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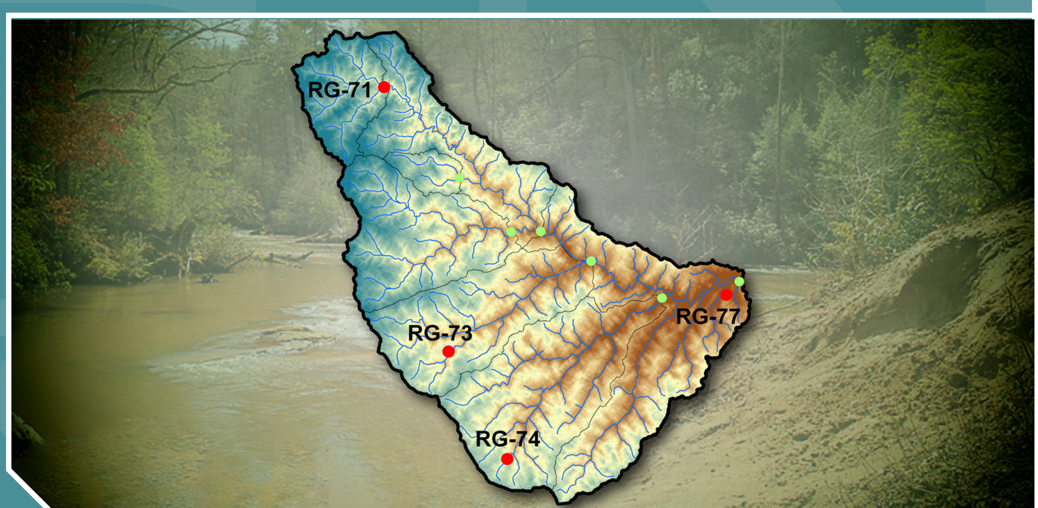
United States Environmental Protection Agency

Application of BASINS/HSPF to Data-scarce Watersheds



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ABSTRACT

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS 4.1) is a program developed by the US EPA for local, regional, and state agencies responsible for water resources management, particularly the development of total maximum daily loads (TMDLs) as required under the Clean Water Act (CWA). BASINS facilitates water quantity and quality modeling applications to support EPA's policy and regulatory decisions, e.g., water quality criteria development and total maximum daily load calculations. BASINS 4.1 has pre-packaged cartographic, environmental, and climate data within its databases and BASINS users in the United States often use it. Where pre-packaged data is not available, however, BASINS users must obtain data from other sources and upload it to BASINS. This tutorial summarizes data requirements of BASINS users who want to use data other than pre-packaged or who want to apply BASINS/HSPF to watersheds outside the United States. This report presents steps to import data to BASINS, delineate watersheds, and launch BASINS to build an HSPF model project.

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PART I. BASINS & HSPF USER INFORMATION

Chapter 1: Introduction

As local, regional, national, and international agencies and organizations tackle water quality and quantity issues with watershed-based solutions, it is necessary to model watershed characteristics and responses to rainfall and pollution effectively. BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) is a multi-purpose tool that enables users to delineate watersheds, perform various analyses, and manage data. HSPF (Hydrological Simulation Program—Fortran) is the core watershed model in BASINS. BASINS also has other models including SWAT (Soil Water Assessment Tool), SWMM (Stormwater Management Model), and WASP (Water Quality Analysis Simulation Program).

1.1 Purpose

This document has been written specifically for HSPF users. It facilitates the use of BASINS\HSPF in watersheds where pre-packaged BASINS data is not available.

1.2 Introduction to BASINS 4.1

BASINS is a watershed assessment tool used for downloading data, delineating watersheds, building modeling projects, evaluating data, and developing reports. BASINS utilizes a geographic information system (GIS) framework to analyze geospatial data and other tools that generate charts or summarize data.

Following enactment of the Clean Water Act Section 303(d), the United States Environmental Protection Agency (EPA) developed BASINS to establish measures of total maximum daily loads (TMDLs) for water quality-impaired water bodies and to allow local, state, and regional agencies to perform watershed analyses. The Office of Water within EPA created BASINS specifically to address three key objectives:

1. Facilitate examination of environmental information,
2. Support analysis of environmental systems, and
3. Provide a framework for examining management alternatives.

Before BASINS was developed, conventional approaches to watershed analyses and HSPF model applications were tedious efforts that required many steps and a variety of tools and computer software. The BASINS environment facilitates data acquisition, data management, geographic data processing, and watershed delineation. BASINS provides model-specific data input formatting capabilities and can parameterize and launch models including HSPF, SWMM, SWAT, and WASP. This intuitive and efficient design not only decreases processing time but also minimizes errors associated with incompatible data formats for each model. When available, BASINS allows users to incorporate higher resolution local data in place of the pre-packaged datasets. International BASINS users whose study areas are outside the United States may obtain input data from external sources following the guidelines presented in this document.

1.2.1 Additional Features and Compatible Programs

One quality that makes BASINS a multi-purpose tool is its compatibility with other programs, assessment tools, models, and post-processing tools. The table below describes the utilities available within BASINS and additional features that can be downloaded separately (Table 1). Readers are strongly encouraged to view the full list of BASINS-related information on the BASINS website.

Table 1: Basins Supported Models and Utilities

Type/Name		Function	Download
Utilities	GenScn	• Displays output data from models in various formats to facilitate data interpretation • Performs statistical functions	Download
	WDMUtil	• Manages and formats input and output time-series data for HSPF	Download
	Manual Watershed Delineation Tool	• Enables users to subdivide and edit a watershed, stream network, or outlet/inlet points manually	BASINS
	Automatic Watershed Delineation Tool	• Performs watershed delineation based on digital elevation data and user-specified parameters	BASINS
	Land Use Reclassification Tool	• Edits land use classification tables	BASINS
	Lookup Tables	• Enables quick look-up of data and information	BASINS
Watershed Models	Hydrological Simulation Program - FORTRAN (HSPF)	• Models point source runoff and nonpoint pollutant loadings	BASINS
	The Soil and Water Assessment Tool (SWAT)	• Models impacts of land management practices on water and sediment	BASINS
	The EPA Storm Water Management Model (SWMM)	• Models storm water runoff for planning, analysis and design of storm water systems for urban and non-urban areas	BASINS
	Generalized Watershed Loading Function model extension (GWLF-E)	• Estimates monthly nutrient and sediment loads within a watershed	BASINS
	The Pollutant Loading Estimator (PLOAD)	• Estimates nonpoint sources of pollution	BASINS
Water Quality Models	AQUATOX	• Models fate and effects of various environmental stressors in aquatic ecosystems	BASINS
	Water Quality Analysis Simulation Program (WASP)	• Simulates water quality in aquatic systems	BASINS

Source: BASINS Framework and Features:
http://water.epa.gov/scitech/datait/models/basins/framework.cfm

1.2.2 Installation and Hardware Requirements

Information regarding installing the program and a BASINS download link can be found on the BASINS website. The minimum requirements for installation and use are shown below (Table 2).

Table 2: Hardware/Software Requirements for BASINS Installation and Operation

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
Internet Connection	WiFi	DSL or better
Operating system	Windows XP, Vista, Windows 7 and Windows 8	Windows XP, Vista, Windows 7 and Windows 8

Reproduced from EPA BASINS Downloads and Installation Page: http://water.epa.gov/scitech/datait/models/basins/download.cfm

1.3 Introduction to HSPF Modeling

HSPF was developed in the early 1960s as the Stanford Watershed Model (SWM). SWM was a hydrology model until water quality modeling capabilities were added in the 1970s. The Ecosystem Research Laboratory in Athens, GA funded development of the Fortran version that combined three programs: the EPA Agricultural Runoff Management Model (ARM), the EPA Nonpoint Source Runoff Model (NPS), and a privately developed, proprietary Hydrologic Simulation Program (HSP).

As mentioned above, HSPF simulates water quantity and quality at user-specified spatial and temporal scales. The model's simulation timestep — from sub-hourly to daily to monthly, with a duration of a couple minutes to hundreds of years can be specified. HSPF can assess the effects of land-use change (e.g., urbanization), reservoir operations, point and nonpoint source pollutant loadings, and flow diversions.

1.3.1 Applications and Model Capabilities

HSPF modeling applications include:

- Flood control planning and operations
- Hydropower studies
- River basin and watershed planning

- Storm drainage analyses
- Water quality planning and management
- Point and nonpoint source pollution analyses
- Soil erosion and sediment transport studies
- Evaluation of urban and agricultural best management practices (BMPs)
- Fate, transport, exposure assessment, and control of pesticides, nutrients, and toxic substances

Beyond those general capabilities, individual utilities and application modules perform functions that serve specific modeling purposes. The three HSPF application modules summarized below simulate water quality and quantity from three land use segments: IMPLND, PERLND, and RCHRES that represent impervious land, pervious land, and stream reaches, respectively.

PERLND
The PERLND land segment simulates water quality and water balance for pervious land surfaces. PERLND accounts for different flow types (e.g., surface runoff, interflow, and baseflow), and tracks chemicals transported by these flows.

IMPLND
IMPLND represents impervious urban areas. Due to the nature of this land cover, the primary mode of pollutant removal is surface runoff.

RCHRES
This module represents water bodies such as streams, rivers and lakes. HSPF simulates flow and water quality constituents that include biochemical oxygen demand, temperature, hydraulic behavior, sediment deposition, chemical decay and transport, dissolved oxygen, alkalinity, pH and carbon dioxide.

1.3.2 HSPF Assumptions and Limitations

As with all modeling programs, HSPF has limitations. It is dependent on the accuracy and resolution of the input data. Additionally, it requires significant amounts of input data and users must have strong modeling skills and adequate training. Explore tutorials and user information on EPA's Website.

1.4 Additional BASINS/HSPF Supporting Software

Depending on user needs, BASINS/HSPF users may require or benefit from freely available supplemental programs in addition to the BASINS/HSPF software.

1.4.1 GIS Software

- **3DEM Visualization Software:** Depending on the size of a watershed, the user may need to merge multiple DEM files, but geo-processing tools in BASINS may not be able to do so. 3DEM, available for download here, is less restrictive in file size when merging DEMs for use in BASINS. The program also allows DEM editing.

- **MapWindow:** MapWindow is a spatial data viewer and GIS tool that the BASINS graphical user interface (GUI) was built upon which allows users to perform geospatial analyses and geo-processing tasks such as projection of data layers. Note that MapWindow is pre-packaged in BASINS, but users may also download it from the MapWindow website and install it separately.

1.4.2 Time Series Data Management Software

- **WDMUtil:** WDMUtil enables users to import HSPF model input data into a WDM (Watershed Data Management) file. This program is available free from the AQUA TERRA website and EPA has published a tutorial explaining how to use WDMUtil to properly format input time series data into a WDM. It is necessary to use scripts that can read the data format, as described in the aforementioned hyperlink and defined in the User's Manual that can be accessed through WDMUtil at the Help tab. The tutorial hyperlinked above also explains other capabilities of the WDMUtil.

- **HSPF Data Formatting Tool (HDFT):** While WDMUtil is useful for coarse resolution time series data, it has limited capabilities for other formats, including data with sub-hourly temporal resolutions. HDFT was designed to format such fine resolution data for use in HSPF. It is available in web-based and desktop-based versions. Information regarding HDFT's data-formatting capabilities can be found here. Tutorials on how to use the HDFT versions are included in the HDFT Report.

- **SARA Time Series Utility:** This data management tool developed by AQUA TERRA Consultants allows users to import times series data and produce WDM files that can be added to and used in BASINS. It can be downloaded from the AQUA TERRA Website.

The use of BASINS to perform watershed delineation with data not accessible from within BASINS requires additional data acquisition procedures. The steps illustrated in Figure 1 are explained in detail in Chapters 3 and 4. This chapter summarizes BASINS/HSPF data requirements and potential data sources.

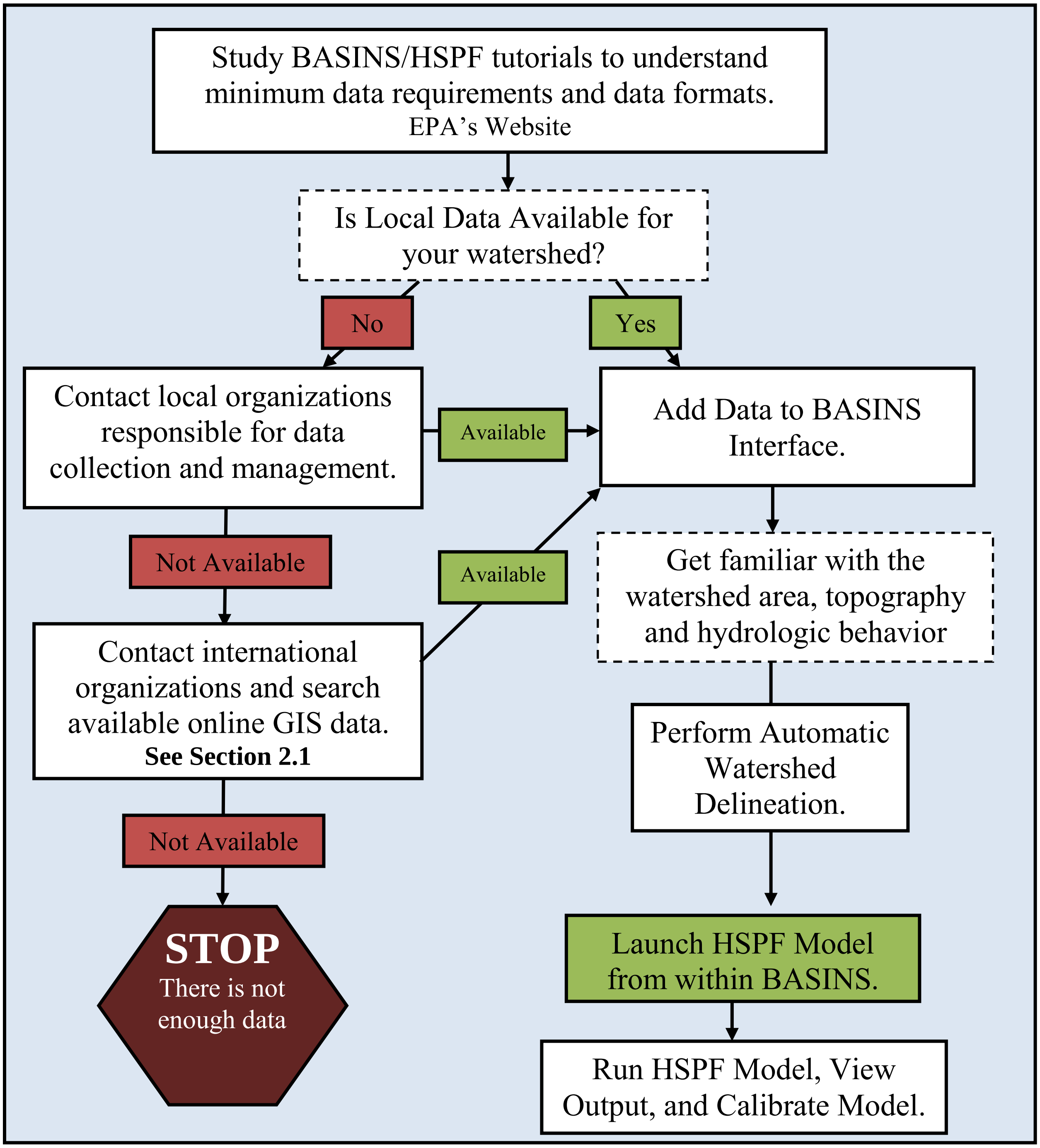


Figure 1: Overview of BASINS and HSPF Application Procedure

2.1 Minimum Required Data and Sources

Before performing watershed analyses and running HSPF using BASINS, acquiring sufficient input data is necessary. This section discusses the input data required to perform a successful HSPF simulation, and where users may obtain input if data sources accessible from within BASINS are inadequate for watershed analysis. Data sources outlined below represent a basic list; site-specific data may be available from regional agencies and/or downloadable from other sites on the internet. Minimum data required for BASINS/HSPF include GIS data (e.g. DEM, land cover, and river networks) and climate data such as precipitation and evapotranspiration.

2.1.1. Digital Elevation Models (DEMs)

Digital elevation models are GIS layers, usually of raster type, whose cell values describe the elevations of an area. They are generated through processes involving remote sensing technology and are required for BASINS to perform watershed delineations. Geospatial data layers like DEMs can be projected in a number of different coordinate systems; as such, it is necessary to know their projection and reference datum to ensure that all other geographic data is projected accordingly. BASINS requires DEMs to be in a projected coordinate system as explained in Chapter 3.

- **Global Data Explorer:** This interactive mapping interface enables registered users to download DEMs and other geographic data; users can register by following the steps outlined on the website which are also included in Appendix A. The **Global Data Explorer** is the result of collaboration between Land Processes Distributed Active Archive Center (LP DAAC), a joint NASA and USGS data center, and George Mason University's Center for Spatial Information Science and Systems. A number of geospatial datasets are available for download from this resource, including ASTR Global DEM, NASA Blue Marble, and NASA and NGA STRM.
  Website: http://gdex.cr.usgs.gov/gdex/

2.1.2. Land Use Data

Incorporating land use data enables BASINS to estimate land use categories in a watershed. To minimize HSPF model output errors, the resolution of the land cover data should be as high as possible, particularly for small watersheds. When land use and land cover data are not available within the BASINS software package, users can download data from the following global databases:

- **Global Land Cover 2000:** The European Commission's Joint Research Centre (JRC) organized a global collaboration for sharing land use data. The website provides relevant metadata. Descriptions of the project include the source of the data, projection, and other information that help BASINS users assess its accuracy and applicability. An example data extraction is included in Appendix C.
  Website: http://bioval.jrc.ec.europa.eu/products/glc2000/products.php

- **USGS Land Cover Institute:** This site contains links to various land cover data sources including land use trends, soil characteristics, and forest fire maps. Some sources cannot be incorporated into an HSPF modeling project, however, they may be of interest to BASINS users as the data can assist in judging if further sub-delineation/segmentation is needed, based on land surface characteristics.

Website: http://landcover.usgs.gov/landcoverdata.php

2.1.3 Climate Data

Since BASINS was developed for use in the United States, default units are in U.S. customary units. International users must convert input from International System of Units (SI) to US customary units while running the HSPF Model see Table 3 for conversion factors. Chapter 4: HSPF Application Example shows how to perform a conversion. Table 3 contains key input parameters, default BASINS/HSPF U.S. customary units, and the conversion factors required to convert data from SI to US customary units.

Table 3: BASINS/HSPF Default Climate Data Units and Conversions

Data Description	U.S. Customary Units used in HSPF	Conversion factor ***from*** SI to U.S.	Common SI Units
Air Temperature	°F	$({}^{9}/_{5}*°C) + 32$	°C
Precipitation	in/hr	0.3937	cm/hr
Dewpoint Temperature	°F	$({}^{9}/_{5}*°C) + 32$	°C
Wind Movement	mph	2.237	m/s
Solar Radiation	Ly/hr	11.63	Watt/m^2
Cloud Cover	Range 0-10 (tenths)	-	Otka
Potential Evapotranspiration	in/hr	0.3937	cm/hr

*Multiply SI unit by conversion factor to get U.S. customary unit

HSPF requires different input data for different modeling applications. Table 4 summarizes the data needs for the three different application modules, PERLND, IMPLND, and RCHRES. For more information on modeling options and applications, review tutorials on the EPA BASINS webpage. HSPF Input data must be imported into a Weather Data Management (WDM) format in time steps congruent with those required by the intended application. In general, data of hourly time steps is required, but not always available. The WDMUtil software can be used to disaggregate daily data to hourly data. WDMUtil can also calculate potential evapotranspiration from meteorological data. Note that sub-hourly simulation time steps are more appropriate for event-based urban stormwater modeling applications and hourly simulation time steps are typically used for continuous simulation of non-urban watersheds. A link to the WDMUtil download site is included in Section 1.4.2.

Table 4 illustrates the meteorological data required by the HSPF model for water quantity and quality modeling applications. Note: for water quantity (streamflow) simulation, only precipitation and evapotranspiration are required.

Table 4: HSPF Weather Data Requirements

	PERLND/IMPLND						RCHRES				
	Temp.	Snow*	Water Quantity	Sediment	Soil Temp.	Agriculture Chemicals**	Water	Heat	Gen. Qual.	DO	Plankton
Precipitation	R	R	R	R	-	C	O	O	-	-	-
Potential ET	-	-	R	C	-	C	O	-	-	-	-
Air Temperature	R	R	-	-	R	C	-	R	-	-	-
Wind Speed	-	R	-	-	-	-	-	R	C	C	-
Solar Radiation	-	R	-	-	-	-	-	R	-	-	R
Dewpoint Temp.	-	R	-	-	-	-	-	R	-	-	-
Cloud Cover	-	-	-	-	-	-	-	R	-	C	-

R= Required, C= Conditional, O=Optional. Adapted from BASINS Tutorial 4:
http://water.epa.gov/scitech/datait/models/basins/upload/Lecture-4-Weather-Data-WDM.pdf.
*Conditional: Degree Day option requires only precipitation and air temp.
**Nutrients and pesticides.

Weather Data Sources:

- **NOAA Climate Data Online:** NOAA's interactive mapping tool allows BASINS users to view weather stations to access available data. The program sends users a data download link via email. NOAA also has a search tool to extract the same data from specific regions or countries. An example data extraction from NOAA is included in Appendix E.
  Map: http://gis.ncdc.noaa.gov/map/viewer/#app=cdo&cfg=cdo&theme=hourly&layers=1&node=gi
  Search Tool: http://www.ncdc.noaa.gov/cdo-web/search

- **LocClim:** This program was designed to estimate climate data for areas lacking monitoring equipment. It is available as a web tool or downloadable desktop software. The software generates climate data by interpolating between known observations from 28,800 weather stations in the FAOClim 2.0 Database. The user can specify daily, 10-day, or monthly temporal resolution.
  Website: http://www.fao.org/nr/climpag/pub/en0201_en.asp
  Web Tool: http://www.fao.org/nr/climpag/locclim/locclim_en.asp

2.2 Other Useful Data and Sources

To increase reliability of model-generated output, BASINS users are encouraged to find the best available input data. Depending on intended use of the HSPF model, input data requirements will vary. The sections below provide information on additional publicly available data sources.

2.2.1 Soil

Soil data may be necessary to perform simulations on erosion and sediment transport. International BASINS users can use the digital soil map of the world.

- **Digital Soil Map of the World:** The Food and Agricultural Organization of the United Nations' GeoNetwork has maps and publicly available data for download such as the Digital Soil Map of the World. A tutorial demonstrating how to download this map is included in Appendix D.
  Website: http://www.fao.org/geonetwork/srv/en/metadata.show?id=14116

2.2.2 Hydrogeographic Data

Hydrogeographic data including stream networks are generally polyline shape files that designate locations of streams. They are often developed the same way BASINS develops stream segments – by geo-processing digital elevation data. These files can improve the accuracy of watershed delineation and watershed analysis, particularly when the stream file has higher resolution than the DEM. Stream files can often be useful when using DEMs of very high resolution, as such datasets may contain large amounts of noise that make it difficult for BASINS or other GIS software to accurately identify the stream network.

- **USGS HydroSHEDS:** The USGS-developed stream and river network files from 90 m resolution DEMs obtained from NASA's Shuttle Radar Topography Mission (SRTM). This source also contains other geo-referenced data sets. A tutorial demonstrating how to download data layers is included in Appendix B.
  Website: http://hydrosheds.cr.usgs.gov/dataavail.php

2.2.3 Global Flow Data

Calibrating HSPF model simulated streamflow is vital for refining the model's parameter values and providing more accurate simulations. Flow data from specific outlet points is required to perform such calibrations. When delineating watersheds, it is recommended to select an outlet point corresponding to the location of a stream gauge that measures river flow. Like climate data, these must be formatted in a time-series and added to the WDM file.

- **Global Runoff Data Centre (GRDC):** This organization works under the auspices of the World Meteorological Organization, in partnership with the German Federal Institute of Hydrology. The site contains global flow data and associated metadata which can be downloaded as monthly averages from the website.
  Website:
  http://www.bafg.de/GRDC/EN/03_dtprdcts/32_LTMM/longtermmonthly_node.html

PART II. TUTORIALS

Chapter 3: BASINS Application Example

This chapter presents the steps required to build an HSPF Model project within BASINS for a tributary of the Shebelle Watershed in central Ethiopia (Figure 2). The approximate area is 2400 square kilometers, or 927 square miles. The files used in this tutorial are available for download at the following web address and information about the files are included in this document's appendices: http://www2.epa.gov/exposure-assessment-models/tmdl-models-and-tools

Figure 2: Location of Upper Shebelle Tributary in Ethiopia

3.1 Starting a new BASINS project

When using BASINS within boundaries of the United States, required input data can be acquired from sources accessible within the software package. BASINS users in other countries, however, must obtain BASINS/HSPF data elsewhere. This tutorial guides users through that process.

a. Download BASINS from the EPA Website and install the program. Depending on the intended application, install additional programs discussed in Section 1.2.1.

b. Open BASINS 4.1. Figure 3 shows the welcome screen.

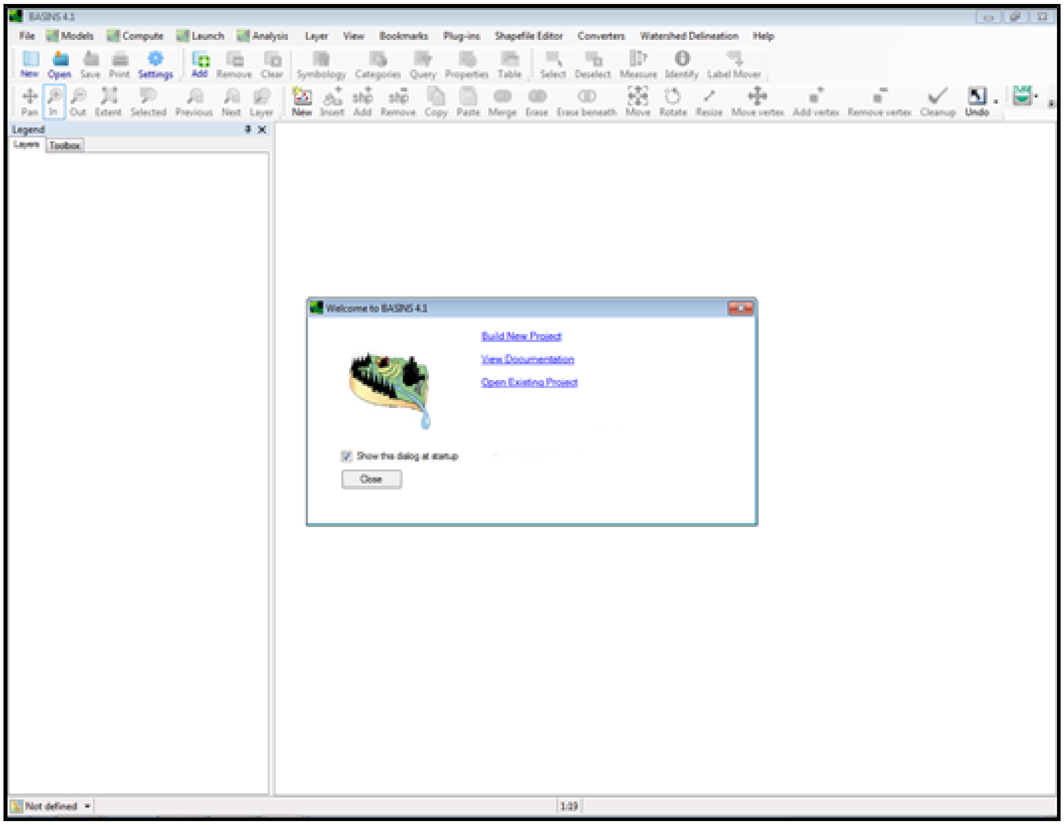


Figure 3: BASINS Welcome Screen

c. Press '**Close**' or exit the Welcome to BASINS 4.1 window which opens a blank BASINS 4.1 interface.

d. Select a projection. In the bottom left-hand corner of the BASINS window (Figure 4), a drop-down menu enables the user to select a project coordinate system and projection. **'Choose Projection'** opens a window with various coordinate systems (Figure 5).

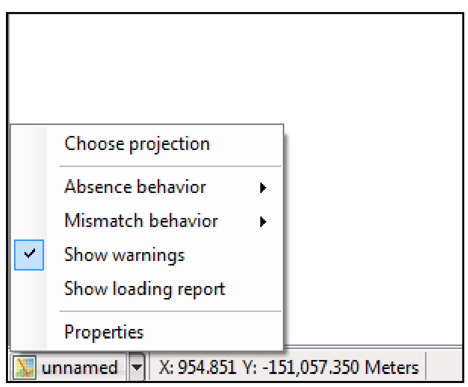


Figure 4: Choosing a Project Projection

e. Click on the preferred coordinate system, and then click **'Ok'**. For this example, the initial coordinate system selected is geographical WGS 84 to match the coordinate system of the downloaded data described in this document. Alternatively, users may select a projection by clicking File on the BASINS toolbar, then Settings, then the **'…'** button when "ProjectProjection" is selected.

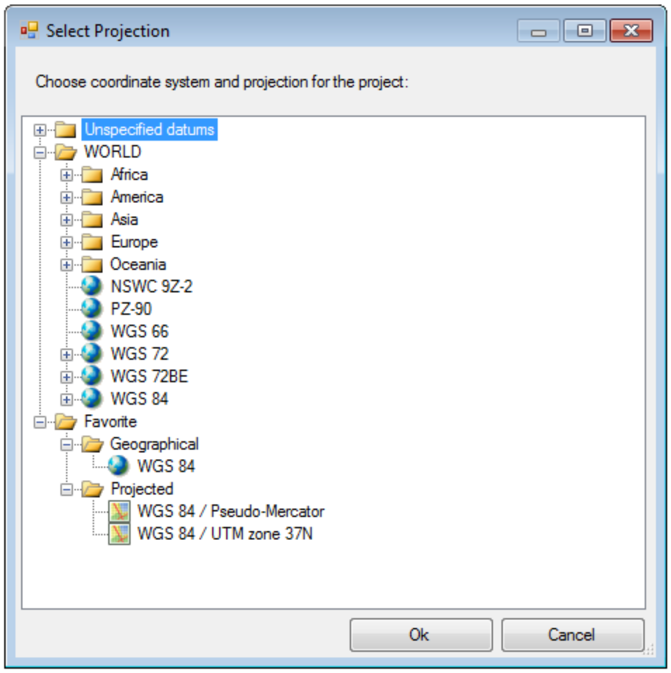


Figure 5: Selecting a Project Projection

d. If the current project needs to be saved and the tutorial continued later, users can click the Save button 

. Alternatively, users may save the project by first clicking 'File' and then 'Save'. They may save the project in an alternate directory by using 'Save As'.

3.2 Adding Digital Elevation Model (DEM)

The DEM was downloaded from the Global Data Explorer (GDEx), a process explained in more detail in Appendix A.

