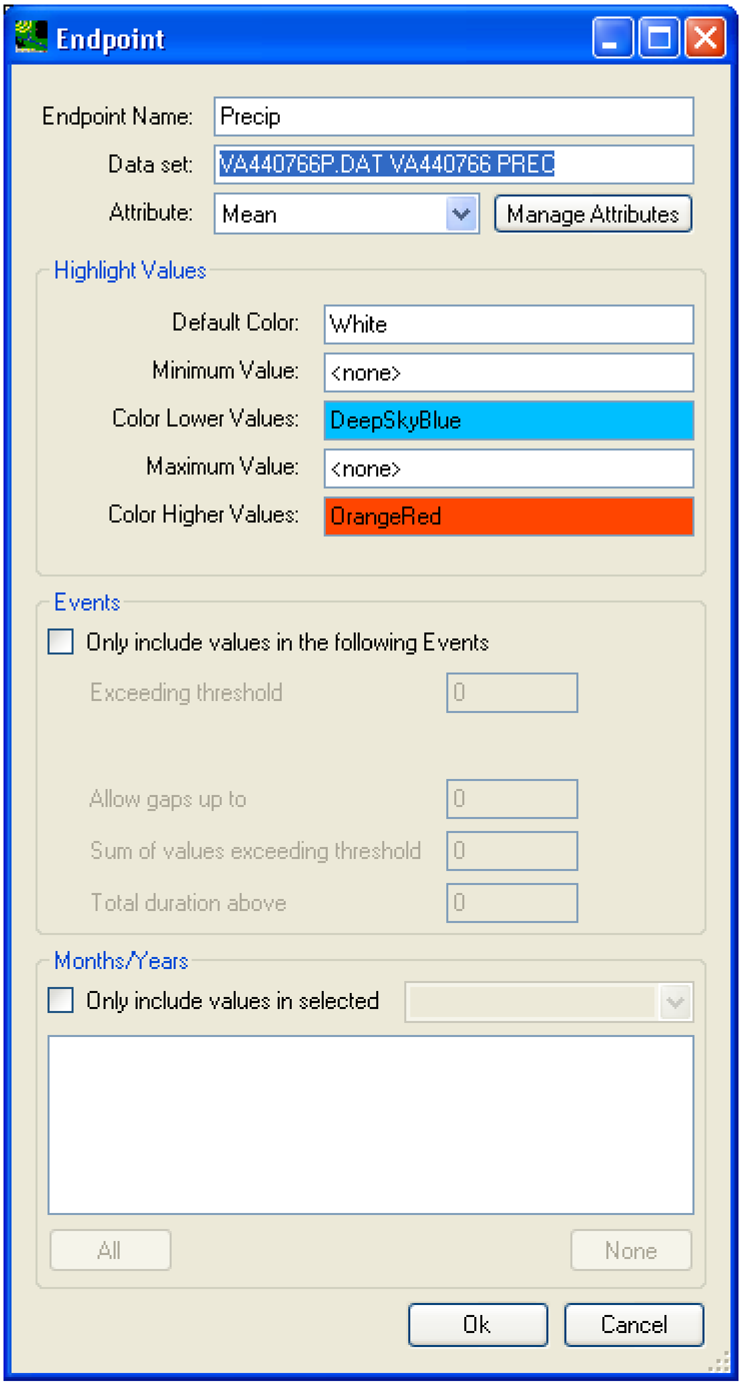
In this endpoint definition window, specify the endpoint name as **Precip** as shown below:



Click in the **Data set** field to open data selection window to select PREC at VA440766 as below:

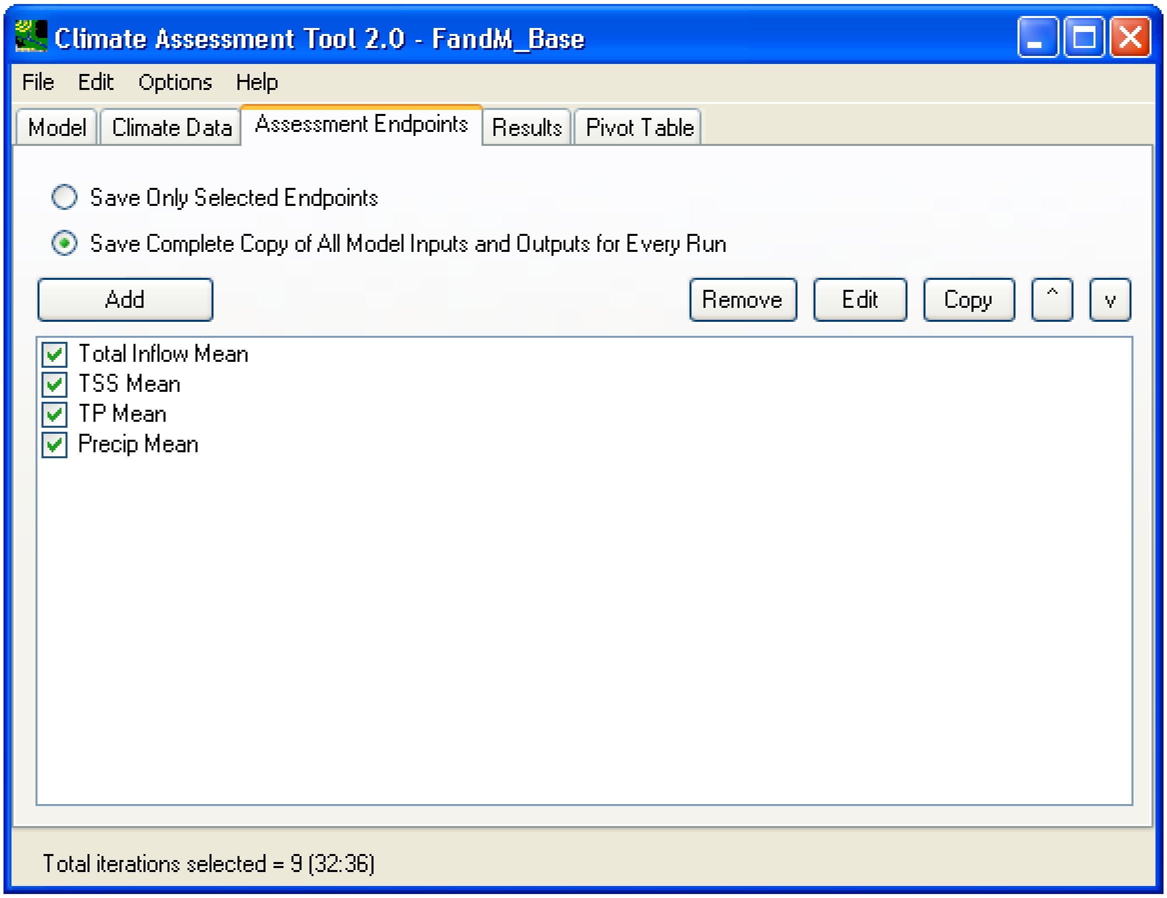


Click **OK** to accept data selection, then the endpoint definition window will look like below:



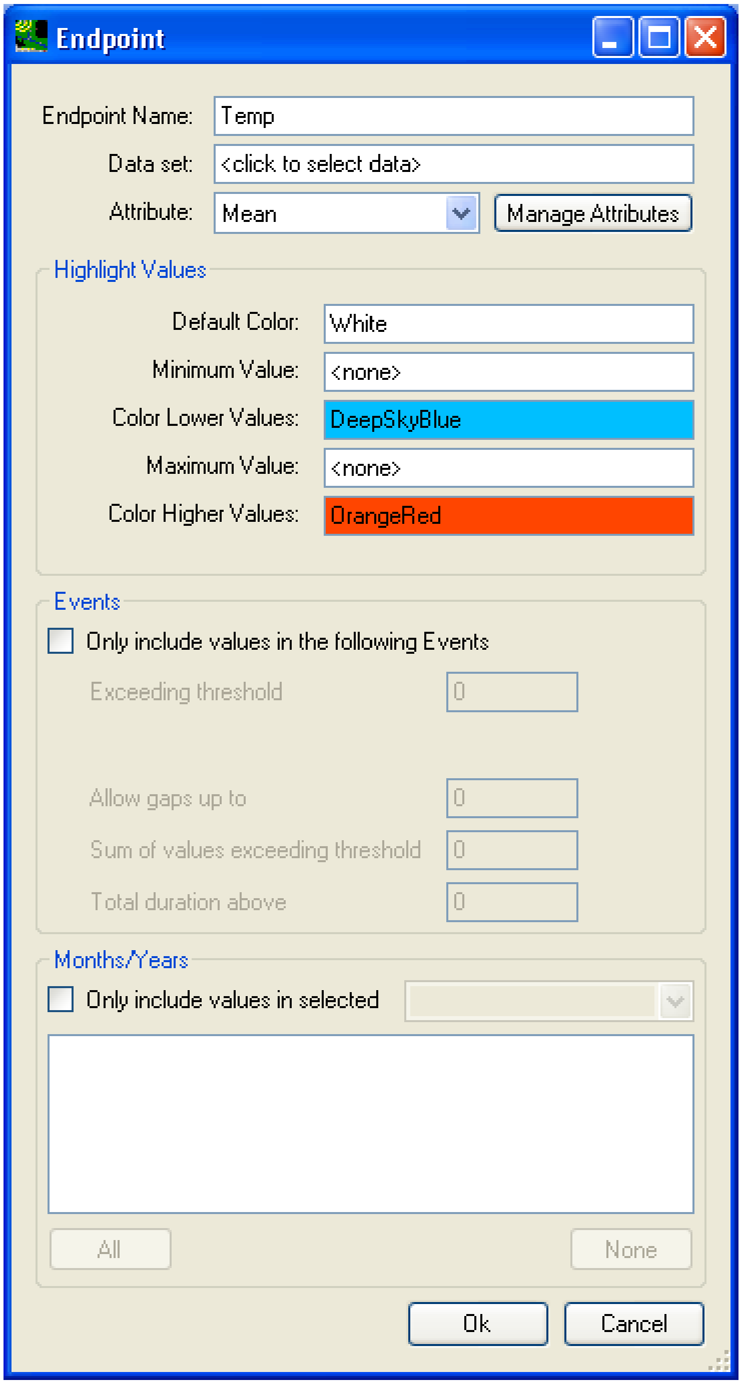
Be sure to use the default statistic attribute, i.e. 'Mean'.

Click **OK** to accept the endpoint definition, then, the **Endpoint Assessment** tab will look like below:

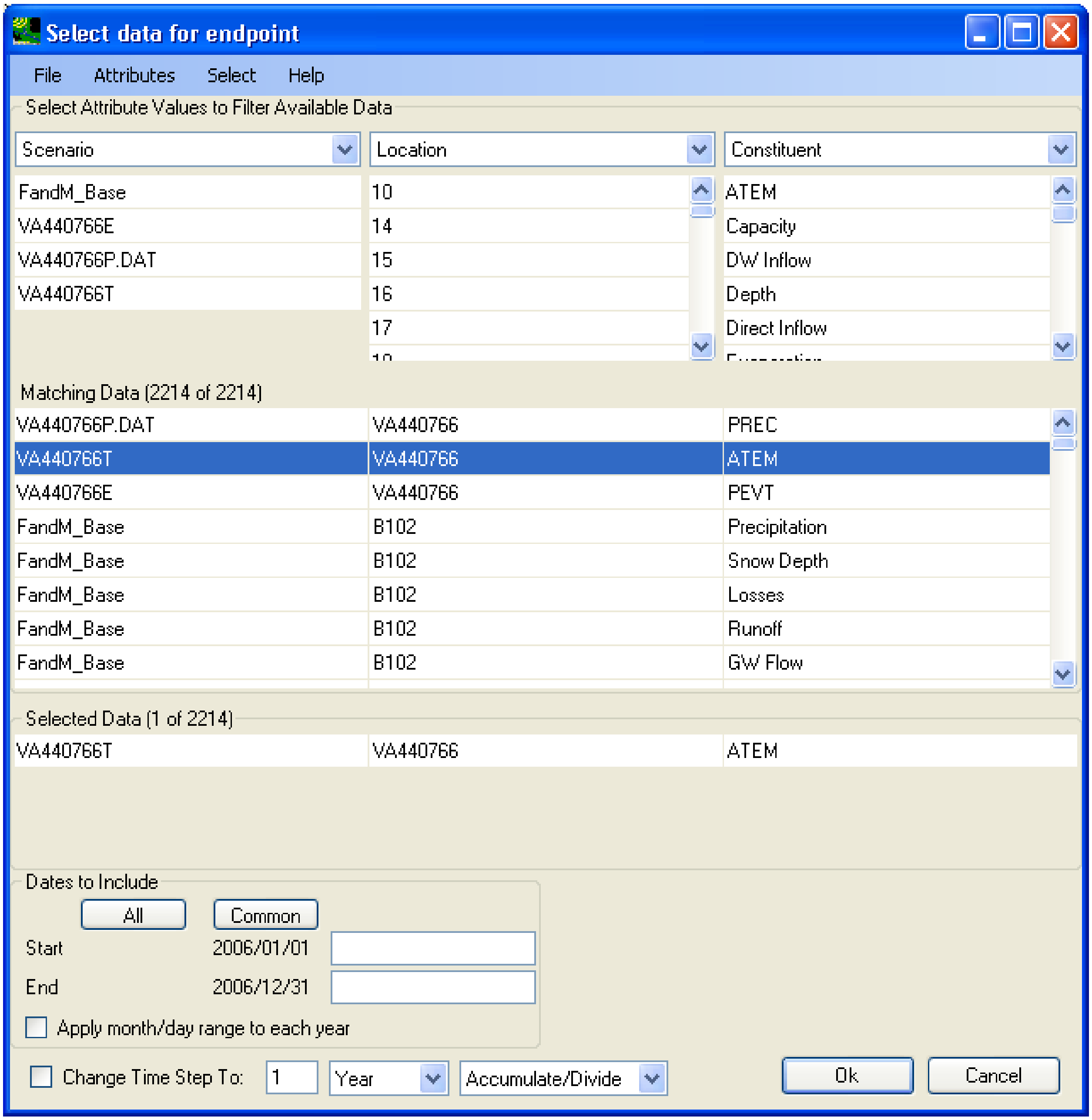


Next, click the **Add** button to bring up the endpoint definition window.

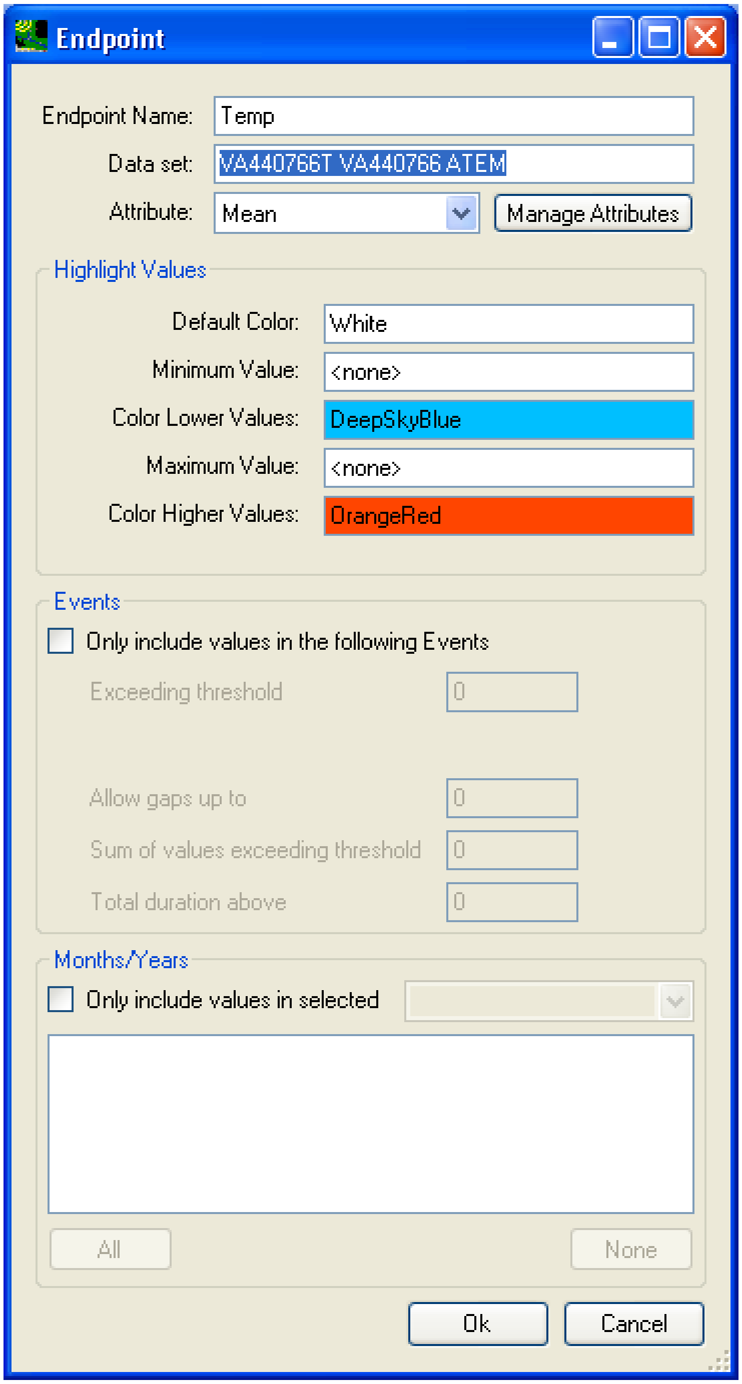
In this endpoint definition window, specify the endpoint name as **Temp** as shown below:



Click in the **Data set** field to open data selection window to select ATEM at VA440766 as below:

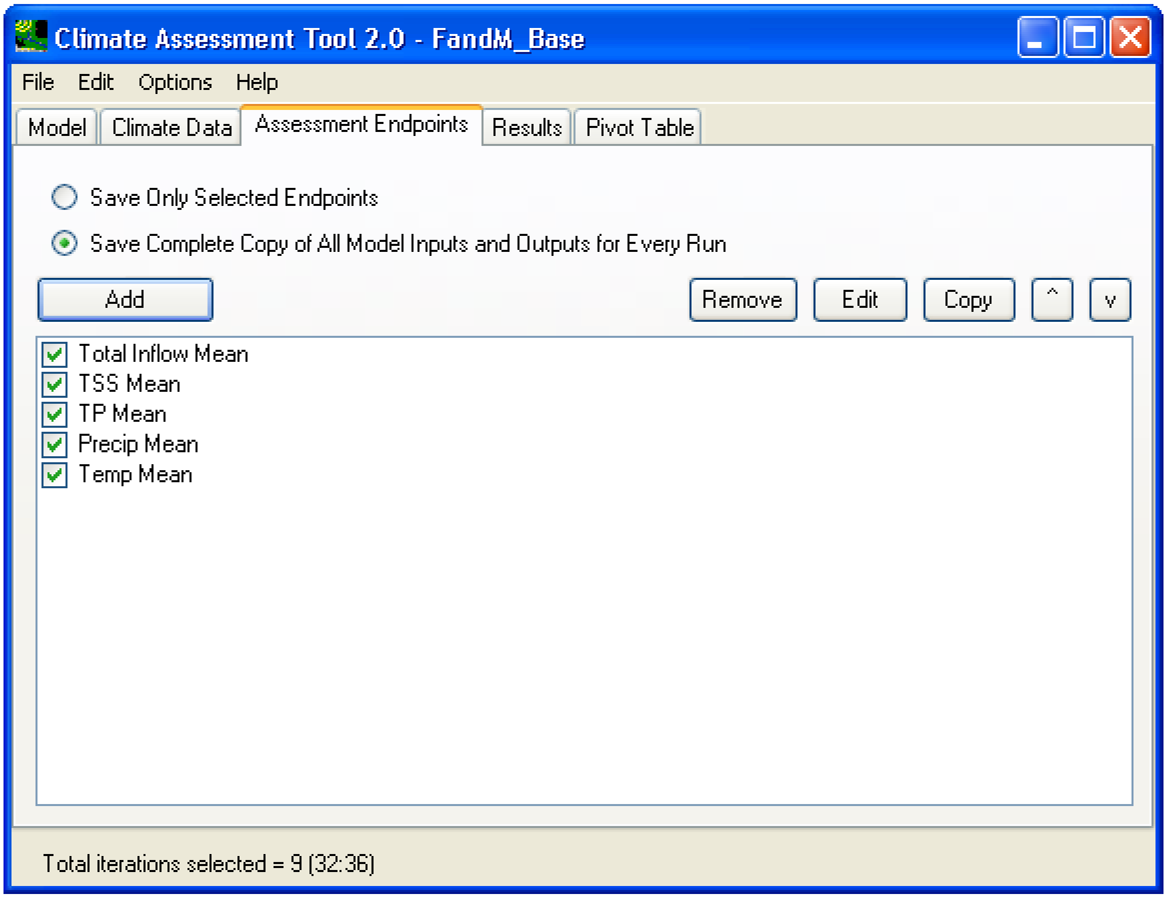


Click **OK** to accept data selection, then the endpoint definition window will look like below:



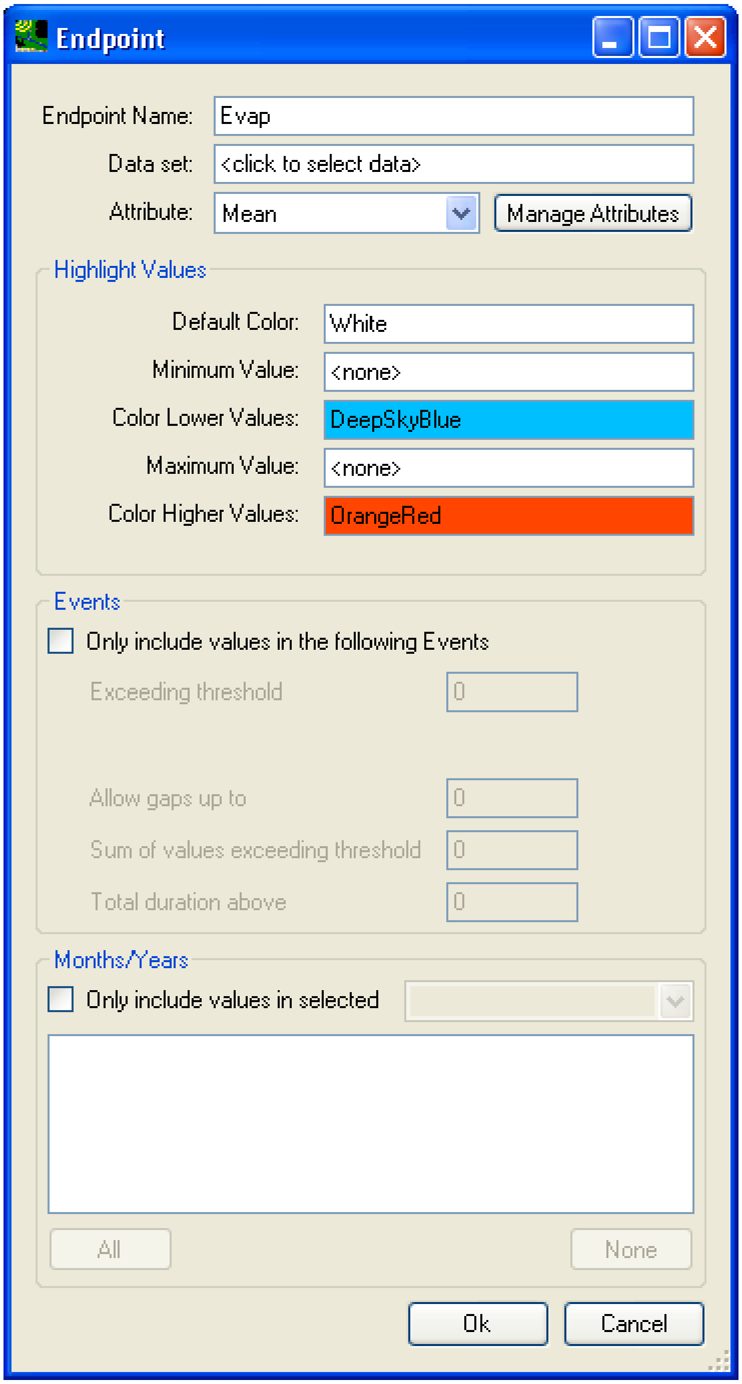
Be sure to use the default statistic attribute, i.e. “Mean”.

Click **OK** to accept the endpoint definition, then, the **Endpoint Assessment** tab will look like below:

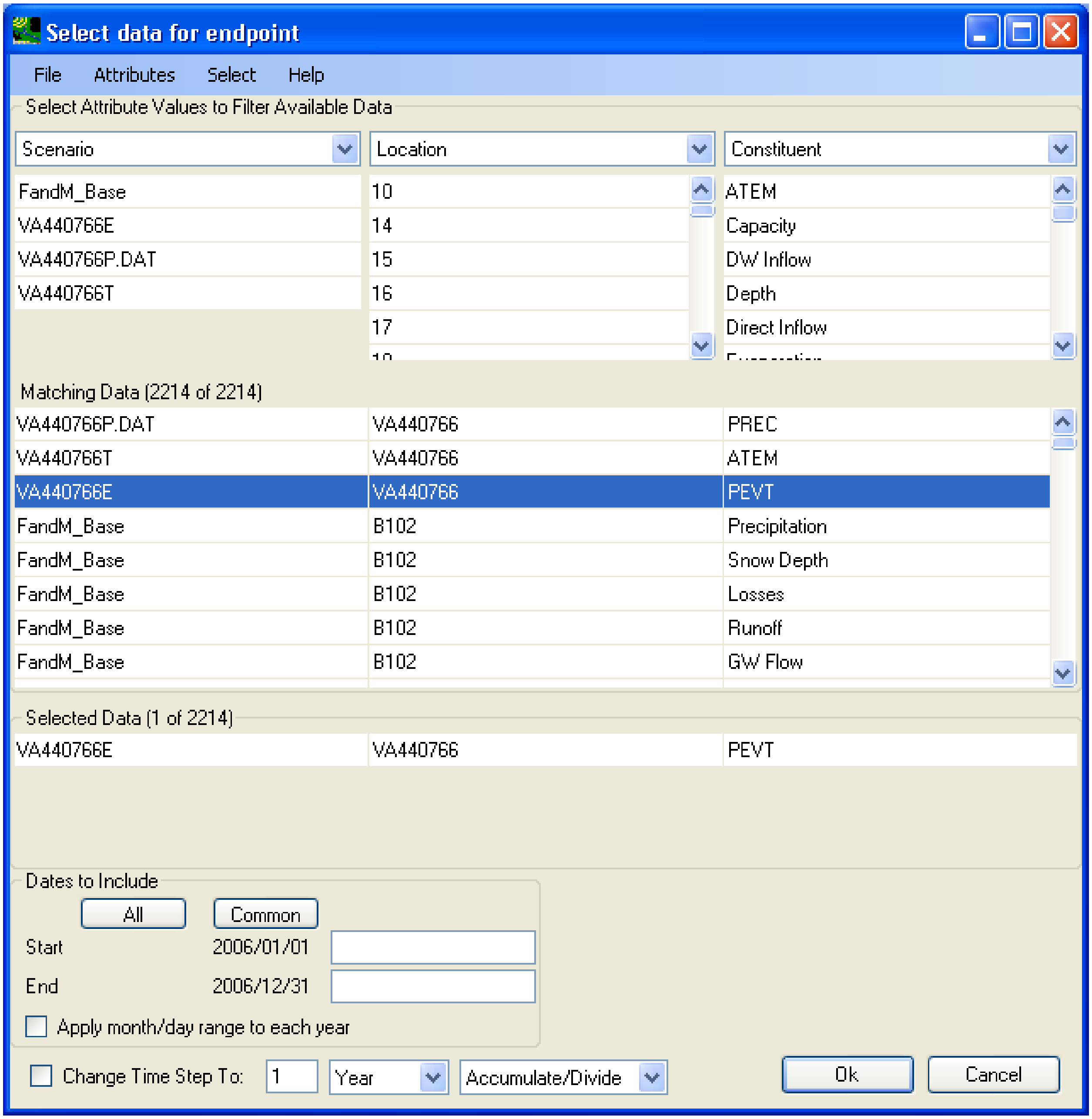


Next, click the **Add** button to bring up the endpoint definition window.

