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EPA H2O
User Manual

USEPA
H2O
HYDRO-ECOLOGY GIS

Office of Research and Development
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EPA H2O User Manual

by

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Table of Contents

Introduction

About EPA H2O

EPA H2O is a Geographic Information System (GIS) based demonstration tool for assessing Ecosystem Services (ES). ES can be defined as the use of ecological structures and functions that humans can directly relate to their state of well-being (Russell et al., 2013). ES may also be referred to as ecosystem goods and services (EGS). EPA H2O was developed as a preliminary assessment tool in support of research being conducted in the Tampa Bay watershed. EPA H2O provides information, data, approaches and guidance that communities can use to examine alternative land use scenarios in the context of nature's benefits to the human community. Knowledge gained from using this tool may help community representatives make strategic decisions for moving towards a more environmentally sustainable future.

As packaged, EPA H2O allows users to:

- Gain a greater understanding of the significance of ES
- Explore the spatial distribution of ES and other ecosystem features
- Obtain map and summary statistics of ES production's potential value
- Analyze and compare potential impacts from predicted development scenarios or user specified changes in land use patterns on ES production's potential value
- Get started with a prepackaged database specifically designed for the Tampa Bay, FL estuary and its watershed

EPA H2O is designed to be used at a range of skill levels for use and analysis of GIS data. Database creation does require a basic understanding of GIS tools for creating data layers, but analysis of existing databases (e.g., Tampa) using the tool can be performed at a Basic or Advanced level as appropriate. EPA H2O is designed for analyzing data at neighborhood to regional scales. While this software tool is packaged with data from the Tampa Bay region, advanced users can edit existing Tampa Bay data, substitute different datasets for the Tampa Bay region, and/or build completely new databases for new assessment areas. The tool is transferable to other locations if the required data are available, and if the data are processed into an EPA H2O compatible format. See the Database Creation section for guidance on how to create EPA H2O compatible datasets.

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About GIS

EPA H2O is a Geographic Information System (GIS) based hydro-ecology tool. A GIS is typically used to describe and characterize the earth and other geographies to visualize and analyze spatially referenced information. The purpose of a GIS is to create, share, and apply useful map-based information products that strengthen the work of organizations, as well as to create and manage the supporting geographic information.

Maps portray logical collections of geographic information as map layers. They provide an effective metaphor for modeling and organizing geographic information as a series of thematic layers. In addition, interactive GIS maps provide the user an interface for interacting with geographic information.

Examples of widely used GIS systems are:

- **Esri ArcGIS Suite** (Commercial) - https://www.esri.com
- **QGIS** (Open Source) - https://www.qgis.org
- **MapInfo** (Commercial) - https://www.mapinfo.com
- **PostGIS** (Open Source) - https://postgis.net/

About QGIS

EPA H2O is based on the open source GIS software QGIS. QGIS provides sophisticated tools to perform advanced geographic analysis. The following links are helpful resources about QGIS software:

- **QGIS Official Website** - https://www.qgis.org/
- **QGIS Help** - https://download.osgeo.org/qgis/doc/manual/qgis-1.8.0_user_guide_en.pdf
- **QGIS Documentation** - https://www.qgis.org/en/docs/index.html

Definitions of GIS Terms

Definitions for additional terms can be found using the Esri GIS Dictionary:
https://support.esri.com/en/other-resources/gis-dictionary

User Interface – The part of the software that allows users to interact with a GIS system through graphical icons and visual indicators; sometimes referred to as a Graphical User Interface (GUI).

Map Projection – Describes how the curved surface of the earth is manipulated to display properly on a plane. Map projections distort either distance, area, shape, direction, or some combination thereof. There are a number of common map projections, and the one that is most suitable depends on the specific area/region being mapped, the type of analysis being performed and the end use of map product (Esri Support, 2018).

Coordinate System – A reference framework consisting of a set of points, lines, and/or surfaces, and a set of rules, used to define the positions of points in space in either two or three dimensions (Esri Support, 2018).

Extent – The minimum bounding rectangle (xmin, ymin and xmax, ymax) defined by coordinate pairs of a data source. All coordinates for the data source fall within this boundary (Esri Support, 2018).

Data Layer – The visual representation of a geographic dataset in a digital map environment (Esri Support, 2018). Each environmental variable is represented as a distinct data layer – for example Eagle Nests or Wetland Areas. Each data layer can be stored as either feature vector data or raster image data.

Raster Data – In raster data, each cell, or pixel, of a given color marks a value such as elevation or priority level. *Figure 1* and *Figure 2* illustrate raster data on two different scales.

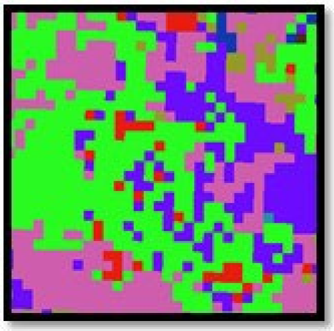


Figure 1 Fine scale view of raster data

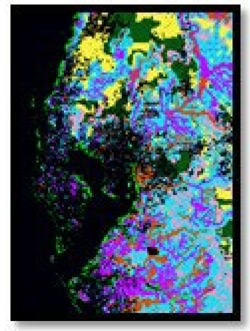


Figure 2 Sample raster data for the Tampa Bay region

Feature Data – A representation of a real-world object on a map (e.g. a specific eagle's nest or wetland area). Feature types in a GIS are Point, Line, and Polygon (Esri Support, 2018). In addition to geographic information that allows each feature to be visualized on a map, features may also be associated with non-spatial attribute data (*Figure 3*).

Figure 3 Sample map showing example features with points, lines and polygons

Attribute Data – Non-spatial information associated with a geographic feature in a GIS. Attributes are usually stored in a table and linked to the feature by a unique identifier. For example, attributes of a river might include its name, length, and flow rate.

Symbology – The set of conventions, rules, or encoding systems that define how geographic features are represented with symbols on a map. A characteristic of a map feature may influence the size, color, and shape of the symbol used (Esri Support, 2018).

EPA H2O Download and Installation

System Requirements

The EPA H2O application was developed around the open source GIS software QGIS, version 1.8. The special EPA H2O tools and capabilities are not all forward compatible with newer versions of QGIS. System requirements for EPA H2O are the same as for QGIS 1.8 for Windows systems. It is recommended that EPA H2O be installed on a system with:

- Windows XP or newer
- 1GB of available RAM
- 1.6GHz processor
- 5GB Hard Disk Space

Installing EPA H2O

This section illustrates the step-by-step procedure for installing EPA H2O.

1. Download the latest version of EPA H2O from: https://www.epa.gov/water-research/ecosystem-services-scenario-assessment-using-epa-h2o
2. Save the *H2O_Set_Up.exe* installation file to your computer.
3. Ensure you have administrative rights to install the program on your computer or contact your network/systems administrator.
4. Double-click on the *H2O_Set_Up.exe* installation file. If you receive a security warning (*Figure 4*), ignore it by clicking *Run*.

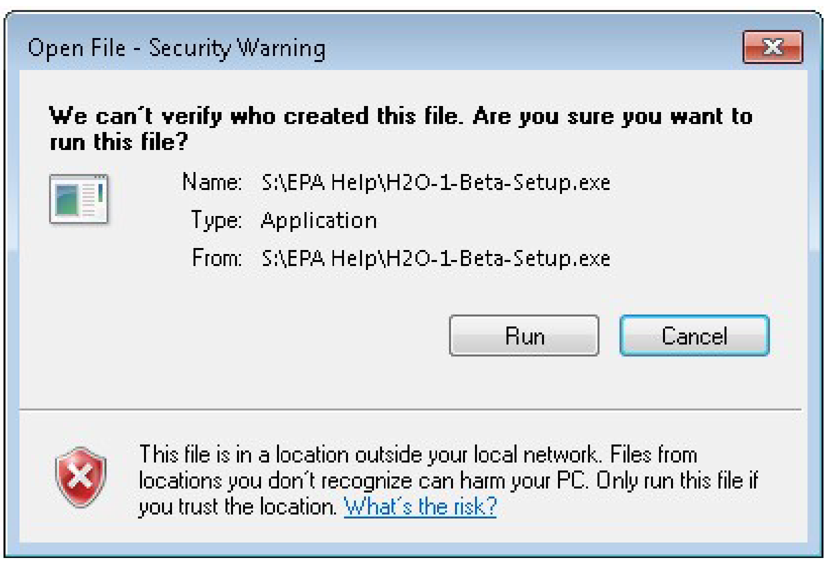


Figure 4 Security Warning window that may be received when running the H2O_Set_Up.exe installation

5. Setup may take a few moments to load, during which time a window may appear with progress (*Figure 5*).
6. Once the *EPA H2O Setup Wizard* appears (*Figure 6*), click the *Next* button to proceed.

Figure 5 Window displaying Setup Wizard loading progress

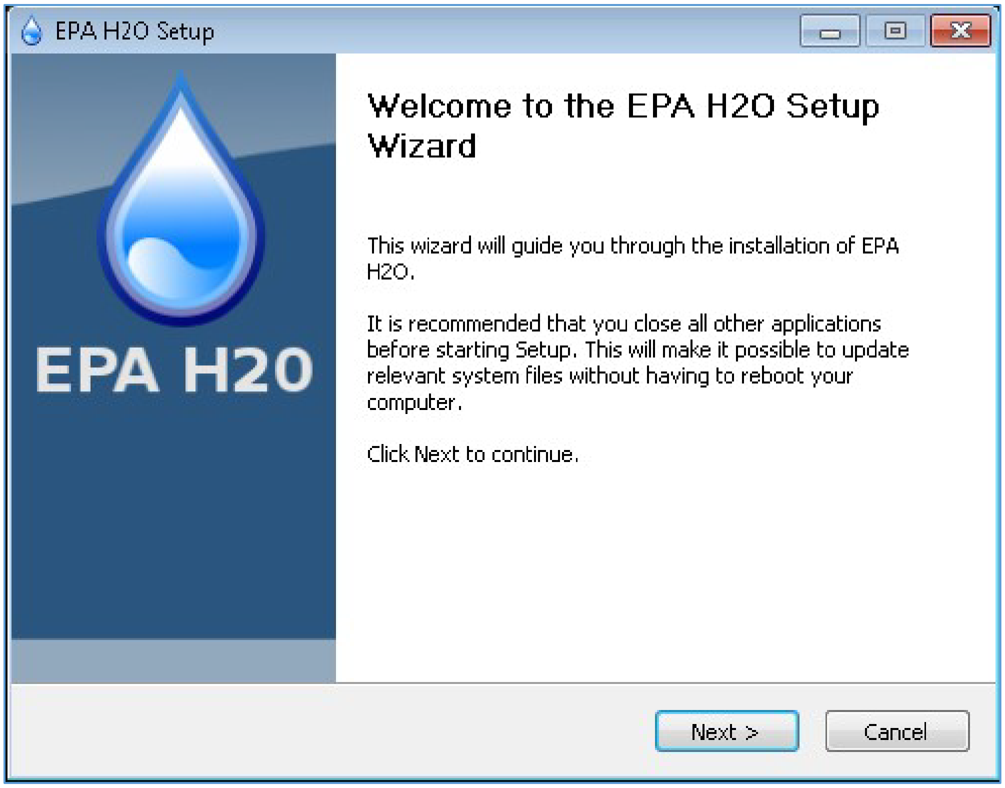


Figure 6 EPA H2O Setup Wizard welcome window

7. Next the *EPA H2O license agreement* window will appear (*Figure 7*). Click the *I Agree* button, to agree with the EPA H2O license agreement.

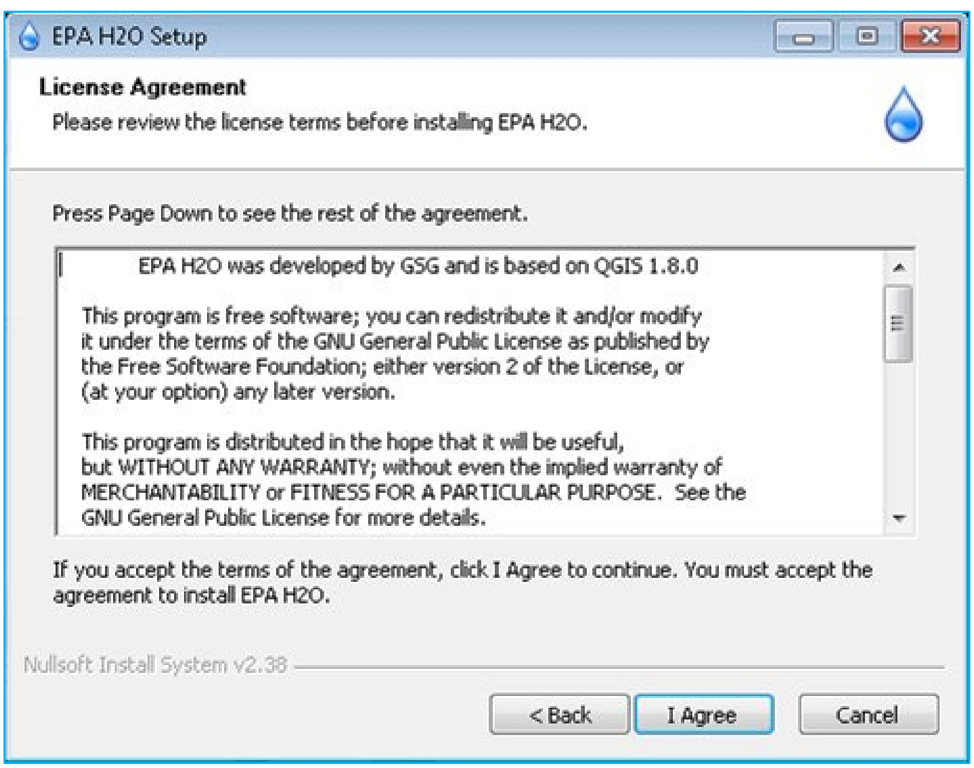


Figure 7 EPA H2O Setup license agreement window

8. In the *EPA H2O Setup Install Location* window (*Figure 8*), choose the *Destination Folder* where EPA H2O program files will be stored. The recommended destination folder is the *Program Files* directory, as shown in *Figure 8*.

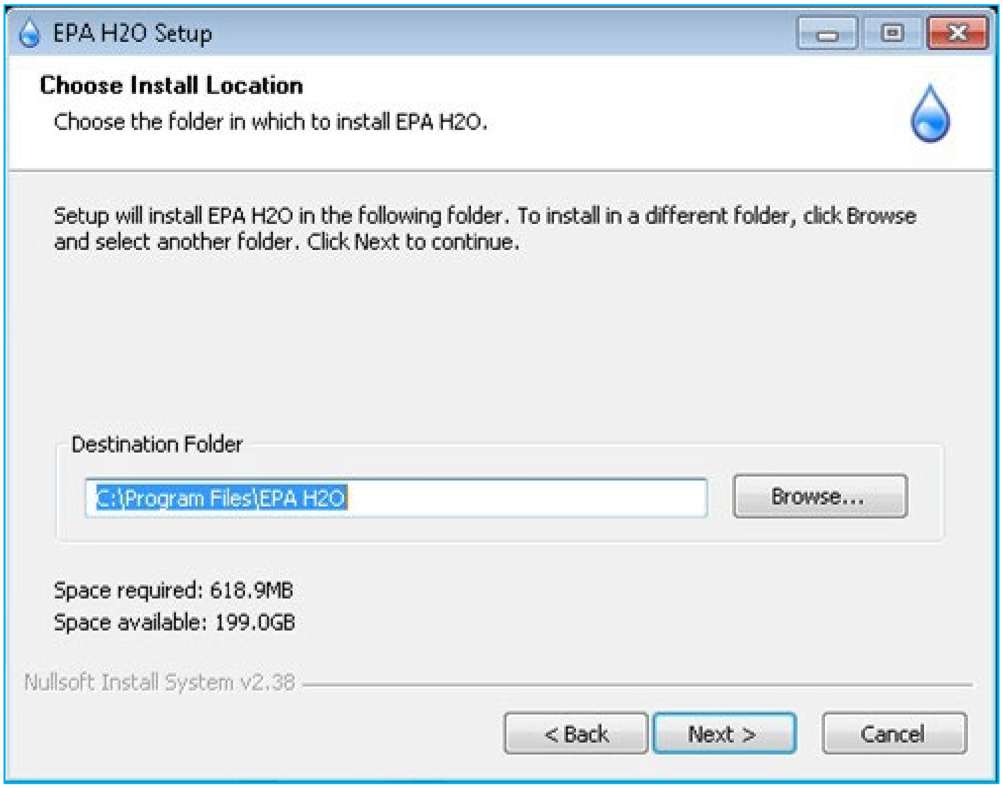


Figure 8 EPA H2O Setup Install Location window

9. EPA H2O will be selected for installation by default on the *Components* window (*Figure 9*). Click the *Install* button to install the program.

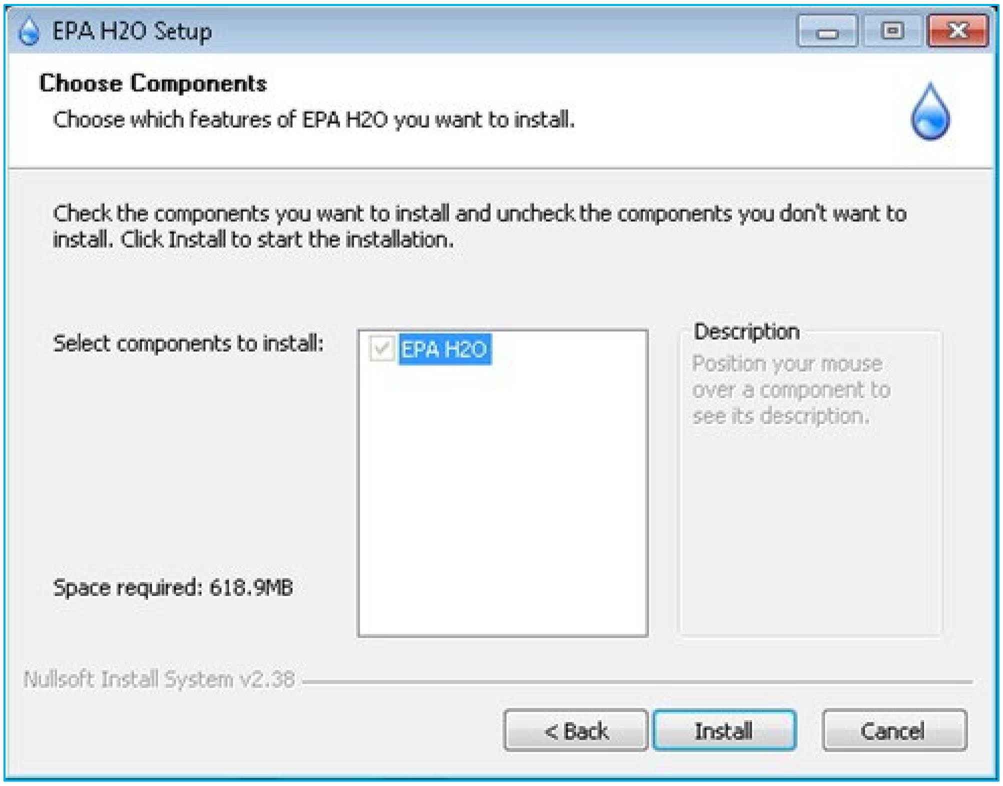


Figure 9 EPA H2O Setup Components window

10. An installation progress window will appear (*Figure 10*). Please wait while EPA H2O is being installed. This may take a few moments.

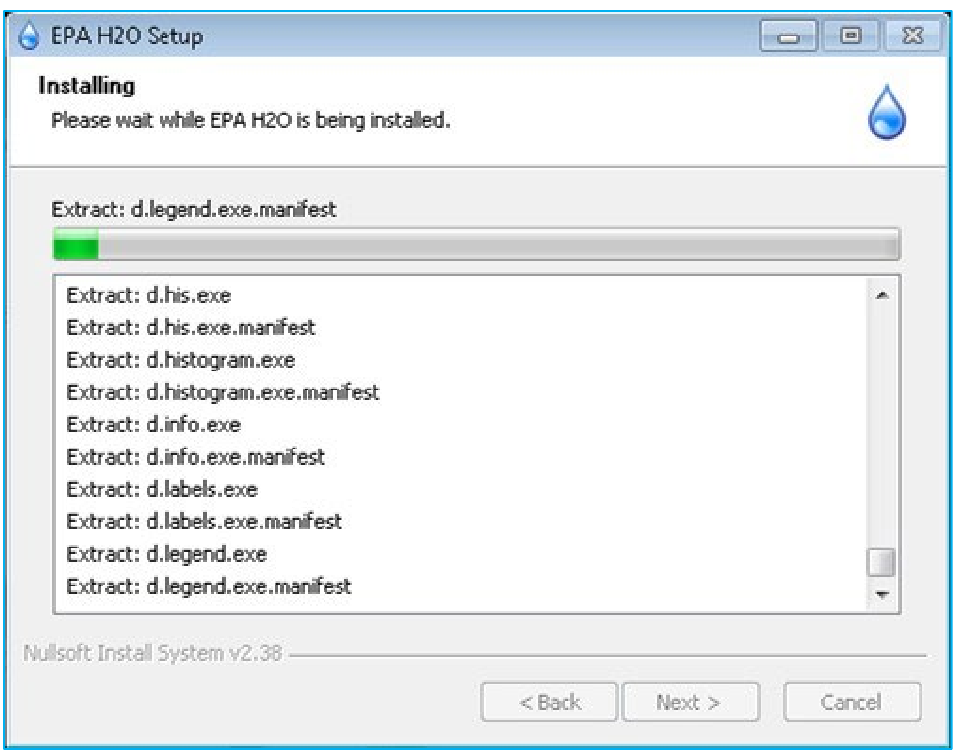


Figure 10 EPA H2O Setup Progress window

11. For EPA H2O installation to take effect, the computer will have to be rebooted/restarted. On the *Setup Reboot* window (*Figure 11*), choose to *Reboot now* or *manually reboot later* and click on the *Finish* button.

Figure 11 EPA H2O Setup Reboot window

After installation, EPA H2O and EPA H2O Browser shortcuts will automatically be created on the desktop (*Figure 12*). Both the EPA H2O program and EPA H2O Browser can also be accessed from the Windows *All Programs* menu.

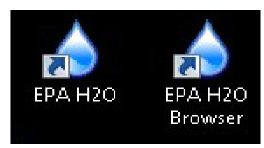


Figure 12 EPA H2O and EPA H2O Browser shortcuts

Uninstalling EPA H2O

EPA H2O does not have a separate uninstallation utility that can be accessed from the Windows *All Programs* feature, this section describes how to uninstall EPA H2O.

1. Access the *Control Panel* through the Windows start menu (*Figure 13*).

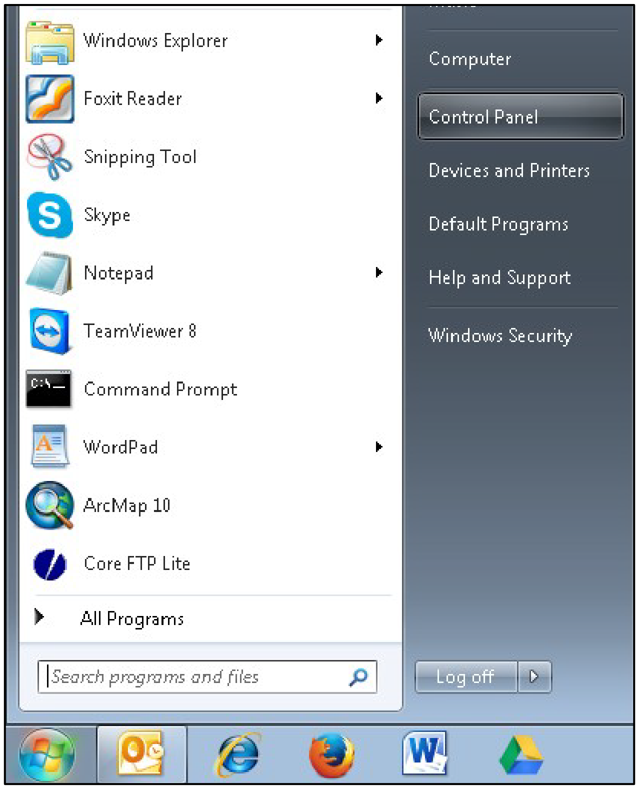


Figure 13 Location of Control Panel in Windows 7 start menu

2. Click on the *Uninstall a program* under *Programs* (*Figure 14*). Depending on the version of Windows, the *Uninstall a Program* option may have to be accessed through the *Programs and Features* menu.

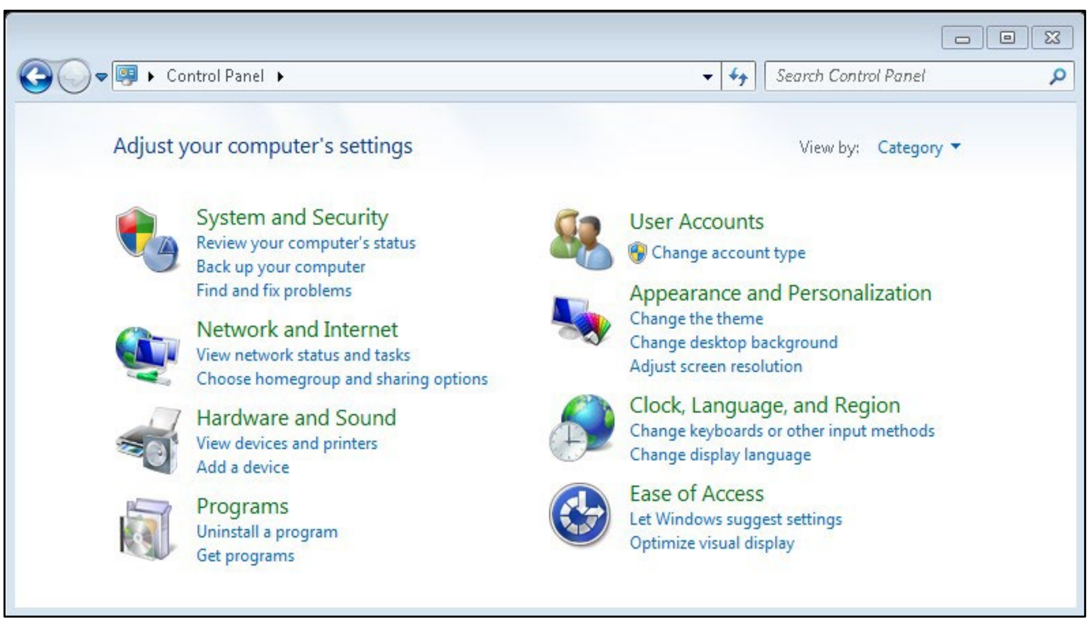


Figure 14 Windows 7 Control Panel with Programs option

3. The *Uninstall/Change* window listing installed programs will appear. Right-click on the *EPA H2O 1.0.0 Beta* program and select the *Uninstall/Change* option (*Figure 15*).

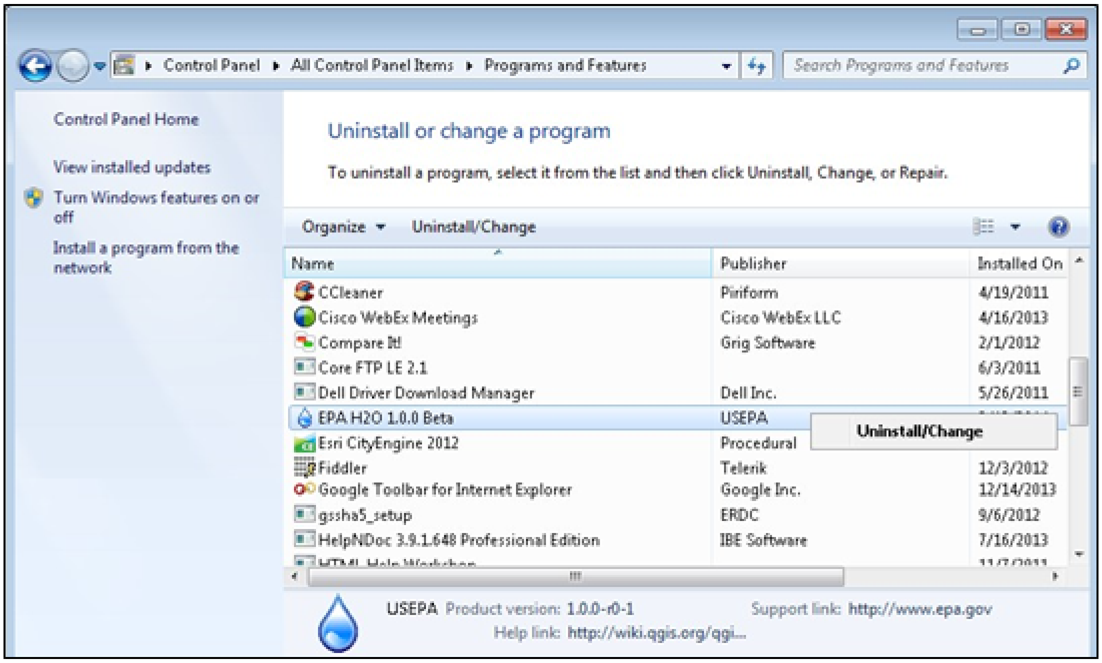


Figure 15 Uninstall/Change the EPA H2O 1.0.0 Beta program

4. Click *Next* in the *EPA H2O Uninstall Wizard* (*Figure 16*).

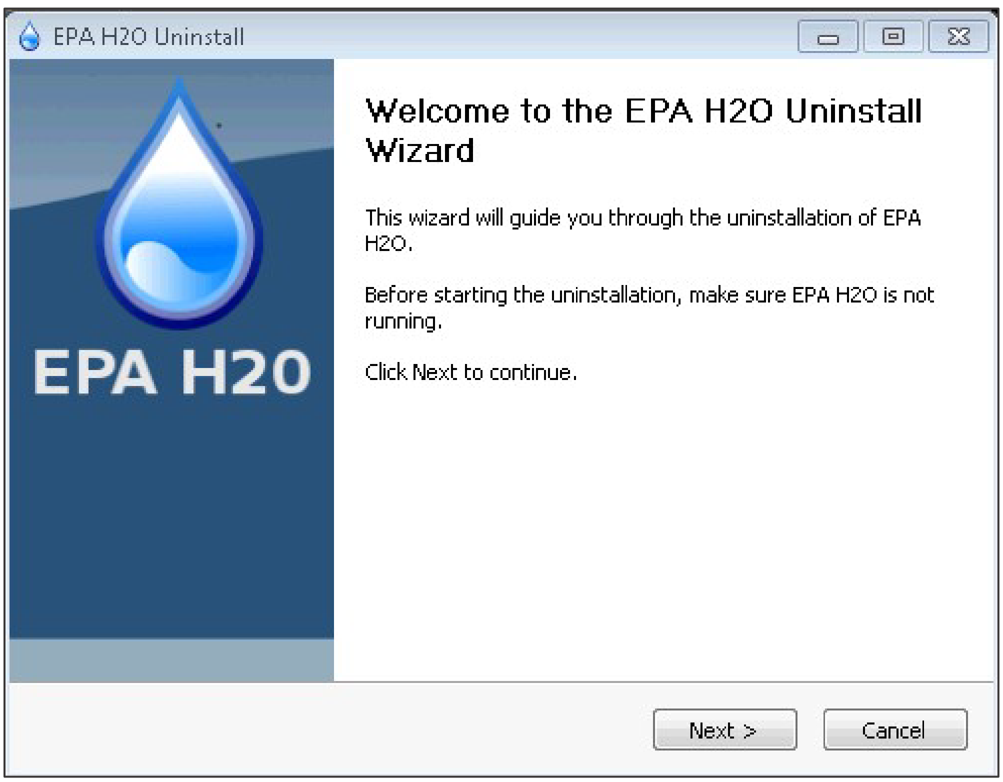


Figure 16 EPA H2O Uninstall Wizard Startup

5. Click *Uninstall* (*Figure 17*). It may take a few moments for uninstallation to complete.

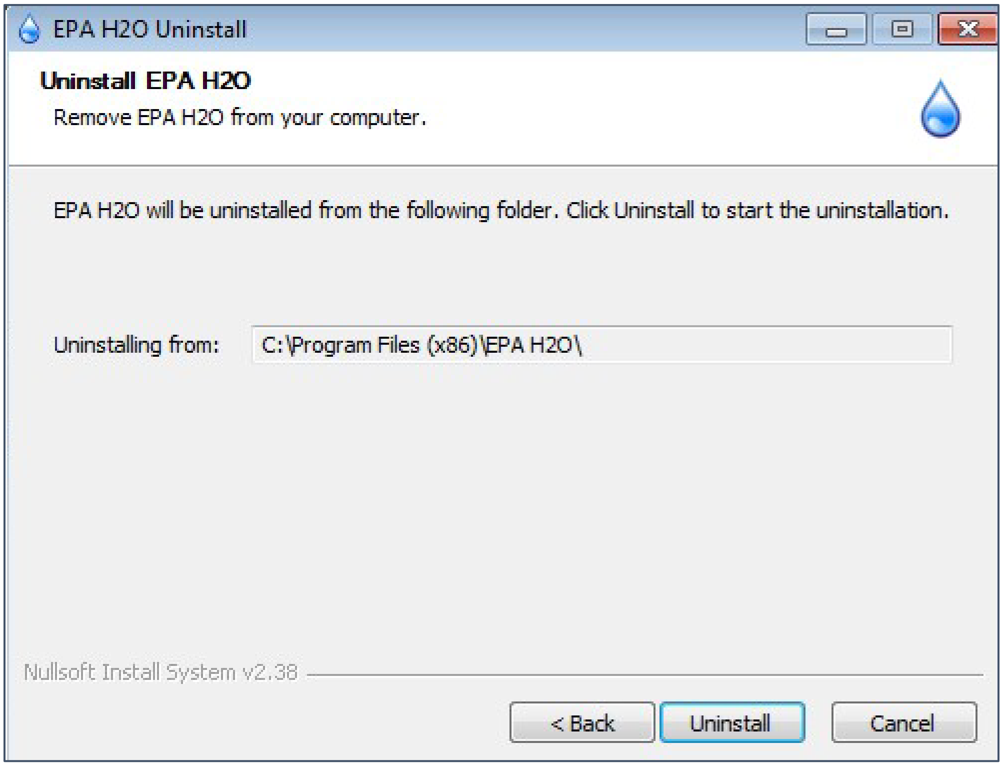


Figure 17 Uninstall window, with file location of EPA H2O

6. Click *Finish* (Figure 18).

Figure 18 Finish in the EPA H2O Uninstall Wizard

7. The *EPA H2O Setup* window may appear (*Figure* 19). **<u>Do not continue</u>** with EPA H2O installation. Instead click *Cancel* to close the EPA H2O Setup Wizard.

Figure 19 *Beginning of EPA H2O Setup Wizard*

8. The EPA H2O program has successfully been uninstalled.

GIS Tools

QGIS software includes various GIS tools to assist users navigating, analyzing and visualizing data within the EPA H2O program. These tools are accessed by selecting icons from dropdown menus or by clicking individual icons on toolbars.

View Menu

Many tools can be accessed using the *View* dropdown menu (*Figure 20*). Common tools are available on toolbars for quicker access. Toolbars are activated/deactivated using the *View* menu > *Toolbars* and can be moved around to different locations on the screen. Panels show the user specific information about their current map. Panels are activated/deactivated using the *View* menu > *Panels*.

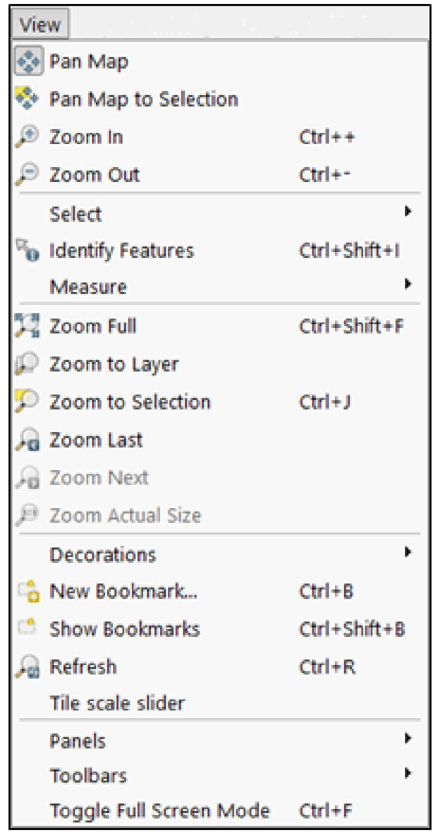


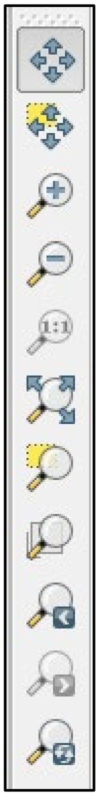
Figure 20 View dropdown menu in EPA H2O

Map Navigation Toolbar

These navigation tools are in the Map Navigation Toolbar (*Figure 21*) and can also be accessed using the *View* menu.

Tools in dropdown menus and in toolbars are greyed out if prerequisite requirements for using that tool are not met. For example, *Zoom Next* appears greyed out until the user moves back to a previous zoom or pan (*Figure 20* and *Figure 21*).

Depending on the tool, clicking a tool icon may perform a function once or enable functionality until turned off or a different tool functionality is enabled. Enabled functions are shown in a grey, highlighted box; the *Pan* icon, for example, is highlighted when enabled (*Figure 20* and *Figure 21*). There may be alternative ways to perform functions without enabling these tools.



***Pan* icon** – When enabled, panning allows the user to click or click-and-drag to move the map across the screen. Alternatively, holding down the mouse scroll wheel while dragging the map will also pan.

***Pan to selection* icon** – Pan to selected feature/features.

***Zoom In/Out* icons** – When enabled, click or draw a rectangle to zoom in or out. Alternatively, the mouse up-scroll will zoom in and down-scroll will zoom out.

***Zoom Actual Size* icon** – Zoom to native pixel resolution. For example, if the selected raster is a 30m raster, the map will zoom to a 30m by 30m area.

***Zoom Full* icon** – Zoom to the full extent of all layers visible in the Layers panel.

***Zoom to Selection* icon** - Zoom to selected feature/features.

***Zoom to Layer* icon** – Zoom to a selected layer's full extent.

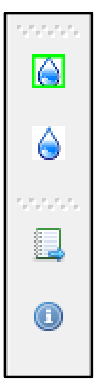
***Zoom Last/Next* icons** – Use this tool to return to the previous or next viewing frame (i.e. undo and redo for zoom or pan).

***Refresh* icon** – Update the map canvas.

Figure 21 Map Navigation Toolbar

EPA H2O Toolbar

The default location for the EPA H2O Toolbar is above the Layers panel. There are slight differences in the toolbar between the Basic (*Figure 22*) and Advanced (*Figure 23*) Modules. In the Basic Module the EPA H2O Toolbar has an added *Generate Report* icon that allows the user to generate a statistical report (see Basic Module Report Section); whereas in the Advanced Module, the user instead manages and compares different scenarios in reports (see the Create Scenario section). The main function of the EPA H2O Toolbar is that it allows the user to move between module types, and between projects. The EPA H2O Toolbar also allows easier access to the *Identify Feature* tool; alternatively found in the *View* menu (*Figure 20*).



***Select EPA H2O Module* icon** – Click to open the EPA H2O Project Manager window (*Figure 22)* and switch between Basic and Advanced Modules (see Getting Started section).

***Select EPA H2O Project* icon** – Click to open a new or existing EPA H2O project (see Create New Project section).

***Generate Report* icon** – Click to run an analysis report in the Basic Module. The Basic report is detailed further in the Basic Module Report Analysis section.

***Identify Feature* icon** – Click on a feature in a layer selected in the Layers panel, and an *Identify Results* window will display attribute table information for the clicked feature in the selected layer. This tool is also accessed using the *View* menu.

Figure 22 Basic EPA H2O Toolbar

Figure 23 Advanced EPA H2O Toolbar

Layers/ Table of Contents Panel

The Layers panel, or Table of Contents, lists each data layer on the map (*Figure 24*). Data layers are listed in the order they appear on the map (e.g. if the *Roads_2013* layer is listed above *NHD_flowlines,* they will appear in front or on top of those flowline features). The Layers panel indicates the symbology of each layer, and whether each layer is currently visible in the map. QGIS software incorporates other tools in the Layers panel, which may help the user manipulate EPA H2O.

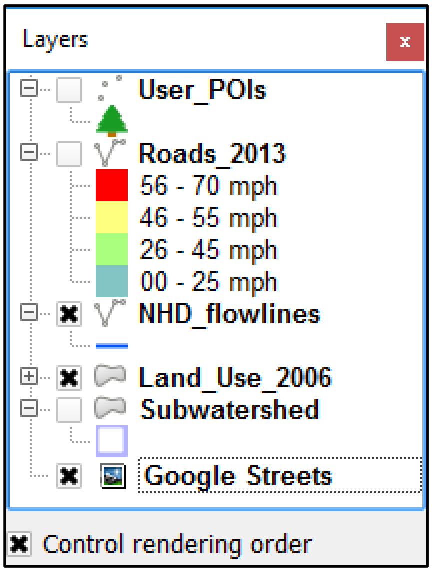


Figure 24 Layers/ Table of Contents Panel in EPA H2O

Layer icons – Each data layer added to the map appears in the Layers panel, in the order it appears on the map.

Change layer order – Rearrange the data in the Layers panel by clicking, dragging, and dropping the name of the data layer into its new, desired position.

Show Layer in Overview – The checkbox next to each data layer heading demonstrates whether the layer is currently turned on in the map. The Layers panel in *Figure 24* indicates that the *NHD_flowlines, Land_Use_2006* and *Google Streets* layers are displayed in the map.

Collapse Symbology – Clicking the (+)/(-) sign to the left of the checkbox expands or collapses a list of possible values for the data layer to the right.

A list of functions can also be accessed through the Layers panel, with a right-click on each data layer (*Figure 25*). This list provides shortcuts to certain QGIS operations and assists in EPA H2O navigation.

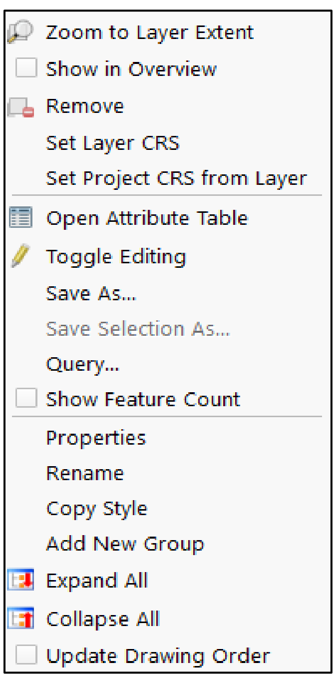


Figure 25 Right-click functions in EPA H2O Layers panel

Remove – Click to remove the selected data layer from the Layers panel. The removed layer will no longer appear in the Layers panel, or in the map canvas.

Set Layer CRS – The shapefile Coordinate Reference System (CRS) must match all spatial layers. Click to edit or add a CRS or to confirm a match for new data layers. Details on setting CRS are given in the database creation section.

Open Attribute Table – Click to open the attribute table of the selected data layer. The attribute table contains characteristics for the spatial data. In QGIS, attribute tables can only be opened for vector data.

Toggle Editing – Click to start or stop editing the selected layer. Editing can also be turned on and off by clicking the *pencil* icon  in the attribute table or in *Layer Properties.*

Properties – Click to open the *Layer Properties* window for the selected data layer. This window provides information regarding metadata, coordinate reference system, fields in the attribute table, as well as tools for data processing and display.

Selection Tools

EPA H2O utilizes six different *Select Tools* to select and highlight specific features in a layer. The tools are located under *View* menu > *Select* (*Figure 26*). In the Layers panel, click on the layer the user wants to select the features from. Once selected, a feature will be highlighted in yellow. Line and polygon layers, such as trails or conservation areas, respectively, are grouped together to enable faster processing time. Therefore, large areas may be highlighted outside the selection shape drawn.

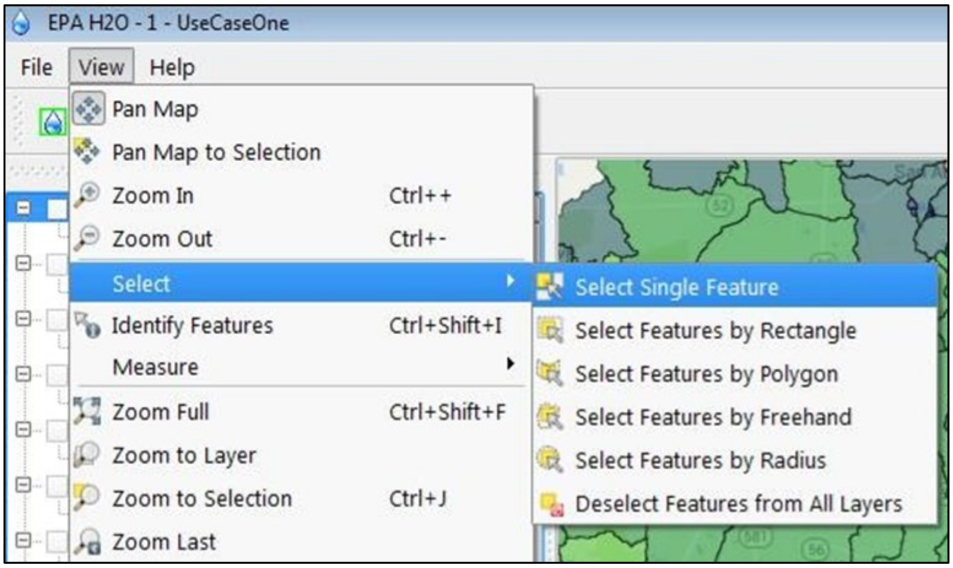


Figure 26 The six Selection Tools located in the EPA H2O View menu > Select

Select Single Feature **icon** – When enabled, clicking a feature will select it. Holding down the *Control Key* while *Select Single Feature* is enabled allows one to add features to the current selection.