Note: If the watershed is larger than approximately 45,000 square miles, it may be necessary to download the DEM in separate sections and merge them in BASINS or in another GIS software. To minimize processing time and prevent reaching BASINS's processing limit, it is recommended to remain within the download capacity of GDEx. When downloading digital elevation data, be sure to select the projection that matches the other available input data. In this example (Figure 6), Lat/Long was selected and the DEM was downloaded as a GeoTIFF.

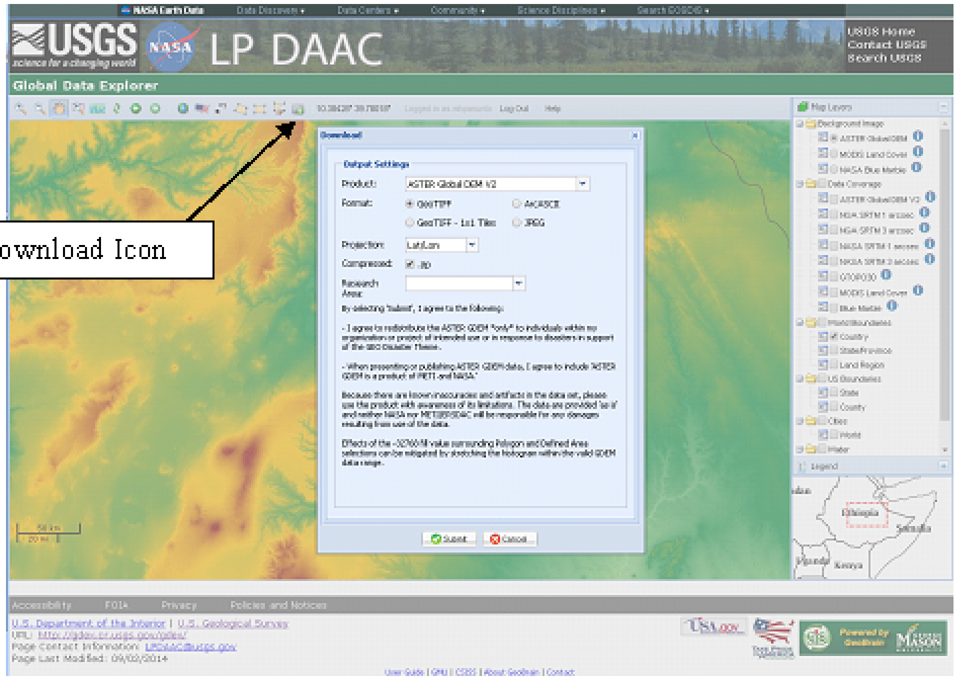


Figure 6: Downloading DEM of Shebelle Watershed Tributary

a. Add the DEM to BASINS. After downloading the DEM(s), click the Add Layer Icon  in Basins, navigate to the file and Open it. Users can adjust the projection, merge rasters, and perform other geo-processing activities with available tools.

b. Check the projection. Since the DEM was downloaded in the same coordinate system as the map project, no projection is required. BASINS may not be able to identify the projection of the DEM when imported to the project, however, and if that is the case, the following pop-up window (Figure 7) will appear. Since we know the DEM used for this example is the same as the map project, click **'Assign projection from project'**. If you also know remaining data layers will be in the same projection, check the box beside **'Use this answer for the rest files'**.

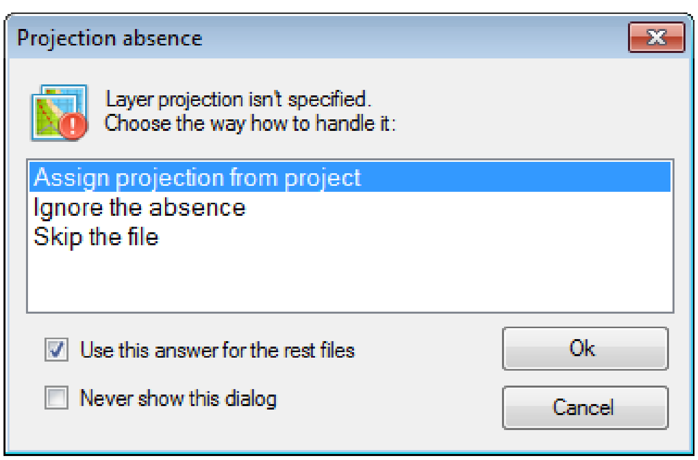


Figure 7: Projection Absence Window

c. Click **'Ok'**. The window should resemble Figure 8.

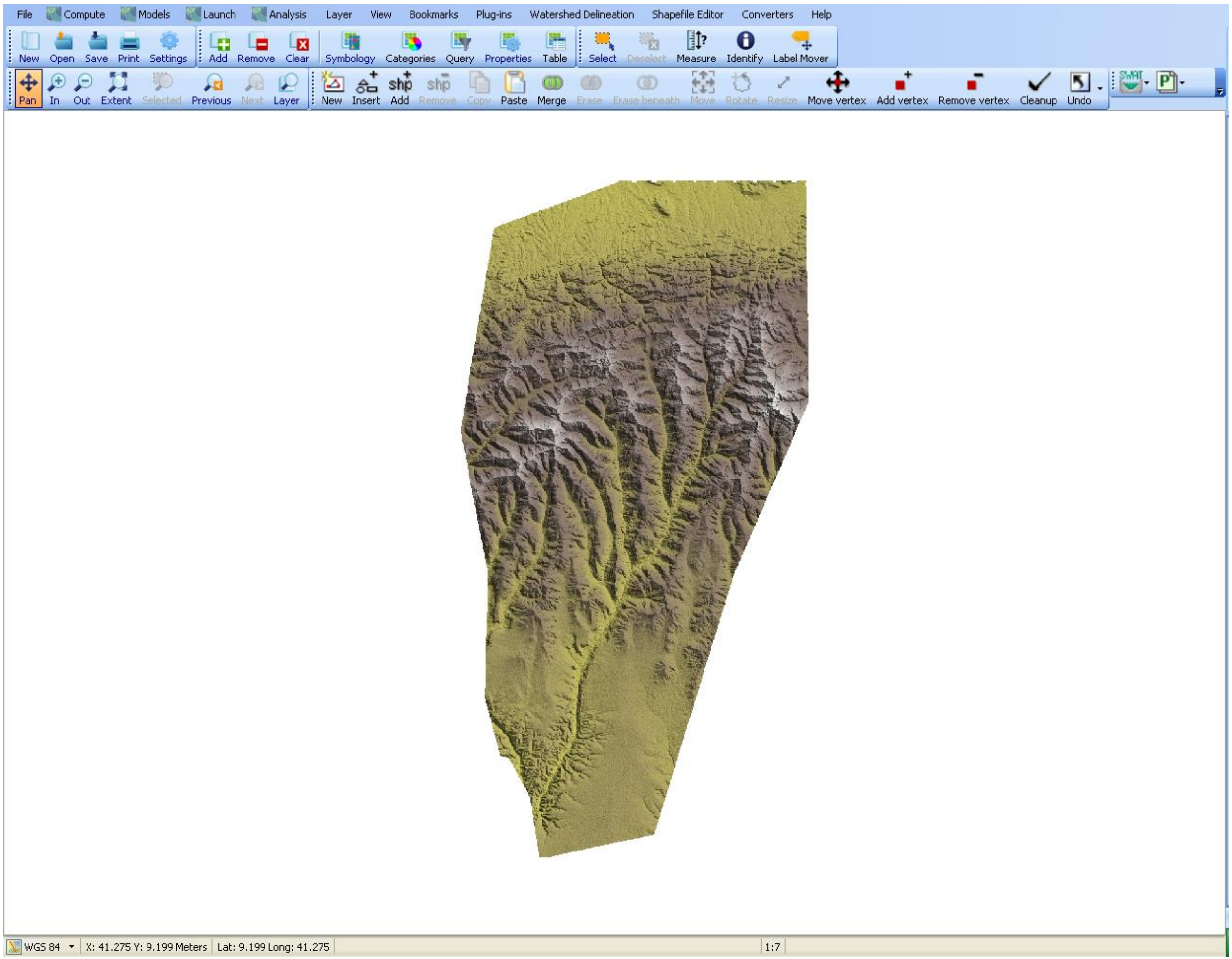


Figure 8: DEM Uploaded to BASINS

If the legend is not visible on the left side of the window, click the **View** tab at the top of the window, hover the mouse over **'Panels'** and select **'Legend,'** as shown in Figure 9.

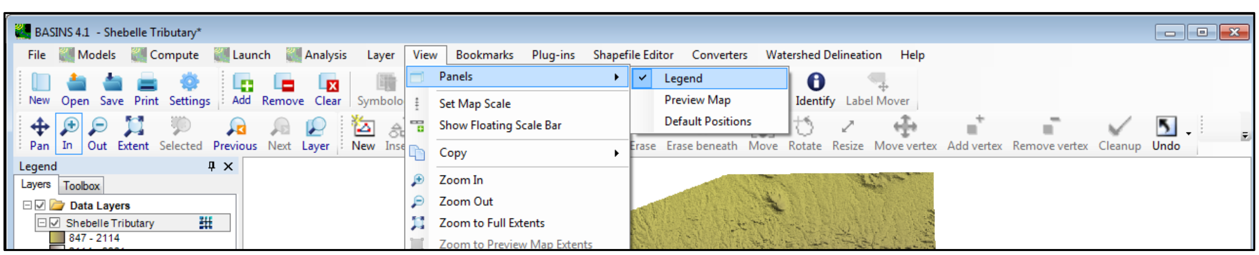


Figure 9: Displaying the Legend Menu

3.3 Adding River Network Files

The river network file for the watershed was downloaded from the USGS HydroSHEDS Database. The default coordinate system is a geographic system (latitude/longitude) referenced to WGS84 datum, and is the same as the DEM downloaded in this example.

a. Following the same procedure for adding the DEM to the BASINS Project, add the river file. The window shown in Figure 10 will appear.

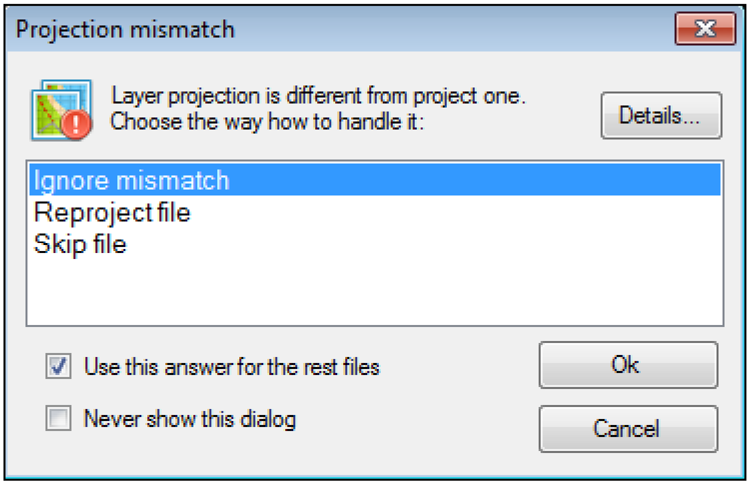


Figure 10: Projection Mismatch Window

b. In this example, the river file already has the same projection as the data frame and DEM, so **'Ignore mismatch'** was selected. After making the selection, press **'Ok'**. The BASINS interface should resemble Figure 11. Adjust colors and properties of the layers by double-clicking on the layer icon as shown below.

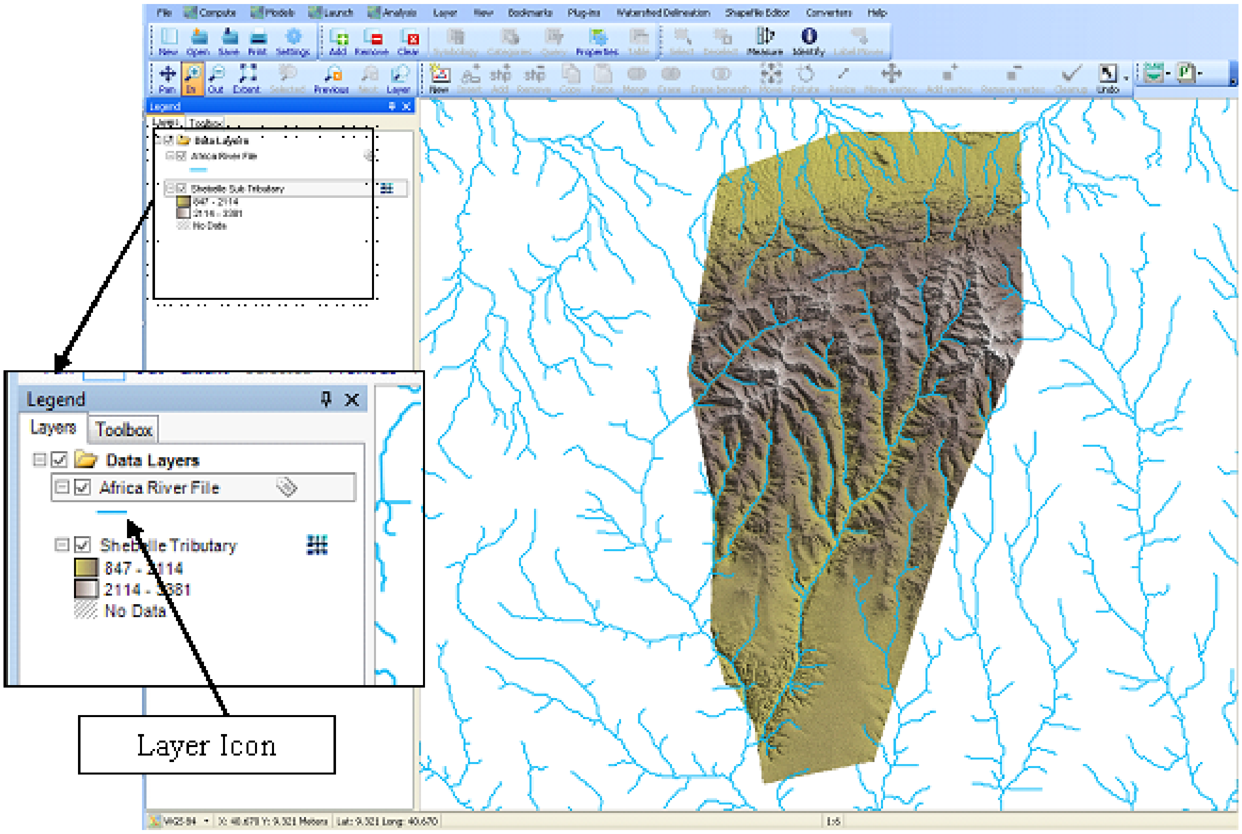


Figure 11: DEM with River Network Shapefile

3.4 Adding Land Cover Data

Note: The terms "Land Use" and "Land Cover" are used interchangeably throughout this document.

a. Land cover data can be added as a raster file or a shapefile. The land cover data in this tutorial was a raster downloaded from the Global Land Cover 2000 (GLC) (see Appendix C). Specific characteristics of the land use files vary slightly between different regions in the GLC. It is therefore essential to get more information about the land use data prior to incorporating these files into an analysis. The land use dataset for Africa, like many other continents, has a 1-km resolution. The default coordinate system for the downloaded dataset for this example is the WGS84 geographic (Lat/Long) coordinate system (the same coordinate system as the downloaded DEM and streamline shapefile).

b. Once the land use raster is added to the BASINS project and the layers are adjusted so it is in the background, the map window should resemble Figure 12.

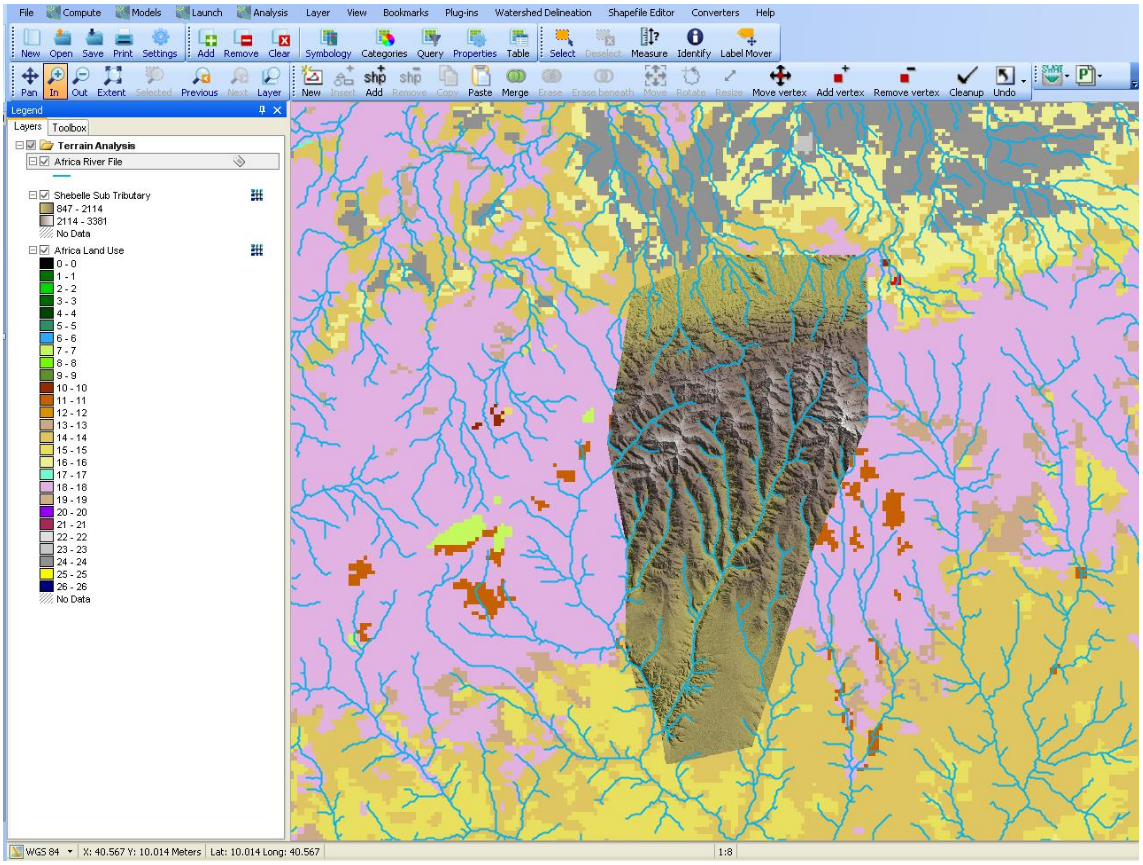


Figure 12: DEM with River Network and Land Cover Raster

3.5 Clipping input data in BASINS

The smallest river network and land cover dataset that can be downloaded for the region in this example is the entire continent of Africa. To minimize the amount of data BASINS must store and process, the layers can be clipped to a smaller, more manageable size. There are several ways to do this, but one is to create a polygon shapefile around the watershed area, then clip the dataset to it. This method is described below. In the event this causes BASINS to crash, skip to Step o. for an alternative clipping method.

a. A Clipping Box shapefile has been provided with the tutorial, or you can create a new one by clicking the New Shapefile icon 

. The New Shape File Options Dialog box will appear (Figure 13).

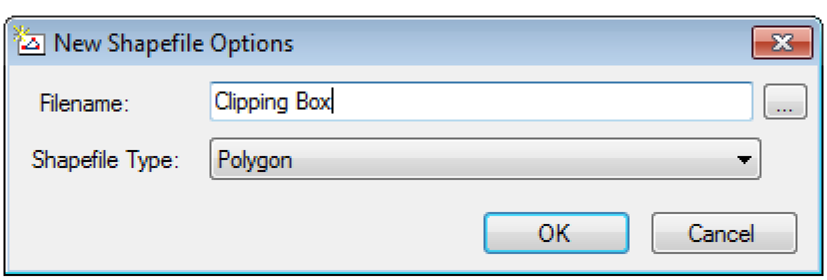


Figure 13: New Shapefile Options Dialog Box

b. Click the **'…'** button to save the shape file in a location other than the default. Users may need to type the name of shapefile in the directory listing to save it.

c. Select **'Polygon'** as the shapefile type and press **'OK'**.

d. The following window (Figure 14) will appear; press **'OK'** to dismiss the warning and continue.

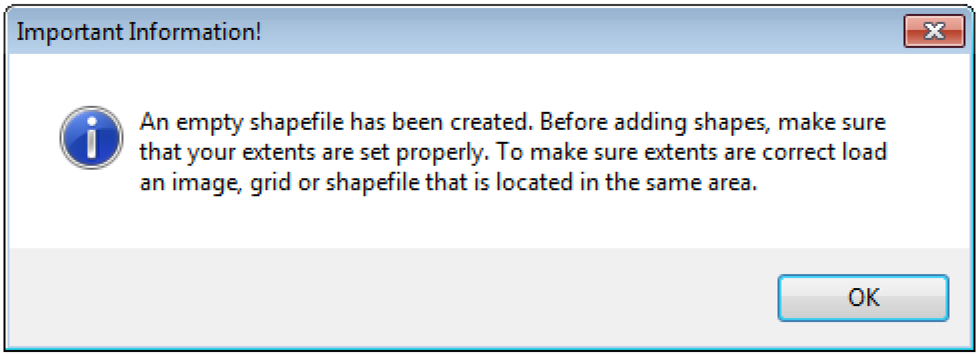


Figure 14: Checking Extents Set-Up

e. Create a polygon feature around the watershed area by clicking the Add Shape icon 

while the Clipping Box layer is selected on the Data Layers Table of Contents, although this may not be necessary since that shapefile has already been selected if you are following the tutorial. Create vertices around the DEM where you will clip the river network and land cover raster by clicking points on the map window around the DEM (see Figure 15). It may be necessary to zoom out prior to creating vertices.

f. To complete the polygon feature, double-click on the origin of the polygon or right click. The finished box is shown in Figure 16. Note that the Clipping Box is the active layer since the name is highlighted in the Data Layers Table of Contents. To bring the DEM layer back to the top, click on the Clipping Box layer in the legend and drag it below the DEM and River layers. The result of the reorganized data layers is shown in Figure 17.

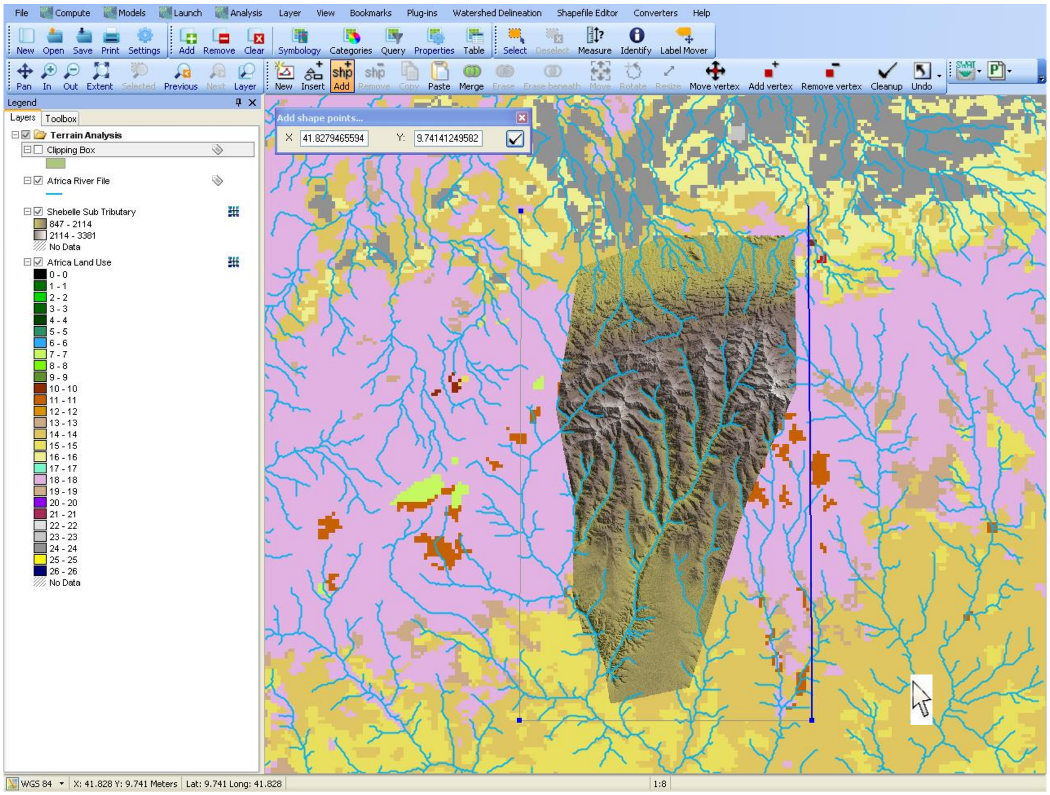


Figure 15: Drawing a Polygon around the DEM

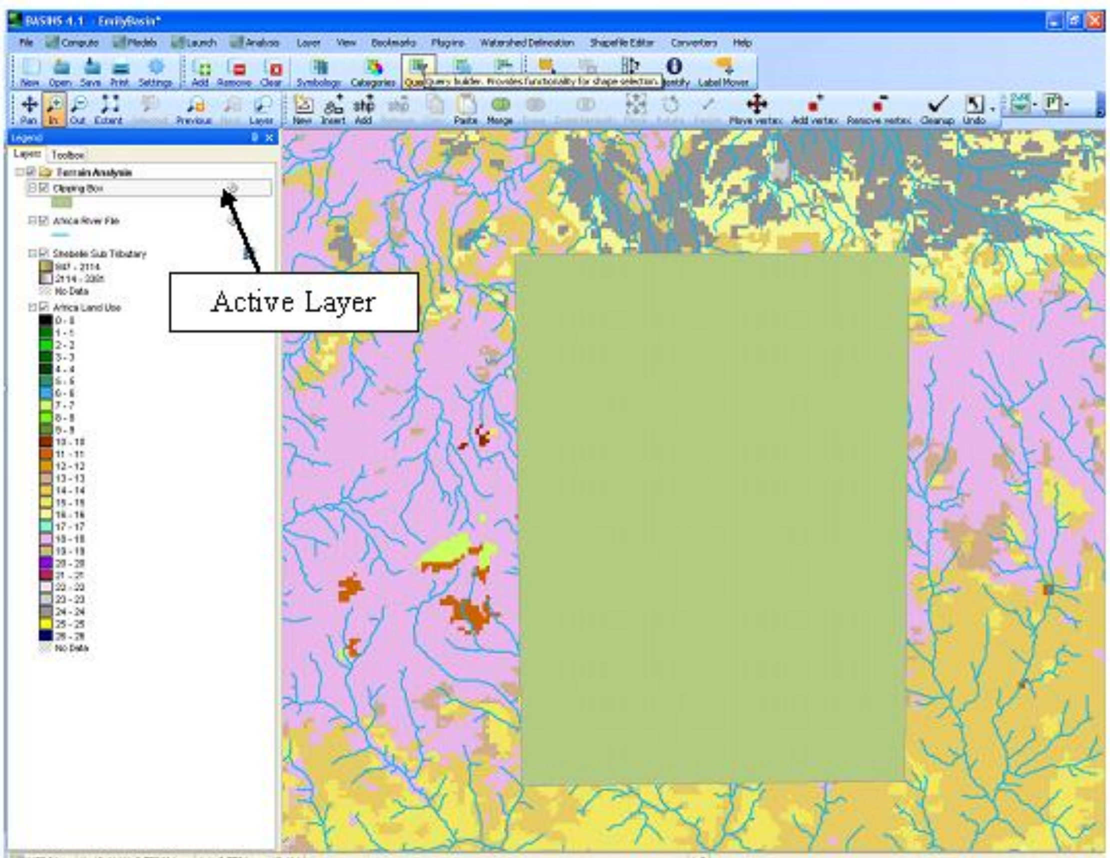


Figure 16: Map Window with New Shapefile "Clipping Box"

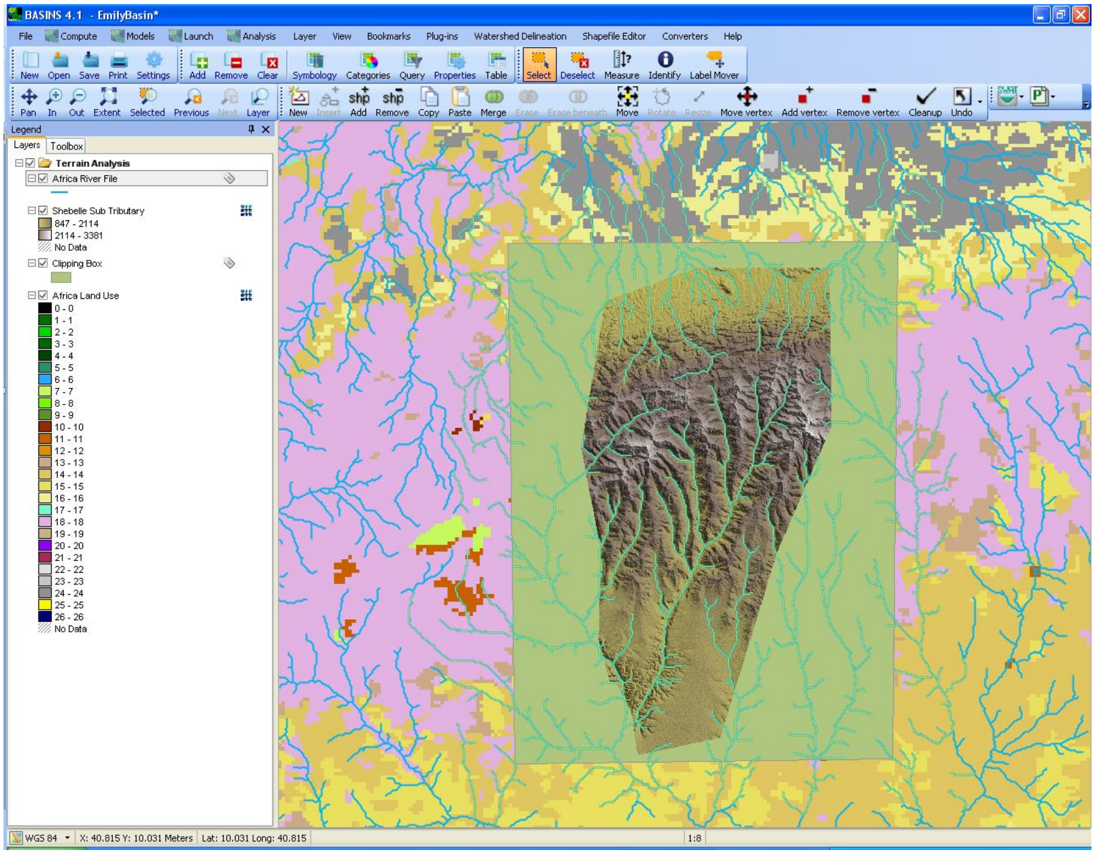


Figure 17: Selecting Polyline Shapefiles

g. Make the river shapefile the active layer. If the layer is turned off, turn it on by checking the box to the left. The layer will then be visible in the map window. To activate the layer, click on its name in the legend. When selected, it will be highlighted with a grey box, as in Figure 17.

h. Turn on the **Select Tool** by pressing the **Select** icon 

and draw a selection box that incorporates the full extent of the DEM, the selection being about the size of the Clipping Box shapefile; the window should resemble Figure 17. Note that the rivers in the box around the DEM are now yellow to indicate they have been selected.

i. Make the Clipping Box the active layer, then turn on the Select Tool and click on the polygon, which should change color. When both items are selected, the window should resemble Figure 18. Execute the clipping command now.