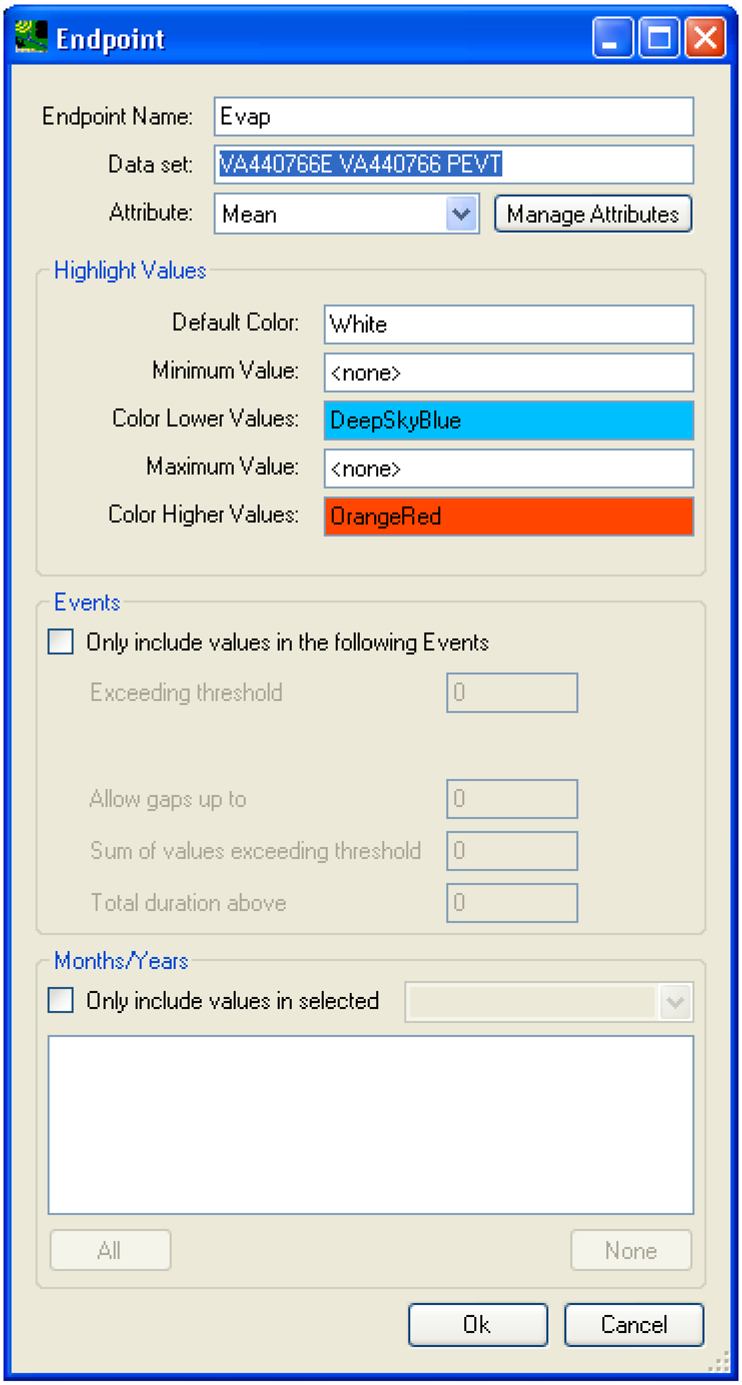
In this endpoint definition window, specify the endpoint name as **Evap** as shown below:



Click in the **Data set** field to open data selection window to select PEVT at VA440766 as below:

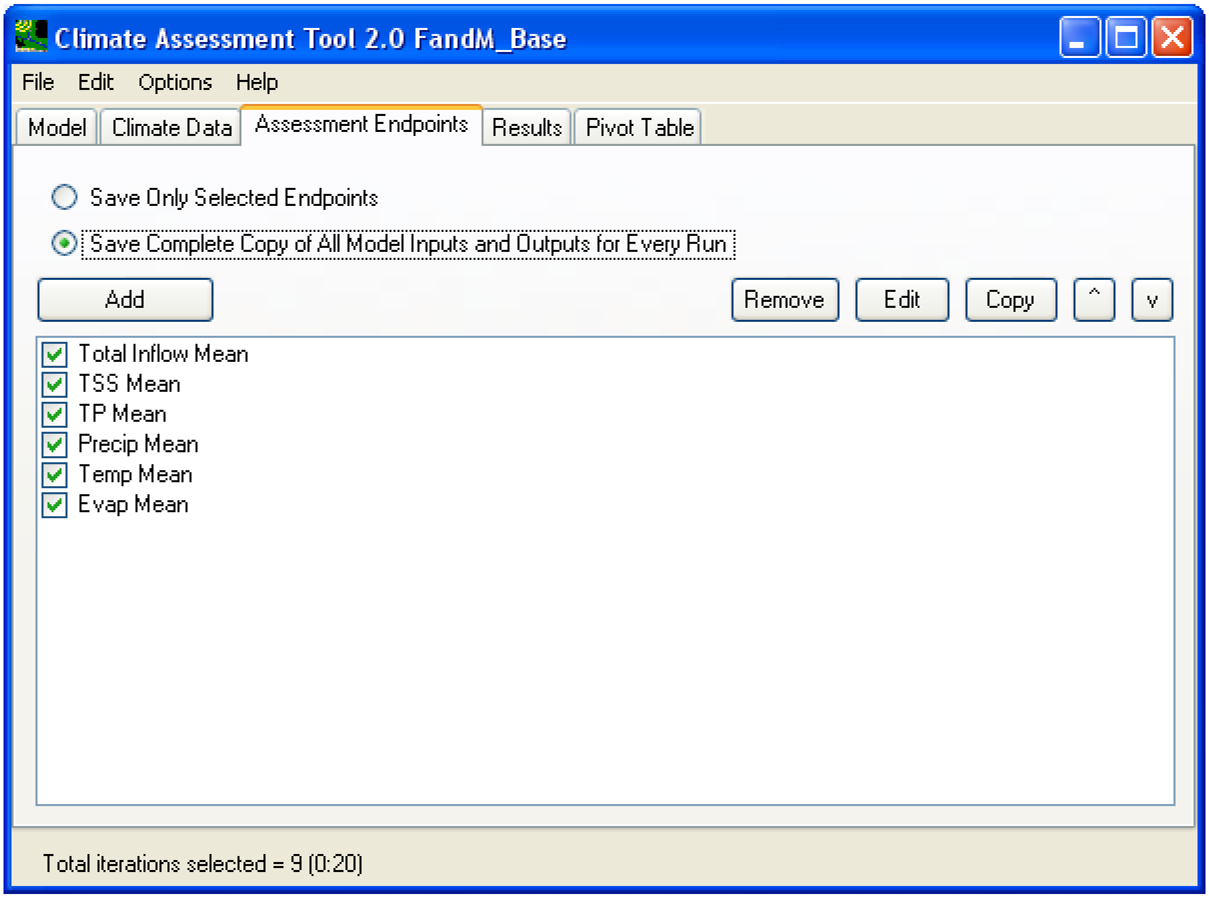


Click **OK** to accept data selection, then the endpoint definition window will look like below:



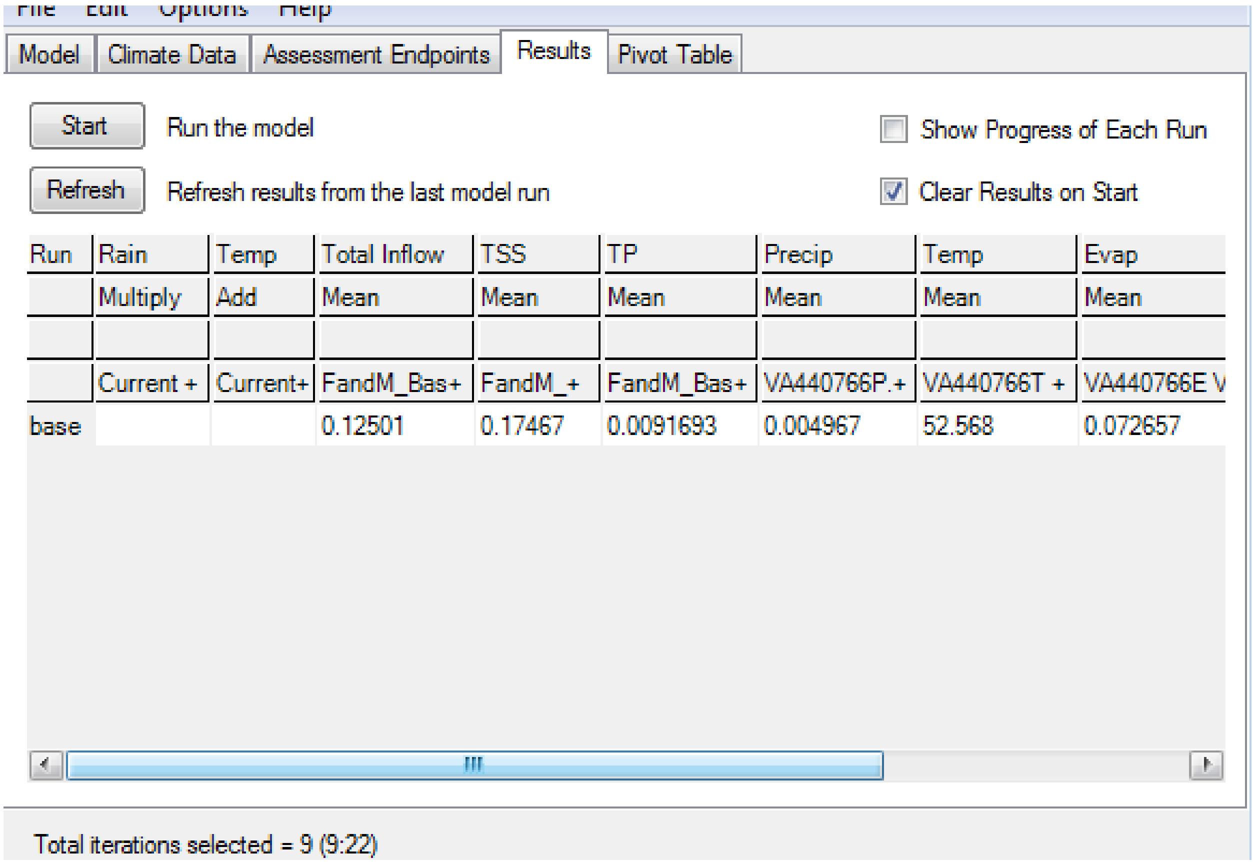
Be sure to use the default statistic attribute, i.e. 'Mean'.

Click **OK** to accept the endpoint definition, then, the **Endpoint Assessment** tab will look like below:

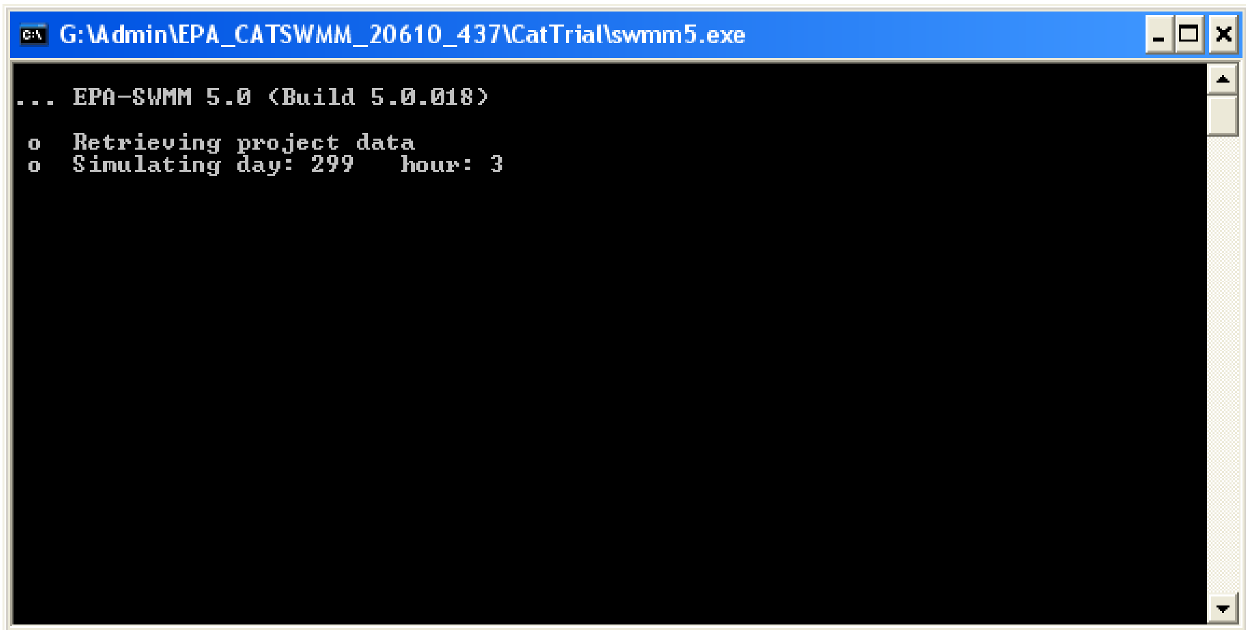


Now you have defined both input modifications and endpoints to be inspected, you are ready to conduct the analysis by running the SWMM model for the defined combination of climate change scenarios.

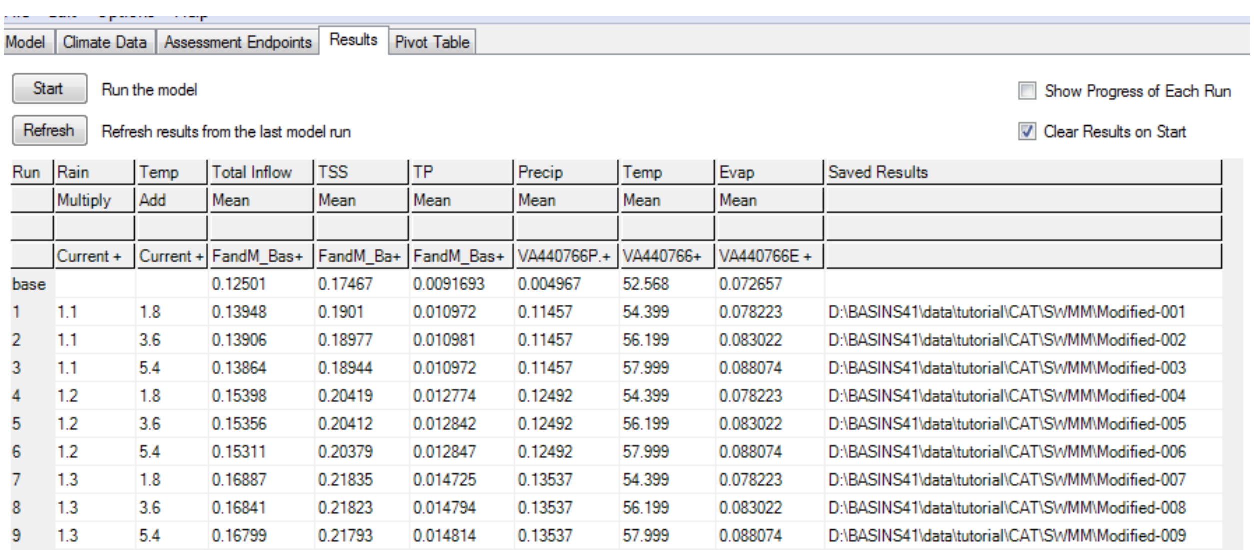
Click the **Results** tab and right away, you will see the result grid has already been populated with the endpoints' statistics from the base case scenario, it is in the first row of the result grid as shown below:



Since this is a brand new CAT analysis, click the **Start** button to initiate the simulations. You will see SWMM execution in the popup DOS window for each combination of the defined climate data modifications as shown below:



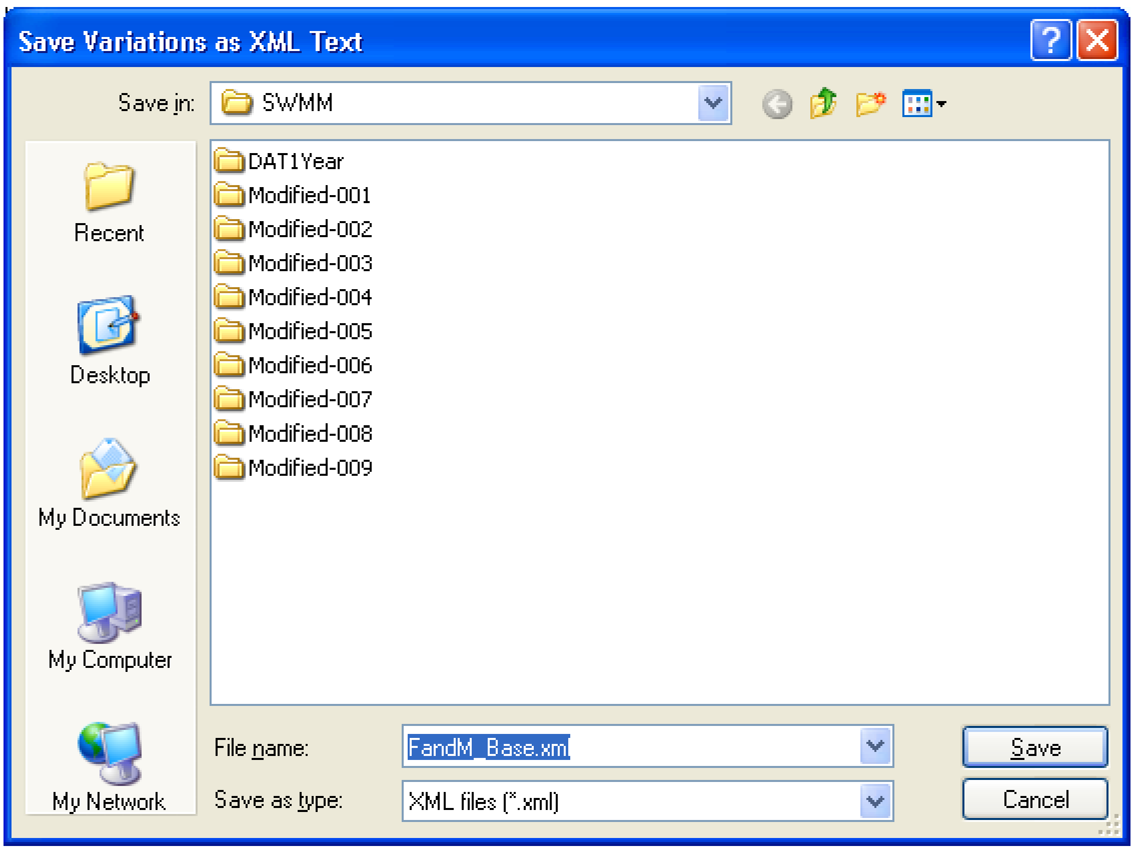
Since we defined 3 levels of changes in precipitation and 3 levels of changes in temperature, hence, there will be 9 (3 x 3) SWMM simulations in total as shown below on the **Results** tab. Evaporation is recalculated every time temperature data is changed, it is not considered as an independent climate change scenario.



Run	Rain	Temp	Total Inflow	TSS	TP	Precip	Temp	Evap	Saved Results
	Multiply	Add	Mean	Mean	Mean	Mean	Mean	Mean	
	Current +	Current +	FandM_Bas+	FandM_Ba+	FandM_Bas+	VA440766P.+	VA440766+	VA440766E +	
base			0.12501	0.17467	0.0091693	0.004967	52.568	0.072657	
1	1.1	1.8	0.13948	0.1901	0.010972	0.11457	54.399	0.078223	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-001
2	1.1	3.6	0.13906	0.18977	0.010981	0.11457	56.199	0.083022	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-002
3	1.1	5.4	0.13864	0.18944	0.010972	0.11457	57.999	0.088074	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-003
4	1.2	1.8	0.15398	0.20419	0.012774	0.12492	54.399	0.078223	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-004
5	1.2	3.6	0.15356	0.20412	0.012842	0.12492	56.199	0.083022	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-005
6	1.2	5.4	0.15311	0.20379	0.012847	0.12492	57.999	0.088074	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-006
7	1.3	1.8	0.16887	0.21835	0.014725	0.13537	54.399	0.078223	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-007
8	1.3	3.6	0.16841	0.21823	0.014794	0.13537	56.199	0.083022	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-008
9	1.3	5.4	0.16799	0.21793	0.014814	0.13537	57.999	0.088074	D:\BASINS41\data\tutorial\CAT\SWMM\Modified-009

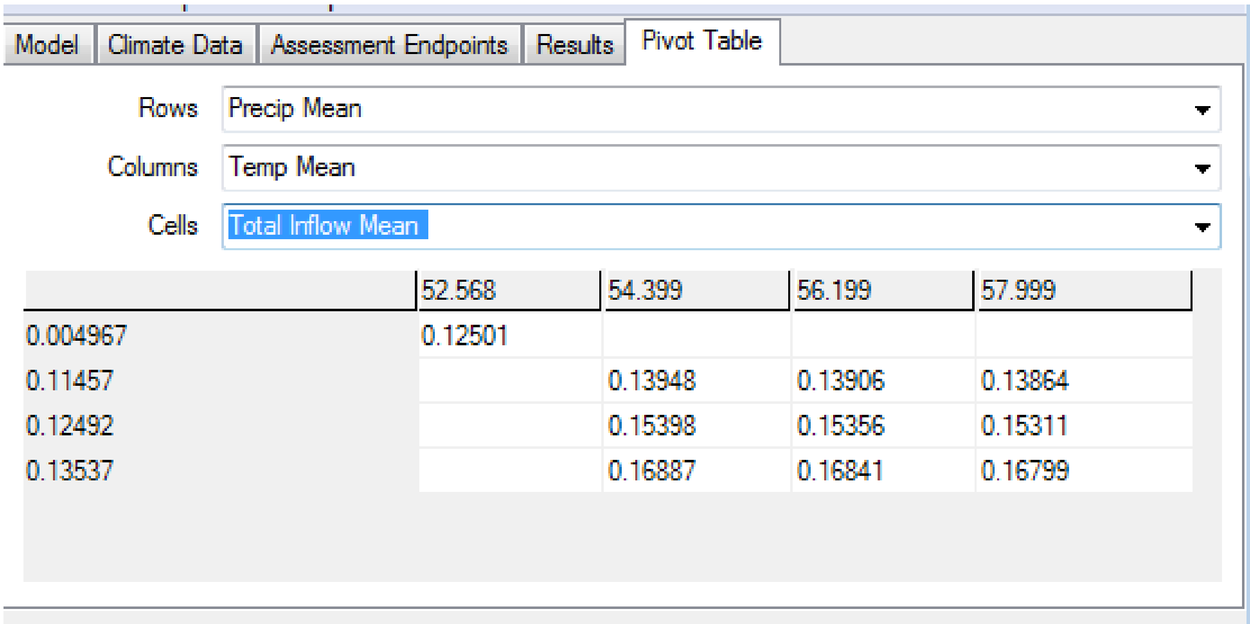
On the above **Results** tab, endpoints are listed on the top as column headers and the scenarios' ordinal number are listed as row numbers.

Now we can save our work. From the 'File' menu on the top of the CAT window, select "Save Model with CAT Settings" option to save all of our input modifications and output endpoint statistic choices into a XML file as shown below:

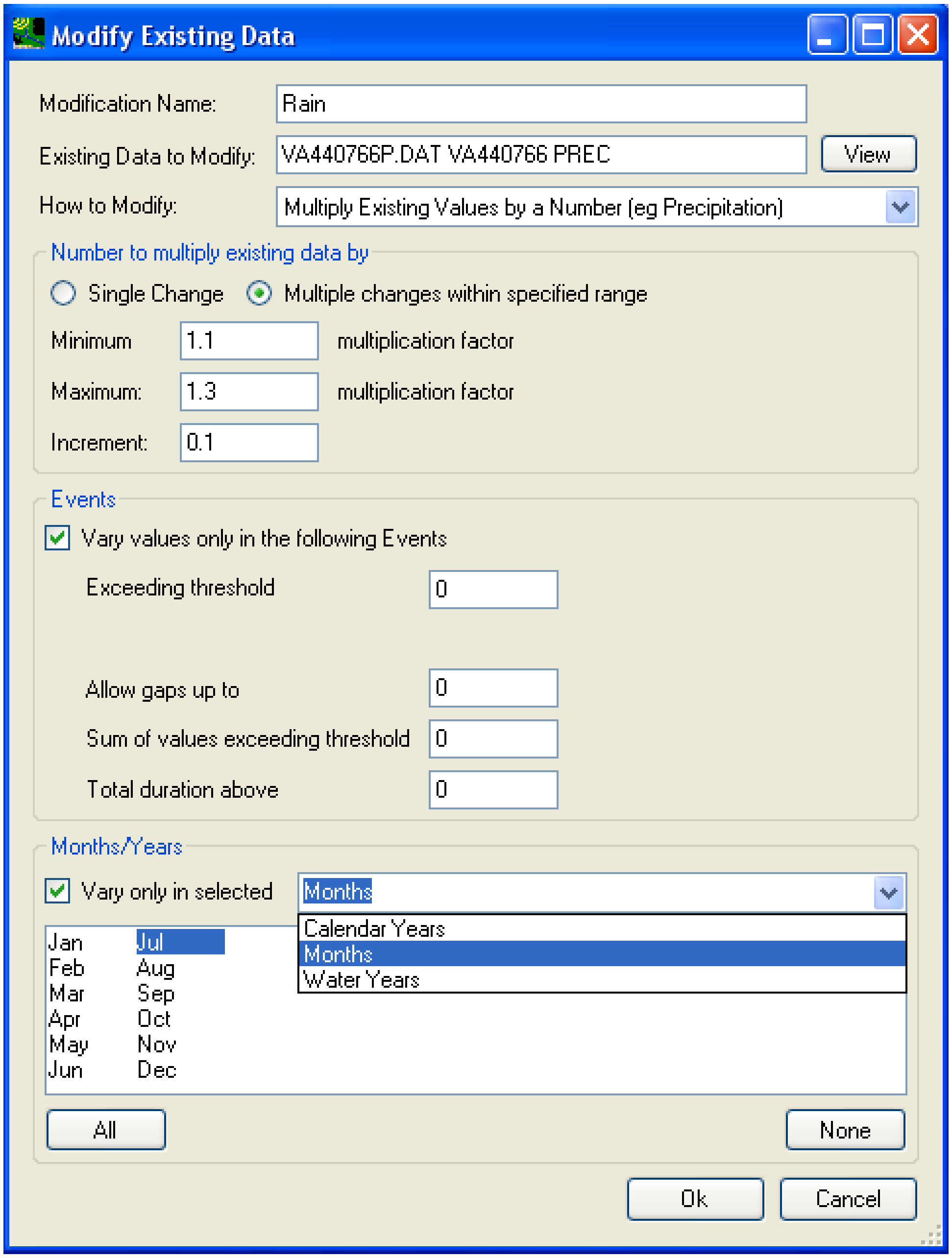


From the 'File' menu, select 'Save Results Table' option to save the result grid into a tab-delimited text file.

We can examine the results in a pivot table on the **Pivot Table** tab as shown below:

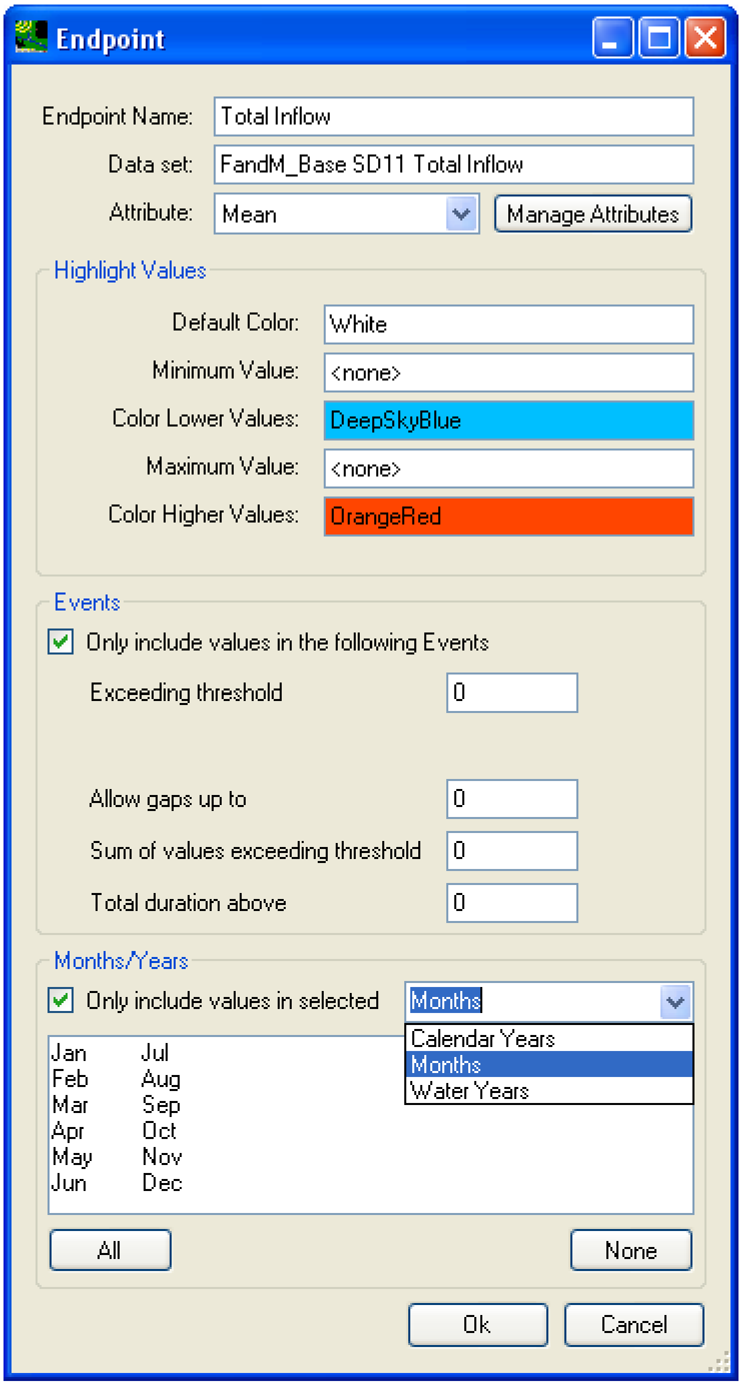


Lastly, users can explore additional options offered in CAT during climate data modification and endpoint statistic definition. For example, rainfall data change can be specified to be applied only to certain events or months/years as shown below:



Events are defined in terms of intensity, duration, volumes, and gaps. Changes in rainfall pattern are represented by applying changes to selected calendar years, water years, or months within a year. The combined event- and selective duration-based changes offer tremendous flexibility in representing varying degree of changing climate patterns.

The same event- and duration-based logic also applies to endpoints' statistics as shown below.



This gives user maximum control over the extraction of endpoints statistics.

Users are encouraged to try out different approach for setting up input climate data modification and endpoint statistic representations. This concludes this tutorial on climate assessment analysis using BASINS CAT with the SWMM model.

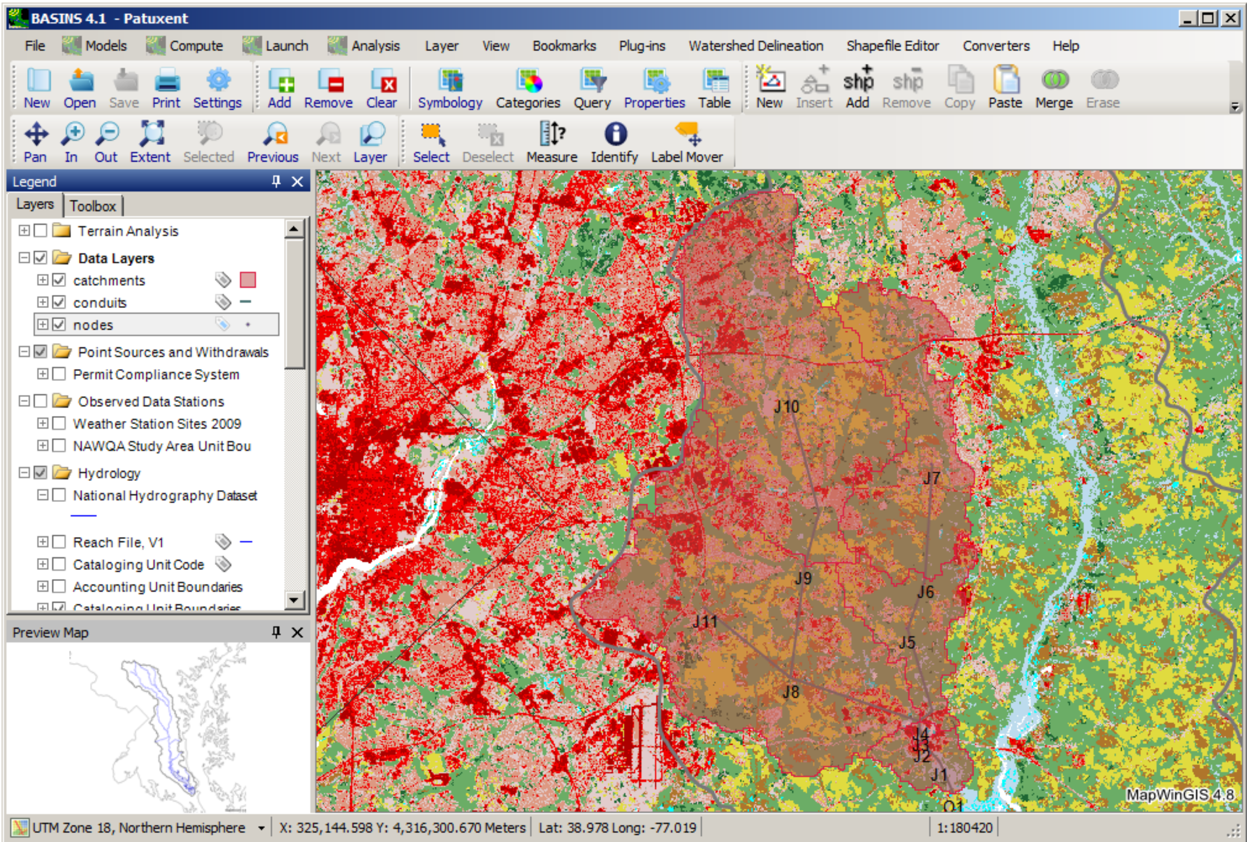
Starting SWMM

The EPA **Storm Water Management Model (SWMM)** can be setup using GIS data and the meteorologic timeseries data available within BASINS. Execute the following steps to construct and run a *SWMM* model for a select area within the Patuxent watershed.

Note: SWMM 5.0 is not included with this package. It may be downloaded from http://www.epa.gov/ednnrmrl/models/swmm/

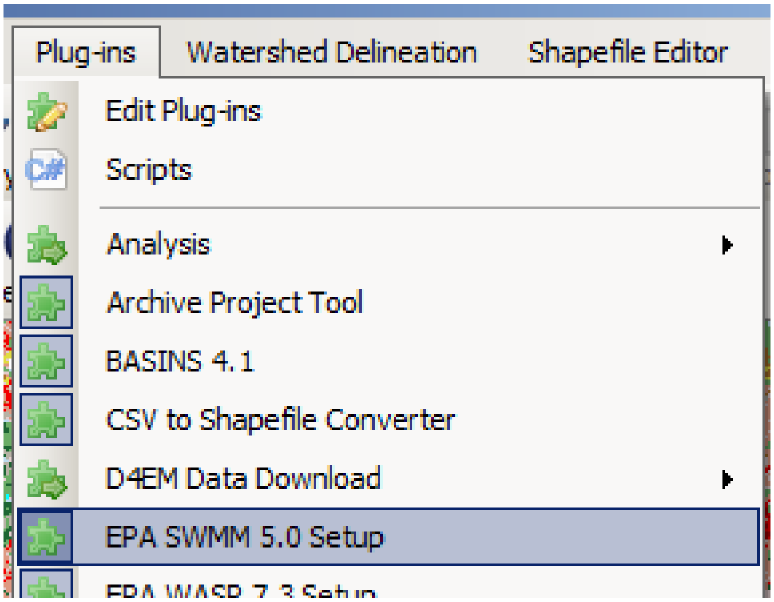
Before beginning this tutorial, be sure you have completed the first two tutorials, *Building a BASINS 4.5 Project* and *Downloading Additional Data*. This tutorial also uses the NLCD Land Cover data, so use the Download Data tool to download the Land Cover data from NLCD2001.