Select Features by Rectangle **icon** – When enabled, click and drag to draw a rectangle around features to select.

Select Features by Polygon **icon** – When enabled, left click to draw vertices for the polygon, right-click to finish the polygon and select features within it.

Select Features by Freehand **icon** – When enabled, click and drag to draw an abstract shape around the area to select. The selection will follow the cursor; no vertices are drawn.

Select Features by Radius **icon** – When enabled, click and drag to draw a circle around the area to select.

Deselect Features from All Layers **icon** – Clears the current selection; features will no longer be highlighted.

Getting Started

EPA H2O is opened from the program list or by double clicking the EPA H2O shortcut on the desktop. Once opened, the first window that appears is the *EPA H2O Project Manager* window (*Figure 27*). The user must choose which module to operate in, but the module can be changed later using the EPA H2O *Select Module* icon (*Figure 22*). This section describes the major differences between the two modules.

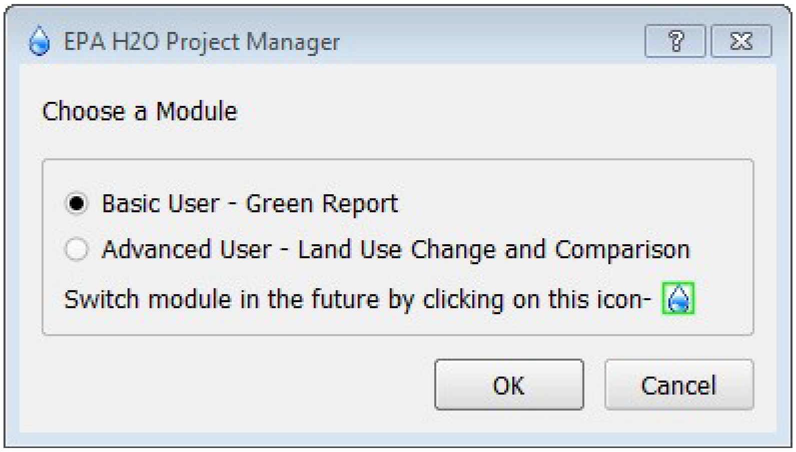


Figure 27 EPA H2O Project Manager window

Basic Module

The Basic Module is designed for a user with limited GIS software experience. Basic users can explore the various ES and other environmentally relevant features in their area of interest and generate maps and reports to summarize what those features are and their ES values.

An example of a basic user would be a neighborhood association member who wants to explore the value of surrounding “greenspace” in their neighborhood. The user can quickly get simple summaries for a suite of ecosystem services the area produces and the resulting cumulative value of benefits using the Basic Module. The user is then able to share this info with neighbors interested in preserving that “greenspace,” and/or finding hotspot areas for producing or delivering ES value.

Advanced Module

The Advanced Module is designed for a user with more GIS expertise who wishes to expand from exploring ecosystem services to scenario creation and comparison. Users can compare preexisting scenarios for the Tampa Bay region or create custom land use scenarios. Scenarios are then able to be analyzed and compared, with a map and report summarizing the ES values generated for each.

An example of an advanced user would be a regional planner interested in the cumulative effects of increased impervious surfaces on the provision and value of water retention ecosystem services. The user can select a multi-county area and appropriate drainage areas as their area of interest. New land use scenarios can then be generated by modifying a copy of the initial land use map. The user is then able to compare the changes in ES value that result from their modifications to land uses.

Create New Project

This section illustrates how to start a new EPA H2O project.

1. Select either the Basic or Advanced Module from the *EPA H2O Project Manager* window (*Figure 27*), click *OK.* The user can click *Cancel* to exit EPA H2O.
2. The *Select Project* window will appear (*Figure 28*). Select *Create new project* and click *OK*.

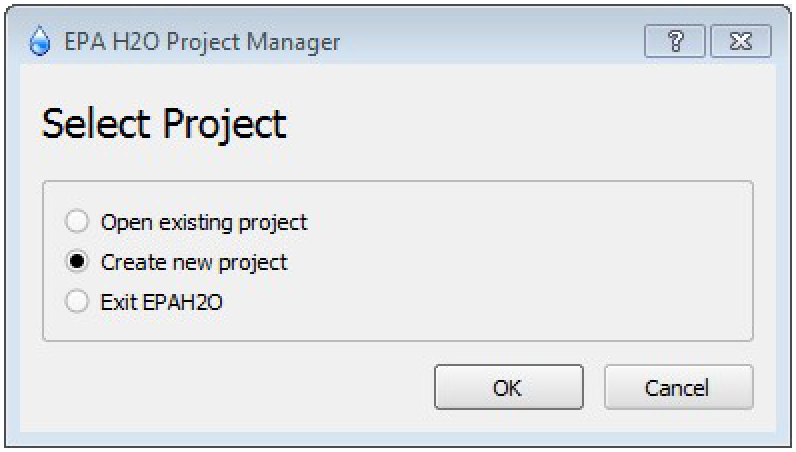


Figure 28 EPA H2O Select Project window

3. The *Select Database Location* window will appear (*Figure 29*). Click on the *Select* button if you want to change the *Data Folder Path* from the default "C:\Users*USERNAME*\\.qgis\0.0.3". If using a different *Data Folder Path*, start by navigating to the root EPA H2O data folder.

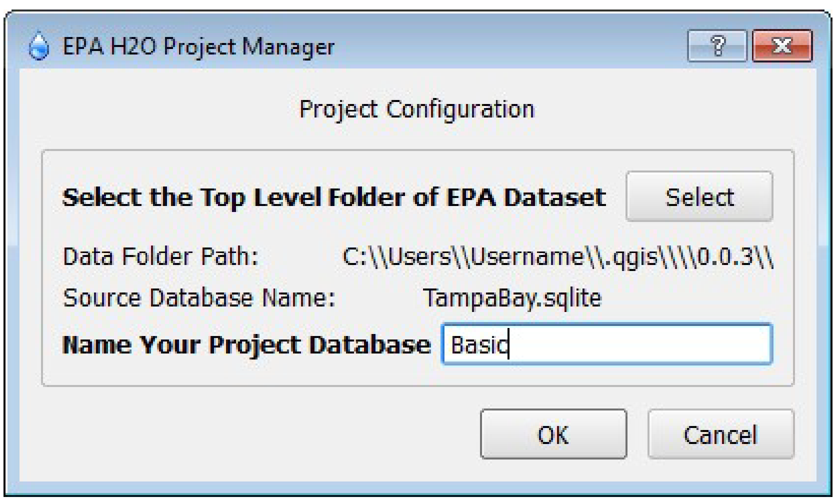


Figure 29 EPA H2O Select Database Location window

4. Enter a name for the new database in the *Name Your Project Database* field (e.g. "Basic" in *Figure 29*) and click *OK* to proceed.

The *Select Area of Interest* (AOI) window will appear (*Figure 30* & *Figure 31*). Selecting an area of interest is illustrated under the Select AOI section.

Select AOI

This section illustrates how to select an area of interest for a new EPA H2O project starting from the *Select Area of Interest* window (*Figure 30* & *Figure 31*). The options available in this window depend on the current project user module, where the Advanced Module has the additional option to *Select by River Basin*. Each option in the EPA H2O *Select Area of Interest* window is detailed in its own section.

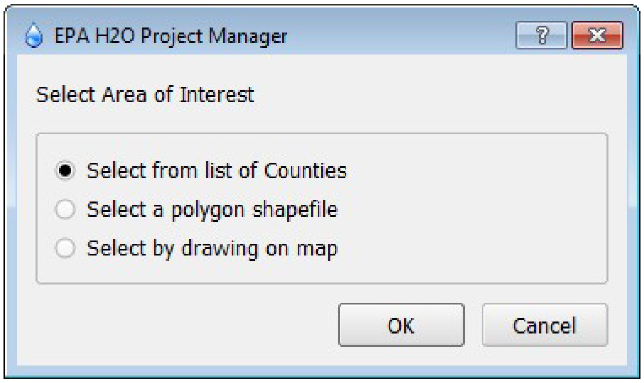


Figure 30 EPA H2O Select Area of Interest window in Basic Module

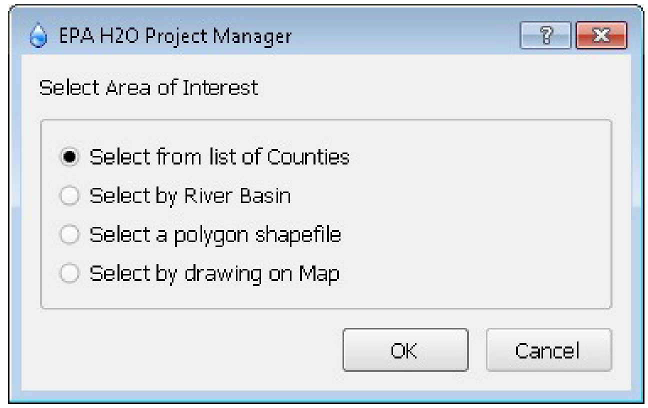


Figure 31 EPA H2O Select Area of Interest window in Advanced Module

By County

1. In the EPA H2O *Select Area of Interest* window (*Figure 30* & *Figure 31*), choose the *Select from list of counties* option. Click *OK*.
2. The *Select counties to create project* window will appear in front of the EPA H2O map screen (*Figure 32*).
3. The window in the foreground will list counties in Florida to choose a county from. Click to select or unselect counties from the list.
4. Note that the default data are only available for areas in Pinellas, Hillsborough, Polk, Manatee, Hardee, and Pasco counties, which drain to Tampa Bay. Selecting other counties may yield no data.
5. In the background map the program will load base layers - *Counties*, *River basins* and *Google Streets*. As counties are selected from the list they will be highlighted in yellow on the map (e.g. Alachua County in *Figure 32*).

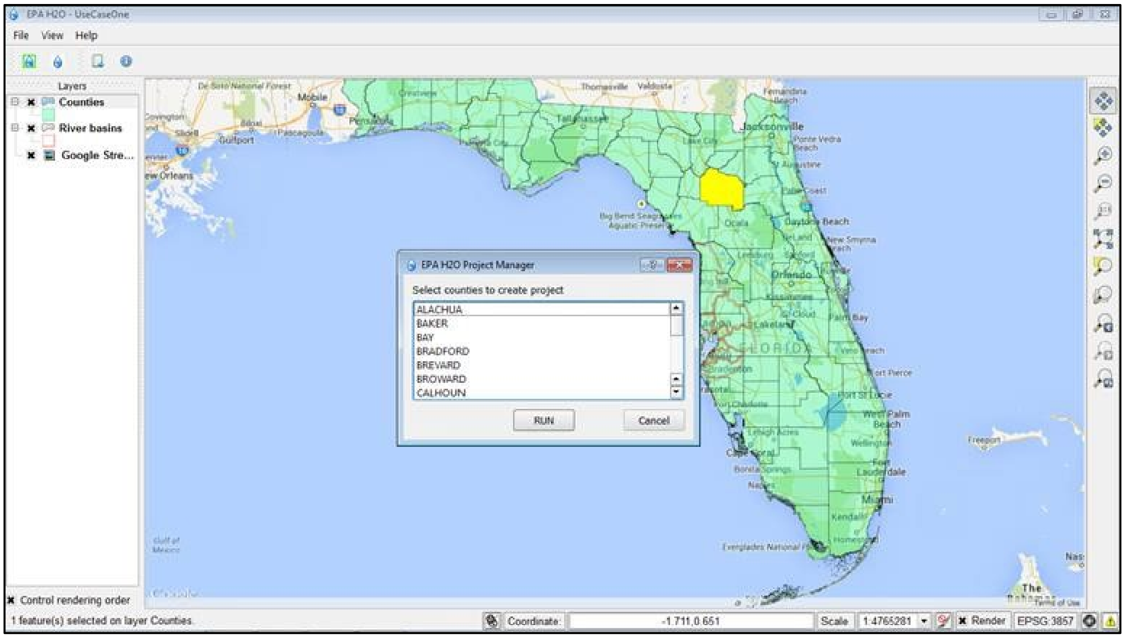


Figure 32 Select Florida county from list in EPA H2O map

6. Hillsborough County, FL will be used as the AOI for illustration purpose. Select Hillsborough county from the list and click *RUN* (*Figure 33*).

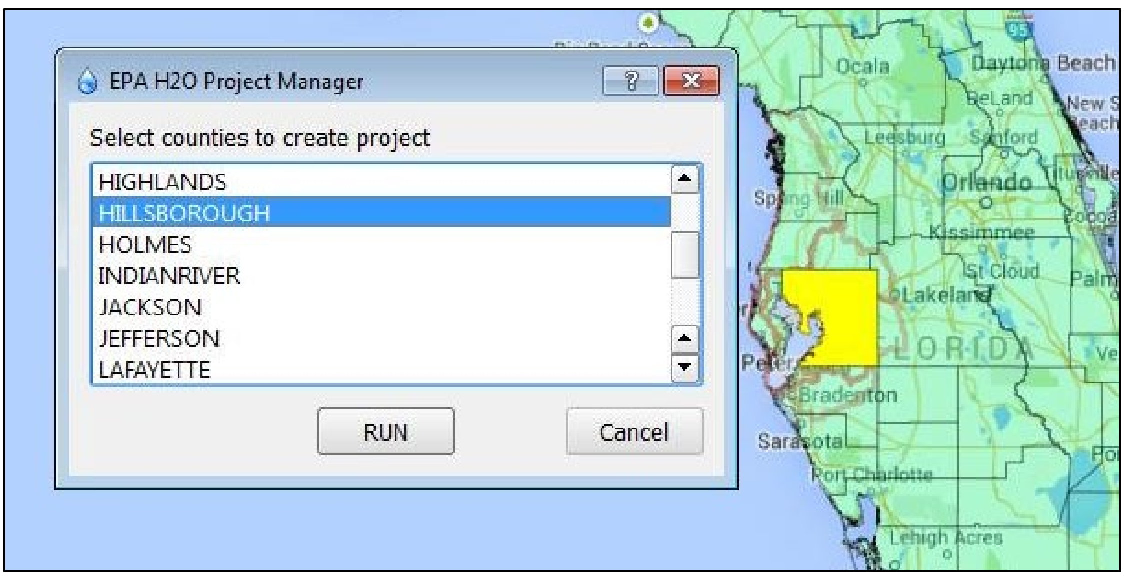


Figure 33 Select Hillsborough county for illustrative purposes; county is highlighted in yellow

7. All EPA H2O data will be clipped to the selected AOI and its upstream area. Depending on the AOI it may take a few moments, during which time the user will see the progress bar (*Figure 34*).

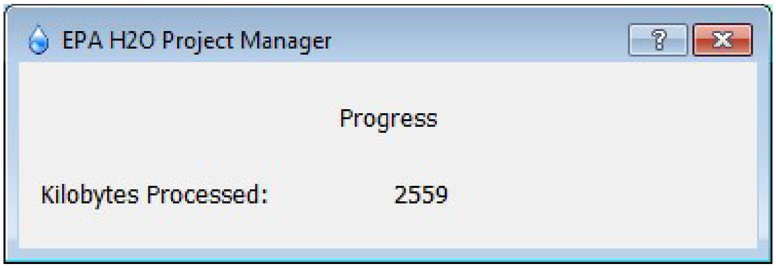


Figure 34 Select AOI progress bar window

8. **Please note**: EPA H2O may display the phrase "Not responding" while processing data. This error may be shown in the progress bar (*Figure 35*), or at the top of the project window. Despite the message, the program is still actively processing. Please do not close the window, or the EPA H2O program.

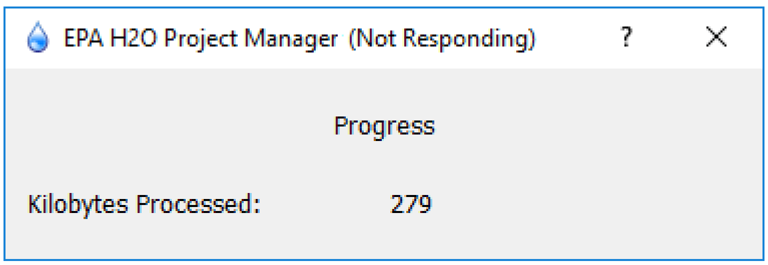


Figure 35 Select AOI progress bar window, with (Not Responding) error shown

9. When clipping is complete the *Save Project* window will appear (*Figure 36*). To save the project, choose the desired File name and location, and click *Save*. The project should be saved as a QGIS file with the extension ".qgs" (e.g. *Basic.qgs* in *Figure 36*).

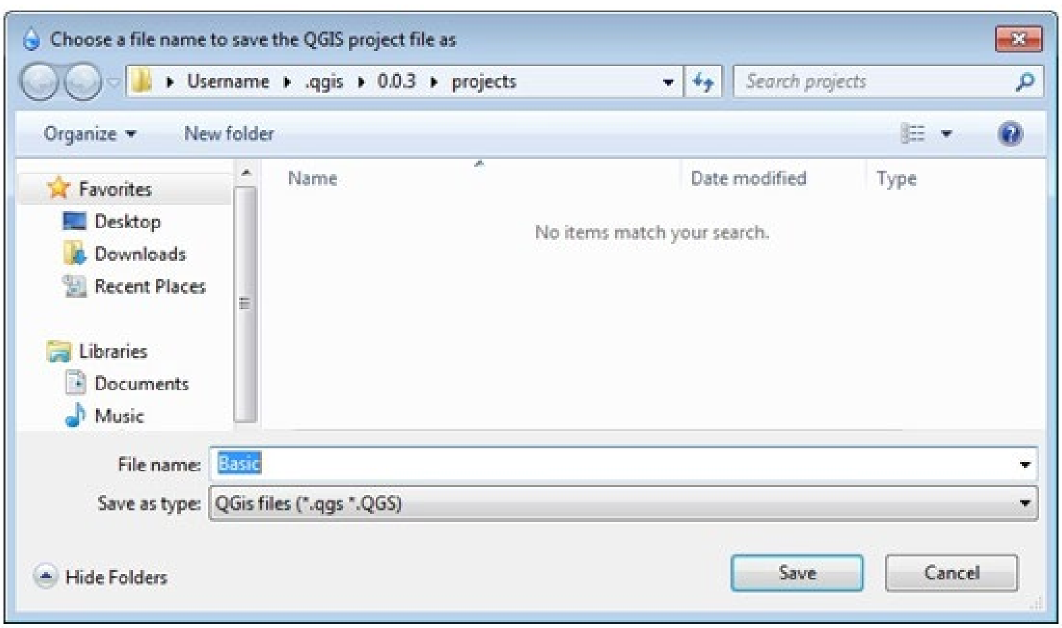


Figure 36 Window to save the EPA H2O project

10. By default, all data layers except *Google Streets* and *River basins* will be turned off. Other layers must be turned on to make them visible on the map (see Layers/ Table of Contents Panel). Once

made visible, land use layer results using Hillsborough County, FL as the AOI can be examined in the EPA H2O map (*Figure 37*).

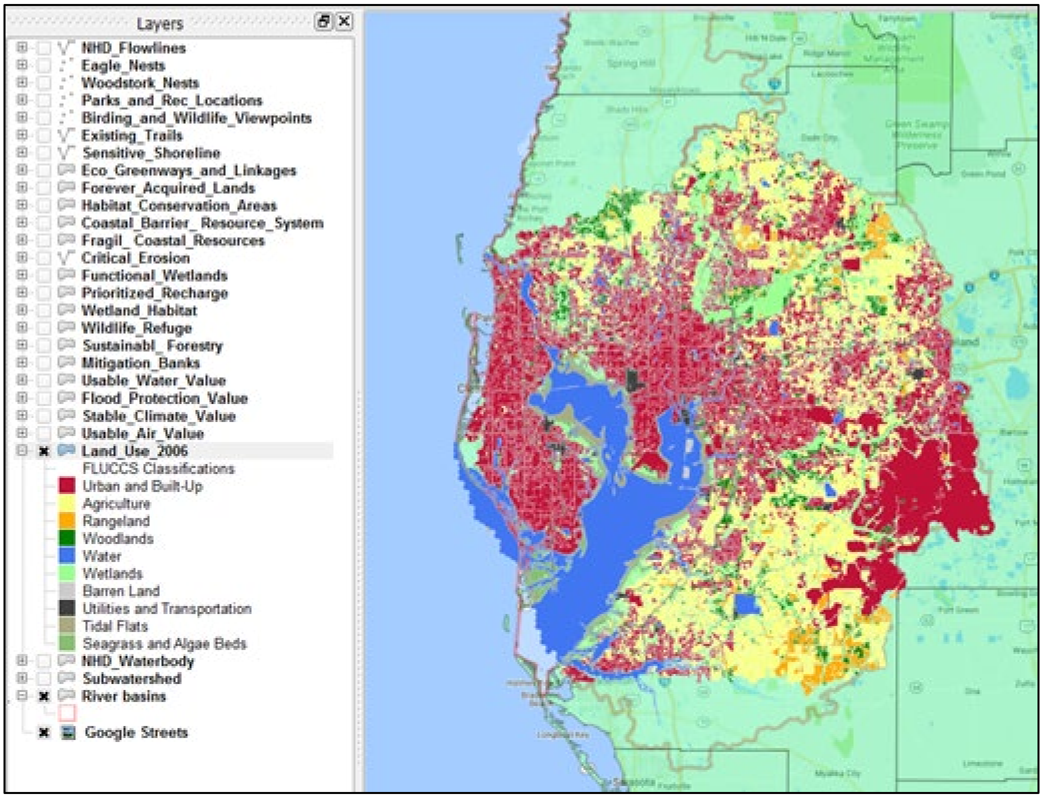


Figure 37 EPA H2O map for Hillsborough County, with River basins, Counties, and Google Streets visible, and Land Use layer turned on

By Shapefile

1. In the EPA H2O *Select Area of Interest* window (*Figure 30* & *Figure 31*), choose the *Select a polygon shapefile* option. Click *OK*.
2. The *Select Shapefile* window will appear (*Figure 38*), click the *Select* button to choose the shapefile to use as the AOI.

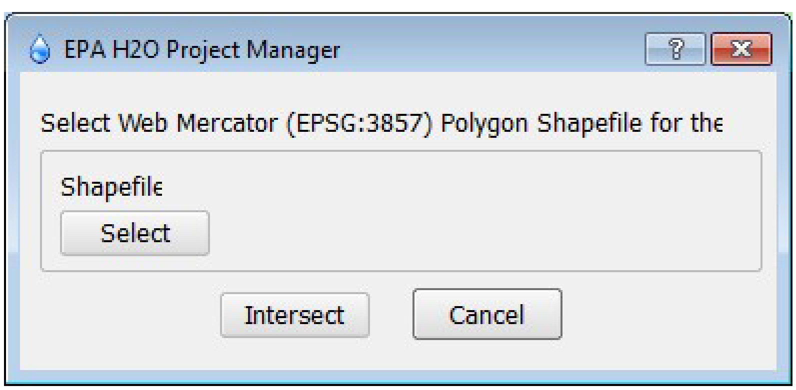


Figure 38 EPA H2O Select Shapefile window

3. A window will appear to select a shapefile (*Figure 39*). Navigate to and select a shapefile with the .shp file extension (e.g. the *EMA.shp* file is used in *Figure 39*).
   Please Note:

a. Only one shapefile can be selected as an AOI at a given time.
b. No shapefile is included in the H2O download package.
c. The *XML metadata* file type with extension *.shp.xml* cannot be opened using EPA H2O.
d. The shapefile Coordinate Reference System (CRS) must match the data CRS in EPA H2O. The Tampa data CRS is "EPSG:3857", and the Geographic Coordinate System is "GCS_WGS_1984".
    i. In Esri software (ArcGIS), this coordinate system is called ***WGS_1984_Web_Mercator_Auxiliary_Sphere.***
    ii. In QGIS, this coordinate system is named ***WGS 84 / Pseudo Mercator.***
    iii. The naming schemes are different between the two programs, but they represent the same coordinate system.

4. Click *Open* to select the shapefile and return to the *Select Shapefile* window.

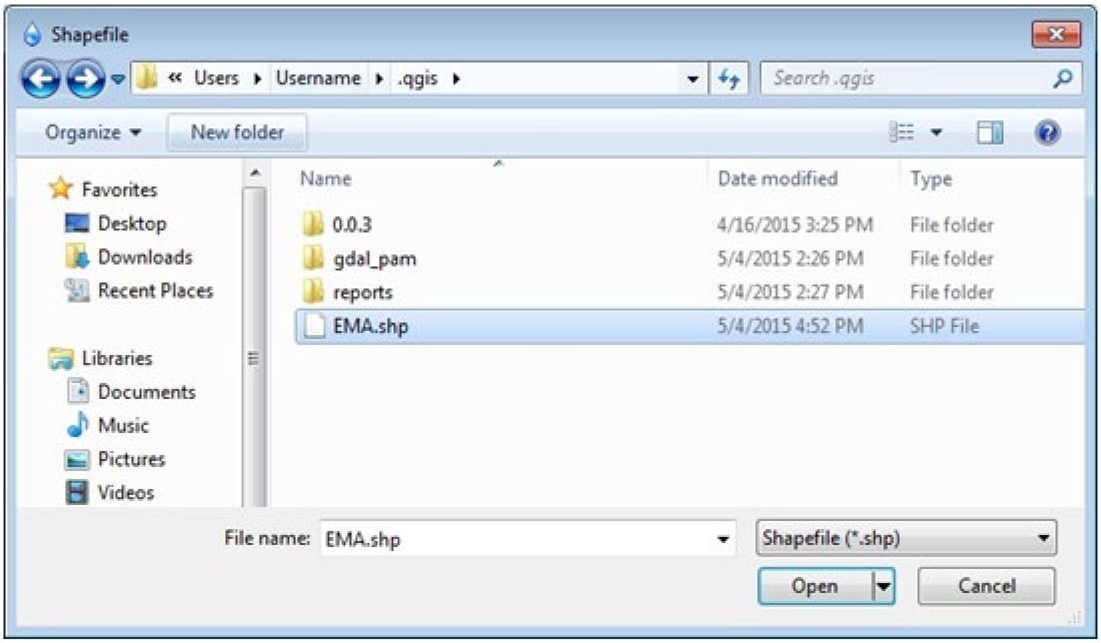


Figure 39 Window to select a shapefile as the AOI

5. Once selected, the shapefile will be displayed on the map in the background (*Figure 40*). Click *Intersect* in the *Select Shapefile* window to clip the AOI to the shapefile area.

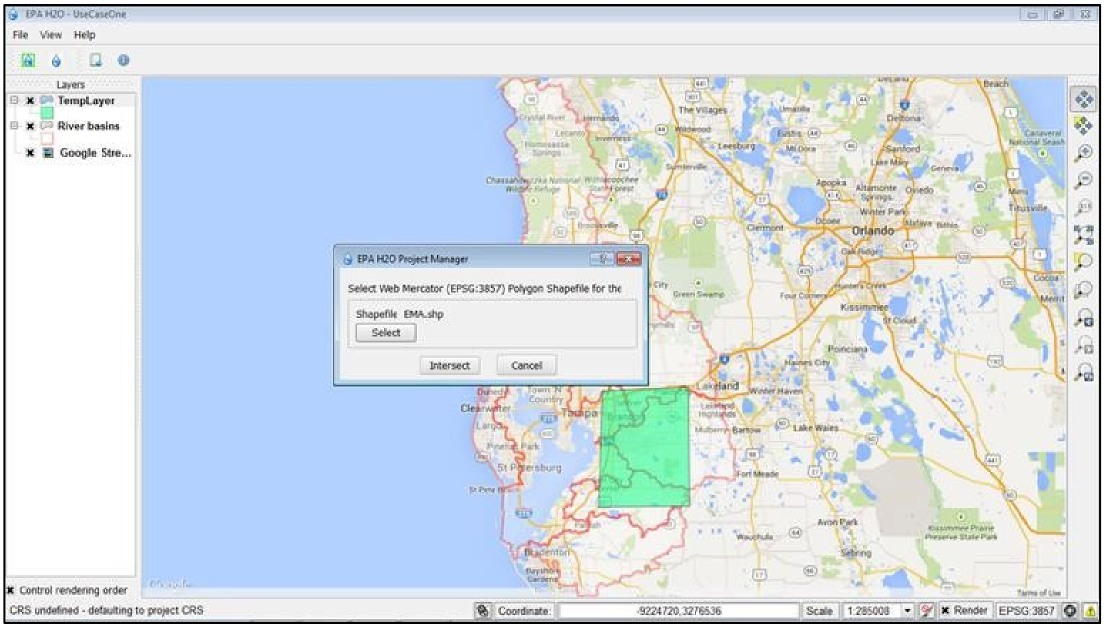


Figure 40 Shapefile selected in Select Shapefile window is displayed on the map in background

6. All the EPA H2O data will be clipped to the selected AOI and its upstream areas. Depending on the AOI this may take several moments, during which time a progress bar will appear (*Figure 41*).

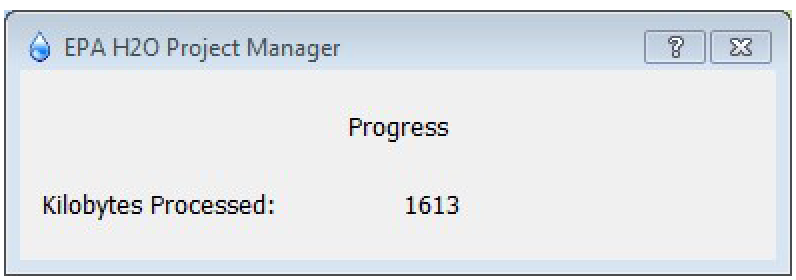


Figure 41 Select AOI by Shapefile progress bar window

7. When clipping is complete the *Save Project* window will appear (*Figure 42*). To save the project, choose the desired File name and location, and click *Save*. The project should be saved as a QGIS file with the extension ".qgs" (e.g. *Basic.qgs* in *Figure 42*).

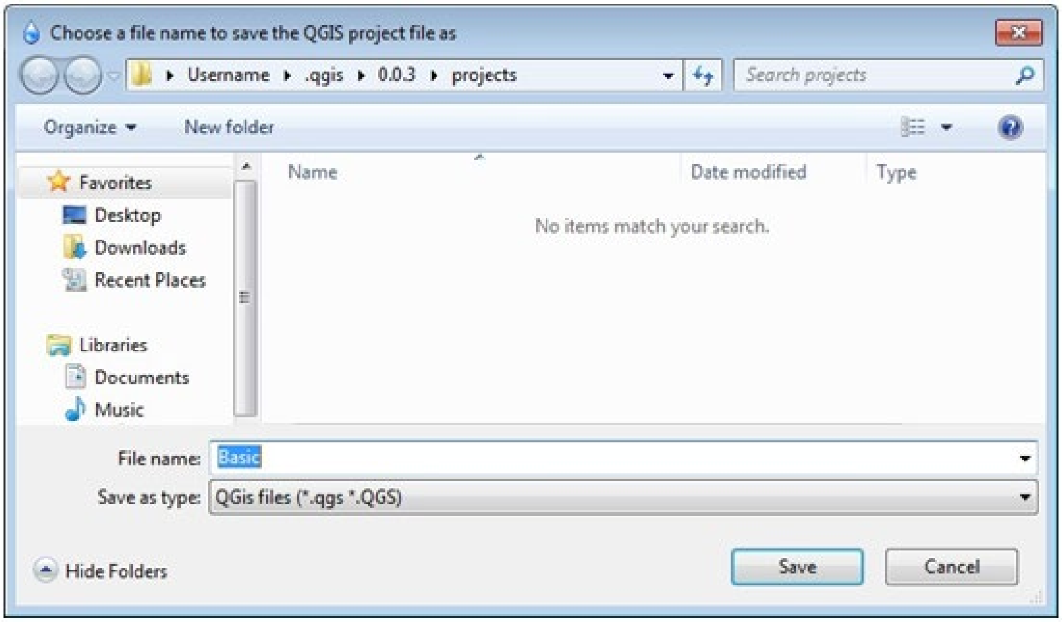


Figure 42 Window to save the EPA H2O project

8. By default, all data layers except *Google Streets* and *River basins* will be turned off. Other layers must be turned on to make them visible on the map (see Layers/ Table of Contents Panel). Land use layer results using a shapefile as the AOI can be examined in the EPA H2O map once made visible (*Figure 43*).

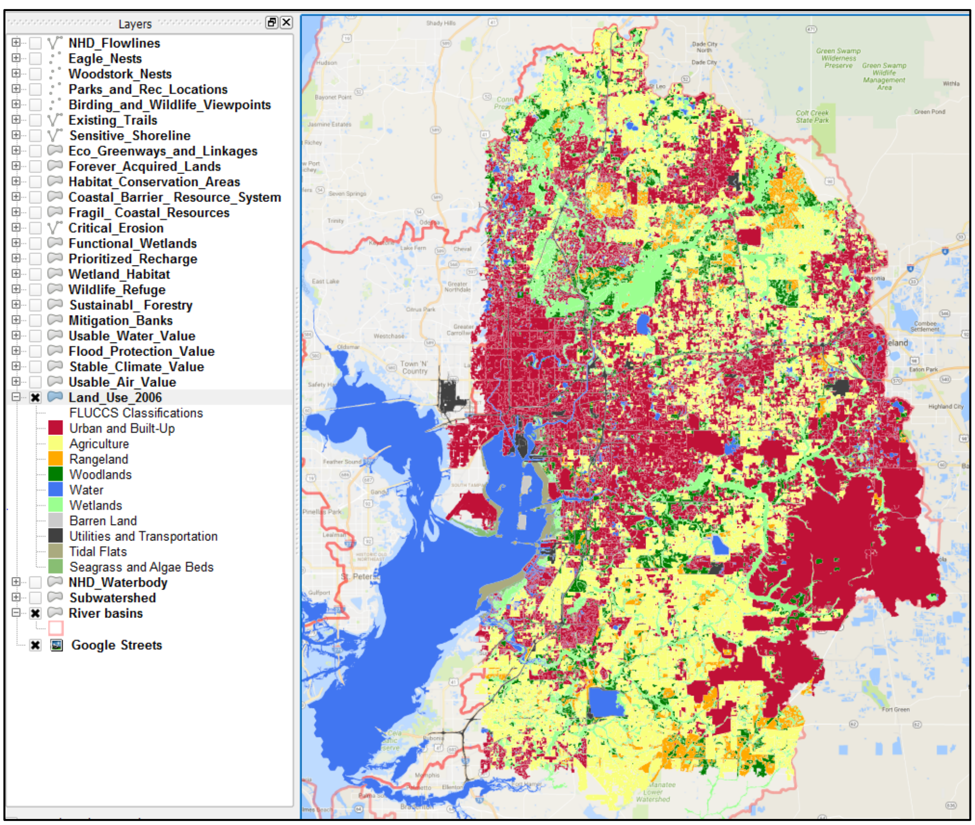
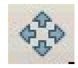


Figure 43 EPA H2O map drawn by shapefile; River basins and Google Streets are visible, and the Land Use layer is turned on

By Drawing on Map

1. In the EPA H2O *Select Area of Interest* window (*Figure 30* & *Figure 31*), choose the *Select by drawing on map* option. Click *OK*.
2. The *Draw the AOI* window will appear with Navigation tools, and the *Select Features by Rectangle* tool to draw the AOI onto the map (*Figure 44*). The map will load in the background with pre-loaded base layers - *River basins* and *Google Streets* (*Figure 45*).

    a. Use the *Zoom In* , *Zoom Out* , and *Pan*  icons to focus the map on the Area of Interest (*Figure 44*).

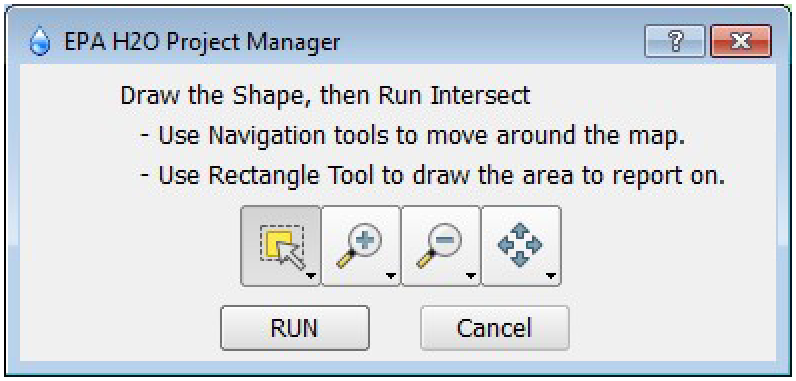
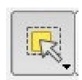


Figure 44 Draw the AOI Shape window with navigation icons

    b. Click the *Select Features by Rectangle* icon  to click and draw a rectangle around the desired AOI on the map.
    c. Click *RUN* to confirm the selected AOI.

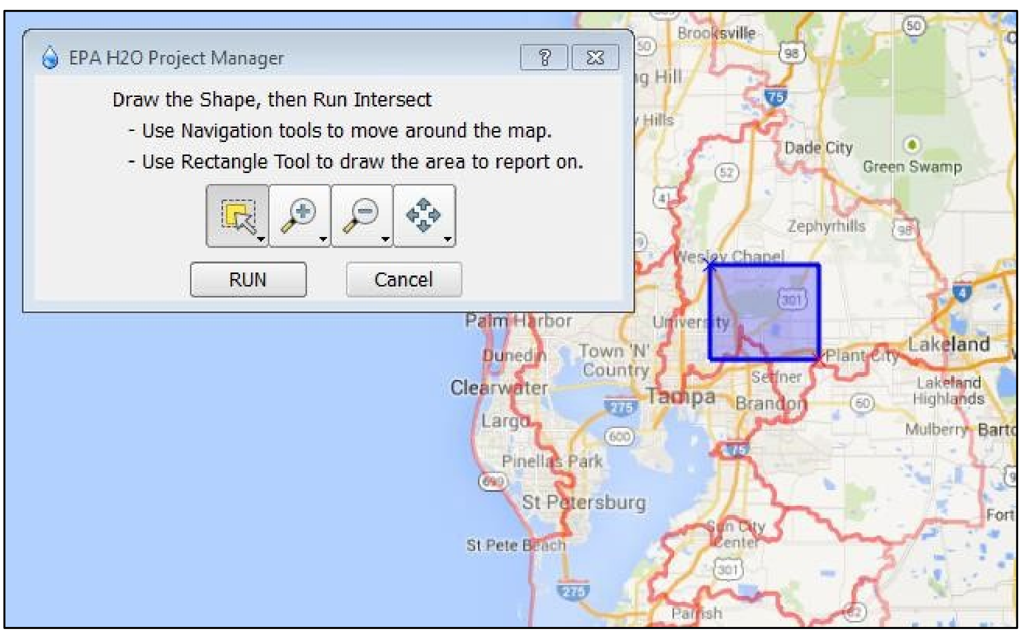


Figure 45 AOI drawn by shape on the EPA H2O map

3. All the EPA H2O data will be clipped to the selected AOI and its upstream areas. Depending on the AOI this may take several moments, during which time the user will see the progress bar (*Figure 46*).

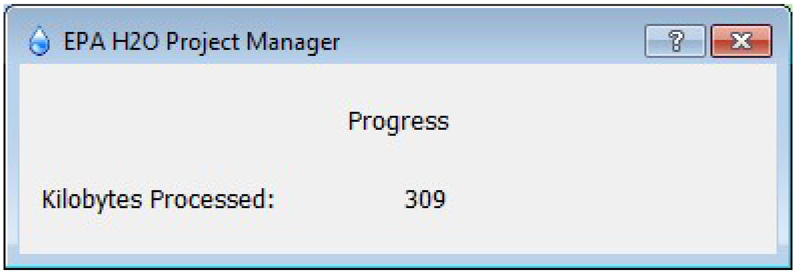


Figure 46 Select AOI progress bar

4. When clipping is complete the *Save Project* window will appear (*Figure 47*). To save the project, choose the desired File name and location and click *Save*. The project should be saved as a QGIS file with the extension ".qgs" (e.g. *Basic.qgs* in *Figure 47*).

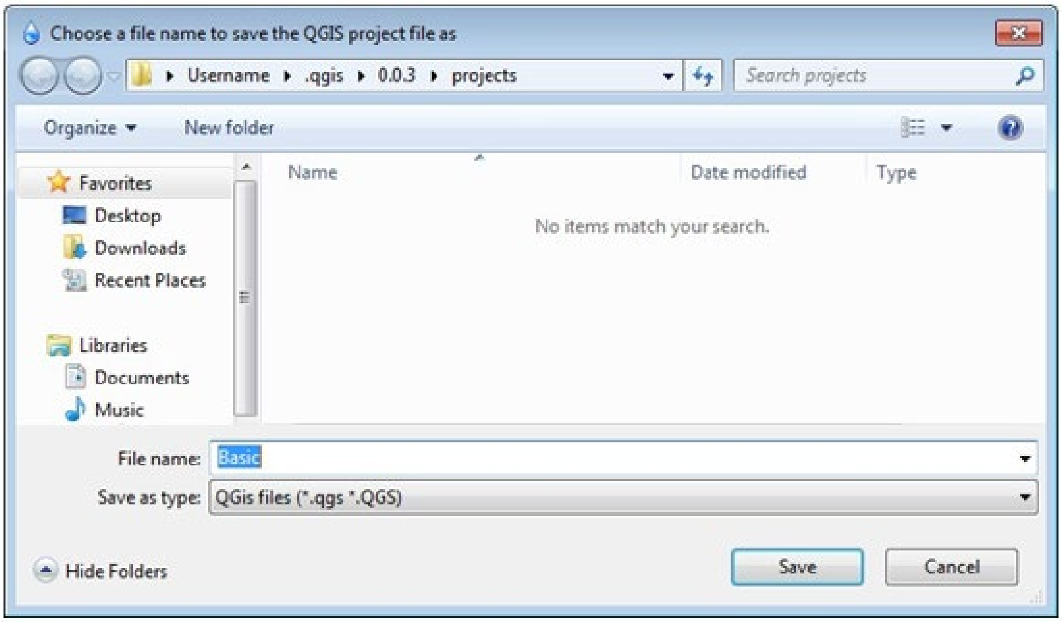


Figure 47 Window to save the EPA H2O project

5. By default, all data layers except *Google Streets* and *River basins* will be turned off. Other layers must be turned on to make them visible on the map (see Layers/ Table of Contents Panel). Land use layer results using the drawn AOI can be examined in the EPA H2O map once made visible (*Figure 48*).

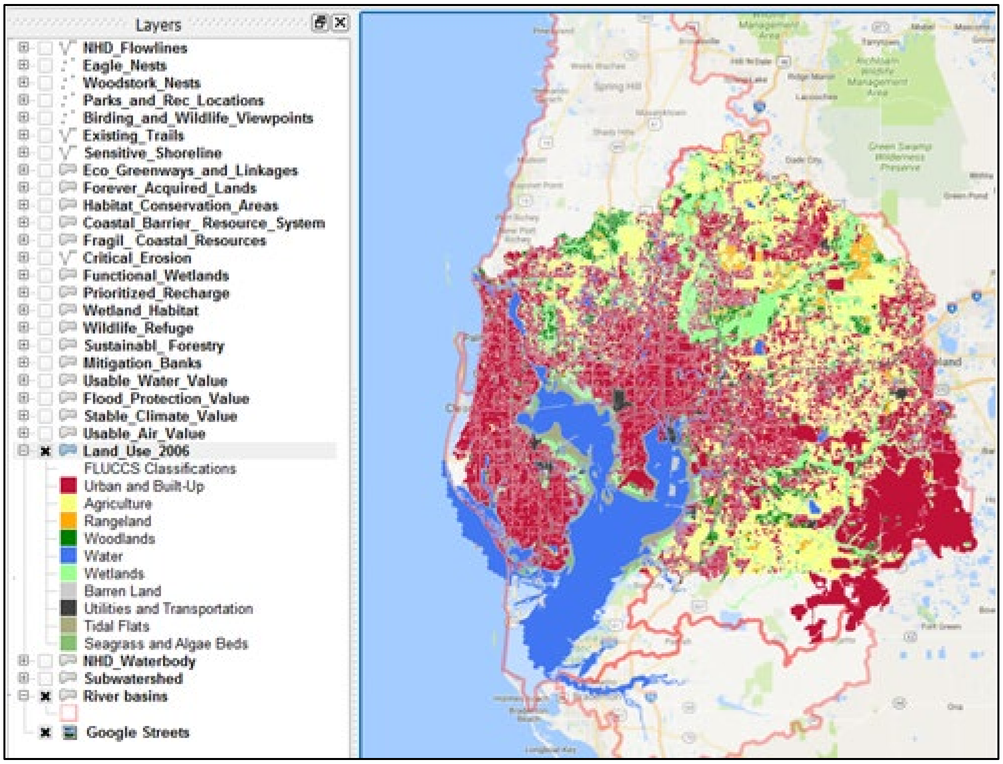


Figure 48 AOI drawn on map, with Google Streets and River basins layers visible, and Land Use turned on

By River Basin (Advanced Module Only)

1. In the EPA H2O *Select Area of Interest* window (Advanced Module, *Figure 31*), choose the *Select by River Basin* option. Click *OK*.
2. The *Watershed Selection* window will appear (*Figure 49*). The map will load in the background with pre-loaded base layers - *River basins* and *Google Streets* (*Figure 50*).