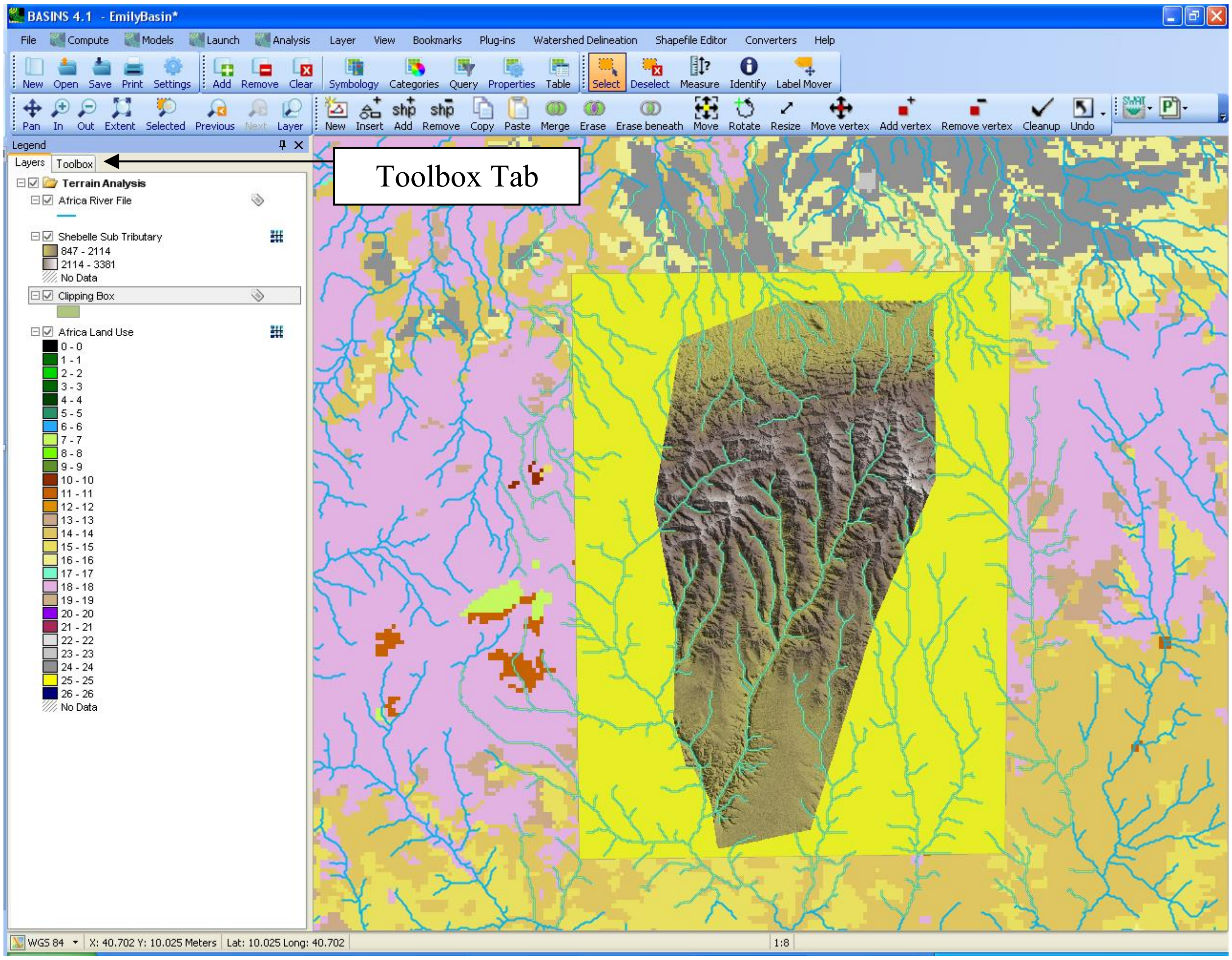


Figure 18: Selecting Elements in BASINS

j. Go to the Toolbox by clicking the tab in the legend, as illustrated in Figure 18.

k. As shown in Figure 19, open the **Overlays** folder within **Vector Operations** by clicking the plus sign at the left. Select **'Clipping'** by double-clicking on the option**.**

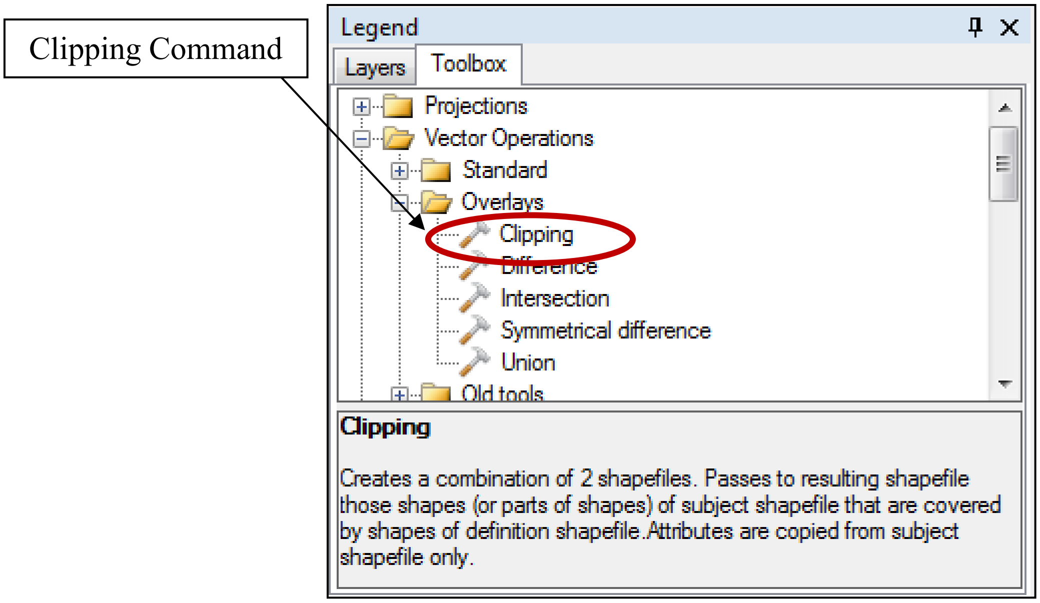


Figure 19: Clipping Command in Toolbox

The following Shapefile Clipping dialog box (see Figure 20) will appear. Make the proper selections as indicated in Figure 20. The number of selected elements in the Africa River File will vary with size of the selection box.

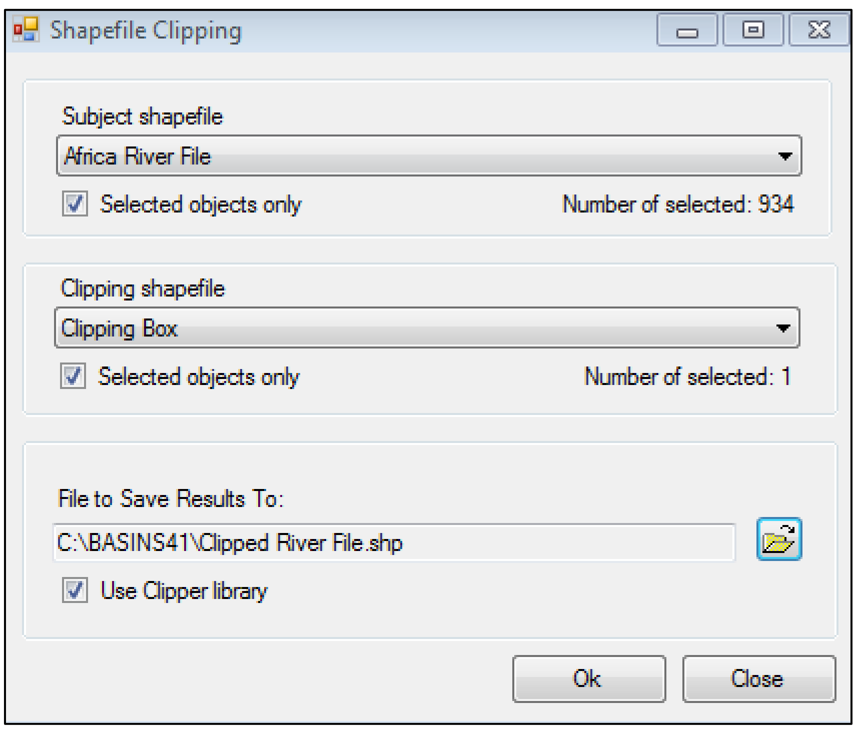


Figure 20: Shapefile Clipping Dialog Box

l. Click **'Yes'** in the GIS Tools dialog box (see Figure 21) to add the clipped layer to the map.

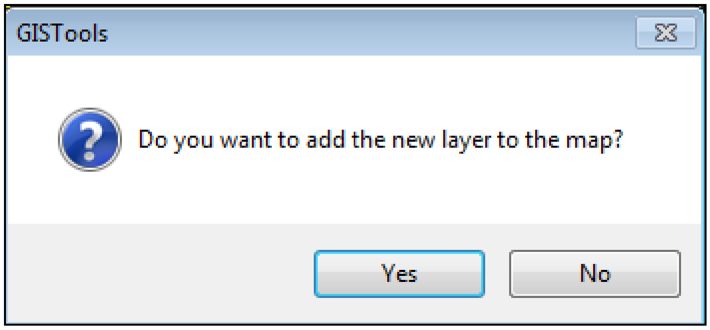


Figure 21: GIS Tool Dialog Box

m. Deselect the river layer by making it active and pressing **'Deselect'** 

.

n. Remove the original rivers file by right-clicking the name of the layer in the legend and selecting **'Remove Layer'**. With the original layer removed and the Clipping Box layer turned off, the Window should resemble Figure 22.

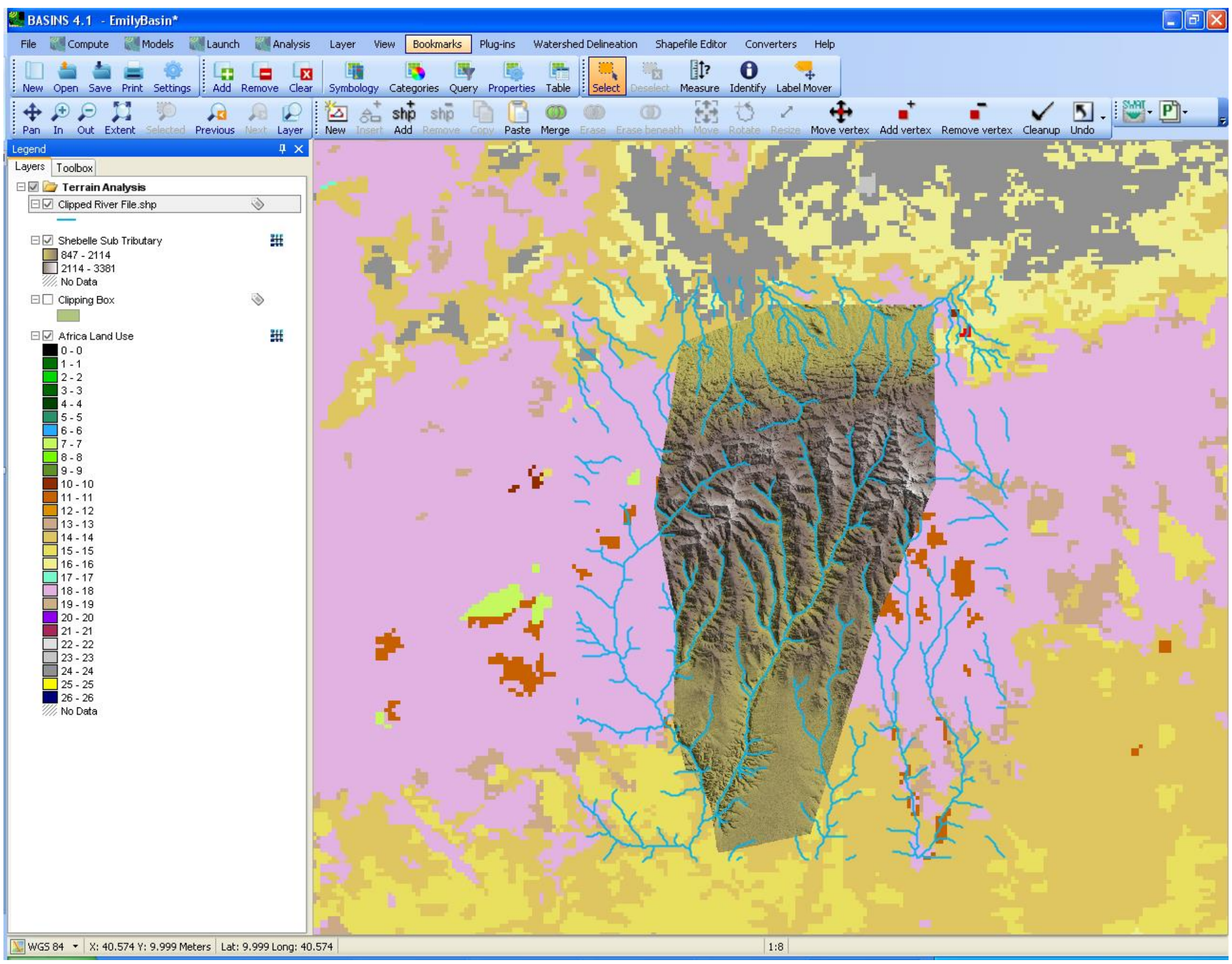


Figure 22: Clipped River Layer with Land Cover and DEM

o. It is possible that the above procedure for clipping stream lines may cause BASINS to crash. If so, users should follow the process outlined in the following steps to successfully clip the input files.

p. Instead of selecting the “Clipping” tool from the Overlay folder within the Vector Operations toolbox folder (as outlined in Step k.), users should select the “**Clip Shapefile With Polygon**” tool located within the **Old Tools** folder as shown in Figure 23.

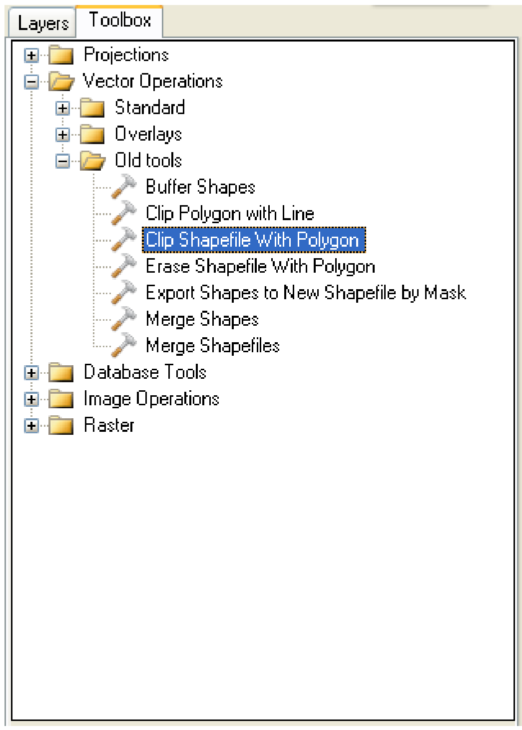
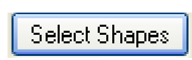
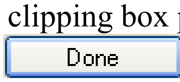


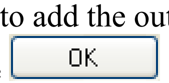
Figure 23: Clip Shapefile with Polygon Tool

q. When the “Clip Shapefile” dialogue box appears, select the river file as the “Shapefile to Clip” and the Clipping Box as the “Polygon Shapefile to Clip With”, as shown in Figure 23.

r. To apply the clipping directly to the Clipping Box, click the 

button (Figure 24), and manually select the clipping box polygon feature in the map window. Once the feature has been selected, click the 

button.

s. Select the “**Add Results to Map**” checkbox to add the output directly to the map window when the clipping process completes. Click the 

button to run the clipping tool.

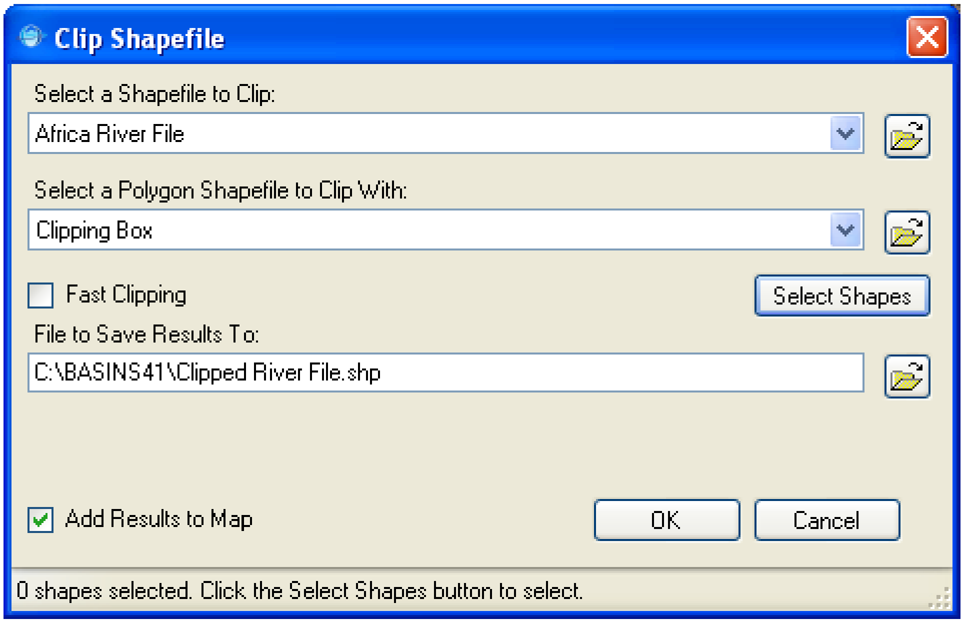


Figure 24: Clip Shapefile with Polygon

t. If prompted for how BASINS should assign projection information to the clipped streamfile output, select "**Assign projection from project**". The clipped stream file should now be added to the list of data layers.

u. A clipping of the land cover raster should be performed with the "Clip Grid With Polygon" tool located in the "Raster" toolbox folder. Similarly to clipping a shapefile, select the Africa Land Use grid as the grid to clip, and the Clipping Box shapefile as the polygon shapefile with which to clip (Figure 25). Apply the clipping directly to the Clipping Box by repeating Step r.

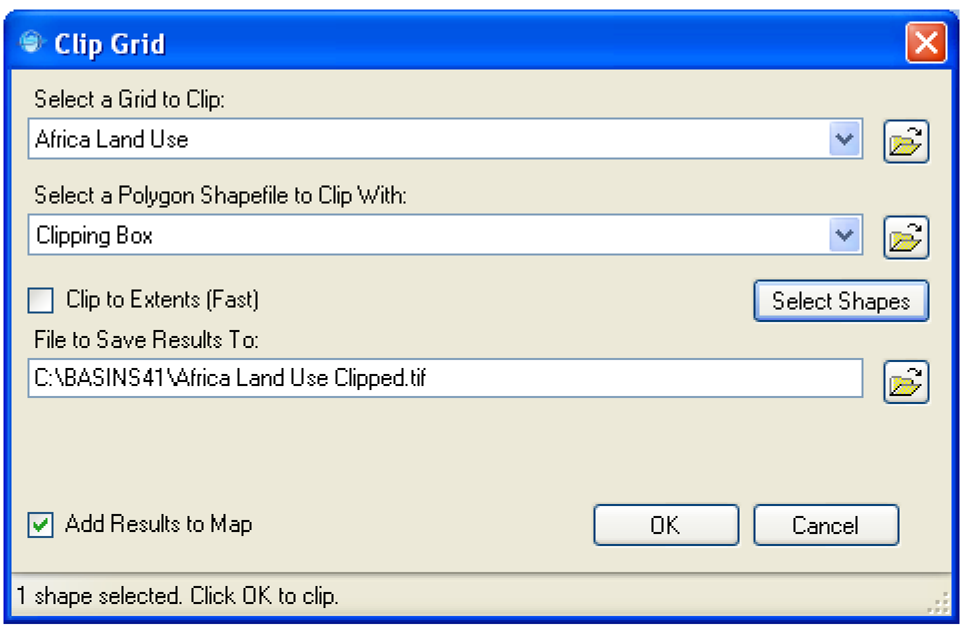


Figure 25: Clip Grid with Polygon

v. Once the raster clipping has completed, a new clipped grid should be added to the map window. Users may remove the original land cover grid and turn off the clipping box. The final result of the clipping process is shown in Figure 26.

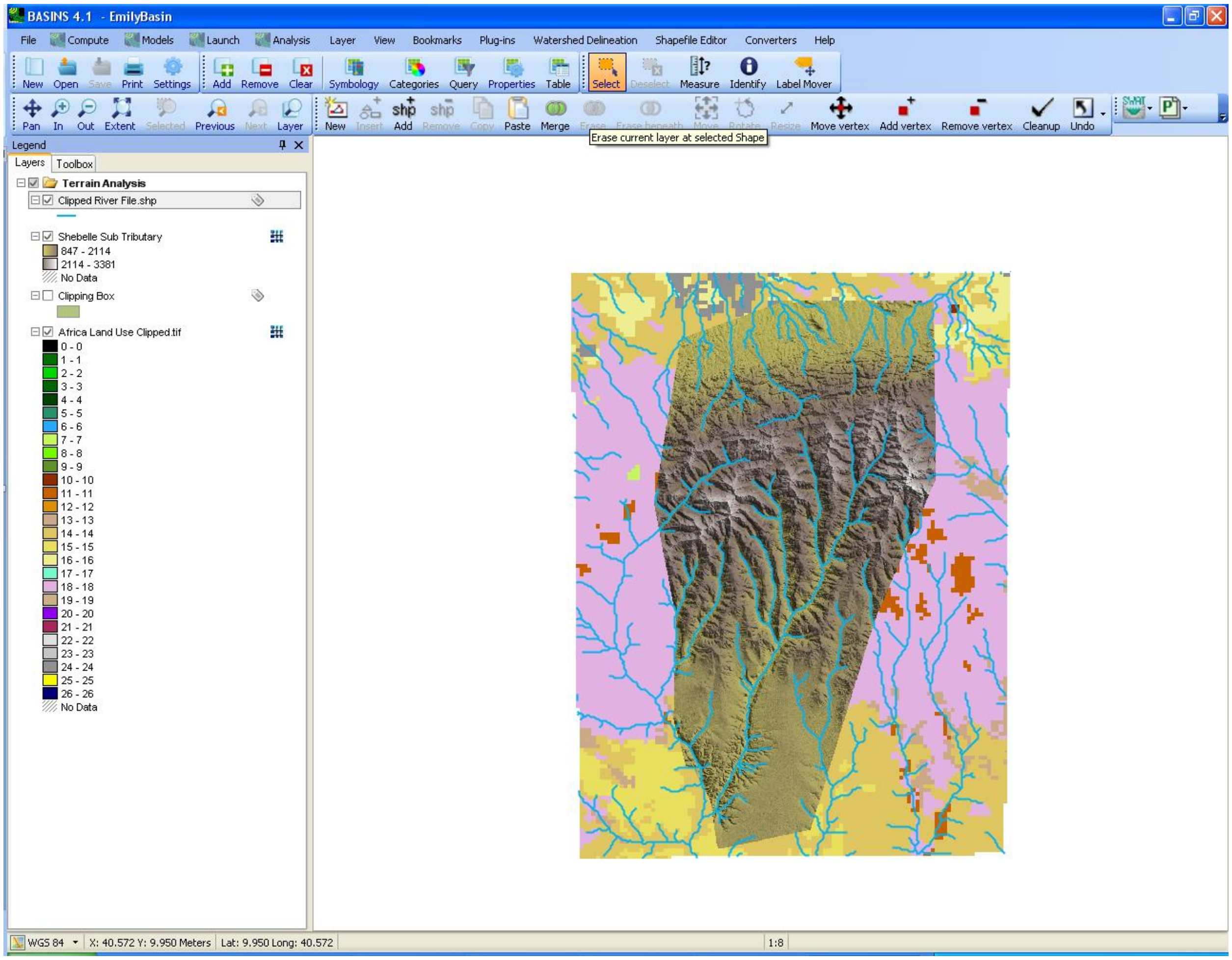


Figure 26: Clipped Rivers, Land Cover, and DEM

3.6. Reprojection of files to UTM 37N

a. For BASINS to properly read and use input files for watershed delineation, files must have a projected coordinate system. As such, each of the three input files (River file, DEM, and land cover raster) must be re-projected from their current WGS84 geographic projection. In this example, each file was re-projected to UTM Zone 37N.

b. If the input files do not have a projection assigned, the re-projection tool will not process correctly. Use the "**Assign Projection to Shapefile**" or "**Assign Projection to Grids**" tools, and select the geographical WGS 84 projection to assign to the files.

c. The "**Reproject Shapefile**" tool in the **Projections** folder of the toolbox is used to re-project the Clipped River File to UTM Zone 37N. This projection can be found by referring to the hierarchical organization of projections shown in Figure 27.

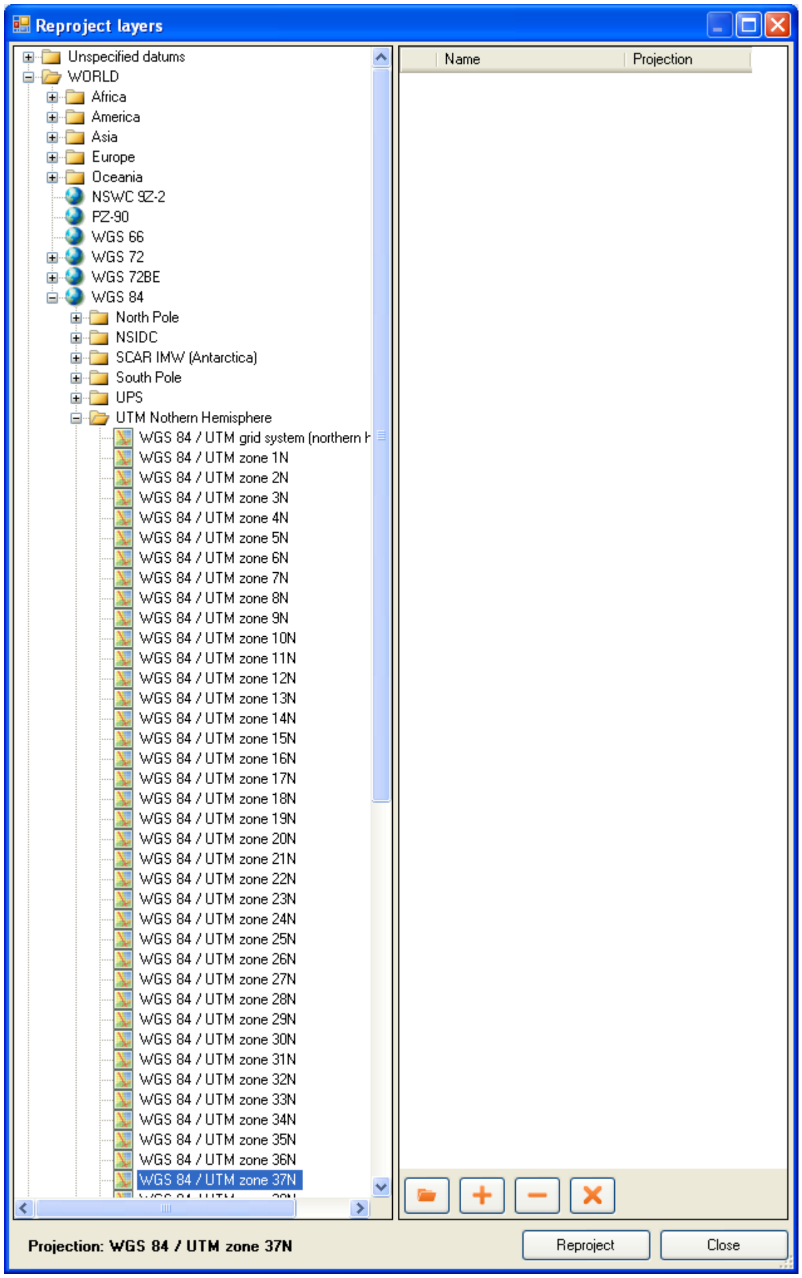


Figure 27: Projection List

c. Once the correct projection has been selected, click the  button to select the Clipped River File, and then click "Reproject". If a prompt appears stating that the projection of the output file is not the same as the projects data frame, click OK.

d. The "Reproject Grids" tool located in the **Raster** folder of the toolbox is used to reproject the DEM and Clipped land cover grids to UTM Zone 37N. Once this tool is selected, navigate to either grid file and select Open. Then select the  button to navigate to and import the second grid. When both have been specified, click OK, select UTM Zone 37N from the list of projections, and click OK.

e. After re-projecting the input files to UTM 37N, it is suggested that users close the current project and open a new BASINS project. For the new project, select UTM 37N as the data frame projection prior to importing the newly re-projected stream, land cover, and DEM files and proceeding to watershed delineation.

3.7 Watershed Delineation

Now that input files have been clipped and properly projected, users may initiate watershed delineation. This tutorial shows how to use automatic delineation. **BASINS** is also equipped with a manual delineation option which is recommended if the user is very familiar with the topography of the watershed.

a. Click on **Watershed Delineation** in the toolbar at the top of the window, then **'Automatic',** as illustrated in Figure 28.

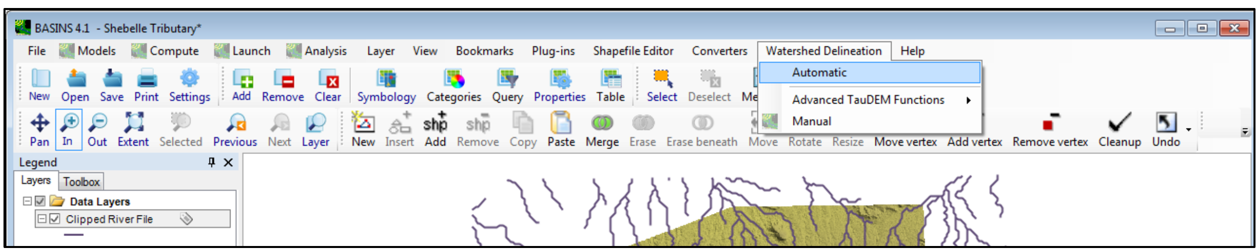


Figure 28: Automatic Delineation Command

The Automatic Watershed Delineation dialog box (Figure 29) will appear.

b. Click the drop-down menu for **'Base Elevation Data (DEM) Layer'** and select the added DEM layer. If the DEM layer selected is not shown in **the drop-down**, it is not in a form BASINS can use and must have its coordinate system re-projected from a geographic to a projected coordinate system.