The BASINS/SWMM Setup Plug-in is normally used in conjunction with existing shapefiles of subcatchments, conduits, and nodes, as might be available for an existing storm or sanitary sewer system. (More details about building these layers using BASINS tools can be found in the Tutorial section entitled Tutorial: Preparing GIS Data for use in the BASINS/SWMM plug-in.) Add the catchments, conduits, and nodes shapefiles from the \BASINS\data\SWMMtutorial folder to the current Patuxent project. (In the image below, the nodes are labeled on the map and the Terrain Analysis group from the Automatic Watershed Delineation is visible in the legend; both are optional steps that are not required to run this tutorial.)

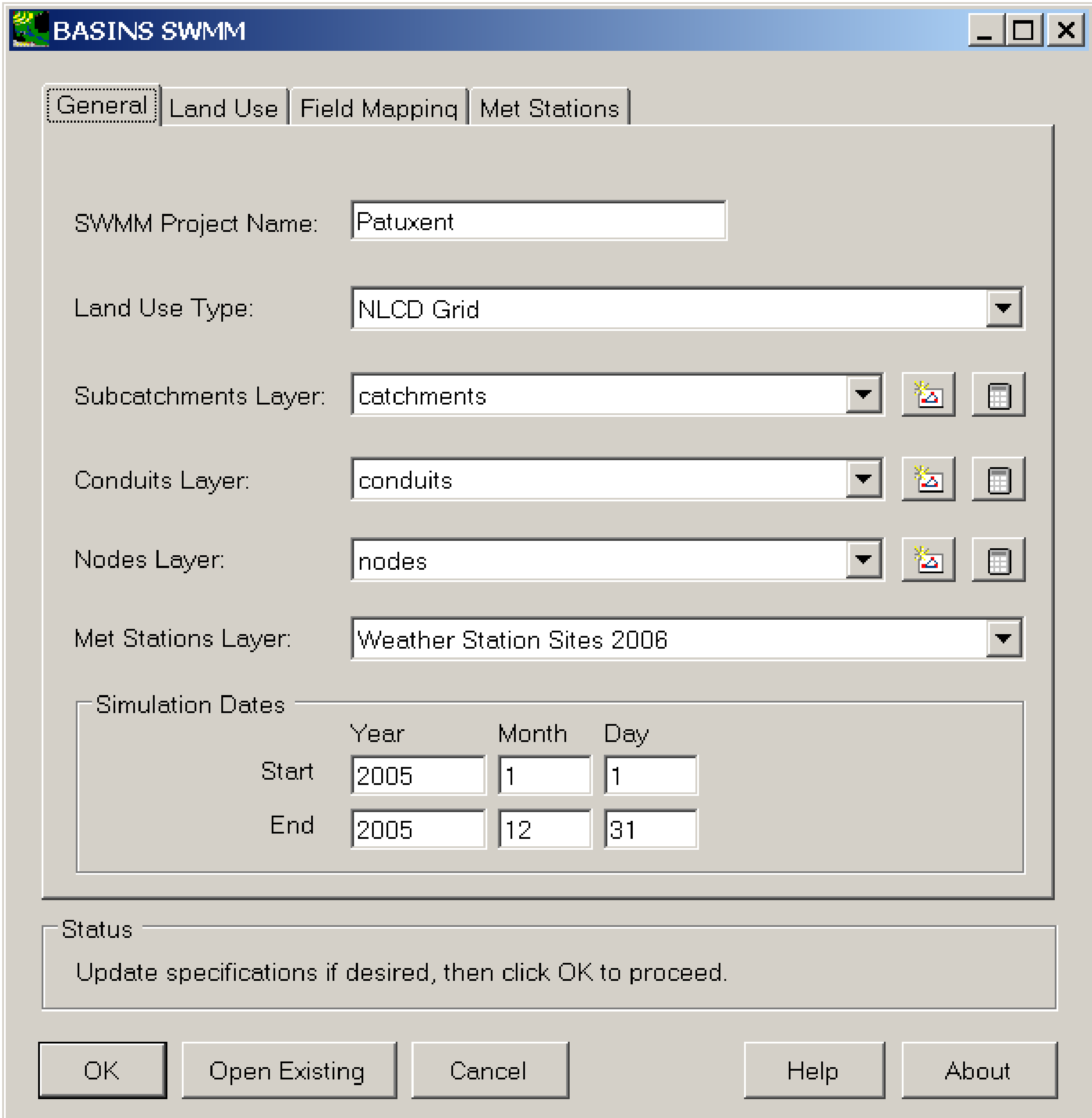


BASINS 4.1 - Patuxent
File
Models
Compute
Launch
Analysis
Layer
View
Bookmarks
Plug-ins
Watershed Delineation
Shapefile Editor
Converters
Help
New
Open
Save
Print
Settings
Add
Remove
Clear
Symbology
Categories
Query
Properties
Table
New
Insert
Add
Remove
Copy
Paste
Merge
Erase
Pan
In
Out
Extent
Selected
Previous
Next
Layer
Select
Deselect
Measure
Identify
Label Mover
Legend
Layers
Toolbox
Terrain Analysis
Data Layers
catchments
conduits
nodes
Point Sources and Withdrawals
Permit Compliance System
Observed Data Stations
Weather Station Sites 2009
NAWQA Study Area Unit Bou
Hydrology
National Hydrography Dataset
Reach File, V1
Cataloging Unit Code
Accounting Unit Boundaries
Preview Map
J10
J7
J9
J6
J11
J5
J8
J4
J2
J1
O1
MapWinGIS 4.8
UTM Zone 18, Northern Hemisphere
X: 325,144.598 Y: 4,316,300.670 Meters
Lat: 38.978 Long: -77.019
1:180420

1. Select **EPA SWMM 5.0 Setup** from the **Plug-ins** menu so that it is active. This will add **SWMM** to the Models menu on the main form.

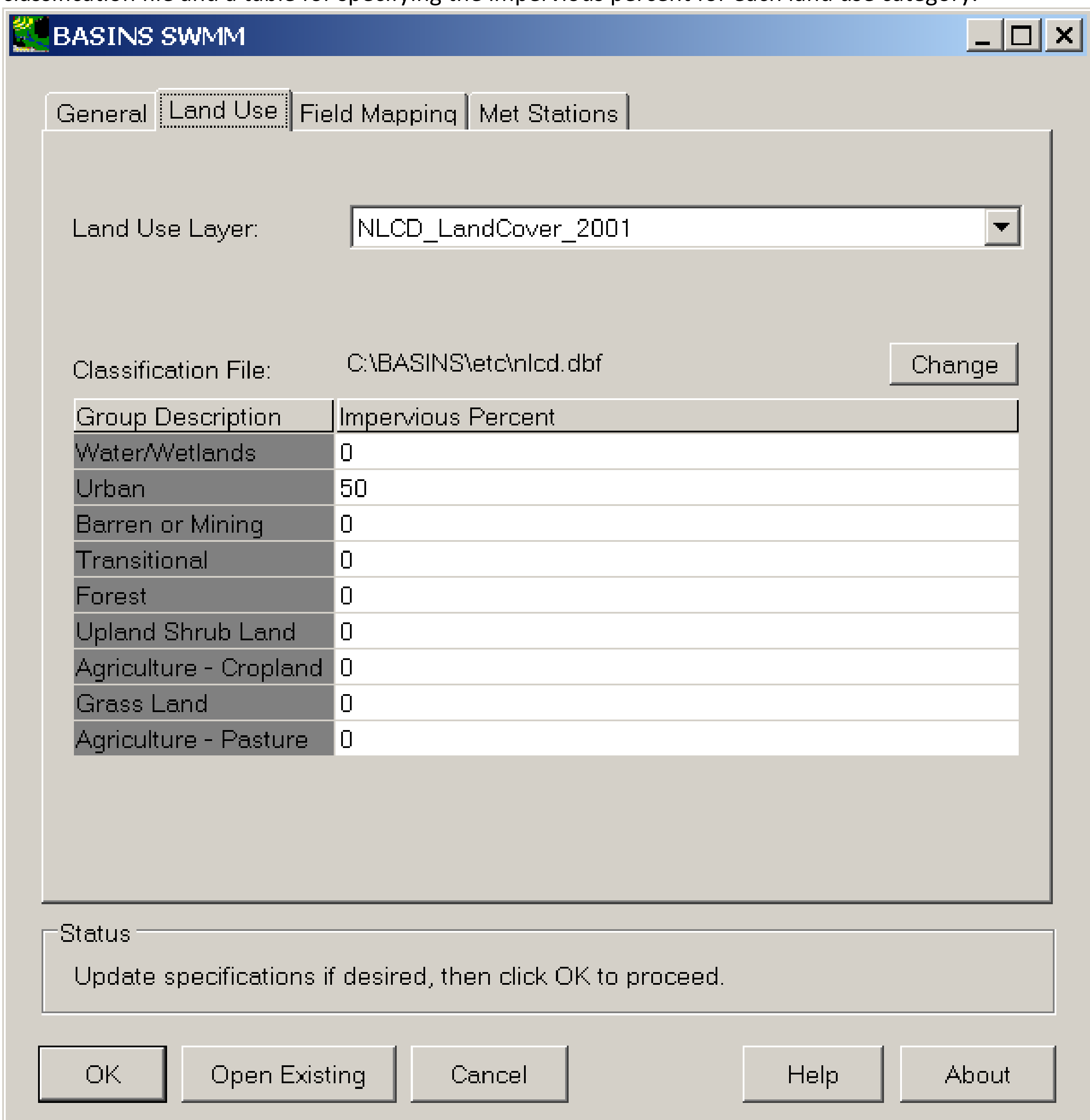


2. Select **Models:SWMM** from the main menu, and the *BASINS SWMM* form appears. The interface loads with the **General** tab active. This tab includes fields for the user to specify the SWMM project name (which defaults to the name of the BASINS project), the land use type (NLCD Grid and USGS GIRAS shapefile are 2 types available in BASINS depending upon the data downloaded for the project, or a user may choose to specify another grid or shapefile), map layers for catchments, conduits, and nodes (nodes layer is optional), the BASINS met stations layer (usually called Weather Station Sites 2009 in BASINS), and start and end dates for the simulation.



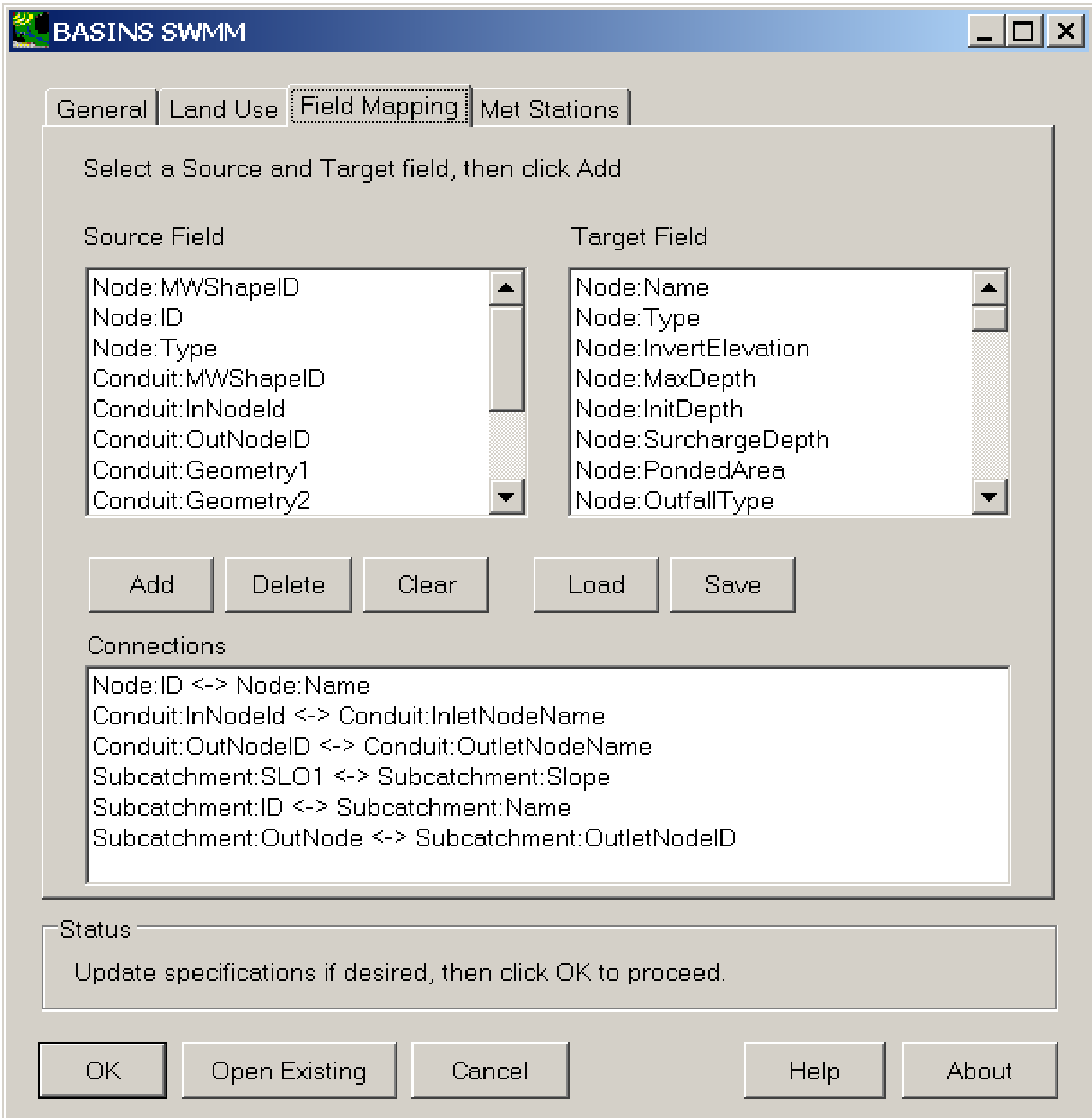
All of the fields will be defaulted appropriately, specifying that the user-provided layers of subcatchments, conduits, and nodes will be used along with the NLCD landuse data. Provided that the BASINS meteorological data has been downloaded as specified in the Downloading Additional Data lesson, the Met Stations Layer will default to 'Weather Stations Sites 2009'. As the BASINS/SWMM PlugIn loads, the meteorological data is scanned to build the lists of available met data. This process may take a minute or two, depending upon how much met data is included in the BASINS project. The start and end dates for the simulation default to the most recent calendar year of data for the selected met stations (specified on the Met Stations tab). The simulation dates can be changed to any period within the span of the selected met stations, but be aware that using many years of hourly met data will result in a very large SWMM project file.

3. The **Land Use** tab contains the user interface for specifying details about the land use layer to be used. The particular land use layer is specified on this tab, and it is defaulted based on the type of land use specified on the General tab. For this example, it will be set to 'NLCD LandCover 2001', which is the land use type specified. Also, on this tab is a dialog for specifying a classification file and a table for specifying the impervious percent for each land use category.



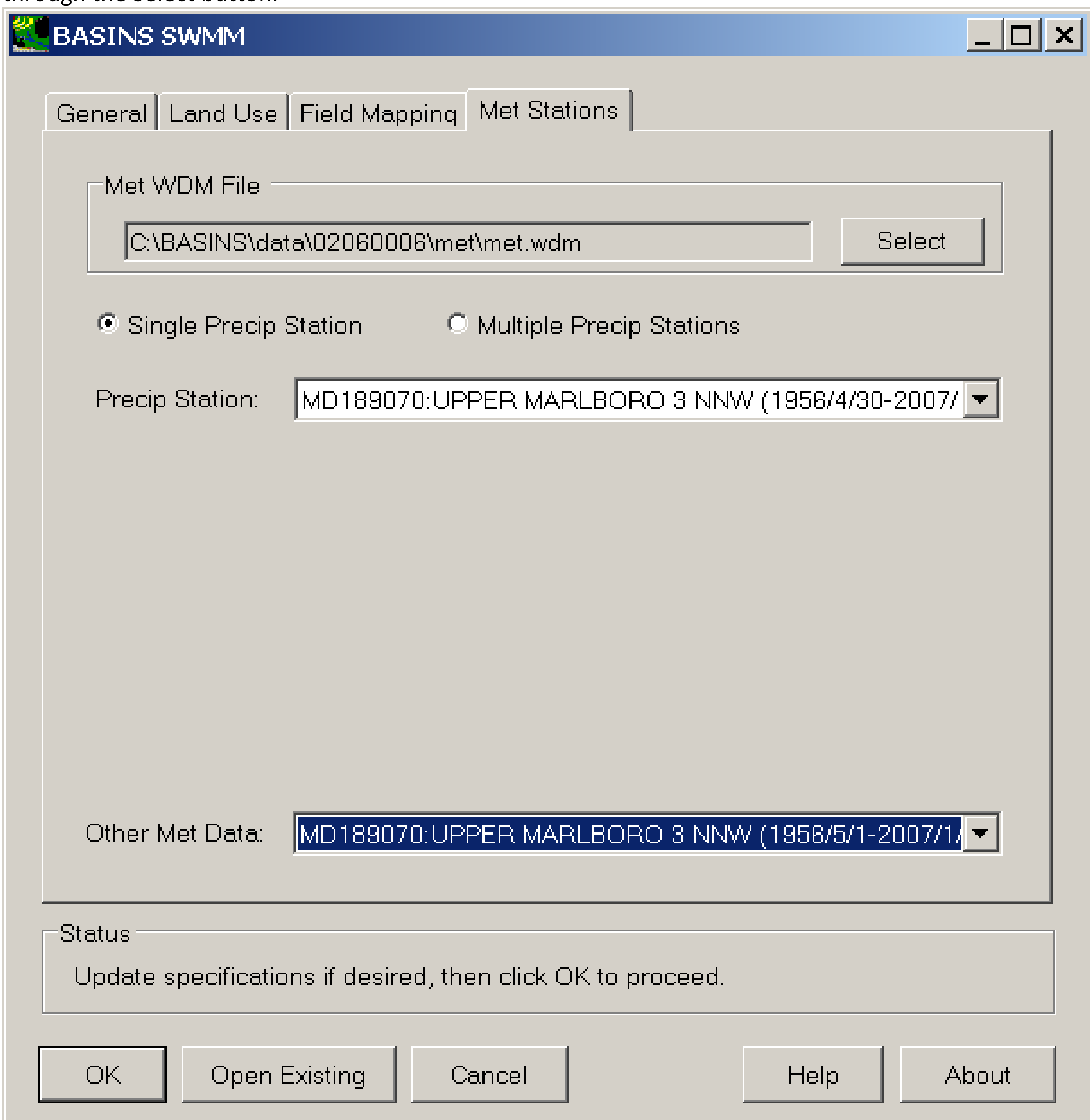
The land use classification file is a simple dbf file that contains a list of land use codes and a corresponding group description, for use in grouping land use codes into categories. A very similar interface is available in BASINS/HSPF Plug-in. For instance, the land use classification file might indicate that codes 21 through 24 should all be grouped together into one ‘Urban’ category. The user may create or modify this file as desired. By default, the file will be set to one called nlcd.dbf when using NLCD data.

4. The **Field Mapping** tab is used to map fields from the subcatchment, conduit, and node shapefile attribute tables specified on the ‘General’ tab to the variables in the BASINS/SWMM PlugIn data structure where that data will be used. This field mapping will default appropriately if using the output from a BASINS watershed delineation as the subcatchments and conduits, but it is needed if the user has obtained this data from a source other than BASINS.

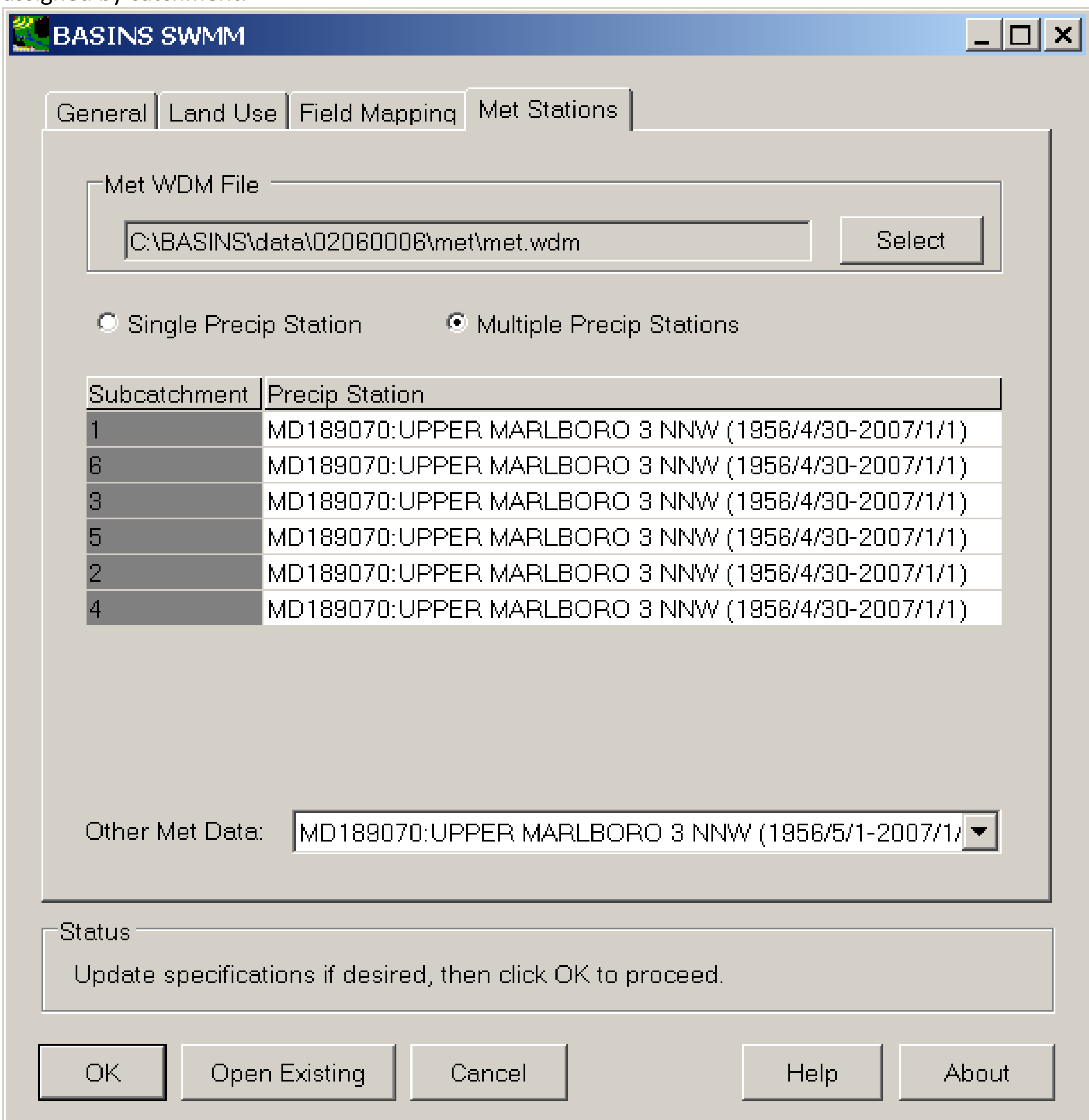


The list entitled 'Source Field' includes all of the fields of each attribute table associated with the specified subcatchment, conduit, and node shapefiles. The 'Target Field' list includes all of the information the BASINS/SWMM PlugIn can populate given corresponding information from a shapefile attribute. The user adds to the list of connections below by selecting a source field, and target field, and then clicking 'Add'. For instance, a user might have a field on the nodes shapefile attribute table named 'InvertElev' containing invert elevations. The user could map this field to the Invert Elevations of the nodes in SWMM by selecting Node:InvertElev on the source field list, selecting Node:InvertElevation in the target field list, and then clicking the 'Add' button to add it to the list of field connections. The Delete button is used to delete a connection from the connections list, while the Clear button is used to clear all the connections from the connections list. The Load and Save buttons are used to read in and write out the list of connections for use in a later application of the BASINS/SWMM Plug-in, if desired.

5. The **Met Stations** tab is used to specify which meteorological stations will be used to provide meteorological input for the model. In normal BASINS use, the met WDM file will be set to the name of the WDM that corresponds to the met stations layer specified on the General tab. Any other WDM file containing met data can be used through this interface by choosing that file through the Select button.



The precipitation station is specified through a single drop down list, as is the station for obtaining all other meteorological constituents. The BASINS/SWMM interface allows a user to specify a single precipitation station for the entire SWMM study area, or a precipitation station for each SWMM catchment. To specify a precipitation station for each catchment, chose the 'multiple precip stations' option. With this option selected, a precipitation stations may be assigned by catchment.



6. Once all of the specifications are set as desired, click OK to create the SWMM project. After processing, the SWMM 5.0 interface will open with the newly created project.

7.

Tutorial: Preparing GIS Data for use in the BASINS/SWMM Plug-in

The BASINS/SWMM plug-in is normally used in conjunction with existing shapefiles of subcatchments, conduits, and nodes, as might be available for an existing storm or sanitary sewer system. If available these layers should be used in building the new SWMM project. See the SWMM section of this User's Manual for more details.

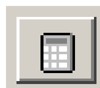
The GIS layers of subcatchments, conduits, and nodes may also be created using the BASINS watershed delineation and/or shapefile editing tools. This section provides brief tutorials illustrating how the BASINS delineation and shapefile editing tools can be used to create the shapefiles of subcatchments, conduits, and nodes, expected by the BASINS/SWMM plug-in.

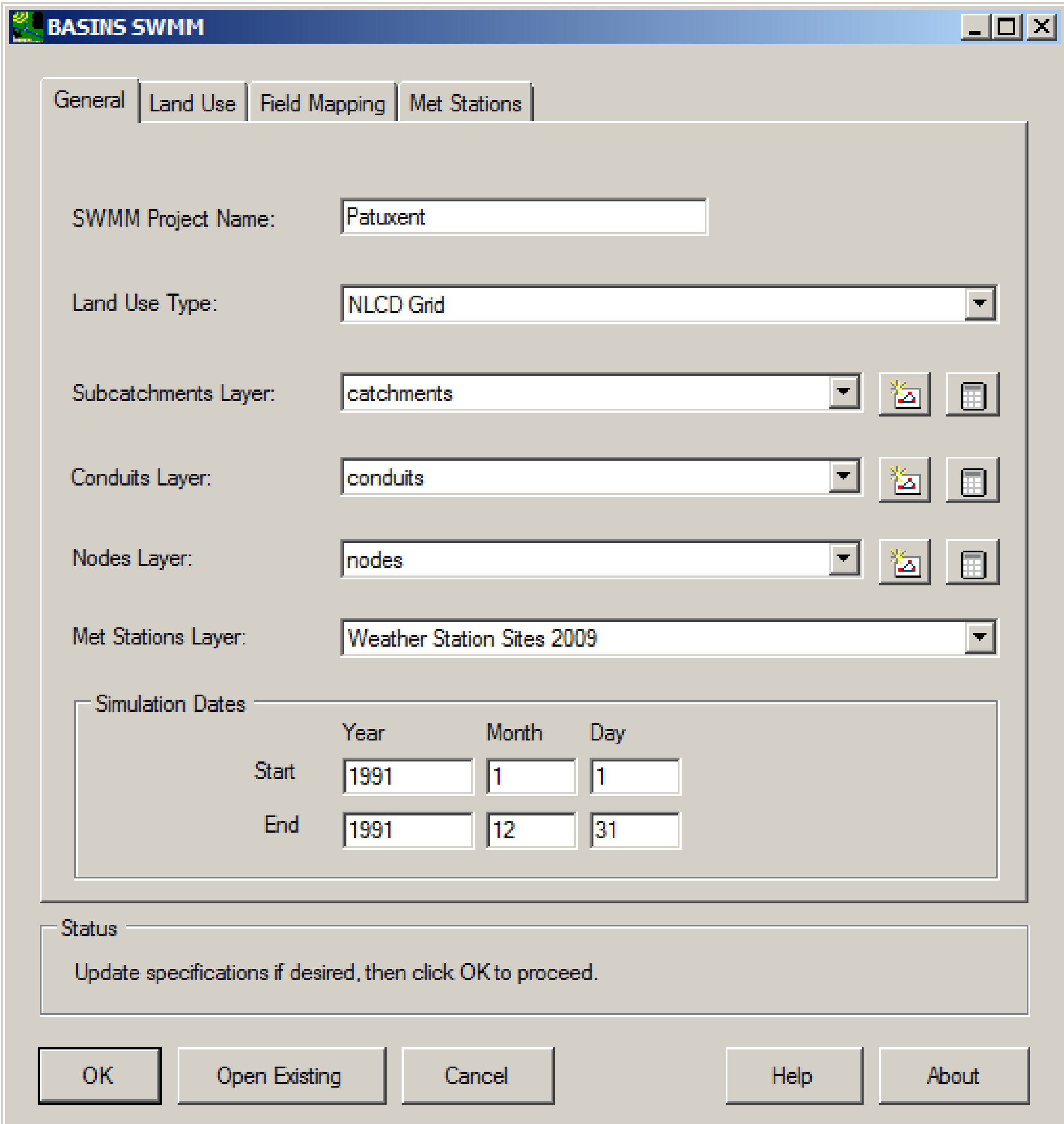
Tutorials are provided for preparing GIS data by the following methods:

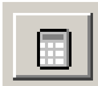
- Using the Automatic Watershed Delineation Tools
- Using the Manual Watershed Delineation Tools
- Using the BASINS Shapefile Editor Tools

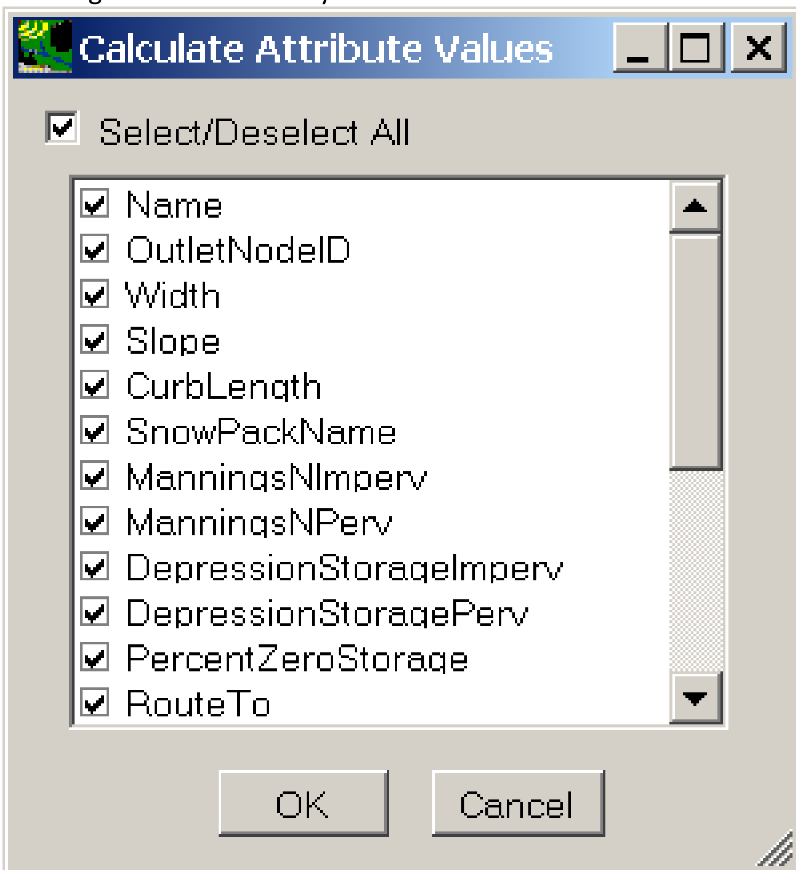
•

More details about preparing GIS data for use in the BASINS/SWMM Plug-in can be found in the User's Manual section titled Preparing GIS Data for use in the BASINS/SWMM Plug-in.