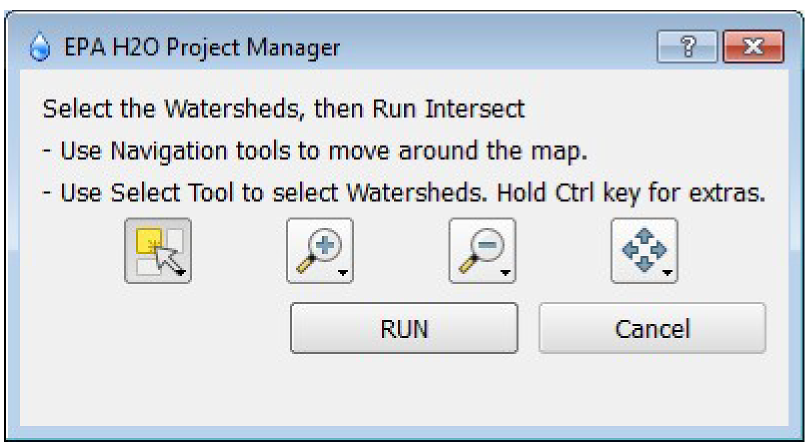


Figure 49 Watershed Selection window with navigation and selection icons

a. The *Watershed Selection* window is the same as the *Draw the AOI* window, except that instead of *Select Features by Rectangle,* it has the *Select Features* tool to choose single or multiple watershed(s) as the AOI. As watersheds are selected on the map they will appear in yellow (*Figure 50*).

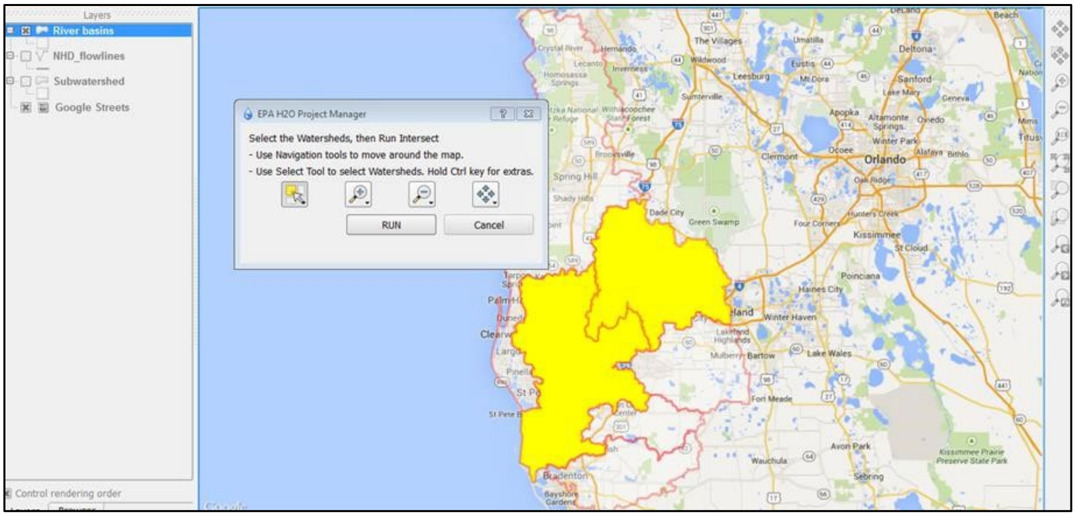


Figure 50 Watersheds selected using the Select by River Basin tool, highlighted in yellow

   b. Once the desired watersheds have been selected, click *RUN* in the *Watershed Selection* window.

3. All the EPA H2O data will be clipped to the selected AOI and its upstream areas. Depending on the AOI this may take several moments, during which time the user will see the progress bar (*Figure 51*).

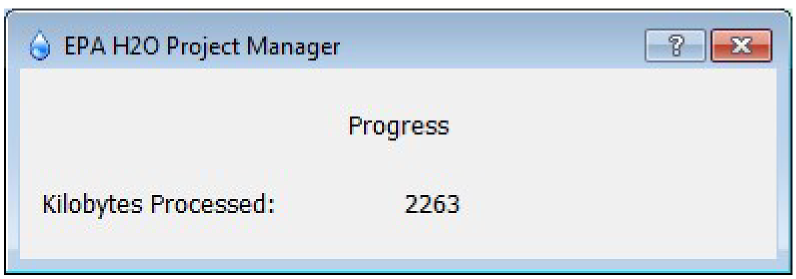


Figure 51 Select by River Basin progress bar

4. When clipping is complete the *Save Project* window will appear (*Figure 52*). To save the project, choose the desired File name and location and click *Save*. The project should be saved as a QGIS file with the extension ".qgs" (e.g. *Advanced.qgs* in *Figure 52*).

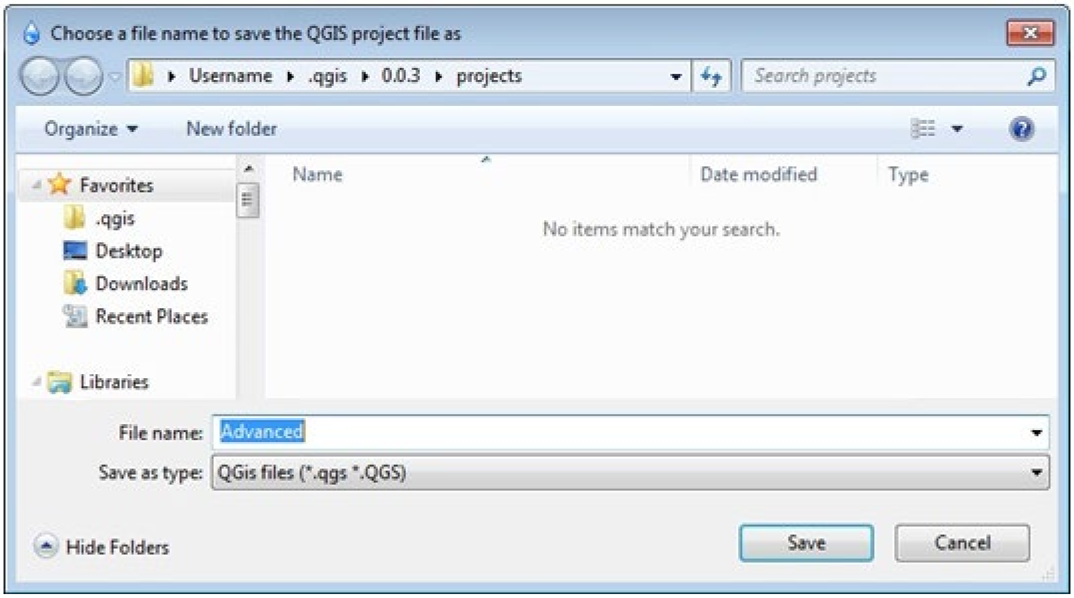


Figure 52 Save project with .qgs extension in Save Project window

5. By default, all data layers will be turned off except Google Streets and River basins. Other layers must be turned on to make them visible on the map (see Layers/ Table of Contents Panel). Land use layer results using the selected watersheds as the AOI can be examined in the EPA H2O map once made visible (*Figure 53*).

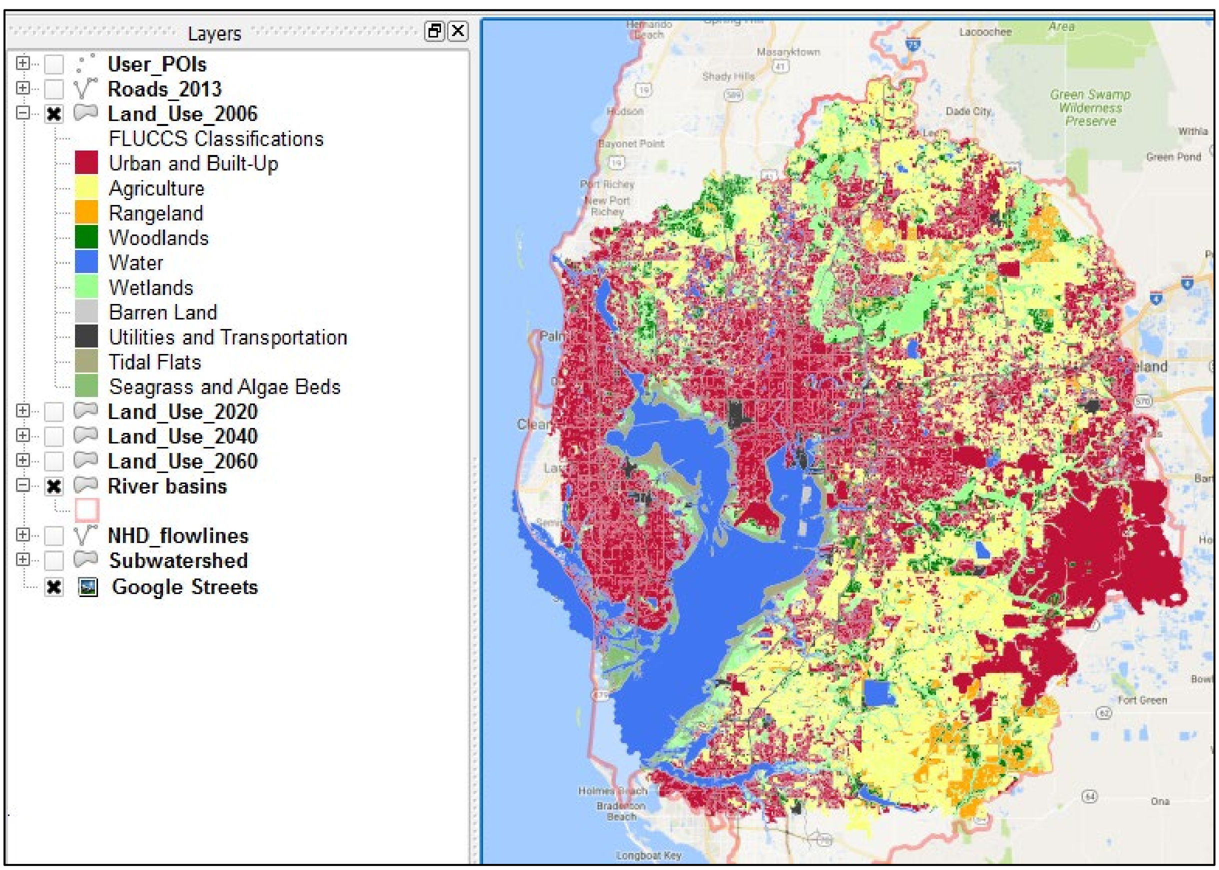


Figure 53 Advanced Module map drawn by River Basin; Land Use, River basins, and Google Streets are visible

Saving and Moving the Project

Saving the Project

EPA H2O will allow the user to save work in the QGIS file format (.qgs) using *Save* or *Save As* functions in the *File* menu of EPA H2O. Saved projects preserve all loaded data layers, drawing order, symbology, and view extents.

It is recommended that all EPA H2O data and files be saved in the same folder directory to facilitate moving of projects. EPA H2O does not support relative pathing; if a user moves the EPA H2O project file (.qgis file) or relevant data, the EPA H2O program will no longer be able to find the source data to map the layers. Transferring data and project files is not supported within EPA H2O default functionality, however, advanced QGIS users will be able to perform this task.

The Tampa Bay data provided with the EPA H2O software follows the recommended folder structure with specific types of content in each folder (*Table 1*). Keeping this folder structure will help the advanced QGIS user more easily navigate and move projects.

Table 1 folder structure of EPA H2O software with content descriptions

Folder/Filename	Content Description
Root Folder	0.0.3
Data	
Rasters	Contains raster files for ES layers.
Databases	
Legends	Contains the legend file (.qml) for each standard data layer used by EPA H2O.
TampaBay.sqlite	Contains the original data provided with EPA H2O for the Tampa Bay region. These are standard data layers used by EPA H2O.
Projects	Contains a sqlite database for each project, clipped to the user specified Area of Interest. Database names are also user specified.
Reports	Contains reports saved by the user. Note: the user specifies the location to save reports, it is not required to be saved to this folder.

Moving a Project

When a user moves the EPA H2O project file (.qgis file) or relevant data, the EPA H2O program is not able to find the source data for layers in the expected location, resulting in a broken data connection. The step-by-step procedure to fix broken data connections is as follows:

1. If there is a broken data connection(s), the *Handle bad layers* window will appear when opening the project file (*Figure 54*). Each line represents a data layer that cannot be found in the expected location, with the expected location shown in red under the *New file* column.

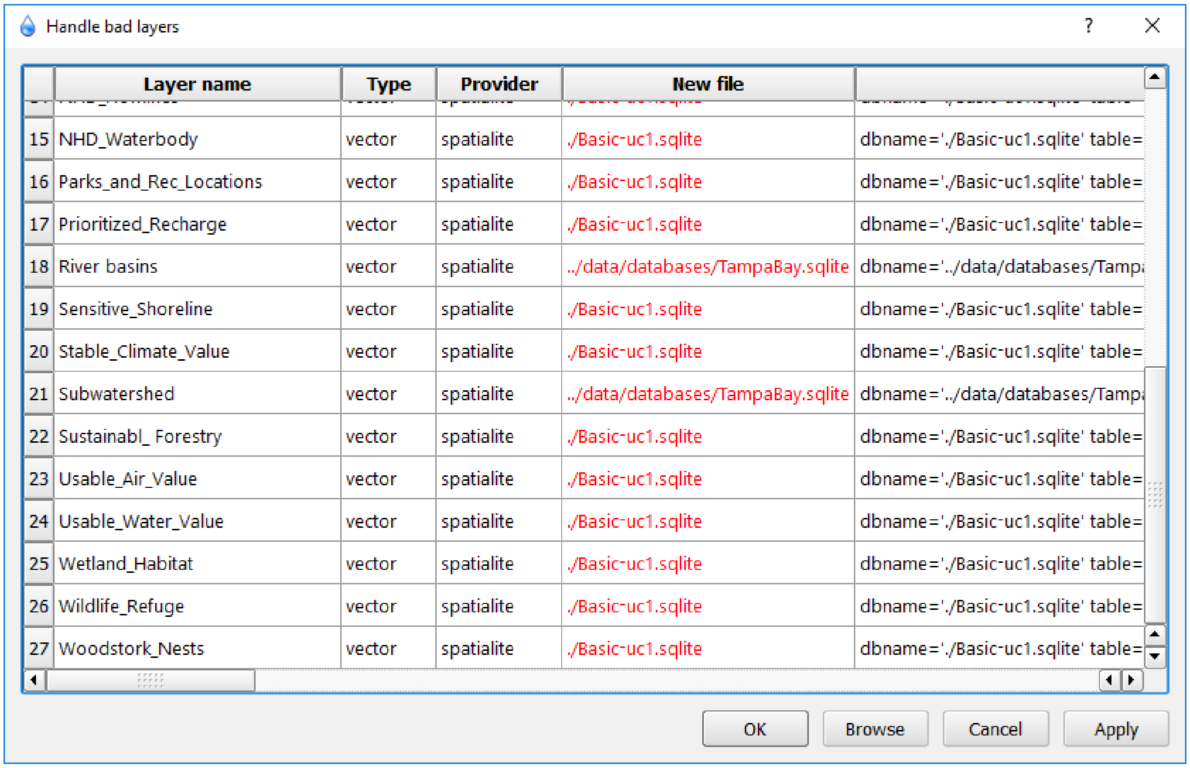


Figure 54 Handle bad layers window in EPA H2O

2. In the *Handle Bad Layers* window, double click on a file in the *New File* column. A *File Selection* window will open (*Figure 55*). Navigate to and select the appropriate file that represents the data layer, then click *Open.*

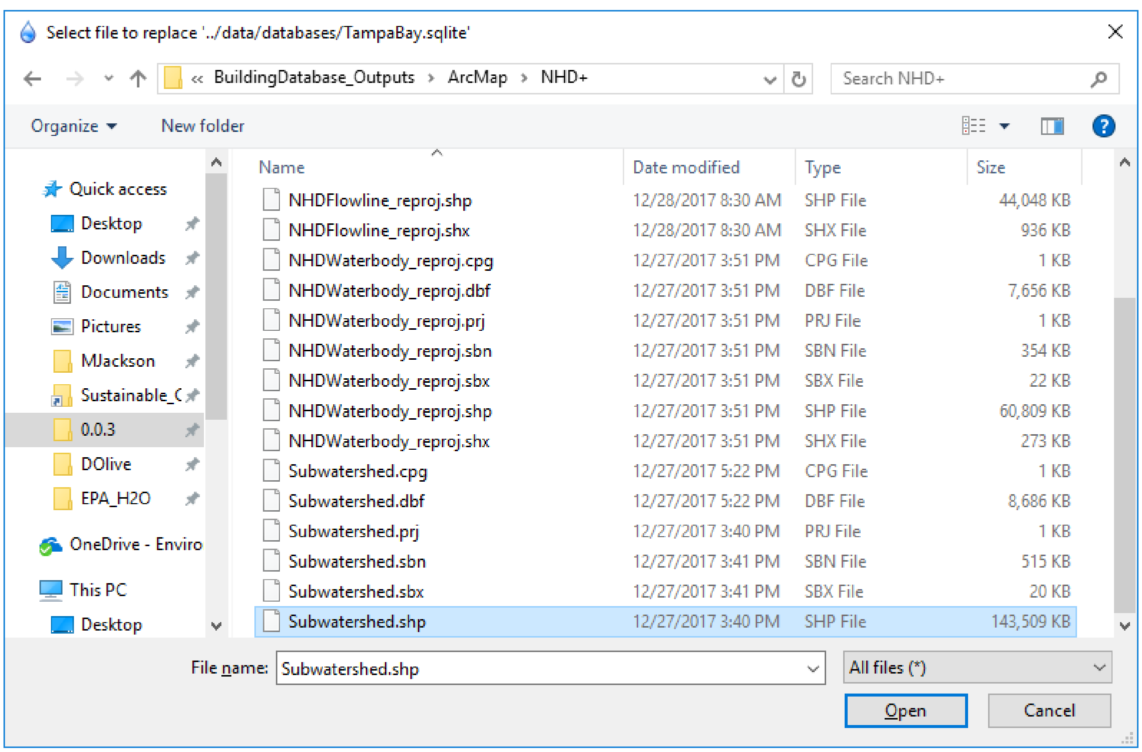


Figure 55 File Selection window in EPA H2O to reconnect a broken data connection

3. The broken data connection will now appear in green and be fixed (*Figure 56*).

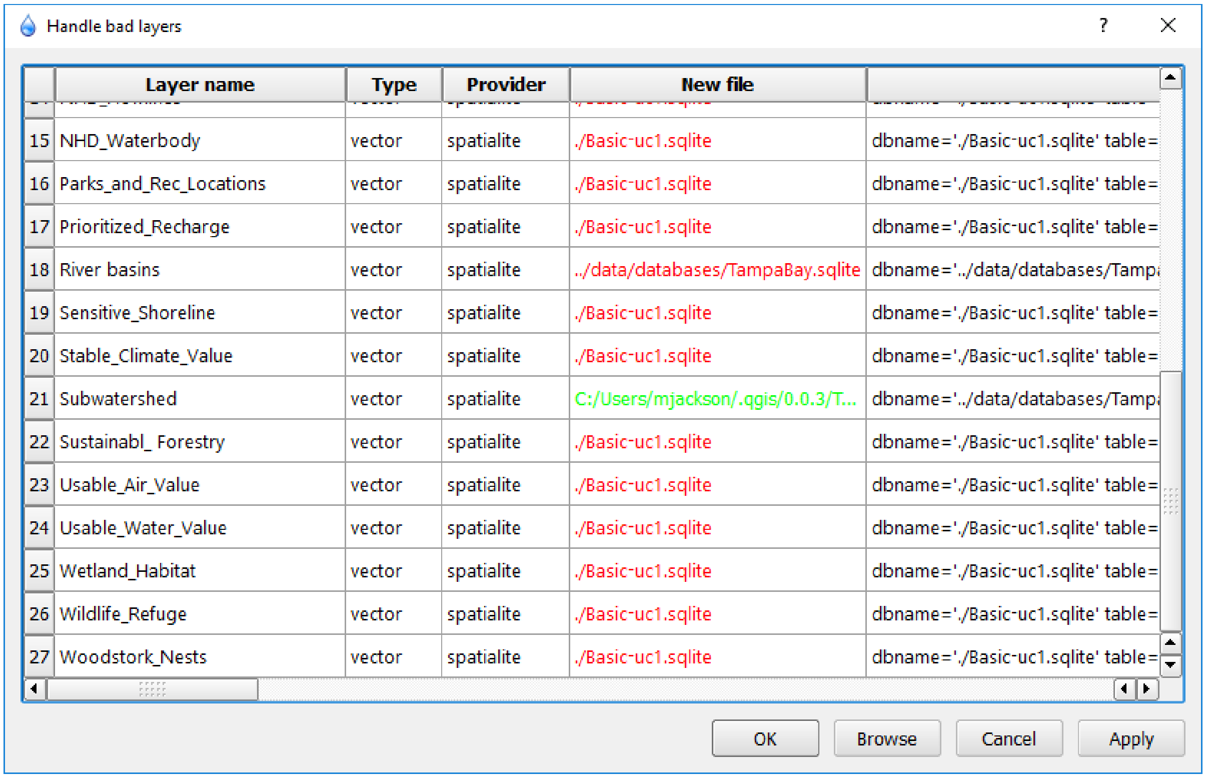


Figure 56 Data connection fixed for Subwatershed layer in Handle bad layers window

Once all the broken data layers are fixed in this fashion, the EPA H2O project can be successfully opened again.

Tampa Bay Data Layers

Basic Module Tampa Data

The EPA H2O download packages a variety of different Tampa Bay datasets into the Basic Module: Note: Depending on the selected AOI not al of the datasets may be visible.

NHD Flowlines - This dataset consists of line features that make up a linear surface water drainage network. The National Hydrography Dataset (NHD) contains Reach Codes for networked features, flow direction, names, and centerline representations for areal water bodies allowing upstream and downstream flow to be traced (Horizon Systems Corporation, 2016).

Eagle Nests – Point features representing eagle nests from 2008 to 2009. The Bald Eagle is the national bird of the United States of America and was once severely endangered in the United States. Populations have recovered, and although the Bald Eagle is no longer protected under the Endangered Species Act, it is still protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act (FWC, 2018).

Wood Stork Nests – Point features representing Wood Stork nests. The US Breeding Population of Wood Storks is protected under the Endangered Species Act (Federal Register, Feb. 1984; proposed status upgrade to Threatened, Dec. 2013). Nesting sites specifically are protected. Wood Storks are birds of freshwater and estuarine wetlands, primarily nesting in cypress or mangrove swamps. Primary reasons for the decline of Wood Stork populations are a decrease in food availability (mainly small fish) and loss of wetland habitat (USFWS, 2018).

Parks and Recreational Facilities – This dataset consists of point features, indicating parks and recreational locations. Parks provide opportunities for residents to enjoy outdoors, and recreational activities including hiking, biking, fishing, boating, swimming, camping, wildlife viewing and more. Parks benefit businesses such as tourism and recreational supply industries (camping equipment etc.) and are a source of employment. They can also provide added benefits, such as improvement in air or water quality, reduction of noise pollution, reduction of heat island effects in urban areas, and increased habitat for wildlife.

Birding and Wildlife Viewpoints – Point features representing sites along Florida trails, which provide opportunities for Birding and Wildlife viewing. The total spent annually in Florida for wildlife viewing is two and a half times greater than the value of the state's annual orange crop harvest ($3.08 billion and $1.23 billion, respectively, in 2006; Southwick Associates Inc., 2013).

Existing Trails – This dataset consists of line features that indicate existing trails. These are publicly accessible paved or unpaved trails for motorized use (e.g. ATV, OHM, ROV), as well as hiking, biking, equestrian, multiple-use, or paddling. In-road bike lanes and sidewalks are not included (Florida Department of Environmental Protection, 2012).

Sensitive Shoreline - These line features exhibit shorelines that are environmentally and economically sensitive to oil and hazardous material spills from 1993 to 2003 (FWC, 2017). The Clean Water Act with amendments by the Oil Pollution Act of 1990 requires response plans for immediate and effective protection of sensitive areas. These areas may contain sensitive shoreline habitats, sensitive biological resources, and human-use resources.

Ecological Greenways and Critical Linkages – This dataset consists of polygon features that represent ecological greenways and critical linkages. The Florida Ecological Greenways Network outlines the largest and most intact landscapes that aid in the conservation of biodiversity and ecosystem services in Florida (University of Florida GeoPlan Center, 2005). The Florida Greenways project is an analysis of potential ecological connectivity, using land use data to identify landscape-scale areas with conservation significance (e.g. ecological hubs) and potential landscape linkages (e.g. ecological greenways and wildlife corridors).

Forever Acquired Lands – Polygon features indicating Forever Acquired lands (Florida Natural Areas Inventory, 2012). Florida Forever is the nation's largest conservation land buying program. As of December 2017, collectively, the State of Florida has protected over 770,279 acres of land with $3 billion in Florida Forever funds (Florida DEP, 2017). Florida Forever lands are proposed for acquisition because of outstanding natural resources, opportunity for natural resource-based recreation, or historical and archaeological resources. However, these areas may not currently be managed for their resource value.

Strategic Habitat Conservation Areas – This dataset consists of polygon features that represent strategic habitat conservation areas (SHCAs). SHCAs are utilized to determine the minimum amount of land in Florida required to maintain long-term biological diversity for 33 terrestrial vertebrates (Florida Natural Areas Inventory, 2017). Over 8 million acres of privately-owned areas have been identified as SHCAs, to conserve habitat for these 33 species. SHCAs also include potential habitat within conservation lands for 29 other vertebrate species.

Coastal Barrier Resources System - These polygons indicate areas which were designated under the Coastal Barrier Resources Act (CRBA). This Act limits federal expenditures that support development, such as federal flood insurance. This, in return, promotes the conservation of biologically diverse coastal barriers often impacted by hurricanes. Areas within the Coastal Barrier Resources System (CBRS) can only be developed if the private developers (or other non-federal parties) cover all costs (USFWS, 2018). The CBRA is intended to save federal dollars, protect human lives, and conserve natural resources.

Fragile Coastal Resources – This dataset consists of polygon features that exhibit fragile coastal resources. These areas include natural communities most susceptible to disturbance or development, such as beach dune, coastal grassland, coastal strand, coastal scrub, maritime hammock, salt marsh, and mangrove communities (Florida Natural Areas Inventory, 2017). These coastal communities face a variety of threats, especially invasion by non-native species, encroaching development and other human activities.

Coastal Critical Erosion Areas – Line dataset representing eroded coastal areas, which have been negatively impacted by natural processes or human activity. The erosion and recession of the beach or dune system in these areas jeopardize upland development, recreational interests, wildlife habitat, or important cultural resources (Florida DEP, 2017). These coastlines are necessary to protect these important resources and ecosystem services.

Functional Wetlands – This dataset consists of polygon features that indicate functional wetland locations. In addition to being unique ecosystems, wetlands act as a filter for pollution and sediment. When rainwater runoff laden with pesticides, excess nutrients, and other pollutants flows through a wetland prior to reaching open water, the pollutants are naturally filtered out. Excess sediment builds up in the wetland instead of in rivers or other water bodies. Wetlands also offer flood protection by storing runoff and releasing it slowly. The prioritization method was based on a Land Use Intensity index and Florida Natural Areas Inventory (FNAI) Potential Natural Areas ranking (Florida Natural Areas Inventory, 2017). Wetlands in the most natural state are given the highest priority.

Prioritized Recharge - These polygon features represent recharge locations, which provide ground water recharge important to natural and human use. This recharge is critical to springs, sinks, aquifers, natural habitats, and human water supply. The data are prioritized by aquifer vulnerability factors; these include thickness of the intermediate aquifer confining unit and closed topographical depressions, as well as prioritizing those that are within springshed protection zones and in proximity to public water supply wells (Florida Natural Areas Inventory, 2017).

Wetland Habitat – Polygon dataset indicating the distribution of 35 wetland-dependent species, which were used to determine priority wetlands for listed species. Documented and potential wetland habitats were identified using known occurrence records and vegetative cover derived from 1985-1989 Landsat Thematic Mapper Imagery (FGDL, 2006). The "hot spot" dataset was created by aggregating predictive habitat maps for each of the 35 listed species.

Wildlife Refuge – This dataset consists of polygon features that represent the location of wildlife refuges (USFWS, 2017). The National Wildlife Refuge system is a system of public lands and waters protected by the US Fish and Wildlife Service. These lands help to conserve America's wildlife for future generations. The National Wildlife Refuges in the Tampa Bay area are Passage Key and Pinellas, which are closed to the public because of their small size and importance to wildlife, and Edgemont Key, which is open to the public for recreational activities. These include hiking, swimming, boating, fishing, and wildlife viewing (USFWS, 2018).

Sustainable Forestry - This polygon data layer identifies existing pinelands (natural and planted) and former pinelands that are potentially available for forest management. Prioritization is based on four criteria set by the Florida Forest Service: whether trees are natural or planted, size of tract, distance to market, and hydrology (Florida Natural Areas Inventory, 2017). Large tracts of natural pine on mesic soils (compared to very dry or wet soils) that are within 50 miles of a mill receive the highest priority. Former pinelands that currently do not have trees receive the lowest priority.

Mitigation Banks – Polygon dataset representing the location of mitigation banks (Florida DEP, 2004). Mitigation banking is the restoration, creation, enhancement, or preservation of a wetland, stream, or habitat conservation area, which offsets expected adverse impacts to similar nearby ecosystems (Florida DEP, 2018). The goal is to replace the exact function and value of the specific wetland habitats that would be adversely affected by a proposed development project.

Usable Water Value – This polygon dataset indicates the categorized value of usable water. Human activities produce water pollutants (University of Florida GeoPlan Center, 2006). As water moves through a watershed, it is filtered by wetlands, forests, and aquatic areas. Replacement costs for removing a pound of nitrogen from various sources range from less than $10 to as high as $855 (U.S. EPA, 2016). Cost increases as the nitrogen becomes harder to route towards treatment areas and as simpler, more cost-efficient mechanisms for removing nitrogen need to be replaced by more centralized advanced wastewater treatment facilities. Click to see how usable water value is determined.

Flood Protection Value* - Polygon dataset representing the categorized value of flood protection (University of Florida GeoPlan Center, 2006). Human activities alter the way water moves through the landscape. Natural landscapes retain and slow the movement of water, offering protection from flooding (U.S. EPA, 2016). The loss of these natural landscapes would result in an increased need for manmade flood protection at much higher cost. Click to see how flood protection value is determined.

Stable Climate Value - This dataset consists of polygon features that exhibit the categorized value of a stable climate (University of Florida GeoPlan Center, 2006). Stored carbon provides a more stable climate by reducing greenhouse gases. In 2010, CO_2 accounted for about 84% of all U.S. greenhouse gas emissions from human activities (U.S. EPA, 2016). Click to see how stable climate value is determined .

Usable Air Value – Polygon feature dataset that represents the categorized value of usable air (University of Florida GeoPlan Center, 2006). Human activities produce air pollutants. Trees and other plants remove these harmful pollutants. Pollution removal results in healthier people with reduced health care costs (U.S. EPA, 2016). The relative air pollutant cost to human health was used to translate the various pollutant removal rates to decreases in human health impact costs. Click to see how usable air value is determined.

Land Use 2006 – Polygon feature dataset that indicates land use type. Land use maps based on Florida Land Use and Cover Classification System (FLUCCS) data derived from aerial imagery (Southwest Florida WMD, 2007).

NHD Waterbodies – Polygon features in the National Hydrography Dataset (NHD) represent areas that contain water such as lake/pond, swamp/marsh, stream/river, canal/ditch, area of complex channels, estuary, ice mass, playa, reservoir, sea/ocean, and wash (Horizon Systems Corporation, 2016).

Subwatershed – Polygon areas that define drainage basins; used to identify a hydrological feature such as a river, river reach, lake, or area like a drainage basin. Subwatershed data are obtained from the National Hydrography Dataset (Horizon Systems Corporation, 2016).

Counties – This dataset consists of polygon features that represent Florida counties. Population data from 2004 and 2009 Florida Statistical Abstract was sampled for each county to create the shapefile layer (University of Florida GeoPlan Center, 2010).

River Basins – Polygon feature dataset that represents river basins. River basins are areas of land where rivers and tributaries drain to the same point or body of water. In this scenario tool, that body of water is Tampa Bay. Eight-digit hydrologic unit codes (HUC) are used to identify these hydrological features (USGS, 2018).

Google Streets - OpenLayers map of Google Street map data (Google, 2018).

*The reported values for Flood Protection will be slightly smaller in the Basic Module report versus the Advanced Module report. This difference is less than 5% between the two modules and is further detailed in the ES Calculations Theory section.

Advanced Module Tampa Data

The EPA H2O download packages a variety of different Tampa Bay datasets into the Advanced Module:

Roads 2013 – Line features that define the name and speed limit of roads and highways in the Tampa Bay area (U.S. Census Bureau, 2018).

Land Use 2006 – Polygon feature dataset that indicates land use type. Land use maps based on Florida Land Use and Cover Classification System (FLUCCS) data derived from aerial imagery (Southwest Florida WMD, 2007).

Land Use 2020 – Polygon feature dataset representing possible land use in 2020. Future scenarios resulting from models or subjective tabletop exercises (U.S. EPA, 2016).

Land Use 2040 - Polygon feature dataset representing possible land use in 2040. Future scenarios resulting from models or subjective tabletop exercises (U.S. EPA, 2016).

Land Use 2060 - Polygon feature dataset representing possible land use in 2060. Future scenarios resulting from models or subjective tabletop exercises (U.S. EPA, 2016).

To learn more about the land use scenarios:
https://archive.epa.gov/ged/tbes/web/html/landuse.html

Counties – This dataset consists of polygon features that represent Florida counties. Population data from 2004 and 2009 Florida Statistical Abstract was sampled for each county to create the shapefile layer (University of Florida GeoPlan Center, 2010).

NHD Flowlines - This dataset consists of line features that make up a linear surface water drainage network. The National Hydrography Dataset (NHD) contains Reach Codes for networked features, flow direction, names, and centerline representations for areal water bodies allowing upstream and downstream flow to be traced (Horizon Systems Corporation, 2016).

Subwatershed - Polygon areas that define drainage basins. Subwatershed data are obtained from the National Hydrography Dataset (Horizon Systems Corporation, 2016).

Google Streets - OpenLayers map of Google Street map data (Google, 2018).

River Basins – Polygon feature dataset that represents river basins. River basins are areas of land where rivers and tributaries drain to the same point or body of water. In this scenario tool, that body of water is Tampa Bay. Eight-digit hydrologic unit codes (HUC) are used to identify these hydrological features (USGS, 2018).

Creating Reports

Basic Module Report

Create Report Tool

This section illustrates the *Create Report* tool functionality in the Basic Module.

1. Click on the *Create Report* icon located in the EPA H2O Toolbar. The *Create Report* window will appear (*Figure 57*).
    a. In the *Report Name* box, enter the preferred report name. **WARNING: re-running Create Report with same *Report Name* will overwrite the previously saved report.**
    b. If necessary, click the *Change* button to designate a different *Report Folder* location.

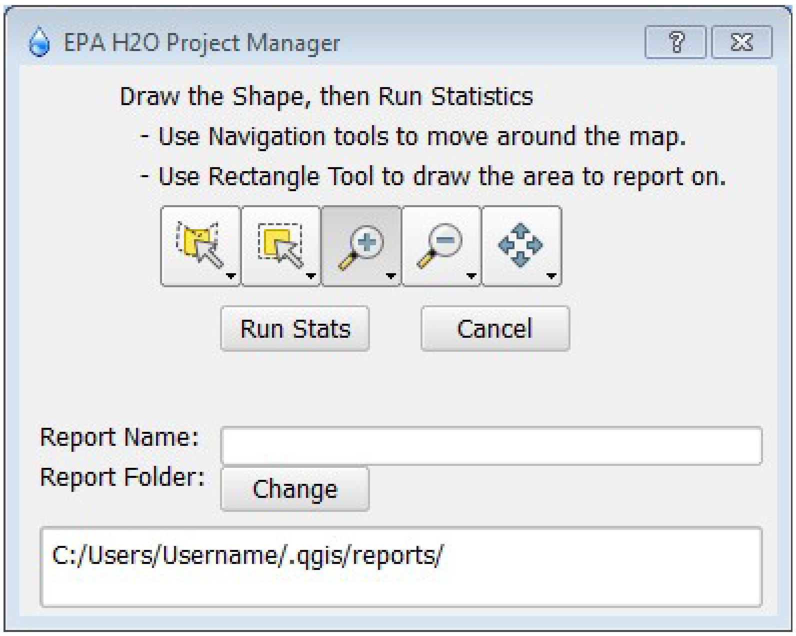


Figure 57 Create Report window

    c. Use either the *Select by Irregular Polygon* icon or the *Select by Rectangle* icon to select the area to run the report on. These selection tools work much like the *Select Features by Polygon* or *Select Features by Rectangle* tools (see GIS Tools section), except that the report area appears as a semi-transparent blue polygon while drawing (*Figure 58*) and the polygon area is closed by double clicking the final vertex instead of right-clicking, as is done when making a selection.
    d. Once the desired report area is drawn, click *Run Stats* to generate the report using that area.

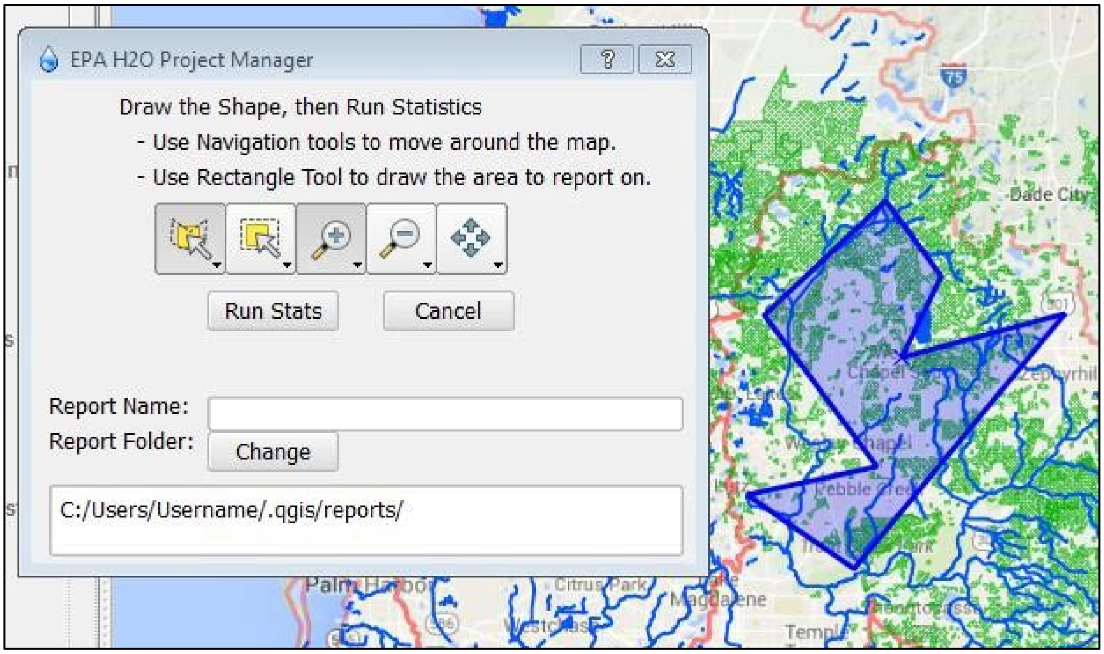


Figure 58 Report area (indicated by the blue polygon) selected with the irregular polygon tool

2. Depending on the size of the report area, it may take a few moments to generate the report in PDF format. A progress bar displaying the percentage of the process completed for each layer will be displayed during this time (*Figure 59*).

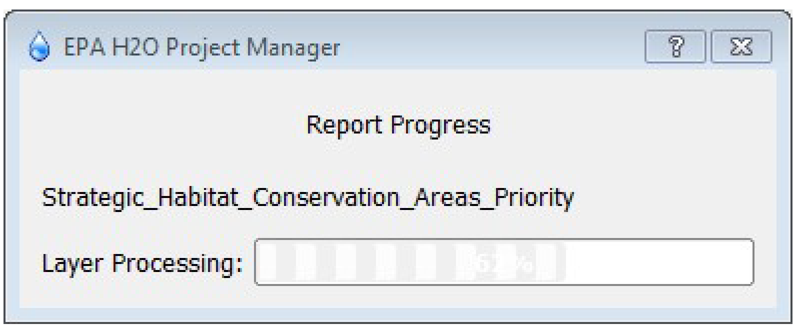


Figure 59 Report progress bar window

3. The report area will automatically be added to the Layers panel as *Area of Interest* (*Figure 60*).

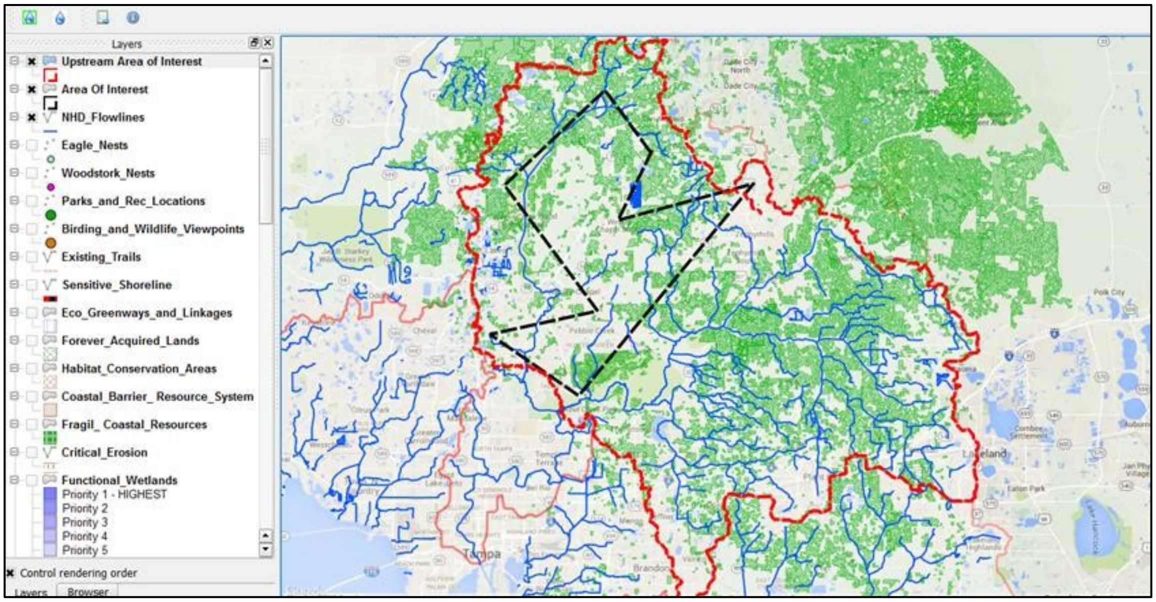


Figure 60 EPA H2O map with report area displayed and added to the Layers panel

4. The report will be saved as a PDF in the user specified location.

Basic Module Report Analysis

This section overviews the contents of the Basic Module report (*Figure 61*).

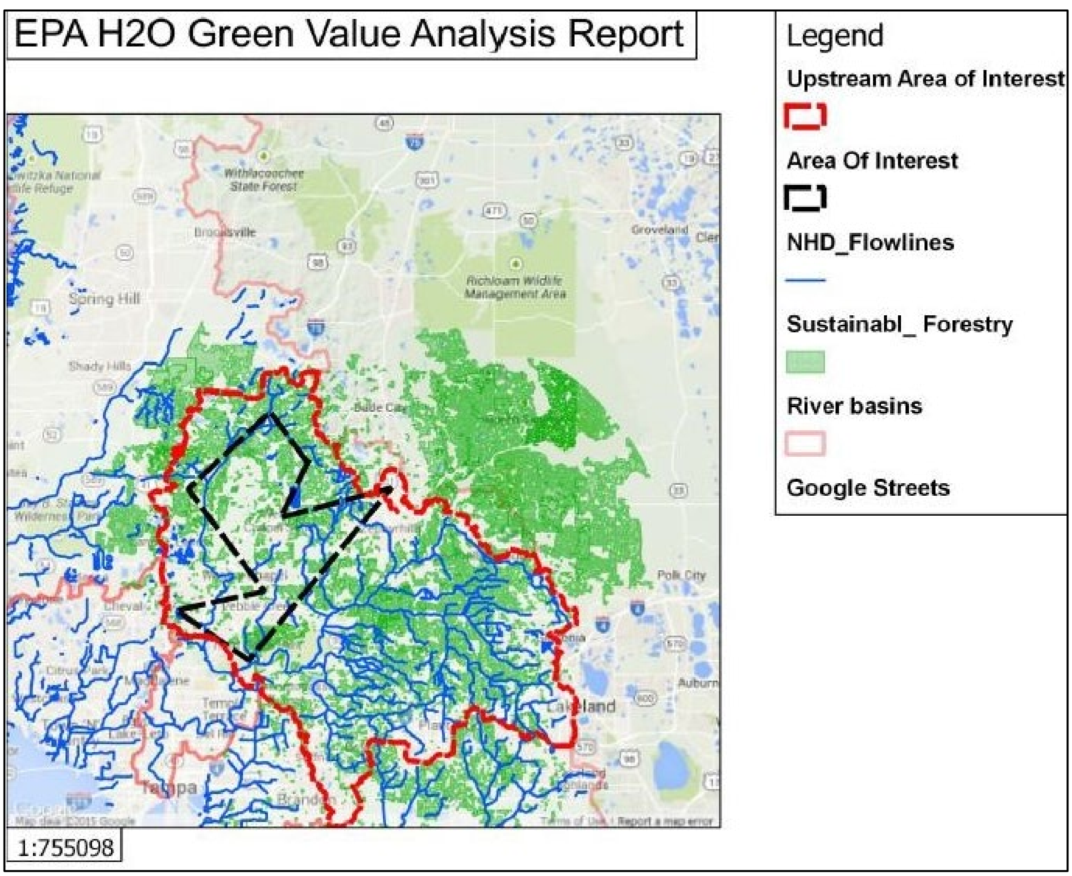


Figure 61 Basic Module Report, map with legend

The cover page of the Basic Module report contains four main map elements (*Figure 61*):

Title – Generic description of the Basic report, “EPA H2O Green Value Analysis Report.”