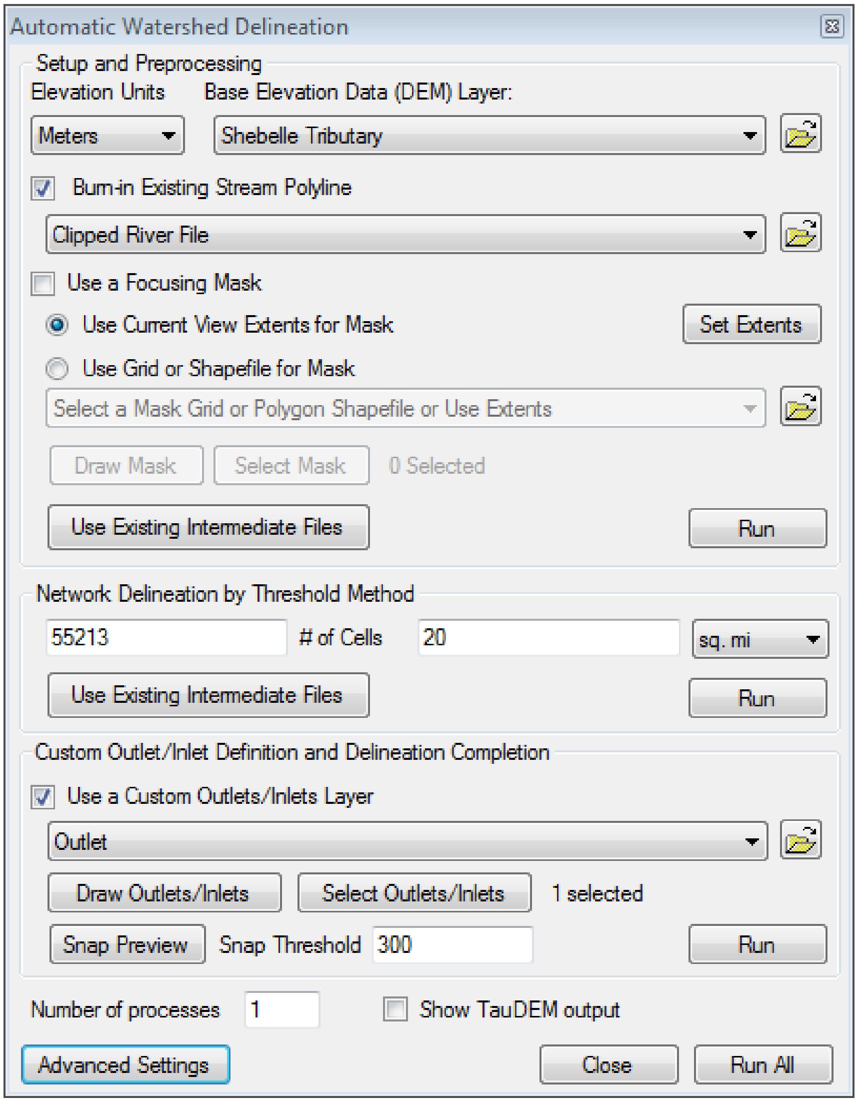


Figure 29: Automatic Watershed Delineation Dialog Box

c. If you have a stream network, check the box beside **'Burn-in Existing Stream Polyline'**.

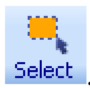
d. Add the outlet point of the watershed. Outlet points should correspond to stream confluences, stream gauges, and sampling locations.

- If an outlet point shapefile has already been added to the project, select it by clicking the drop-down menu in the **Custom Inlet/Outlet Definition and Delineation Completion** and select the outlet shapefile. For this tutorial, use the Outlet Point shapefile provided.

- If users wish to have specific outlets or points for the watershed and have not yet added them to the BASINS project, click **'Draw Inlets/Outlets'** to create a new shapefile. Click **'Yes'** in the Create new Outlets/Inlets File dialog box (Figure 30), specify the working directory in which the created shapefile should be saved, and provide a shapefile name.

Figure 30: Create New Outlets/Inlet File Dialog Box

e. To draw the outlet, click the desired location on the DEM. Users may need to zoom in for a better picture of the landscape. If the point is not on top of the stream or riverline specified, or within the snap threshold, BASINS will not run the delineation.

f. If an inlet/outlet point was drawn incorrectly or needs to be removed, users must first select the point with the Select tool 

. The selected point(s) will be highlighted and can be deleted by clicking Remove 

.

g. After drawing the inlets and outlets layer, click **'Done'** (Figure 31) and complete the rest of the Watershed Delineation dialog box.

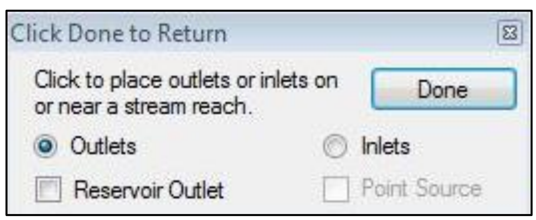


Figure 31: Drawing Outlet/Inlet Tool

Note: The **Network Delineation by Threshold Method** section allows the user to define the number of sub-basins BASINS delineates. The number and size of sub-basins appropriate for a particular project depend on several factors. Generally, as the number of sub-basins increases, the level of spatial detail for the generated watershed will also increase. To increase the number of sub-basins, decrease the threshold. If a watershed is very large and without significant variability in land cover, soil characteristics or weather patterns, fewer sub-basins will typically be needed to develop and run an efficient modeling project.

h. After the dialog box is completed as depicted in Figure 29, press **'Run All'**. Be patient while BASINS delineates the watershed as processing could take 30-45 minutes or longer. If the delineation is successful, the map window will resemble Figure 32.

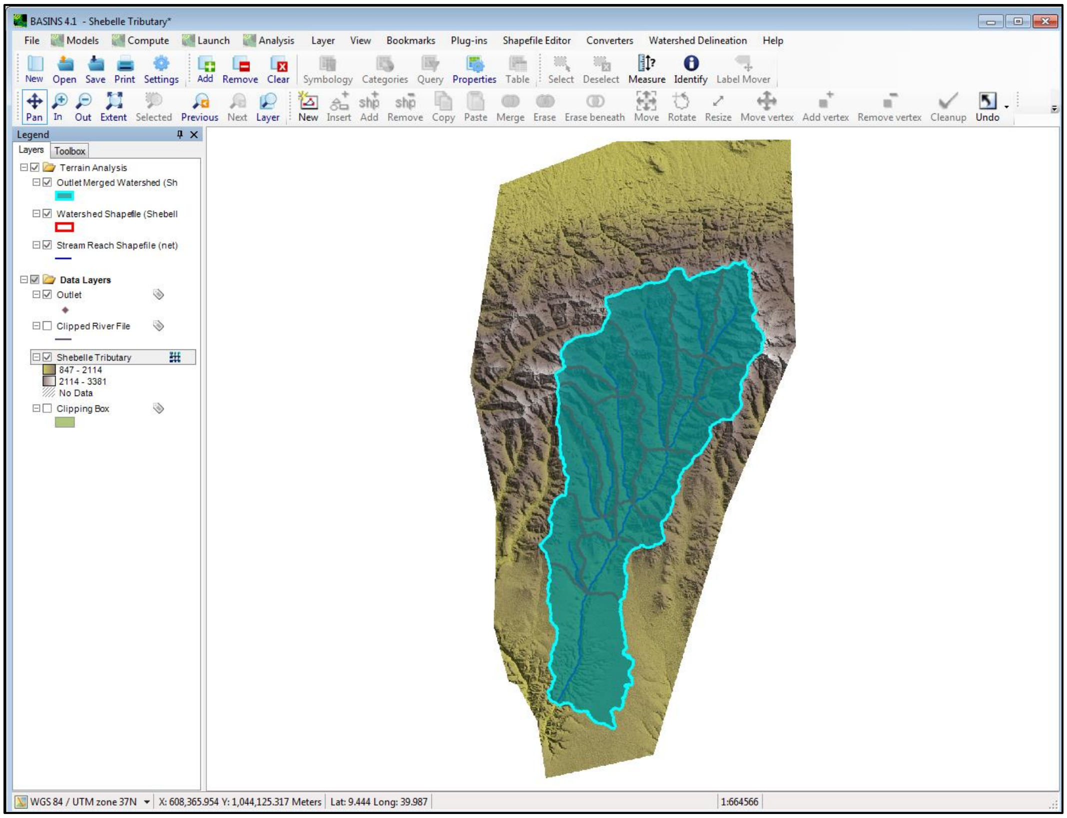


Figure 32: BASINS Watershed Delineation Output

3.7.1 Watershed Delineation Errors

When delineating a watershed, BASINS may encounter memory limit issues. If so, close all unnecessary programs running on your computer, then close and restart BASINS. Try the delineation again with the same settings. If the problem continues, the watershed area may be too large. Delineate a smaller sub-basin by moving the outlet point upstream or clipping the DEM to a smaller size. Clipping raster files is explained in Section 3.5 A smaller area can also be analyzed by zooming to the region of interest and checking the box beside **'Use a Focusing Mask'** in the Automatic Watershed Delineation Dialog box. This allows users to manually specify the analysis extent or use the current window/map view as the extent.

3.8 Land Use Clip

a. In this example, the land cover has already been clipped and re-projected to UTM Zone 37N. By clicking and dragging names of the data layers in the legend, their order was rearranged so that the **Outlet Merged Watershed** generated by the Automatic Delineation was on top, followed by **Africa Land C** (Figure 33). Since we are only concerned with land use inside the watershed, clip the land use raster to the watershed boundary once again.

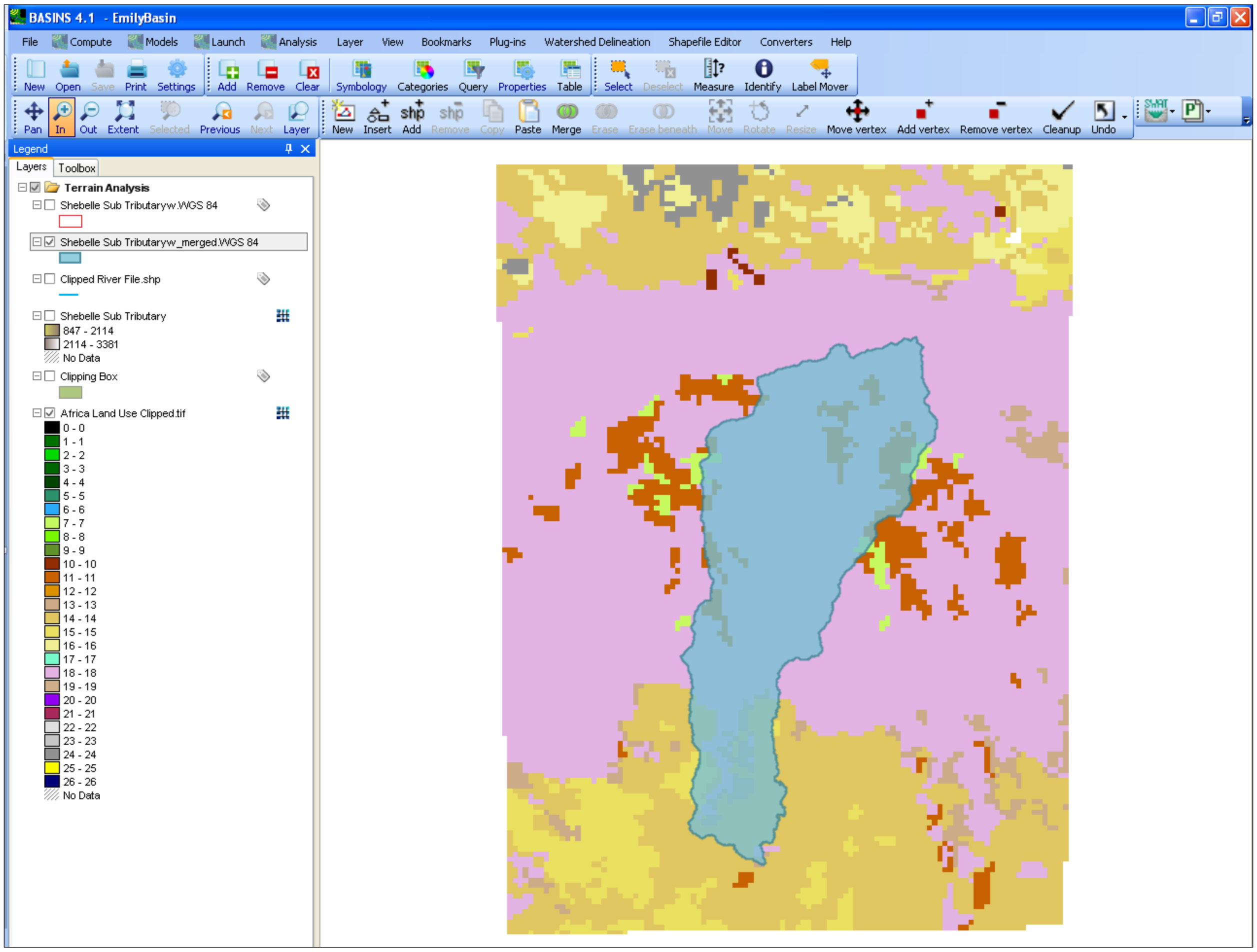


Figure 33: Adding Land Use File

b. Follow the steps in **Section 3.5** to clip the land use raster to the shape of the watershed. If the land use file added to the project is a shapefile, follow the steps used to trim the river network file, also described in Section 3.5.

c. After clipping the land use layer to the size of the watershed and deleting the full land use file, the map window should resemble Figure 34.

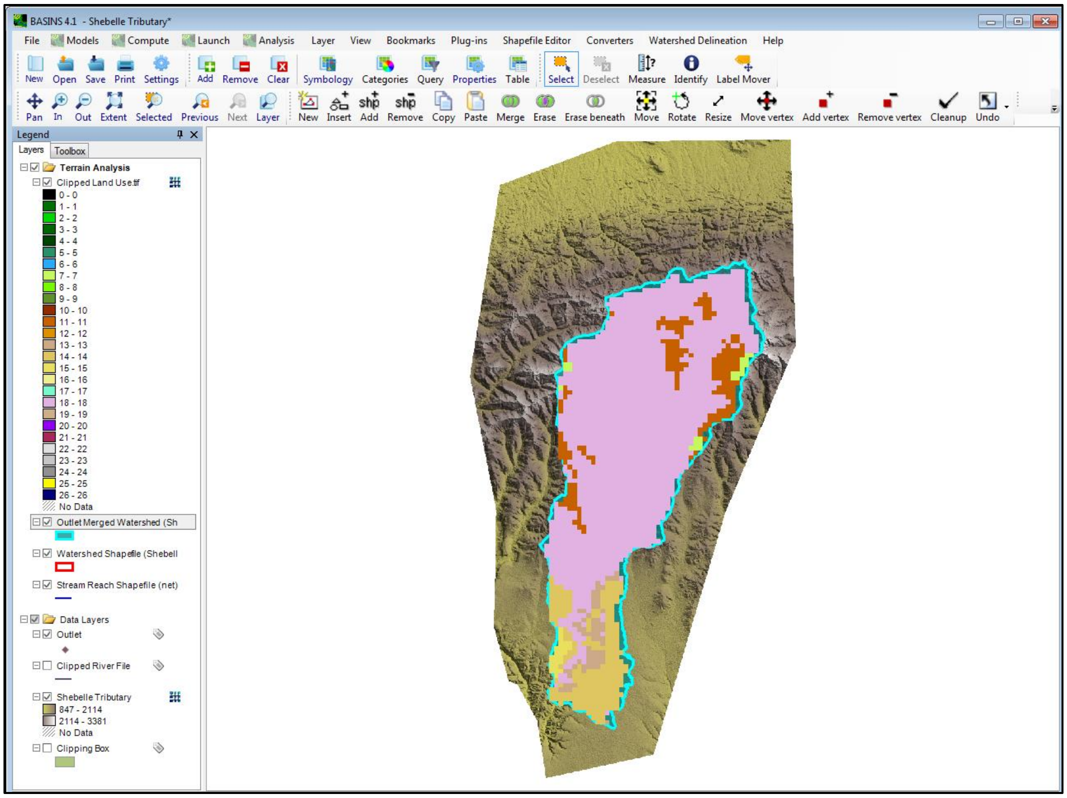


Figure 34: Clipped Land Use Files and DEM

3.9 Reclassifying Land Use

Since the land surface data was added to the project from a source not accessible within BASINS, it is necessary to reclassify the raster categories.

a. Find the legend that accompanies the land use metadata which may be included in the downloaded folder (as here) or elsewhere. To add it directly to BASINS, it must be a database file; if not available as a database file, the information must be entered manually. Both methods are explained in the following steps.

b. Click on **'Analysis'** in the toolbar and click **'Reclassify Land Use'** at the bottom of the menu (Figure 35). If the '**Analysis'** menu is not visible, click **'Plug-ins,'** then **'Edit Plug-ins'**. Select '**Analysis,'** then '**Reclassify Land Use,'** and click on the selection box to turn on the plug-in.

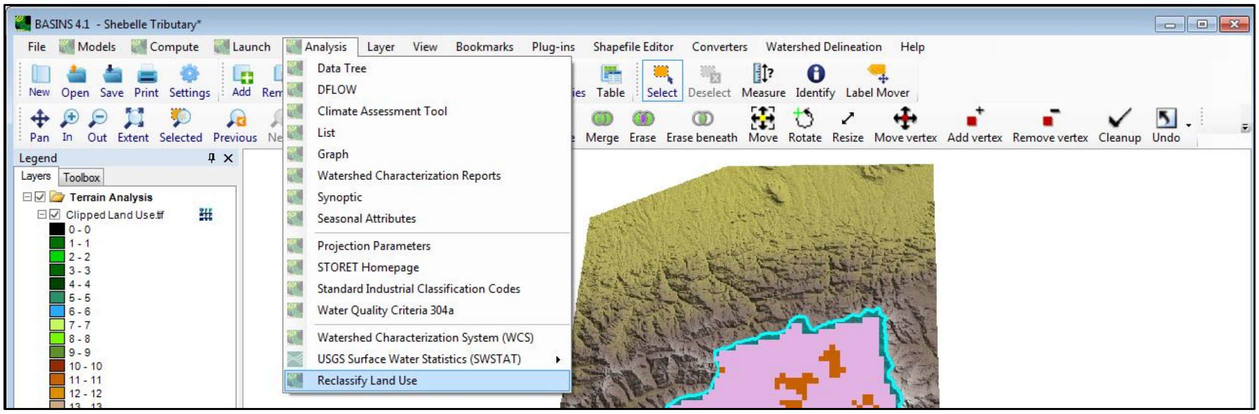


Figure 35: Reclassifying Land Use

The BASINS Land Use Reclassification window, as shown in Figure 36, will appear.

c. Select **'User Grid'** from the **Land Use Type** drop-down menu if using a land use raster, or **'Other Shapefile'** if using a land use shapefile. As this example uses the raster downloaded from Global Land Cover 2000, **'User Grid'** was selected.

d. Select the clipped land use layer in the **Land Use Layer** drop-down that is available after designating Land Use Type. Whether the land use layer has been clipped to the size of the watershed or not, choose **Summarize within Layer** by selecting the Outlet Merged Watershed layer from the drop-down menu. This tells BASINS to calculate percentage of each land use type in the watershed.

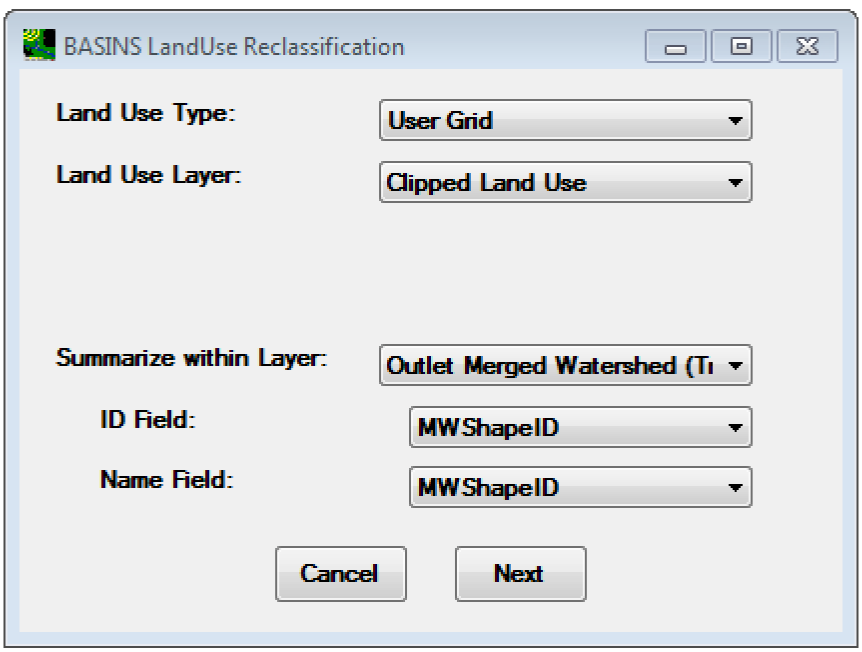


Figure 36: Land Use Reclassification Dialog Box

e. After clicking **Next**, the window depicted in Figure 37 will appear. In the bottom left corner, select **'Load'** and navigate to the database file that contains the legend for the land use file. To upload, double-click on the file or Select it and press **Open**.

If the land use legend is not available in a usable database format, click in the white boxes under **Group** and manually enter land use types that correspond to the number code.

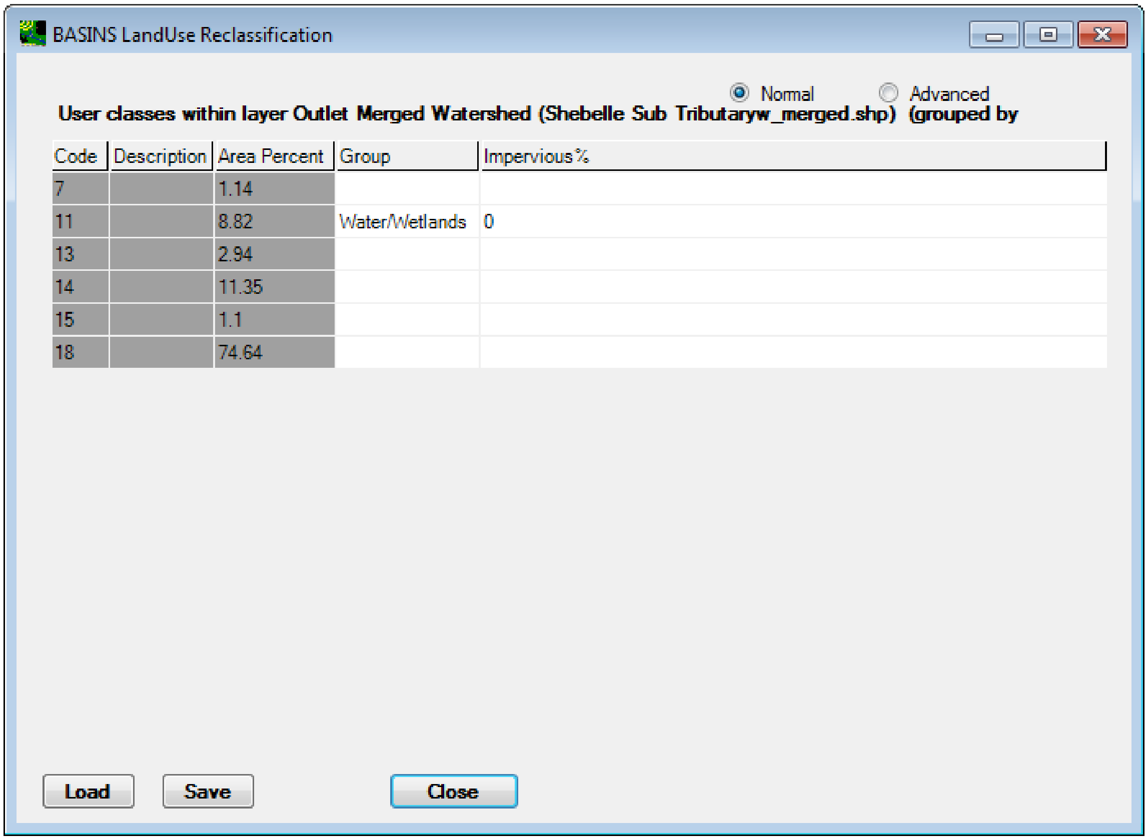


Figure 37: User Classified Land Use Groups

The **Land Use Reclassification** window should be similar to Figure 38.

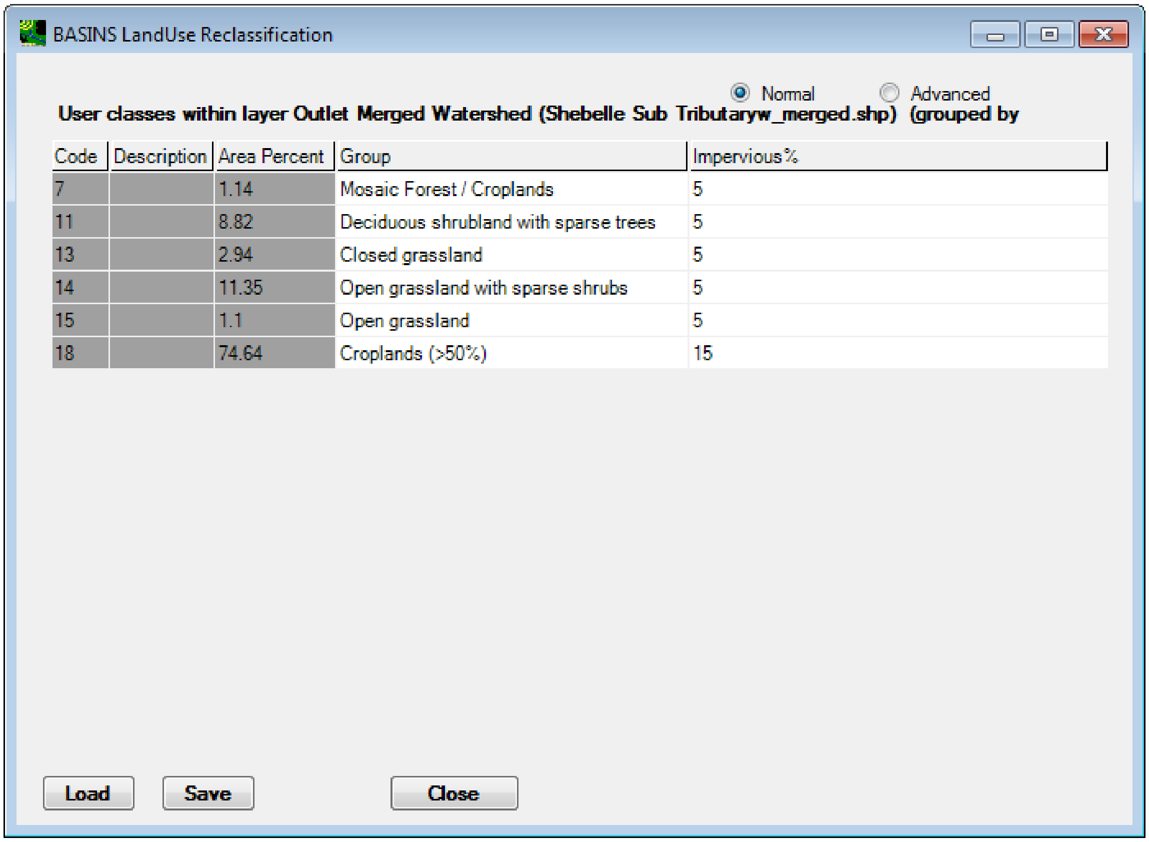


Figure 38: Completed Land Use Reclassification Window

f. Enter values for the Impervious Percent. Refer to documentation from the data source to assist in assigning the percentage. For options to increase the level of detail in the model, select **'Advanced' i**n the top right corner.

g. After completing the dialog box, click **'Save'** and 'Close.'

3.10 Adding Soil Data

The Soil Data in this example was downloaded from the UN FAO Website discussed in Section 2.2.1. The FAO GeoNetwork has a number of options. In this example, the Digital Soil Map of the World - ESRI shapefile format was chosen (see Appendix D) and projected (from Lat/Long coordinate system) to align with other data layers.

a. To add the soil map to the BASINS project and trim it to the size of the watershed, follow the steps to add and clip the previous shapefile data layers. Figure 39 shows the watershed with sub-basins (thick red outline), land use (colored grid) and soil zones (navy lines).

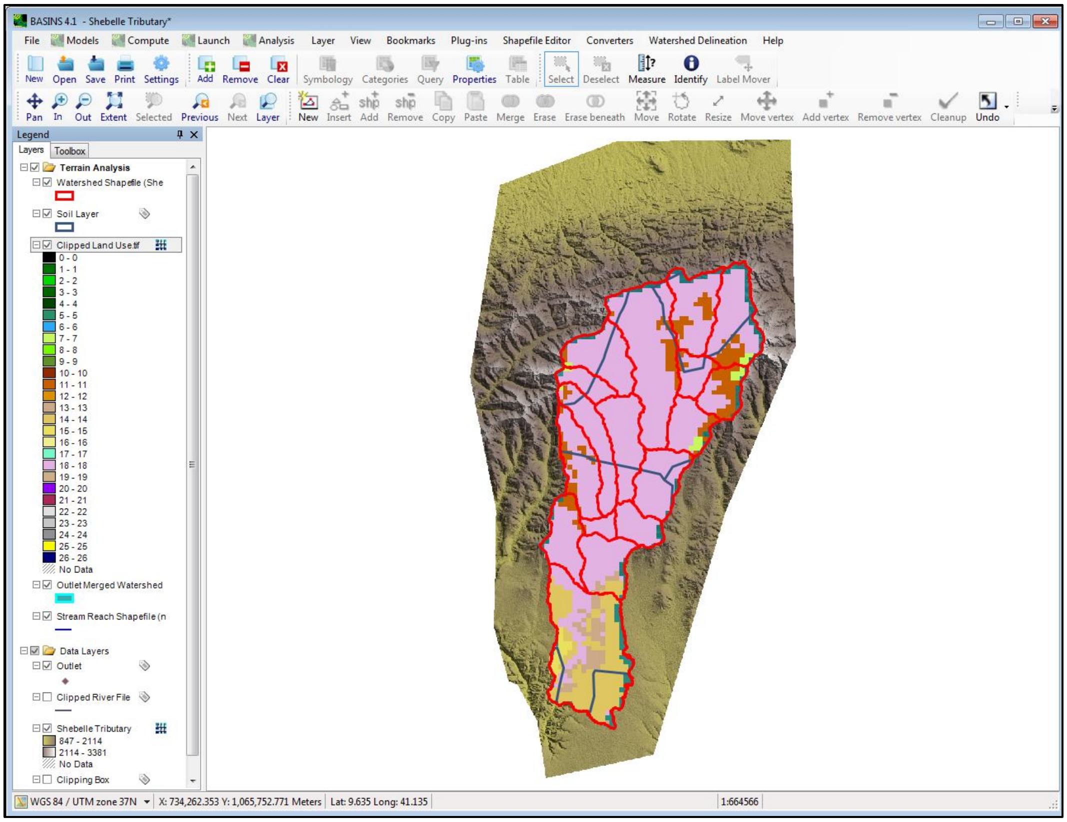


Figure 39: BASINS Window with Soil, Sub-basins, Land Use, and Elevation Layers

By comparing soil designations, land use, and watershed segments, users can determine whether to segment the watershed further to better characterize its properties. Segmentation involves generating sub-basins with similar land use, soil properties or other land surface characteristics. The EPA has a lecture on watershed segmentation and a tutorial detailing the watershed segmentation procedure.