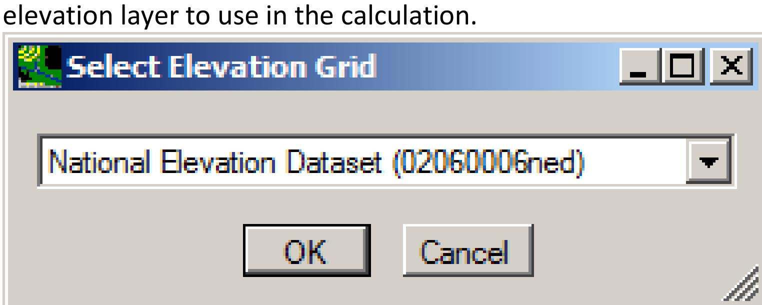
Shapefile attributes may be added to the subcatchments, conduits, and nodes layers once these features have been created. (In the images below these features were created using the Shapefile Editor; the number of features and initial attributes will differ depending upon which method was used to create these features.) Use the  buttons to add the shapefile attributes.


BASINS SWMM
General
Land Use
Field Mapping
Met Stations
SWMM Project Name:
Patuxent
Land Use Type:
NLCD Grid
Subcatchments Layer:
catchments
Conduits Layer:
conduits
Nodes Layer:
nodes
Met Stations Layer:
Weather Station Sites 2009
Simulation Dates
Year
Month
Day
Start
1991
1
1
End
1991
12
31
Status
Update specifications if desired, then click OK to proceed.
OK
Open Existing
Cancel
Help
About

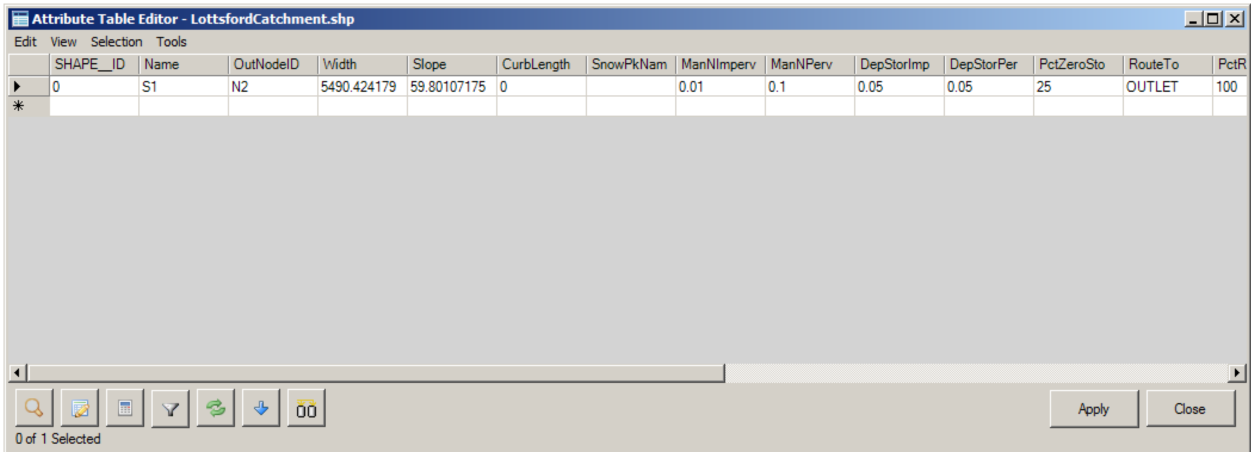
1. Click the  icon next to the Subcatchments Layer field. The following window will appear, showing the fields that may be calculated for the Subcatchments layer.

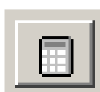


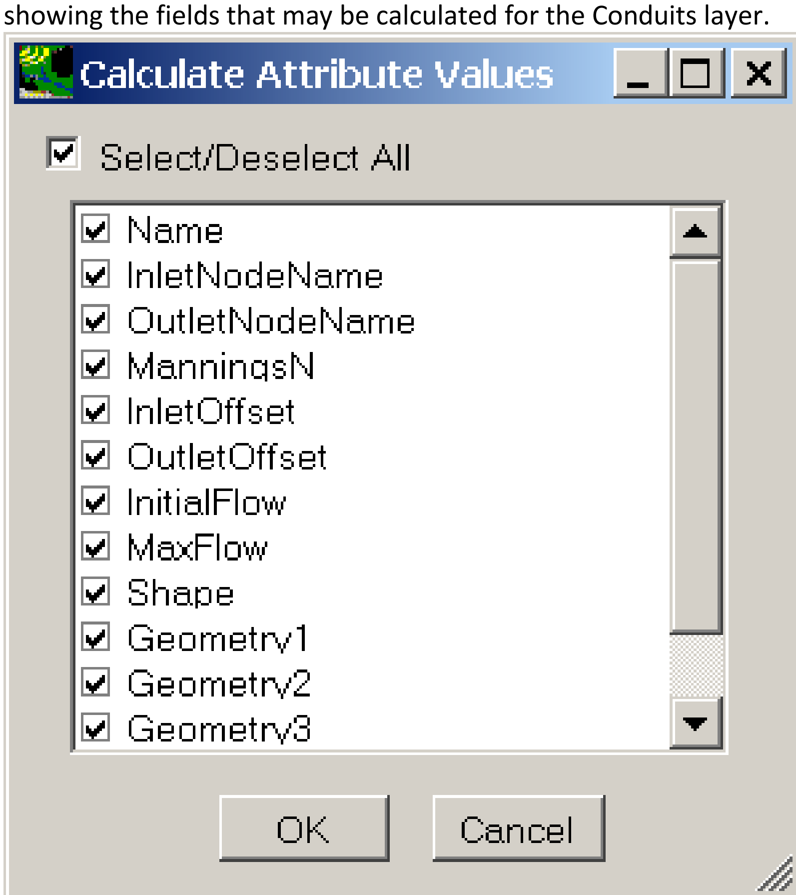
2. The user may choose any or all of the possible attribute values that may be added for each subcatchment feature. Clicking ‘OK’ on this form will calculate the selected values for each feature, in many cases using the default value. If a value for an attribute already exists on the shapefile, it will be recalculated if that field is checked. If the field does not exist, it will be added. In the case of the average slope of a subcatchment, the interface will prompt for an elevation layer to use in the calculation.



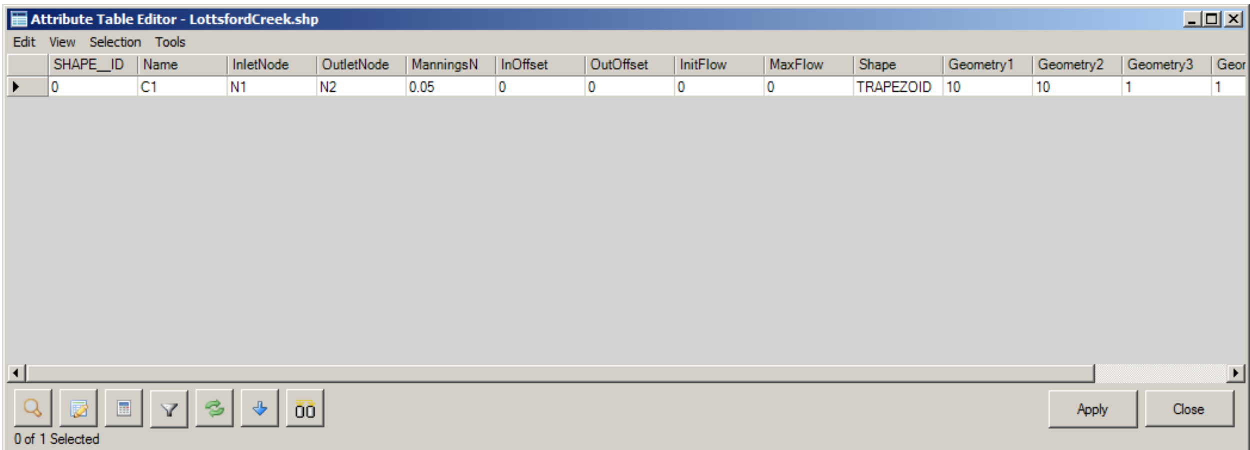
3. After calculating the attributes, the user may use the Table Editor icon  to view the attributes that have been added.

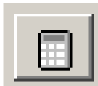


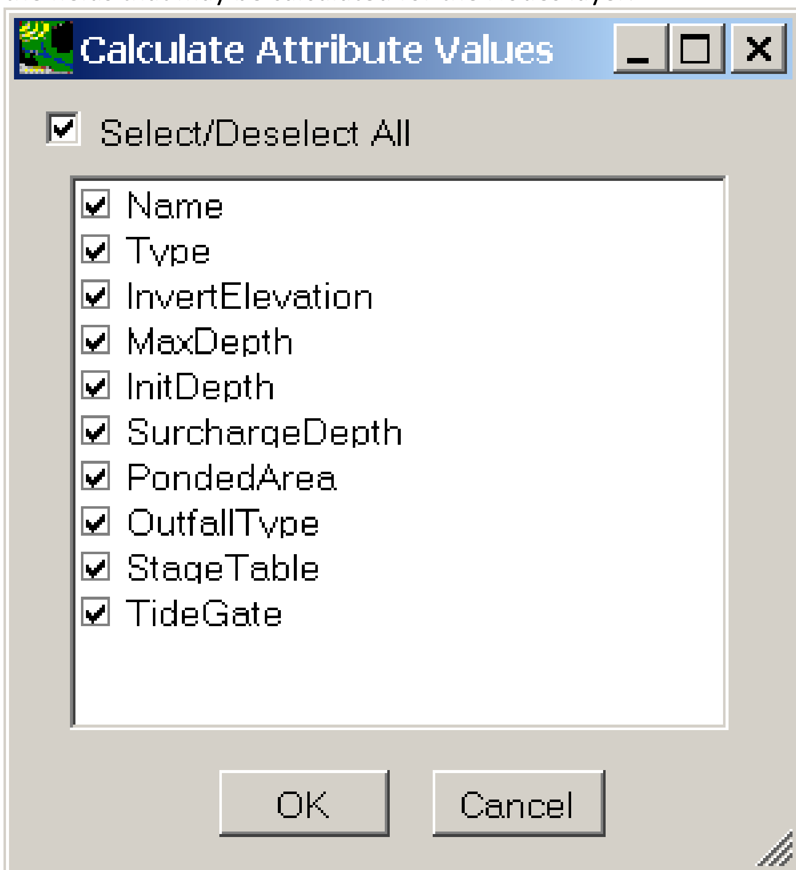
4. Click the  icon next to the Conduits Layer field. The following window will appear, showing the fields that may be calculated for the Conduits layer.



5. The user may choose any or all of the possible attribute values that may be added for each conduit feature. Clicking 'OK' on this form will calculate the selected values for each feature, in many cases using the default value. If a value for an attribute already exists on the shapefile, it will be recalculated if that field is checked. If the field does not exist, it will be added. After calculating the attributes, the user may use the Table Editor icon  to view the attributes that have been added.

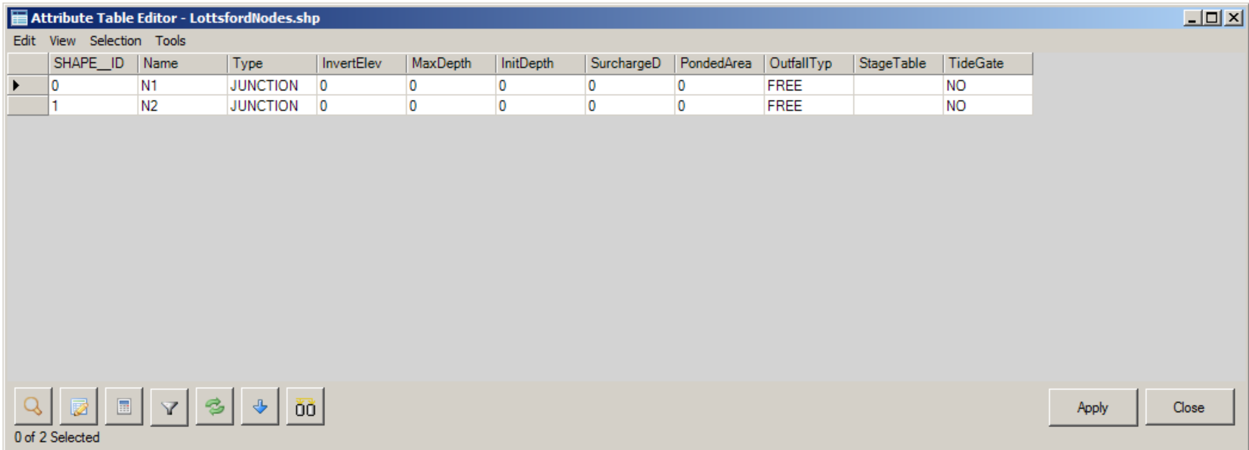


6. Click the  icon next to the Nodes Layer field. The following window will appear, showing the fields that may be calculated for the Nodes layer.



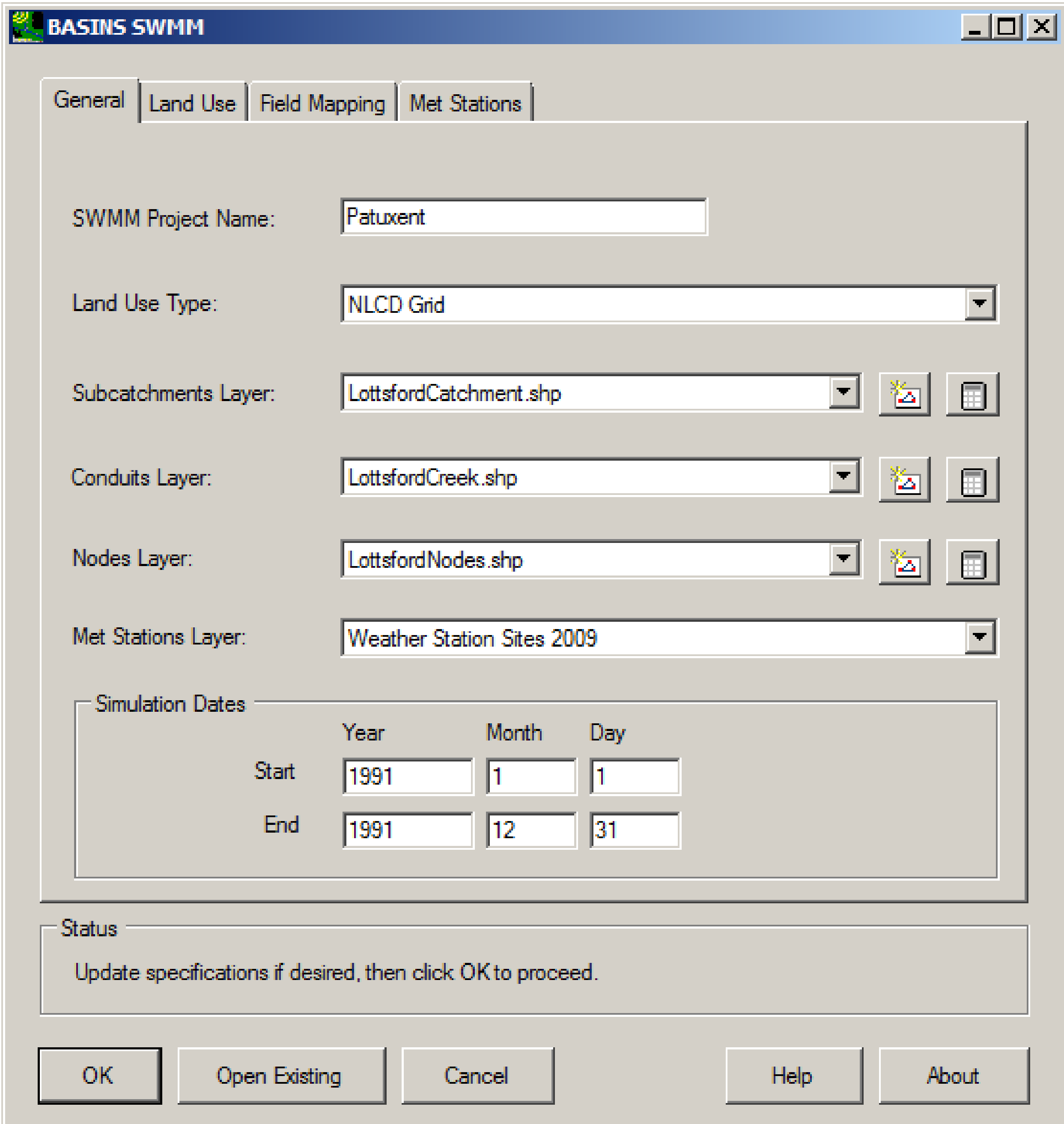
7. The user may choose any or all of the possible attribute values that may be added for each node feature. Clicking 'OK' on this form will calculate the selected values for each feature, in many cases using the default value. If a value for an attribute already exists on the shapefile, it will be recalculated if that field is checked. If the field does not exist, it will be added. After calculating the attributes, the user may use the Table Editor icon  to view the attributes that have

been added.



SHAPE__ID	Name	Type	InvertElev	MaxDepth	InitDepth	SurchargeD	PondedArea	OutfallTyp	StageTable	TideGate
0	N1	JUNCTION	0	0	0	0	0	FREE		NO
1	N2	JUNCTION	0	0	0	0	0	FREE		NO

At this point the new layers for Subcatchments, Conduits, and Nodes have been created and populated. The user may proceed with the BASINS/SWMM plug-in using these layers.

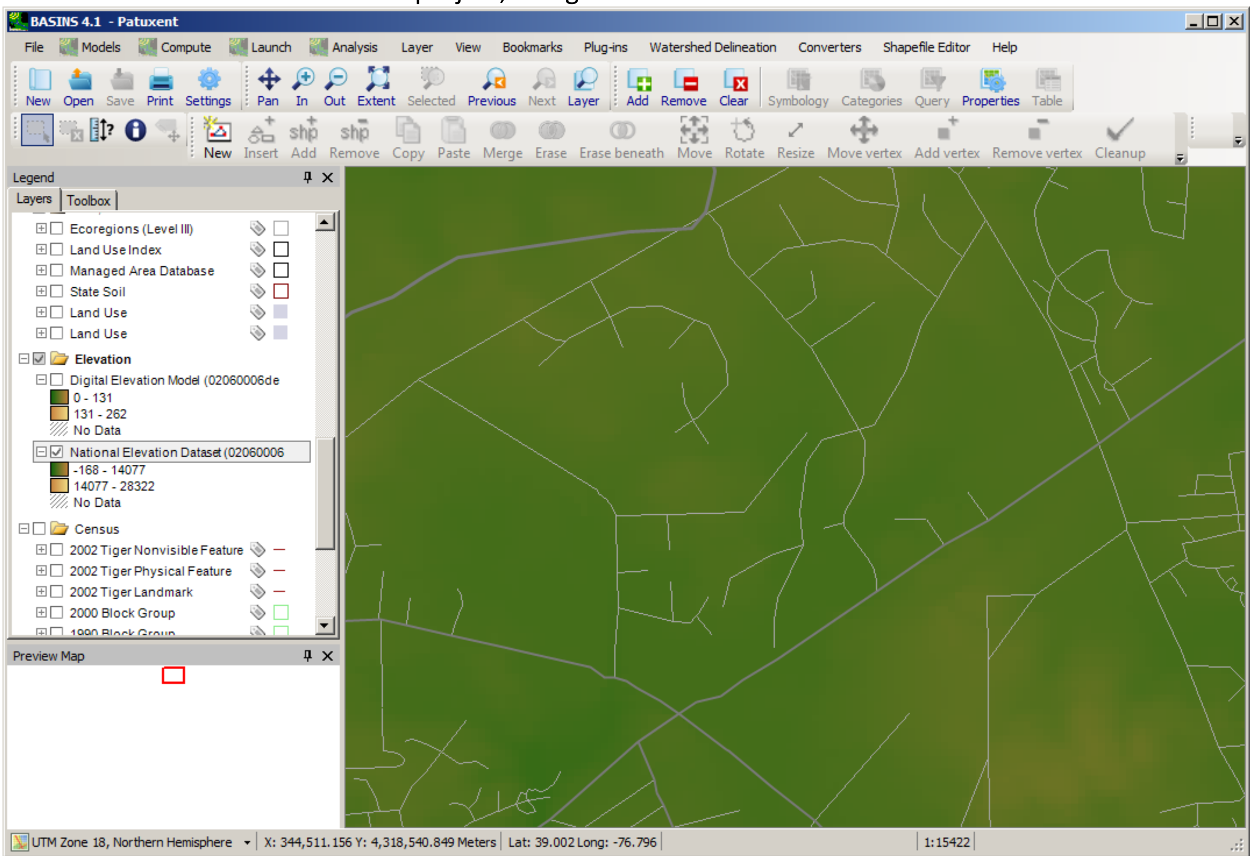

BASINS SWMM
General
Land Use
Field Mapping
Met Stations
SWMM Project Name:
Patuxent
Land Use Type:
NLCD Grid
Subcatchments Layer:
LottsfordCatchment.shp
Conduits Layer:
LottsfordCreek.shp
Nodes Layer:
LottsfordNodes.shp
Met Stations Layer:
Weather Station Sites 2009
Simulation Dates
Year
Month
Day
Start
1991
1
1
End
1991
12
31
Status
Update specifications if desired, then click OK to proceed.
OK
Open Existing
Cancel
Help
About

Using the BASINS Automatic Watershed Delineation Tools to Set Up BASINS/SWMM

The BASINS *Automatic Watershed Delineation* tools may be used to create subcatchment and conduit shapefiles for use in SWMM modeling. The delineation process requires a Digital Elevation Model (DEM) in grid format. Two forms of DEM grids are available through the BASINS Download Data menu. The BASINS DEM Grid (DEMG) has a 100 m resolution while the National Elevation Dataset (NED) has a 30 m resolution.

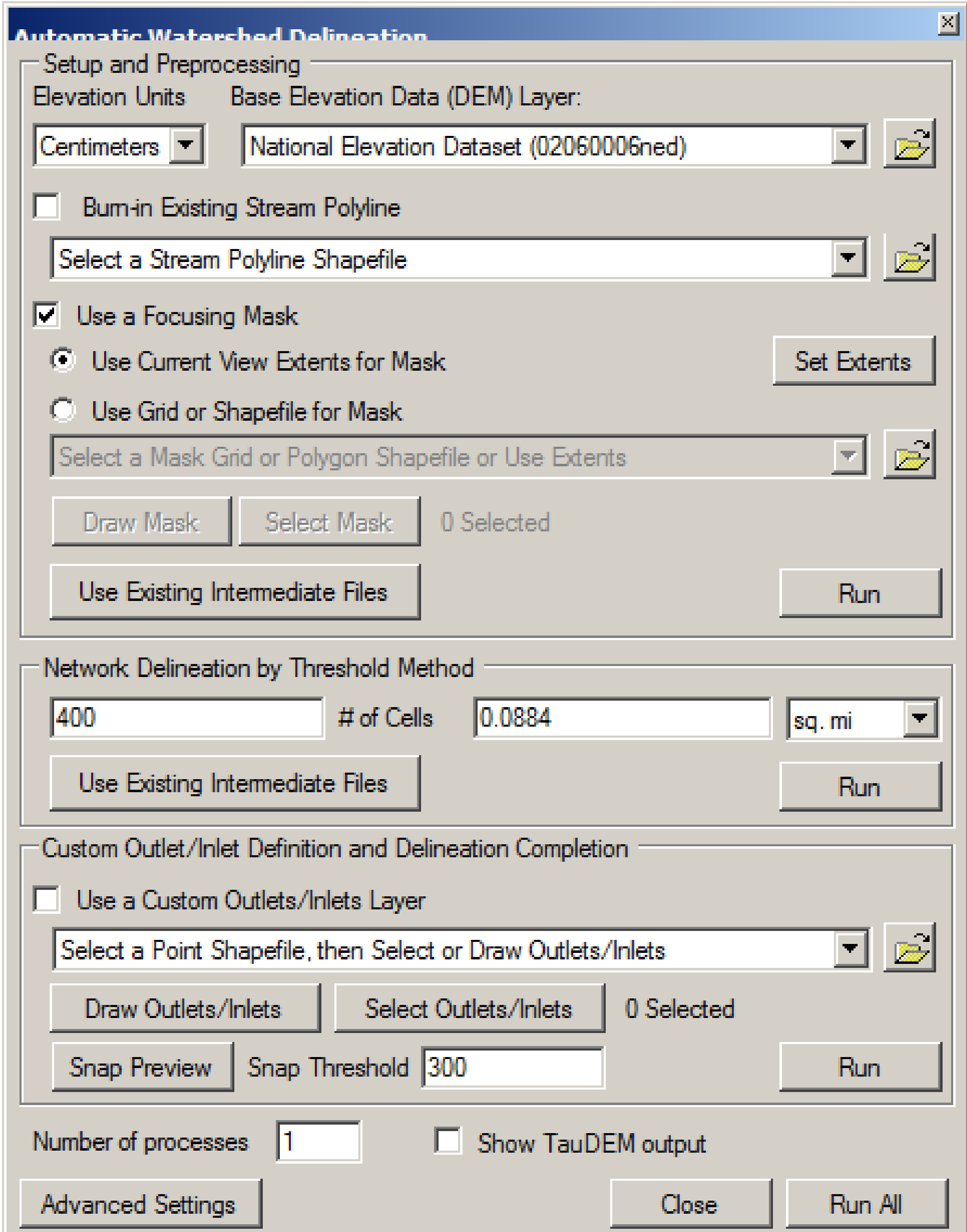
1. For this tutorial, be sure you have built a BASINS project and have downloaded a DEM grid. The following image shows a BASINS project with an NED grid loaded, zoomed in to the approximate

area to be modeled in the SWMM project, along with a street network for reference.



2. Select the **Plug-ins:Watershed Delineation** menu item, which will make the automatic delineation tool available under the **Watershed Delineation:Automatic** menu item. Then select the **Watershed Delineation:Automatic** menu item, and the **Automatic Watershed Delineation**

form will pop up.

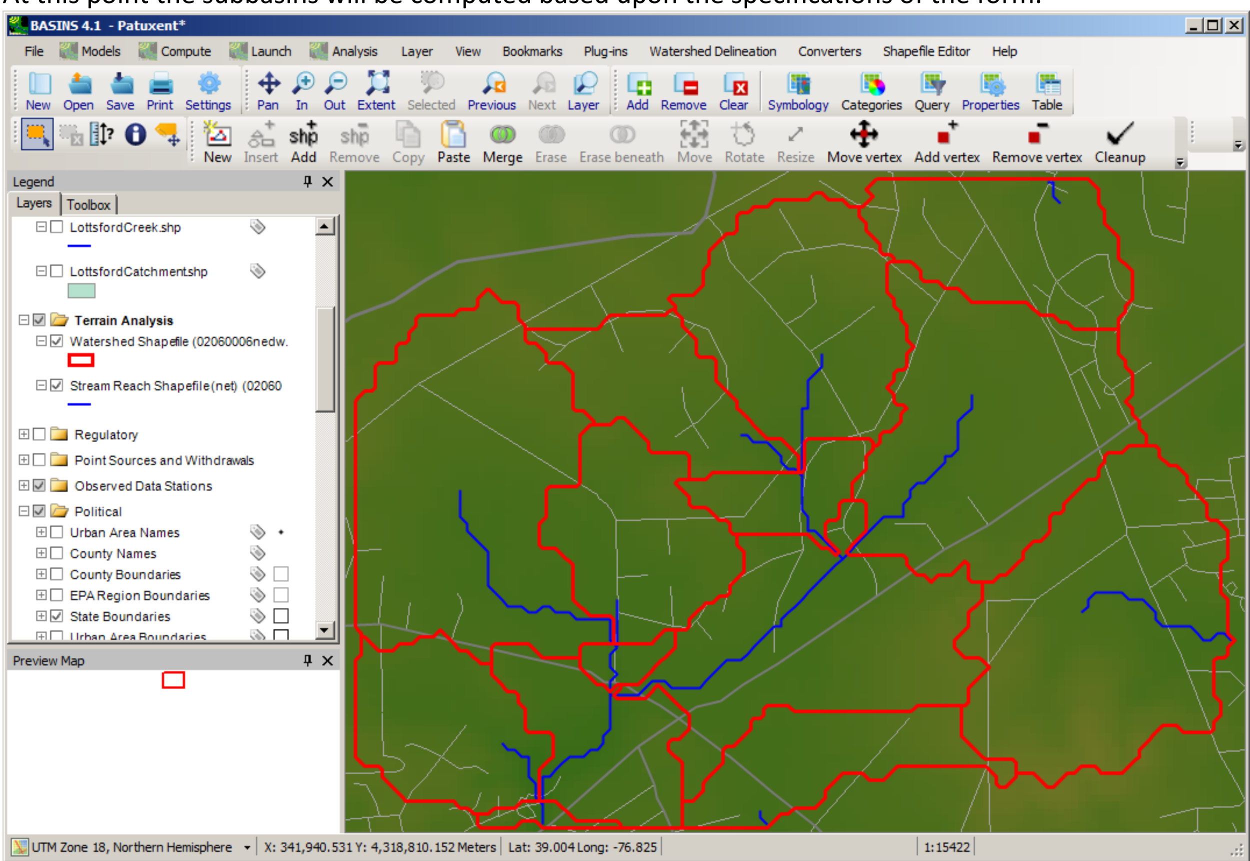


3. Select the DEM grid to provide topographic data for the delineation process. Check the **Use a Focusing Mask** box to delineate subbasins in only a portion of the specified input DEM grid. When the **Use a Focusing Mask** box is checked, specify the current view extents as the mask to delineate subbasins only within the area currently shown on the map.

4. Click the **Run** button within the **Setup and Preprocessing** frame. At this point the DEM will be preprocessed for use in the following delineation options.

5. Enter the minimum number of cells to be used as the threshold for delineation. Click the **Run** button within the **Delineation** frame. At this point the stream network will be computed based upon the input threshold level.

6. Click the **Run** button within the **Custom Outlet Definition and Delineation Completion** frame. At this point the subbasins will be computed based upon the specifications of the form.