Legend - List of layers that are turned on/visible in the Layers panel, in the order they appear on the map. Each layer has its name and symbology, the symbols used to represent layer data and values.

Map – Data layers from the legend shown using their respective symbologies on a map.

Scale - Displayed as a ratio of map units to the actual measurement.

The Map and Legend both include layers defining the areas compared in the report:

Upstream Area of Interest – A red dashed line that is comprised of subwatersheds that overlap with or drain into the chosen AOI.

Area of Interest – A black dashed line that shows the user defined AOI for the report.

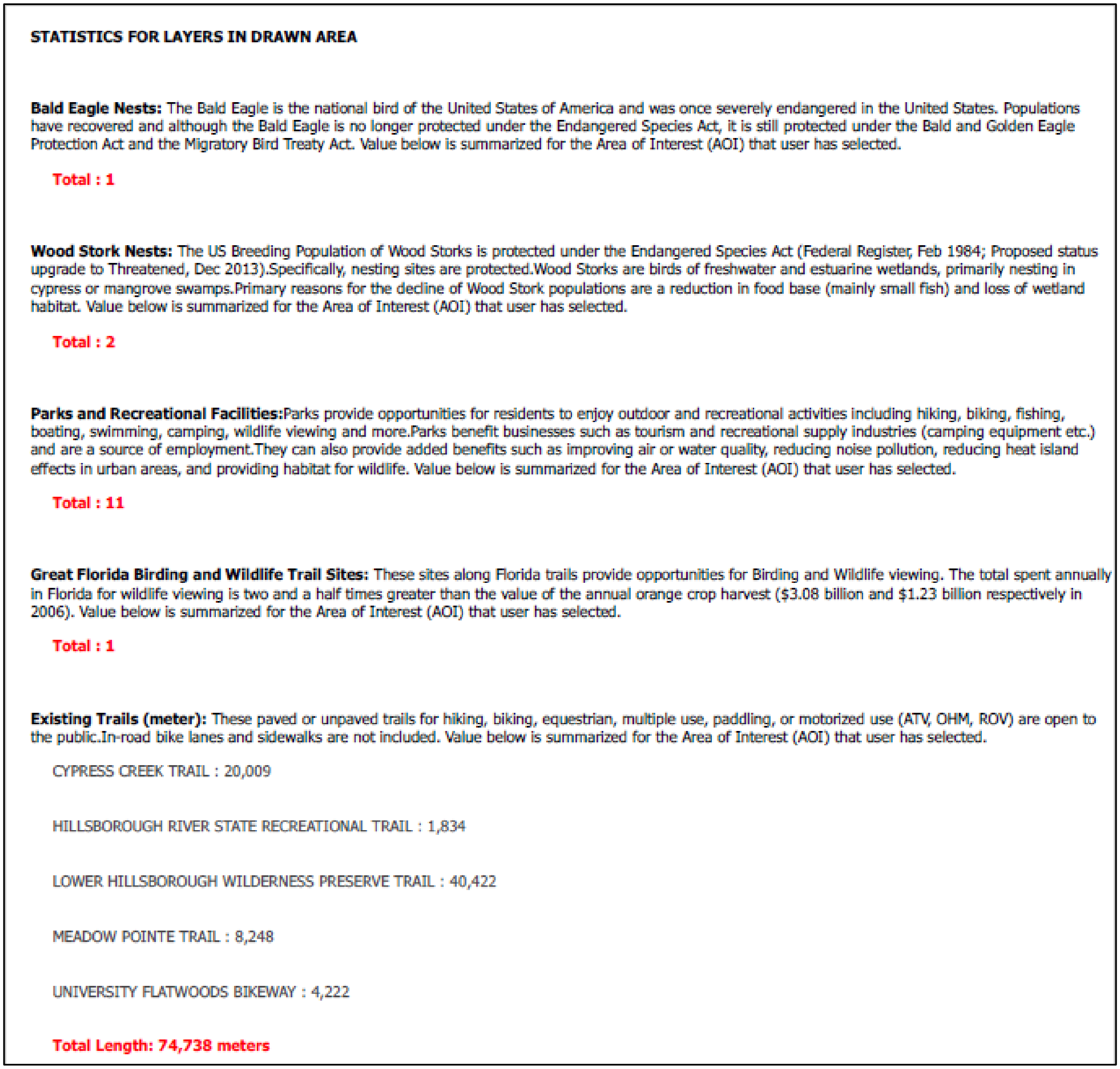
The second page of the Basic report summarizes statistics for all non-water flow related features in the user-selected AOI (*Figure 62*). The statistics for water flow related features, Functional Wetlands, Prioritized Recharge, Flood Protection Value, and Usable Water, are summarized for the user-selected AOI and its upstream area.

The report summarizes each feature data type differently:

Point Features - Displays the total number of features in the summarized area.

Polyline Features - Displays the lengths and units for each feature and the total length for all features in the summarized area.

Polygon Features- Displays areas and units for each feature and the total area of all features in the summarized area.


STATISTICS FOR LAYERS IN DRAWN AREA

Bald Eagle Nests: The Bald Eagle is the national bird of the United States of America and was once severely endangered in the United States. Populations have recovered and although the Bald Eagle is no longer protected under the Endangered Species Act, it is still protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Value below is summarized for the Area of Interest (AOI) that user has selected.

Total : 1

Wood Stork Nests: The US Breeding Population of Wood Storks is protected under the Endangered Species Act (Federal Register, Feb 1984; Proposed status upgrade to Threatened, Dec 2013).Specifically, nesting sites are protected.Wood Storks are birds of freshwater and estuarine wetlands, primarily nesting in cypress or mangrove swamps.Primary reasons for the decline of Wood Stork populations are a reduction in food base (mainly small fish) and loss of wetland habitat. Value below is summarized for the Area of Interest (AOI) that user has selected.

Total : 2

Parks and Recreational Facilities: Parks provide opportunities for residents to enjoy outdoor and recreational activities including hiking, biking, fishing, boating, swimming, camping, wildlife viewing and more.Parks benefit businesses such as tourism and recreational supply industries (camping equipment etc.) and are a source of employment.They can also provide added benefits such as improving air or water quality, reducing noise pollution, reducing heat island effects in urban areas, and providing habitat for wildlife. Value below is summarized for the Area of Interest (AOI) that user has selected.

Total : 11

Great Florida Birding and Wildlife Trail Sites: These sites along Florida trails provide opportunities for Birding and Wildlife viewing. The total spent annually in Florida for wildlife viewing is two and a half times greater than the value of the annual orange crop harvest ($3.08 billion and $1.23 billion respectively in 2006). Value below is summarized for the Area of Interest (AOI) that user has selected.

Total : 1

Existing Trails (meter): These paved or unpaved trails for hiking, biking, equestrian, multiple use, paddling, or motorized use (ATV, OHM, ROV) are open to the public.In-road bike lanes and sidewalks are not included. Value below is summarized for the Area of Interest (AOI) that user has selected.

CYPRESS CREEK TRAIL : 20,009

HILLSBOROUGH RIVER STATE RECREATIONAL TRAIL : 1,834

LOWER HILLSBOROUGH WILDERNESS PRESERVE TRAIL : 40,422

MEADOW POINTE TRAIL : 8,248

UNIVERSITY FLATWOODS BIKEWAY : 4,222

Total Length: 74,738 meters

Figure 62 Statistics for example features in the user's AOI report

Advanced Module Report

Create Scenario

This section illustrates the workflow to create a user-defined land use scenario in the EPA H2O Advanced Module.

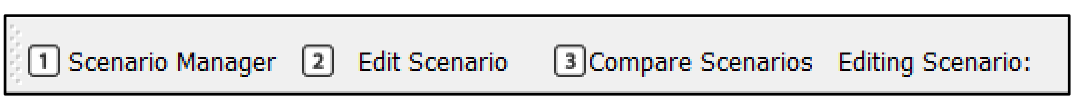


Figure 63 EPA H2O Toolbar 4: Scenarios Toolbar

1. Click on the *Scenario Manager* button found on the EPA H2O Scenarios Toolbar (*Figure 63*).

2. In the *Scenario Manager* window that appears (*Figure 64*), type the desired scenario name (e.g. *Demo*) and click *Run Scenario*.

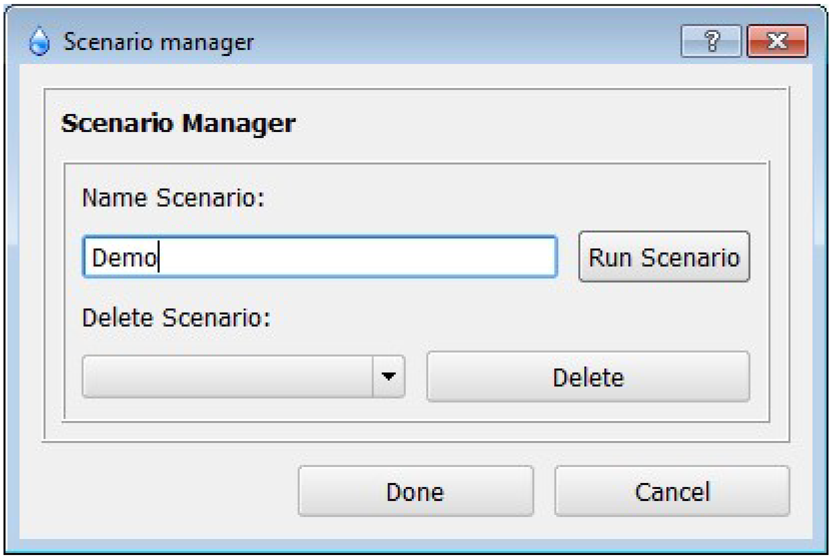


Figure 64 Scenario manager window, where user may name and run the scenario

3. Depending on the size of the area of interest, it may take a few moments for the scenario to be created. A progress bar will be displayed while creation is in progress (*Figure 65*).

Figure 65 Scenario Manager progress bar

4. After all new scenarios of interest have been created, click *Done* to close the *Scenario Manager* window.
5. Note that the new scenario(s) with the user-specified name(s) will be created in the Layers panel (*Figure 66*). Each newly created scenario is an exact copy of the default land use data loaded in the Advanced Module. New scenarios can later be modified/edited as shown in the Edit Scenarios section.

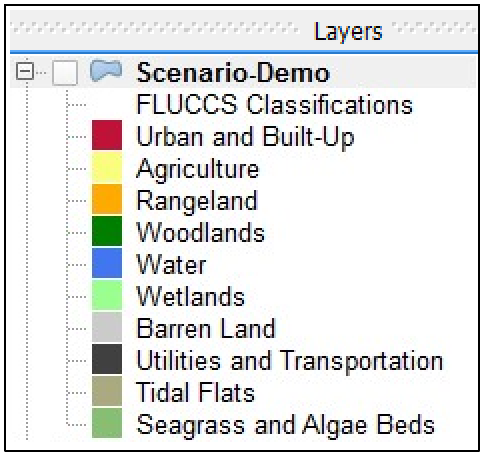


Figure 66 New scenario located in the Layers panel

Edit Scenarios

This section illustrates the workflow to edit a user-defined scenario in the Advanced Module of EPA H2O. For illustration purposes, land use types in the example scenario created in the Create Scenario section will be edited for selected features for hypothetical scenarios.

Edit Scenario Land Use

1. Click the *Edit Scenario* button on the EPA H2O toolbar to open the *Edit Scenario* window (*Figure 67*).

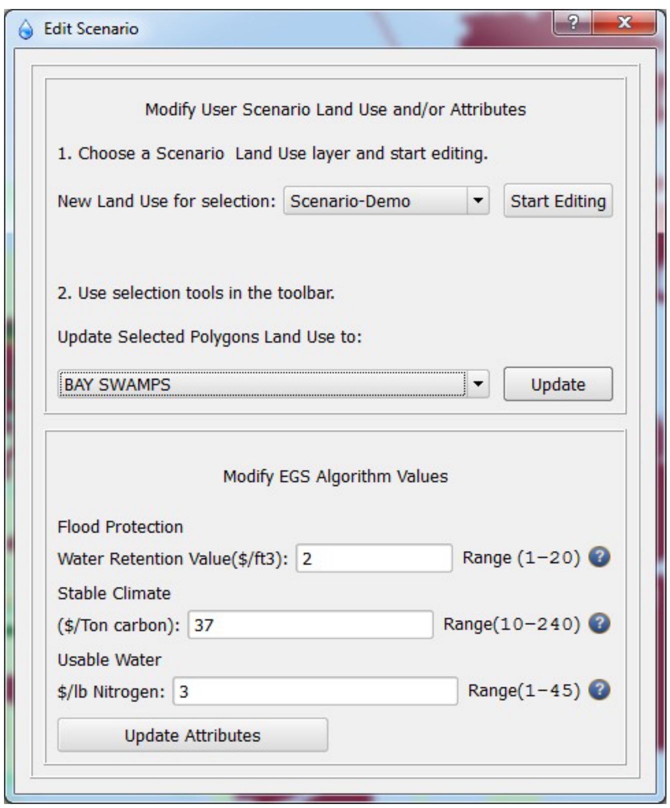


Figure 67 Edit Scenario window

2. Make sure *Scenario-Demo* is selected and click on the *Start Editing* button (*Figure 67*). This will cause several things to occur in the EPA H2O interface (labeled A-D in *Figure 68*):
   a. The name of the scenario being edited (e.g. *Scenario-Demo)* will display in red on the EPA H2O toolbar.
   b. The *edit* icon will appear next to the layer being edited (e.g. *Scenario-Demo*) in the Layers panel.
   c. The *Selection* tools will appear in the upper left corner of the user interface.
   d. The *Stop Editing* Stop Editing button will replace the *Start Editing* button in the *Edit Scenario* window.

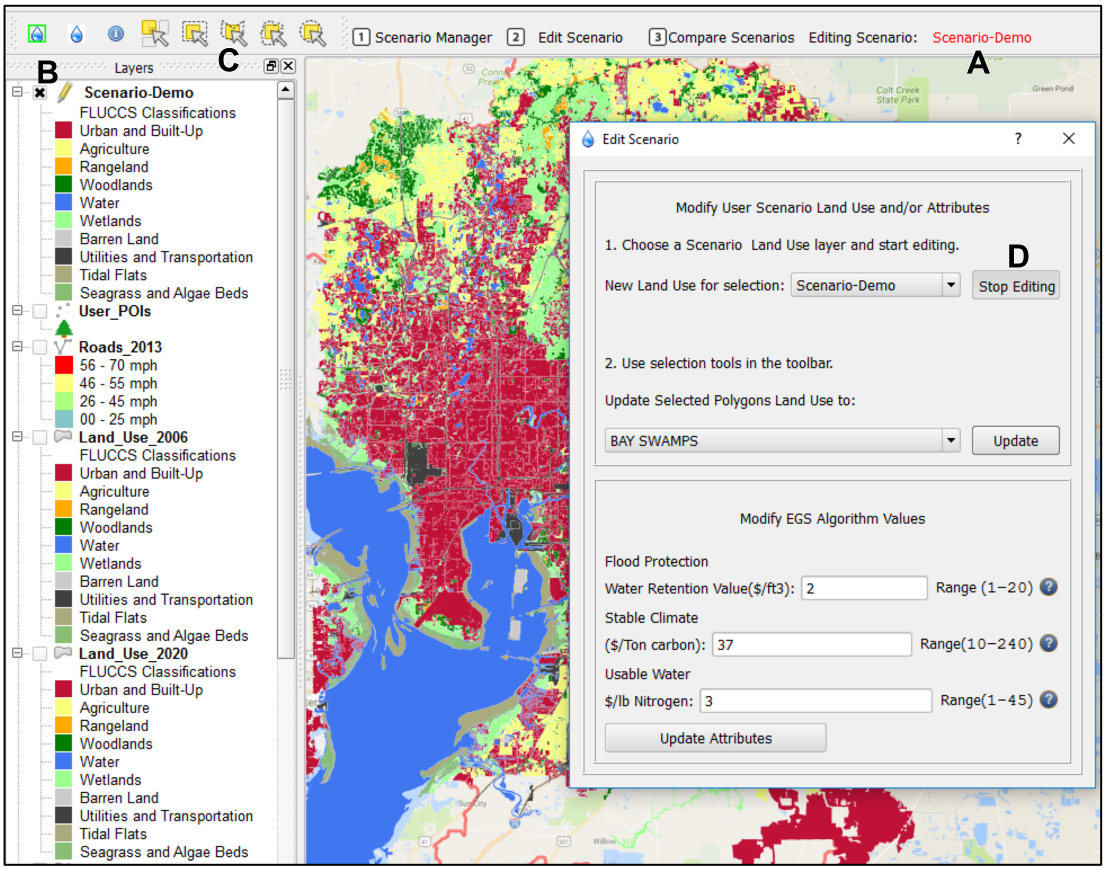


Figure 68 Edit the scenario in the Edit Scenario window; changes to the program are indicated with letters A-D

3. The user can navigate and zoom to the to-be-edited area (*Figure 69*) using normal map navigation controls (the GIS Tools section describes these). Zooming in on an area within the AOI makes it easier to observe and update the land use of individual features. For example, in *Figure 69* it is easier to see that land use types for most of the area are *Urban and Built-Up* or *Agriculture*.

Figure 69 Zoomed in area within the AOI, demonstrating symbology of polygons

4. While EPA H2O is in edit mode (see step 2 a-d) use the *Feature Selection* tools (see GIS Tools section) to select the polygon(s) the user wants to change in the scenario. Selected polygons will appear bright yellow in color, with the vertices outlined by red crosshairs (*Figure 70* shows an *Agriculture* polygon (TREE CROPS) from *Figure 69* after being selected).

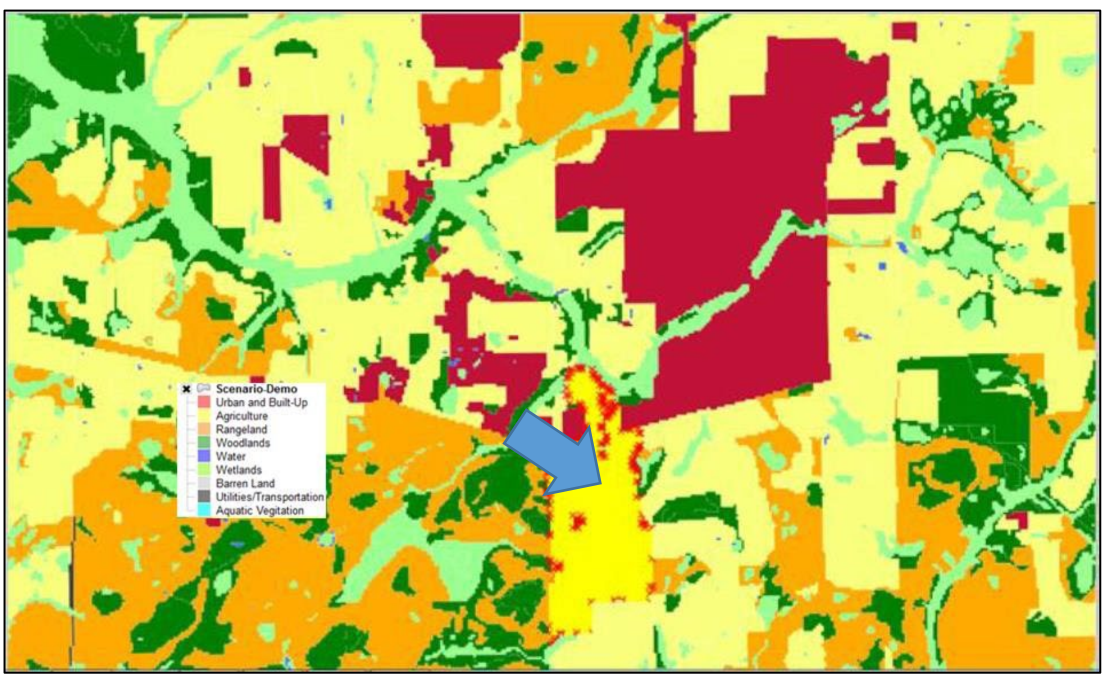


Figure 70 Tree Crops polygon is selected during scenario editing, indicated by the blue arrow

5. In the *Edit scenario* window, use the dropdown list under the *Update Selected Polygons Land Use to:* label to choose the land use type the selected polygons will become (e.g. COMMERCIAL AND SERVICES in *Figure 71*).

6. Click the *Update* button to update the selected polygon land use to the type in the dropdown list (*Figure 71*).

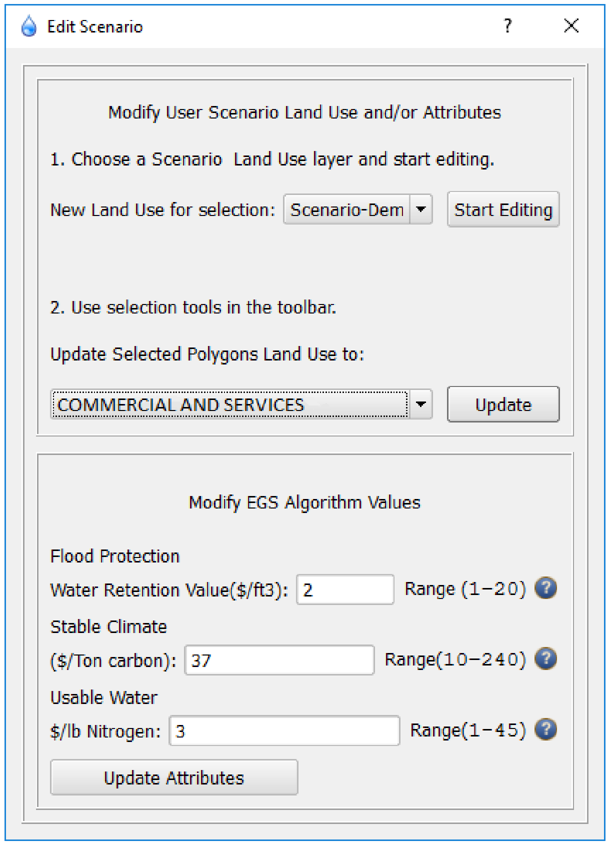


Figure 71 Edit Scenario window, allows the user to change the land use type of selected polygons

7. Updating the land use type may take a few moments depending on the area of interest and the features selected. **Do not close the program while the update process is in progress.**
8. Once complete a pop-up window will appear, click *OK* to continue (*Figure 72*).
9. Click on the *Stop Editing* button in the *Edit Scenario* window to commit changes made to the land use polygon.

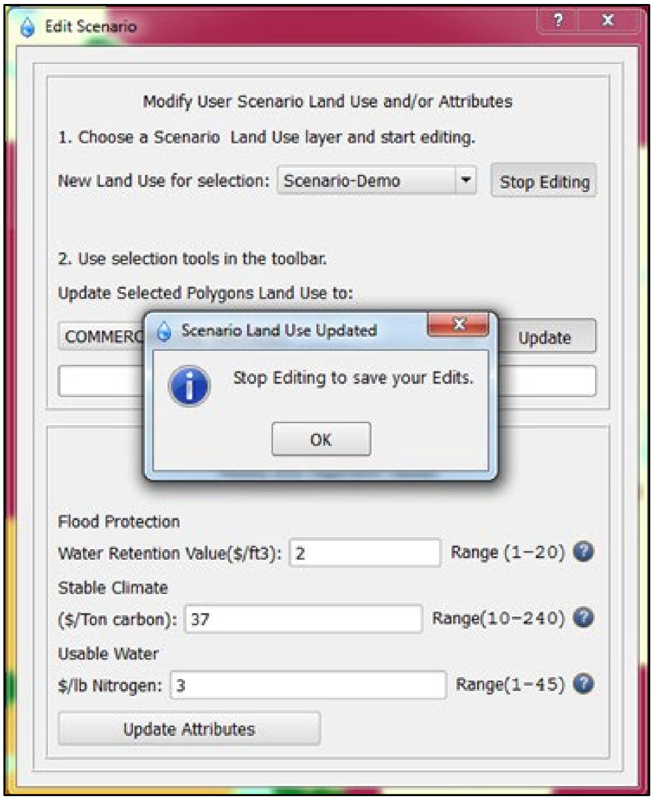


Figure 72 Scenario Land Use Updated message window

10. The user can continue editing the land use scenario in this fashion to create alternative land use scenarios for comparison and analysis.

In the example here, TREE CROPS type land use features were converted into COMMERCIAL AND SERVICES. *Figure 73* displays the newly converted land use polygon in a light red color for *Urban and Built up* land use. Multiple land uses are combined into single symbology categories for better representation on the map. In this case, the COMMERCIAL AND SERVICES land use type falls under the *Urban and Built up* land use category. This hypothetical scenario could represent an urban development project being evaluated using EPA H2O. The next step of the scenario comparison is assessment of the impact of this land use change on ES values.

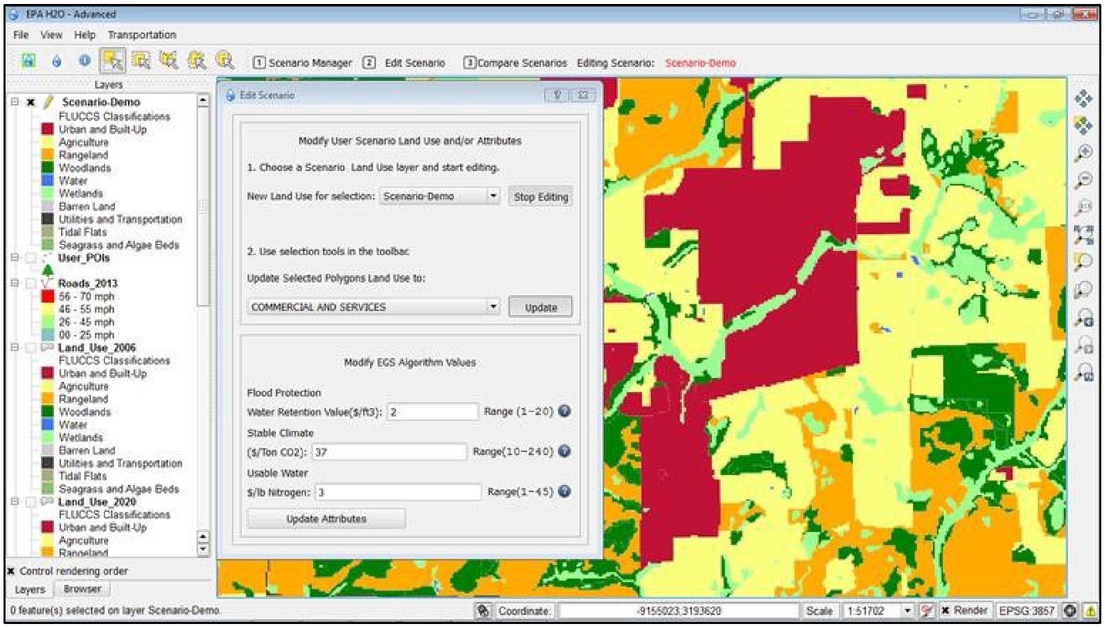


Figure 73 Edit Scenario window; the TREE CROPS polygon was converted to COMMERCIAL AND SERVICES

Technical users may also input their own land use comparison data into EPA H2O. This land use data may be edited in the same fashion, and can be used to Compare Scenarios. The Create Land Use Comparison Data section explains how the technical user may insert their own data.

Changes in land use are summarized in the Compare Scenarios section.

Edit ES Unit Values

The ES value estimation algorithm used for each ES is explained below and detailed further in the ES Calculations Theory section.

Stable Climate - https://archive.epa.gov/ged/tbes/web/html/AStableClimate.html

The social cost of carbon was used to value carbon sequestration. The dollar value of carbon reductions in the form of the greenhouse gas carbon dioxide has been estimated as \$20 per ton (\$0.01 per lb) of Carbon Dioxide in 2010 (US Government 2010). We applied this 2010 estimate across years without year specific corrections for inflation. This social cost of carbon is an estimate of the monetized damages associated with an incremental increase in carbon emissions for a given year. It is intended to include, but is not limited to, changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. Even without year specific cost adjustments the \$20 per ton of CO represents a conservative estimate that has been recalculated as 12 times larger using a discount rate more appropriate for intergenerational cost-benefit analysis (Johnson and Hope, 2012). Carbon sequestration rates were multiplied by the conservative cost estimate to arrive at the total value of this ecosystem good that benefits humans by moderating climate change and then summarized by National Hydrography Dataset Plus catchments (http://www.horizon-systems.com/nhdplus/).

Flood Protection - https://archive.epa.gov/ged/tbes/web/html/FloodProtection.html

The replacement cost for installing drainage infrastructure to compensate for lost water retention was used as an estimated value of reduced flooding. Retained volume of water was multiplied by \$2 per cubic foot, a default cost of built drainage infrastructure. For our 30x30m cells:

$Value = mm* 304.8 mm per ft * 9687.5 ft2 per cell * $2 per ft3 = $63.57 per mm water retained.

These values were then summarized by National Hydrography Dataset Plus catchments. (http://www.horizon-systems.com/nhdplus/).

Usable Air - https://archive.epa.gov/ged/tbes/web/html/UsableAir.html

The relative air pollutant cost to human health was used to translate the various pollutant removal rates to decreases in human health impact costs. The estimated value for removal of the selected pollutants was $959/ton Carbon Monoxide, $6752/ton Ozone, $1653/ton Sulfur Dioxide, $4508/ton PM10, and $6752 ton NO2 (Murray et al., 1994).

The total value of air pollutant removal was calculated as

Air Pollution Removed= ∑ Value * FluxRate * %Can * Cell Size

where i represents the individual pollutants

Value is the decrease in costs associated with a decrease in pollutant species, and FluxRate is the removal rate of the specific pollutant species. Canopy coverage estimates were used to calculate the total air pollution removed in U.S. dollars ($) per year summarized by National Hydrography Dataset Plus catchments (http://www.horizon-systems.com/nhdplus/).

Usable Water - https://archive.epa.gov/ged/tbes/web/html/UsableWater.html

Replacement costs for removing a pound of nitrogen from various sources range from less than $10 to as high as $855. Costs increase as the nitrogen becomes harder to route towards treatment areas and as simpler, more cost-efficient mechanisms for removing nitrogen need to be replaced by more centralized advanced wastewater treatment facilities. Compton et al. (2011) reviewed the cost of removing nitrogen from a wide range of sources and concluded that costs ranged from $1.22 - $43.54 per pound of nitrogen ($2.71 - $96 kg N). Abatement costs of reducing nitrogen from point sources are estimated as $8.16 per pound ($18 kg) of nitrogen (Birch et al. 2011). We use this cost as our conservative ecosystem replacement value estimate based on using traditional wastewater treatment to remove nitrogen from upstream point sources. The values are summarized by National Hydrography Dataset Plus catchments (http://www.horizon-systems.com/nhdplus/).

Several lifecycle estimates, however, including upgrading and maintaining existing or building additional advanced wastewater treatment facilities and drainage structures to remove nitrogen, put the cost as high as $855 per pound ($388 kg) of nitrogen removed (Roeder 2007). This higher ecosystem replacement value may be more appropriate than our more conservative number for illustrating the potential future value for bay habitats in a scenario of increasing nitrogen removal needs.

Users can use the *Edit Scenario* tool to modify ES dollar values. Default dollar values for flood protection ($2), stable climate ($37) and usable water ($3) can all be updated in the *Edit Scenario* window (*Figure 74*, for example these were changed to $4, $47 and $6, respectively).

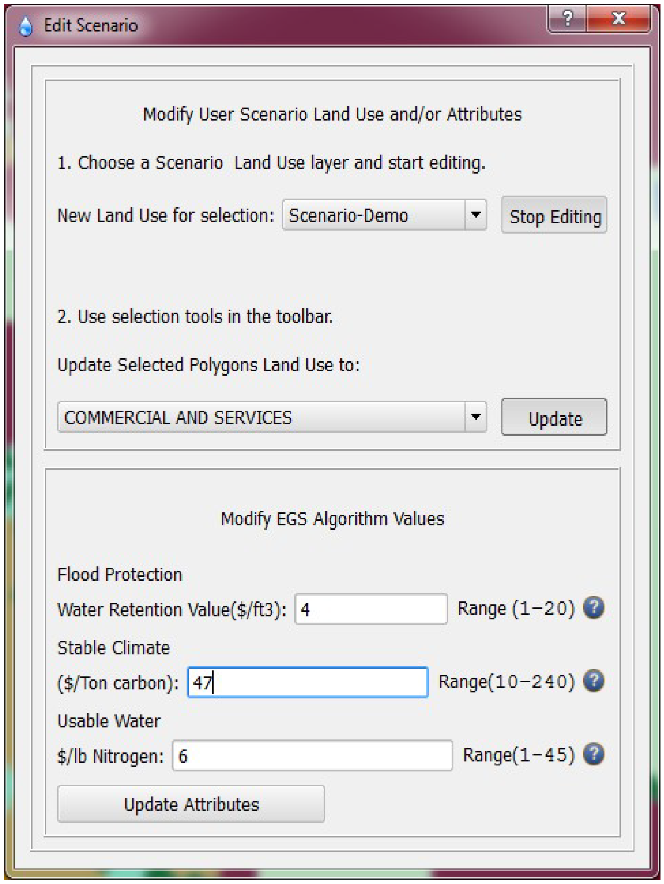


Figure 74 Edit Scenario window allows the user to change the ES Algorithm Values

1. Click the *Edit Scenario* tool to open the *Edit Scenario* window (*Figure 74*).
   a. In the *Modify EGS Algorithm Values* section, enter the preferred ES monetary value.
   b. Click the *Update Attributes* button.
2. The progress bar will appear while attributes are being updated (*Figure 75*). This may take few moments, depending on the number of the features within the area.

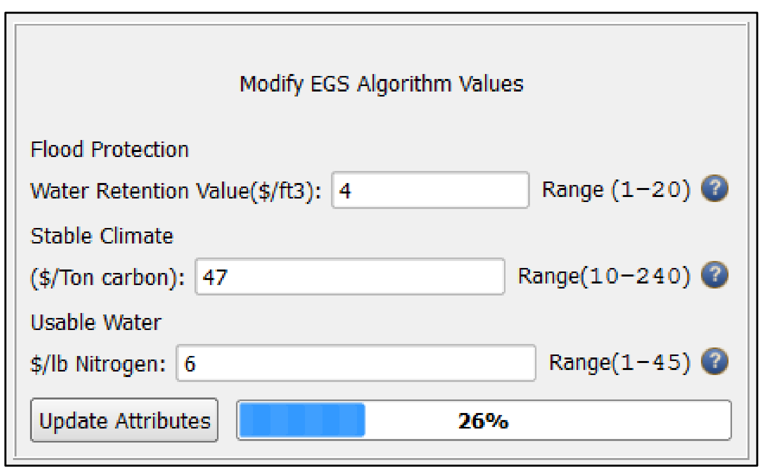


Figure 75 Modify ES Algorithm Values progress bar

3. Once the ES attributes are updated, a message will be displayed, stating the attributes have been successfully updated, and to commit changes using the *Stop Editing* button (*Figure 76*).

4. Please make sure to click *Stop Editing* to save the changes.

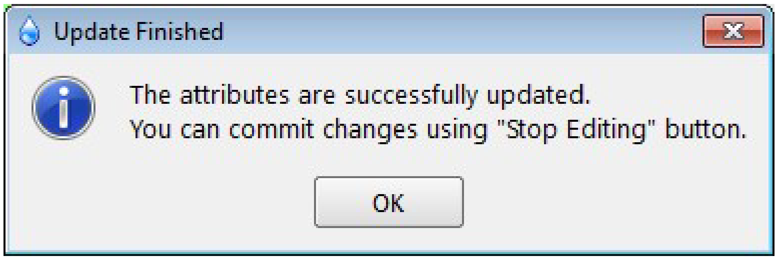


Figure 76 ES Algorithm Values Update Finished window

Changes to ES dollar values are summarized in the Compare Scenarios section. Please note, updating the ES values may result in a slight change in Flood Protection; this is due to rounding during the repopulation of the scenario's attribute table.

Compare Scenarios

This section illustrates the workflow for comparing scenarios in the Advanced Module of EPA H2O. **Note that only two scenarios can be compared at a given time**.

1. Click on the *Compare Scenario* button.
2. The *Compare Scenario* window will open (*Figure 77*):
   a. In the *Scenario A* and *Scenario B* dropdown lists, select the scenarios to be compared (e.g. *Land_Use_2006* and *Scenario-Demo*).
   b. In the *Report Name* box, type the preferred report name. If an existing report name is chosen, it will overwrite the existing report.
   c. The default report folder will be displayed in *Compare Scenario* window (C:/Users/Username/.qgis/reports/); click on the *Change* button to modify the report location.
   d. Use the *Zoom In* , *Zoom Out* , and *Pan*  icons to focus on the desired area.

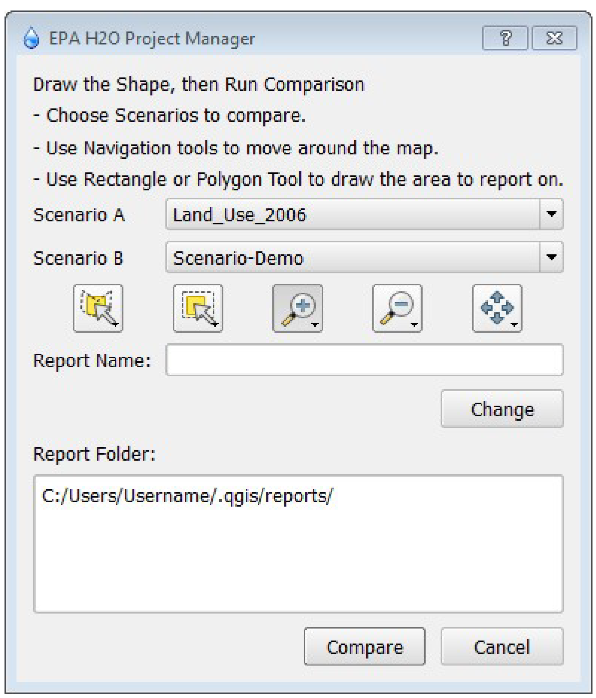


Figure 77 Compare Scenario window

e. Click on the *Area Selection*  icon and draw an area on the map for which the user wants to create the report (AOI). Please note that EPA H2O will automatically compute the upstream area and the statistics for it.

f. The user-selected area will be highlighted in a blue color (*Figure 78*). Click on the *Compare* button to generate the PDF report.

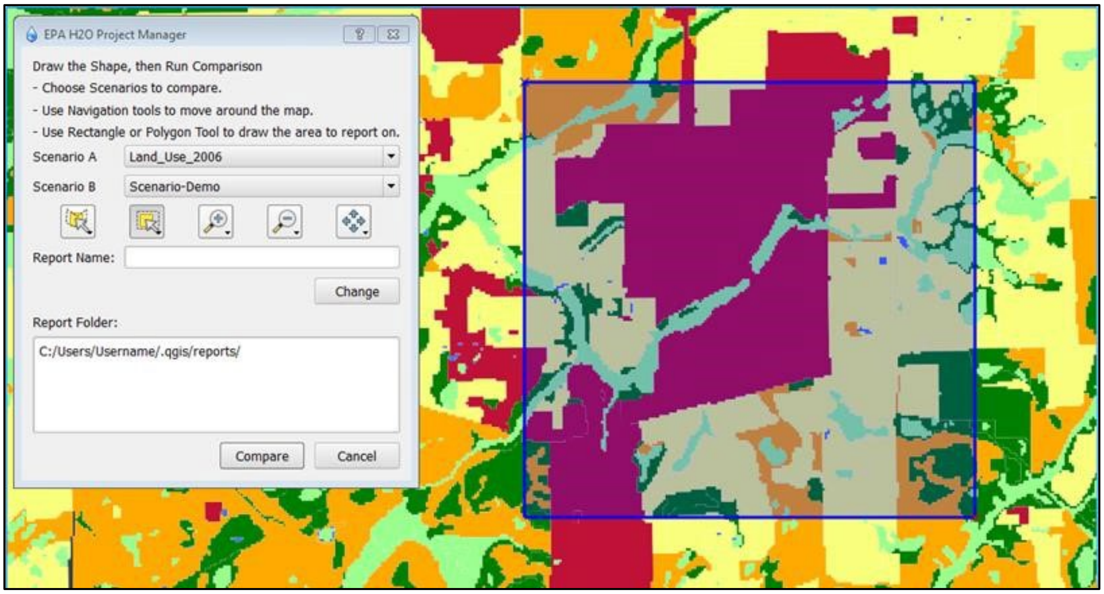


Figure 78 User-selected area is shown inside the blue box, to be used in the Compare Scenario tool

3. A progress bar will be displayed while the report is generated (*Figure 79*). It may take a few moments, depending on the size of AOI and its upstream area.

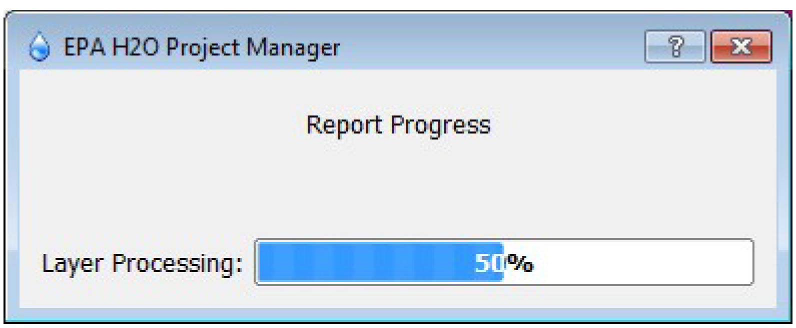


Figure 79 Compare Scenario progress bar

4. New data layers, *Area of Interest* and *Upstream Area of Interest*, will be generated in the Layers panel (*Figure 80*). The *Upstream Area of Interest* includes subwatersheds that overlap with or drain into the chosen AOI.

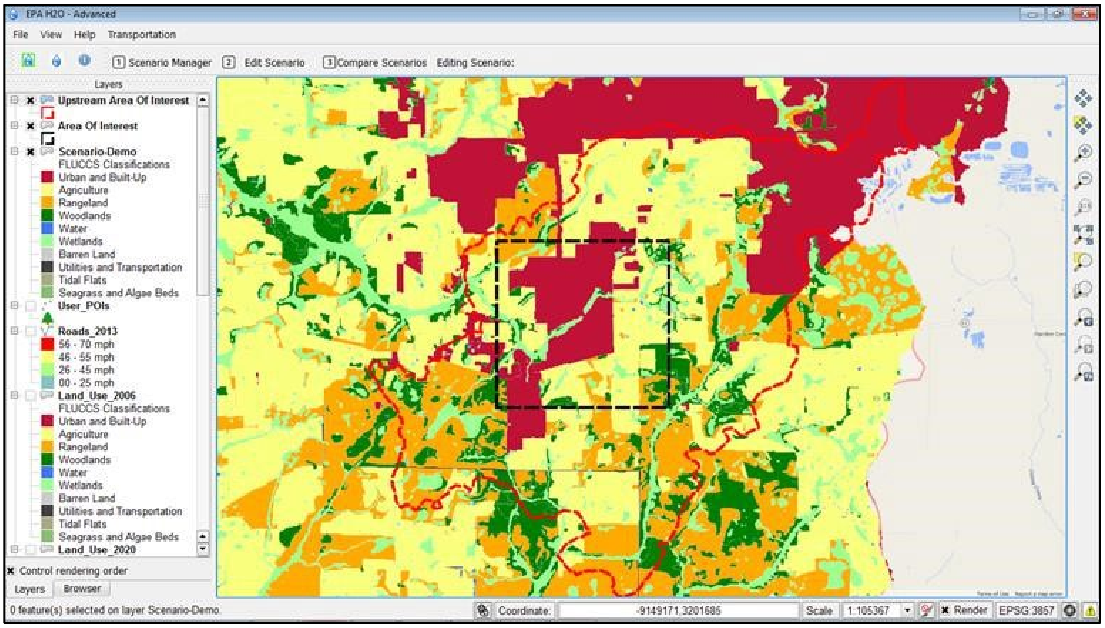


Figure 80 EPA H2O map after the Compare Scenario tool is run

Advanced Module Report Analysis

This section overviews the contents of the Advanced Module report (*Figure 81*).