3.11 Adding Climate Data

Climate data must be in U.S. customary units as discussed in Table 3, in Section 2.1.3, and in WDM file format discussions. EPA's tutorial shows how to use the free WDMUtil software to import time series data into WDM files. The following flow diagram (Figure 40) summarizes the process of acquiring local climate data and ensuring that its format is compatible with BASINS/HSPF. How to find data when local data is not available is outlined in Appendix E.

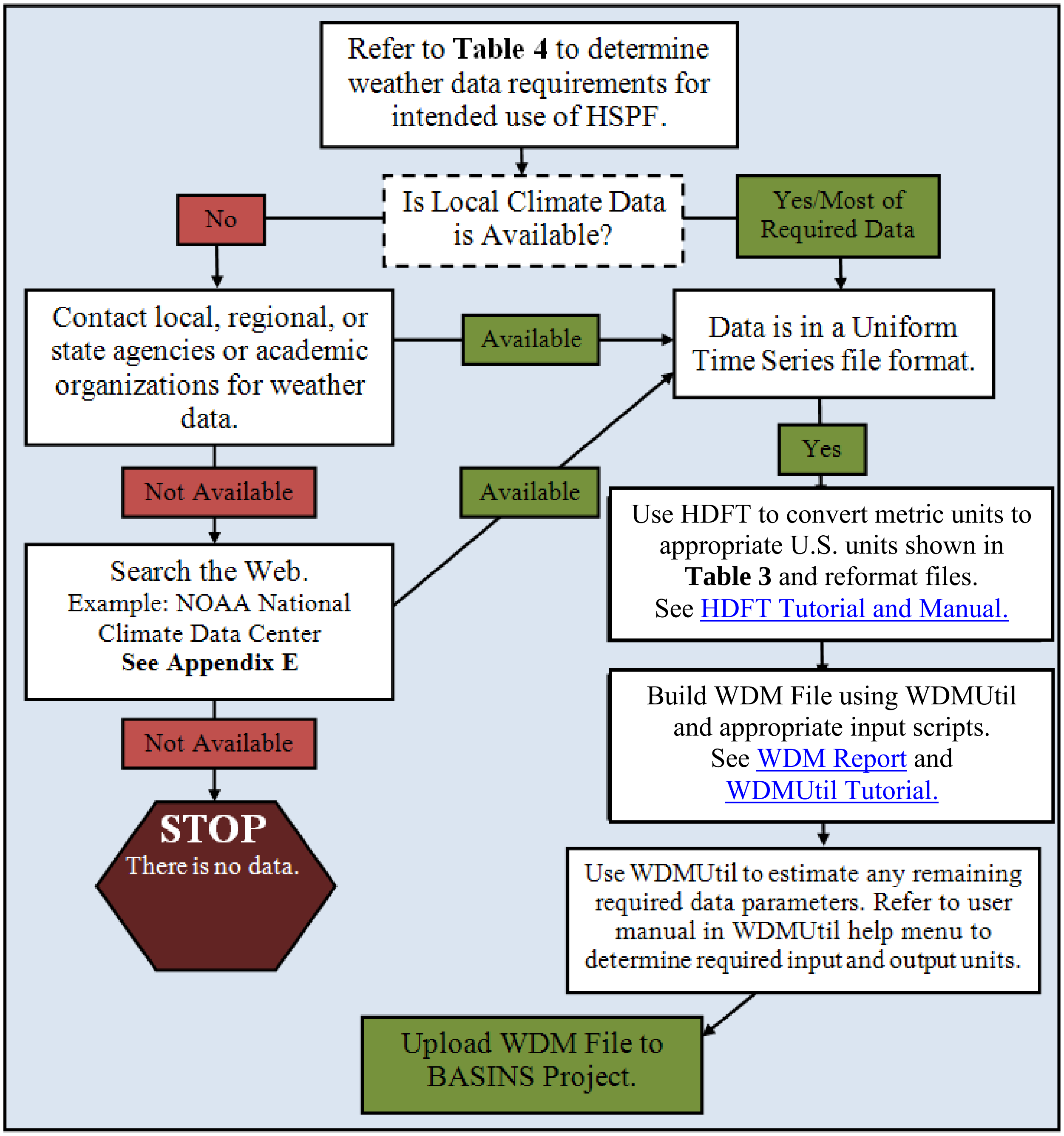


Figure 40: Weather Data Flow Chart

The steps below detail how to add Climate Data that is already in WDM format.

a. Click **'Manage Data'** under the **File** tab (Figure 41).

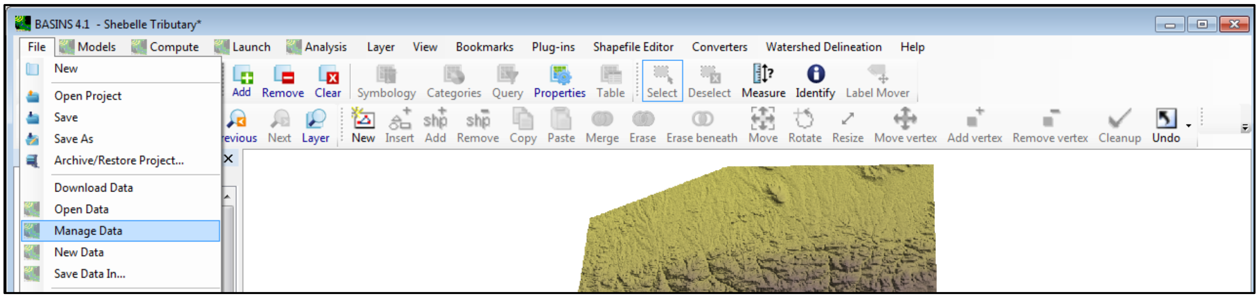


Figure 41: Adding Climate Data through 'Manage Data'

b. In the **Data Sources** dialog box (Figure 42), click **'Open'** under the File tab.

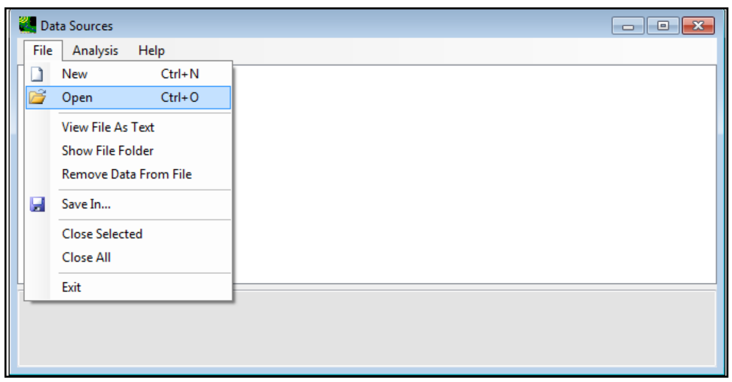


Figure 42: Manage Data Sources Window

The '**Select a Data Source**' window (Figure 43) opens.

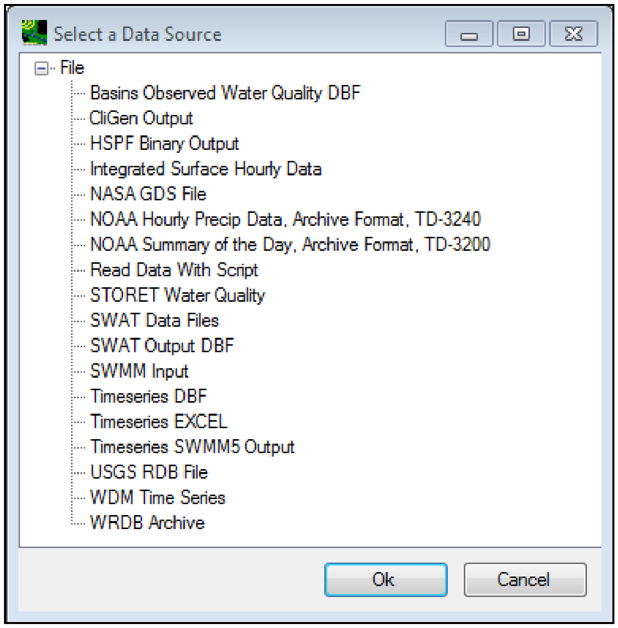


Figure 43: Select a Data Source Window

c. Double-click **'WDM Time Series'** on the list to navigate to the climate data file, then select the WDM file which will be displayed in the Data Source window (see Figure 44). The Data Source window can now be closed.

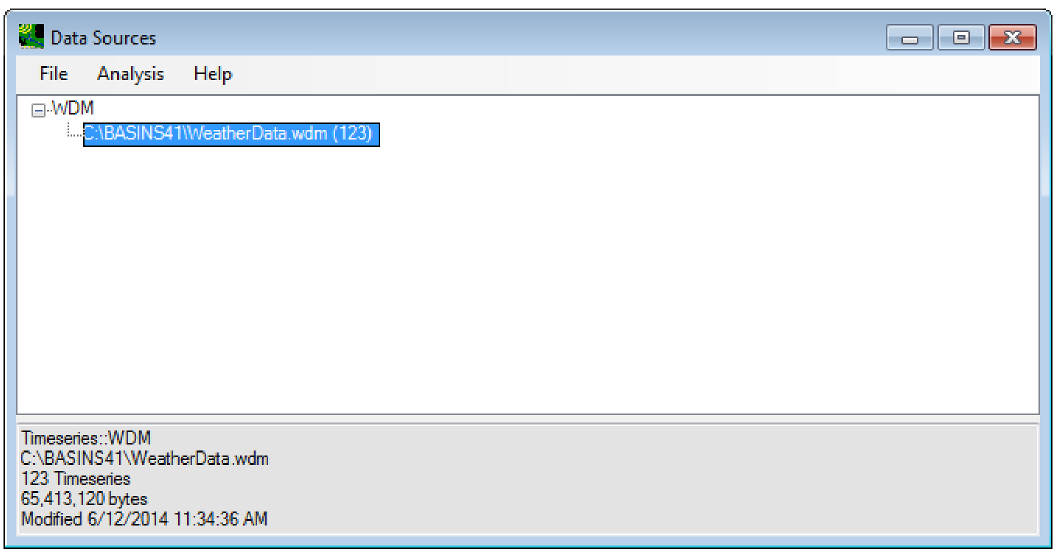


Figure 44: Data Sources Window with User-Selected WDM File

Note: Due to lack of available time series data, weather data from Ethiopia was not used and a sample WDM file from a watershed in the United States was substituted. The resulting model thus does not reflect actual conditions in Ethiopia's Shebelle watershed.

All required data has now been added to BASINS and HSPF can be launched. For a tutorial on using BASINS to launch HSPF and run a simulation, continue to the next section.

3.12 Launching HSPF

a. Click on **Models** on the tool bar and select **'HSPF,'** as illustrated in Figure 45. If 'Models' is not visible, click 'Plug-ins' and then 'Edit Plug-ins'. Select Model Setup (HSPF/Aquatox) and click on the selection box to turn on the plug-in.

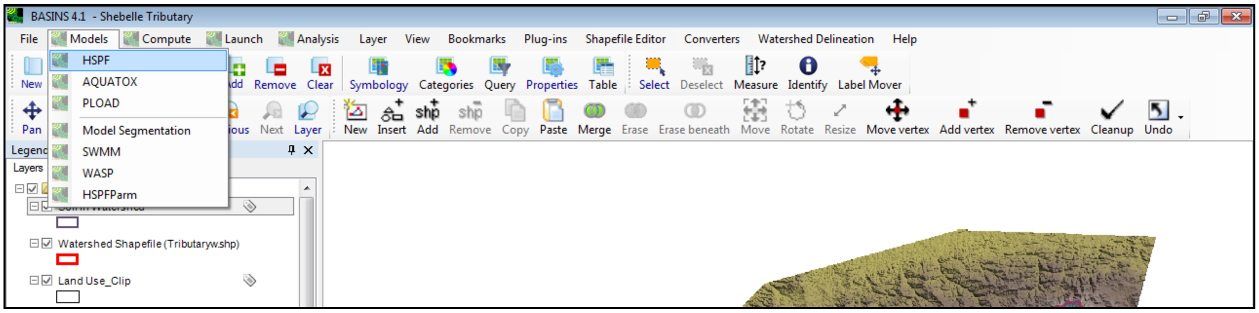


Figure 45: Setting up HSPF Model

The **BASINS/HSPF** window (see Figure 46) will appear.

b. Next to **Land Use Type**, select **'User Grid'** from the drop-down menu if the land use file is a raster (as in this tutorial). If it is a shapefile, select **'Other Shapefile'**.

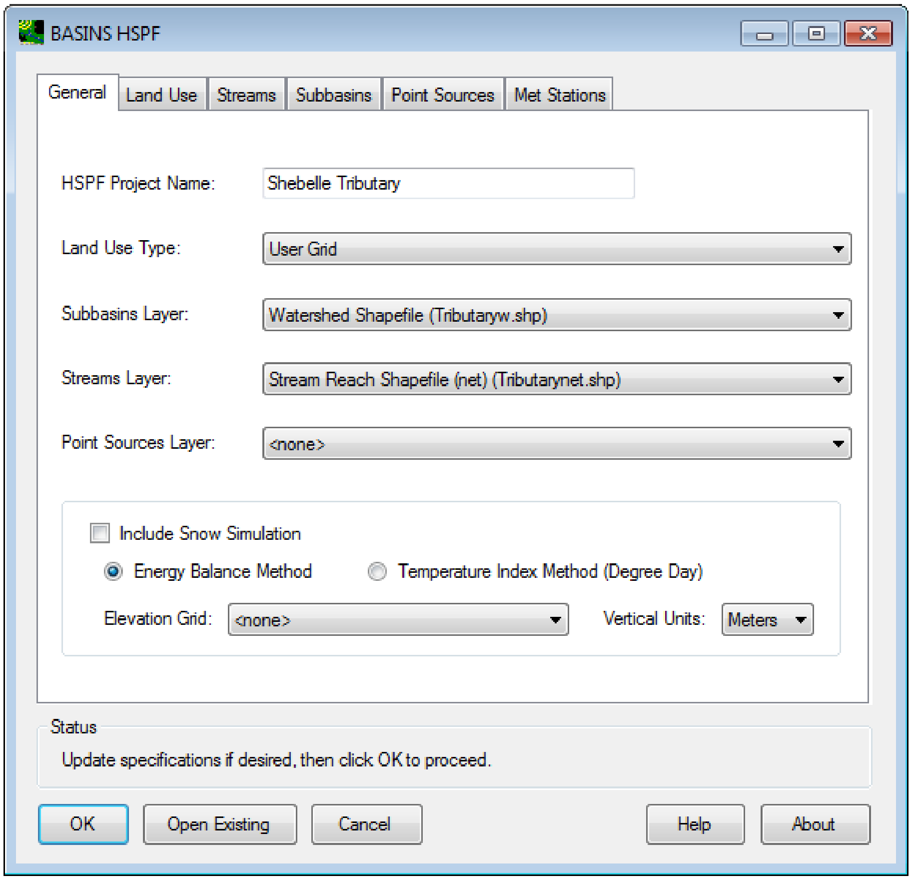


Figure 46: General Tab of HSPF Setup

c. Click the **Land Use** tab at the top of the dialog box; Figure 47 shows the tab before any adjustments are made. Note the default Classification File is the GIRAS Land Use File, which is not the same as the classification used in this project.

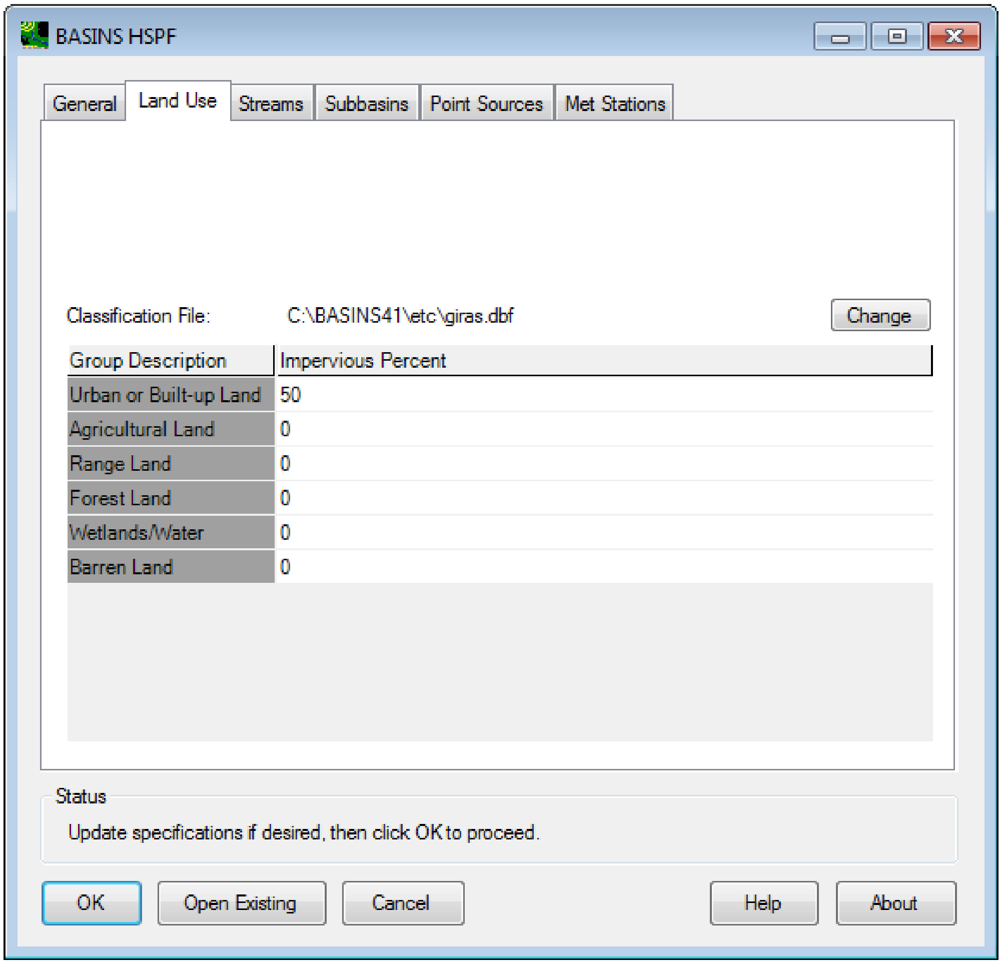


Figure 47: Land Use Tab in HSPF Setup

d. Next to **'Classification File,'** click **Change**. Navigate to and select the file created in the **Reclassify Land Use** procedure to bring up correct group descriptions and impervious percentages (Figure 48).

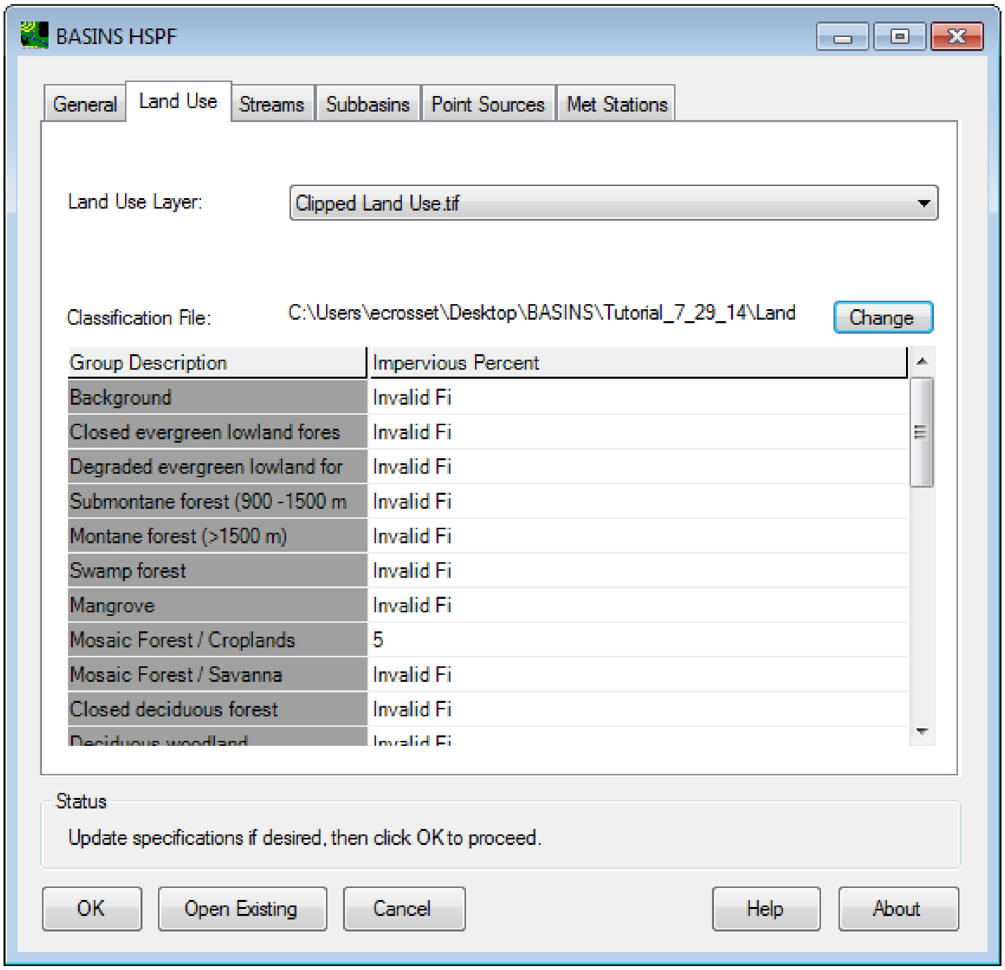


Figure 48: Land Use Tab with Reclassified Land Use File

Note: Some of the impervious percentage fields show 'Invalid Field' because these land use categories are not within the watershed boundary and were therefore not edited when the land use was reclassified. These fields can be ignored.

e. Click on the **Met Stations Tab**. All data contained in the WDM file added earlier will be available to select (see Figure 49). If there are multiple met stations in the file, choose the one that best represents the watershed and contains the highest quality data.

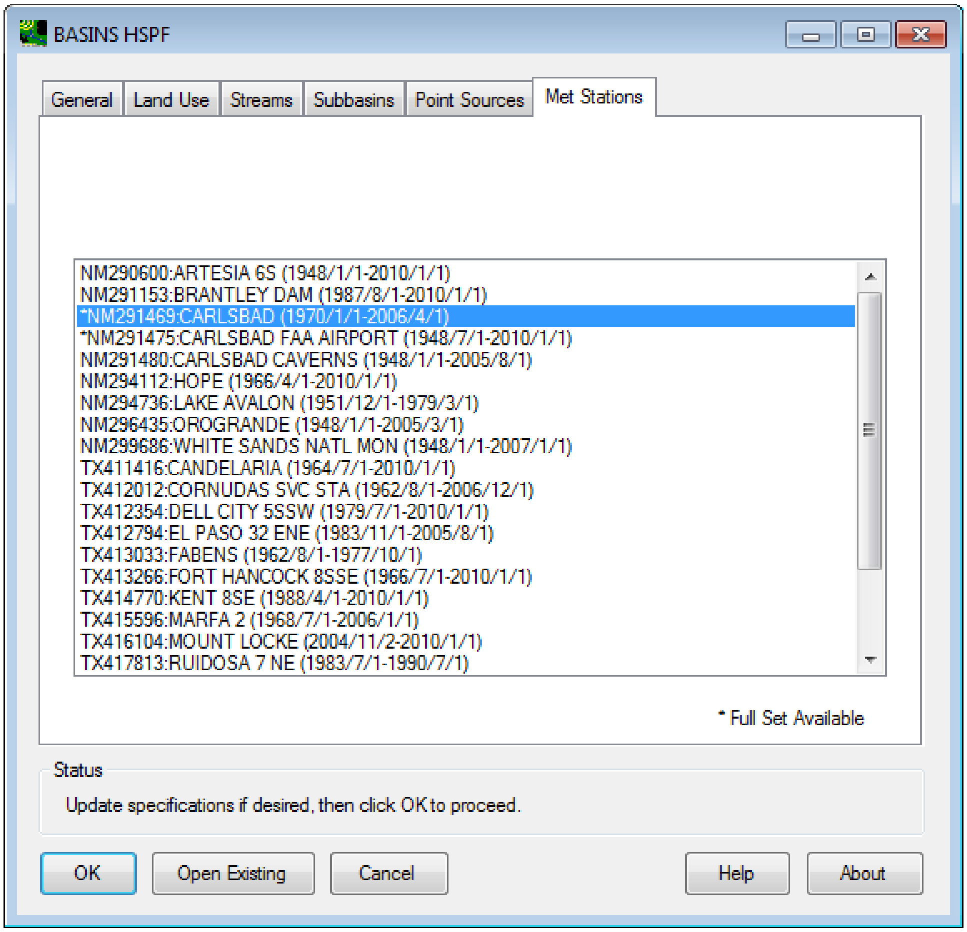


Figure 49: Met Stations in BASINS HSPF Setup

f. After all parameters have been adjusted, click **'OK'** to build a HSPF project. BASINS will now take a moment to set up the model. The generated HSPF model is presented in Figure 50.

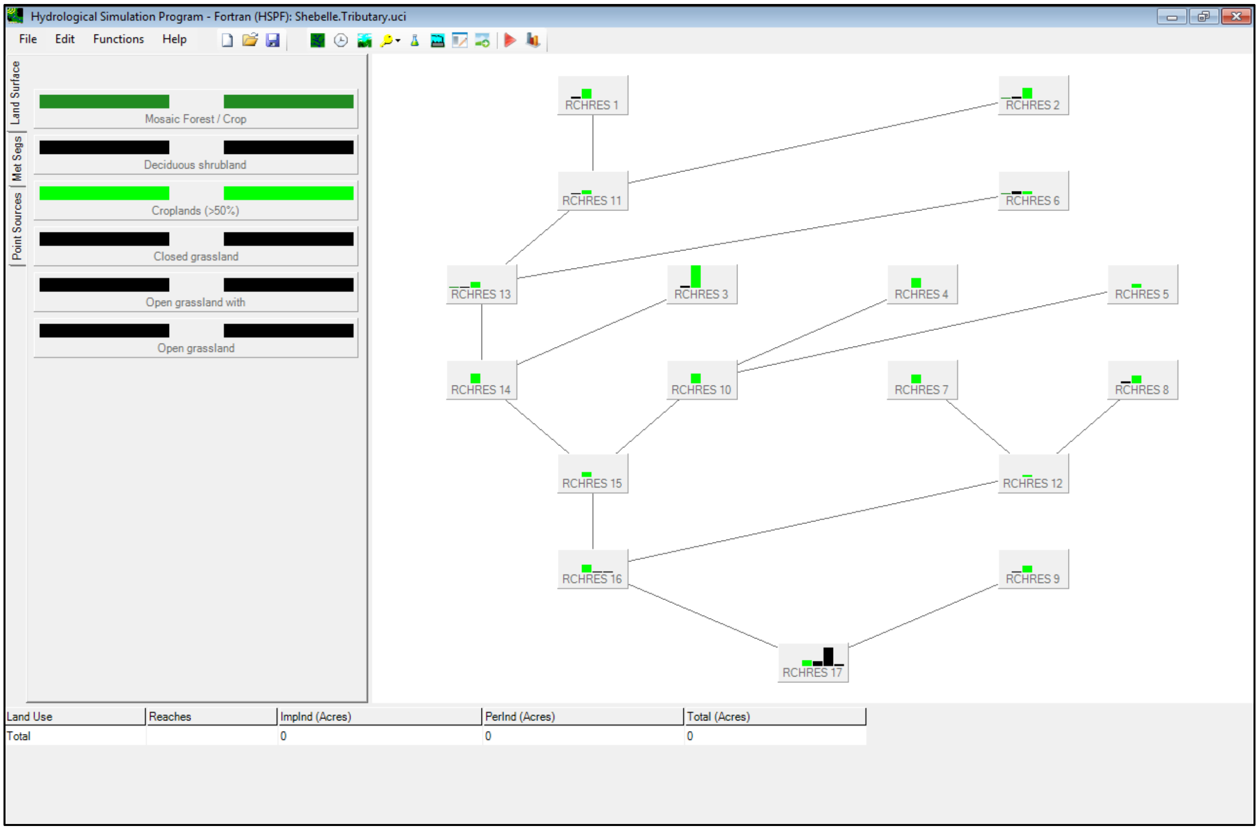


Figure 50: Generated HSPF Model

After migration from BASINS, users are brought to the HSPF GUI-WinHSPF. The next section includes a tutorial on running the model and navigating HSPF's interface.

Chapter 4: HSPF Application Example

As described in the Introduction, HSPF is a powerful watershed tool that can predict a watershed's hydrologic response to rain events and simulate water quality. Since the process of setting up HSPF within BASINS has already been completed, running the model should result in few problems for international users, but if present, will be limited to unit output and conversion primarily. This portion of the tutorial introduces basic functions within HSPF and addresses problems international users may encounter. For a more comprehensive summary of HSPF, refer to the user manual that can be accessed in the WinHSPF environment by clicking **'Help'** on the tool bar and selecting **'HSPF Manual'**., Exercise 4 from the Basins User information and guidance website also contains a detailed tutorial on running HSPF.

As mentioned previously, it is recommended that users input data in U.S. customary units and convert output back to desired units which is shown in the following tutorial.

4.1 Starting HSPF

Launching HSPF through BASINS was discussed in Section 3.12. If you have already generated the model (.uci file) through BASINS, proceed as follows to open the program.

a. Open WinHSPF 3.0. The welcome screen will resemble Figure 51.