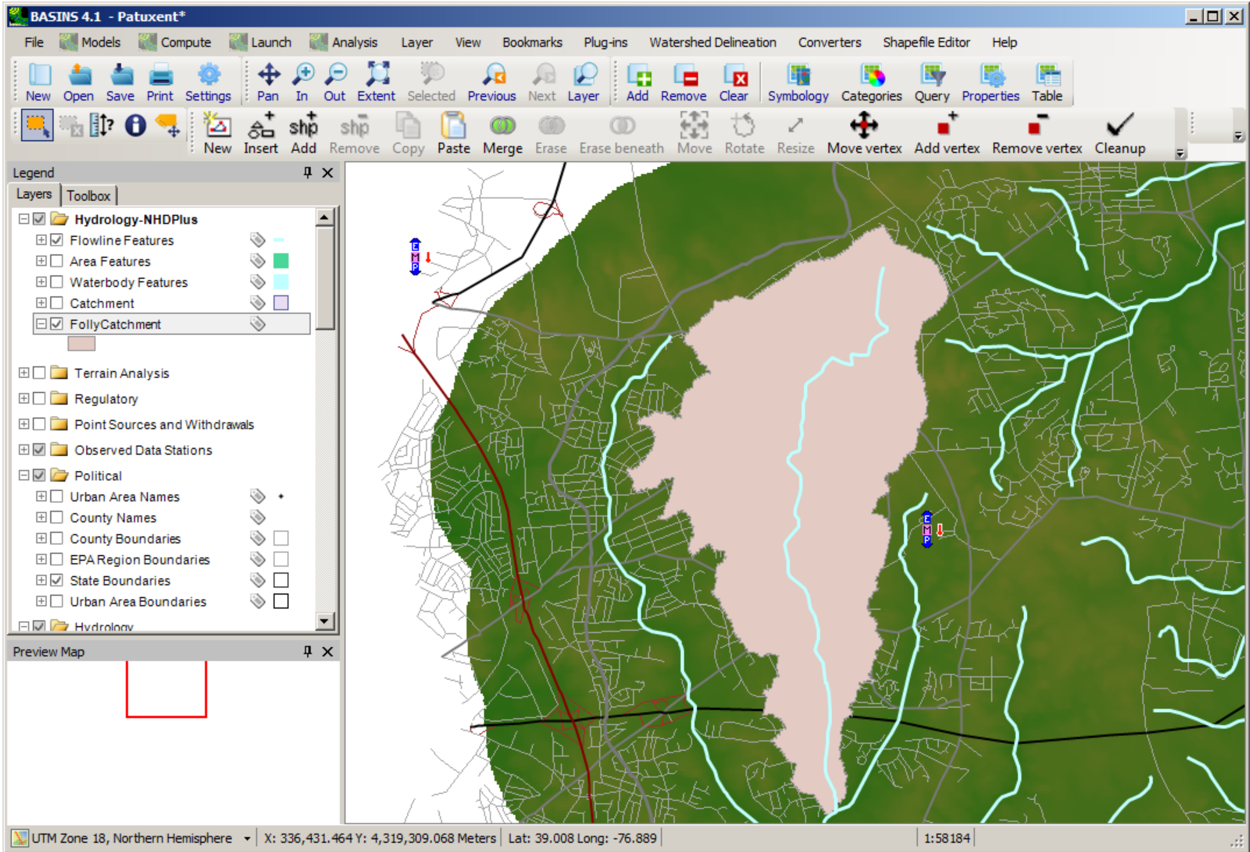
The *Watershed* and *Stream Reach* Shapefiles that are added to the map may be used as the Subcatchment and Conduit layers in the BASINS/SWMM plug-in. Complete instructions for using the BASINS Automatic Watershed Delineator can be found in the Automatic Watershed Delineation section.

Using the BASINS Manual Watershed Delineation Tools to Set Up BASINS/SWMM

The BASINS 4 *Manual Watershed Delineation* tool may also be used to create subcatchment and conduit shapefiles for use in SWMM modeling. This tool allows the user to manually subdivide a watershed into several smaller hydrologically connected watersheds.

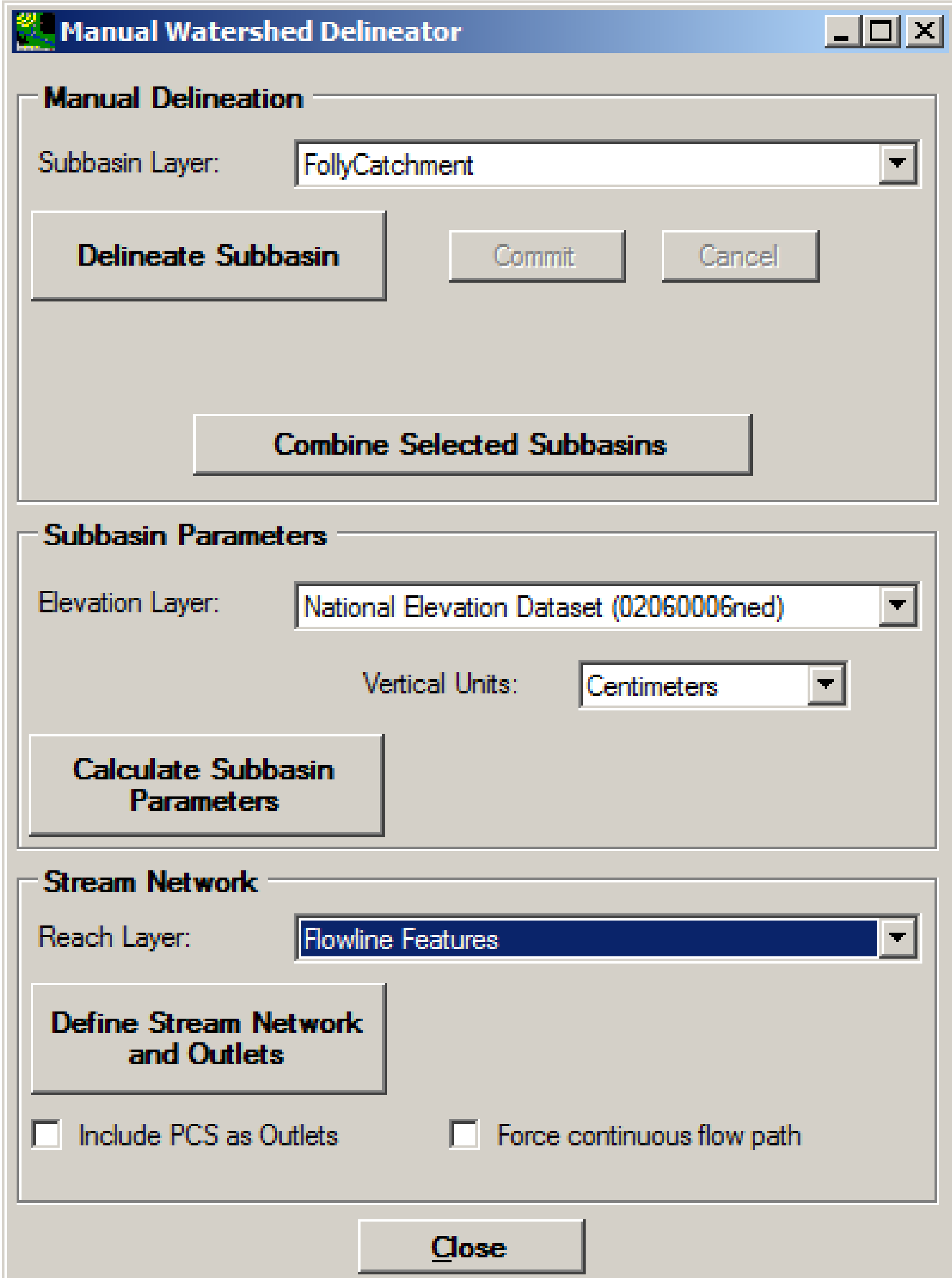
1. For this tutorial, be sure you have built a BASINS project and have downloaded a DEM grid via the **File:Download Data** menu item. Also download the National Hydrography Dataset Plus (NHDPLus) Catchments and Hydrography via the **File:Download Data** menu item. The BASINS NHDPlus catchment and flowline layers have a high resolution that works well for detailed analyses, such as a SWMM study. (In the example shown here, only a single NHDPlus catchment is used to define the SWMM subcatchments. The single NHDPlus catchment was obtained by selecting a single NHDPlus catchment and then saving that single catchment as a new shapefile

using the BASINS Table Editor.)



2. Select the **Plug-ins:Manual Delineation** menu item, which will make the manual delineation tool available under the **Watershed Delineation:Manual** menu item. Select the **Watershed**

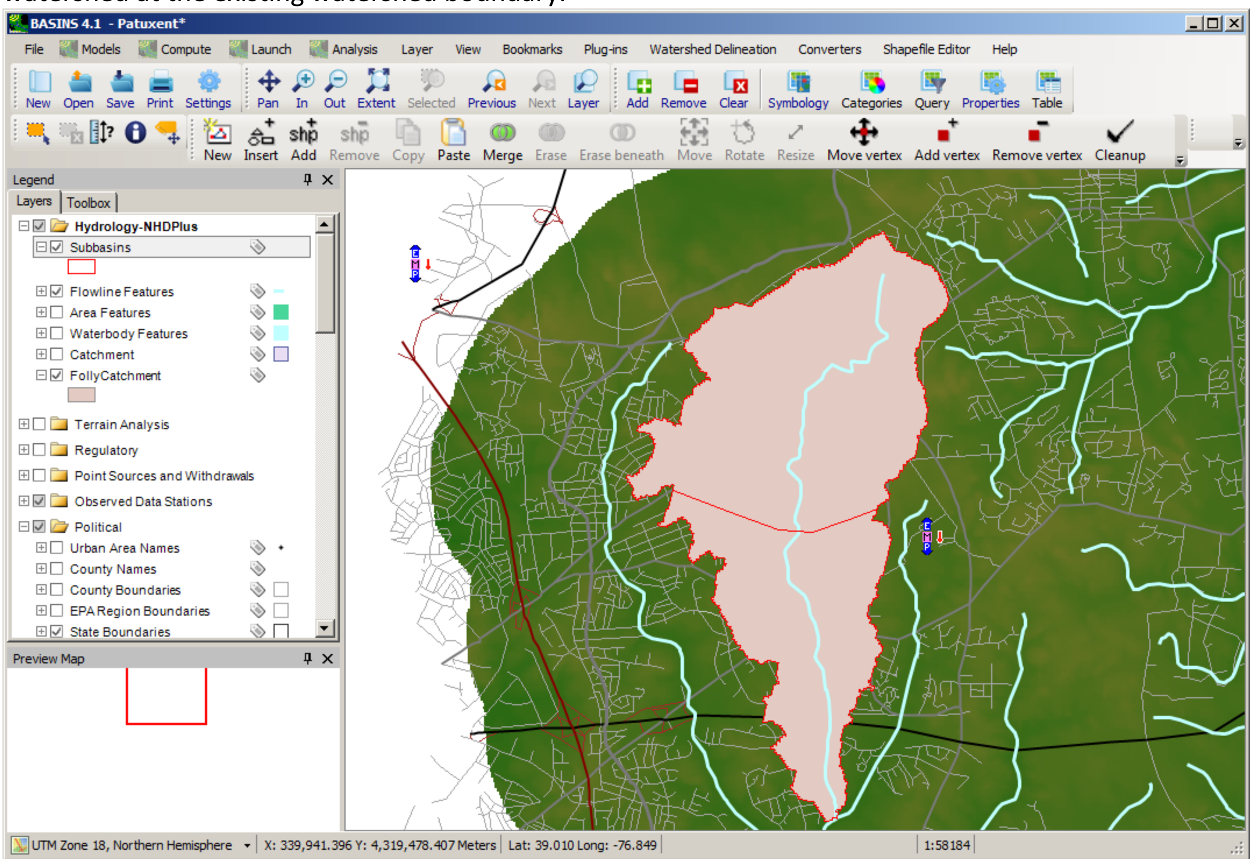
Delineation:Manual menu item, and the **Manual Watershed Delineator** form will pop up.



3. Select the watershed boundary layer from the **Subbasin Layer** pull-down menu. Click the **Delineate Subbasin** button. Change focus to the main BASINS window. Draw a new interior

boundary to subdivide the watershed by clicking on the beginning and end point, as well as any intermediate vertices, of the new boundary line.

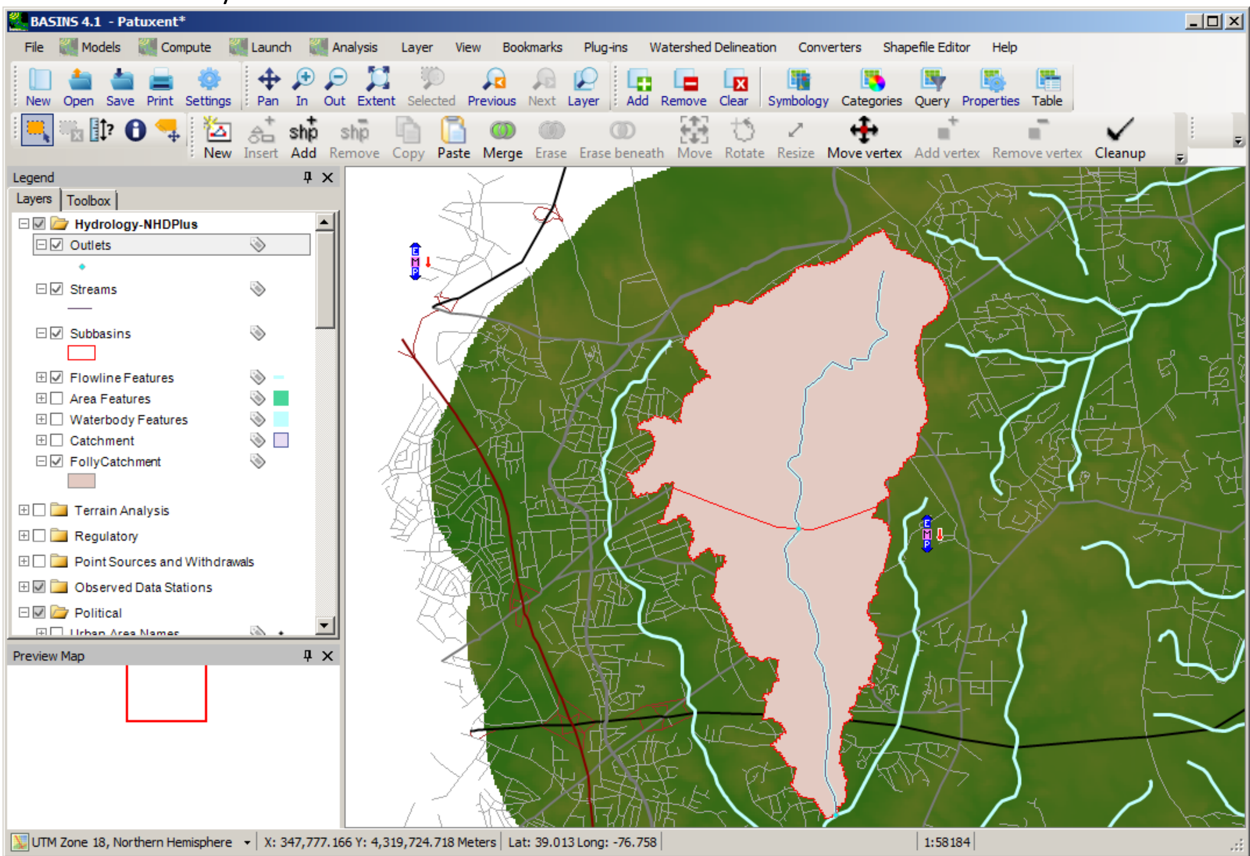
4. To finish the watershed outline, make a final mouse-click at a point outside the existing watershed boundary and right-click; or return to the **Manual Watershed Delineator** form, and click the **Commit** button. It is not necessary to delineate the portion of your watershed that coincides with the existing watershed boundary. The delineation tool automatically clips your watershed at the existing watershed boundary.



5. The **Delineate Subbasin** step may be performed as many times as desired to break a single catchment into multiple catchments.

6. To demarcate the stream segments in the newly delineated watershed, select the polyline stream layer from the **Reach Layer** pull-down menu. Click the **Define Stream Network and Outlets** button. The new stream segment parameters will be stored in the DBF file associated

with the stream layer.



The *Subbasins* and *Streams* Shapefiles that are added to the map may be used as the Subcatchment and Conduit layers in the BASINS/SWMM plug-in. Complete instructions for using the BASINS Manual Watershed Delineator can be found in the Manual Watershed Delineation section.

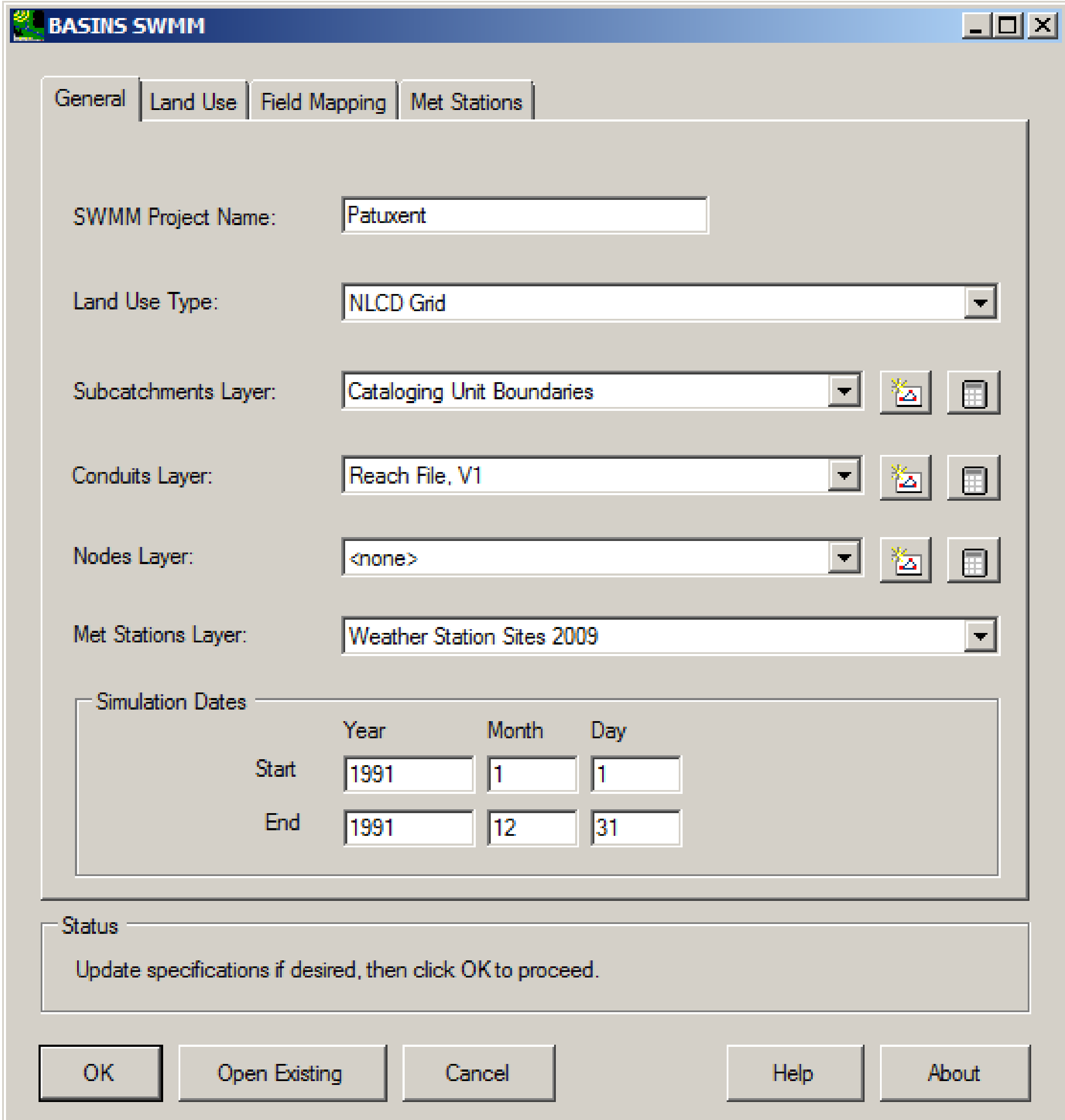
Using the BASINS Shapefile Editor to Set Up BASINS/SWMM

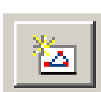
The BASINS Shapefile Editing tools may be used to create subcatchment and conduit shapefiles for use in SWMM modeling. These tools allow a user to create these shapefiles by digitizing the features directly. The BASINS/SWMM plug-in provides convenient tools for creating empty shapefiles for subcatchments, conduits, and nodes, and for calculating the attributes of these features. These tools require no data other than a Digital Elevation Model (DEM) in grid format for calculating the average slope of a subcatchment.

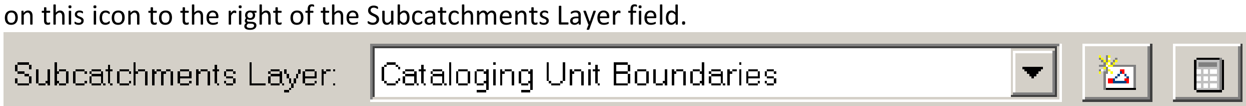
Within the BASINS/SWMM plug-in user interface, icons are available for creating new shapefiles of subcatchments, conduits, and nodes, as well as icons for populating the attribute values of these shapefiles.

1. For this tutorial, be sure you have built a BASINS project and have downloaded a DEM grid. Select **Models:SWMM** from the main menu, and the *BASINS SWMM* form appears. The

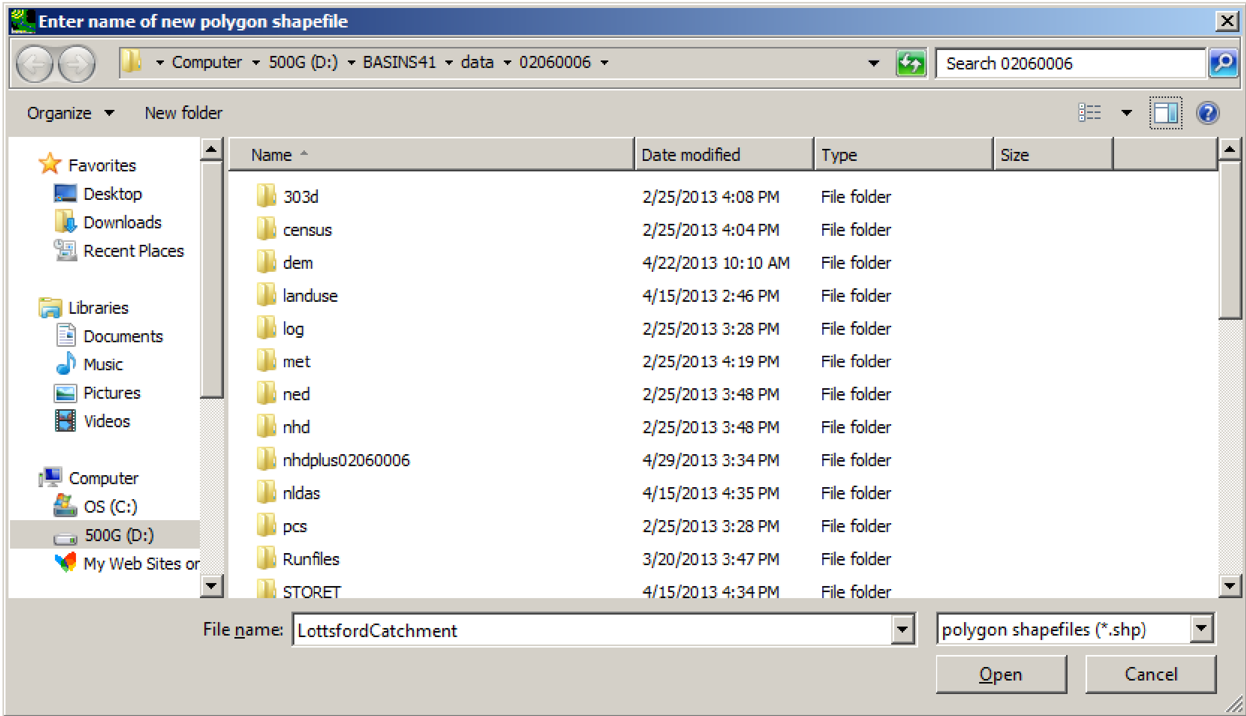
interface loads with the **General** tab active.



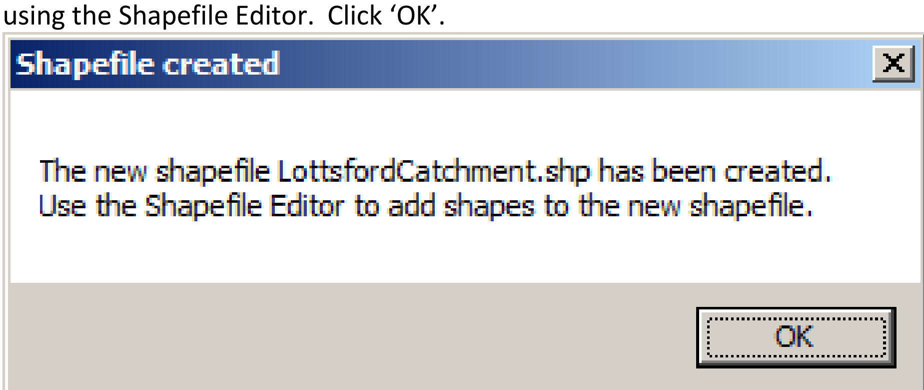
2. The  icon is used to create a new shapefile of subcatchments, conduits or nodes. Click on this icon to the right of the Subcatchments Layer field.



3. A dialog will appear for the user to enter the name of the new subcatchments shapefile. Enter the name of the new shapefile and click 'Open'.

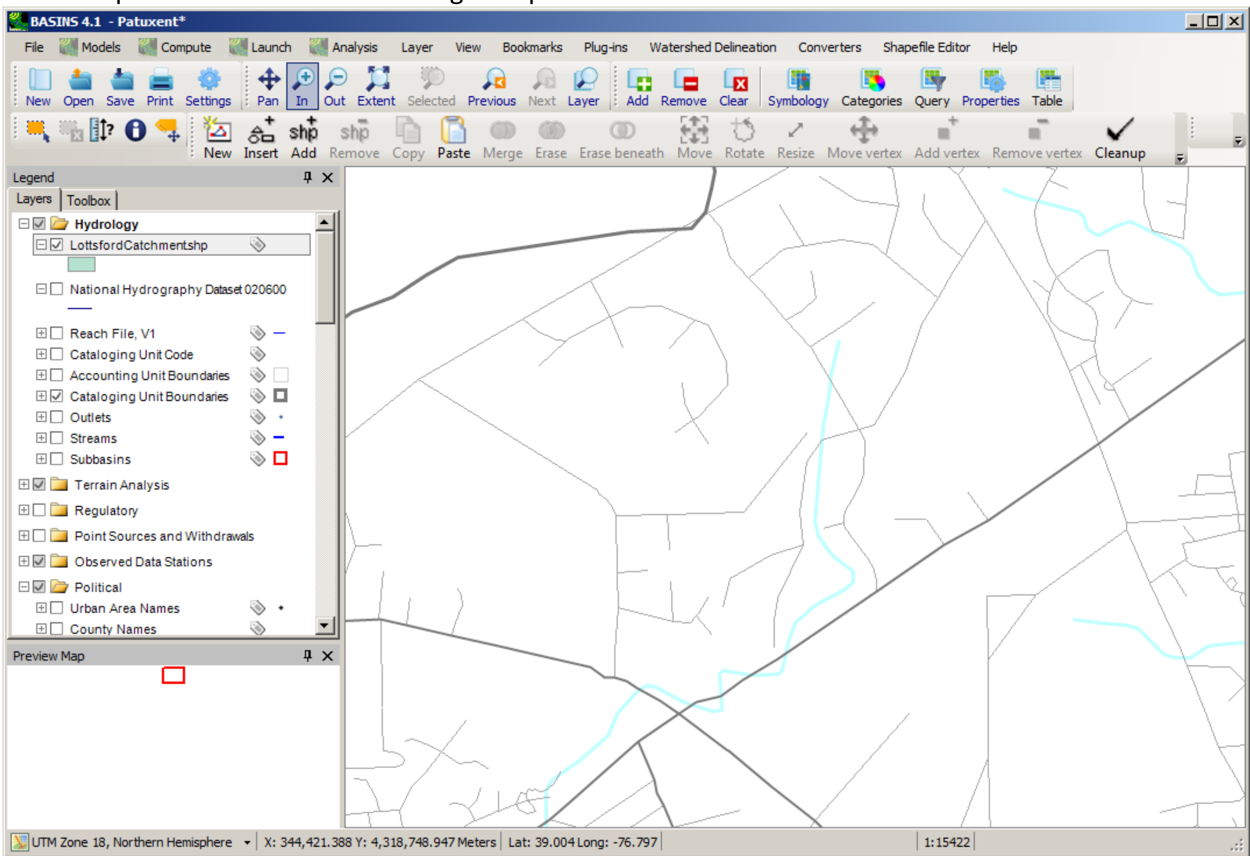


4. After clicking 'Open', a message will appear to indicate that features can be added to this layer using the Shapefile Editor. Click 'OK'.



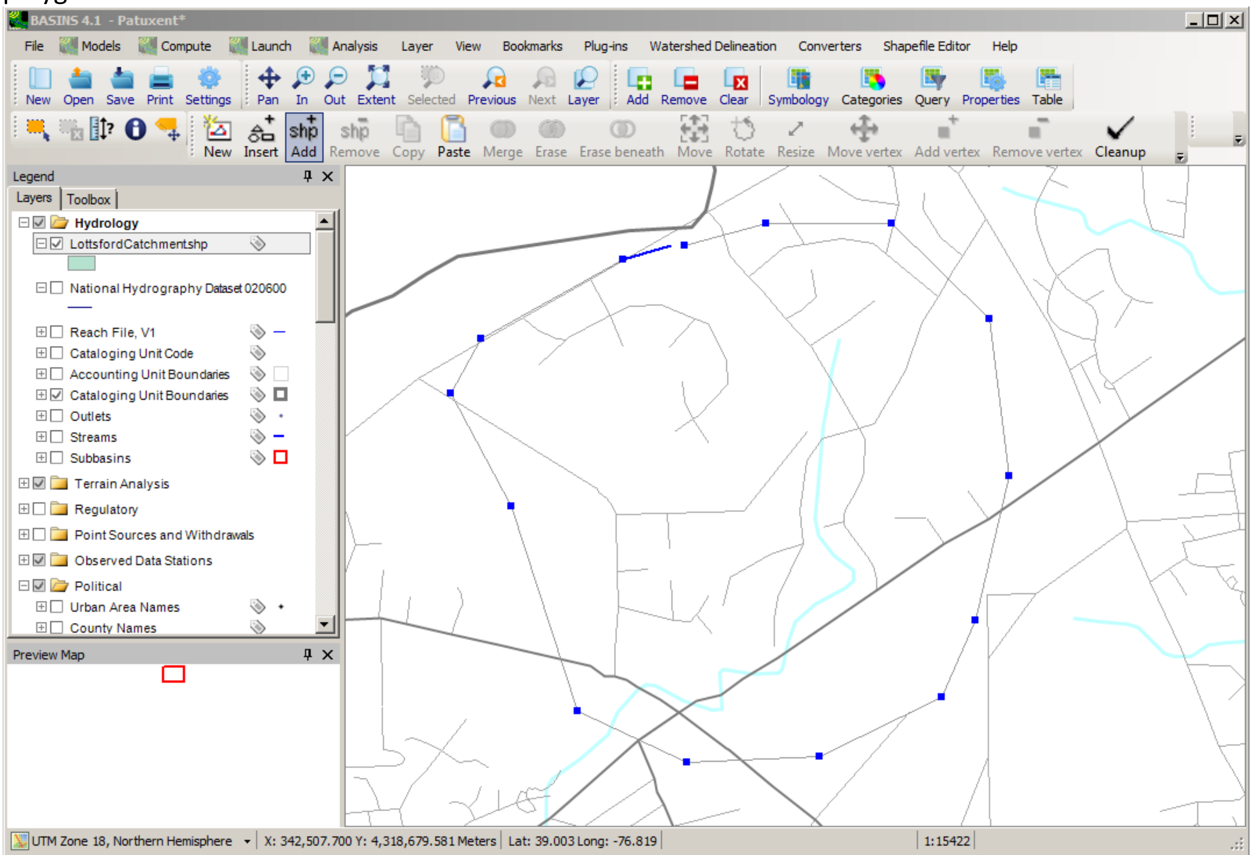
At this point a

blank shapefile has been created using the specified name.