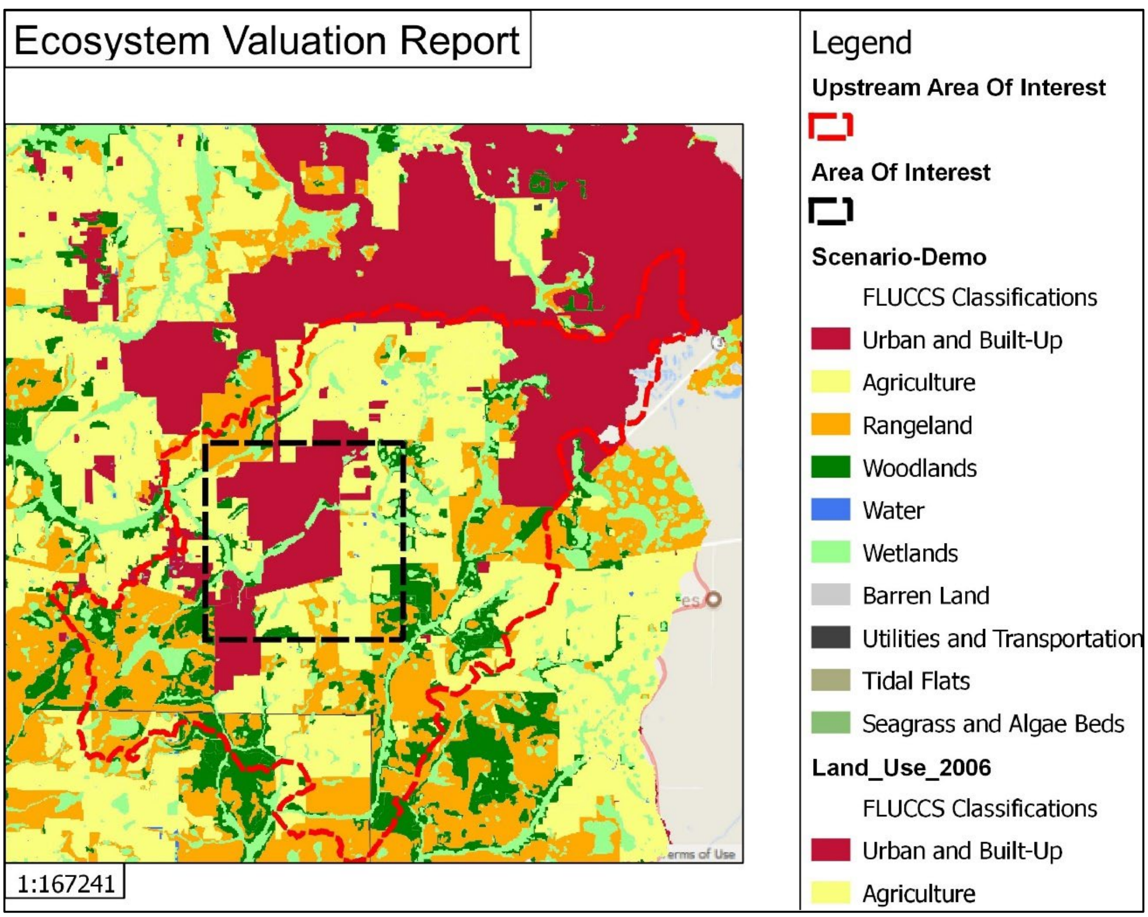


Figure 81 Sample Advanced Module report, map with legend

The cover page of the Advanced Module report contains four main map elements (*Figure 81*):

Title – Generic description of the Advanced report, "Ecosystem Valuation Report."

Legend - List of layers that are turned on/visible in the Layers panel, in the order they appear on the map. Each layer has its name and symbology, the symbols used to represent layer data and values.

Map – Data layers from the legend shown using their respective symbologies on a map.

Scale - Displayed as a ratio of map units to the actual measurement.

The Map and Legend both include layers defining the areas compared in the report:

Upstream Area of Interest – A red dashed line that is comprised of subwatersheds that overlap with or drain into the chosen AOI.

Area of Interest – A black dashed line that shows the user defined AOI for the report.

The second page of the sample report summarizes the total value of each ES in the AOI or areas upstream for each scenario (*Figure* 82). The report also provides a short description of each ES, visit US EPA's Archived Tampa Bay Ecosystem Services Project website to learn more about ES and their estimations.

In this example, the user made significant changes to the land use and attribute values in the Edit Scenarios section. Below is the interpretation of the report in relation to those changes:

- The usable water value has been increased from 2,028,898 $/yr to 4,068,561 $/yr. This is the result of increasing the value of nitrogen removed ($/lb) from 3 to 6 in the Edit ES Unit Values section, as well as the change in land use type from TREE CROPS to COMMERCIAL AND SERVICES.
- The usable air value has decreased from 486,382 $/yr to 472,583 $/yr. This is a result of converting an area of TREE CROPS to the COMMERCIAL AND SERVICES land use type (Edit Scenario Land Use section).
- The stable climate value has increased from 2,482,571 $/yr to 2,997,867 $/yr. This is a result of increasing the value of carbon removed ($/Ton) from 37 to 47 in the Edit ES Unit Values section, as well as the change in land use type from TREE CROPS to COMMERCIAL AND SERVICES.
- The flood protection value significantly increased, from 27,214,370 $/yr to 50,768,155 $/yr. This is a result of increasing the water retention value ($/ft^3) from 2 to 4 in the Edit ES Unit Values section, as well as the change in land use type from TREE CROPS to COMMERCIAL AND SERVICES.
- The TREE CROPS area has been changed from 2,578,233 sq. meters to 893,548 sq. meters. The reduction of the area is due to converting TREE CROPS to COMMERCIAL AND SERVICES in the Edit Scenario Land Use section.
- The COMMERCIAL AND SERVICES area has increased from 6,903 sq. meters to 1,691,588 sq. meters. This is also a result of converting TREE CROPS to COMMERCIAL AND SERVICES in the Edit Scenario Land Use section.

STATISTICS FOR LAYERS IN DRAWN AREA
DRAWN AREA OF INTEREST: 3,373 Hectares

Usable Water: Human activities produce water pollutants. As water moves through a watershed it is filtered by wetlands, forests, and aquatic areas. Replacement costs for removing a pound of nitrogen from various sources range from less than $10 to as high as $855.Costs increase as the nitrogen becomes harder to route towards treatment areas and as simpler, more cost efficient mechanisms for removing nitrogen need to be replaced by more centralized advanced waste water treatment facilities.

Land_Use_2006	Scenario-Demo
Estimated total value ($) per year: 2,028,898	Estimated total value ($) per year: 4,068,561

Usable Air: Human activities produce air pollutants. Trees and other plants remove these harmful pollutants. Pollution removal results in healthier people with reduced health care costs. The loss of trees and other plants would result in increased health care costs and decreased human well-being.

Land_Use_2006	Scenario-Demo
Estimated total value ($) per year: 486,382	Estimated total value ($) per year: 472,583

Stable Climate: Stored carbon provides a more stable climate by keeping greenhouse gasses out of our atmosphere. Carbon dioxide (CO2) is the primary greenhouse gas emitted through human activities. Carbon sequestration helps reduce future social costs associated with a more unstable climate.

Land_Use_2006	Scenario-Demo
Estimated total value ($) per year: 2,482,571	Estimated total value ($) per year: 2,997,867

Flood Protection: Human activities alter the way water moves through the landscape. Natural landscapes retain and slow the movement of water offering protection from flooding. The loss of these natural landscapes would result in the need for more man made flood protection at much higher cost. Flood protection value below is summarized for the Area of Interest (AOI) that user has selected.

Land_Use_2006	Scenario-Demo
Estimated total value: 27,214,370	Estimated total value: 50,768,155

Land Use: Land maps are made from Florida Land Use and Cover Classification System (FLUCCS) data. These are photo interpretations of aerial photographs. Future scenarios are the result of models or subjective table top exercises.

Land_Use_2006	Scenario-Demo
COMMERCIAL AND SERVICES : 6,903	COMMERCIAL AND SERVICES : 1,691,588
CROPLAND AND PASTURELAND : 3,013,963	CROPLAND AND PASTURELAND : 3,013,963
CYPRESS : 13,034	CYPRESS : 13,034
EMERGENT AQUATIC VEGETATION : 3,453	EMERGENT AQUATIC VEGETATION : 3,453
EXTRACTIVE : 10,736,479	EXTRACTIVE : 10,736,479
FRESHWATER MARSHES : 540,723	FRESHWATER MARSHES : 540,723
HARDWOOD CONIFER MIXED : 990,388	HARDWOOD CONIFER MIXED : 990,388
INDUSTRIAL : 19,586	INDUSTRIAL : 19,586
OPEN LAND : 225,608	OPEN LAND : 225,608
OTHER OPEN LANDS <RURAL> : 1,483,856	OTHER OPEN LANDS <RURAL> : 1,483,856
PINE FLATWOODS : 1,075,387	PINE FLATWOODS : 1,075,387
RESERVOIRS : 62,145	RESERVOIRS : 62,145
RESIDENTIAL LOW DENSITY < 2 DWELLING UNITS : 556,640	RESIDENTIAL LOW DENSITY < 2 DWELLING UNITS : 556,640
ROW CROPS : 6,655,527	ROW CROPS : 6,655,527
SHRUB AND BRUSHLAND : 2,596,880	SHRUB AND BRUSHLAND : 2,596,880
SPECIALTY FARMS : 97,830	SPECIALTY FARMS : 97,830
STREAM AND LAKE SWAMPS (BOTTOMLAND) : 1,953,085	STREAM AND LAKE SWAMPS (BOTTOMLAND) : 1,953,085
TREE CROPS : 2,578,233	TREE CROPS : 893,548

Figure 82 Sample Advanced Module report; summary of ES in each scenario

Delete Scenario

This section illustrates the workflow for deleting a user-defined scenario in EPA H2O's Advanced Module.

1. Click on *Scenario Manager* to open the *Scenario Manager* window (*Figure 83*).
   a. Under *Delete Scenario* dropdown list, select the desired scenario to-be-removed.
   b. Click on the *Delete* button to delete the scenario. All the land use features and ES value data for that scenario will be deleted. **Deletion of a scenario is irreversible.**

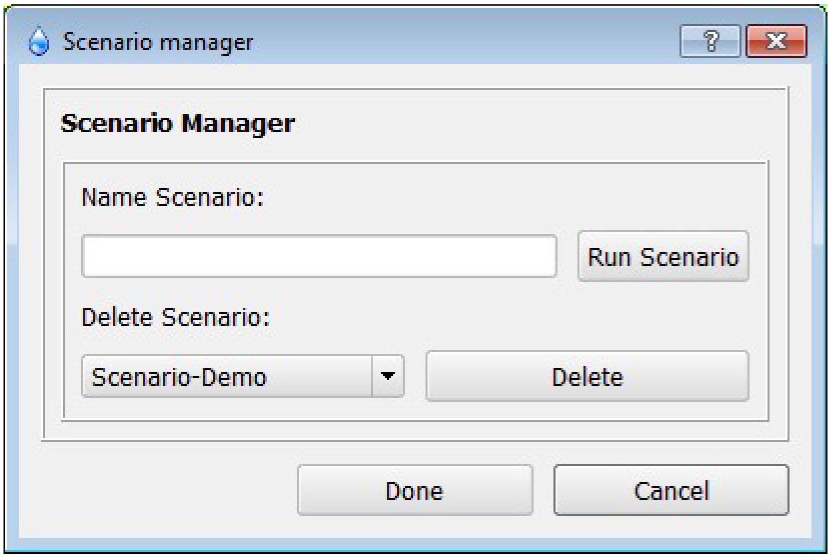


Figure 83 Scenario Manager window, used to irreversibly delete a scenario

Transportation Tool (Advanced Module Only)

The transportation tool allows for an assessment of connectivity between potential users and ecosystem services by measuring the proximity in both distance and time between population centers and ES points of interest defined by the user (e.g., parks, greenways, forests).

The Transportation tool in the Advanced Module of EPA H2O allows users to:

- Add Points of Interest (POI) to the existing transportation network.
- Edit the existing transportation network.
- Compare changes in driving and walking time to POIs for the existing and modified transportation network.

This section illustrates use of Transportation Module features.

1. Create or choose an existing project with a defined AOI (see Select AOI section) and open in the Advanced Module (see Advanced Module section).
2. Click *Transportation* menu > *Transportation scenario manager* (*Figure 84*).

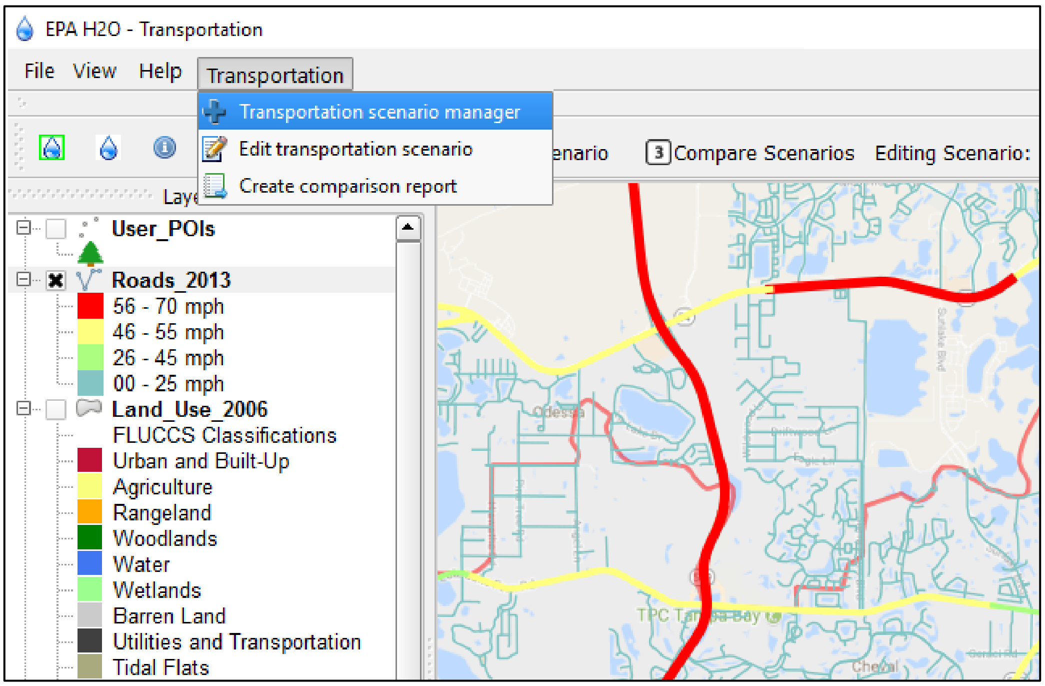


Figure 84 Location of the Transportation scenario manager in EPA H2O

3. The *Transportation scenario manager* window will appear (*Figure 85*):
   a. In the *Name Scenario* box, enter the desired scenario name.
   b. Click the *Run Scenario* button to create a new, editable Transportation layer.
   c. Click *Done* to close the window.

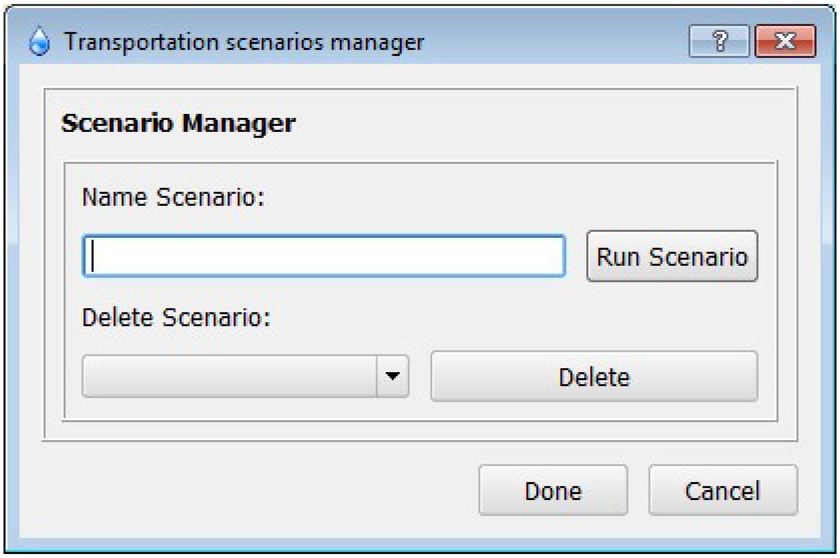


Figure 85 Transportation Scenario Manager window

4. Under the *Transportation* menu, choose *Edit transportation scenario* (*Figure 86*).

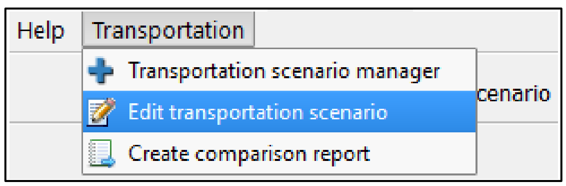


Figure 86 Location of the Edit transportation scenario tool in the Transportation menu

5. The *Edit Transportation Scenario* window will open.
   a. In the *Scenario to Edit* dropdown list, select a scenario to edit (e.g. *Scenario- Demo, Figure 87*).
   b. Click the *Start Editing* button.

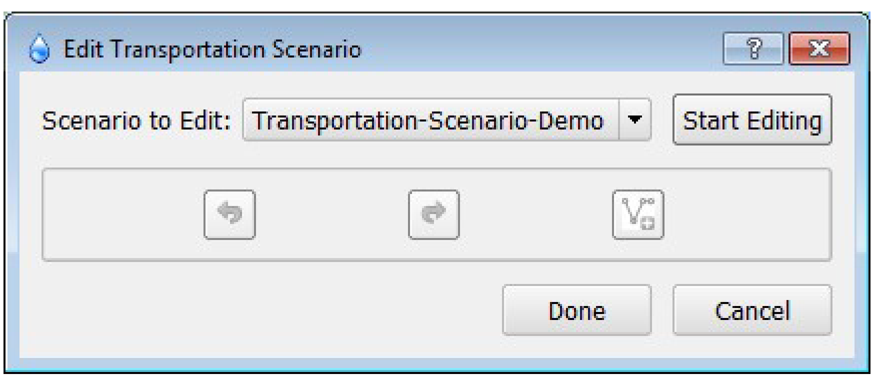


Figure 87 Edit Transportation Scenario window

6. Click the *Connector*  icon to add a new road to the map.
   a. Single click on the map to start drawing the road
   b. Single click again to add a bend or joint in the road
   c. Double click to finish drawing the road

Note: Although new road lines may appear to start at an existing road, the Transportation Module will only route to the existing road if the new road intersects it. To ensure the roads intersect, users should place the start point for new roads before the desired intersection so that the new road crosses over the existing road. The end point for new roads will automatically snap to the nearest vertex of an existing road, ensuring an intersection but potentially altering the end point location of the new road.

7. In the *New Road Feature* window (*Figure 88*):
   a. In the *Road Name* text box, type the preferred road name.
   b. In the *Speed (mph)* text box, designate a speed limit in miles per hour.
   c. Click OK

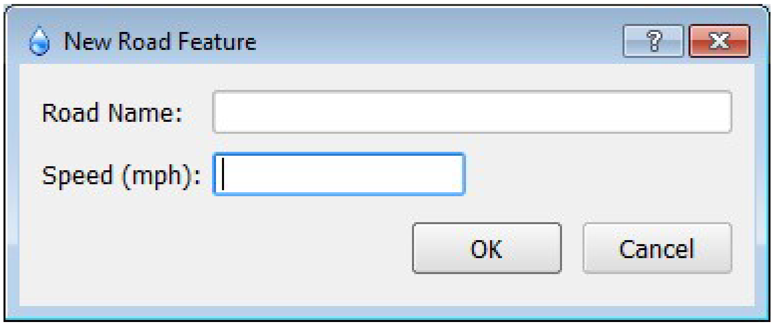


Figure 88 New Road Feature window

8. The user can add multiple roads in a similar fashion (repeating steps 6 & 7).
9. The *New Road Feature* window can also be used to create recreational trails. Roads not intended for driving should receive a speed limit of 1 mph.
   a. The Transportation Module looks for the fastest route of travel during the Transportation Scenario Comparison Report. A speed limit of 1 mph will decrease the likelihood that the new trail is used for driving.
   b. However, when a Point of Interest (POI) is located off the Road network, the point is associated with the nearest road available. If a POI is closest to a user-created trail (with 1 mph speed), the Transportation Module will drive on this slow road.
10. In the *Edit Transportation Scenario* window click *Stop Editing* to save edits and click *Done* to close the window.

Multiple transportation scenarios can be generated each with multiple roads added or altered. These scenarios can then be compared using the *Create Comparison Report* tool.

Transportation Scenario Comparison Report

Comparison reports are tables of travel times between a starting location and all the Points of Interest (POIs) within a given radius. Any two transportation scenarios can be compared by creating comparison reports:

1. Under the *Transportation* menu, choose *Create comparison report* (*Figure 89*).

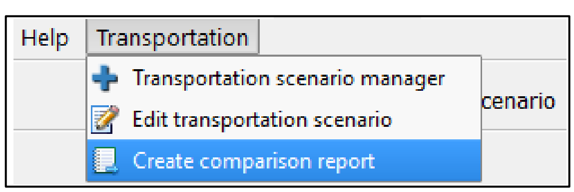


Figure 89 EPA H2O transportation map and location of the Create comparison report tool

2. The transportation report window will appear (*Figure 90*).

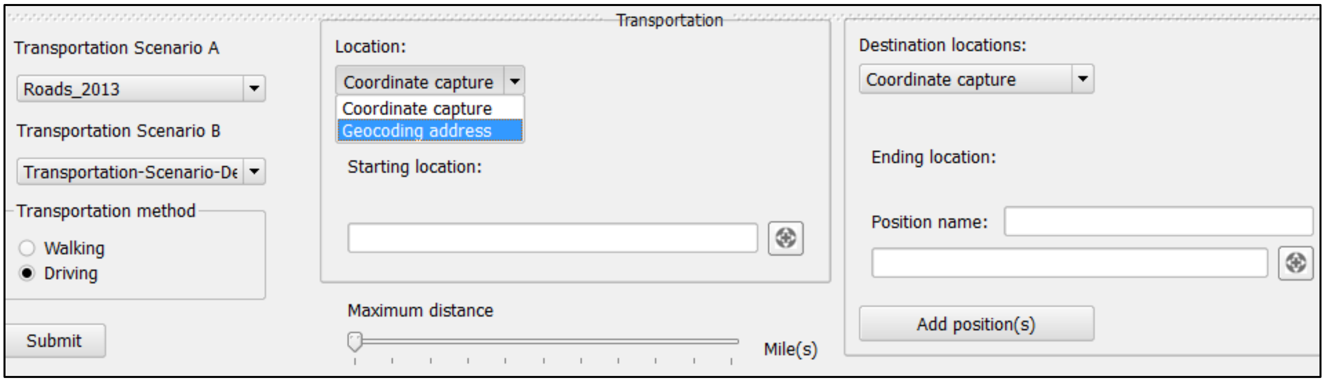


Figure 90 Two input methods for the starting point in the Transportation tool

3. The starting point can be chosen using two input methods (*Figure 90*):
   a. Coordinate capture:
      i. In the *Starting location* box, enter the latitude and longitude coordinates, or click the *Coordinate capture* icon and use the crosshair cursor to select a point on the map (*Figure 91*).

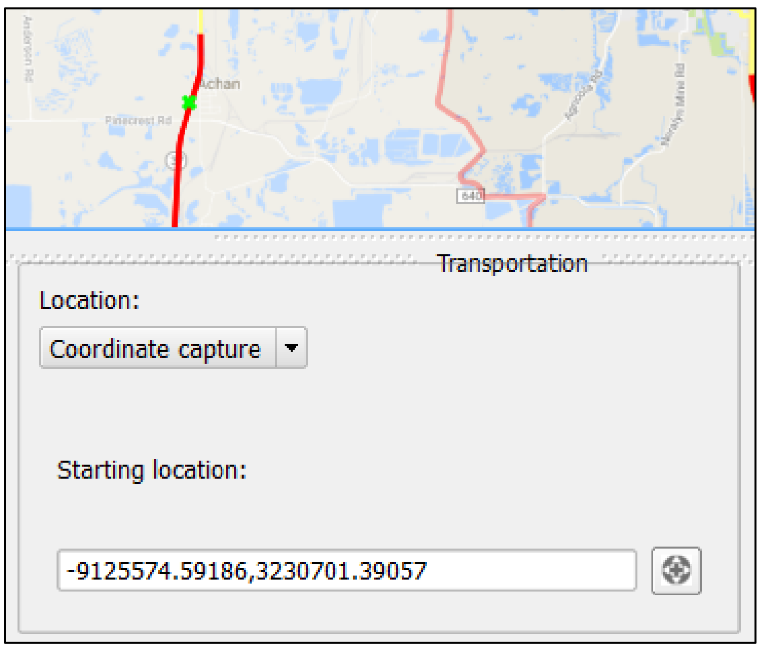


Figure 91 Coordinate capture option chosen to indicate a starting point in the Transportation tool

   b. Geocoding address:
      i. In the *Geocoding address* box, enter the full address (*Figure 92*). All address fields must be filled out to geocode an address (Address, City, State, Zip code).
      ii. Click *Submit.*

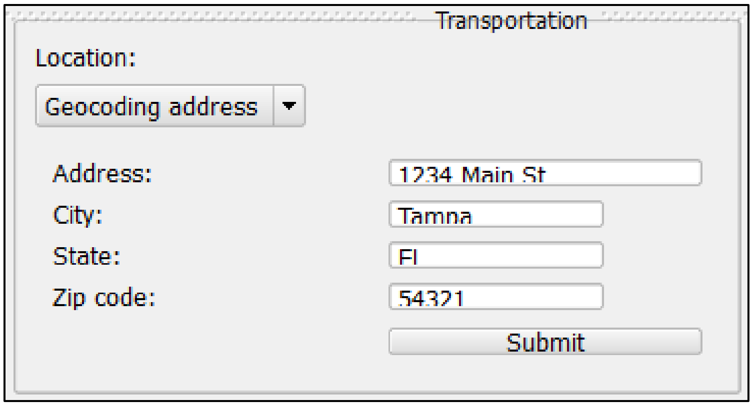


Figure 92 Geocoding address option chosen to indicate a starting point in the Transportation tool

4. Once the starting point is chosen, slide the *Maximum Distance* buffer bar to constrain the analysis to a set Euclidean distance (miles) to POI's. POI's outside this distance will not be considered.
5. In the *Transportation Scenario A* and *Transportation Scenario B* dropdown lists (*Figure 93*), choose two different transportation scenarios to compare.
6. Choose the Transportation method, either *Walking* or *Driving*:
   a. *Walking* – analyzes routes using a constant walking speed of 8 miles per hour in the scenario comparisons. It also limits analysis to roads that are safe for pedestrians. The phrase "No Path" will appear in the comparison report if a point of interest is only accessible using a highway.
   b. *Driving* – analyzes routes using the speed limit designated in the scenario comparisons.

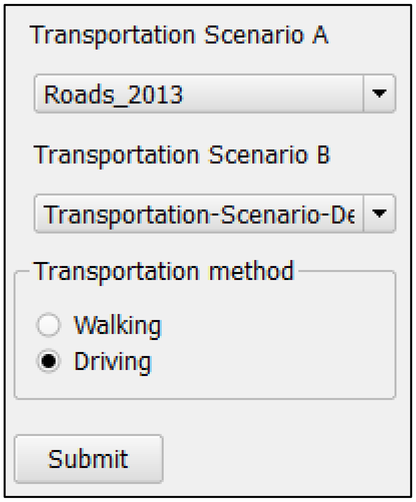


Figure 93 Transportation tool with two different scenarios and the Driving method selected

7. Click *Submit* to run the comparison and generate a report (*Figure 93*).
8. A *Warning!* window may appear (*Figure 94*). If satisfied with the road changes made, click *Yes.* If not, click *No* and adjust the scenario accordingly.

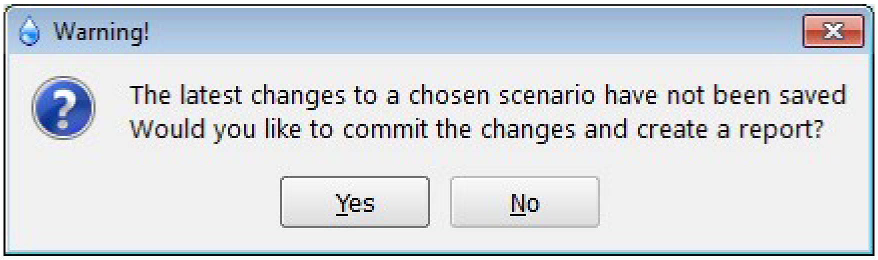
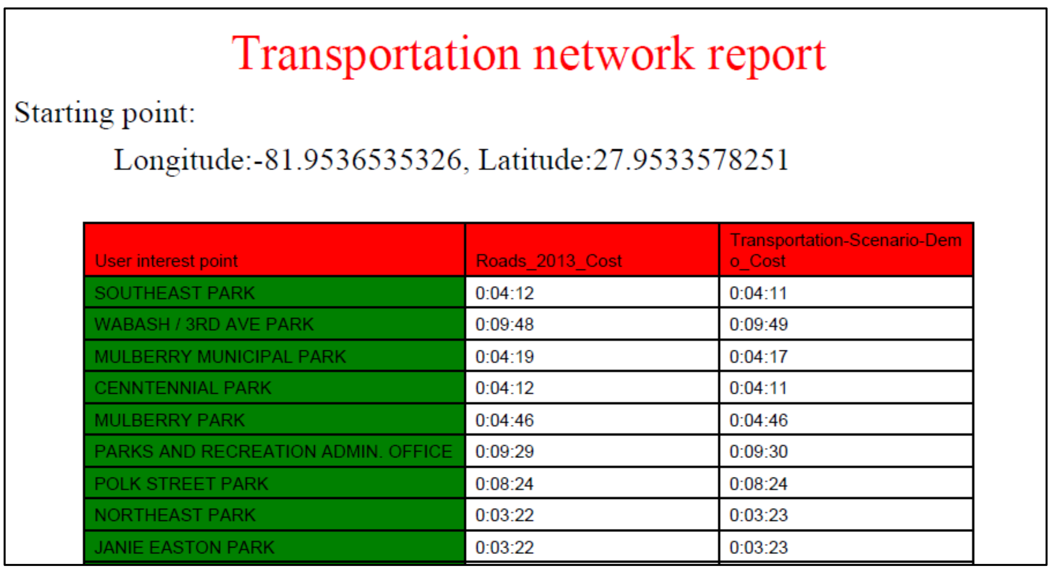


Figure 94 Warning! message to confirm changes to Road network

9. Once generated, a report will open in the system's default PDF reader.
10. The Transportation report contains five main components (*Figure 95*):
    Title – General description of the report, "Transportation network report"
    Starting point – When using the *Geocoding address* option, this is the address entered. If using the *Coordinate capture* option, this is the latitude and longitude selected.
    User interest point column – Lists the names of the points in the *User_POIs* layer.
    Scenario A – Column that contains the name of the first network chosen, and the time in hh:mm:ss it would take to drive or walk from the starting point to each POI.
    Scenario B – Column that contains the name of the second network chosen, and the time in hh:mm:ss it would take to drive or walk from the starting point to each POI.



Transportation network report

Starting point:

Longitude:-81.9536535326, Latitude:27.9533578251

User interest point	Roads_2013_Cost	Transportation-Scenario-Demo_Cost
SOUTHEAST PARK	0:04:12	0:04:11
WABASH / 3RD AVE PARK	0:09:48	0:09:49
MULBERRY MUNICIPAL PARK	0:04:19	0:04:17
CENNTENNIAL PARK	0:04:12	0:04:11
MULBERRY PARK	0:04:46	0:04:46
PARKS AND RECREATION ADMIN. OFFICE	0:09:29	0:09:30
POLK STREET PARK	0:08:24	0:08:24
NORTHEAST PARK	0:03:22	0:03:23
JANIE EASTON PARK	0:03:22	0:03:23

Figure 95 Example of the Transportation Network report in EPA H2O

11. **Please note:** starting points and ending points that are located off the Roads network are calculated differently.
    a. Starting points will snap to the nearest vertex in a road and calculate travel time from that point.
    b. Ending points will snap to the nearest line in the Road network and calculate travel time from that spot in the road.
    c. Therefore, the Transportation network report is an estimate; point locations and travel times may vary slightly.

Select POI

The *Parks_and_Recreation* layer is used for *User_POIs* by default. However, the user may add points of interest (POIs) to the *User_POIs* using the *Destination Locations* dropdown list in the destination locations section (*Figure* 96) of the transportation tool (*Figure 90*). There are three options in this dropdown list for adding points of interest:

- Coordinate Capture – by POI coordinate longitude and latitude, or clicking on the map.
- Geocoding Address – by POI address.
- Load Point of Interest file – by .csv file of POI addresses.

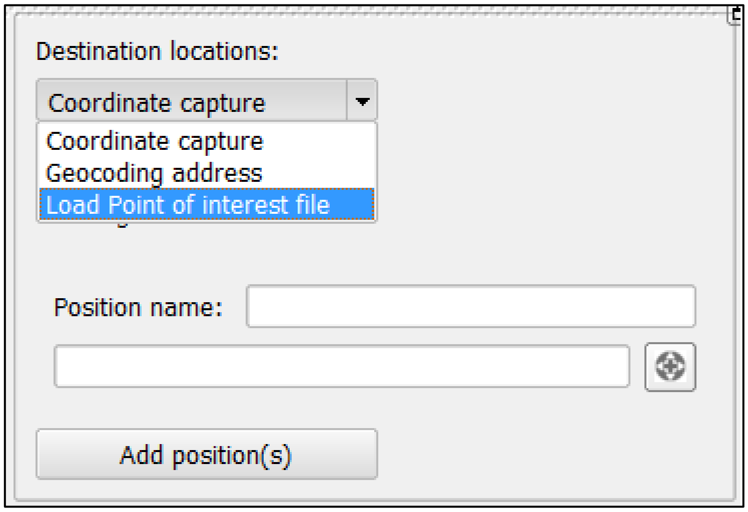


Figure 96 Methods of determining Destination Location in EPA H2O Transportation tool

Coordinate Capture

1. In the *Destination locations* dropdown list, choose *Coordinate capture* (*Figure 96*).
2. In the *Position name* text box, enter the desired POI name.
3. In the following text box, enter the longitude and latitude, or click the *Coordinate capture*  icon and select coordinates on the map for the POI. A blue cross marker will indicate the user-selected POI on the map (illustrated by arrow in *Figure 97*).
4. Click on the *Add positions(s)* button.

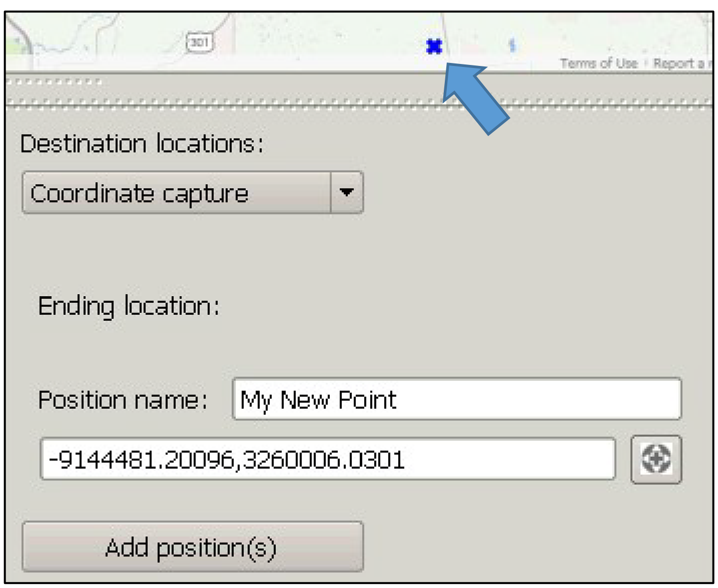


Figure 97 Destination location (blue X, indicated by blue arrow) chosen by Coordinate capture

Geocoding Address

1. In the *Destination locations* dropdown list, choose *Geocoding address* (*Figure 96*).
2. Type in the POI Street Address, City, State, and Zip Code (*Figure 98*).
3. Click the *Submit* button. A blue cross marker will indicate the user selected POI on the map.
4. Click on the *Add positions(s)* button.

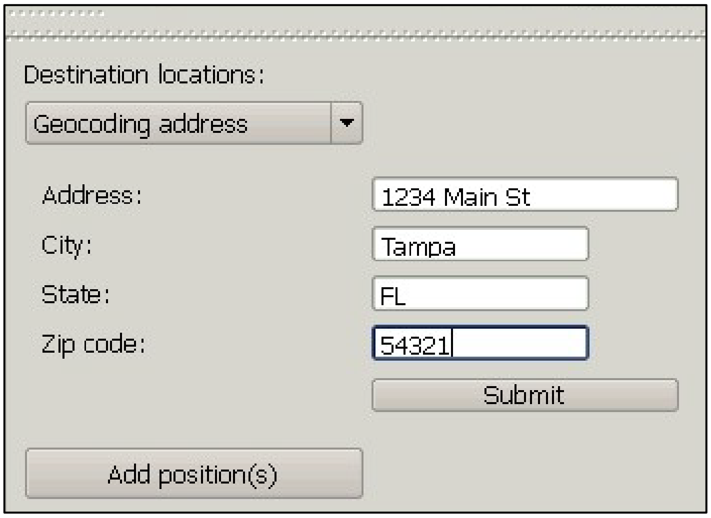


Figure 98 Destination location chosen by Geocoding address in Transportation tool

Load Point of Interest file

1. In the *Destination locations* dropdown list, choose *Load Point of interest file* (*Figure 99*).

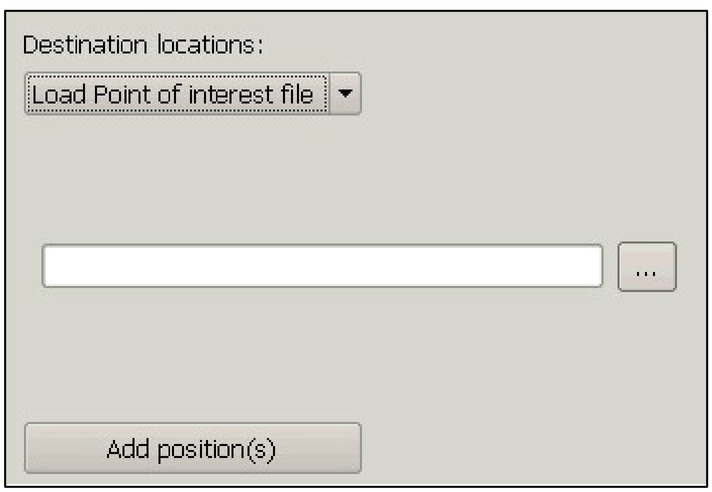
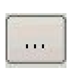


Figure 99 Destination location chosen by Load Point of Interest file in Transportation tool

2. Click on the *Browse* button  (under the *Destination locations* dropdown list) to select the user's POI file on the computer (*Figure 99*).

Note: only comma delimited CSV files are acceptable. The CSV file should have the headers *Name*, *Address* as shown in *Figure 100*.

```
Name,Address
Busch Gardens Tampa,"10165 N Malcolm McKinley Dr, Tampa, FL 33612"
Al Lopez Park,"4810 N Himes Ave, Tampa, FL 33614"
Lowry Park,"7525 N Blvd, Tampa, FL 33604"
Lettuce Lake Park,"6920 E Fletcher Ave, Tampa, FL 33637"
```

Figure 100 Sample comma delimited CSV file as Point of Interest in Transportation tool

Please note: new POIs are not visible until the user refreshes the map (see refresh in Map Navigation Toolbar).

To run a report with the added POIs, click the *Submit* button under the *Transportation method* section (see Transportation Scenario Comparison Report). New POIs will be located at the bottom of the list.

Power Mode

This section illustrates the step-by-step procedure to set EPA H2O to Power Mode by changing the registry settings. Power mode allows the user to enable all the default QGIS functionality in EPA H2O. A few key features available by enabling the Power Mode include:

- Use of all the QGIS tools for navigation, analysis, printing etc.
- Installation of QGIS plug-ins and updates to existing plug-ins.
- Customization of EPA H2O user interface layout.
- Ability to develop a new EPA H2O database, as explained in the Database Creation section.

To set EPA H2O to Power Mode:

1. **Ensure EPA H2O is started at least once in the default mode before switching it to the Power mode.**
2. Open *Command Prompt* from *Windows* menu on the computer (*Figure 101*).

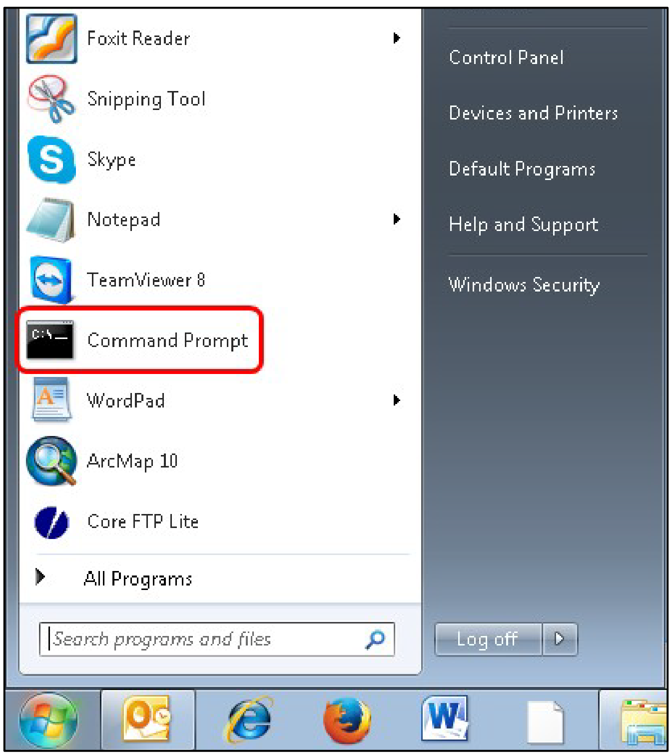


Figure 101 Command Prompt located in Windows menu

3. In a command prompt window, type REGEDIT without spaces before or after the command and press enter (*Figure 102*).

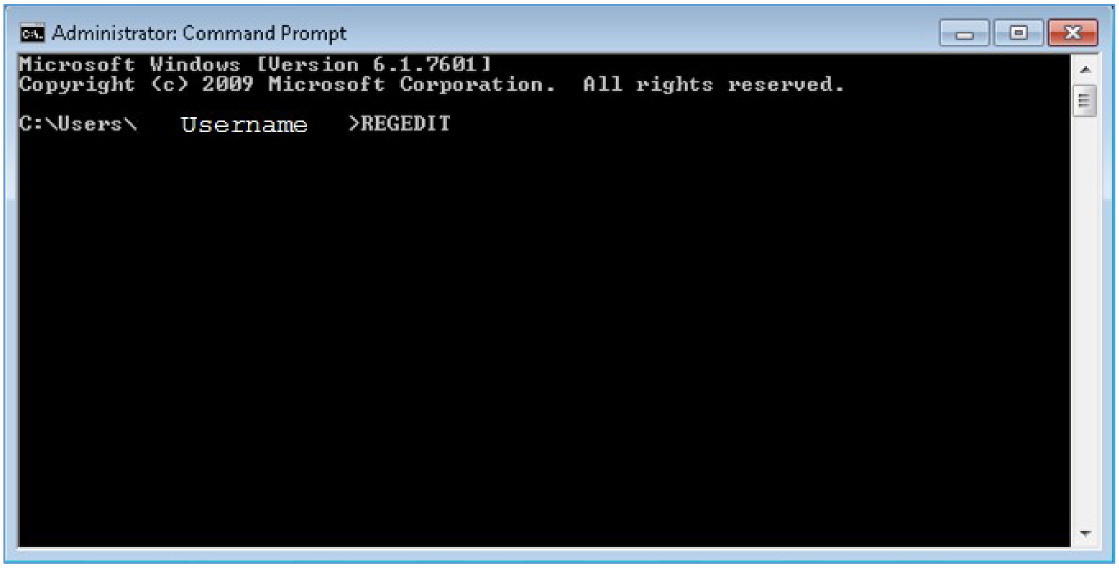


Figure 102 Command Prompt window with REGEDIT command entered

4. Within the *Windows registry* window that opens, navigate to file path:
   "HKEY_CURRENT_USER(S)\Software\EPAH2O\QGIS\PythonPlugins"
5. Right-click on the *userMode* option and select *Modify…* as shown in *Figure 103*.

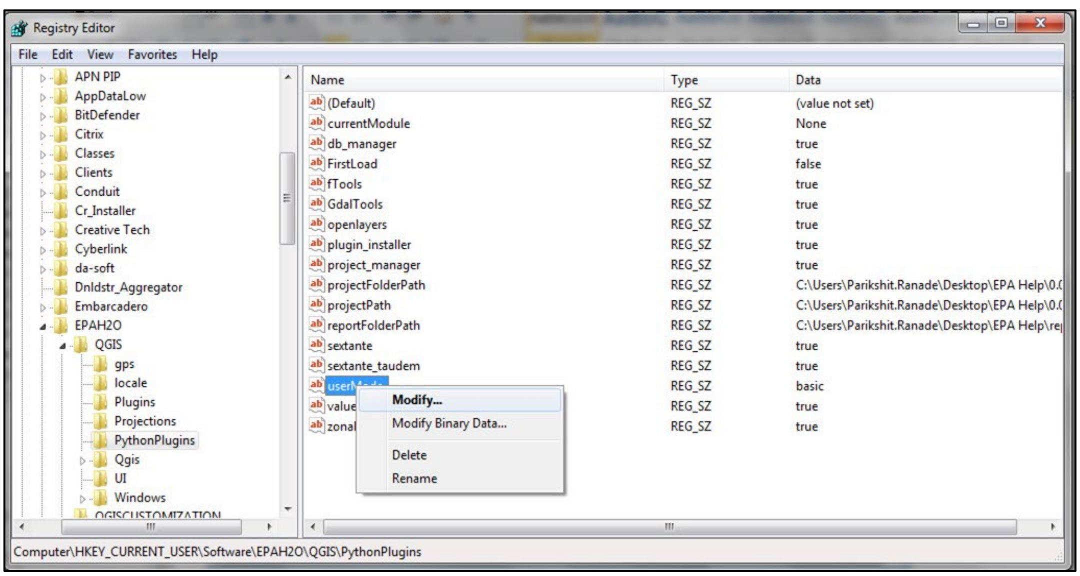


Figure 103 Modify the userMode option

6. The *Edit String* window will open (*Figure 104*). In the *userMode* key's *Value data* box, change from *Basic* to *Power* and click *OK*.