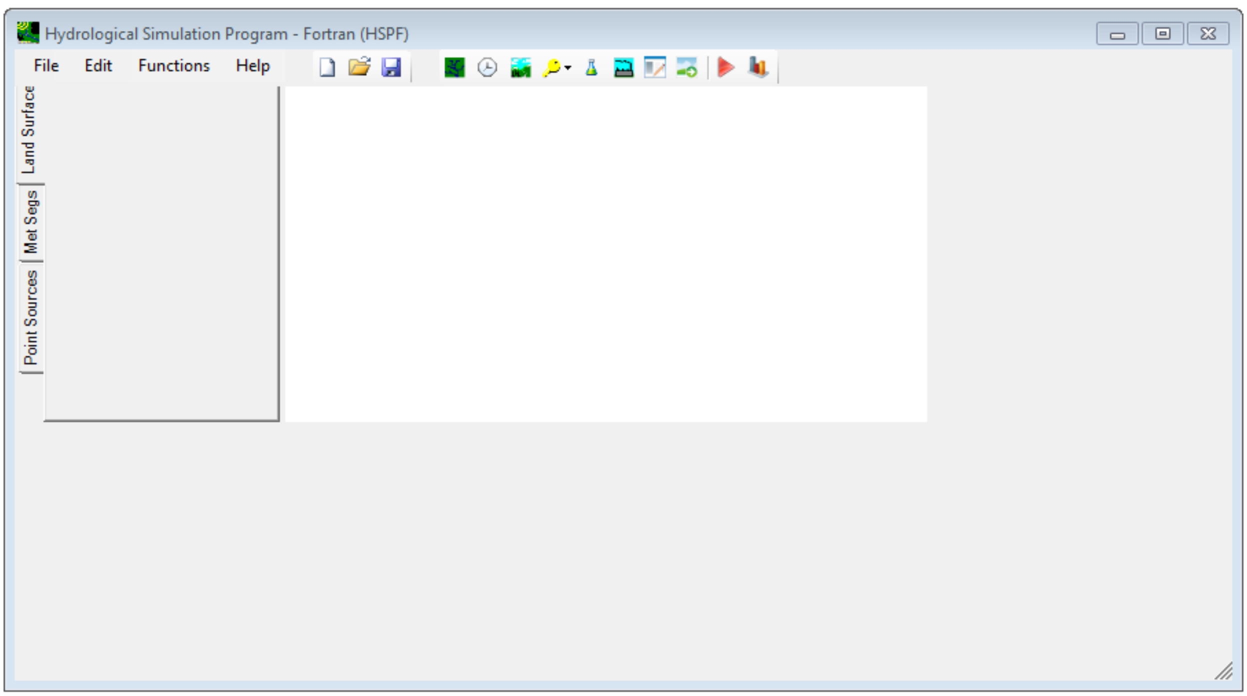


Figure 51: WinHSPF Home Screen

b. Click **File**, then **Open**. The default location for the HSPF project files is in the **'modelout'** folder in the **BASINS41** directory.

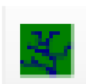
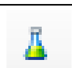
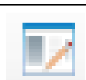
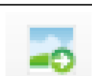
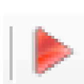
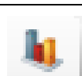
4.2 Navigating the WinHSPF Environment

The WinHSPF environment is equipped with tools and editing options to refine the model and change default parameters. The toolbar is shown in Figure 52 and an explanation of the icons appears in Table 5.

Figure 52: WinHSPF Toolbar

Detailed instructions and explanations of each tool are available in the HSPF Exercise on the BASINS webpage. Basic applications and functions of the tools are shown in the table below.

Table 5: WinHSPF Toolbar Icons and Functions

Icon	Tool		Function
	Reach Editor		• Modify reach parameters including default reach cross-section dimensions, Manning's constant, and stage-flow relationships
	Simulation Time and Meteorological Data Editor		• Assign a start and end to the simulation
	Land Use Editor		• Edit land use area contributing to each reach to test different scenarios • Use in establishing TMDLs
	Control Cards	Definition	• Select parameters to model
		Tables	• Adjust individual modeling parameters
	Pollutant Selection		• Specify pollutants to model
	Point Source Editor		• Manage, edit, and create point sources
	Input Data Editor		• Modify site-specific parameters • Calibrate parameters
	Output Manager		• Select locations on reaches from which model outputs will be generated
	Run Model		• Run the model. • [An explanation of the preceding steps is found in Section 4.3.]
	View Output		• Return to the BASINS interface to launch WDMUtil and view model output

Adapted from the EPA HSPF Exercise. For more information, visit the exercise linked in the paragraph above.

4.3 Running HSPF Model

a. Using the tools and options explained previously, HSPF users can modify default parameter values.

b. Press the **'Run Model'** icon. The following window (Figure 53) appears if the user has made changes since the last Save.

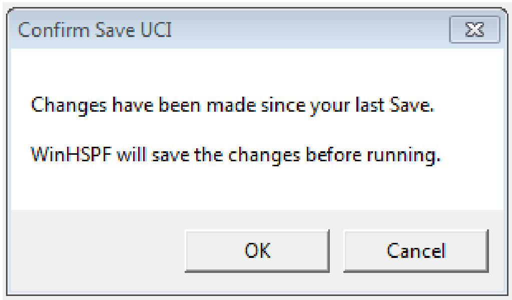


Figure 53: Saving Changes Warning

c. Press **'OK'** and another window will appear to show the progress of the model run. Note that the model can return an error, and users must identify and address its source to achieve a successful model run.

d. Press the **'View Output'** icon to open the BASINS interface.

e. Click **'Launch'** from the BASINS toolbar and select **WDMUtil,** as shown in Figure 54. The WDMUtil Window will appear (Figure 55).

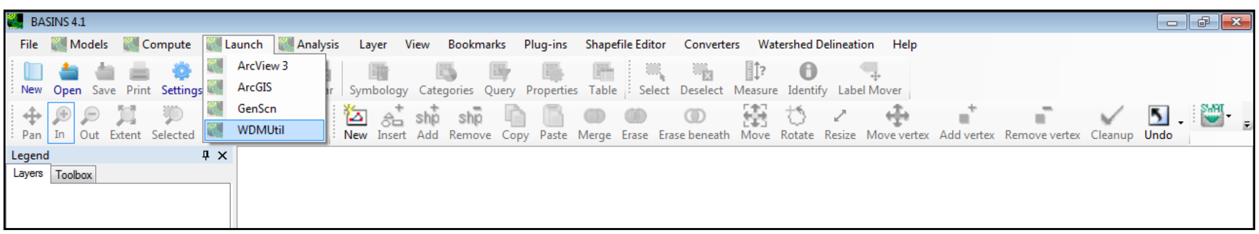


Figure 54: Launching WDMUtil from the BASINS Interface

Note: If WDMUtil is not installed on the user's computer, refer to Section 1.4.2 for a link to download the product.

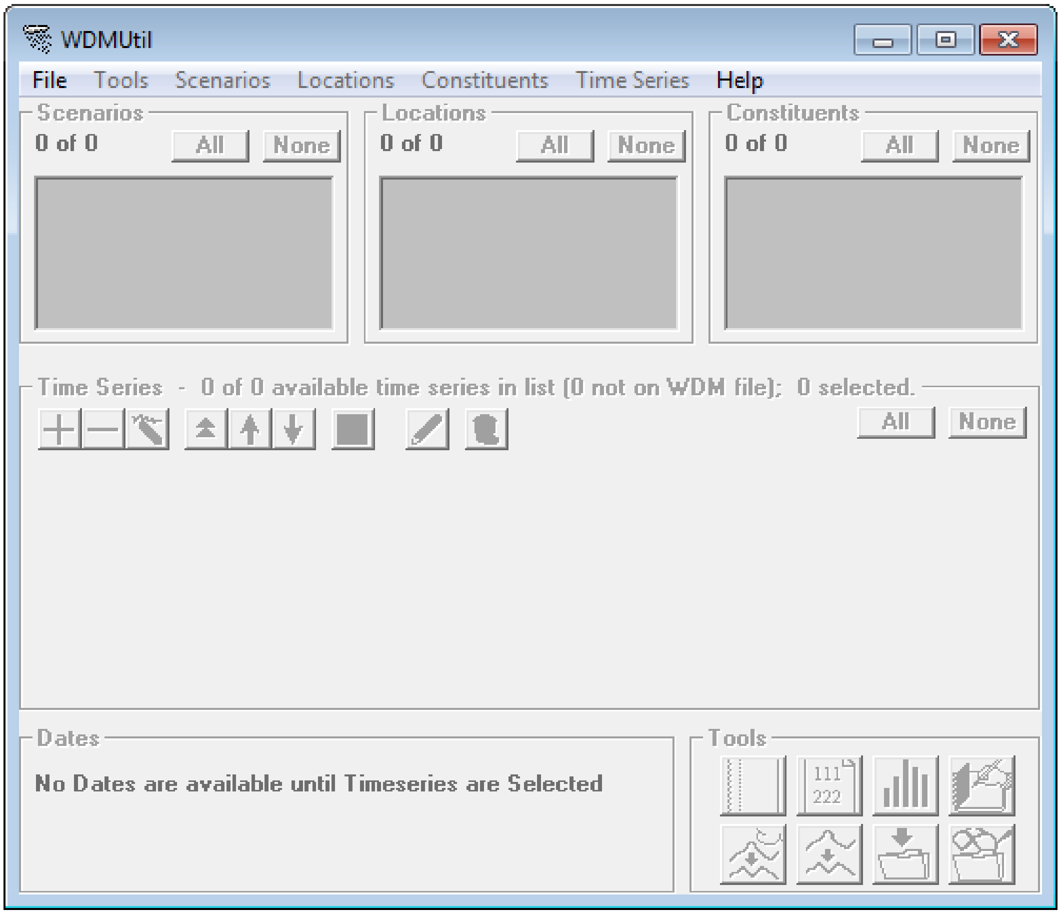


Figure 55: WDMUtil Program Launched from BASINS

f. Click **File**, then **Open**. Navigate to the WDM file generated by HSPF and open the model.

The Window will resemble Figure 56. The file will should be found in the following directory:

C:\BASINS41\data\projectname\met\met.wdm

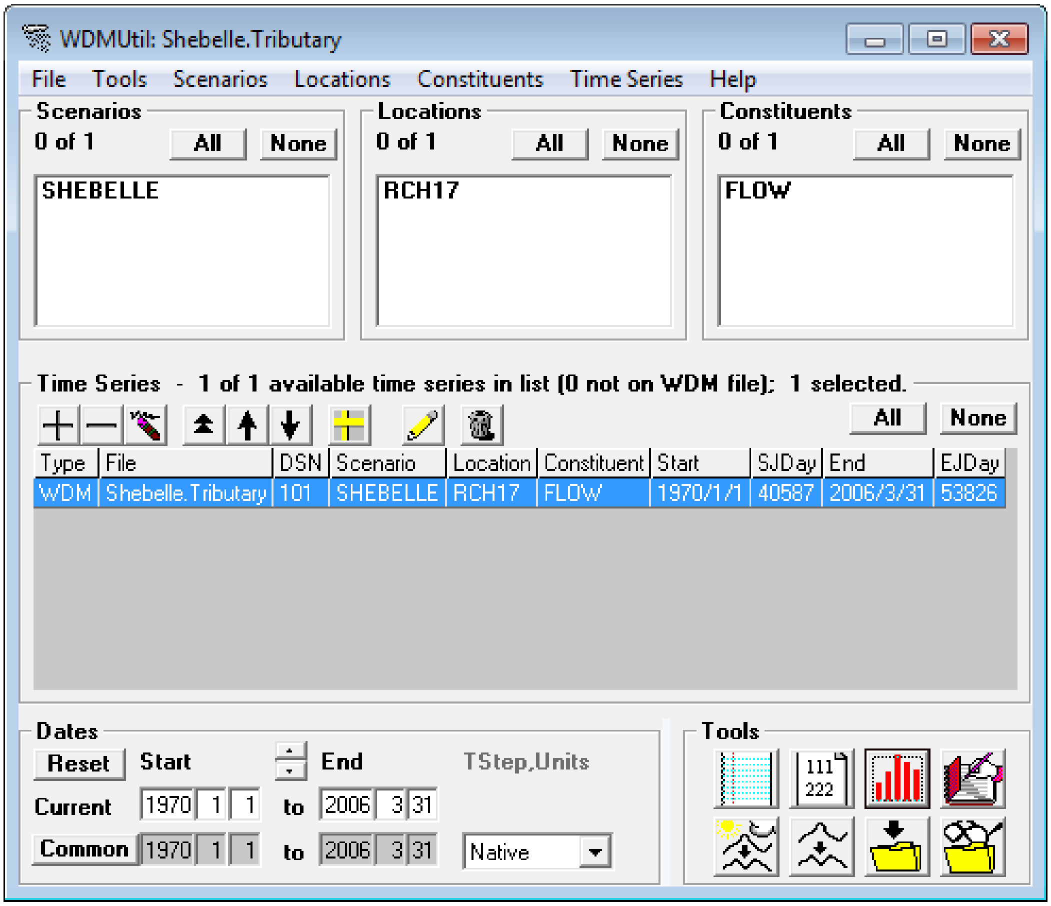
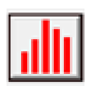


Figure 56: WDMUtil Window with Shebelle HSPF Model Output

g. View output by clicking the graph icon  in the tools section of the window (Figure 56) which will open the window pictured in Figure 57. Adjust the time range of output data in the **Dates** section at the bottom left in the WDMUtil window.

Note: Units of flow displayed on the graph are in cubic feet per second (cfs). The next section discusses how to extract the data to process and convert it into desired units using external data-processing tools.

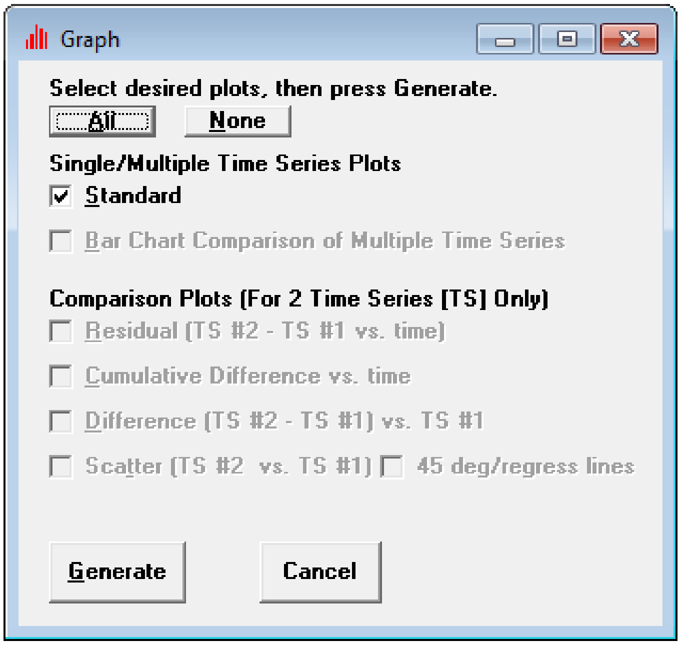


Figure 57: Graph Options Dialog Box

h. Since only one time series dataset was selected in the WDMUtil window (Figure 56), there is only one option for graphing output. If more were selected, plots that compare data by different methods could be generated. Figure 58 shows a graph of flow at the output, Reach 17, as a function of time.

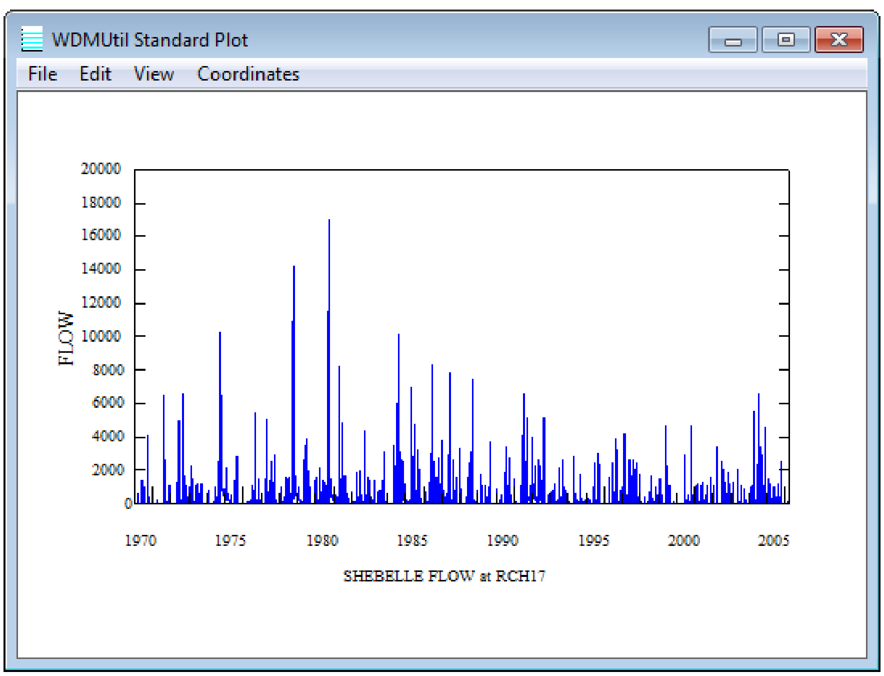


Figure 58: Flow vs Time at Reach 17

Note:	As mentioned in the previous section, sufficient climate data were not found at the project site, so a WDM file containing climate data from another watershed was used. Therefore, this model does not generate representative output flow values for this tributary of the Shebelle Watershed.

4.4 HSPF Output Units and Conversions

Flow outputs estimated by HSPF are usually in cubic feet per second. This section provides an example of how to extract data and conduct unit conversions.

a. After generating the graph, as shown in the previous section, click on the **View** tab in the WDMUtil Standard Plot window, then click **'Listing,'** as shown in Figure 59. The **WDMUtil Standard Plot List** window (Figure 60) will appear.

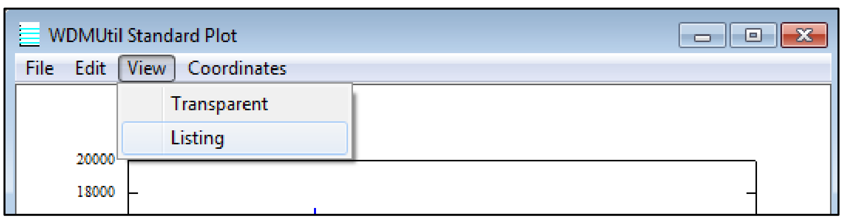
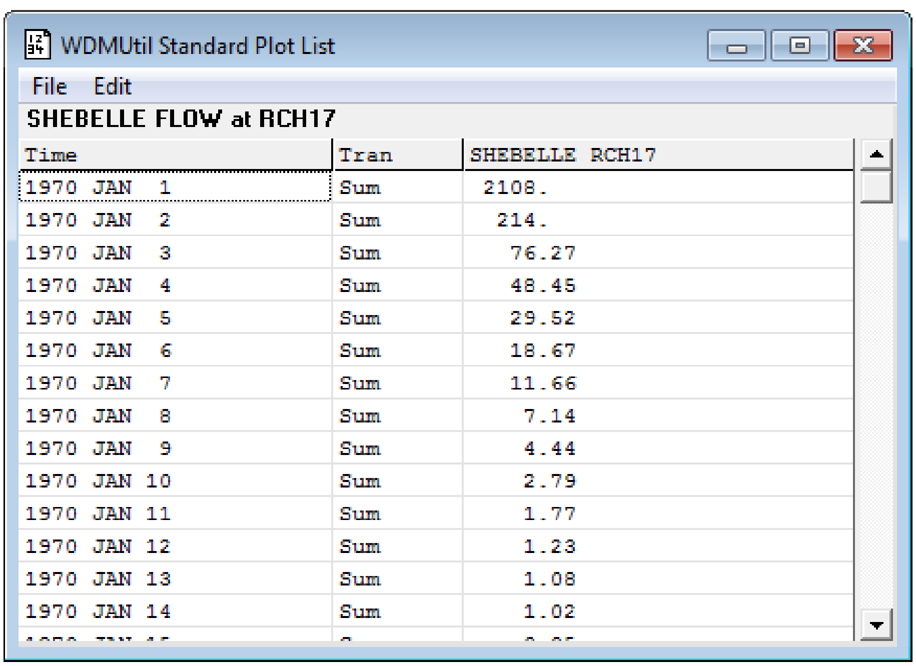


Figure 59: Accessing Data List - WDMUtil Standard Plot Window



WDMUtil Standard Plot List

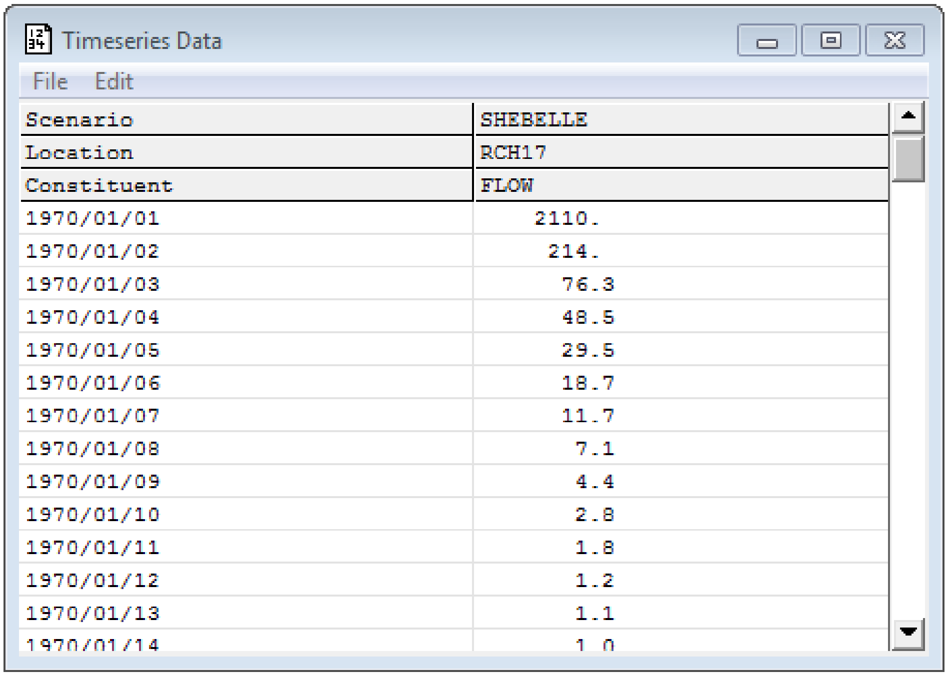
SHEBELLE FLOW at RCH17

Time	Tran	SHEBELLE RCH17
1970 JAN 1	Sum	2108.
1970 JAN 2	Sum	214.
1970 JAN 3	Sum	76.27
1970 JAN 4	Sum	48.45
1970 JAN 5	Sum	29.52
1970 JAN 6	Sum	18.67
1970 JAN 7	Sum	11.66
1970 JAN 8	Sum	7.14
1970 JAN 9	Sum	4.44
1970 JAN 10	Sum	2.79
1970 JAN 11	Sum	1.77
1970 JAN 12	Sum	1.23
1970 JAN 13	Sum	1.08
1970 JAN 14	Sum	1.02

Figure 60: WDMUtil Standard Plot List - Data Table Output

b. Generated output values can be copied and pasted into an external software package for further data analysis and unit conversion if desired.

Note: This data can also be accessed by clicking the **List/Edit Time Series** icon from the main WDMUtil window. Selecting this icon opens the window pictured in Figure 61.



Scenario	SHEBELLE
Location	RCH17
Constituent	FLOW
1970/01/01	2110.
1970/01/02	214.
1970/01/03	76.3
1970/01/04	48.5
1970/01/05	29.5
1970/01/06	18.7
1970/01/07	11.7
1970/01/08	7.1
1970/01/09	4.4
1970/01/10	2.8
1970/01/11	1.8
1970/01/12	1.2
1970/01/13	1.1
1970/01/14	1.0

Figure 61: Time Series Data Window

4.5 Model Calibration

Model calibration is an important process involving parameter adjustment to achieve a close match between observed time series and simulated time series data. The BASINS website provides an example in the HSPF Calibration Tutorial.

Chapter 5: Available Tutorials and Resources

5.1 Tutorials and Training

EPA's BASINS User Information and Guidance
This site contains a library of tutorials and lectures teaching program basics, as well as how to adjust and calibrate different parameters; among them is a guide to WDMUtil. BASINS-related publications and additional resources are included in User Information and Guidance. The User Manual can be found on this page and is also accessible in the BASINS interface by clicking 'Help' on the tool bar and selecting BASINS Documentation.

Introduction to HSPF Modeling
This tutorial appears in the BASINS User Information and Guidance collection. It details how to use basic editing tools, explains assumptions, and describes default parameter values, that a BASINS user may be interested in, to calibrate a model.

Hydrological Simulation Program – Fortran (HSPF) Data Formatting Tool (HDFT)
This tool details how to use both the web and desktop versions of HDFT that enable BASINS and HSPF users to properly format time series data for HSPF using the WDMUtil.

5.2 Documentation and Additional Information

HSPF Support
This site contains HSPF support with a summary of the program. It lists possible applications, modeling capabilities and limitations, as well as a link to download WinHSPF, WDMUtil, and other modeling programs and components.

Summary of HSPF
This USGS report summarizes the history of software development, model data requirements, output options, system requirements, applications, and documentation. It offers resources such as publications and training.

Note: Some tutorials are written for older versions of a program or utility, but may still be useful for understanding and running the software. Always check software updates to determine if changes made in updates affect intended uses and functions.

5.3 Listserv Subscription – from BASINS website

Subscribe to the BASINS Listserve to post your questions to the BASINS/HSPF community and receive timely answers from other users. Instructions on joining can be found at this website: **http://water.epa.gov/scitech/datait/models/basins/index.cfm.**

Appendix A: DEM Retrieval from Global Data Explorer

a. Navigate to the Global Data Explorer website shown below in Figure 62.

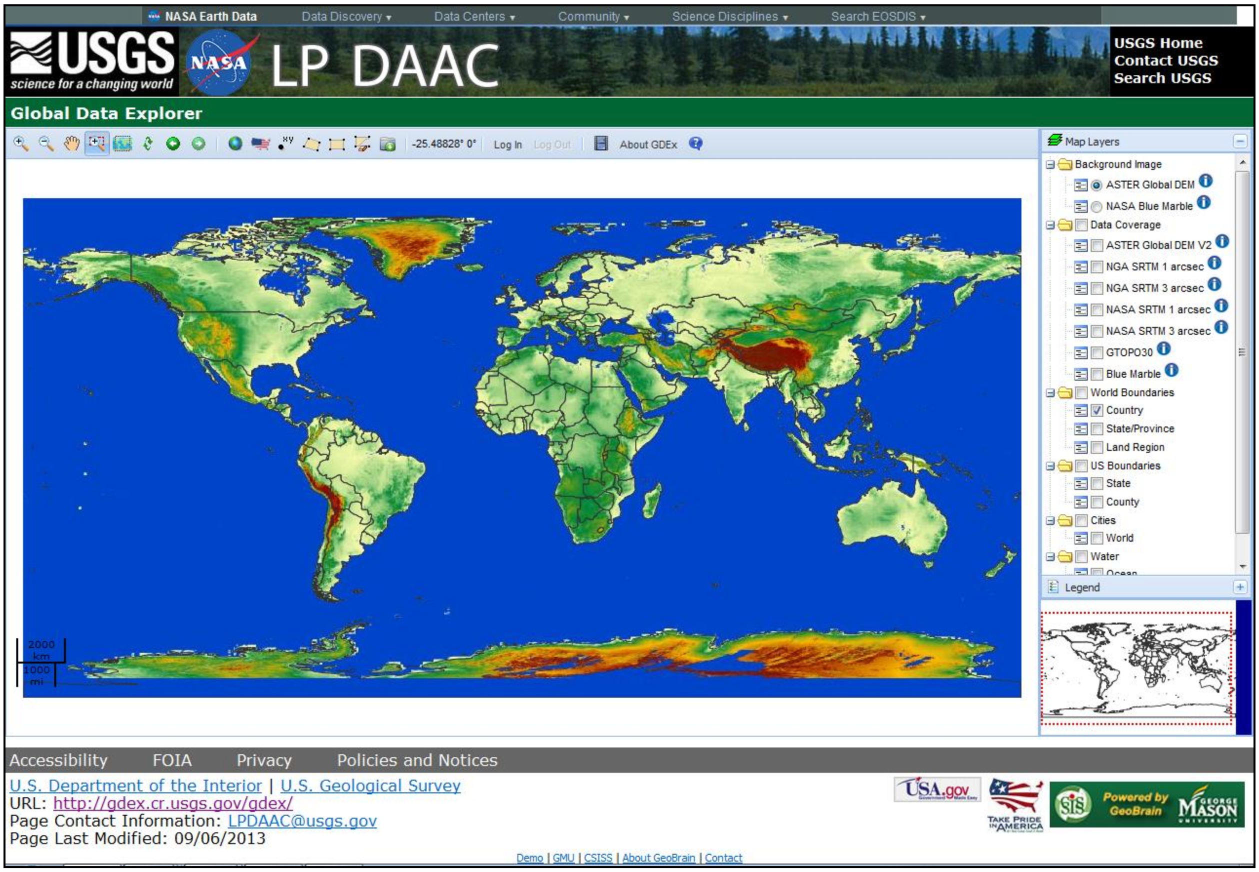


Figure 62: Global Data Explorer Interface

b. Create an account. In the tool ribbon above the map, click **'Log in'** to see the window shown in Figure 63.

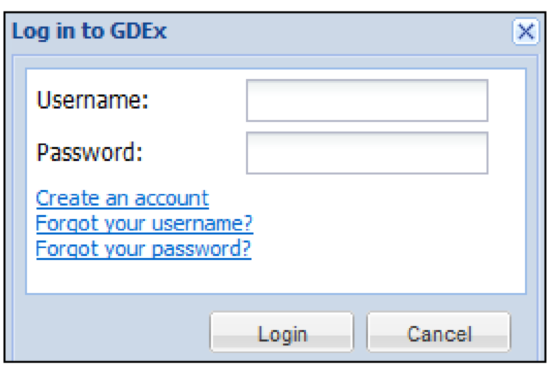


Figure 63: Log in Window in GDEx

c. Click **'Create an account'** to open the window shown in Figure 64. Fill out the required fields to create an account.