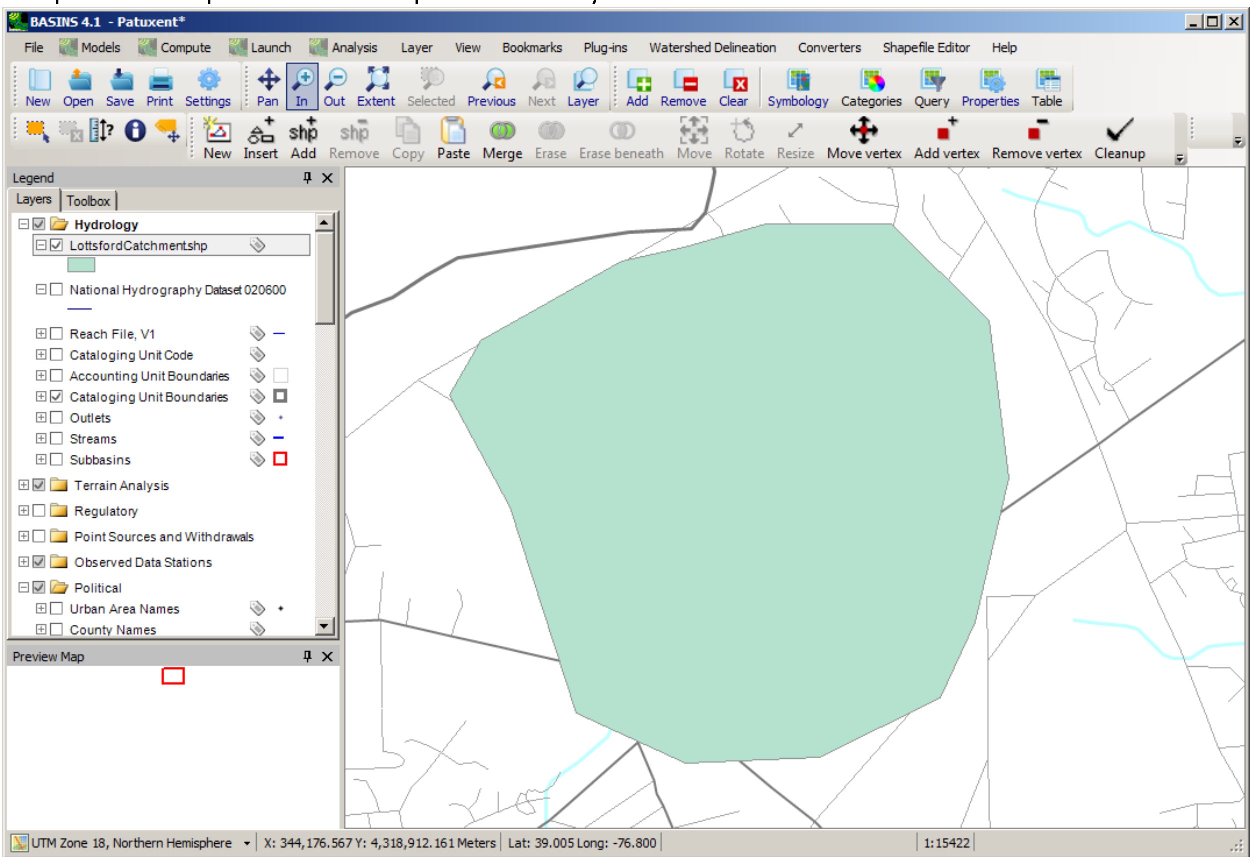


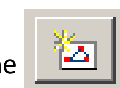
5. Now within the Shapefile Editor toolbar, the user can click on the  icon to add a shape to the new shapefile. The shape is added by clicking a series of points on the map representing the

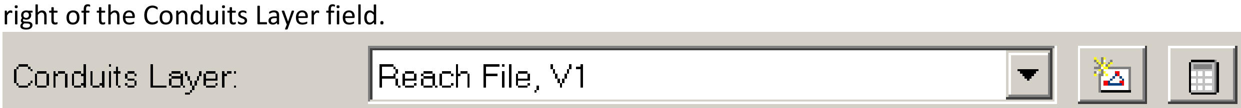
polygon vertices.



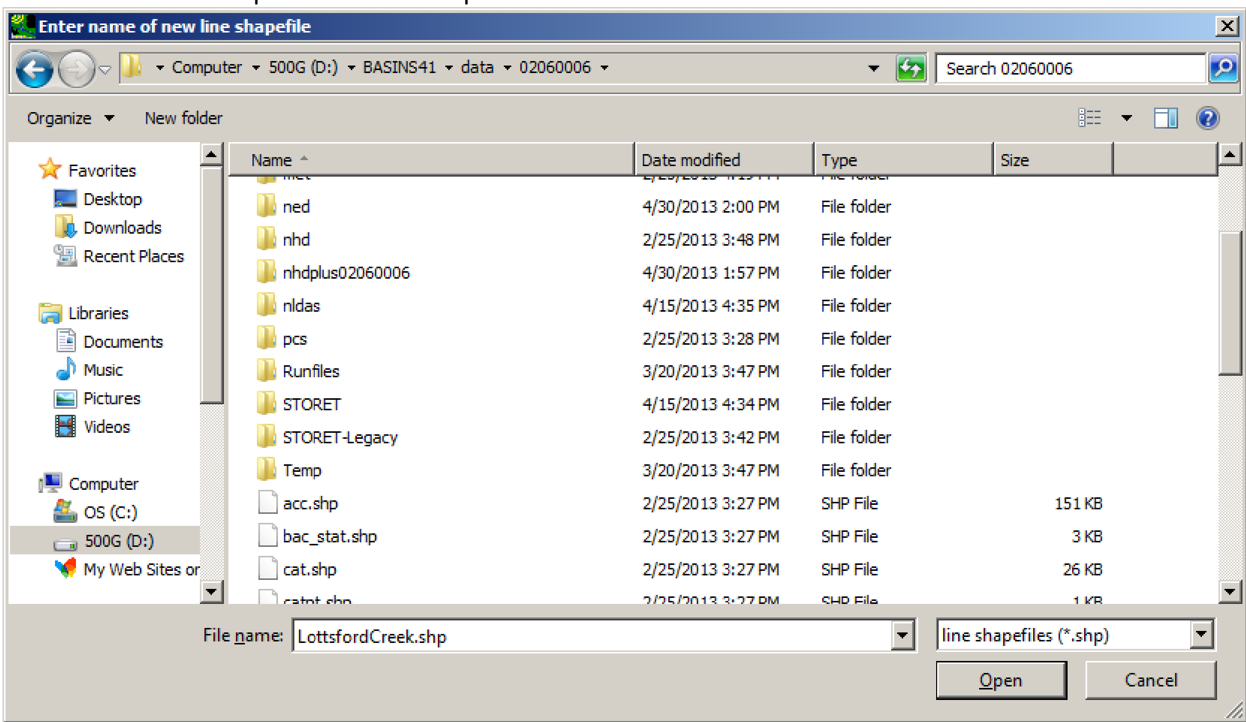
6. When finished drawing the vertices, double click on the first vertex and the figure will be completed. This process can be repeated as many times as desired.



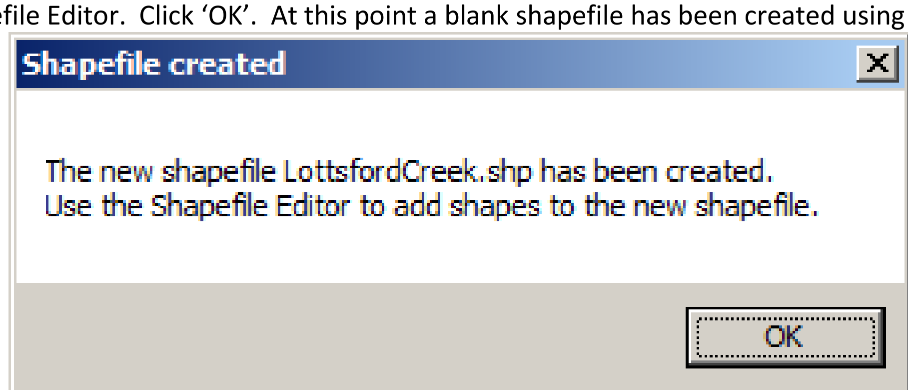
7. The same process can be used to create a shapefile of conduits. Click on the  icon to the right of the Conduits Layer field.



8. A dialog will appear for the user to enter the name of the new conduits shapefile. Enter the name of the new shapefile and click 'Open'.

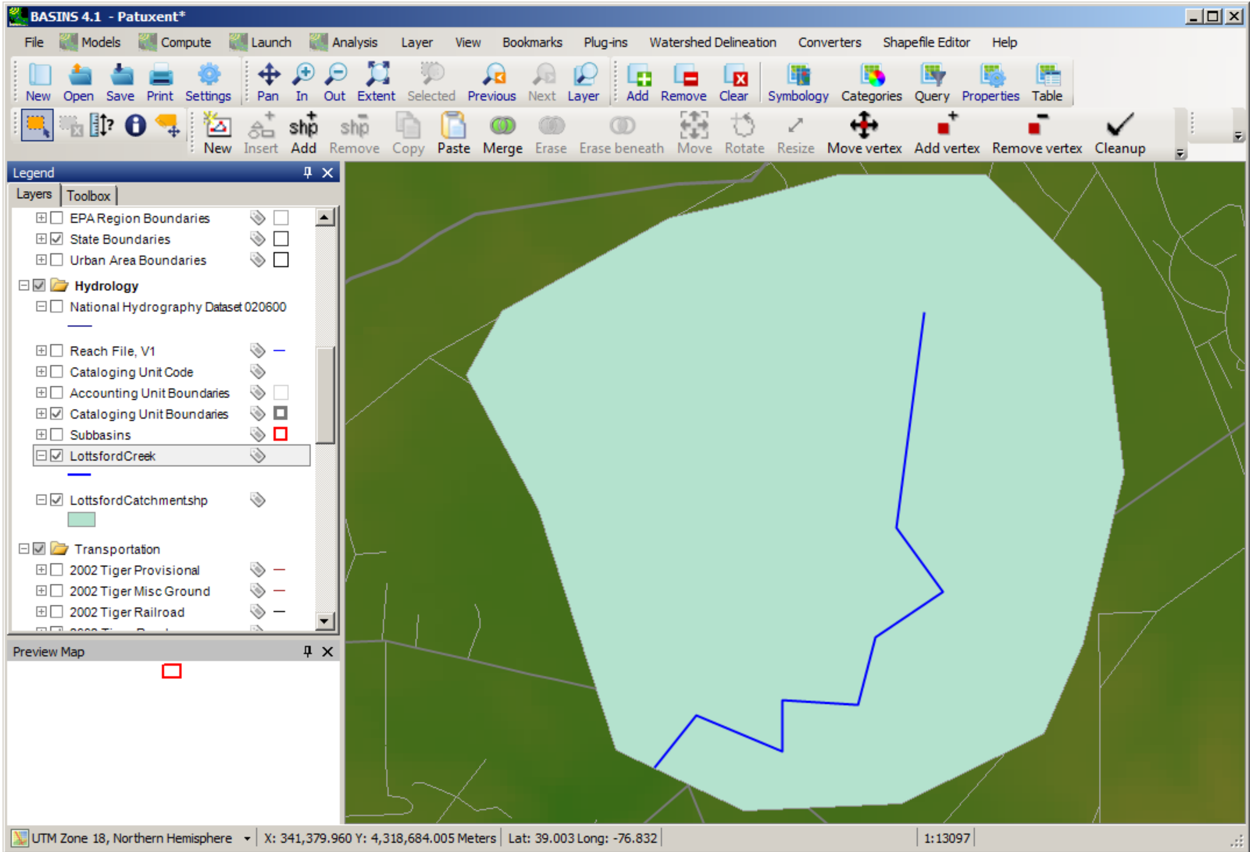


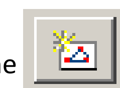
9. After clicking 'Open', a message will appear to indicate that features can be added to this layer using the Shapefile Editor. Click 'OK'. At this point a blank shapefile has been created using the specified name.

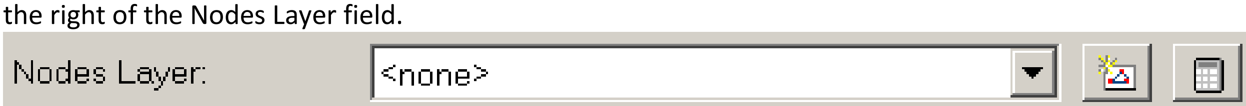


10. Now within the Shapefile Editor toolbar, the user can click on the  icon to add a shape to the new shapefile. The shape is added by clicking a series of points on the map representing the vertices of the line. When finished drawing the vertices, right-click and the figure will be

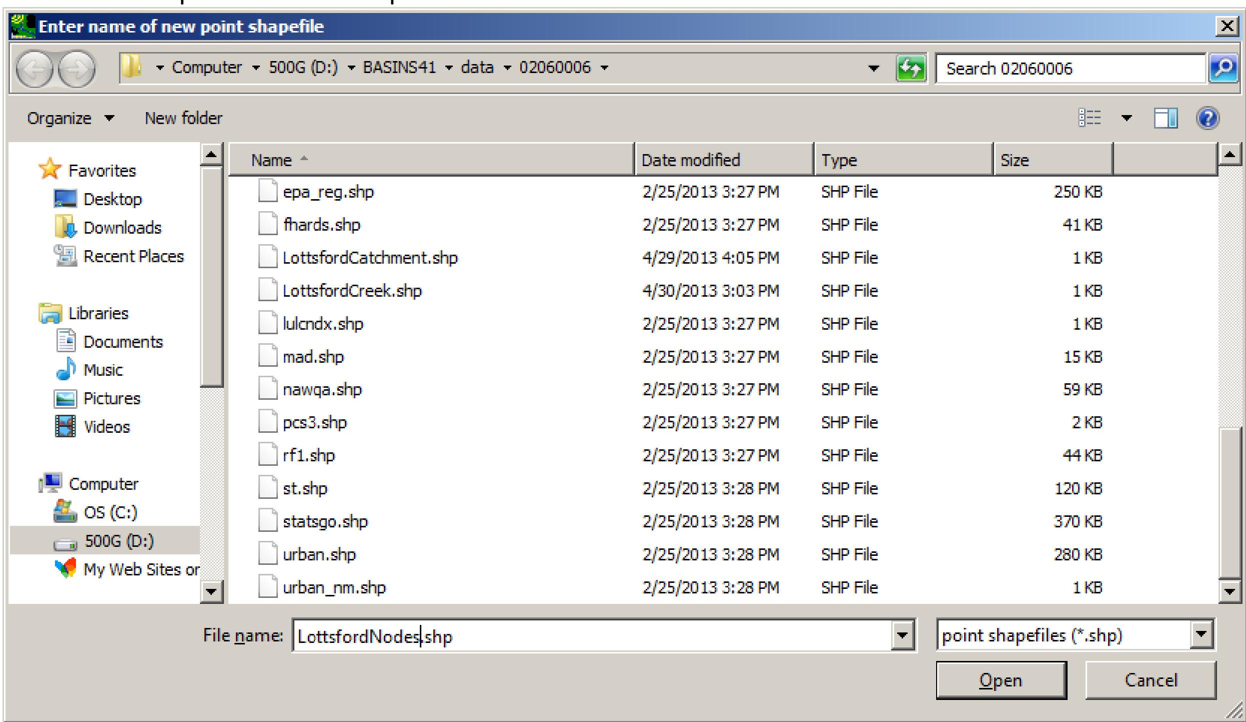
completed. This process can be repeated as many times as desired.



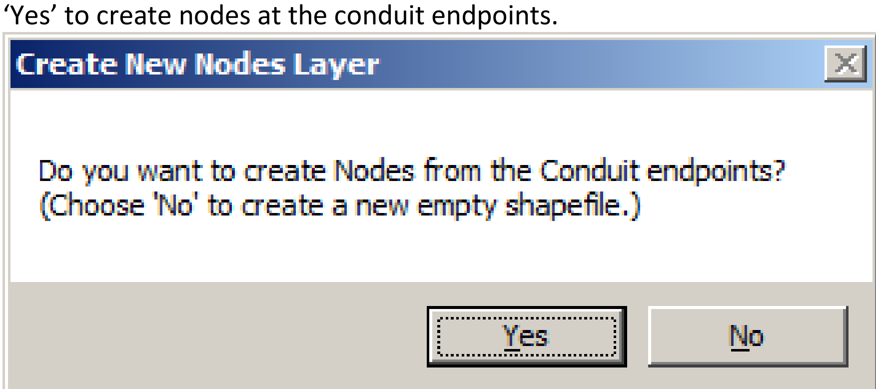
11. Similarly, this process can be used to create a shapefile of nodes. Click on the  icon to the right of the Nodes Layer field.



12. A dialog will appear for the user to enter the name of the new nodes shapefile. Enter the name of the new shapefile and click 'Open'.

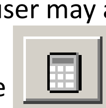


13. After clicking 'Open', a message will appear to indicate that nodes may be added either automatically at the ends of the conduits or by point-and-click using the Shapefile Editor. Click 'Yes' to create nodes at the conduit endpoints.



The nodes will appear as a new layer on the map.

14.

After the user creates the Subcatchment, Conduit, and Node layers, the user may also wish to add some attributes to these shapefiles. Attributes may be added by clicking on the  buttons within the

BASINS/SWMM interface. See the section entitled Tutorial: Preparing GIS Data for use in the BASINS/SWMM Plug-in for more details.

Starting SWAT

The **Soil and Water Assessment Tool (SWAT)** can be setup using GIS data available within BASINS. Execute the following steps to construct and run a *SWAT* model for a select area within the Patuxent watershed.

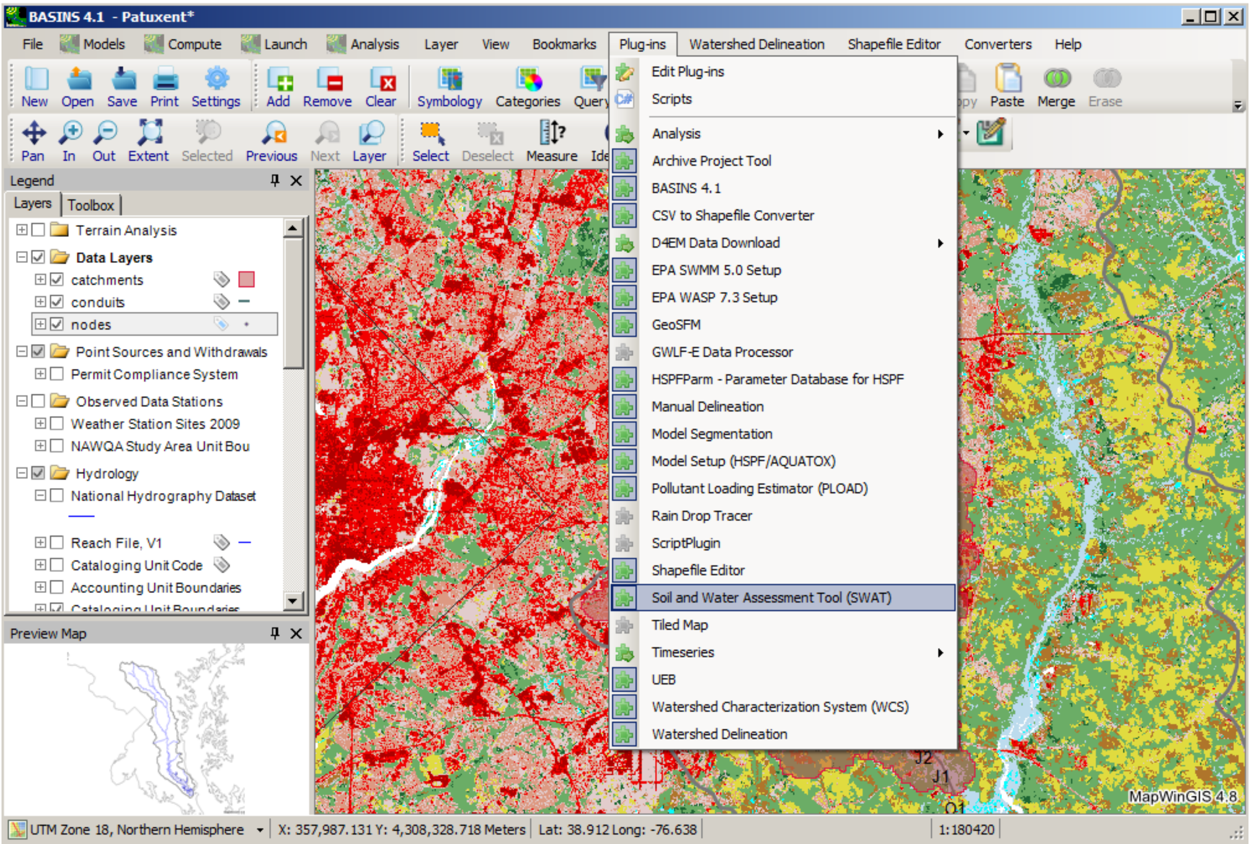
Before beginning this tutorial, be sure you have completed the first two tutorials, *Building a BASINS 4.5 Project* and *Downloading Additional Data*. This tutorial also uses a few additional data types not downloaded in the earlier tutorials, including the NLCD Land Cover data, the NHDPlus Hydrography, and a predefined delineation of the West Branch watershed. Execute the following steps to load these layers onto the map:

- Using the Download Data tool, download NLCD 2001 Land Cover.
- Using the Download Data tool, download NHDPlus Hydrography.
- Using the Add button on the main MapWindow toolbar, add the shapefile *w_branch.shp* from the BASINS "Predefined Delineations" folder (In *BASINSInstall**Predefined Delineations* where *BASINSInstall* is the name of the folder where BASINS is installed, such as C:\BASINS.

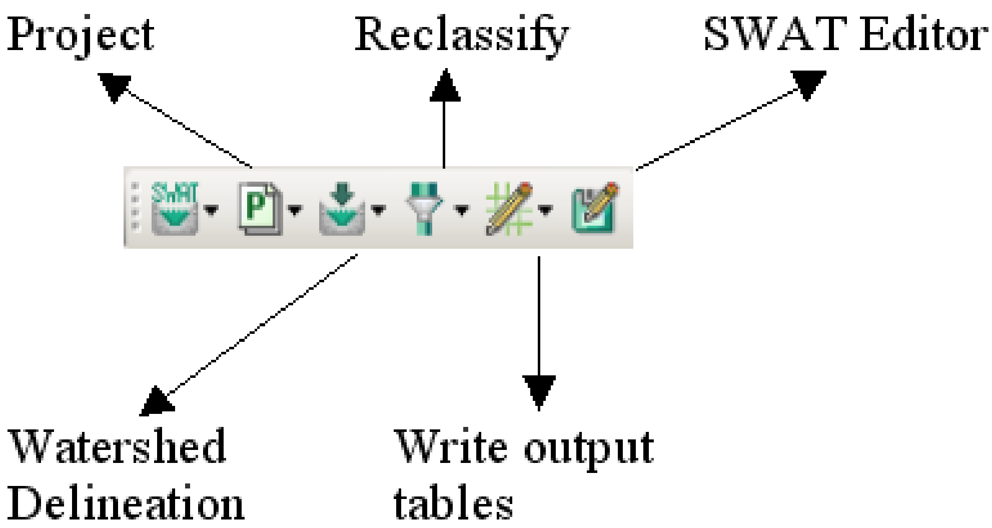
Note: SWAT2005 and the SWAT Editor are not included with this package. They may be downloaded from http://swatmodel.tamu.edu/

Enabling the SWAT Plug-In

From the main menu in BASINS, select the Plug-Ins menu and then select the Soil and Water Assessment Tool (SWAT) to activate the SWAT plug-in.

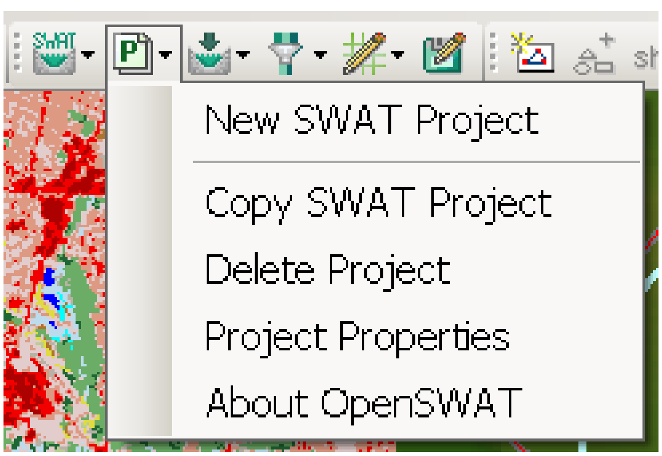


With the Open SWAT plug-in active, you will see the SWAT toolbar.

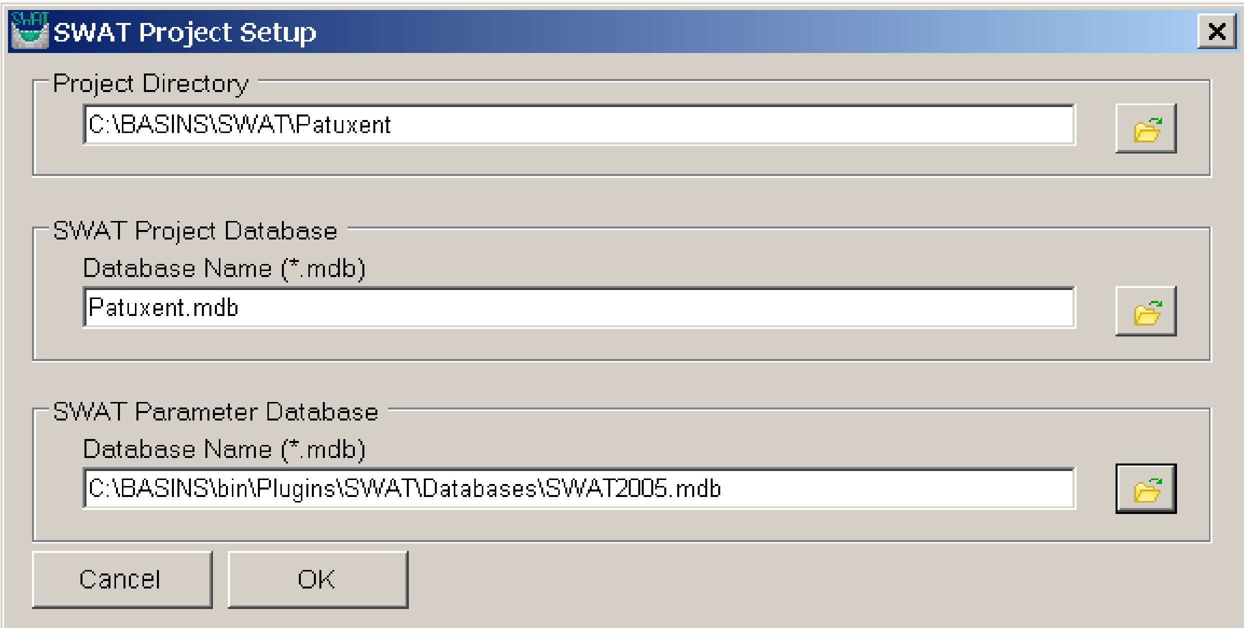


Creating a New SWAT Project

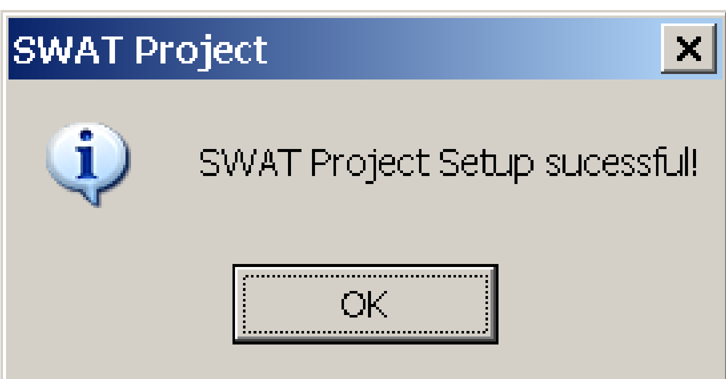
Project-related functionalities are grouped under the SWAT project icon; these functionalities can be accessed by clicking the arrow next to the project icon.



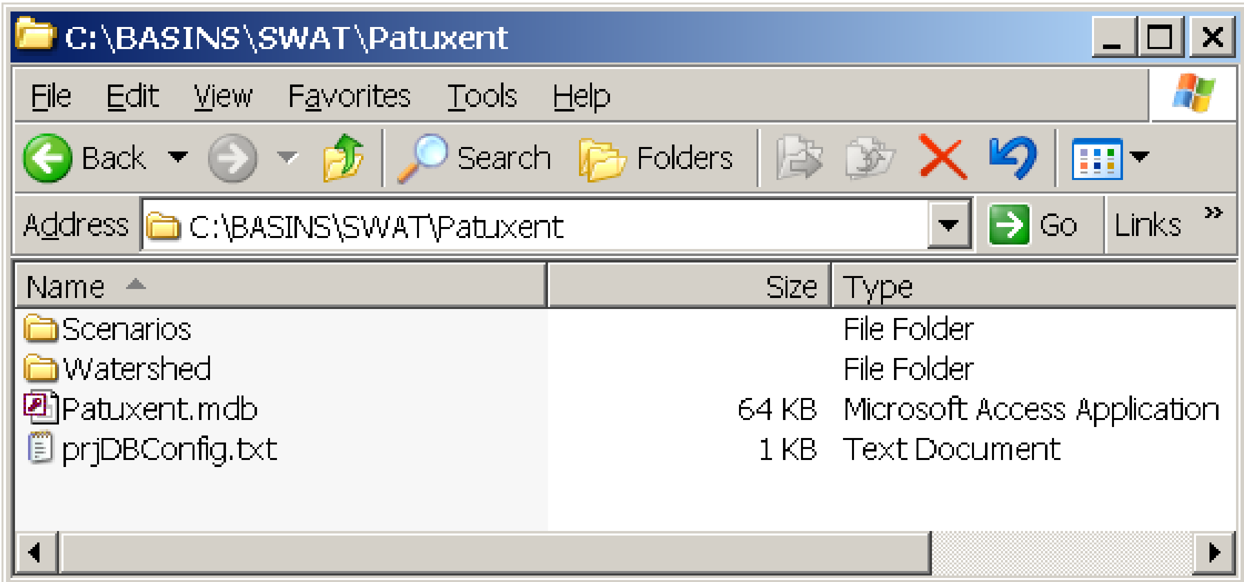
Click the “New SWAT Project” option to create a new project. Users can select a directory by clicking the browse button next to the “Project Directory” name box. A new directory can be created by clicking the “Make New Folder” button in the Windows interface.



Once you have given the required parameters for the SWAT Project Setup dialog, press the “OK” button.