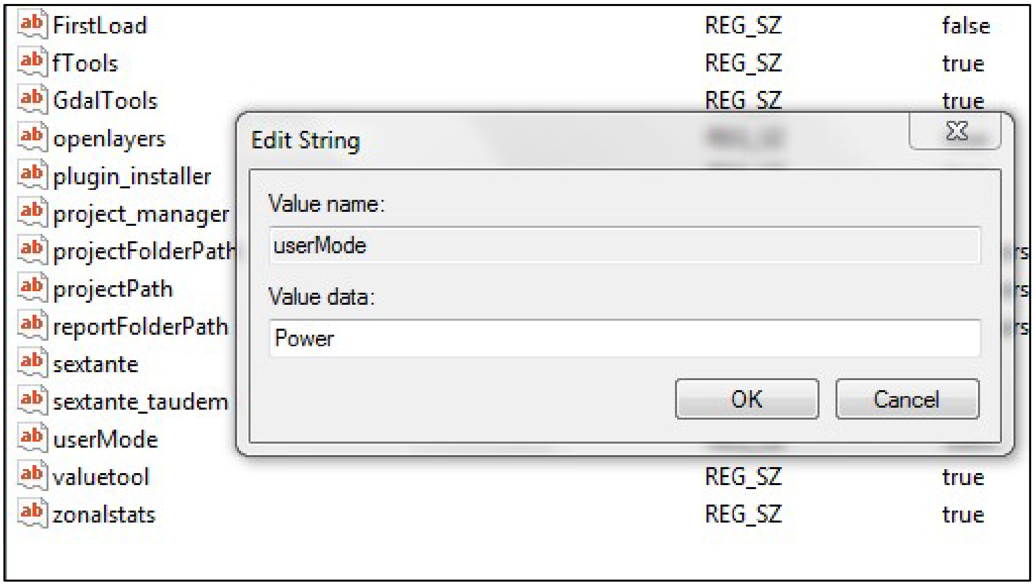


Figure 104 Change the userMode Value data to Power

7. Restart the EPA H2O program. The *Project Manager* window will appear as the EPA H2O program starts up (*Figure 105*).

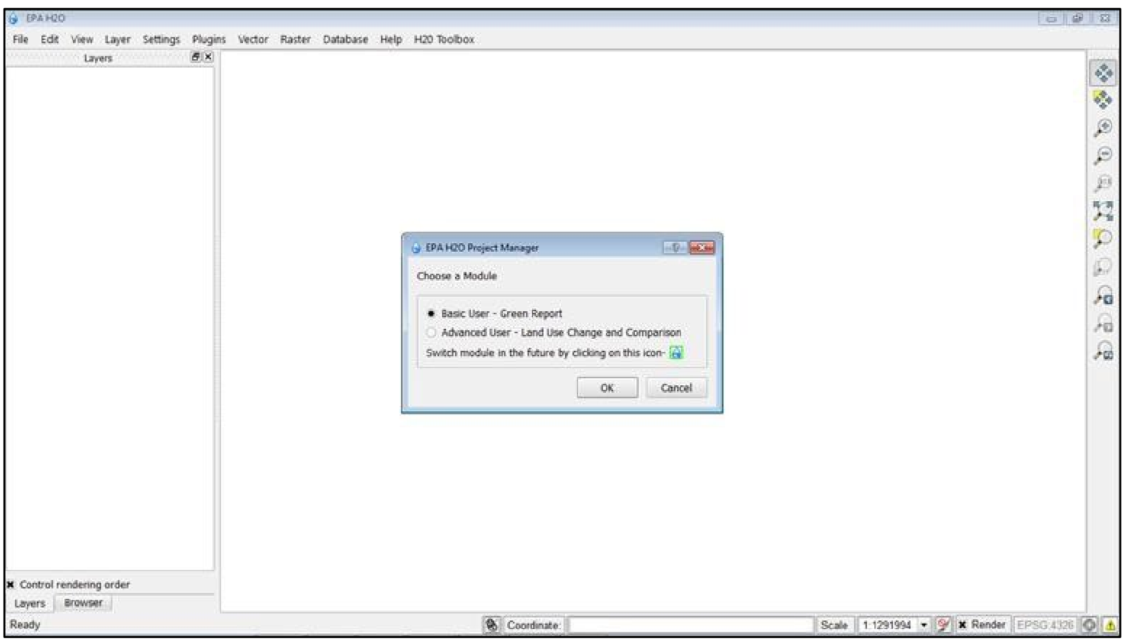


Figure 105 EPA H2O program with access to QGIS menu functionality

Menus now include *File*, *Edit*, *View*, *Layer*, *Raster,* etc., and the user now has access to complete QGIS functionality.

To change EPA H2O back to Basic/default mode, repeat steps in this section but changing the *userMode* key's *Value data* from *Power* to *Basic*.

ES Calculations Theory

This section describes the assumptions and theory underlying calculations of ES values assigned in reports. This section is **for technical users** who want to better understand calculations the tool makes so that they may adjust inputs to those calculations to make results better reflect their use case. This section starts with the Tampa dataset and FLUCCS lookup table included with EPA H2O. All descriptions, references and values used in this section are from the Tampa database and FLUCCS lookup table. The Database Creation section provides guidance on how to generate new databases and specifics on how to update lookup tables to reflect new user inputs. The Edit ES Unit Values section describes how to change the specific dollar value per unit of ES used in the calculations.

Flood Water Retention Value

The value of flood water retention (\$/ft^3) is calculated for each land use feature based on its infiltration rate, or ability to hold water, measured as the runoff Curve Number (CN) (*Figure 106*). The lower a CN is, the lower its runoff potential. For example, a land use type with a CN of 30 has a very high-water retention rate and a low runoff potential, whereas a land use type with a CN of 100 has a very low water retention rate and a high runoff potential.

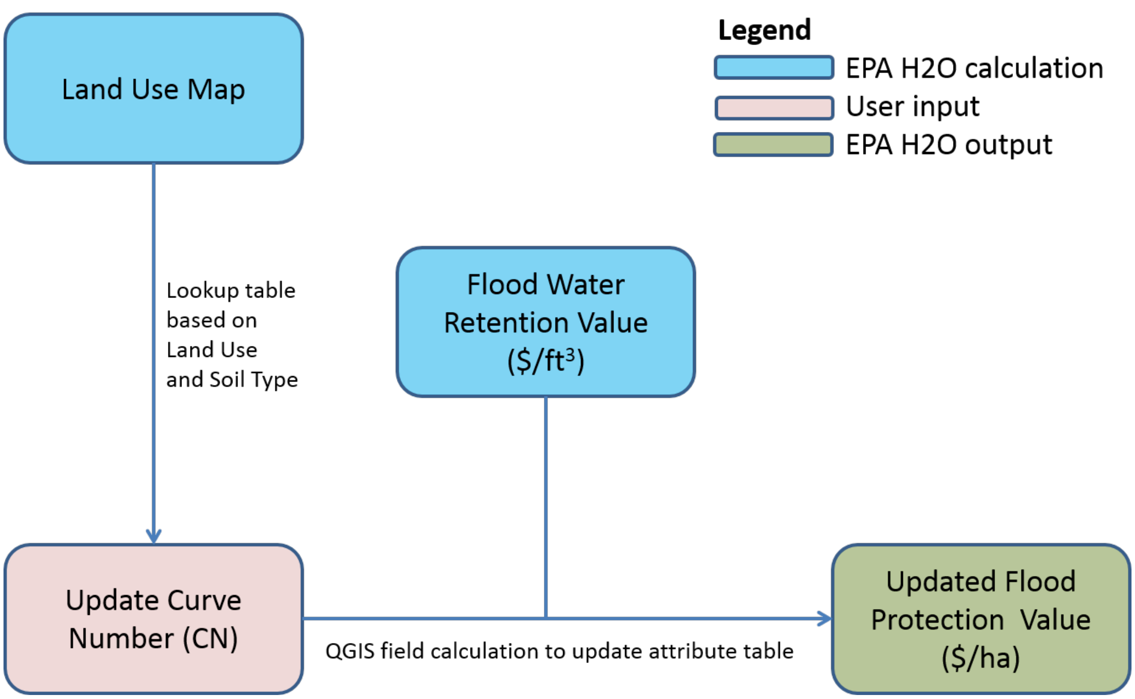


Figure 106 Flood Water Retention calculation model in EPA H2O

An area's Curve Number (CN) is determined based on the area's main SSURGO hydrologic group ("A", "B", "C" or "D") and the area's land use type. Both these feature characteristics are stored in the land use layer and can be updated as described in the Create Soil Data Layer section of database creation.

The following equations show how the flood water retention volume ("FloodProt" field) and value ($/$ft^3$) are calculated from a feature's CN and area:

Water retention depth is calculated using the feature's CN:

Depth (mm) of water retained = 0.05 * ((25,400mm / CN) – 254mm)

Depth (m) of water retained = (0.05 * ((25,400mm / CN) – 254mm))) / 1000

Total volume (m^3) of water retained is calculated using this water retention depth (m) and the feature Area (m^2):

Volume (m^3) of water retained = (0.05 * ((25,400mm / CN) – 254mm))) / 1000 * Area m^2

The Volume (m^3) of water retained can be converted from m^3 to ft^3:

Volume (ft^3) of water retained = Volume retained (m^3) * 35.3147 m^3/ft^3

To estimate the value of this retention, the Volume (ft^3) of water retained is multiplied by the replacement cost, the cost to retain the same volume using stormwater infrastructure ("waterRet" field, where the default is $2/$ft^3$):

Total Value ($/$ft^3$) = Volume retained ($m^3$) * 35.3147 m^3/ft^3 * $2/$ft^3$

This can be simplified to:

Total Value ($/$ft^3$) = Volume retained ($m^3$) * $70.629265

To calculate the value of an area using a different per unit Cost (e.g. $3/$ft^3$) a percent-change multiplier is added:

Total Value ($/$ft^3$) = Volume retained ($m^3$) * $70.629265 * ($3/ft^3/$2/$ft^3$)

The full equation would be:

Total Value ($/$ft^3$) = (0.05 * ((25,400mm / CN) – 254mm))) / 1000 * Area m^2 * 70.629265 * (Cost/2)

Usable Air Value

The usable air value ($/yr) is calculated for each land use feature based on the pollutants trees on that feature will remove, estimated using a local removal rate and the average canopy cover for that feature's land use type (*Figure 107*). The method used to determine the % Canopy Cover for each feature is described in the Tree Canopy section of database creation. Although the "Canopy" field in the lookup table is an integer value it represents the % Canopy Cover for each land use type.

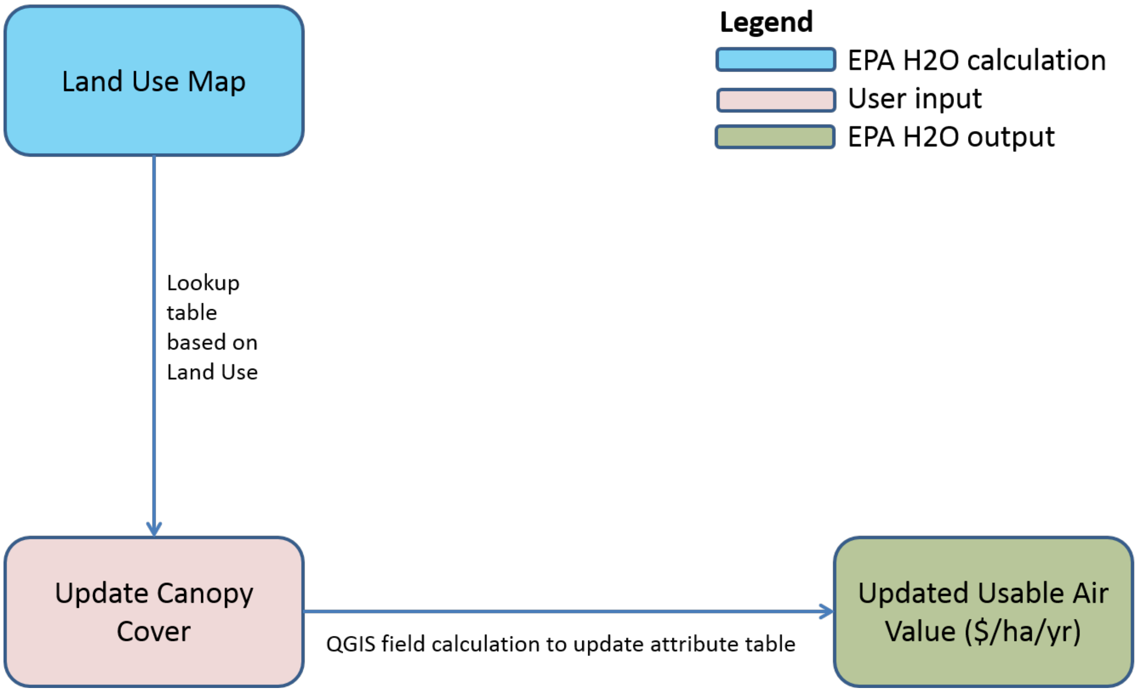


Figure 107 Air Pollution Removal calculation model in EPA H2O

The removal rate of carbon monoxide (CO), ozone (O_3), particulate matter (PM10), sulfur dioxide, and nitrogen dioxide (NO_2) were previously estimated for 55 metropolitan areas in the continental United States by Nowak et al. (2006), as the dry deposition to tree canopies. Removal rates vary depending on location; different estimated rates should be used when creating a database in a different location, following the Air Quality section. The following equations use values for Tampa, FL. The following equations are tedious, but only need to be solved once and then the lookup table can be used to directly relate land use classes to their value ($/m²/yr) for removal of pollutants.

The estimated values for removal of the selected pollutants in Tampa FL, (Murray et al., 1994), were:

$ 959/ton Carbon Monoxide
$6752/ton Ozone
$1653/ton Sulfur Dioxide
$4508/ton Particulate Matter (PM10),
$6752/ton Nitrogen Dioxide

To get the value of Carbon Monoxide removal by a feature:

Value ($/yr) = 0.5 $g/m^2/yr$ * %Canopy * (1 ton/1000000 g) * Area m^2 * 959 $/ton/yr

To get the value of Ozone removal by a feature:

Value ($/yr) = 5.8 $g/m^2/yr$ * %Canopy * (1 ton/1000000 g) * Area m^2 * 6752 $/ton/yr

To get the value of Sulfur Dioxide removal by a feature:

Value ($/yr) = 2.4 $g/m^2/yr$ * %Canopy * (1 ton/1000000 g) * Area m^2 * 1653 $/ton/yr

To get the value of Particulate Matter (PM10) removal by a feature:

Value ($/yr) = 4.5 $g/m^2/yr$ * %Canopy * (1 ton/1000000 g) * Area m^2 * 4508 $/ton/yr

To get the value of Nitrogen Dioxide removal by a feature:

Value ($/yr) = 1.1 $g/m^2/yr$ * %Canopy * (1 ton/1000000 g) * Area m^2 * 6752 $/ton/yr

Values from the removal of each pollutant are combined to get the total value of pollutant removal by a feature. The values for %Canopy and Area m^2 are consistent for a feature across all the pollutants, allowing the following simplification of the equation:

Total Value ($/yr) = 713121.5 * 1^{-6} (ton/g) * %Canopy * Area m^2

The Total Value can also be calculated in ($/$m^2$/yr):

Total Value ($/$m^2$/yr) = 0.07131215 * %Canopy

The total removal rate and value for all the pollutants removed (e.g. 0.07131215) will change when creating a database for a new location other than Tampa, FL. In the original land use layer, the Total Value equation was solved for each feature and stored in the "US_Air_Dol" Field. The lookup table now includes a "canopyVal" field with the air pollutant removal rate and value as $/$m^2$/yr. This makes calculation of "US_Air_Dol" more transparent and allows the user to update it more easily. See the Air Quality section for more directions on updating field values.

Usable Water Value

The usable water value ($/yr) is calculated for each land use feature based on the nitrogen that feature will removal, estimated using a denitrification coefficient (g N/m^2/yr) for that feature's land use type (*Figure 108*).

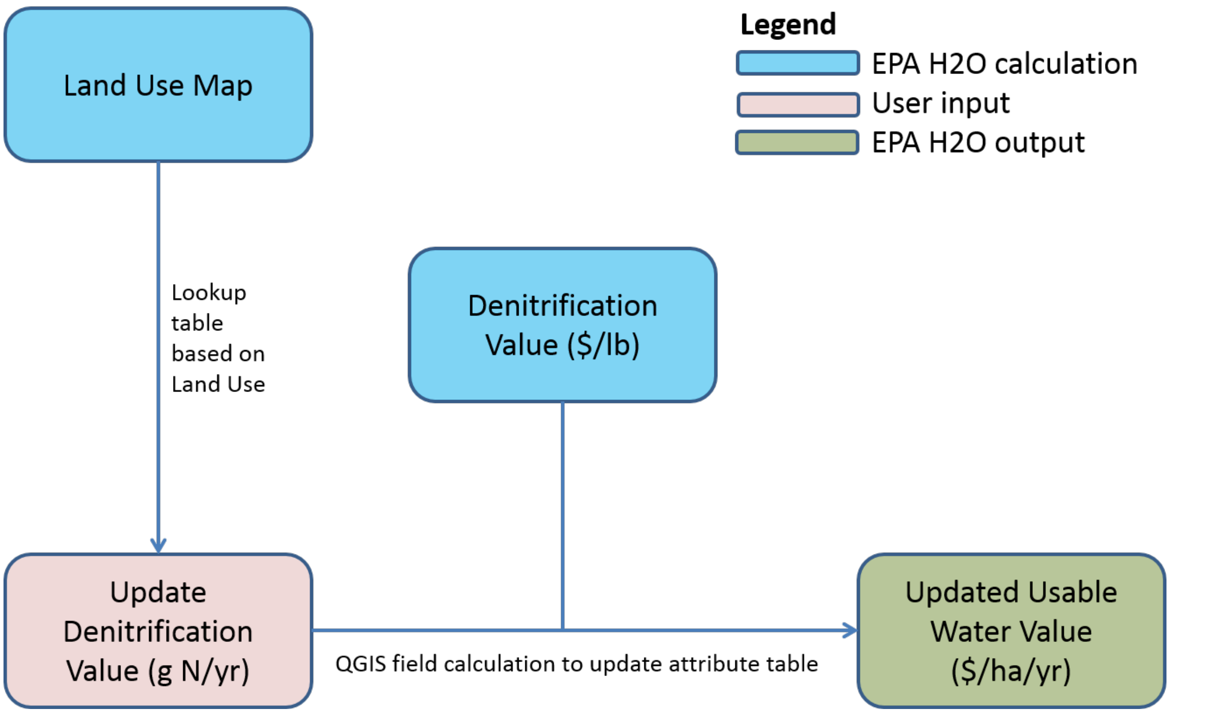


Figure 108 Usable Water Value calculation model in EPA H2O

Denitrification coefficients (g N/m^2/yr) are determined from literature values. The literature values used in Tampa, FL are shown in *Table 2*. The characteristics that influence denitrification rates for the same land use class may vary from one location to another. For example, in Tampa FL, the rate from Morris 1991 for freshwater marshes is reflective of intertidal fresh and salt water marshes, a marsh type not present in many other regions.

For more developed land use classes, buildings and impervious surfaces will prevent denitrification. However, developed land use classes commonly include lawns which have high denitrification rates, particularly where lawns are well irrigated and fertilized (Raciti et al. 2011). One denitrification coefficient rate was determined for the portion of developed land classes characterized as lawn, 1.4 N/m2/yr (Raciti et al. 2011). For each of the developed land use classes this coefficient is reduced proportionately to the area of that land use class that is impervious. Methods to calculate and update the coefficients are described in in the Denitrification section.

The costs for reducing nitrogen from point sources are estimated at $8.16 per pound ($18 / kg) of nitrogen (Birch et al. 2011). The following equation shows how the usable water value ($/yr) is estimated for a land use feature using the feature's denitrification rate (g N/m^2/yr):

Usable Water Value ($/yr) = Denitrification (g N/m^2/yr) * Area (m^2) * 1kg/1000g * $18/kg

Table 2 Denitrification rates assigned to land use classifications

FLUCCS Land Use Description	Denitrification (g N/m^2/yr) Average	Standard Deviation (g N/m^2/yr)	References
Cropland and Pastureland	0.72	0.62	(Espinoza 1997; Robertson et al. 1987; Tsai 1989; Barton et al. 1999)
Row Crops	3.15	4.75	(Espinoza 1997; Piña-Ochoa and Álvarez-Cobelas 2006; Tsai 1989)
Tree Crops	0.45	—	(Robertson et al. 1987)
Feeding Operations	0.06	—	(E. Cooter, personal communication)
Nurseries and Vineyards	0.45	—	(Robertson et al. 1987)
Other Open Lands (Rural)	0.82	0.69	(Tsai 1989; Barton et al. 1999)
Herbaceous	0.06	—	(Tsai 1989)
Shrub and Brushland	0.06	—	(Tsai 1989)
Mixed Rangeland	0.82	0.69	(Tsai 1989; Barton et al. 1999)
Upland Coniferous Forests	0.12	0.10	(Robertson et al. 1987; Barton et al. 1999)
Pine Flatwoods	0.12	0.10	(Robertson et al. 1987; Barton et al. 1999)
Longleaf Pine – Xeric Oak	0.12	0.10	(Robertson et al. 1987; Barton et al. 1999)
Upland Hardwood Forests	0.19	—	(Barton et al. 1999)
Hardwood Conifer Mixed	0.19	—	(Barton et al. 1999)
Tree Plantations	0.45	—	(Robertson et al. 1987)
Streams and Waterways	20.73	12.52	(Piña-Ochoa and Álvarez-Cobelas 2006; Seitzinger et al. 2006)

Lakes	12.16	11.47	(James et al. 2011; Piña-Ochoa and Álvarez-Cobelas 2006; Seitzinger 1988; Seitzinger et al. 2006)
Reservoirs	6.73	5.34	(James et al. 2011; Brenner et al. 2001; Seitzinger 1988; Seitzinger et al. 2006)
Bays and Estuaries	5.66	3.64	(Gardner et al. 2006; Seitzinger 1988; Yoon and Benner 1992)
Gulf of Mexico	6.89	6.16	(Fennel et al. 2009; Gihring et al. 2010)
Wetland Hardwood Forests	25.50	7.21	(Martin and Reddy 1997; Pinay et al. 2007; Seitzinger 1994; Walbridge and Lockaby 1994)
Bay Swamps	25.50	—	(Seitzinger 1994)
Mangrove Swamps	0.69	0.65	(Corredor et al.1999; Kristensen et al. 1998; Nedwell et al. 1994; Rivera-Monroy and Twilley 1996; Sutula et al. 2001)
Stream and Lake Swamps	25.50	—	(Seitzinger 1994)
Wetland Coniferous Forests	25.50	—	(Seitzinger 1994)
Cypress	24.66	7.39	(Martin and Reddy 1997; Pinay et al. 2007; Lindau et al. 2007; Walbridge and Lockaby 1994)
Wetland Forested Mixed	25.50	8.12	(Seitzinger 1994; Walbridge and Lockaby 1994; Dodla et al. 2008)
Vegetated Non-Forested Wetlands	28.26	8.09	(Ensign et al. 2008; Seitzinger 1994; Reddy et al. 1989; Martin and Reddy 1997, Pinay et al. 2007)
Freshwater Marshes	28.26	8.09	(Ensign et al. 2008; Martin and Reddy 1997; Pinay et al. 2007; Reddy et al. 1989; Seitzinger 1994)
Saltwater Marshes	4.52	2.83	(Craft et al. 2009; Morris 1991; Seitzinger et al. 2006)
Wet Prairies	25.48	8.87	(Ensign et al. 2008; Martin and Reddy 1997, Pinay et al. 2007)
Emergent Aquatic Vegetation	26.22	12.42	(Ensign et al. 2008; Martin and Reddy 1997)
Tidal Flats	10.00	5.67	(Cabrita and Brotas 2000; Ensign et al. 2008; Trimmer et al. 2000; Trimmer et al. 2006)
Intermittent Ponds	17.44	—	(Ensign et al. 2008)
Seagrass and Algae Beds	5.00	—	(Eyre and Ferguson 2002)

Carbon Sequestration Value

The carbon sequestration value ($/yr) is calculated for each land use feature based on the carbon that feature will sequester, estimated using a carbon fixation coefficient (g C/m²/yr) for that features land use type (*Figure 109*). Carbon sequestration coefficients (g C/m²/yr) will differ significantly depending on if the carbon is being fixed into biomass or buried.

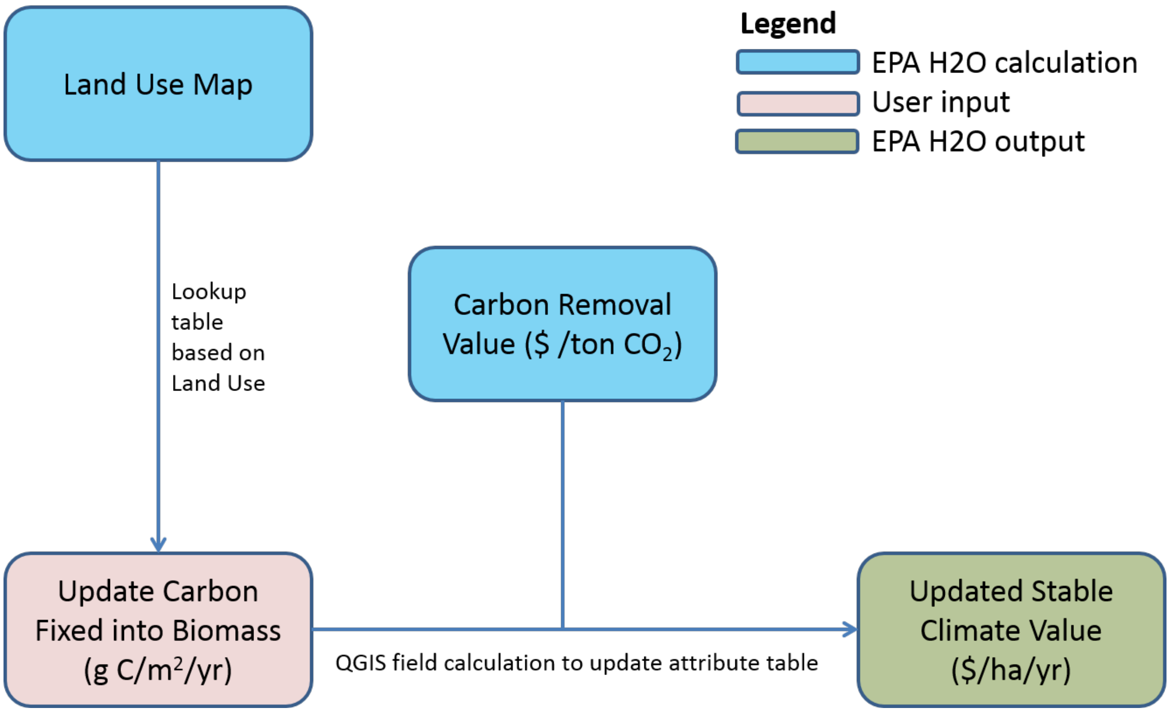


Figure 109 Stable Climate Value calculation model in EPA H2O

Carbon sequestration coefficients (g C/m²/yr) are determined from literature values. The literature values used in Tampa, FL are shown in *Table 3*. Carbon fixed into biomass may later be removed and re-released (e.g. crops fix carbon but are harvested for consumption) whereas carbon that is buried is more likely to remain in the soil even if the vegetation is removed. The characteristics that influence carbon sequestration rates for the same land use class may vary from one location to another. For example, in Tampa FL, the rate from Chmura et al. 2003 for saltwater marshes is reflective of mangroves, a marsh type not present in many other regions.

For more developed land use classes buildings and impervious surfaces will not contribute to carbon sequestration. However, developed land use classes commonly include trees and lawns which have high carbon sequestration rates, particularly where lawns are cut and mulched in place (Pouyat et al., 2009). One carbon sequestration rate was determined for the portion of developed land classes characterized as having trees, 28 g C/m²/yr (average carbon sequestration rate for all tree land use types), and for lawns, 100 g C/m²/yr (*Table 4* summarizes the references used to calculate the Lawn Rate coefficient for “Recreational”, “Open Land”, “Residential Low Density” and “Golf Courses” land use types). For each of the developed land use classes these per unit area coefficients are reduced proportionately to the percent of that area that is impervious. The tree rate is reduced proportional to the canopy cover for that land use class, and the lawn rate is reduced proportional to the percent impervious for that land use class. The carbon sequestration by trees or lawns are then combined to get the coefficient for that developed land use class. Methods to calculate and update the coefficients are described in the Carbon Sequestration section.

The social costs for emitting carbon to, and inversely the value of sequestering the same amount from, the atmosphere are estimated at $37 per ton of Carbon Dioxide (US Government, 2010). To convert this to $ per ton of Carbon removed, the molecular mass of carbon dioxide (44.0095 g/mol) is compared to that of carbon (12.0107 g/mol), for a factor of 3.66 times, or a cost of $135.42 per ton of Carbon. The following equation shows how the stable climate value ($/yr) is estimated for a land use feature using the feature's carbon fixation rate (g $C/m^2/yr$):

$$\text{Stable Climate Value (\$/yr)} = \text{Carbon Fixation } (g/m^2/yr) * \text{Area } (m^2) * 1^{-6} \text{ (ton/g)} * \$37/\text{ton} * 3.66$$
$$\text{Stable Climate Value (\$/yr)} = \text{Carbon Fixation } (g/m^2/yr) * \text{Area } (m^2) * 1^{-6} \text{ (ton/g)} * \$135.42/\text{ton}$$

Table 3 Carbon sequestration rates assigned to non-Developed land use classifications

FLUCCS Land Use Description	Carbon Sequestration (g $C/m^2/yr$) Average	Standard Deviation (g $C/m^2/yr$)	References
Open Land	611	229	(Ajtay et al. 1979; Milesi et al. 2005)
Cropland and Pastureland	423	—	(Ajtay et al. 1979)
Row Crops	959	758	(Ajtay et al. 1979; Schlesinger 1999)
Tree Crops	571	283	(Ajtay et al. 1979; Clark et al. 1999; Montagnini and Nair 2004)
Feeding Operations	423	—	(Ajtay et al. 1979)
Nurseries and Vineyards	571	283	(Ajtay et al. 1979; Clark et al. 1999; Montagnini and Nair 2004)
Other Open Lands (Rural)	673	235	(Ajtay et al. 1979; Milesi et al. 2005)
Herbaceous	743	286	(Ajtay et al. 1979)
Shrub and Brushland	945	—	(Ajtay et al. 1979)
Mixed Rangeland	540	—	(Ajtay et al. 1979)
Upland Coniferous Forest	698	32	(Ajtay et al. 1979; Kroeger 2008)
Pine Flatwoods	698	32	(Ajtay et al. 1979; Clark et al. 1999)
Longleaf Pine – Xeric Oak	313	359	(Ajtay et al. 1979; Clark et al. 1999; Kroeger 2008)
Upland Hardwood Forests	590	113	(Ajtay et al. 1979; Clark et al. 1999; Kroeger 2008)
Hardwood Conifer Mixed	660	85	(Ajtay et al. 1979; Kroeger 2008)
Tree Plantations	731	79	(Ajtay et al. 1979; Clark et al. 1999)
Streams	180	—	(Ajtay et al. 1979)
Lakes	397	141	(Carpenter et al. 1998; Carrick et al. 1993)

Reservoirs	368	112	(Carpenter et al. 1998; Carrick et al. 1993; Knoll et al. 2003)
Bays and Estuaries	195	205	(Zieman et al.1999)
Ocean and Gulf of Mexico	115	—	(De Vooys 1979)
Gulf of Mexico	115	—	(De Vooys 1979)
Wetland Hardwood Forests	808	299	(Lugo et al. 1988)
Bay Swamps	808	299	(Lugo et al. 1988)
Mangrove Swamp	778	672	(Chmura et al. 2003; Duarte et al. 2005; Eong 1993; Estevez and Mosura 1985; Kroeger 2008)
Stream and Lake Swamps (Bottomland)	808	299	(Lugo et al. 1988)
Wetland Coniferous Forests	298	181	(Kroeger 2008)
Cypress	241	256	(Clark et al. 1999; Kroeger 2008)
Wetland Forested Mix	552	—	(Kroeger 2008)
Vegetated Non-Forested Wetlands	142	—	(Kroeger 2008)
Freshwater Marshes	618	—	(Smith et al. 1983)
Saltwater Marshes	492	628	(Chmura et al. 2003; Choi and Wang 2004; Duarte et al. 2005; Lewis III and Estevez 1988; Smith et al. 1983)
Wet Prairies	142	—	(Kroeger 2008)
Emergent Aquatic Vegetation	142	—	(Kroeger 2008)
Tidal Flats	195	205	(Zieman et al.1999)
Intermittent Ponds	142	—	(Kroeger 2008)
Seagrass	814	363	(Duarte et al. 2005; Lewis III and Estevez 1988)

Table 4 Carbon sequestration rates used to calculate the lawn rate coefficient

FLUCCS Land Use Description	Carbon Sequestration (g C/pixel) Average	Standard Deviation (g C/m^2/yr)	References
Recreational	18	—	(Pouyat et al. 2009)
Open Land	3	—	(Pouyat et al. 2010)

Residential Low Density	382	—	(Pouyat et al. 2009, Raciti et al. 2011)
Golf Courses	95	—	(Qian and Follett 2002)

Database Creation

The default database provided with EPA H2O (*TampaBay.sqlite*) only includes data for the Tampa Bay estuary and watershed. However, *.sqlite* databases compatible with the EPA H2O tool can be created for other areas of interest. This section illustrates the step-by-step procedure for creating *.sqlite* databases for use in EPA H2O's Advanced Module.

Please note:

1. Database creation requires EPA H2O to be in Power Mode.
2. EPA H2O Basic Module can only be used for the Tampa Bay region unless data layers are updated for other areas; scenario comparisons in other regions must be done using the EPA H2O Advanced Module.

New .sqlite databases can be created for any area in the contiguous United States using default data sources (*Table 5*). Depending on the area of the new database, an alternative data source may be available. In the Tampa Bay area, most of the default data sources were used for the database (*Table 6*). One exception was the land use dataset used, the Florida Land Use Cover Classification System (FLUCCS), a higher resolution dataset only available within the State of Florida. The lookup table used to assign Ecosystem Service coefficients is based on the land use layer classification, meaning the lookup table included in the Tampa Bay database will not work for other land use classifications such as the default NLCD. A new national lookup table for NLCD is included in Appendix A: Supplemental NLCD Lookup Table. The database creation section uses this lookup table and the default NLCD dataset. Appendix D: Extracting and Updating the Original FLUCCS Lookup Table describes how the Tampa Bay database lookup table can be updated to create databases using FLUCCS. Both lookup tables may be updated with more regionally specific values. The NLCD Percent Tree Canopy data do not need to be downloaded if the lookup table Canopy Cover values are not being updating.

Table 5 Default Data Sources with national scope for new user databases

Dataset	Download Instructions	Download Link
USGS Watershed Boundaries: HUC_8 .shp	Download HUC Boundaries	https://viewer.nationalmap.gov/basic/?basemap=b1&category=nhd&title=NHD%20Vie
National Land Cover Database (NLCD) 2011	Download Land Use Data	https://www.mrlc.gov/data/nlcd-2011-land-cover-conus-0
SSURGO: Soil Classification	Download Soil Data	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
NLCD 2011 Percent Tree Canopy	Download Tree Canopy Data	https://www.mrlc.gov/data/nlcd-2011-usfs-tree-canopy-cover-conus
TIGER/Line Roads	Download TIGER/Line data	https://www.census.gov/cgi-bin/geo/shapefiles/index.php
Maximum Speed	Download Max Speed data	Must be obtained by user on a state or local scale, or be created by user.
NHD+_V2 Hydrography (Catchments, Basins and Flow directions)	Download NHDPlus Data	https://nhdplus.com/NHDPlus/NHDPlusV2_data.php

Original EPA H2O database	Included in Installing EPA H2O	
User copy of TampaBay.sqlite saved in any directory EXCEPT 'C:/Users/<USER_NAME>/.qgis/0.0.3/data/database/'	Setting Up a Project Directory	

Table 6 Data Sources used to create original TampaBay.sqlite database

Dataset	Download Link	File Names
USGS Watershed Boundaries: HUC_8 .shp	https://nhd.usgs.gov/data.html	*hucs00m020_nt00013.tar.gz* to obtain *WBDHU8.shp*
State of Florida FLUCCS Land Use	https://www.swfwmd.state.fl.us/resources/data-maps	*2006_Land_Use_Land_Cover.zip*
SSURGO: Soil Classification	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	*wss_SSA_**FL049**_soildb_FL_2003_[2017-10-05].zip* (Hardee county) *wss_SSA_**FL057**_soildb_FL_2003_[2017-10-04].zip* (Hillsborough county) *wss_SSA_**FL081**_soildb_FL_2003_[2017-10-02].zip* (Manatee county) *wss_SSA_**FL101**_soildb_FL_2003_[2017-10-02].zip* (Pasco county) *wss_SSA_**FL103**_soildb_FL_2003_[2017-10-02*].*zip* (Pinellas county) *wss_SSA_**FL105**_soildb_FL_2003_[2017-10-06].zip* (Polk county)
TIGER/Line Roads	https://www.census.gov/cgi-bin/geo/shapefiles2013/main	*tl_2013_12049_roads.zip* (Hardee) *tl_2013_12057_roads.zip* (Hillsborough) *tl_2013_12081_roads.zip* (Manatee) *tl_2013_12101_roads.zip* (Pasco) *tl_2013_12103_roads.zip* (Pinellas) *tl_2013_12105_roads.zip* (Polk)
Maximum Speed	https://www.arcgis.com/home/item.html?id=4a61f17ab4784202ae10d7d5fb3bf9de#overview	*maxspeed.zip*
NHD+_V2 Hydrography (Catchments, Basins and Flow directions)	https://nhdplus.com/NHDPlus/NHDPlusV2_data.php	*NHDPlusV21_SA_03S_NHDPlusAttributes_02.7z* *NHDPlusV21_SA_03S_NHDPlusCatchment_01.7z* *NHDPlusV21_SA_03S_NHDPlusBurnComponents_02.7z* *NHDPlusV21_SA_03S_NHDSnapshot_03.7z*

Setting Up a Project Directory

During installation EPA H2O creates a default database for the Tampa Bay area (*TampaBay.sqlite*). A new database must be created to use EPA H2O for a different area. The following steps show the procedure to set up a directory for the new database; hereafter referred to as the *User Folder*.

On a Windows machine, by default QGIS data are stored in a ".qgis" folder found in the current user's home directory .

1. Using File Explorer , COPY the directory 'C:\Users\<USERNAME>\.qgis\0.0.3\' to another location in the user directory, e.g.('C:\Users\<USERNAME>\My Documents\0.0.3\') (*Figure 110*).

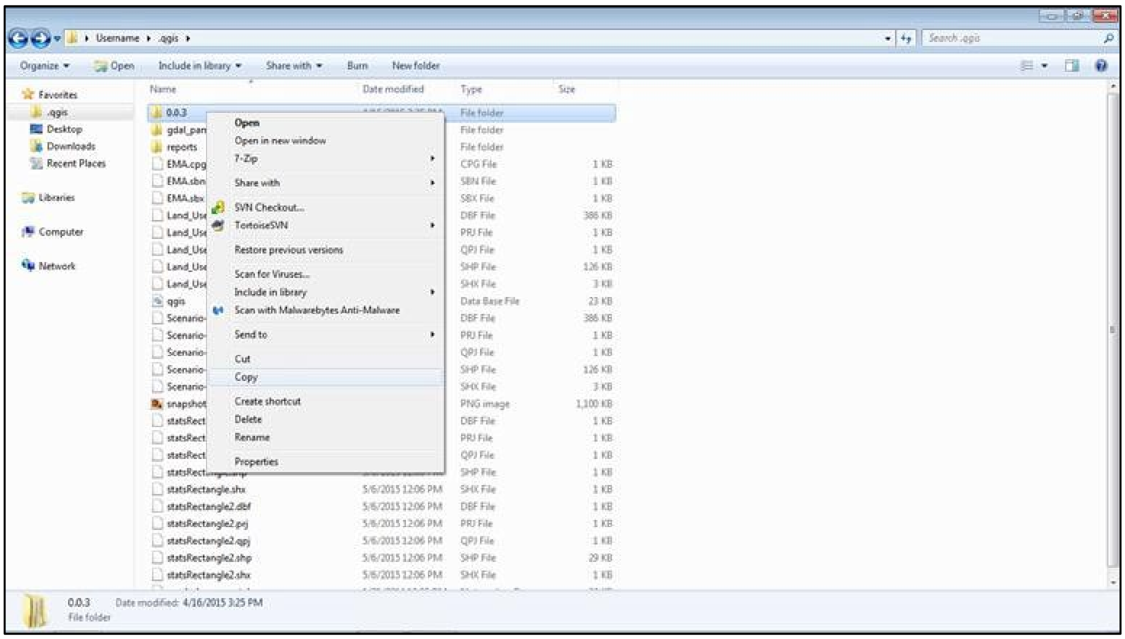


Figure 110 Create a copy of the 0.0.3 folder in File Explorer

2. Make sure the folder contents were copied properly, including the "data" folder, "projects" folder, and the *TampaBay.sqlite* database.
3. Right-click on the new copy of the EPA H2O database (*TampaBay.sqlite*), choose *Rename*, and rename the new database (for example, *UserDatabase.sqlite* in *Figure 110*). The database MUST BE RENAMED; the Qspatialite plug-in cannot connect to two different databases with the same file name regardless of their file paths.

Set Up ArcGIS Map Document

1. Open ArcMap from the *Start* menu > *All Programs* > *ArcGIS* > *ArcMap*.
2. Right-click on the *Layers* icon in the Table of Contents. From the dropdown list, choose the *Properties* option (*Figure 112*).

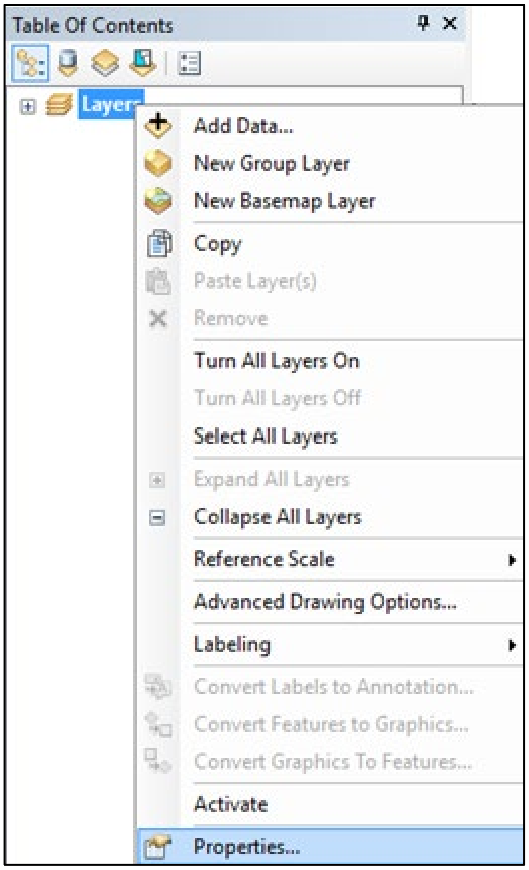


Figure 112 Layer Properties location in ArcMap

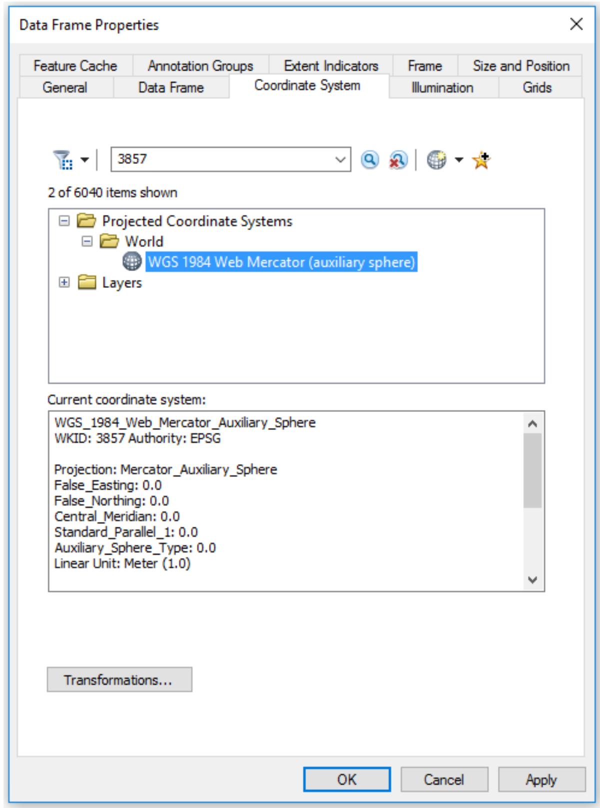


Figure 111 Set Coordinate System for Data Frame

3. The *Data Frame Properties* window will open (*Figure 111*). Under the *Coordinate System* tab, choose *Web Mercator Auxiliary Sphere*. It is located under *Projected Coordinate System* > *World,* or can be located by typing *3857* in the search field and hitting enter, as shown in *Figure 111*.
4. Once the coordinate system is selected, it will appear in blue. Click *OK.*
5. It is suggested that the user save their created map document, in .mxd format (*File* > *Save As…)*.