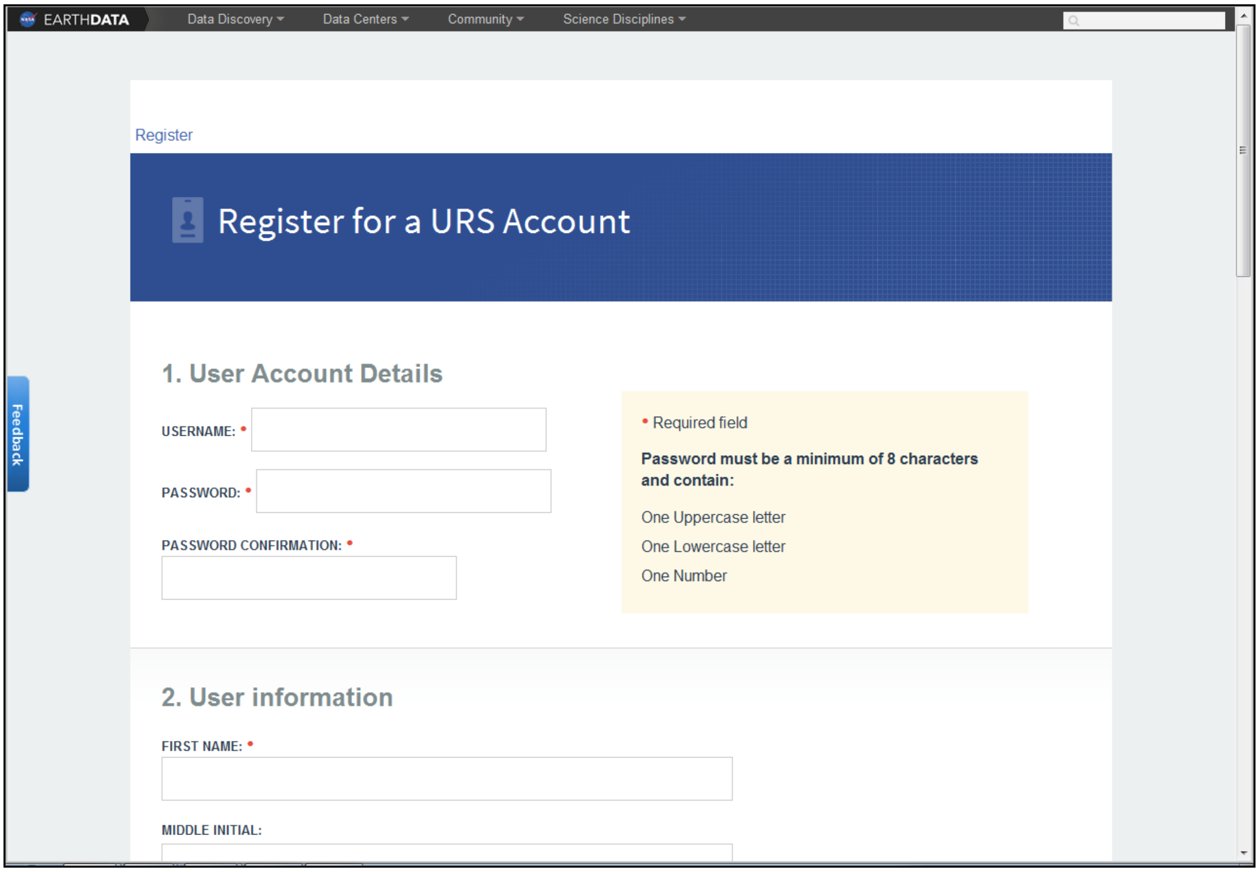


Figure 64: URS Account Registration Window

d. After creating an account, return to the GDEx website and click **'Log In.'**

e. Enter the new credentials and a window will state that the log-in was successful. Press **'OK'** to download data.

f. Zoom to the region. The easiest way is with the **'Dragbox Zoom In'** tool, circled in red as shown in Figure 65. Hovering over the tool identifies its use.

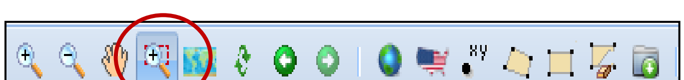
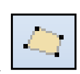


Figure 65: Tool Ribbon with 'Dragbox Zoom In' Tool Selected

g. Once zoomed to the area of interest, select it. The **'Define Polygon Area'** tool  (Figure 66) was used to select the image as it gives the user more control; the alternative is the **'Define Rectangular Area'** tool located to the right.

h. Select the area by clicking points around the watershed or area of interest. Double-click to complete the shape as shown in Figure 66.

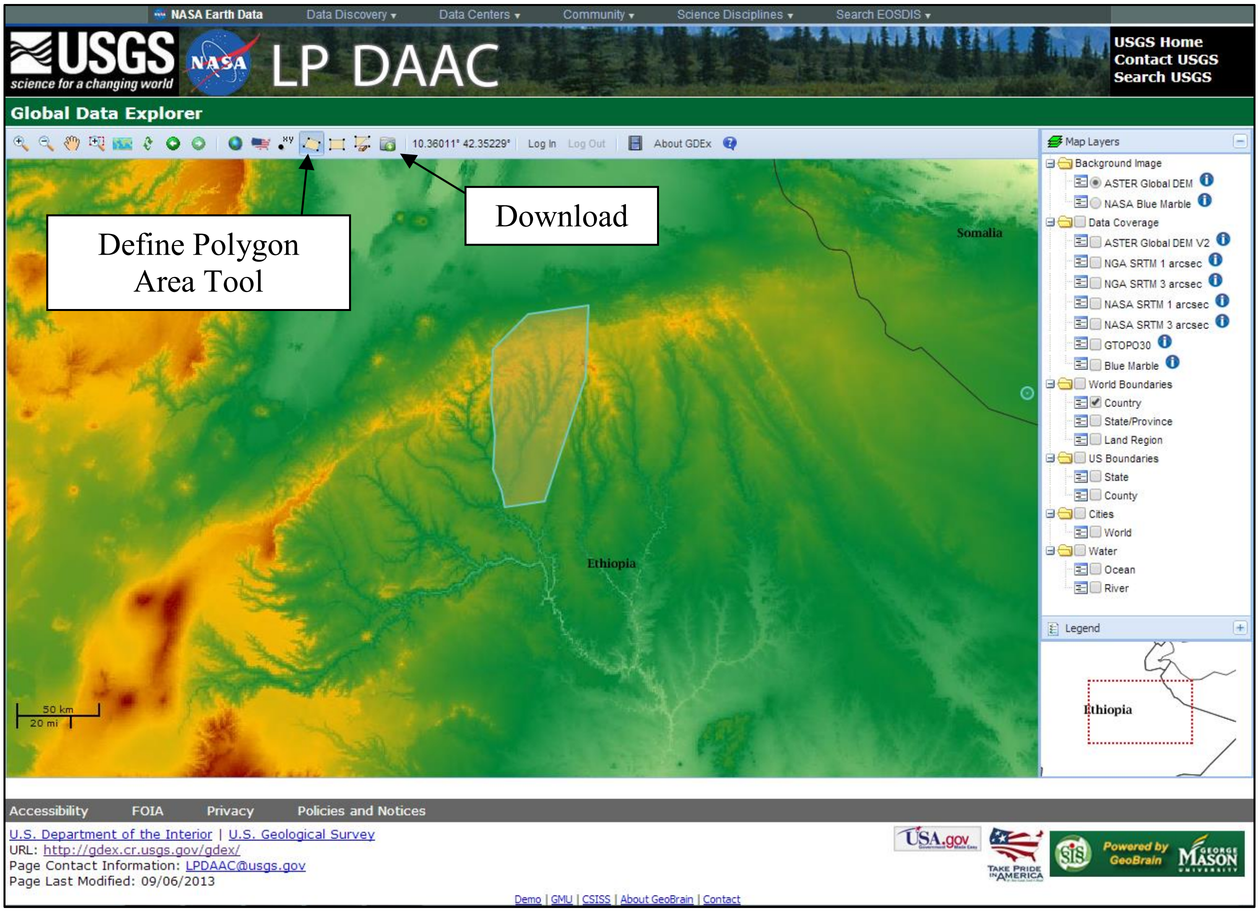


Figure 66: Defining Polygon Area

i. Once the area is selected, click Download , as shown in Figure 66. The dialog box shown in Figure 67 will appear.

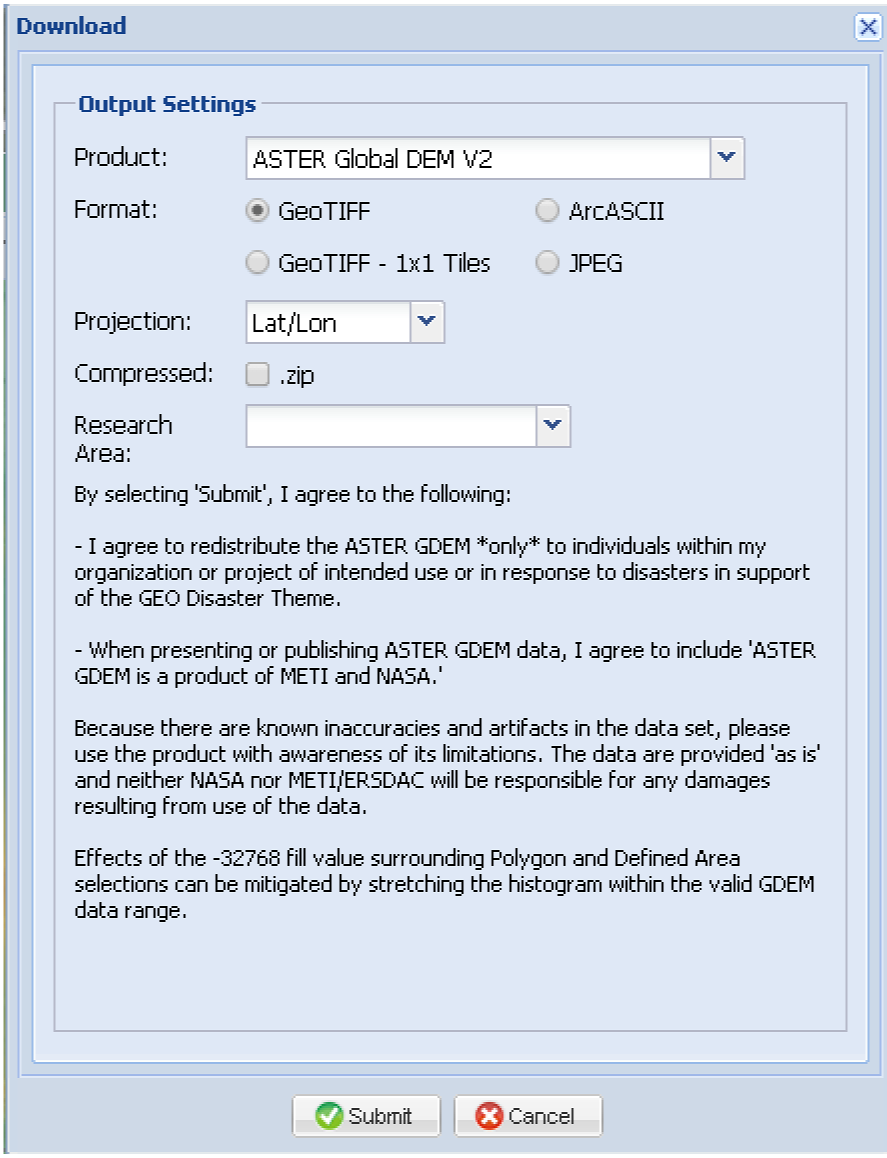


Figure 67: Download DEM Dialog Box

j. Complete the dialog box. For this example, the Lat/Long coordinate system was selected in the projection pull-down since it matches default projections of other required GIS data.

k. Press **'Submit'** to complete the download.

Appendix B: Downloading River Network Files

a. In the Data Download Section of the USGS HydroSHEDS Website, shown in Figure 68, select a **River Network** Shapefile of the desired resolution.

In the example, **15sec SHAPE: River Network** was selected.

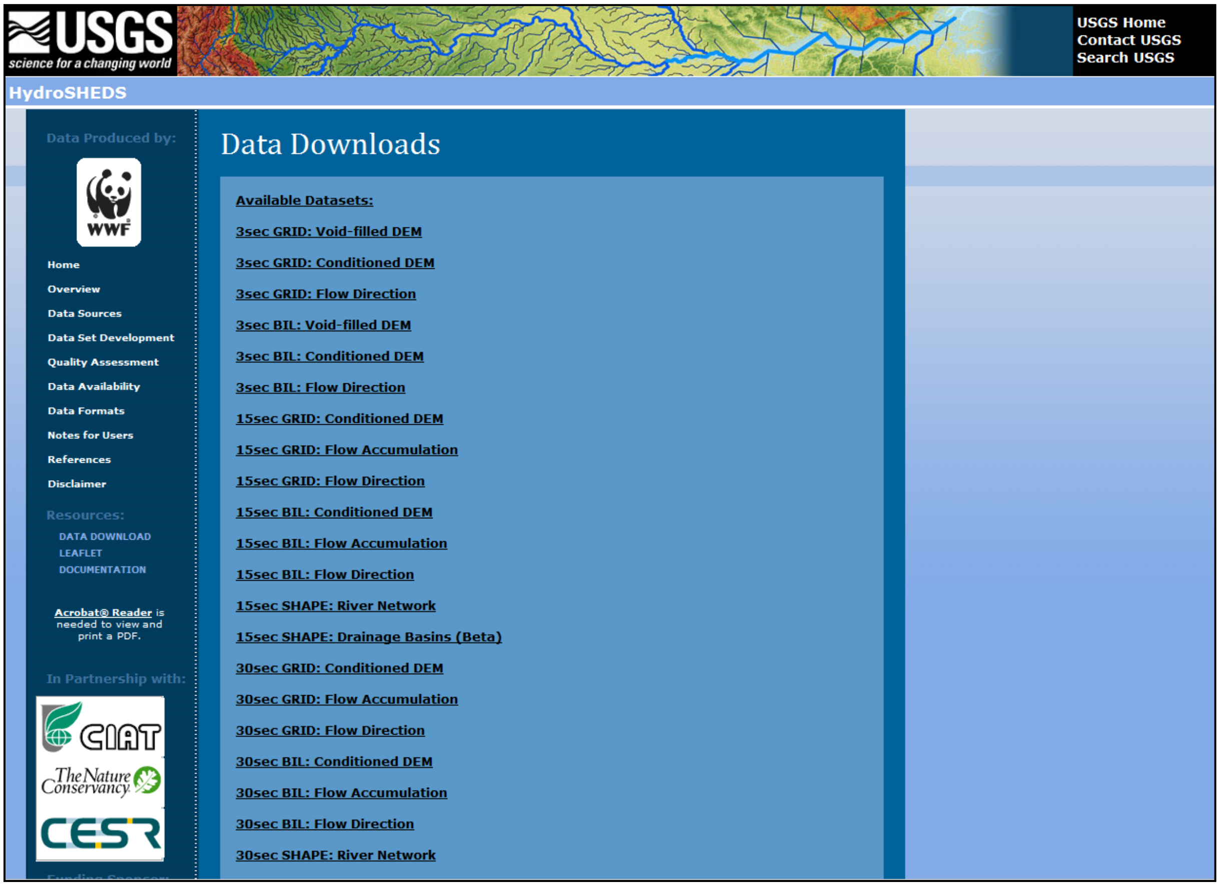


Figure 68: Data Downloads from USGS HydroSHEDS

Selecting the River Network shapefile will open the window shown in Figure 69 that lists all regions available for download.

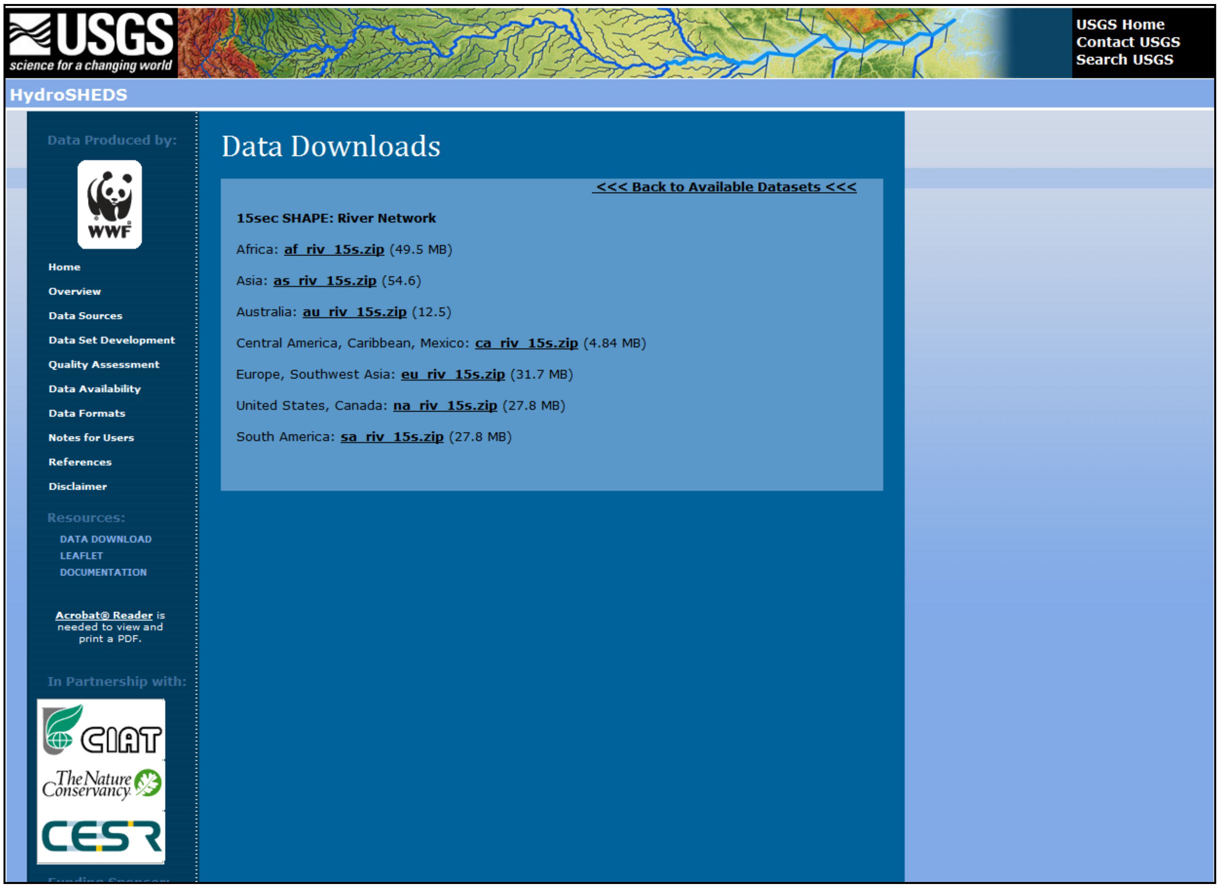


Figure 69: USGS HydroSHEDS 15-sec Resolution River Network Shapefile Download

b. Select the region of interest. Here, all Africa HydroSHEDS were downloaded.

Note: Refer to the Documentation available from the USGS for information on data retrieval and processing, and projection. According to the documentation, the shapefile has a geographic (latitude/longitude) coordinate system, referenced to WGS84 datum. To use the BASINS watershed delineation, this must be re-projected to a projected coordinate system. A GIS program like those mentioned in Section 1.4.1 is recommended. .

Appendix C: Downloading Land Cover Data

a. Navigate to the Global Land Cover 2000 – Products site shown below in Figure 70.

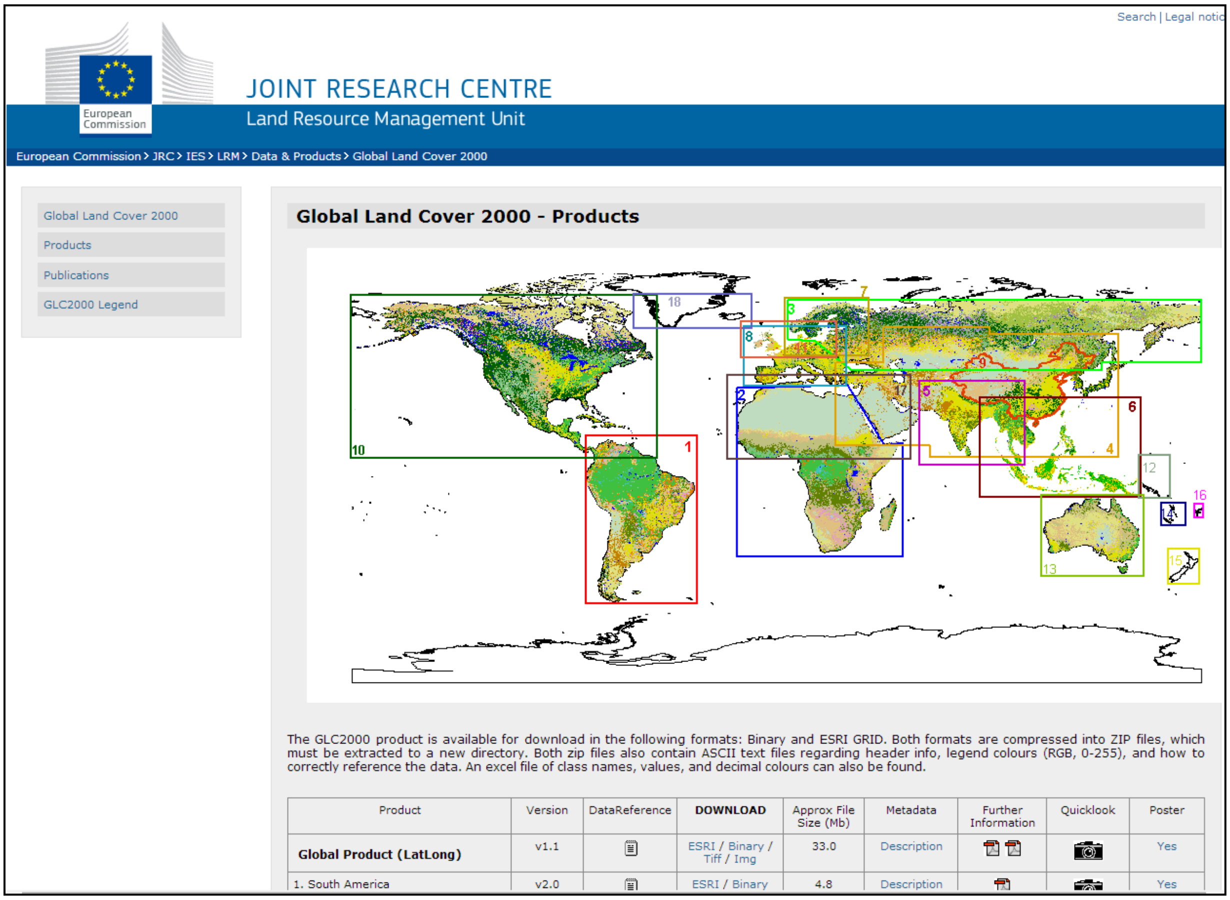


Figure 70: Global Land Cover 2000 from the EU Joint Research Center

b. Scroll down to find downloadable data for the entire globe, **Global Product (LatLong)**, as shown in Figure 71.

Product	Version	DataReference	DOWNLOAD	Approx File Size (Mb)	Metadata	Further Information	Quicklook	Poster
Global Product (LatLong)	v1.1		ESRI / Binary / Tiff / Img	33.0	Description			Yes
1. South America	v2.0		ESRI / Binary	4.8	Description			Yes
2. Africa	v5.0		ESRI / Binary	3.8	Description			Yes
3. Northern Eurasia	v4.0		ESRI / Binary	10.9	Description			Yes

Figure 71: Product Download Options and Information

c. Open the metadata by clicking the **Description** link in the metadata column (Figure 72). Note important details such as spatial resolution, map projection, and datum. Like the river network, the file is in a geographic (latitude/longitude) coordinate system referenced to the WGS84 datum. Again, this must be a projected coordinate system. The PDF file included in the **Further**

Information column heading also has important information on data collection and land use classifications.

DATASET DESCRIPTION	
Title of Dataset	The Land Cover of the World in the Year 2000
Abstract	
Keywords	Global Landcover 2000; SPOT Vegetation;
Language	English
Version / Edition	1.1
Production Date	26/01/2004
Status	Pre-validation Version

CONTACT DETAILS		
Compiled by	Institution Name :	GVM, JRC
	Contact Name :	
	Email :	
	Web Link :	http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php
Project Co-ordination	Institution :	Joint Research Centre
	Contact Name :	Etienne Bartholome
	Email :	etienne.bartholome@jrc.it
	Web Link :	http://www-gvm.jrc.it/glc2000
Other Collaborating Partners	Please see partners page of GVM website	

METHODOLOGY		
Lineage of the Data		
Data Source(s)	SPOT Vegetation	
Temporal Coverage of the Data	Start :	01/01/2000
	End :	31/12/2000
Legend	Name :	Land Cover Classifcation Scheme (LCCS)
	Description :	Based on FAO Land Cover Classification System. Later version will also include regional legends
	Online Resources :	http://www-gvm.jrc.it/glc2000/Legend/GLC2000-LCCS_global-legend_overview.doc
Data Quality Assessment	Qualitative :	Validation of global dataset will begin shortly
	% Assessed by Regional Experts :	

SPATIAL REPRESENTATION INFORMATION		
Geographical Location	ULX : -180.00000	LRX : 179.991070
	ULY : 89.991071	LRY : -56.008928
Spatial Resolution	1km at Equator (0.0089285714dd)	
Map Projection	Geographic (Lat/Lon)	
Spheroid	WGS84	
File Size (Mb)	33	

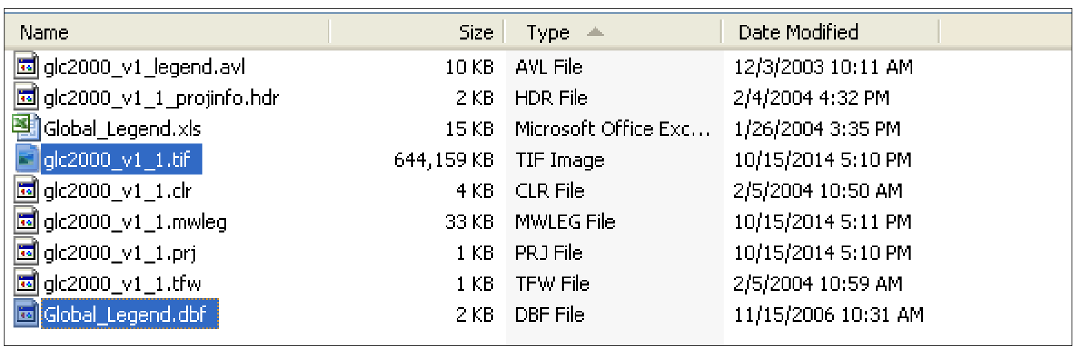
Figure 72: Metadata Information

d. Close the metadata and return to the window shown in Figures 70 and 71. Click **Tiff** in the **DOWNLOAD** column for the **Global Product** to download the geospatial data. Before download begins, the window shown in Figure 73 will request personal information. Fill it out and press **'Submit'**.

Figure 73: Data Access Dialog Box

e. Also download the **ESRI** land cover file. Inside will be a file named "Global_Legend.dbf" to be used for defining land use classifications.

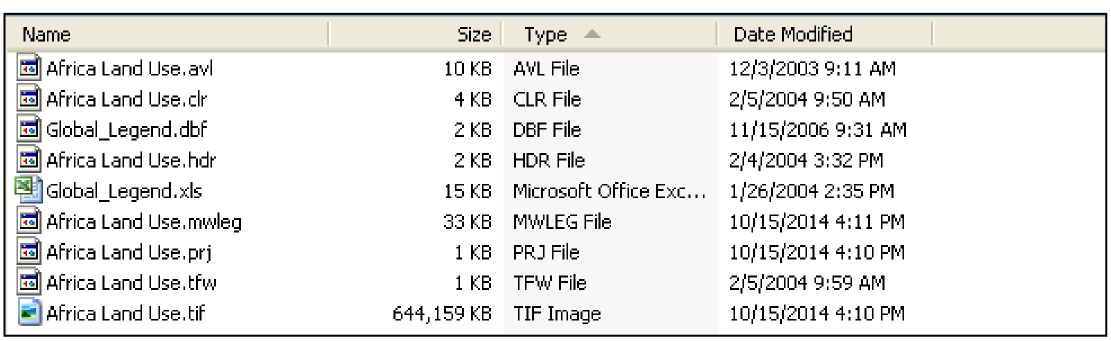
f. Note the files included in the downloads (Figure 74). The one named "**Global_Legend.dbf"** contains legend information and is the file used to reclassify land use, while "**glc2000_v1_1.tif"** is the land cover raster itself.



Name	Size	Type	Date Modified
glc2000_v1_legend.avl	10 KB	AVL File	12/3/2003 10:11 AM
glc2000_v1_1_projinfo.hdr	2 KB	HDR File	2/4/2004 4:32 PM
Global_Legend.xls	15 KB	Microsoft Office Exc...	1/26/2004 3:35 PM
glc2000_v1_1.tif	644,159 KB	TIF Image	10/15/2014 5:10 PM
glc2000_v1_1.clr	4 KB	CLR File	2/5/2004 10:50 AM
glc2000_v1_1.mwleg	33 KB	MWLEG File	10/15/2014 5:11 PM
glc2000_v1_1.prj	1 KB	PRJ File	10/15/2014 5:10 PM
glc2000_v1_1.tfw	1 KB	TFW File	2/5/2004 10:59 AM
Global_Legend.dbf	2 KB	DBF File	11/15/2006 10:31 AM

Figure 74: Global Land Cover Raster and Legend Database File

g. Downloaded files were renamed to be relevant to the project location used in this tutorial, as shown in Figure 75.



Name	Size	Type	Date Modified
Africa Land Use.avl	10 KB	AVL File	12/3/2003 9:11 AM
Africa Land Use.clr	4 KB	CLR File	2/5/2004 9:50 AM
Global_Legend.dbf	2 KB	DBF File	11/15/2006 9:31 AM
Africa Land Use.hdr	2 KB	HDR File	2/4/2004 3:32 PM
Global_Legend.xls	15 KB	Microsoft Office Exc...	1/26/2004 2:35 PM
Africa Land Use.mwleg	33 KB	MWLEG File	10/15/2014 4:11 PM
Africa Land Use.prj	1 KB	PRJ File	10/15/2014 4:10 PM
Africa Land Use.tfw	1 KB	TFW File	2/5/2004 9:59 AM
Africa Land Use.tif	644,159 KB	TIF Image	10/15/2014 4:10 PM

Figure 75: Renamed Global Land Cover Raster Files

Appendix D: Downloading Soil Data

Although not necessary for delineating or running HSPF, soil data can be of interest to BASINS users, depending on the model's intended use..

a. Go to the FAO GeoNetwork website. The page is shown in Figure 76.

Figure 76: FAO GeoNetwork Webpage

b. Scroll down to the **Distribution Information** section shown in Figure 77.

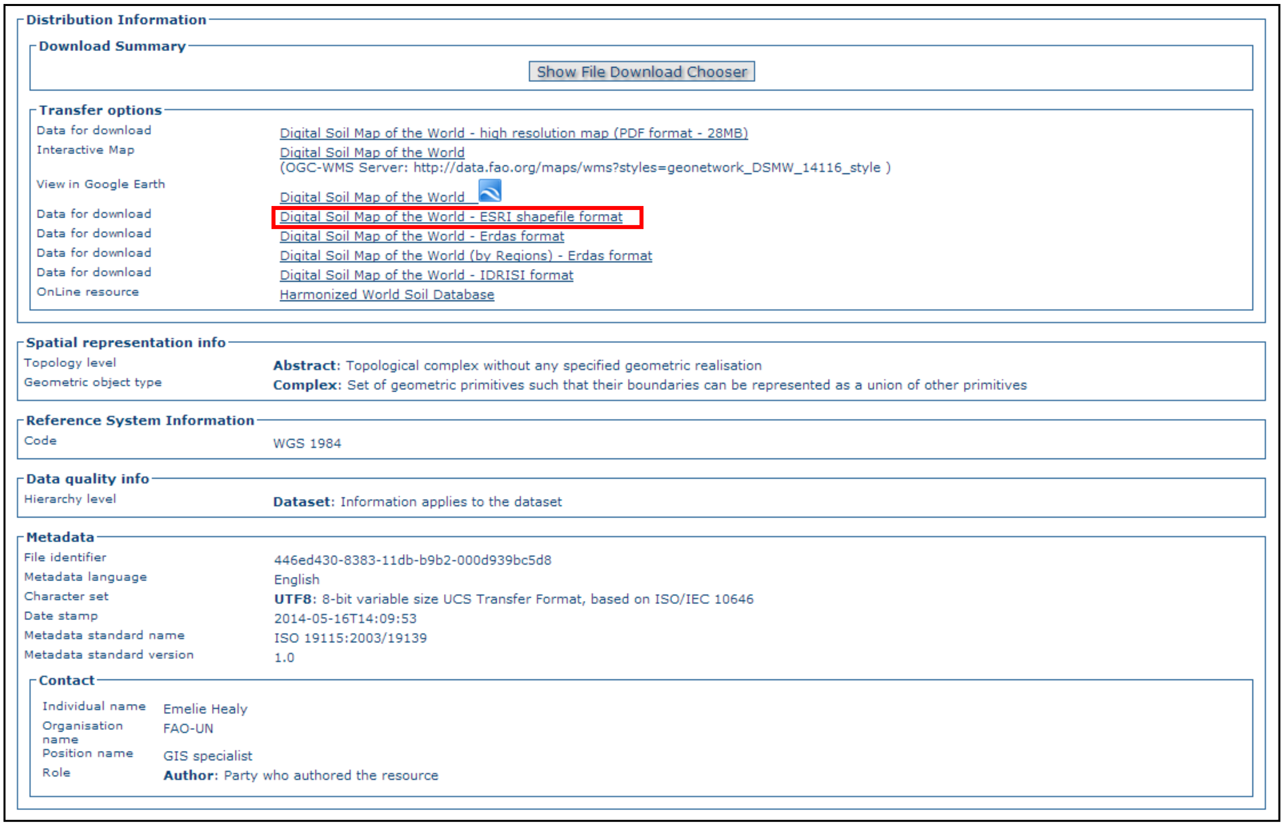


Figure 77: Distribution Information Box

c. To download the file, click on '**Digital Soil Map of the World – ESRI Shapefile format**'.