The files created during the project setup are shown below:

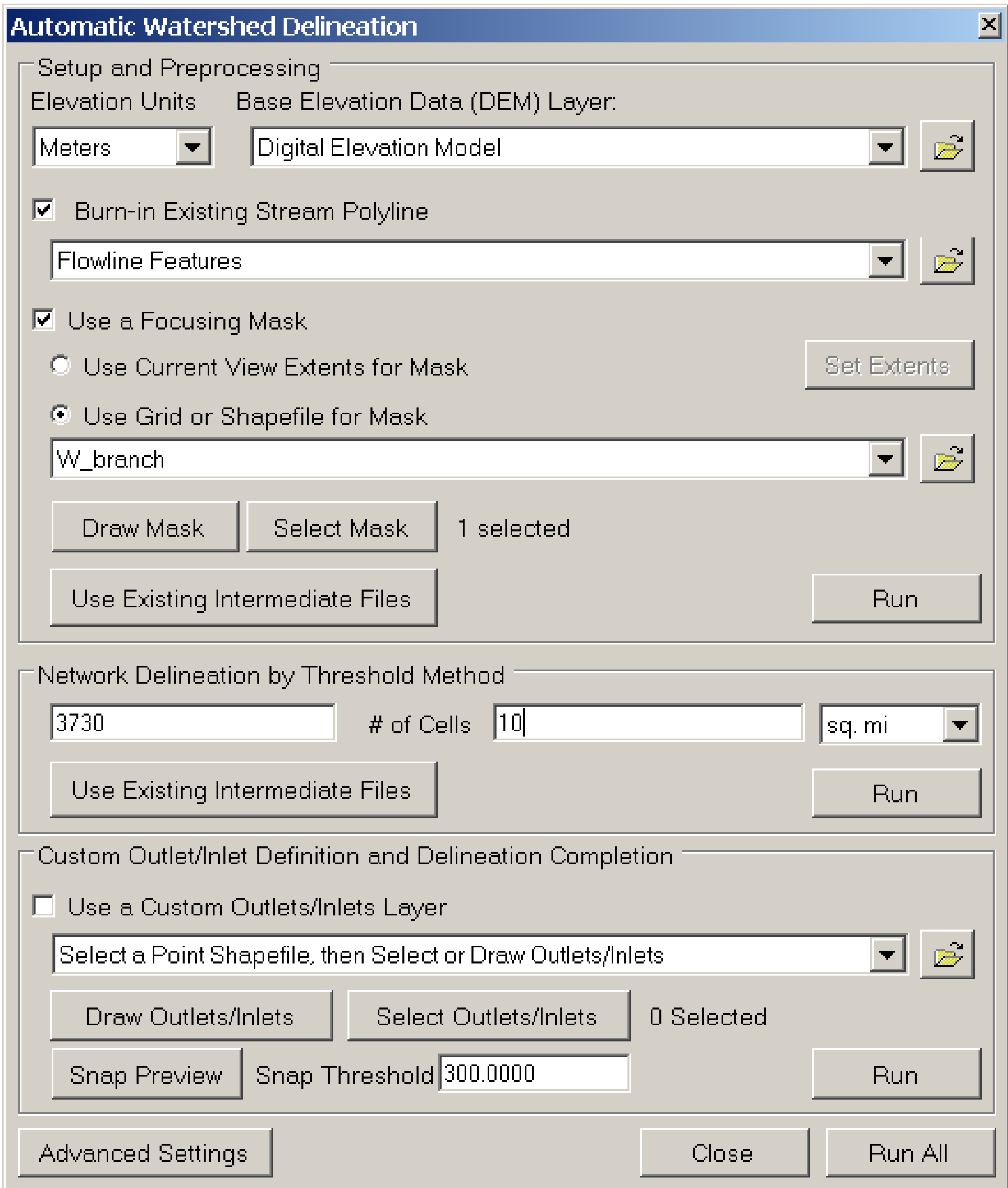


Watershed Delineation

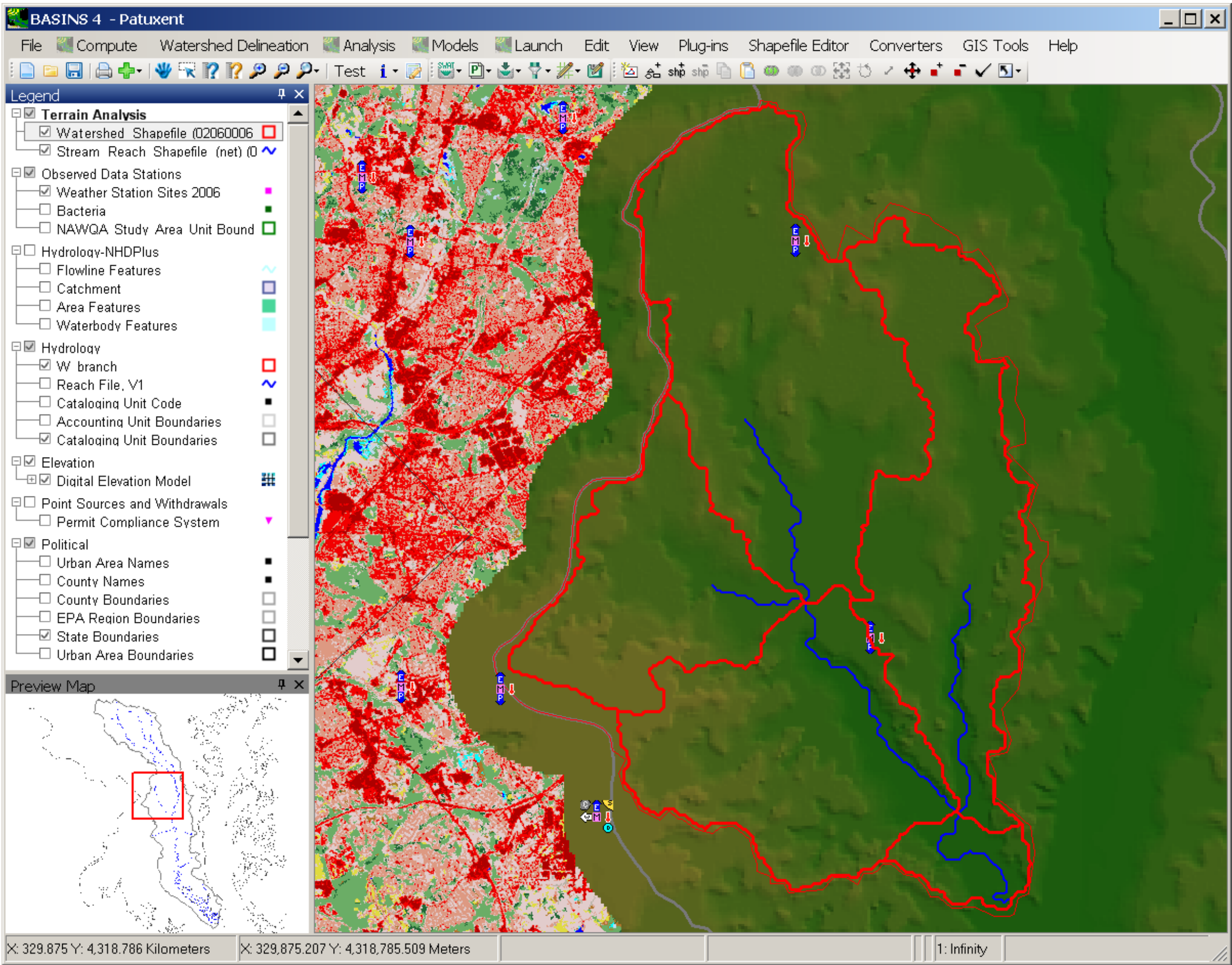
The Watershed Delineation tool on the SWAT toolbar uses a Digital Elevation Model (DEM) grid to create subwatersheds, much like the Automatic Watershed Delineator in BASINS. OpenSWAT may also be used with watershed delineations produced using the BASINS Manual Watershed Delineation tool.

The automatic watershed delineator functions can be accessed through clicking the arrow next to the "Watershed Delineation" icon.

Click the "Automatic Watershed Delineator" to start the watershed delineator.

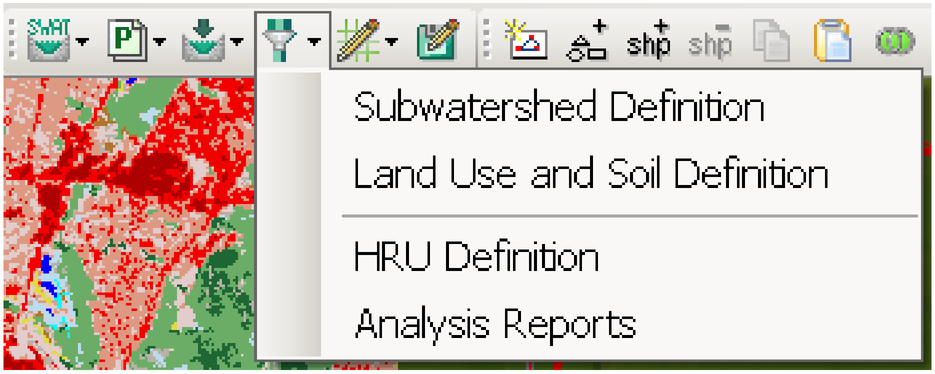

Automatic Watershed Delineation
Setup and Preprocessing
Elevation Units
Base Elevation Data (DEM) Layer:
Meters
Digital Elevation Model
Burn-in Existing Stream Polyline
Flowline Features
Use a Focusing Mask
Use Current View Extents for Mask
Set Extents
Use Grid or Shapefile for Mask
W_branch
Draw Mask
Select Mask
1 selected
Use Existing Intermediate Files
Run
Network Delineation by Threshold Method
3730
# of Cells
10
sq. mi
Use Existing Intermediate Files
Run
Custom Outlet/Inlet Definition and Delineation Completion
Use a Custom Outlets/Inlets Layer
Select a Point Shapefile, then Select or Draw Outlets/Inlets
Draw Outlets/Inlets
Select Outlets/Inlets
0 Selected
Snap Preview
Snap Threshold
300.0000
Run
Advanced Settings
Close
Run All

Using the settings shown above, use the Automatic Delineator to produce the delineation results shown below.

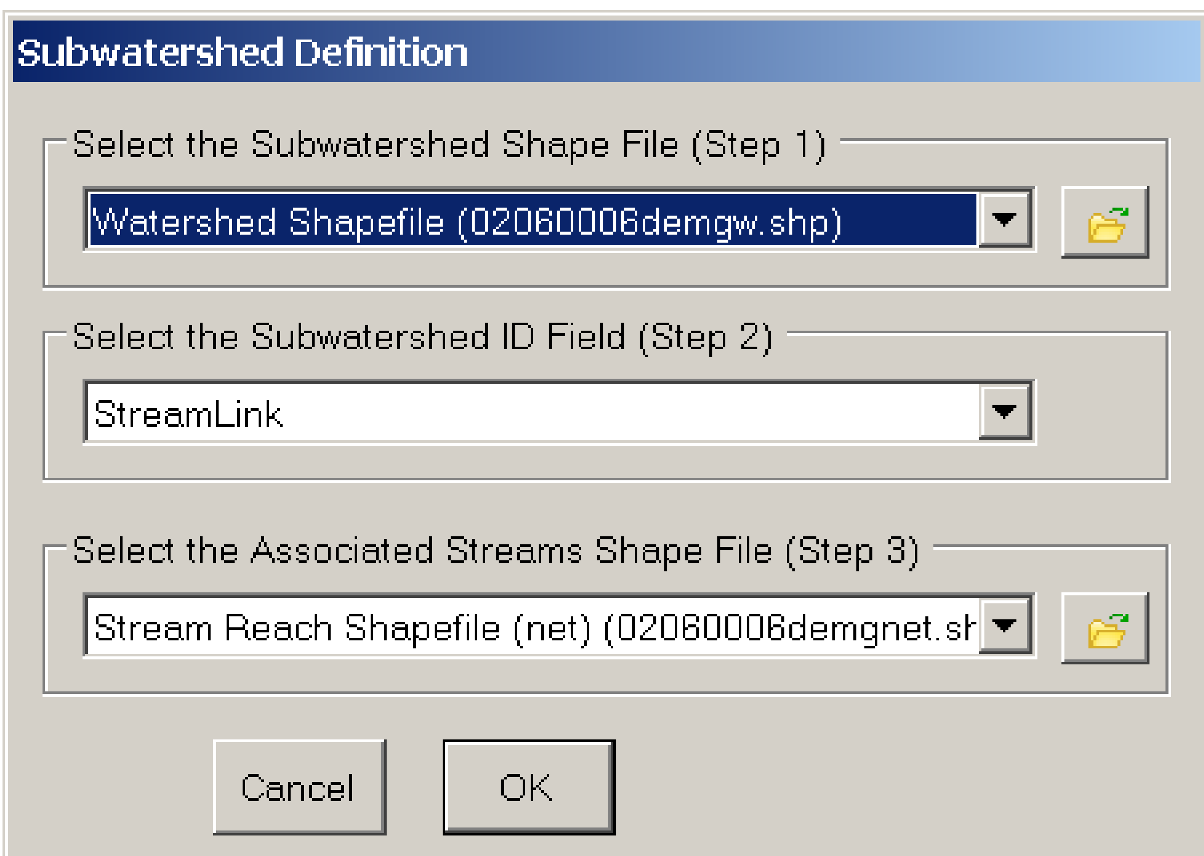


Land use/ Soil/ Slope Reclassification

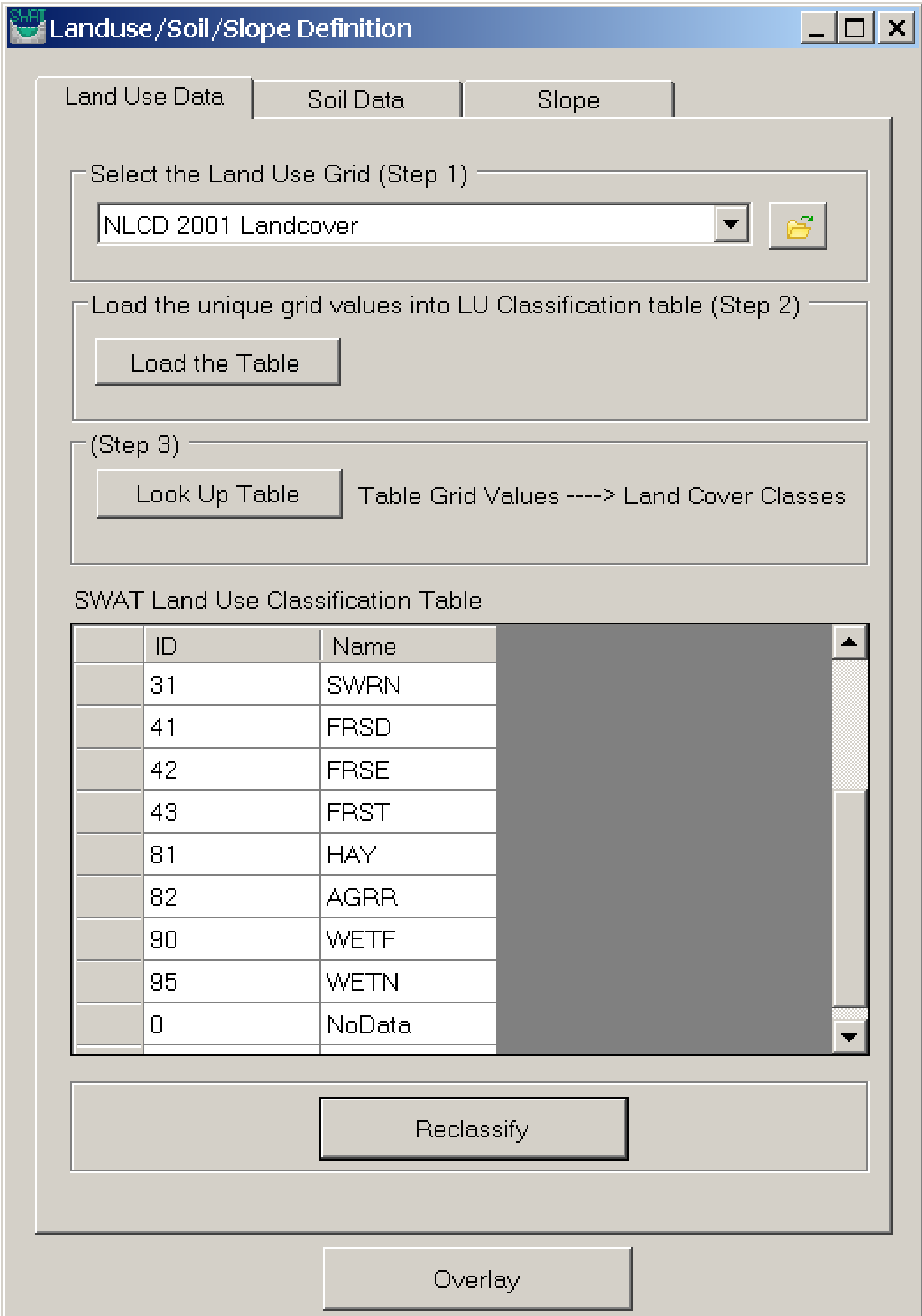
The Land use and Soil definition option in the "Land Use/ Soil/ Slope menu" allows users to specify the land use, soil, and slope layers that will be used for modeling using SWAT. These layers are then used to determine the Hydrological Response Unit (HRU) distribution for each sub watershed.



The “Subwatershed Definition” menu option is used to set the Subwatershed and Streams layers to be used in the reclassification and overlay steps. Specify the output of the automatic watershed delineation process as shown below.

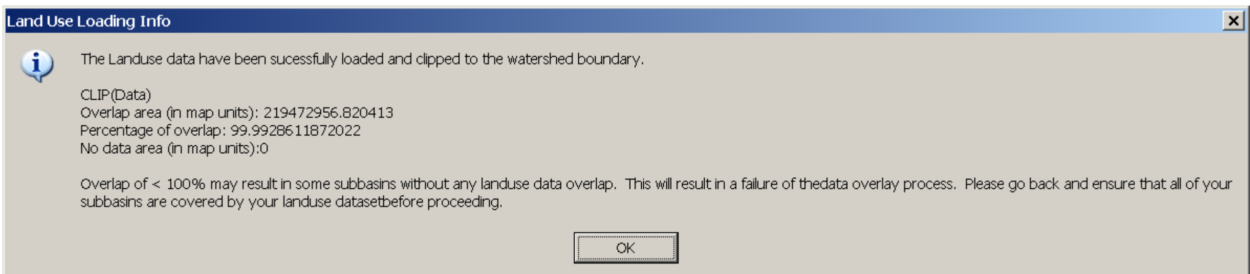


SWAT requires land use data to determine the area of each land category to be simulated within each subwatershed. SWAT also relies on soil and slope data to determine the range of hydrologic characteristics found within each subwatershed. The Land use and Soil Definition option guides the user through the process of specifying the data to be used in the simulation and of ensuring that those data are in the appropriate format.

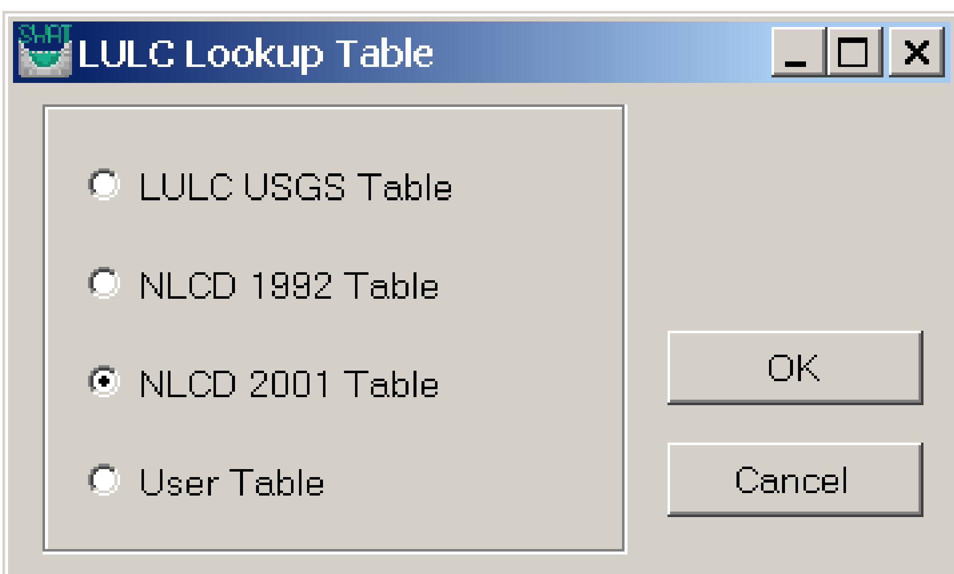

Landuse/Soil/Slope Definition
Land Use Data
Soil Data
Slope
Select the Land Use Grid (Step 1)
NLCD 2001 Landcover
Load the unique grid values into LU Classification table (Step 2)
Load the Table
(Step 3)
Look Up Table
Table Grid Values ----> Land Cover Classes
SWAT Land Use Classification Table
ID
Name
31
SWRN
41
FRSD
42
FRSE
43
FRST
81
HAY
82
AGRR
90
WETF
95
WETN
0
NoData
Reclassify
Overlay

To reclassify Land use and Soil, click on the “Land use and Soil Definition” option. The Land Use/ Soil/ Slope definition window has three different tabs for defining the Land Use, Soil, and Slopes.

To define the Land Use, users should select the NLCD 2001 grid from the “Select the Land use Grid” drop-down list. After selecting the Land use grid, click the “Load the Table” button to load the unique data from the grid to the SWAT Land use classification table. Soon after clicking the “Load the Table”, users will get a message summarizing the information about the grid.



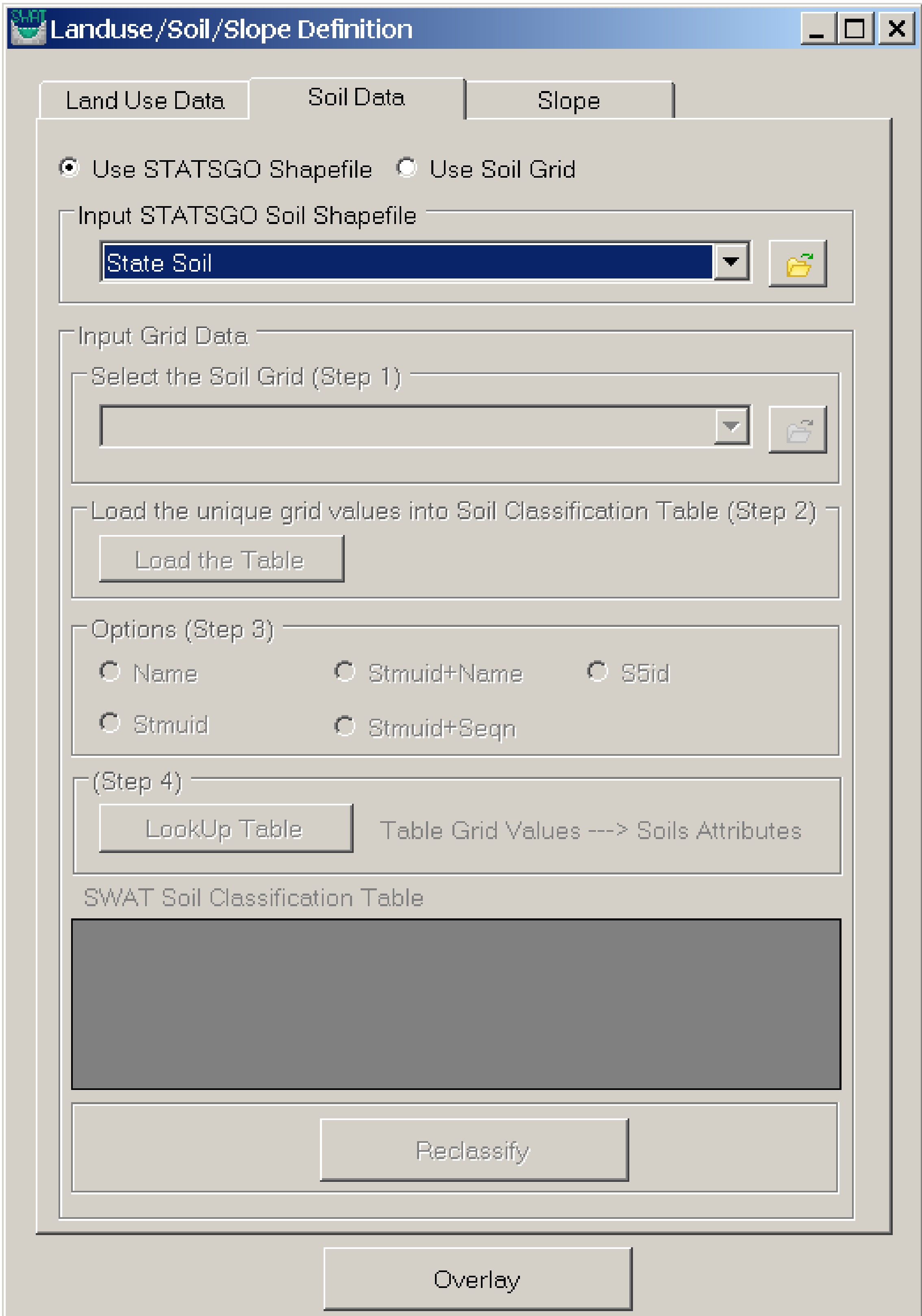
The land use grid codes must be assigned a land cover/plant description. Users may import or manually assign a land cover/plant code. To do so, click on the “Look up Table” button.



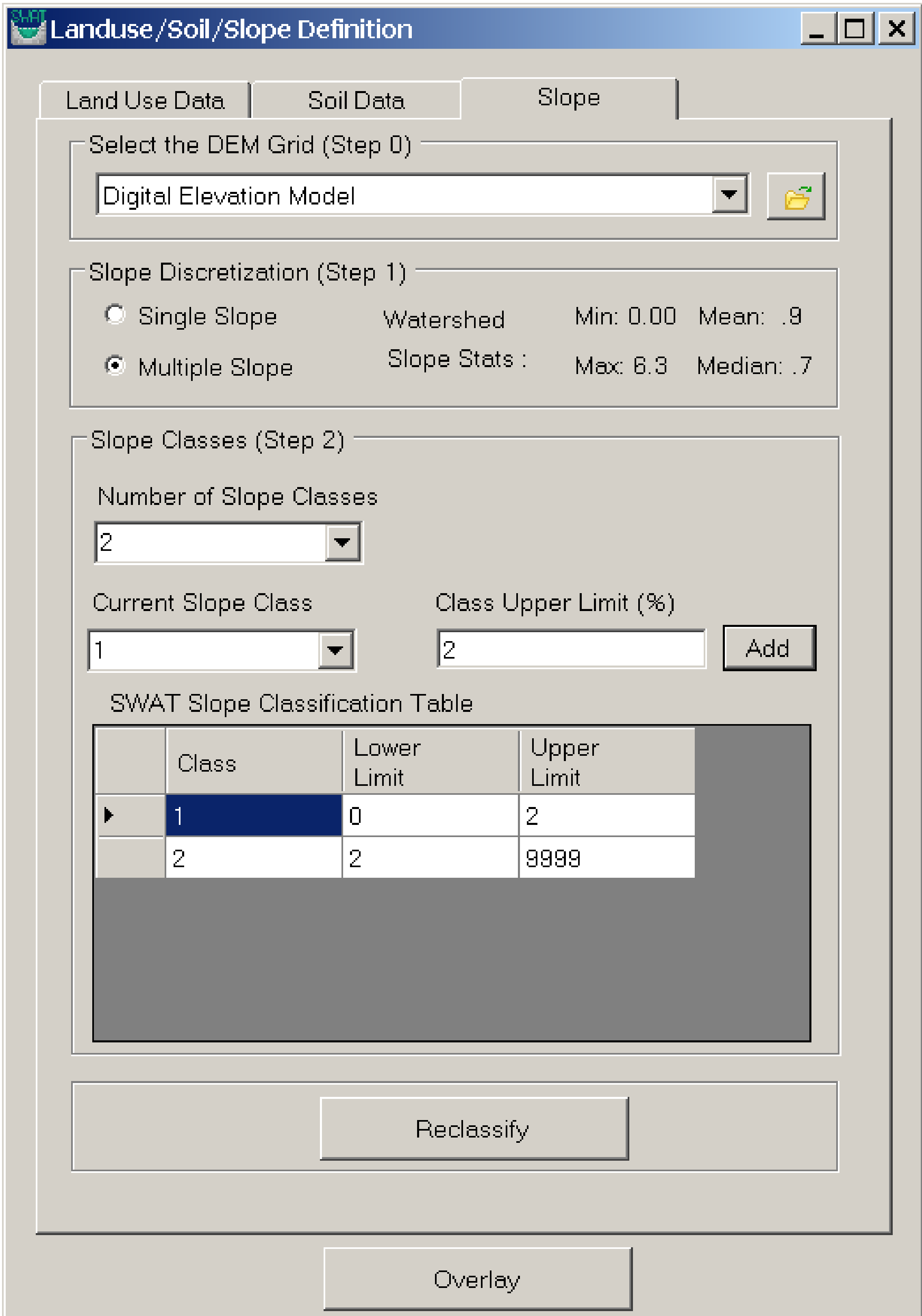
Select the NLCD 2001 look up table, and then view the land use descriptions next to the grid values.

Click the “Reclassify” button to finish the reclassification operation of Land Uses. Upon completion, a notification of the conclusion of the LU Reclassification is shown.

In order to reclassify the soil dataset, go to the “Soil Data” tab. STATSGO soils data is available within BASINS, so a BASINS user will most likely want to choose “Use STATSGO Shapefile”. After choosing this option, select the name of the STATSGO soils layer from the drop-down list.

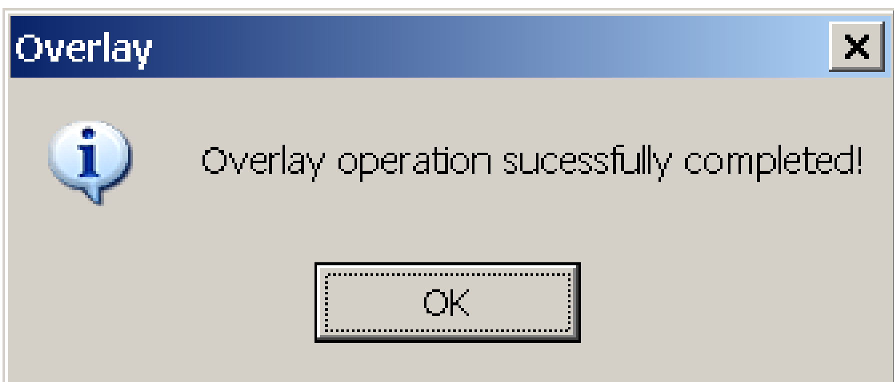

Landuse/Soil/Slope Definition
Land Use Data
Soil Data
Slope
Use STATSGO Shapefile
Use Soil Grid
Input STATSGO Soil Shapefile
State Soil
Input Grid Data
Select the Soil Grid (Step 1)
Load the unique grid values into Soil Classification Table (Step 2)
Load the Table
Options (Step 3)
Name
Stmuid+Name
S5id
Stmuid
Stmuid+Seqn
(Step 4)
LookUp Table
Table Grid Values ---> Soils Attributes
SWAT Soil Classification Table
Reclassify
Overlay

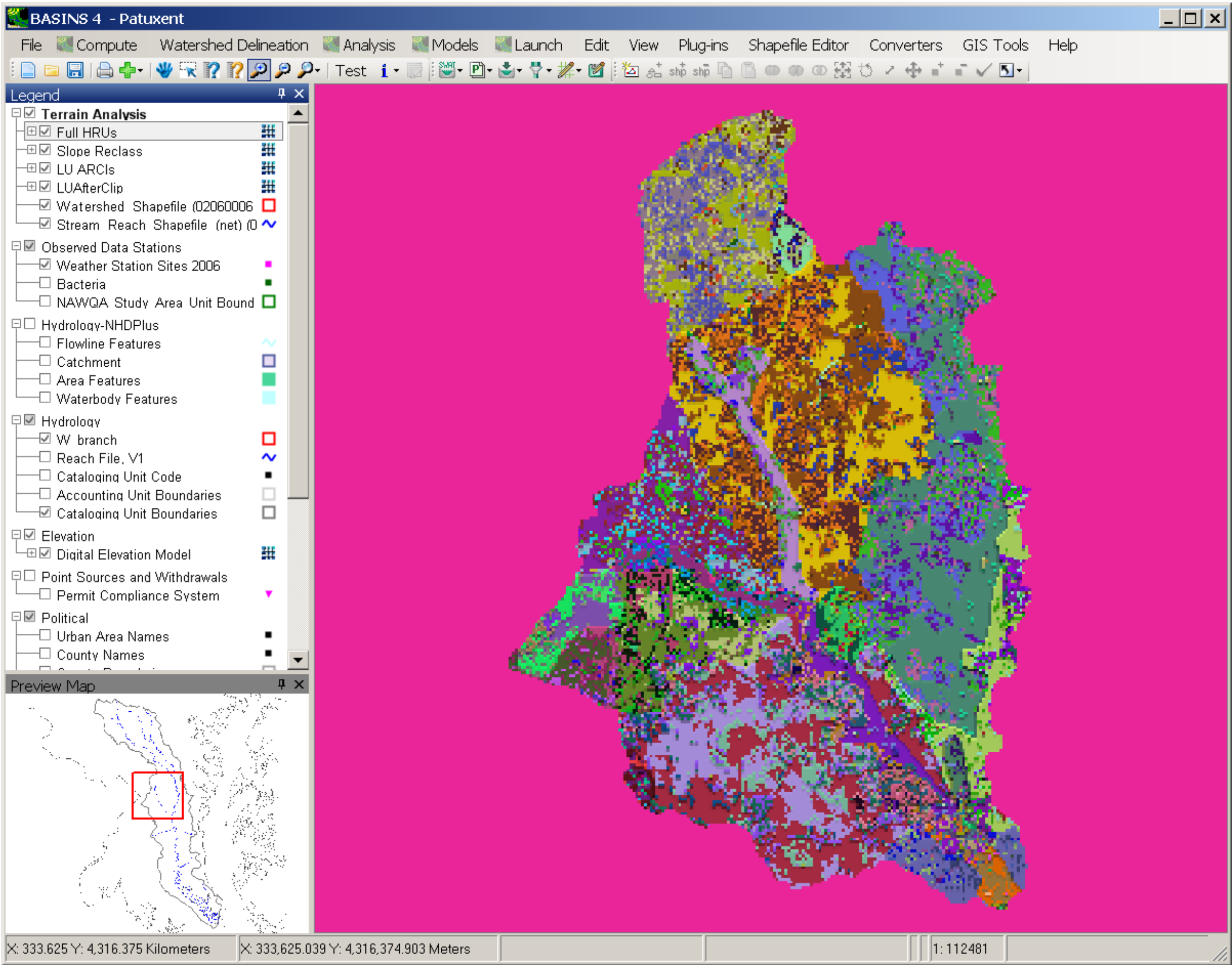
In order to reclassify the slope, users should browse to slope tab. Select the “Multiple Slope” option, click the “Number of Slope Classes” drop-down and select two slope classes to define. Then select the first “Current Slope Class”, specify a “Class Upper Limit” value of 2, and click “Add” to add it into the “SWAT Slope Classification Table”.