Set Up QGIS Map Document

1. Open EPA H2O in Power Mode.
2. In the *Choose a Module* window, click *OK* (*Figure 113*).

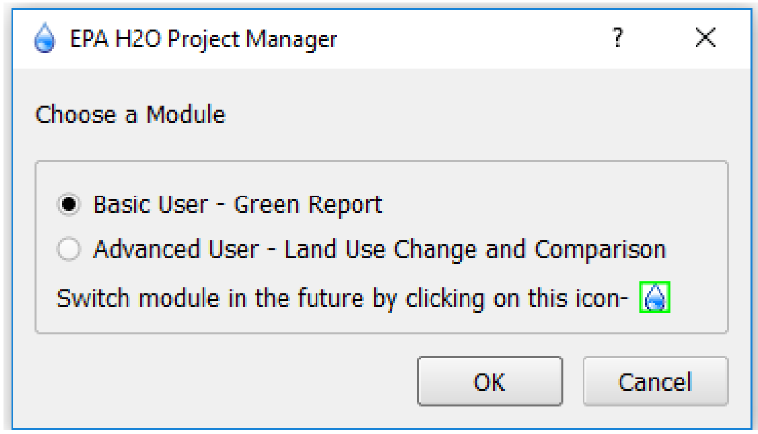


Figure 113 EPA H2O Choose a Module window

3. In the *Select Project* window, select *Open existing project* or *Create new project*. For first time Power Mode users, choose *Create new project* (*Figure 114*).

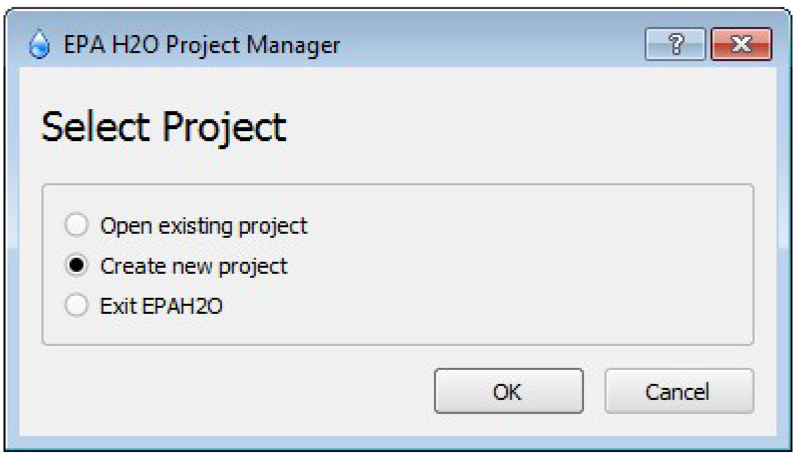


Figure 114 EPA H2O Select Project window

4. In the *Project Configuration* window (*Figure 115*), confirm that the *Source Database Name* is referencing the original *TampaBay.sqlite*.
   a. If the source database is not the original *TampaBay.sqlite*, click the *Select* button, and navigate to the original "0.0.3" folder.
5. In the *Name Your Project Database* box, enter the preferred project name (e.g. *Demo)*, and click *OK.*

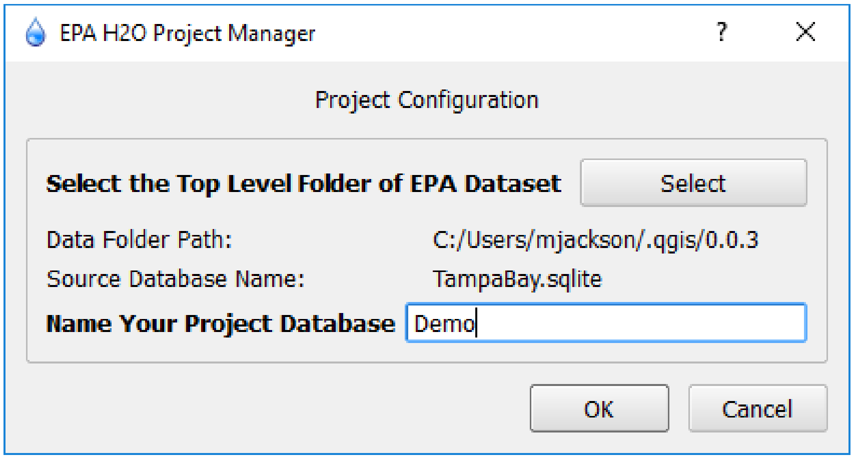


Figure 115 Project Configuration window

6. In the *Select Area of Interest* window, click *Cancel*.
7. From the *Settings* dropdown (*Figure 116*) open the *Project Properties* window (*Main Menu > Settings > Project Properties*).

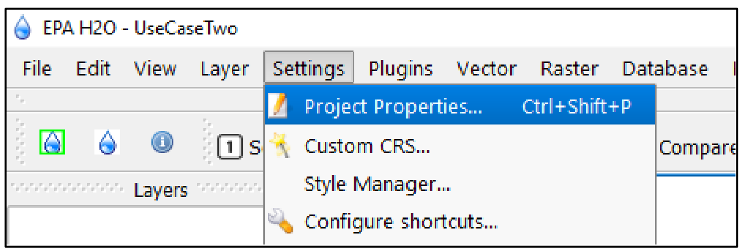


Figure 116 Location of Project Properties in EPA H2O

8. In the *Project Properties* window (*Figure 117*):
   a. Click the *Coordinate Reference System (CRS)* tab and check the box labeled *Enable 'on the fly' CRS transformation*.
   b. In the *Filter* text box, type *3857*. Under the *Coordinate reference systems of the world* section, select *WGS 84 / Pseudo Mercator*.
   c. Click *OK* to apply these changes and close the *Project Properties* window.

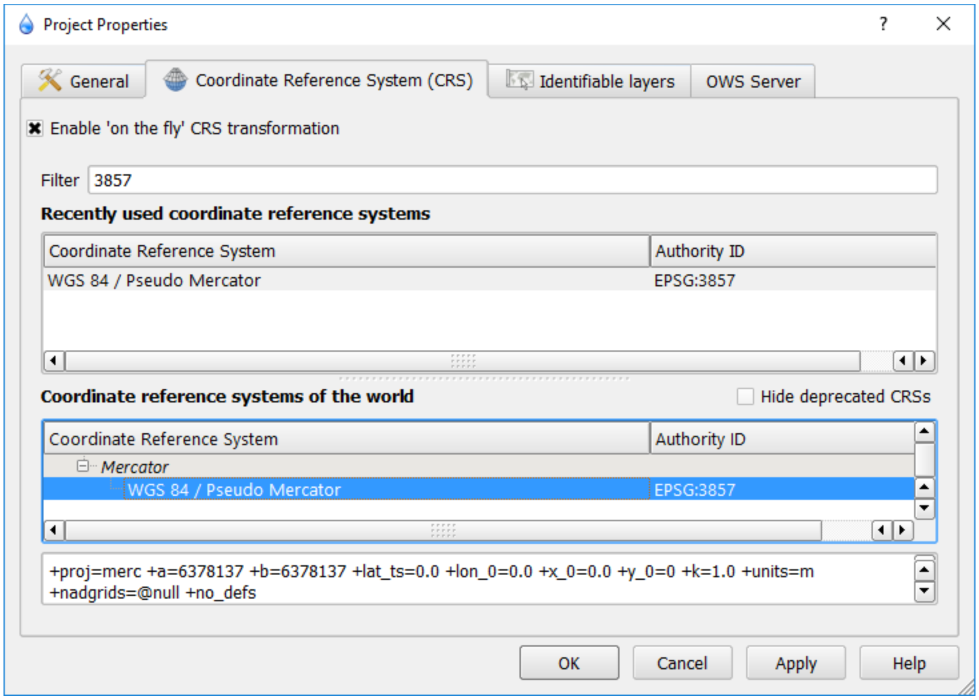


Figure 117 Set the Coordinate Reference System in EPA H2O

9. It is suggested that the user save their created map document, in .qgs format (*File > Save Project As).*

Create HUC Watershed Boundaries

A Watershed defines the area upstream of a point (e.g. an outflow point) where flows of water will be directed to that point. Hydrologic Unit Codes (HUC) are unique codes assigned watershed boundaries that vary in length (2-14 digits) depending of the scale of the watershed. At the broad scale, each region of the United States has a unique 2-digit Hydrologic Unit (*Figure* 118). For example, Tampa Bay is within the HUC 03 South-Atlantic Gulf region. At broader scales (2-digit), HUC watersheds match the NHDPlus catchments, but at finer scale (14-digit) there may be differences. HUC boundaries are often used to define the Area of Interest (AOI) for a new EPA H2O database because these boundaries are similar to the NHDPlus catchments used to define upstream areas.

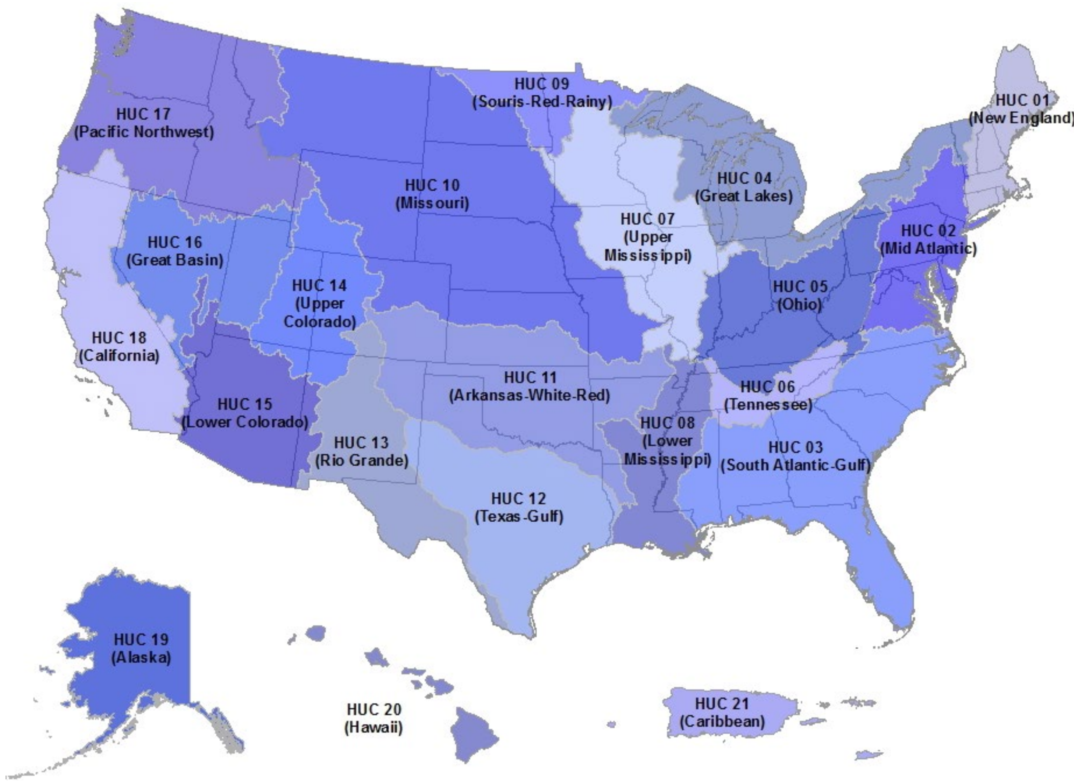


Figure 118 *HUC Region Number for the entire United States and U.S Caribbean territories*

Download HUC Boundaries

This section illustrates the step-by-step procedure to download the HUC watershed boundary dataset from the USGS Website by HU-2 region.

1. Navigate to the following link, to open the USGS National Map website (*Figure 119*): https://viewer.nationalmap.gov/basic/?basemap=b1&category=nhd&title=NHD%20Vie

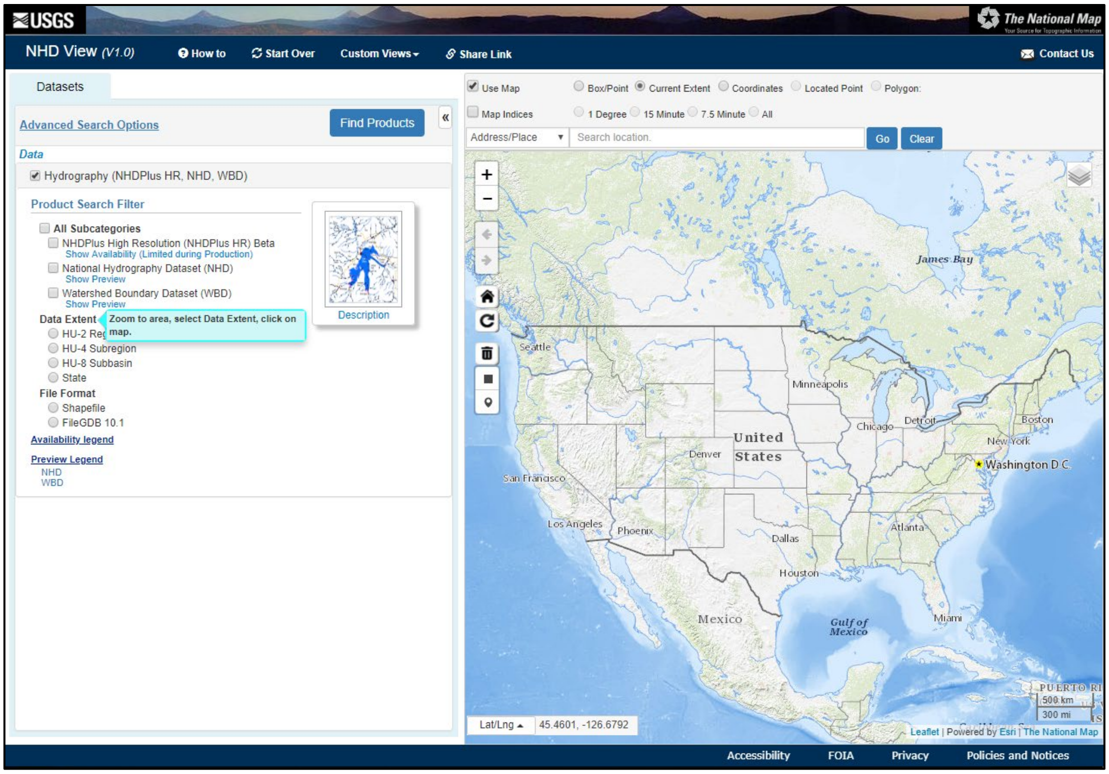


Figure 119 USGS National Map download website

2. Click-and-drag on the National Map to pan and use the *Zoom in* + icon to zoom in to the user's AOI (e.g. Tampa Bay).
3. In the *Product Search Filter* section, check the *Watershed Boundary Dataset (WBD)* option (*Figure* 120).

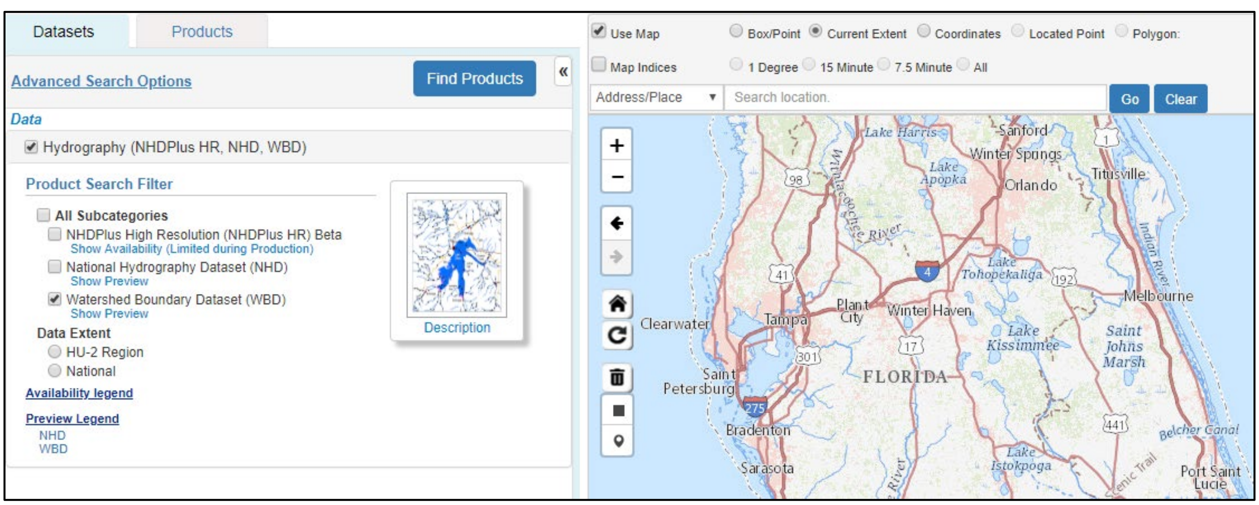


Figure 120 Search for all Watershed Boundary Datasets available for the Tampa Bay area

4. Click the *Find Products* icon, located above the *Product Search Filter* box.
5. The available *USGS Watershed Boundary Datasets* for the user's AOI will replace the search filters (*Figure 121*). The product name will include the 2-digit Hydrologic Unit (03 for Tampa).
6. Locate the *USGS Watershed Boundary Dataset (WBD)* file in the Product list with *Format: Shapefile*. It is strongly suggested that the user download the shapefile, and not the file geodatabase. In the *Actions* column, click the corresponding *Download* link.

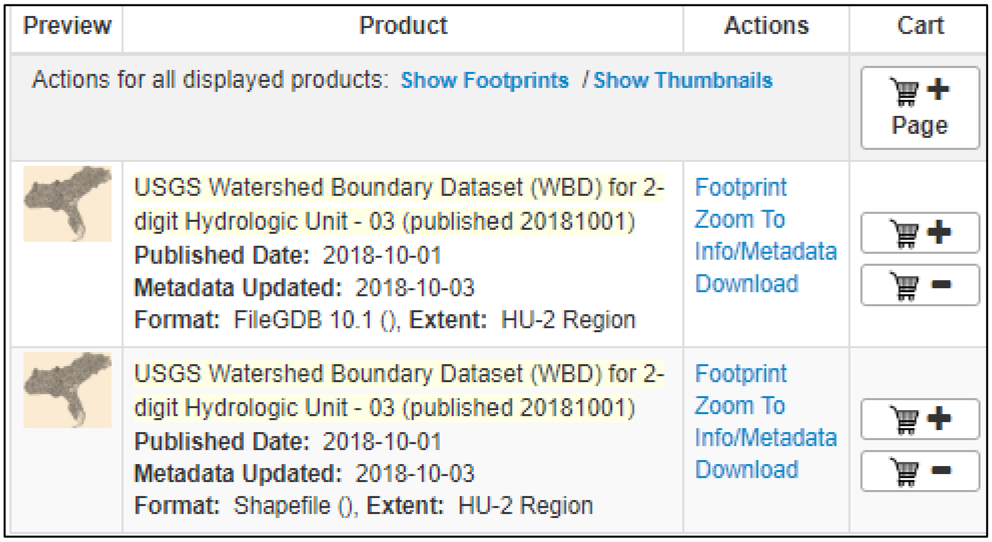


Figure 121 Download the USGS Watershed Boundary Shapefile for Hydrologic Unit 03

7. Save the zip file to the computer and unzip the contents to a known location.

The next section illustrates the creation of EPA H2O compatible watershed boundary data from the unzipped download file, either using Esri ArcGIS software (Using ArcGIS) or QGIS (Using QGIS).

Using ArcGIS

This section illustrates the creation of EPA H2O compatible HUC watershed boundary data using Esri ArcGIS software (About GIS).

1. Download and unzip the HUC Watershed Boundary data, as shown in the Download HUC Boundaries section.
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. Use the *Add Data* icon to navigate to the unzipped HUC watershed boundary dataset. Select the *WBDHU8.shp* file and add the layer to the Table of Contents of the map document.
4. Use the *Select Features* icon to select watersheds that overlap the area of interest:
   a. Watersheds are selected either by clicking and dragging a rectangle around them, or by clicking on each while holding the *Shift* key.
   b. If an incorrect watershed is selected, clear the current selection by clicking the *Clear Selection* icon.

Selected features are indicated by a cyan blue border. For example, watersheds surrounding Tampa Bay are shown selected in *Figure* 122.

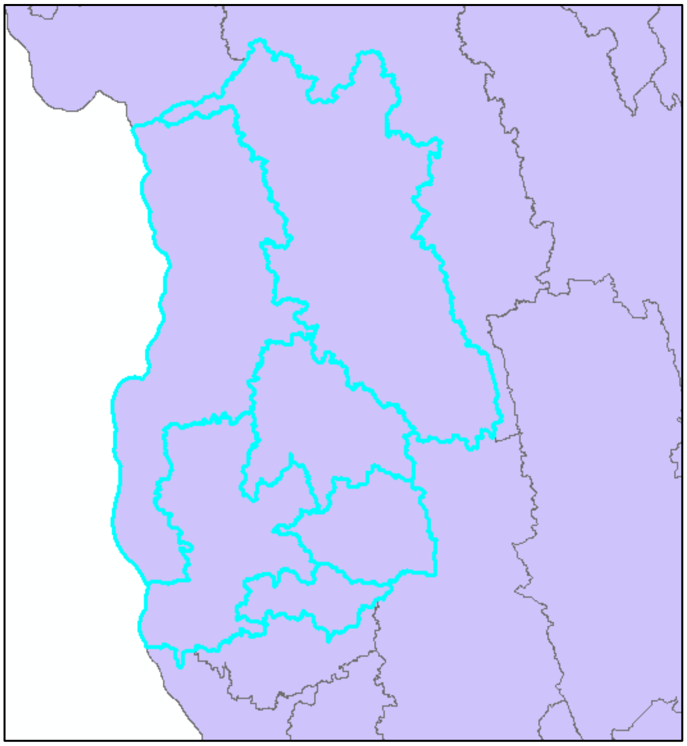


Figure 122 Watersheds selected for the Tampa Bay area in ArcMap

5. Once the watersheds of interest are selected, right-click on the *WBDHU8* layer in the Table of Contents, and choose *Data* > *Export Data,* as shown in *Figure* 123.

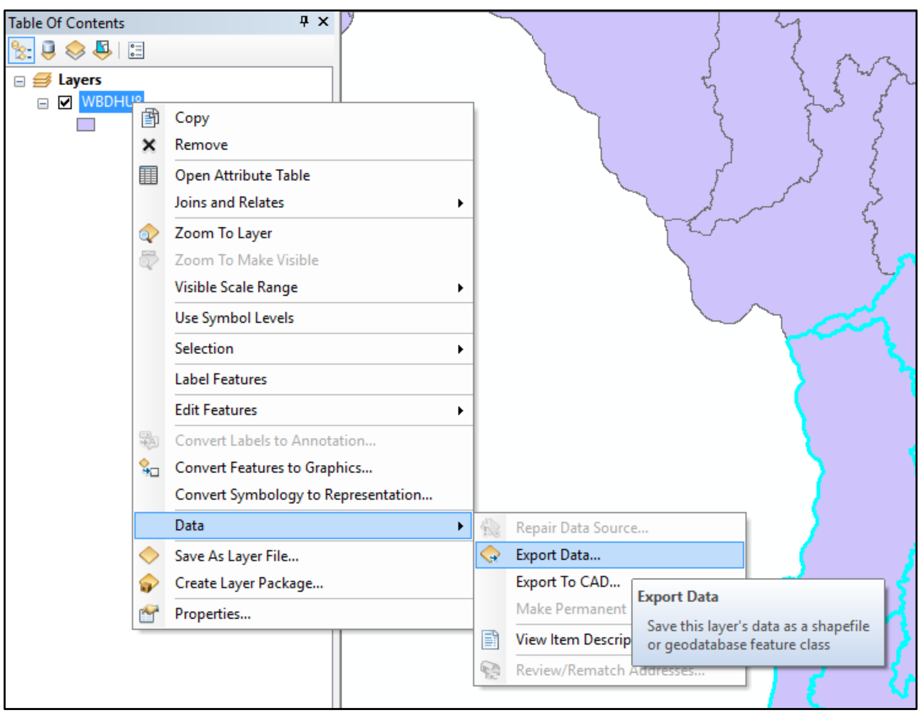


Figure 123 Export the selected watershed data using the Export Data button

6. In the *Export Data* window (*Figure* 124):
   a. In the *Export* dropdown list, select *Selected features*.

b. Under *Use the same coordinate system as,* toggle *the data frame* option.
c. In the *Output feature class* text box, type the desired shapefile name (e.g. *HUC_Tampa)*.
d. Click *OK.*

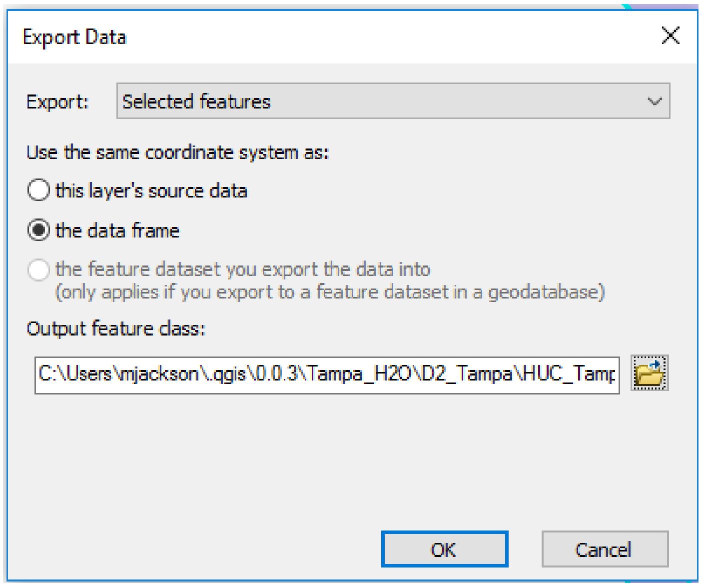


Figure 124 Export Data window

7. A window may appear that asks: "Do you want to add the export data to the map as a layer?" (*Figure 125*). If so, click *Yes.*

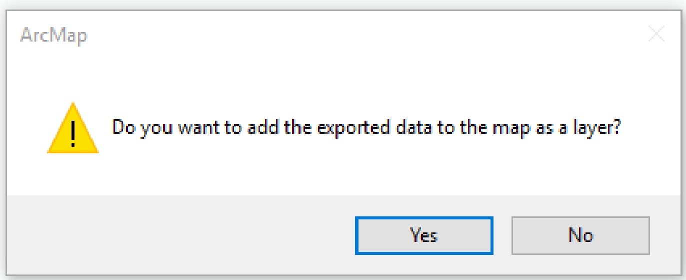


Figure 125 ArcMap window, which will add the newly exported data to the Table of Contents

The Importing Layers into QGIS section details how to upload the HUC watershed boundary into the user database in QGIS. Database creation is continued in the Create Land Use Data Layer section.

Using QGIS

This section illustrates the creation of EPA H2O compatible HUC watershed boundary data using QGIS software (About QGIS).

1. Download and unzip the HUC Watershed Boundary data, as shown in the Download HUC Boundaries section.
2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. From the *Layer* menu (*Figure 126*) open the *Add Vector Layer* window (*Main Menu > Layer > Add Vector Layer*).

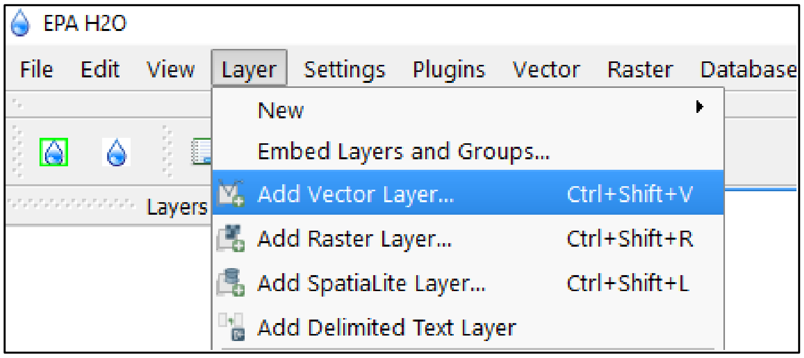


Figure 126 Location of the Add Vector Layer tool in EPA H2O

4. In the *Add vector layer* window (*Figure 127*), click *Browse* to locate and select the unzipped HUC watershed boundaries file (e.g. *WBDHU8.shp*), then click *Open*.

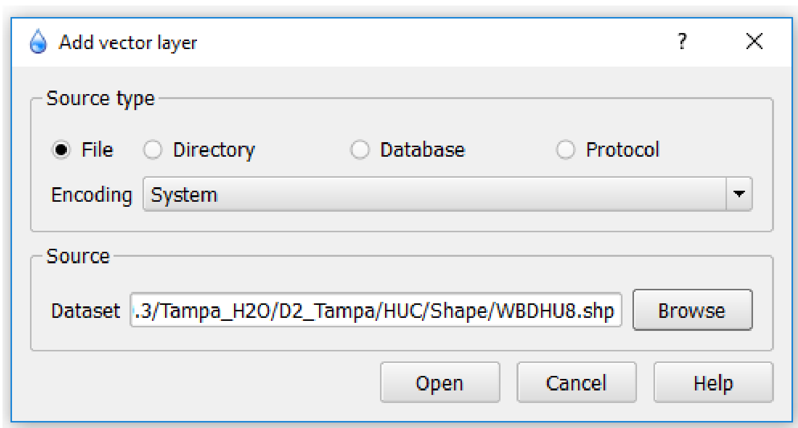


Figure 127 Add vector layer window in EPA H2O

5. Use the *Zoom In*  icon to zoom to the area of interest.
6. From the *View* menu, activate the *Select Single Feature* tool (*Main Menu > View > Select Single Feature, Figure 128*).
7. While holding the *Ctrl* key, select the specific watersheds in the area of interest. Alternatively, other selection tools may be used to make the selection, such as selecting watersheds by drawing a rectangle around them using the *Select Features by Rectangle* tool.

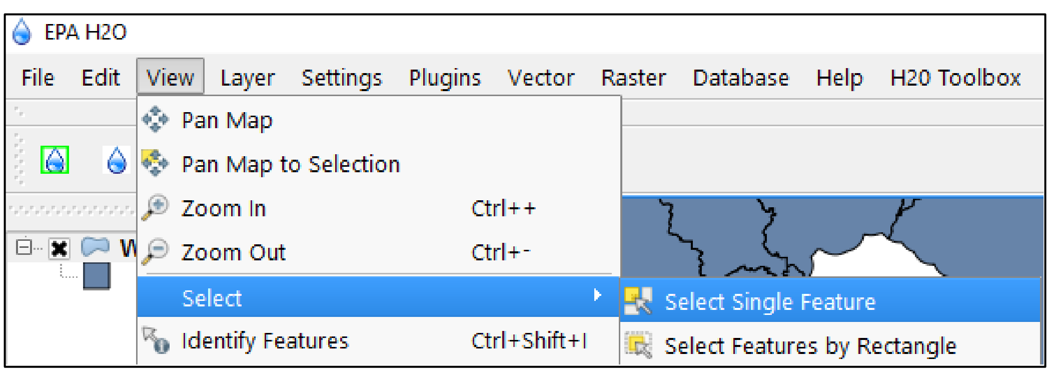


Figure 128 Select Single Feature in EPA H2O

Selected watersheds will be highlighted in yellow; *Figure 129* shows watersheds selected in the Tampa Bay area.

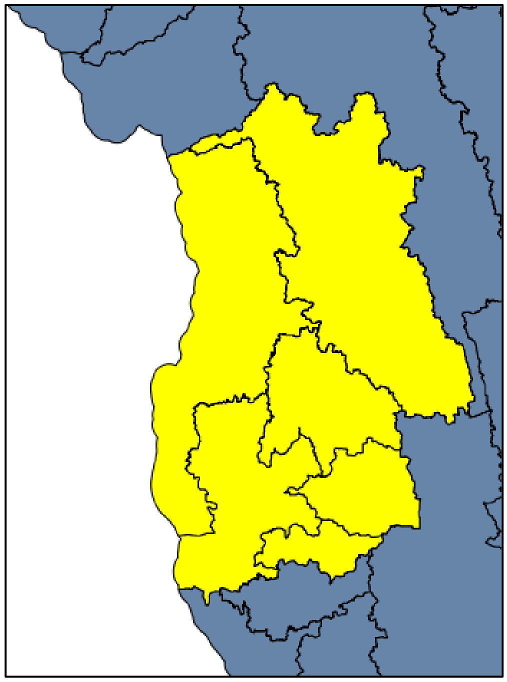


Figure 129 Selected watersheds in the Tampa Bay area

8. With the area-specific watersheds selected, use the *Layer* menu (*Figure* 130) to open the *Save Selection as Vector File* window (*Main Menu > Layer > Save Selection as Vector File…*).

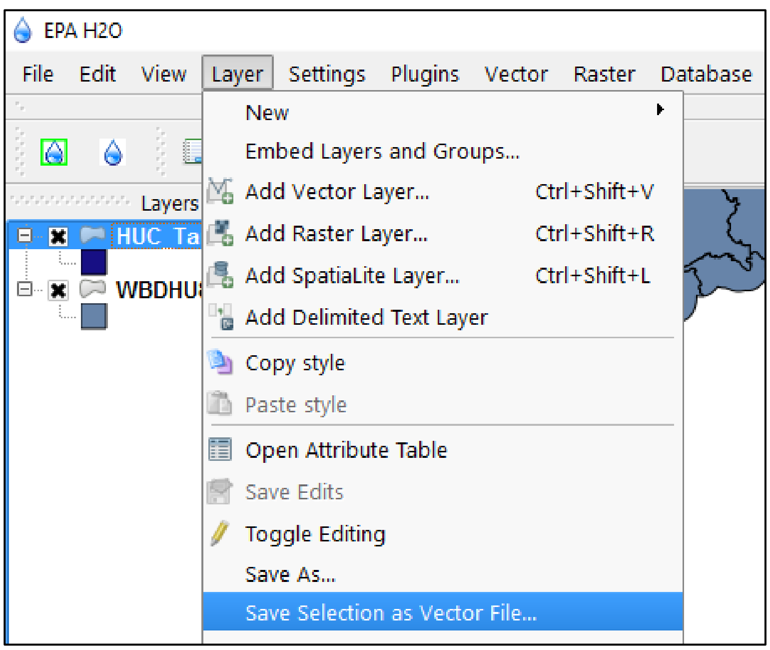


Figure 130 Save the selected watersheds as a vector file in EPA H2O

9. In the *Save vector layer as…* window (*Figure 131*):
   a. In the *Format* dropdown list, select *ESRI Shapefile*.

b. In the *Save as* box, browse to or type the desired output shapefile name and file path (e.g. *HUC_Tampa_QGIS.shp*).
c. In the *CRS* dropdown list, choose *Layer CRS*; *NAD83* should show as the *CRS* automatically.
d. Check *Add saved file to map.*
e. Do not check *Skip attribute creation.*
f. Click *OK.*

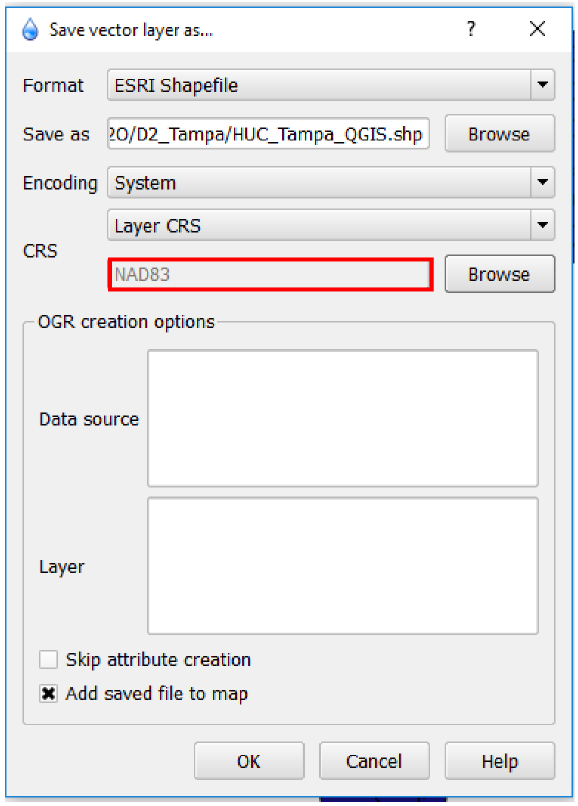


Figure 131 Save vector layer as… window in EPA H2O

This user-specific watershed shapefile (with *NAD83* projection) will be used to clip the land use data in the Create Land Use Data Layer section. The user must create a second copy of the watershed shapefile to upload into the user database, with *WGS84/ Pseudo Mercator* projection.

10. Right-click on the HUC watershed boundary layer (e.g. *HUC_Tampa_QGIS)* in the Layers panel and choose *Save As...* (*Figure* 132).

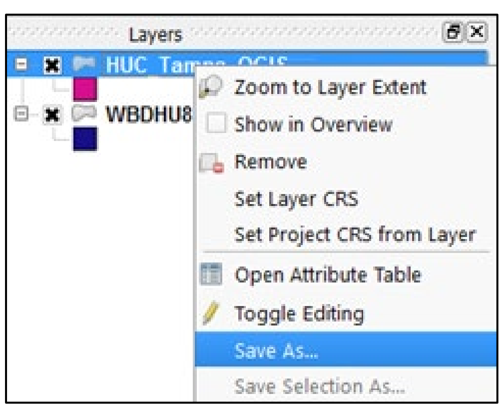


Figure 132 Location of the Save As… tool in EPA H2O

11. In the *Save vector layer as…* window (*Figure* 133):
    a. From the *Format* dropdown list, select *ESRI Shapefile*.
    b. In the *Save as* box, browse to or type the preferred file path and shapefile name (e.g. *HUC_Tampa_reproj.shp).*
    c. In the *CRS* dropdown list, choose *Selected CRS*, and click *Browse*.
    d. In the *Coordinate Reference System Selector* window that opens (*Figure* 134), type *3857* in the *Filter* box, choose *WGS 84/ Pseudo Mercator* and click *OK*.
    e. Be sure to check *Add saved file to map.* Do not check *Skip attribute creation.*
    f. Click *OK.*

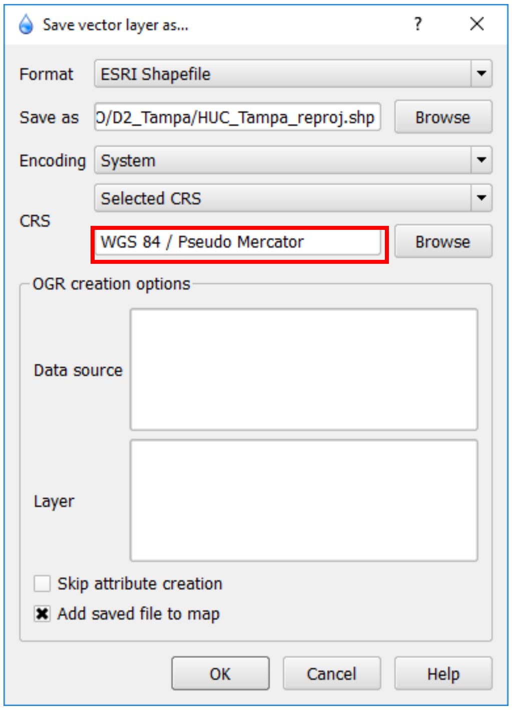


Figure 133 *Save vector layer as… window in EPA H2O*

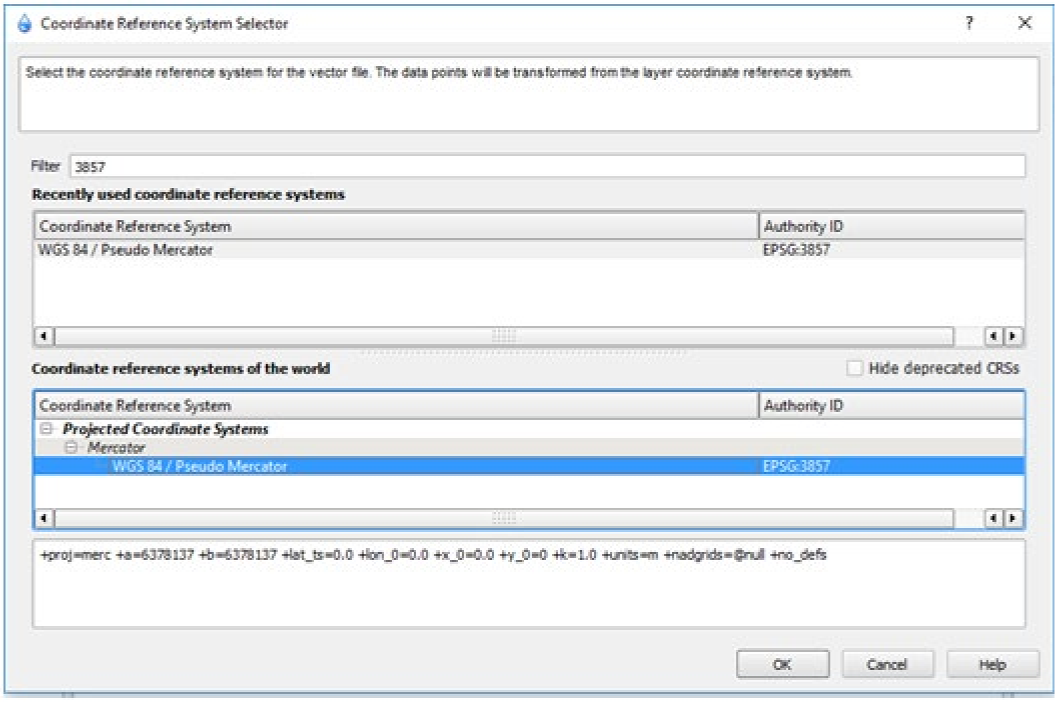


Figure 134 *Select WGS 84/ Pseudo Mercator as the Coordinate Reference System*

The Importing Layers into QGIS section details how to upload this re-projected HUC watershed boundary into the Qspatialite user database in QGIS. Database creation is continued in the Create Land Use Data Layer section, where the other HUC watershed boundary (with *NAD83* projection) will be used to clip the land use data.

Create Land Use Data Layer

The land use data layer is essential to several H2O functions. Several attributes in the land use layer are characterized using other datasets in addition to the initial land cover classification. For example, the EPA H2O tool computes the dollar value of flood protection based on Curve Number (CN). The land use layer is where Curve Number (CN) values, characterized using land cover and soil type, are attributed.

Land cover data can be obtained from a variety of sources, at a variety of resolutions or times, and may be based on a variety of classification systems. More detailed land cover datasets are often available at more limited scales and offer more value when differentiating between areas in EPA H2O, but more detailed land cover data is rarely available across all areas.

The Tampa database that comes with the EPA H2O tool uses the Florida Land Use Cover Classification System (FLUCCS) as the land cover layer. Although this land cover dataset uses a very detailed land use classification system, covering more classes than the National Land Cover Dataset (NLCD), it is only available for Florida. Since the National Land Cover Dataset (NLCD) covers the entire United States, and is updated at a regular interval, it is recommended for areas of interest where other, more detailed land use data is not available. For this reason, this section will describe how to download the National Land Cover Dataset (NLCD) and process it to prepare the land use data layer.

Either Esri ArcMap software or QGIS can be used to prepare the land cover data. The procedure for both software applications is explained in this section.

Download Land Use Data

This section illustrates the step-by-step procedure for downloading NLCD 2011 Land Cover datasets from the MRLC database.