Note: In the **Reference System Information** section, note that the coordinate system is WGS 1984 -- just like the land use and river network files -- so re-projection is not immediately required to match other inputs.

Appendix E: Downloading Weather Data

Time series meterological data is required to run HSPF. If local data is not available, there are multiple data acquisition options. One is to download data from NOAA's National Climate Data Center with a manual searching tool or interactive map. **Appendix E** describes the interactive map process.

a. Follow [this link] to the interactive mapping interface shown in Figure 78.

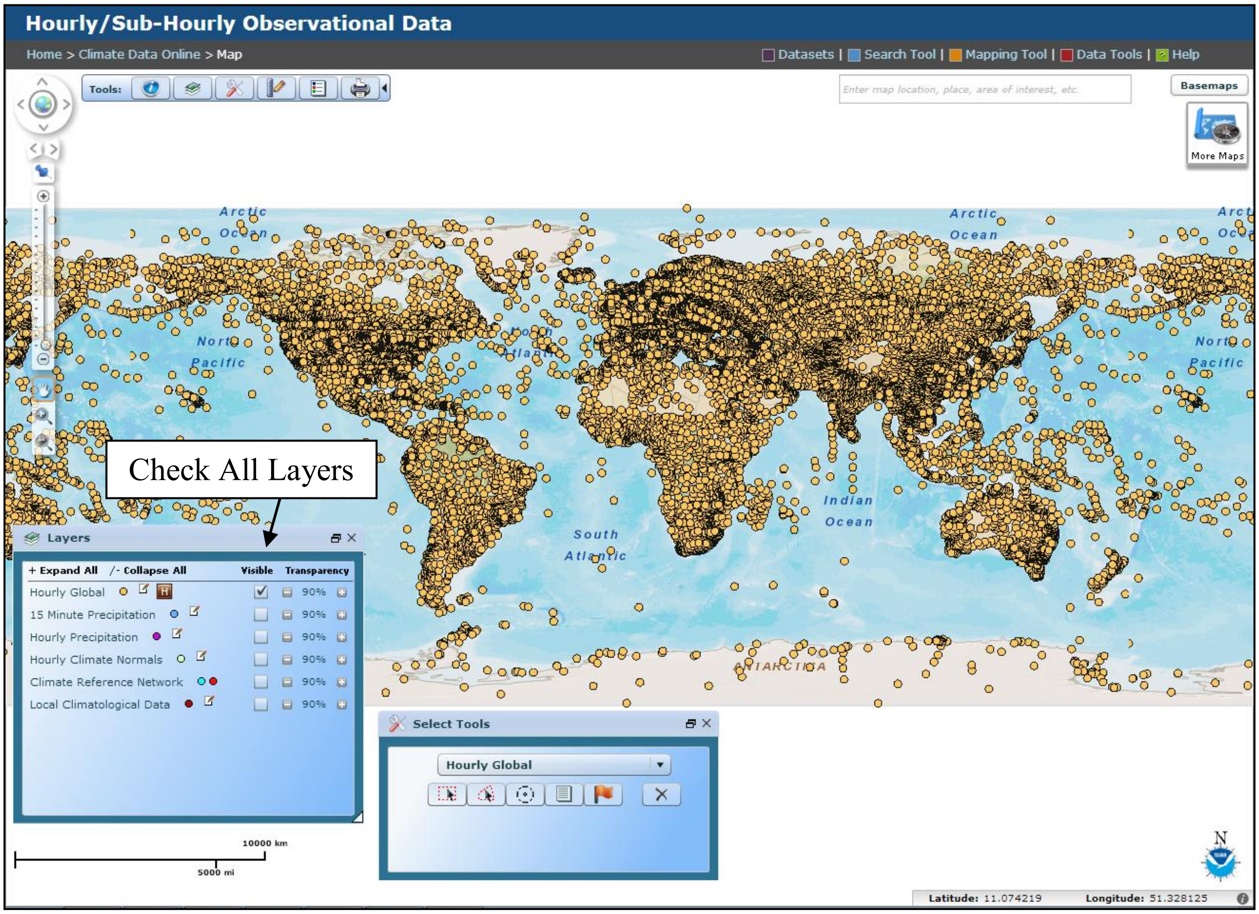


Figure 78: NOAA NCDC Interactive Weather Station Map

b. In the Layers dialog box, check all available layers to make them visible (Figure 78).

c. Click the zoom tool, and draw a box around the region of interest as highlighted in Figure 79.

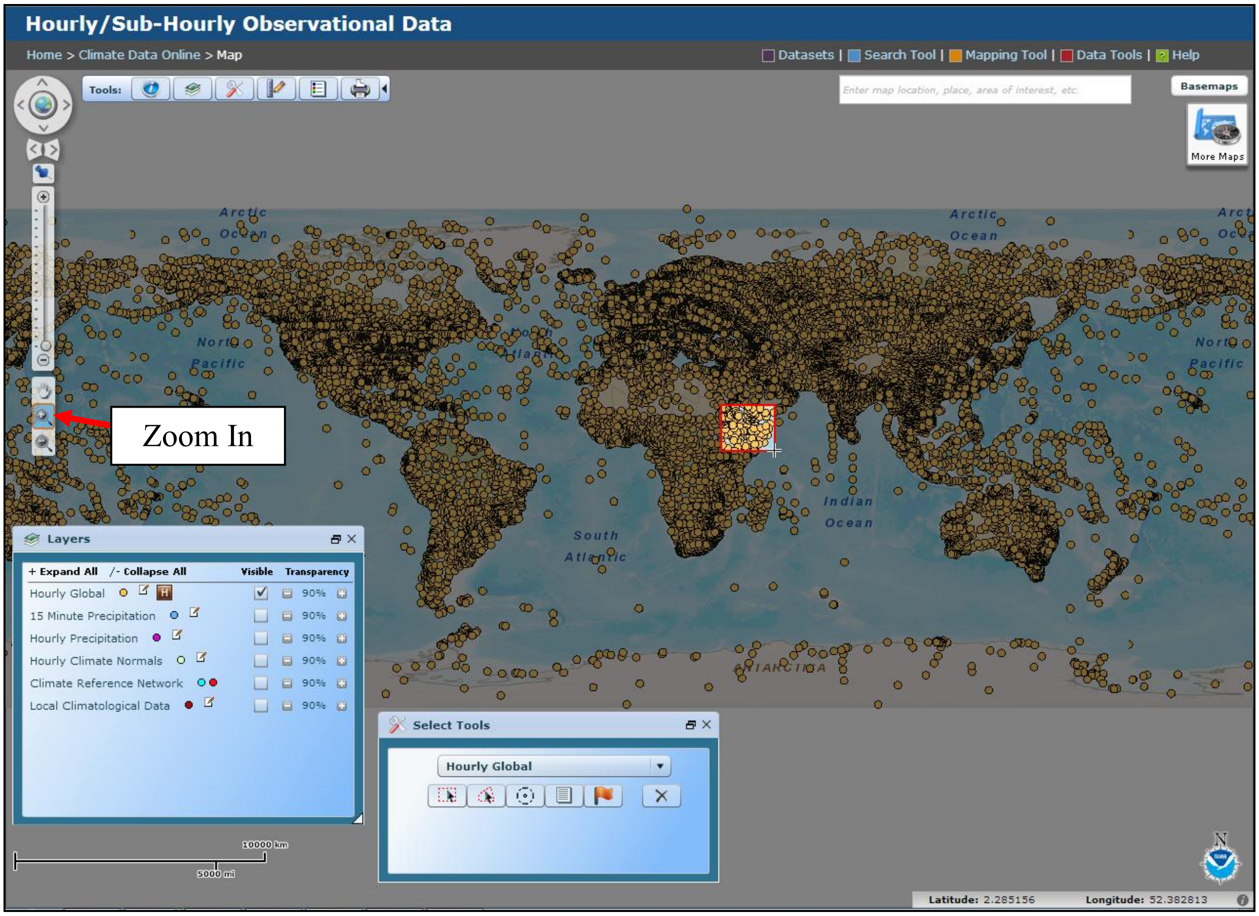


Figure 79: Zooming into Local Weather Stations

d. Once zoomed in, local weather stations become available. Using a Select tool, select 3-4 weather stations representative of the watershed from which to extract data (Figure 80).

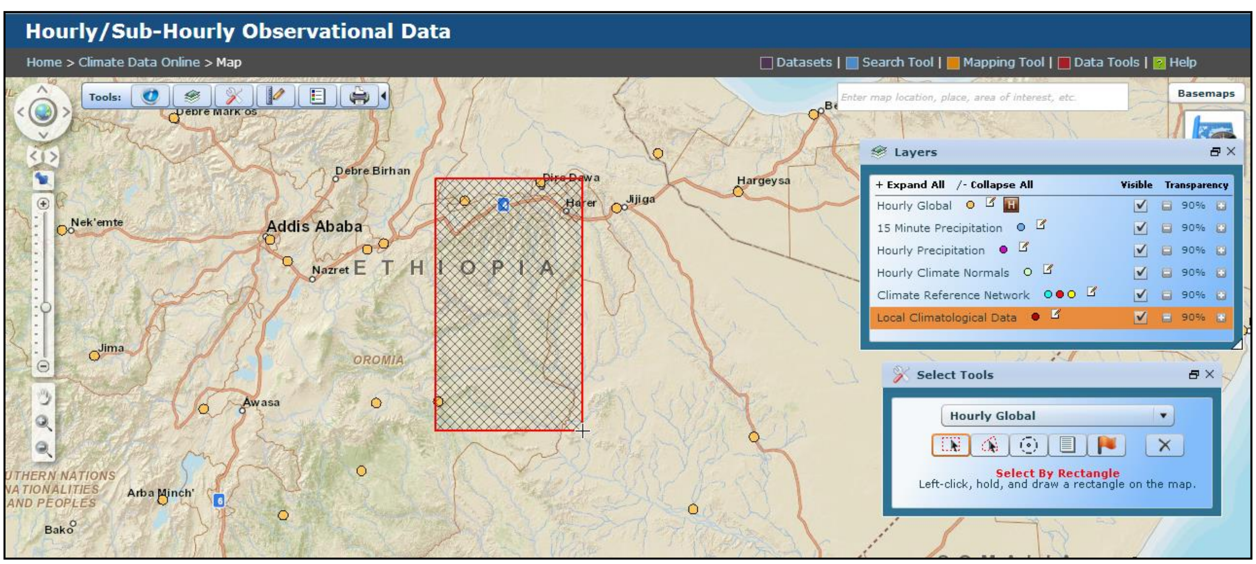


Figure 80: Selecting Weather Stations

e. The weather station selection box appears (Figure 81) to allow users to narrow their selection further. Select the stations by checking the box beside the station name, then click **'Get Selected Data'**.

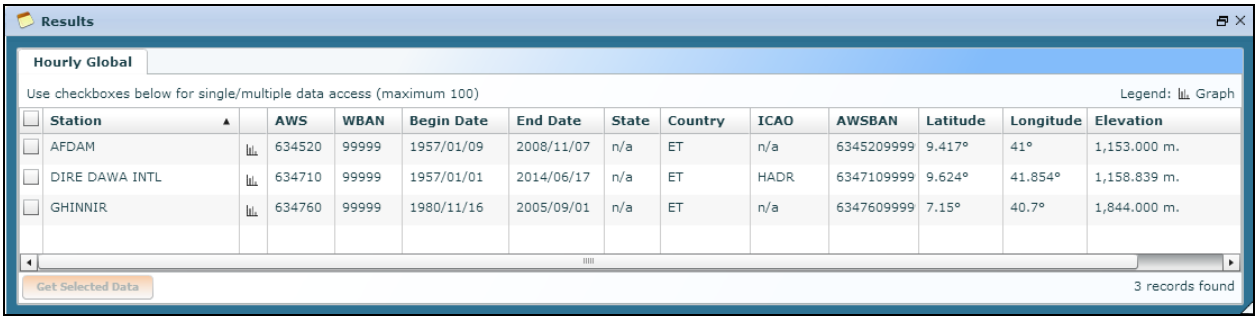


Figure 81: Results of Weather Station Selection

f. Select **Advanced** in the Data Options for more control over the data format, then click **'Access Data'**, as shown in Figure 82. A NOAA Policy window will appear. Read the terms of the policy and agree if appropriate.

.

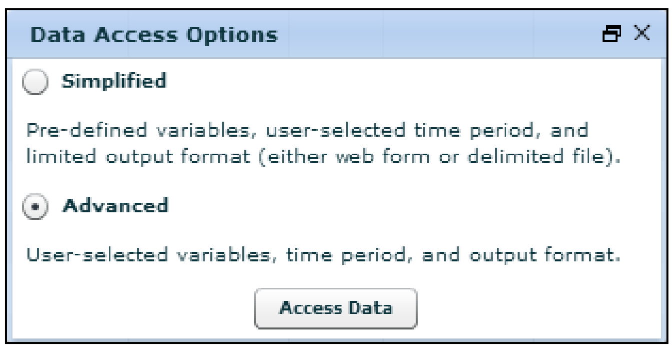


Figure 82: Data Access Options Dialog Box

g. In the window appearing as Figure 83, users are prompted to select various data types. Refer to Table 4 in Section 2.1.3 that describes required weather time series data needed, depending on the model's intended use. These are reproduced in Table 6, in addition to options in the NCDC data access.

Table 6: Weather Data Requirements and Corresponding NCDC Options

Required HSPF Weather Parameters	**Corresponding NCDC Data Download Options**
Precipitation	15 Minute Liquid Precipitation Liquid Precipitation (By Minute)
Potential Evapotranspiration	Not Directly Available
Air Temperature	Air Temperature Observation
Dewpoint Temperature	Air Temperature Observation Dewpoint
Wind Speed	Wind Observation Hourly Wind Section
Solar Radiation	Hourly Solar Radiation Section Solar Radiation Section
Cloud Cover	Sky Condition Observation

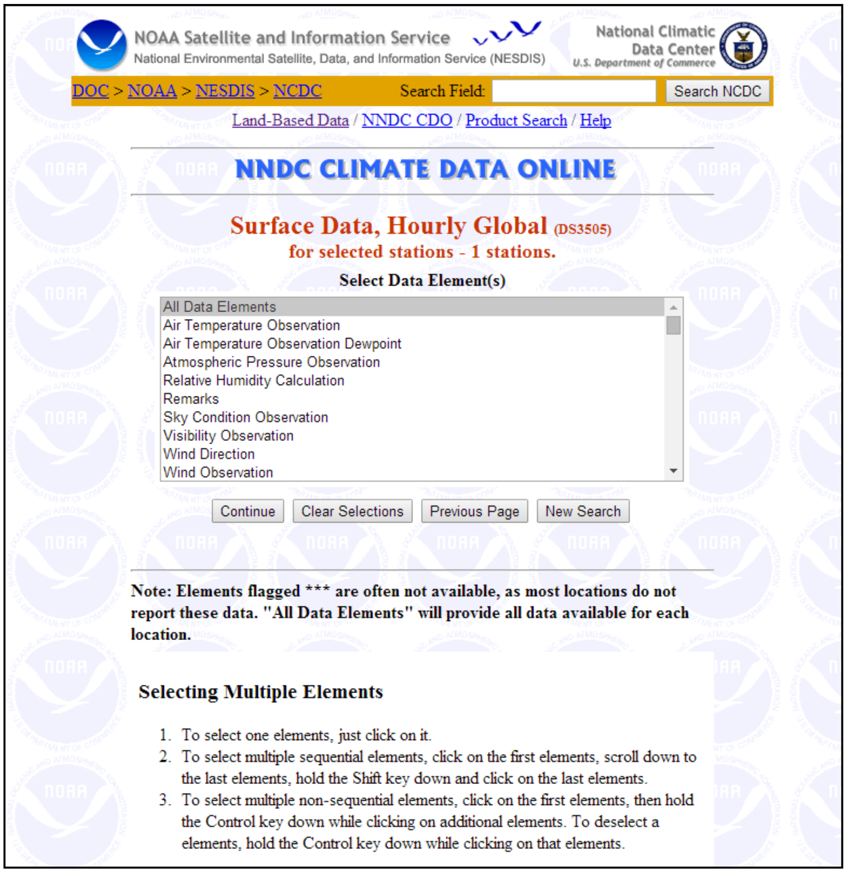


Figure 83: Selecting Data Elements

h. Follow instructions to select multiple elements. Some may not be available in the region of interest; if so, it is advisable to select more parameters to compensate for a possible lack of data. When all desired parameters have been selected, click **'Continue'**.

i. Next, enter the time range of the data and the output format. The selection pane is shown in Figure 84.

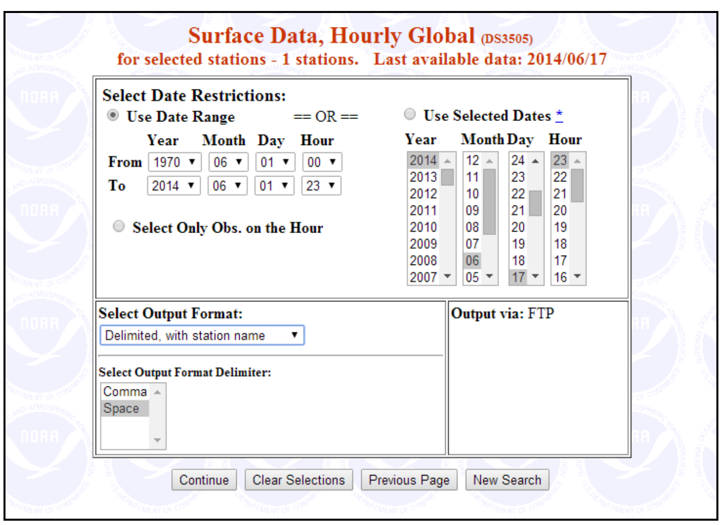


Figure 84: Time Series and Output Format Selection

j. After selecting the output format and time range, click **Continue**. Users are asked to review the Inventory File to ensure the data requested is available and to enter an email address (Figure 85).

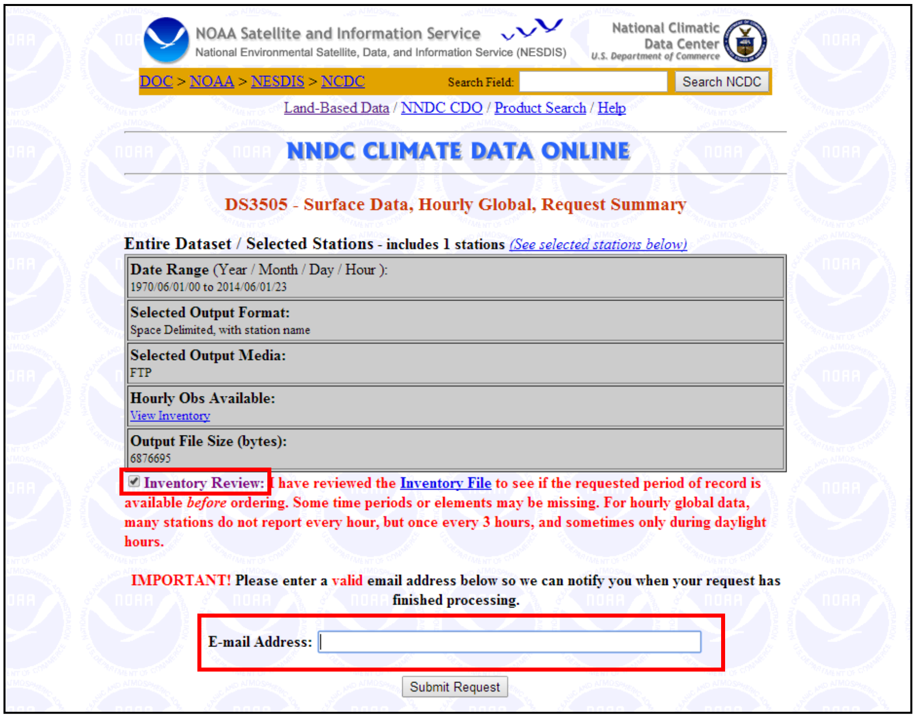
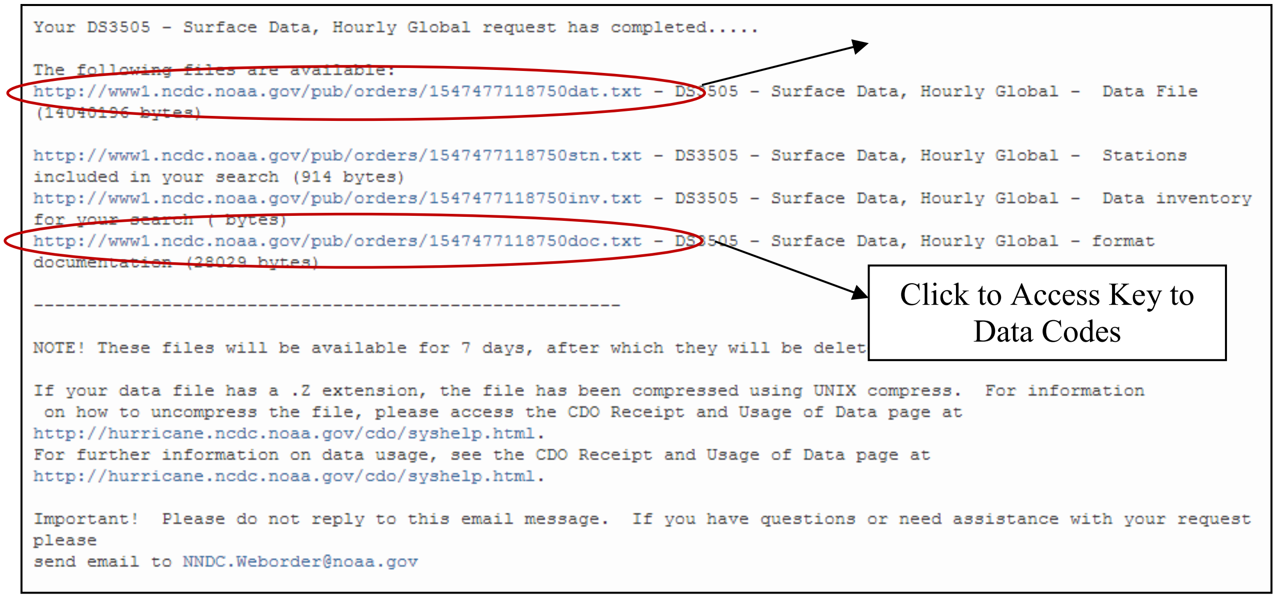


Figure 85: Submitting Request for Time Series Climate Data

k. Data is sent via email. It will include a link to the data as well as a key to terms and abbreviations. An example is shown in Figure 86.



```
Your DS3505 - Surface Data, Hourly Global request has completed.....

The following files are available:
http://www1.ncdc.noaa.gov/pub/orders/1547477118750dat.txt - DS3505 - Surface Data, Hourly Global -  Data File
(14040196 bytes)

http://www1.ncdc.noaa.gov/pub/orders/1547477118750stn.txt - DS3505 - Surface Data, Hourly Global -  Stations
included in your search (914 bytes)
http://www1.ncdc.noaa.gov/pub/orders/1547477118750inv.txt - DS3505 - Surface Data, Hourly Global -  Data inventory
for your search ( bytes)
http://www1.ncdc.noaa.gov/pub/orders/1547477118750doc.txt - DS3505 - Surface Data, Hourly Global - format
documentation (28029 bytes)

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NOTE! These files will be available for 7 days, after which they will be delet

If your data file has a .Z extension, the file has been compressed using UNIX compress.  For information
 on how to uncompress the file, please access the CDO Receipt and Usage of Data page at
http://hurricane.ncdc.noaa.gov/cdo/syshelp.html.
For further information on data usage, see the CDO Receipt and Usage of Data page at
http://hurricane.ncdc.noaa.gov/cdo/syshelp.html.

Important!  Please do not reply to this email message.  If you have questions or need assistance with your request
please
send email to NNDC.Weborder@noaa.gov
```


Figure 86: NCDC Email with Links to Requested Data

l. Access the data by clicking on the first link in the email, as shown in Figure 86. The link connects to a page with data that resembles Figure 87. The format is currently incompatible with BASINS and must be converted to a WDM file. Due to gaps in the downloaded data, this example could not be converted easily to a WDM for this region. If this occurs for the selected study area, an alternative source of time series data must be acquired—possibly from local or regional agencies and/or universities (refer to Flow Chart in Figure 40).

To learn how to format time series data into a WDM file, visit the WDM Exercise in the BASINS User Information and Guidance.

```
Identification                                WIND            CEILING     TEMP     DEWPT    PRECIP        PRECIP        PRECIP        PRECIP        PRECIP
PRECIP        PRECIP        PRECIP        PRECIP     PRECIP     PRECIP     PRECIP    TEMP                     TEMP                     TEMP                     SOLAR
SOLAR                                    WIND                                           WIND
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Q Q SrMax  Q Q SrStd  Q Q Time UpSo Q DTIR Q IRad Q PAR  Q ZAn Q AvW MxGs  Q Q MDr Q Q WdSpS  Q Q WDirS  Q Q AvW MxGs  Q Q MDr Q Q WdSpS  Q Q WDirS  Q Q
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634710 99999 19730125 1200 4 FM-12      110 1 N   4.6 1 22000 1 C N   28.0 1    9.0 1 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99
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634710 99999 19730128 1200 4 FM-12      340 1 N   5.1 1 22000 1 C N   29.0 1   10.0 1 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99
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634710 99999 19730130 0600 4 FM-12      999 1 C   0.0 1 22000 1 C N   22.0 1   11.0 1 99   0.0 9 1 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99
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9 9
634710 99999 19730204 1200 4 FM-12      999 1 C   0.0 1 22000 1 C N   27.0 1    5.0 1 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99
999.9 9 9 99 999.9 9 9 99 999.9 9 9 999.9 9 9 999.9 9 9 999.9 9 9 999.9 9 9 9999.9 9 9 999.9 9 9 9999.9 9 9 999.9 9 9 9999.9 9 9 999.9 9 9 9999.9 9 9
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9 9
634710 99999 19730206 0600 4 FM-12      999 1 C   0.0 1 22000 1 C N   23.0 1   10.0 1 99   0.0 9 1 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99 999.9 9 9 99
999.9 9 9 99 999.9 9 9 99 999.9 9 9 999.9 9 9 999.9 9 9 999.9 9 9 999.9 9 9 9999.9 9 9 999.9 9 9 9999.9 9 9 999.9 9 9 9999.9 9 9 999.9 9 9 9999.9 9 9
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```

Figure 87: Linked Data from NCDC Email

m. Access the fourth link on Figure 86 which is circled in red. This provides the key to all abbreviations and codes within the data file, as well as units of measured parameters in each dataset (Figure 88).

```
        SURF: Surface Radiation Network report*
        SY-AE: Synoptic and aero merged report
        SY-AU: Synoptic and auto merged report
        SY-MT: Synoptic and METAR merged report
        SY-SA: Synoptic and airways merged report
        WBO: Weather Bureau Office*
        WNO: Washington Naval Observatory


WIND: WIND-OBSERVATION header
        Length:0

DIR: WIND-OBSERVATION direction angle

        The angle, measured in a clockwise direction, between true north and the
        direction from which the wind is blowing.
        Length:3
        Scale:1
        Unit:Angular Degrees
        Default Value:999
        Table of Values:

        999: Missing.  If type code (below) = V, then 999 indicates variable wind direction.


Q: WIND-OBSERVATION direction quality code

        The code that denotes a quality status of a reported WIND-OBSERVATION direction
        angle.
        Length:1
        Default Value:9
        Table of Values:

        0: Passed gross limits check
        1: Passed all quality control checks
        2: Suspect
        3: Erroneous
        4: Passed gross limits check , data originate from an NCDC data source
        5: Passed all quality control checks, data originate from an NCDC data source
        6: Suspect, data originate from an NCDC data source
        7: Erroneous, data originate from an NCDC data source
        9: Passed gross limits check if element is present


I: WIND-OBSERVATION type code

        The code that denotes the character of the WIND-OBSERVATION.
        Length:1
        Default Value:9
        Table of Values:

        A: Abridged Beaufort
        B: Beaufort
        C: Calm
        H: 5-Minute Average Speed
        N: Normal
        Q: Squall
        R: 60-Minute Average Speed
```

Figure 88: Key to Data Codes

Appendix F: Guide to Files to Follow Tutorial

This section contains a guide to files available for download and use with the tutorial. More information about downloading this data is found in the appendices. All files are ready to be added directly to BASINS, and can be done so by following the methods described in the Tutorial.

DEM Folder
This file contains the digital elevation model (DEM) used in the tutorial, as downloaded from the GDEx.

River File Folder
This folder contains the river shapefile added to BASINS that was downloaded from the USGS HydroSHEDS.

Outlet Point File Folder
Users can create an outlet point or use the included outlet point. Using the latter produces the same watershed area as the tutorial.

Land Use File Folder
The land use file was downloaded from the Global Land Cover 2000. In addition to the land cover raster, this folder contains the legend database file.

Clipping Box Folder
The polygon used to clip the input files to a smaller size more representative of the study area is stored in this folder.

Soil Map Folder
This file was downloaded from the FAO GeoNetwork. The map is not required for the delineation or to run HSPF, but demonstrates other applications of the BASINS modeling environment.

Weather Data Folder
The included WDM was downloaded from a watershed in the United States since weather data from the Shebelle watershed tributary was not easily obtained. This approach is discouraged, however.

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