Landuse/Soil/Slope Definition
Land Use Data
Soil Data
Slope
Select the DEM Grid (Step 0)
Digital Elevation Model
Slope Discretization (Step 1)
Single Slope
Multiple Slope
Watershed
Slope Stats :
Min: 0.00
Mean: .9
Max: 6.3
Median: .7
Slope Classes (Step 2)
Number of Slope Classes
2
Current Slope Class
1
Class Upper Limit (%)
2
Add
SWAT Slope Classification Table
Class
Lower Limit
Upper Limit
1
0
2
2
2
9999
Reclassify
Overlay

Select “Reclassify” to complete the slope reclassification.

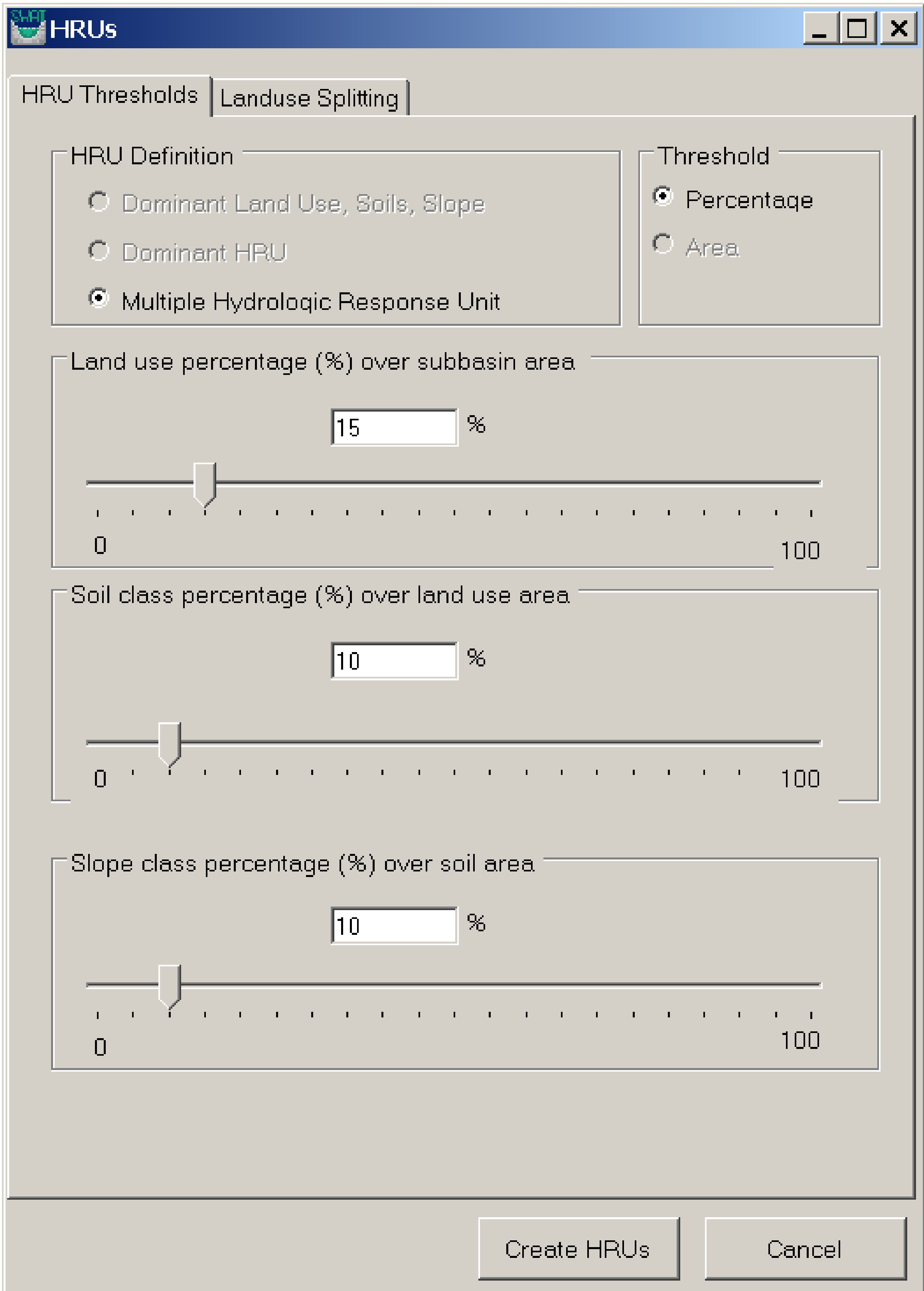
Finally select “Overlay” near the bottom to overlay “Land Use”, “Soil”, and “Slope” grids. This step will produce a complete Hydrological Response Units (HRUs) map. Upon completion the following confirmation message is displayed.





HRU Definition/ Hydrologic Response Unit Distribution

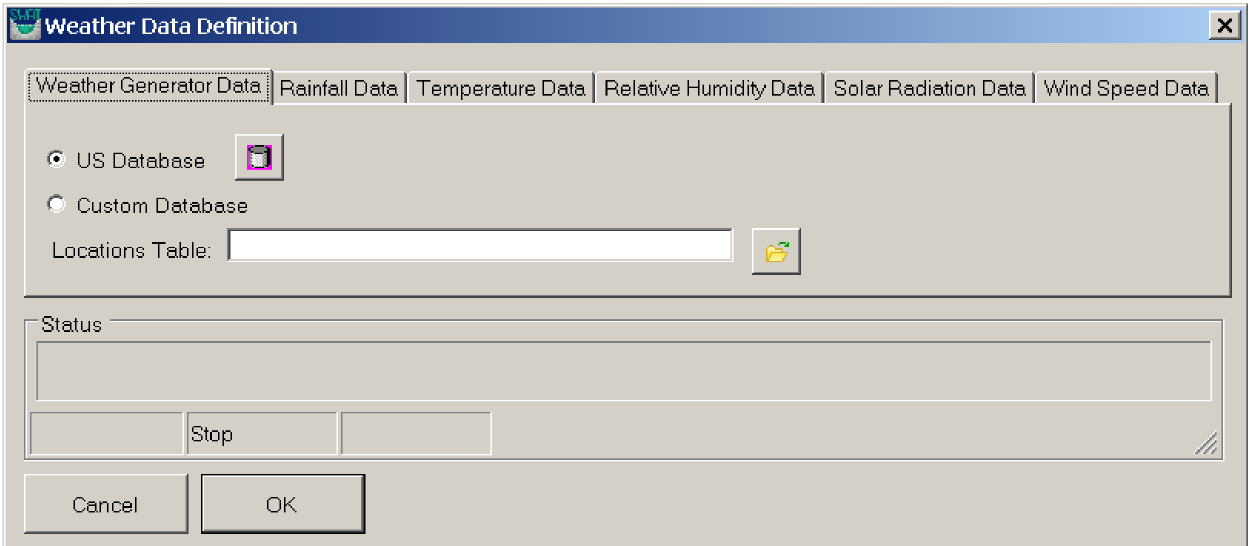
Select the "HRU Definition" from "Land Use/ Soil/ Slope" menu. From this dialog users can specify different threshold values for land use, soil, slope percentages for each subbasin. Select the desired threshold values for land use, soil, and slope (for this example use 15% LU, 10% soil, 10% slope) and click "OK".


HRUs
HRU Thresholds
Landuse Splitting
HRU Definition
Dominant Land Use, Soils, Slope
Dominant HRU
Multiple Hydrologic Response Unit
Threshold
Percentage
Area
Land use percentage (%) over subbasin area
15
%
0
100
Soil class percentage (%) over land use area
10
%
0
100
Slope class percentage (%) over soil area
10
%
0
100
Create HRUs
Cancel

Upon completion of the HRU distribution, a confirmation message is displayed as shown below.

Weather Data Definition

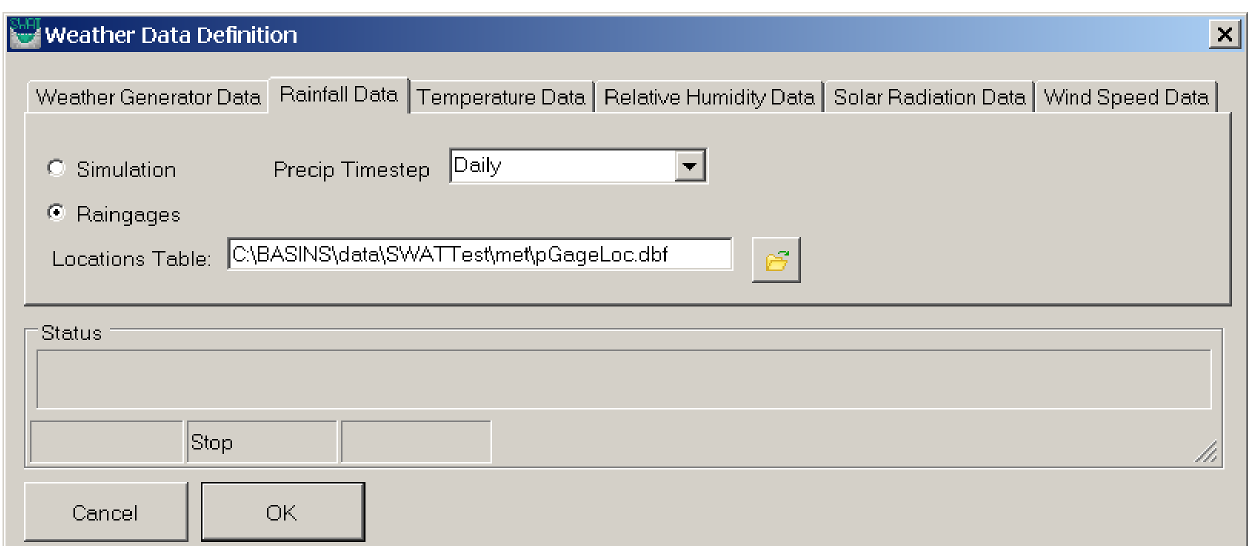
Select the “Weather Stations” option under the “Write Input Tables” menu. A weather data dialog box will be opened. This dialog will let users define the input data for rainfall, temperature, relative humidity, solar radiation, and wind speed. For rainfall and temperature, users have the option of simulating the data in the model or to read from data tables. For the weather data, information can be simulated using a weather generator based on the data from 1112 weather stations around the US stored in a database, or custom weather data can be input though a database tables.

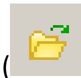


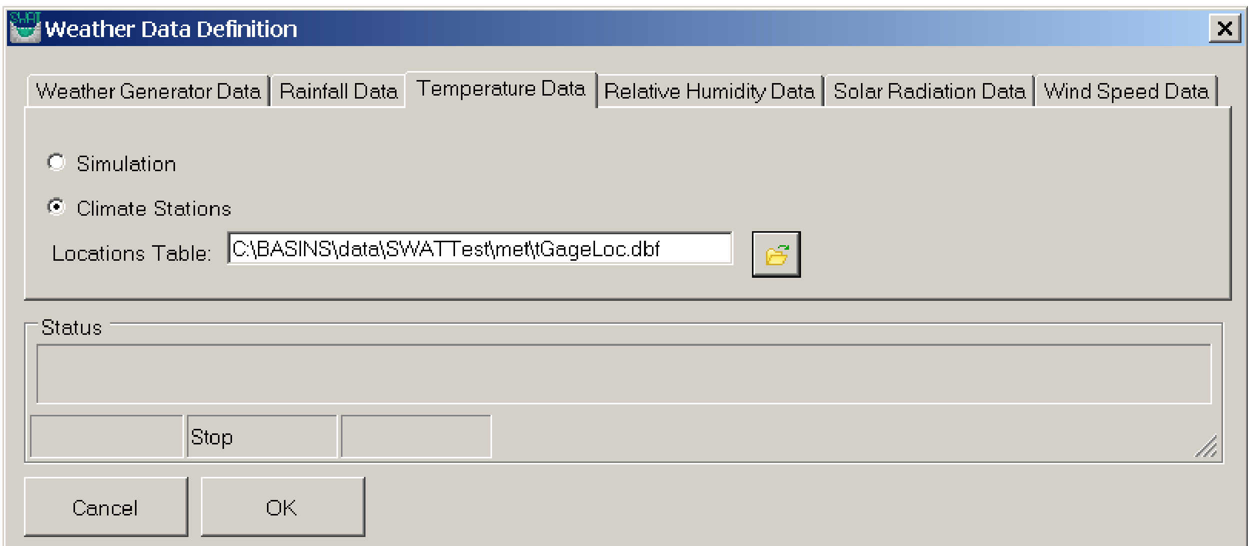
On the ‘Weather Generator Data’ tab, select the “US Database” Option for weather simulation data.

Then click the cylinder-shaped button () to add the weather simulation database automatically.

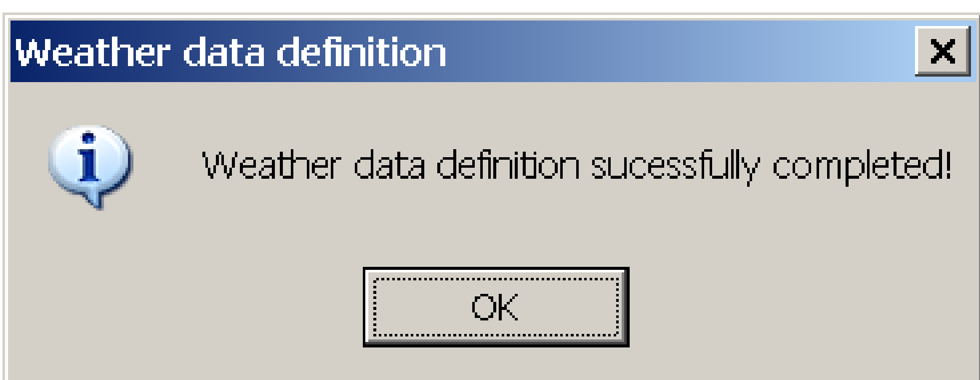
Activate the ‘Rainfall Data’ tab. Specify the ‘Precip Timestep’ to be ‘Daily’ from the dropdown list. Then, check the ‘Raingages’ radio button. Then, click the browse button () to locate the rain gage location file (in dbf file format) as shown below.



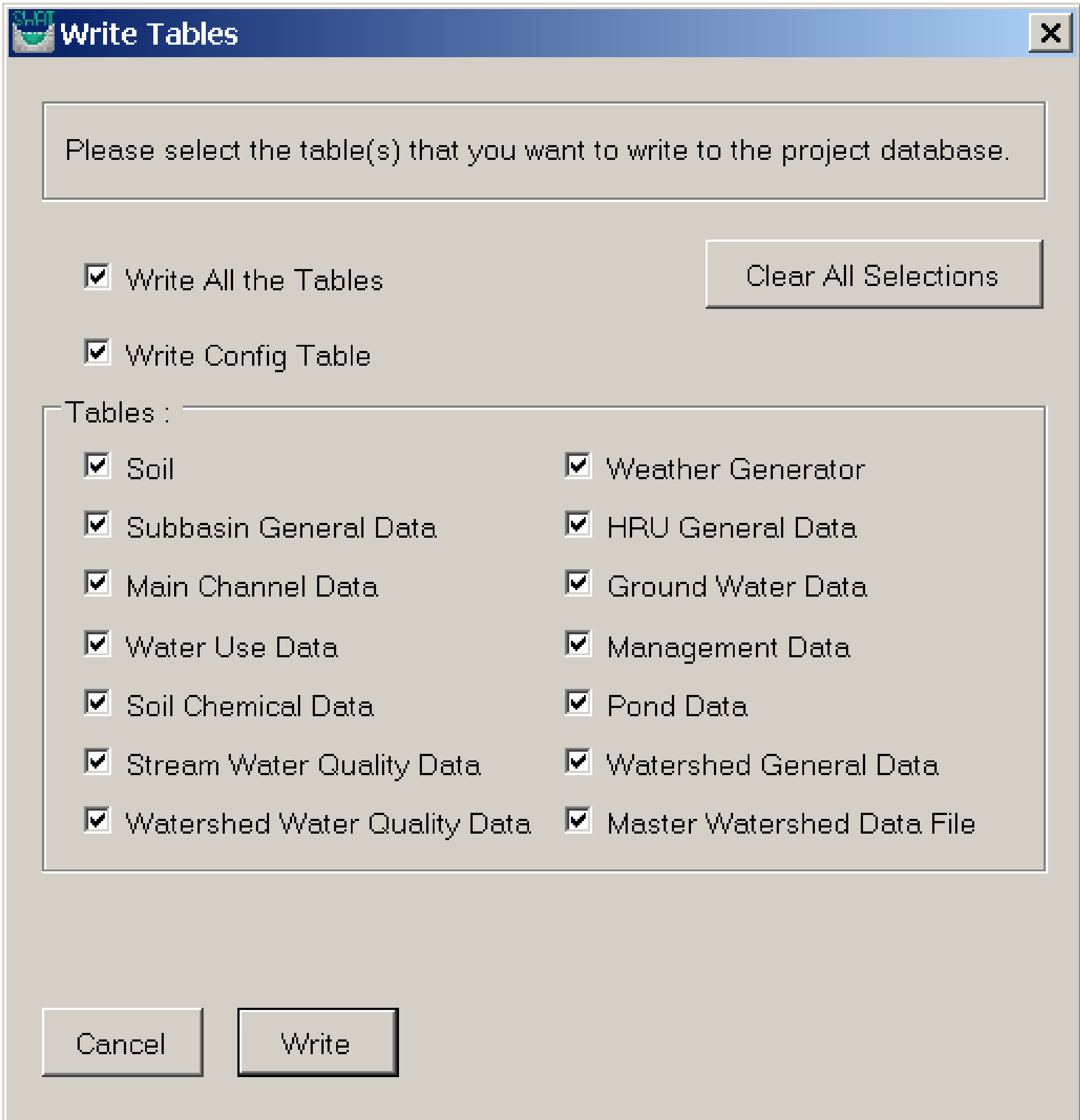
Activate the 'Temperature Data' tab. Select the "Climate Stations" option. Then, click the browse button () next to the "Location Table" text box to locate the temperature gage location file (in dbf file format) as shown below.



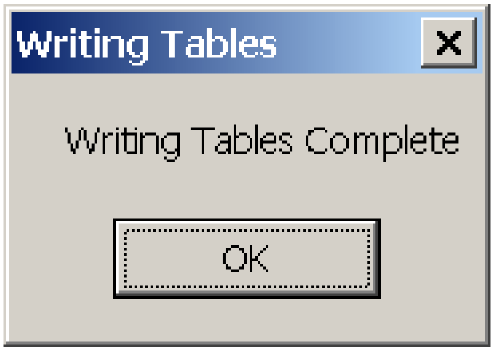
Finally, click the "OK" button at the bottom of the dialog to generate the SWAT weather input data files. Upon its completion, a confirmation message is displayed as shown below:



Writing Input Tables

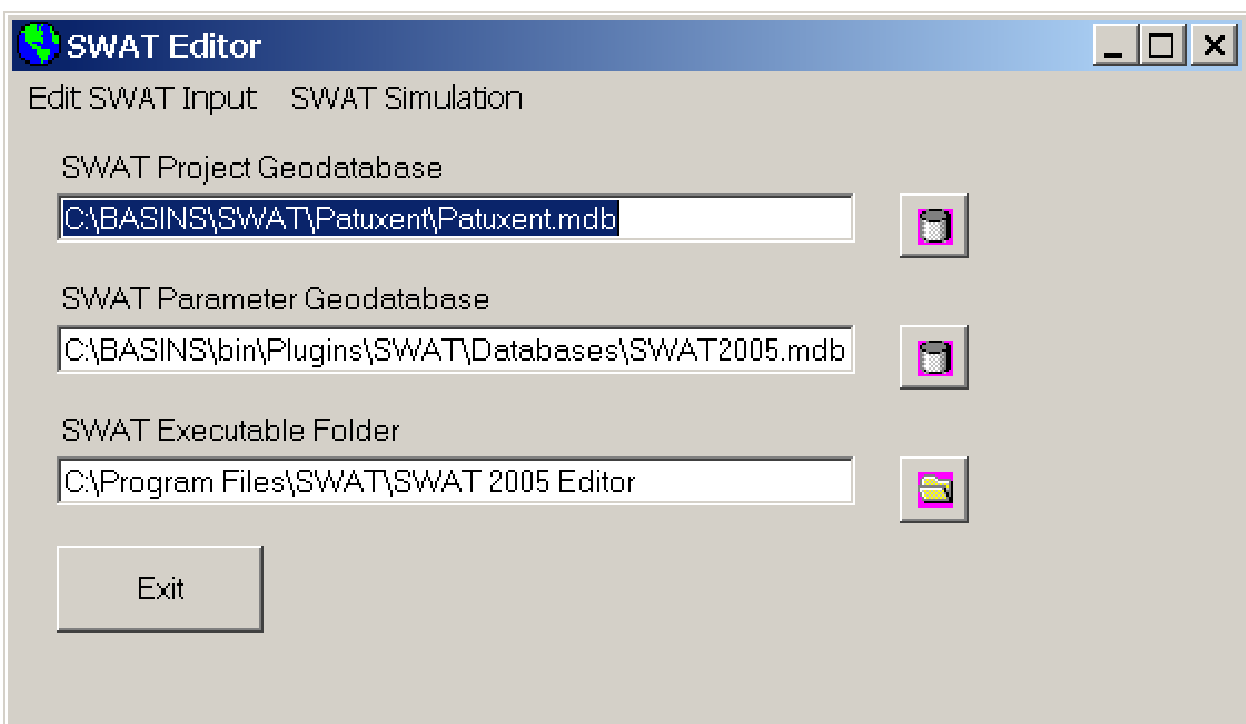


In order to write the remaining input tables, use the “Write Tables” option under “Write Input Tables” menu as shown above. This brings up a dialog box which has all the input tables required for SWAT model run. Click the “Write All the Tables” check box and then click the write button.



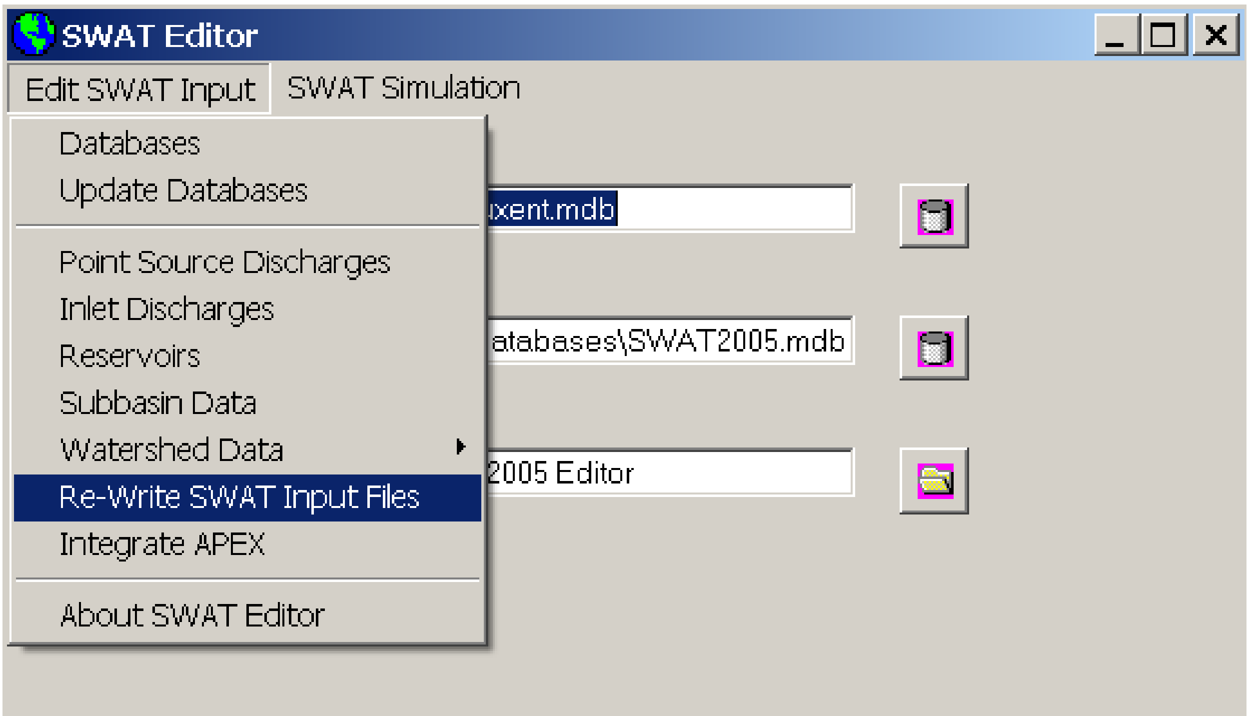
Run SWAT Editor

When a user finishes the writing tables operation using OpenSWAT, the next step is to launch the SWAT Editor to continue watershed modeling. Click the "Launch SWAT Editor" button () on the OpenSWAT toolbar.

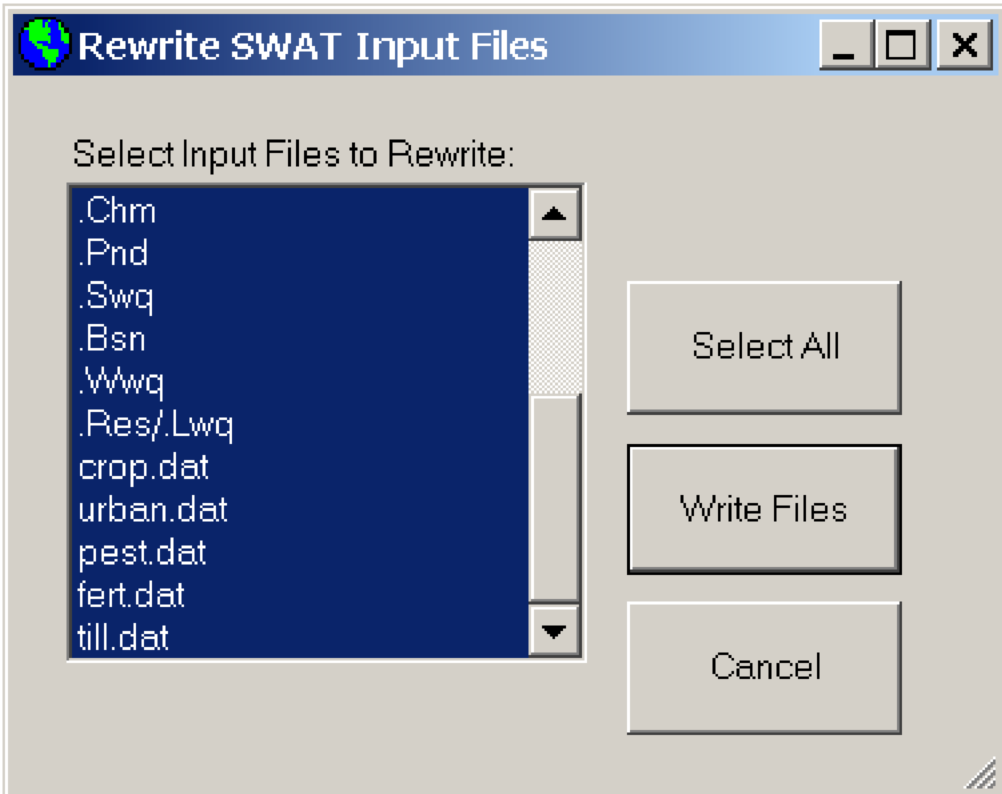


When using the SWAT Editor for the first time for a given project, it is recommended that users re-write all

SWAT input files by choosing “Re-Write SWAT Input Files” from the “Edit SWAT Input” menu.



Since OpenSWAT doesn’t create any text input files, it is recommended to “Select All” items for the first application and to write them using the “Write Files” option.

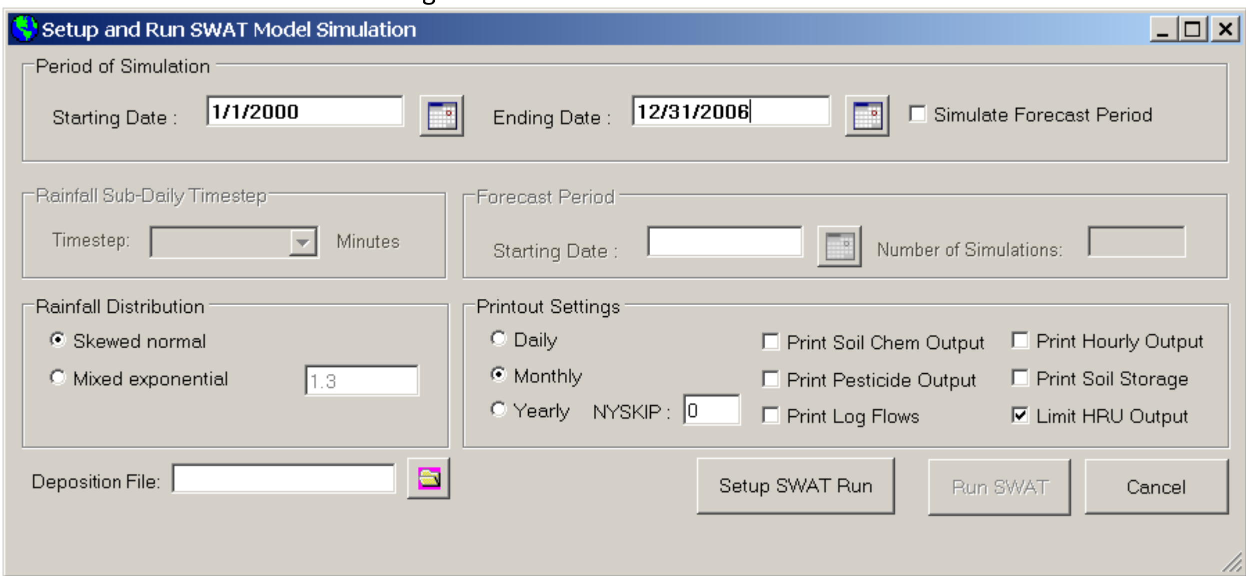


Upon successfully writing input files, a confirmation message is displayed as below.

If users want to edit specific inputs, choose input type from "Edit SWAT Input" menu, edit the values, and save them.

The next step is to run and simulate the model.

1. Go to “SWAT Simulation” and click the “Run SWAT” option. That will bring up the “Setup and Run SWAT Model Simulation” dialog box.



2. Specify the starting and ending simulation dates and then press “Setup SWAT Run.”

3. If the setup is successful, users will get a confirmation message.

4. After that, click the “Run SWAT” button.

5. Users can then view a DOS window showing year of SWAT Run and progress of model run.