1. Navigate to https://www.mrlc.gov/viewer/ as shown in *Figure* 135.

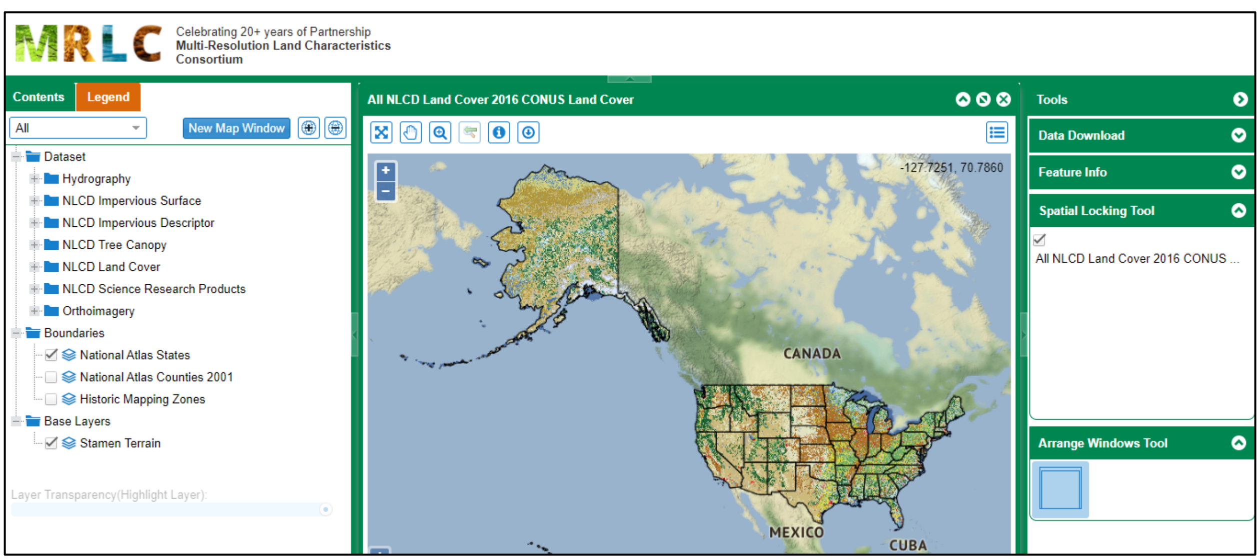


Figure 135 MRLC website, download NLCD Land Cover by AOI

2. Click-and-drag on the National Map to pan and use the *Zoom in*  icon to zoom in to the user's AOI (e.g. Tampa Bay).
3. In the *Contents* section, under the *NLCD Land Cover* dropdown list, check the *2011 CONUS Land Cover* option (or the preferred display year).
4. From the map viewer toolbar, click the *Open Data Download Tool*  icon and click to draw a bounding box around the user's AOI (*Figure 136*).

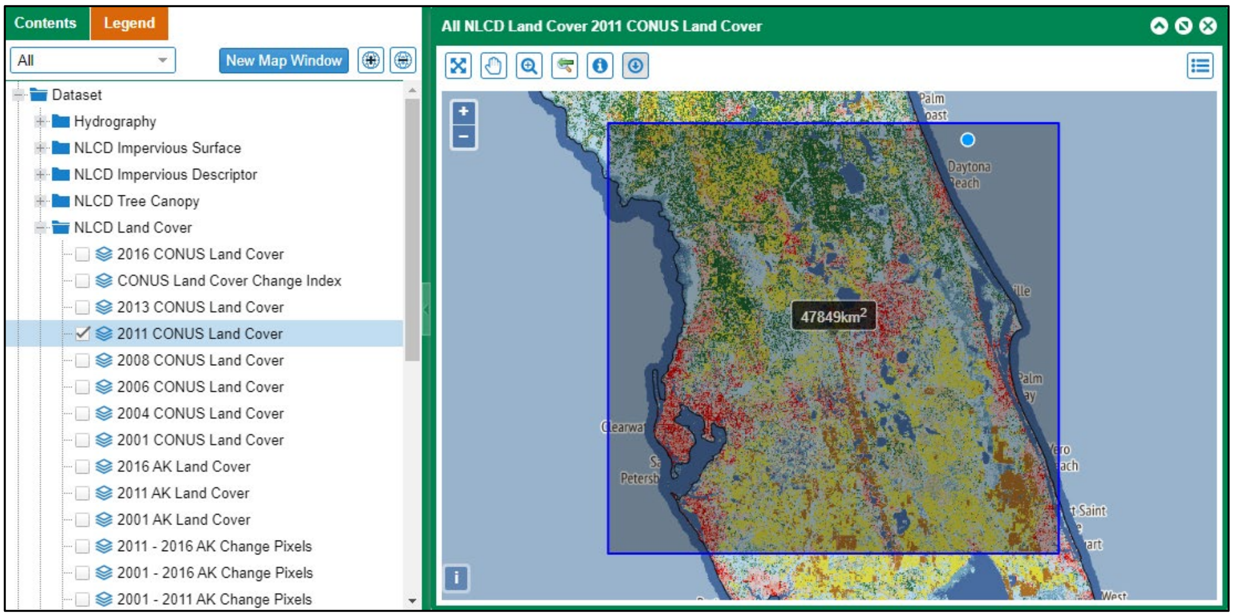


Figure 136 MRLC viewer with bounding box drawn around Tampa Bay AOI

5. Under the *Data Download* dropdown list, check the *Land Cover* option and toggle *All Land Cover Years* (*Figure* 137).

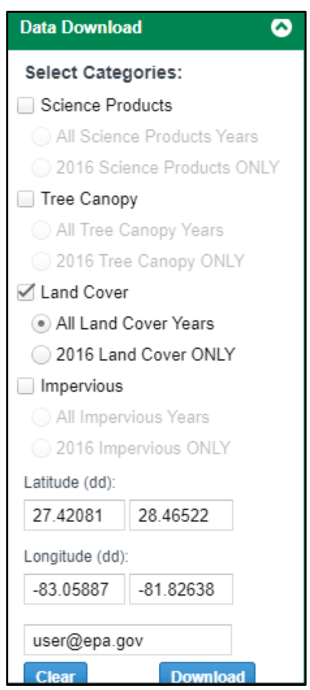


Figure 137 Data Download dropdown list

6. In the *Email* text box, enter the user's email address (e.g. user@epa.gov), then click *Download.*
7. A notification will appear indicating the download request has been sent. Click *OK* (*Figure* 138).

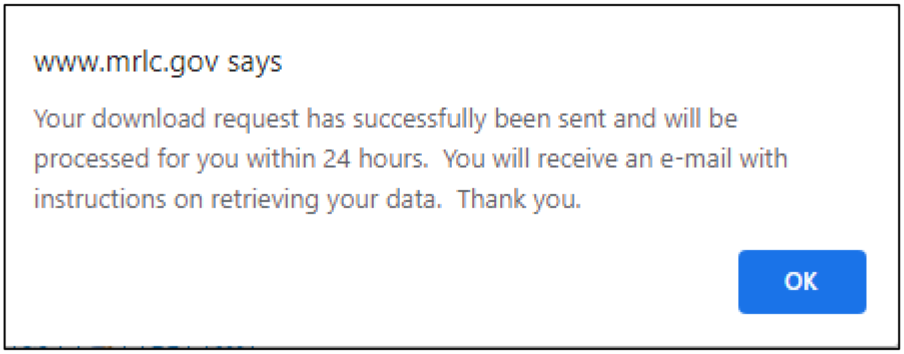


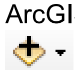
Figure 138 MRLC request notification

8. The download link will be emailed to the user by the USGS server. Click the first link in the email to download the NLCD zip file.
9. Save the zip file to the computer and unzip the contents to a known location.

The next section illustrates the creation of EPA H2O compatible land use data from the unzipped download file, using either Esri ArcGIS software (Using ArcGIS) or QGIS (Using QGIS).

Using ArcGIS

This section illustrates the creation of EPA H2O compatible land use data using Esri ArcGIS software.

1. Download and unzip the NLCD datasets, as shown in the Download Land Use Data section, and locate the appropriate HUC boundaries for the study area, as shown in the Create HUC Watershed Boundaries section.
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. Use the *Add Data*  icon to navigate to the NLCD 2011 .tif dataset (or most recent year) and add the layer to the Table of Contents of the map document.
4. If using a new map document, the shapefile created in the Create HUC Watershed Boundaries section must be added in the same way.

The watershed layer should represent a smaller, more focused area, whereas the new land use layer will be a larger bounding box around the AOI (*Figure 139*).

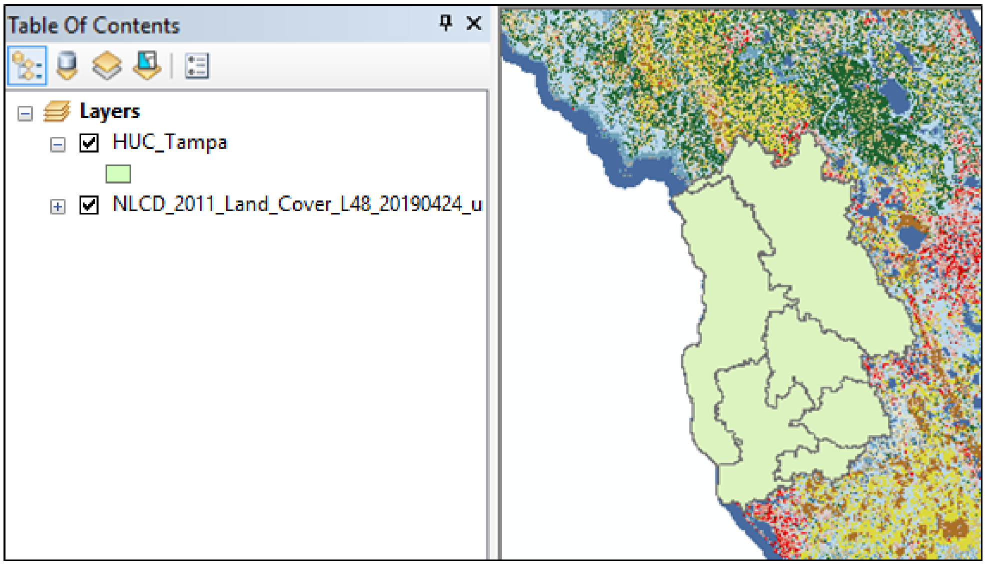


Figure 139 NLCD 2011 dataset, displayed with Tampa Bay watershed shapefile

5. Click on the *Toolbox* icon to open *ArcToolbox.*
6. From the *ArcToolbox* window, navigate to and open the *Clip* tool (*ArcToolbox* > *Data Management Tools* > *Raster* > *Raster Processing* > *Clip*, *Figure* 140).

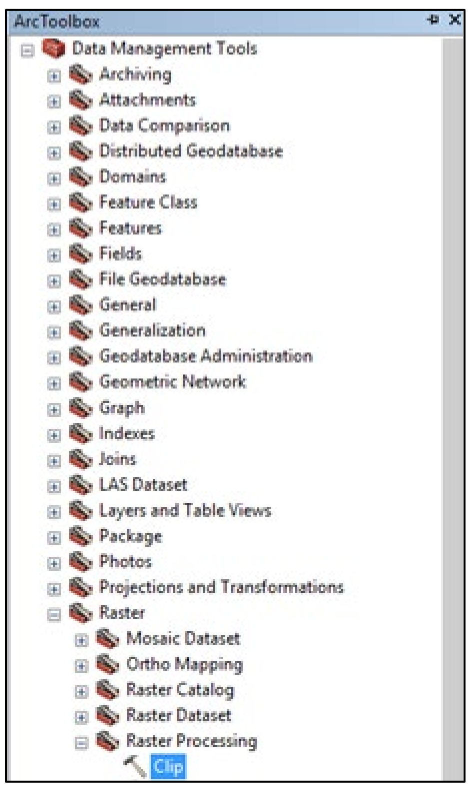


Figure 140 Location of the Clip tool in ArcToolbox

7. In the *Clip* tool window (*Figure 141*):
   a. In the *Input Raster* text box, select the user-specific NLCD dataset (e.g. *NLCD_2011_Land_Cover_L48_20190424_umtxeyAuXzMnsc7vNE8j.tiff)*.

b. In the *Output Extent* text box, select the HUC watershed boundary shapefile (e.g. *HUC_Tampa)*.
c. Check the *Use Input Features for Clipping Geometry* option.
d. In the *Output Raster Dataset* text box, browse to or type the desired file name (e.g. *NLCD_Tampa*) and file path.
e. Click *OK*.

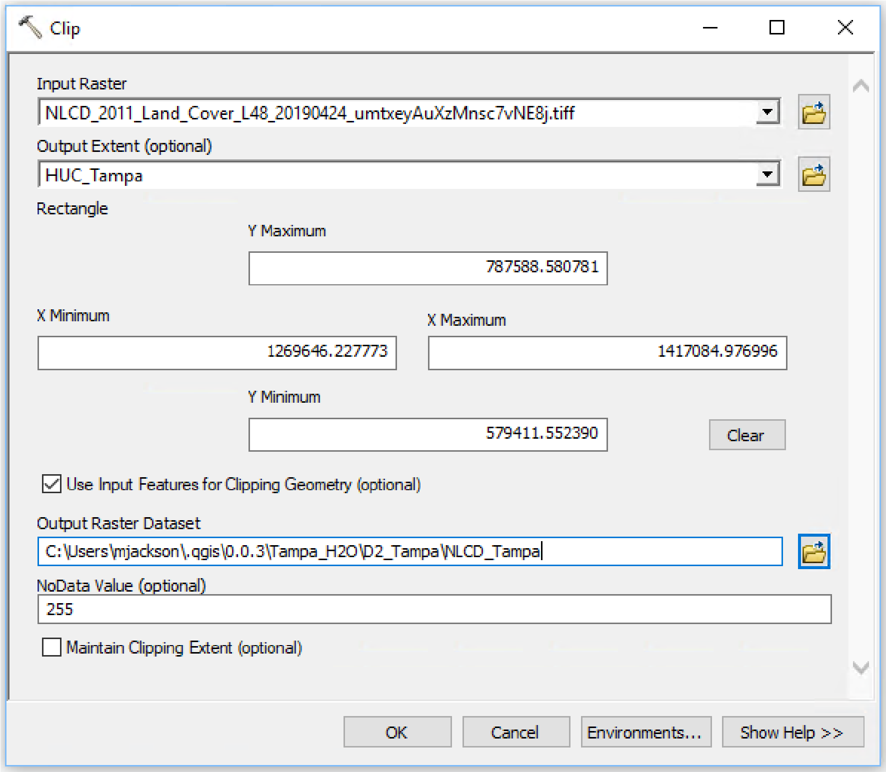


Figure 141 Clip tool window in ArcMap

8. The output is a raster dataset, which needs to be converted to a polygon layer for future processing.
9. From the *ArcToolbox* window, navigate to and open the *Raster to Polygon* tool (*ArcToolbox > Conversion Tools > From Raster > Raster to Polygon)*.
10. In the *Raster to Polygon* window (*Figure 142*):
    a. In the *Input Raster* text box, select the clipped NLCD raster dataset (e.g. *NLCD_Tampa)*.
    b. In the *Field* text box, choose *VALUE*.
    c. In the *Output polygon features* text box, name the output (e.g. *NLCD_Tampa_poly.shp)* and file path.
    d. Check the *Simplify polygons* option if not already checked.
    e. Click *OK*.

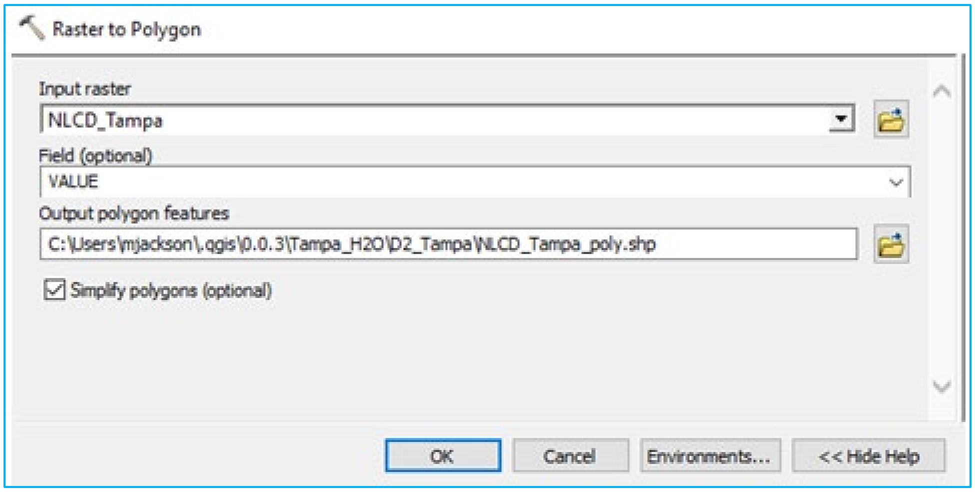


Figure 142 Raster to Polygon tool

Note: The *Simplify polygons* option removes vertices along sides of polygons to smooth and simplify the polygon edges, but this option is not available if using QGIS. To create a more comparable land use layer using ArcGIS, the user must uncheck the *Simplify polygons* option in the *Raster to Polygon* tool.

11. From the *ArcToolbox* window, navigate to and open the *Project* tool (*ArcToolbox > Data Management Tools > Projections and Transformations > Project, Figure* 143).

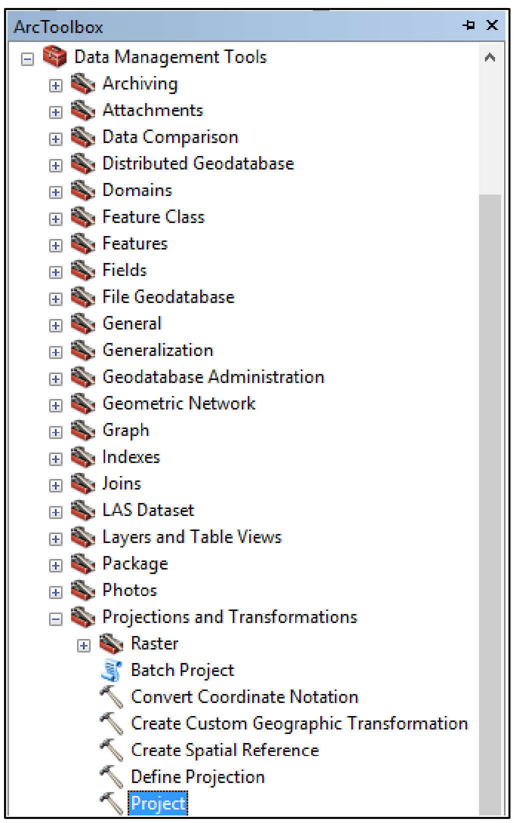


Figure 143 Location of the Project tool in ArcToolbox

12. In the *Project* tool window (*Figure 144*):
    a. In the *Input Dataset or Feature Class* box, select the clipped NLCD polygon (e.g. *NLCD_Tampa_poly).*

b. The *Input Coordinate System* automatically lists the input dataset coordinate system (e.g. NAD_1983_Albers).
c. In the *Output Dataset or Feature Class* text box, browse to or type the desired file name (e.g. *NLCD_Tampa_poly_reproj.shp*) and file path.
d. Click the *Spatial Reference*  icon to set the *Output Coordinate System* to *WGS_1984_Web_Mercator_Auxiliary_Sphere*, located under the *World* folder in *Projected Coordinate Systems*. Alternatively, search for it by typing *3857* into the search box.
e. A *Geographic Transformation* is required to reproject the land use dataset. In the dropdown list, choose *WGS_1984_(ITRF00)_To_NAD_1983*, if not already listed in the box.
f. If the wrong *Geographic Transformation* is listed, click on the name, and click the X button to remove it.
g. Click *OK*.

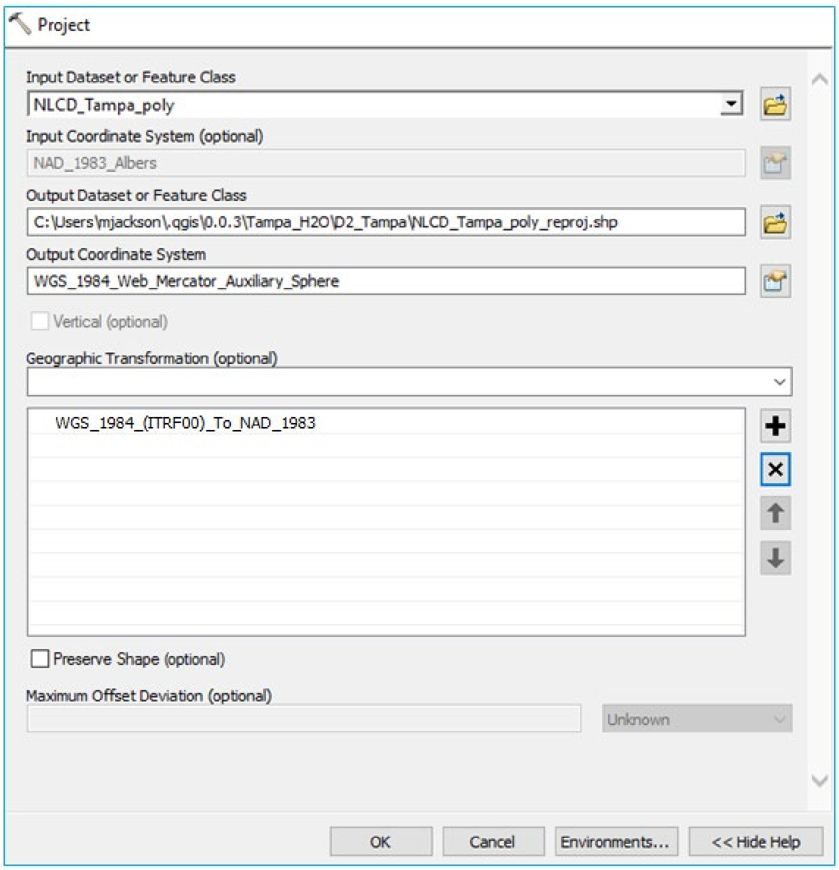


Figure 144 Project tool window in ArcMap

This re-projected output is used to complete a spatial join with the soil dataset in the section. Database creation is continued in the Create Land Use Comparison Data section.

Using QGIS

This section illustrates the creation of EPA H2O compatible land use data using QGIS software.

1. Download and unzip the NLCD land use data, as shown in the Download Land Use Data section.

2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. In the *Add vector layer* window (example shown in *Figure 127*), click *Browse* to locate and select the previously created HUC watershed boundary shapefile, then click *Open*.
   a. Ensure this HUC watershed boundary shapefile has the correct projection of *NAD83* and is not the shapefile that was re-projected to input into the Qspatialite user database.
4. From the *Layer* menu, open the *Add Raster Layer* window (*Main Menu > Layer > Add Raster Layer…*, *Figure* 145).

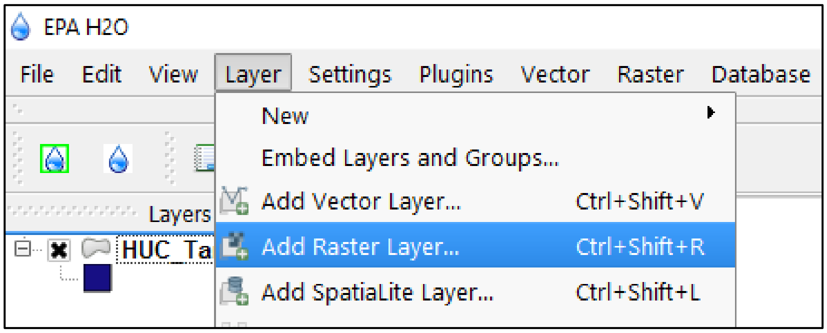


Figure 145 Location of the Add Raster Layer… tool in EPA H2O

   a. Navigate to the NLCD 2011 land use layer (or most recent year) previously downloaded in Download Land Use Data section (e.g. *NLCD_2011_Land_Cover_L48_20190424_umtxeyAuXzMnsc7vNE8j.tiff*).
   b. Choose the file with the ".tif" extension.
   c. Click *Open.*
5. The NLCD 2011 layer needs to be re-projected from the "Custom" projection to *WGS 84/ Pseudo Mercator*. From the *Raster* menu, open the *Reproject* tool (*Main Menu > Raster > Projections > Warp (Reproject)*, *Figure* 146*).*

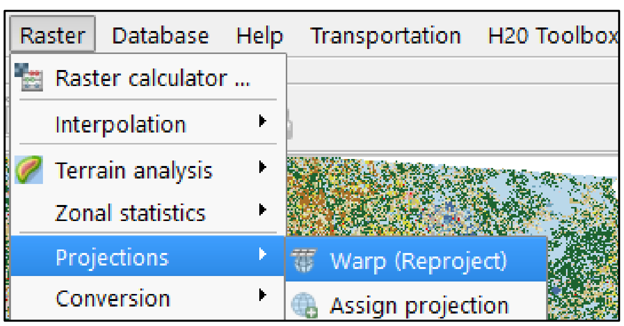


Figure 146 Location of the Warp (Reproject) tool in EPA H2O

6. In the *Warp (Reproject)* window (*Figure 148*):
   a. In the *Input file* dropdown list, select the user-specific NLCD layer (e.g. *NLCD_2011_Land_Cover_L48_20190424_umtxeyAuXzMnsc7vNE8j.tiff).*
   b. Click *Select* next to the *Output file* text box to select a file path and name for the output (e.g. *NLCD_FL_reproj.tif)*. Be sure to name the output with a **.tif extension**.
   c. Check the *Source SRS* box, and click *Select* to open the *Select the source SRS* window.
   d. In the *Select the source SRS* window (*Figure 147*):
      i. Under the *Recently used coordinate reference systems* section, choose the * Generated CRS (+proj = aea…) SRS.
      ii. Click *OK*.
   e. Check the *Target SRS* box and click *Select* to open the *Select the target SRS* window.

f. In the *Filter* box, type *3857*, and under *Coordinate reference systems of the world,* choose *WGS 84/ Pseudo Mercator*. Click *OK*.
g. Check *Load into canvas when finished*.
h. Click *OK*.

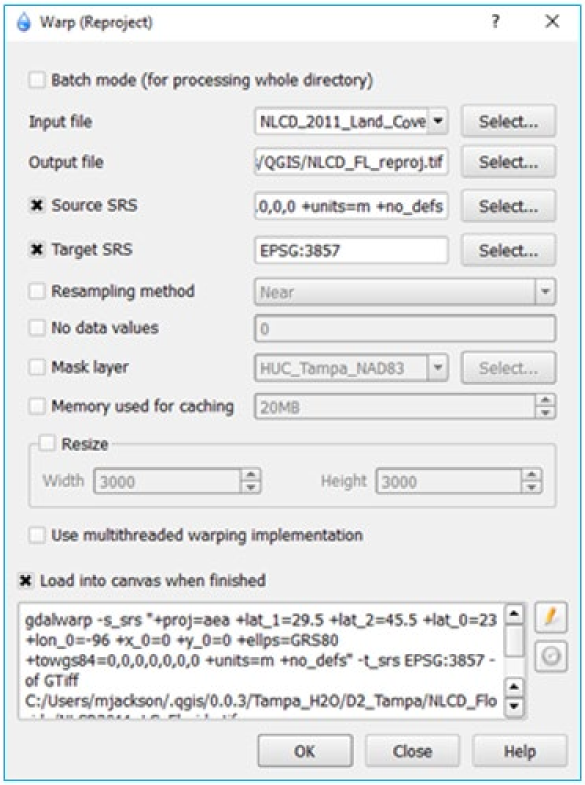


Figure 148 Warp (Reproject) tool window in EPA H2O

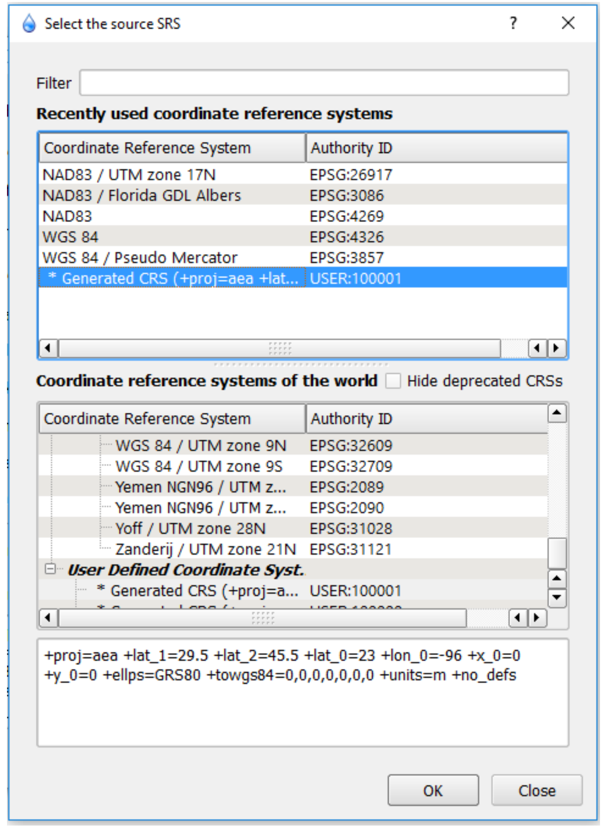


*Figure 147 Select source SRS window, with * Generated CRS highlighted*

7. This reprojection may take a few minutes to process. When a *Finished* window appears, click *OK* to continue.
8. Once the reprojection is complete, click *Close* to close the *Warp* tool.
9. The re-projected NLCD layer will appear added to the Layers panel. The original NLCD layer will also be listed and can be removed to avoid confusion by right-clicking on the layer and choosing *Remove*.
10. The re-projected NLCD layer will be “clipped” down to the area of interest. From the *Raster* menu, open the *Clipper* tool (*Main Menu > Raster > Extraction > Clipper*, Figure 149).

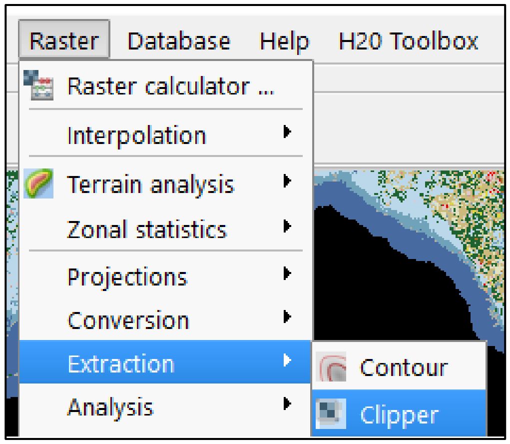


Figure 149 Location of the Clipper tool in EPA H2O

11. In the *Clipper* window (*Figure 150*):
    a. In the *Input file* dropdown list, select the re-projected NLCD layer (e.g. *NLCD_FL_reproj)*, if not selected by default.
    b. Click *Select* next to the *Output file* text box to select a file path and name for the output (e.g. *NLCD_HUC_clip.tif)*. Be sure to name the output with a **.tif extension**.
    c. Check the box next to *No Data Value* and choose the default value of 0.
    d. In the *Clipping mode* section, choose *Mask layer* and select the user-specific HUC watershed boundary shapefile as the *Mask layer*, if not selected by default (e.g. *HUC_Tampa_QGIS)*.
    e. Check *Load into canvas when finished.*
    f. Click *OK*.

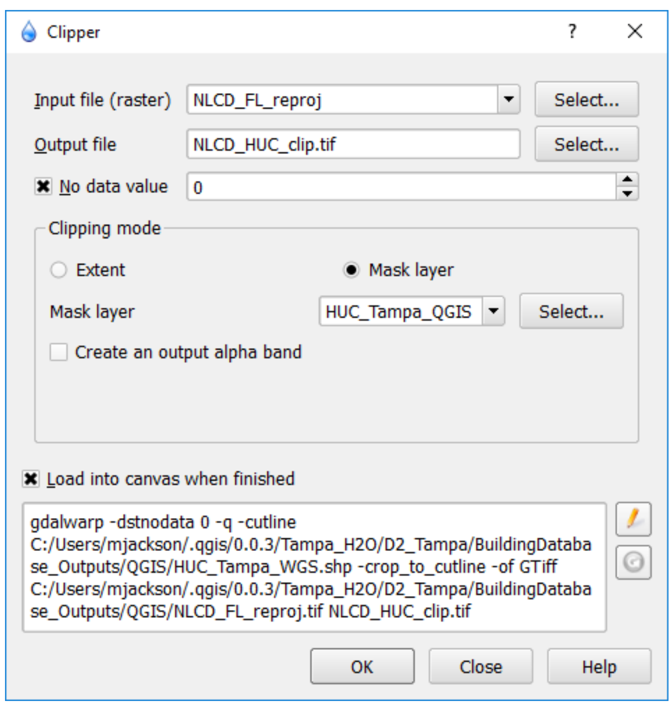


Figure 150 Clipper tool window in EPA H2O

12. When a *Finished* window appears, click *OK* to continue*.*
13. Click *Close* to close the *Clipper* tool after processing is complete.

Troubleshooting Common Errors:

Problem:

A common error with the *Clipper* tool results in the clipped land use layer being shifted from the original shapefile location, as shown in *Figure 151*. This shift occurs if the wrong HUC watershed boundaries shapefile was used as the Mask layer in the clipper tool.

Solution:

Clip the raster using the clipper tool again, repeating steps 10-13, using the re-projected NLCD layer and the HUC watershed boundary shapefile first created in the Using QGIS section. The HUC watershed boundary shapefile projection should be *NAD83.* The outline of the resulting raster from the clipper tool should align with the outline of the watershed boundary.

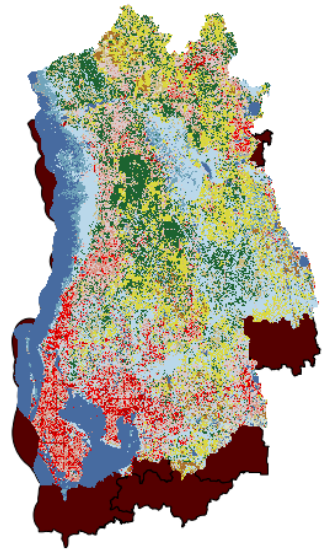


Figure 151 Clipped raster shifted from the original shapefile location used in the tool

After the NLCD raster is clipped to the area of interest it must be converted to a polygon (vector) dataset. First a grid of polygons aligned with the raster cells is generated, then points within each raster cell are generated to sample the raster and copy the values over to the new grid of polygons.

14. From the *Vector* menu, open the *Vector grid* tool (*Main Menu* > *Vector* > *Research Tools* > *Vector grid*, *Figure 152*).

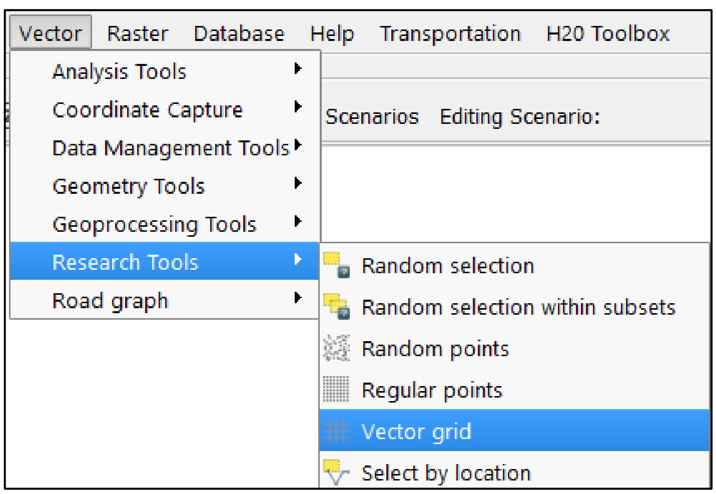


Figure 152 Location of the Vector grid tool in EPA H2O

15. In the *Vector grid* window (*Figure 153*):
    a. For *Grid extent*, select the clipped NLCD layer (e.g. *NLCD_HUC_clip)*.
    b. Check the box next to *Align extents and resolution to selected raster layer* and click the *Update extents from layer* button.
    c. Toggle the button next to *Output grid as polygons.*
    d. In the *Output shapefile* text box, specify the file path and name for the output shapefile (e.g. *NLCD_HUC_poly.shp)*.
    e. Click *OK*.

Note: if processing the NLCD raster in sections the difference in X Min and Y Min parameters between sections must be divisible by a raster cell (e.g. 30m for NLCD) for polygons to align. For example, if section one X Min_1= -9229391.18469, and section two X Min_2 = -9226500, the distance between X Min is 2891.18469m. Decreasing this distance to 2880m, X Min_2 = -9226511.18469, makes it divisible by 30m and moves the sections closer.

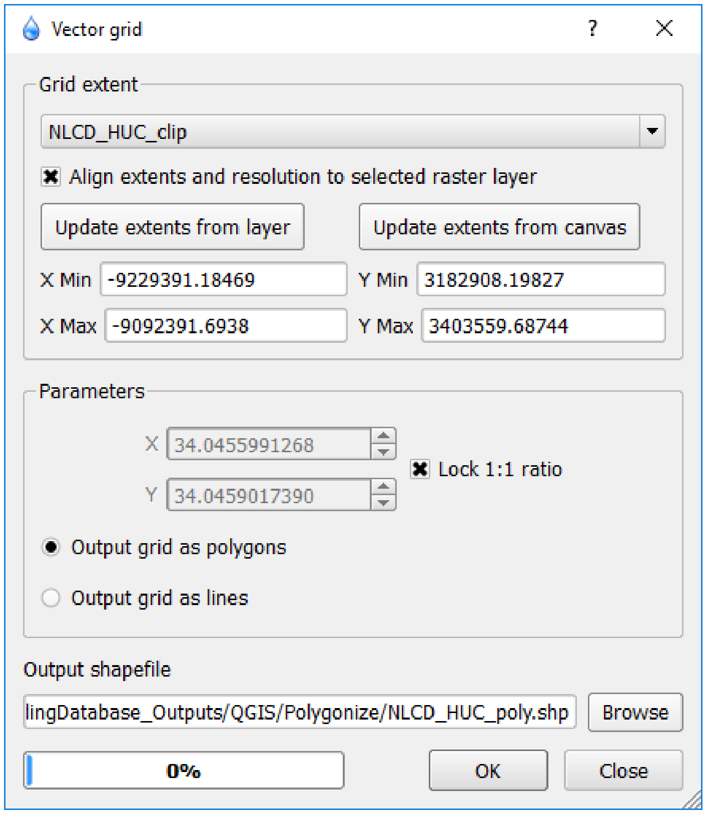


Figure 153 Vector Grid tool window in EPA H2O

Troubleshooting Common Errors:

Problem:

While running the *Vector grid* tool, an error may appear that states the program has stopped working (*Figure 154*). Raster processing has size limitations, which may cause the program to crash.

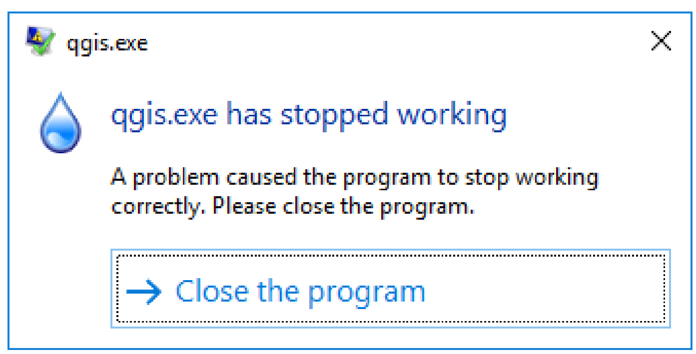


Figure 154 QGIS error message, which appears when the program has stopped working

Solution:

Try repeating the process on a raster clipped to a smaller area. If multiple watersheds were selected in creating the HUC watershed boundary shapefile, try clipping the raster to each watershed boundary individually. Follow the steps outlined in the Create HUC Watershed Boundaries section to create shapefiles for individual watersheds. Use the buffer tool (*Main Menu* > *Vector* > *Geoprocessing Tools* > *Buffer*) to add a 30m buffer to each watershed to help eliminate data gaps between watershed edges. Repeat the steps in this section (Using QGIS) to clip and prepare the NLCD raster for each individual watershed shapefile. The land cover shapefiles created must be recombined (steps 49-52) before importing them into the *.sqlite* database.

16. A *Generate Vector Grid* message will appear when processing is almost complete. Click *Yes.*
17. After the output shapefile appears in the Layers panel, and the *Vector grid* tool progress bar returns to 0%, click *Close* to close the *Vector grid* window.
18. From the *Vector* menu, open the *Regular Points* tool (*Main Menu* > *Vector* > *Research Tools* > *Regular Points*).
19. In the *Regular points* window (*Figure 155*):
    a. From the *Input Boundary Layer* dropdown list, select the clipped NLCD raster (e.g. *NLCD_HUC_clip.tif*).
    b. Toggle the *Use this point spacing* option, and in the text box, enter the resolution of the raster. The 2011 NLCD resolution is 30 m; units in the tool will match the units of the coordinate system.
    c. In the *Initial inset from corner (LH side)* text box, divide the resolution value by 2, and enter the result (e.g. 15 m, half of 30 m).
    d. In the *Output Shapefile* text box, specify a file path and name for the output shapefile (e.g. *NLCD_HUC_points.shp)*.
    e. Click *OK*.

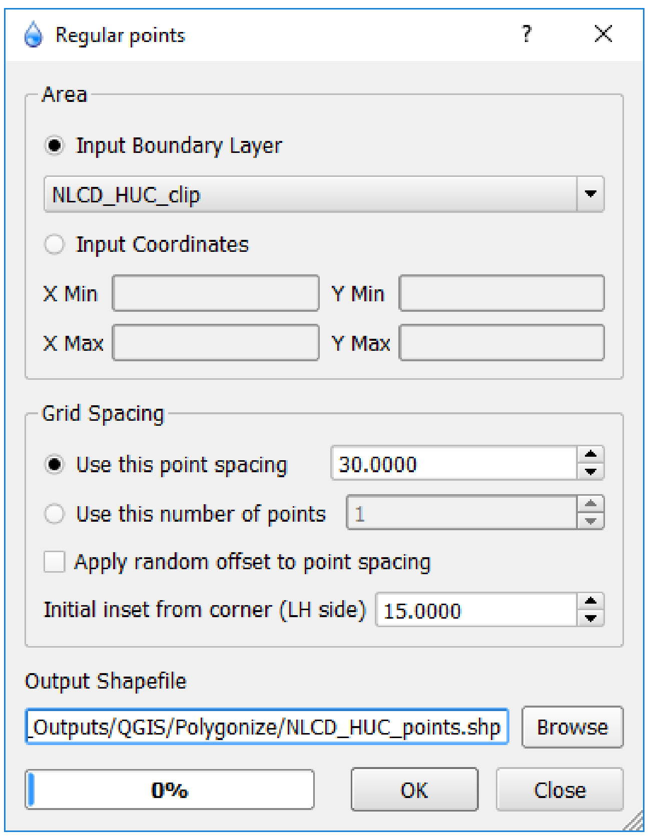


Figure 155 Regular points window in EPA H2O

20. A *Generate Regular Points* message will appear during processing. Click *Yes*.
21. After the output shapefile appears in the Layers panel, and the *Regular Points* tool progress bar returns to 0%, click *Close* to close the *Regular points* window.
22. Sampling the raster at the generated points is done using the *Point sampling tool* plugin. Use the QGIS Plugin Manager (*Main Menu* > *Plugins* > *Manage Plugins*) to make sure the *Point sampling tool* plugin is enabled, as shown in *Figure 156.* If not already enabled, check the box next to *Point sampling tool (Version 0.3.3)* to activate the plugin, and click *OK*.

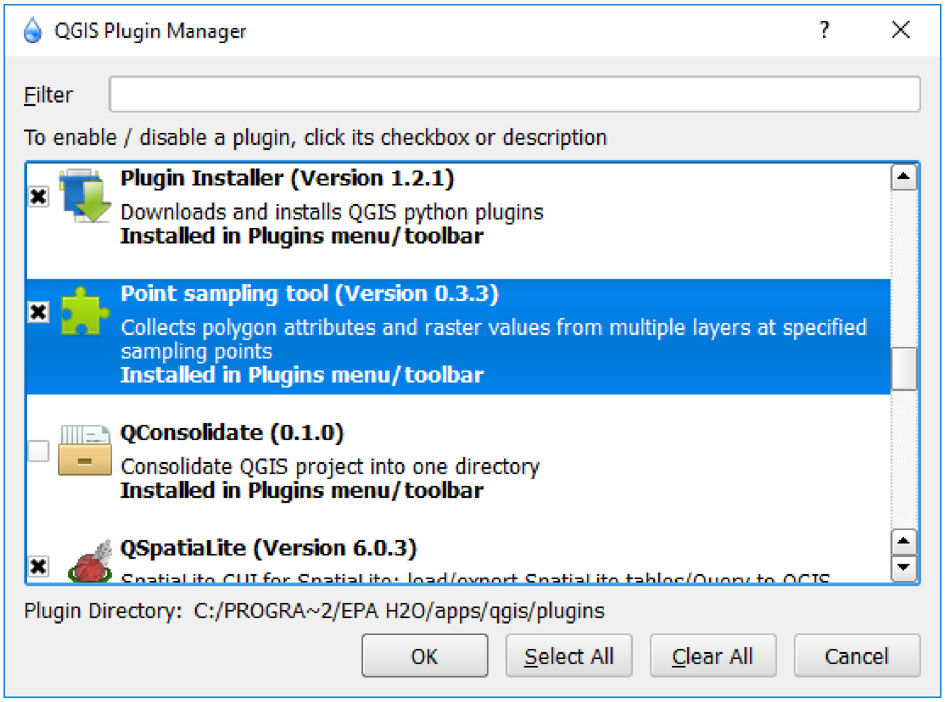


Figure 156 QGIS Plugin Manager, with the Point sampling tool selected and enabled

23. From the *Plugins* menu, open the *Point sampling tool* (*Main Menu > Plugins > Analyses > Point Sampling Tool*).
24. In the *Point Sampling Tool* window (*Figure 157*):
    a. In the *Layer containing sampling points* dropdown list, select the regular points layer generated in the previous step (e.g. *NLCD_HUC_points*).
    b. In the *Layers with fields/bands to get values from* list box, click to highlight the clipped NLCD raster (e.g. *NLCD_HUC_clip.tif*). Only layers that are currently turned on in the Layers panel will be available in the *Layers with fields/bands to get values from* list box.
    c. In the *Output point vector layer* text box, specify a file path and name for the output point vector layer (e.g. *NLCD_HUC_samplepoints.shp*).
    d. Check *Add created layer to the TOC*.
    e. Click *OK*.

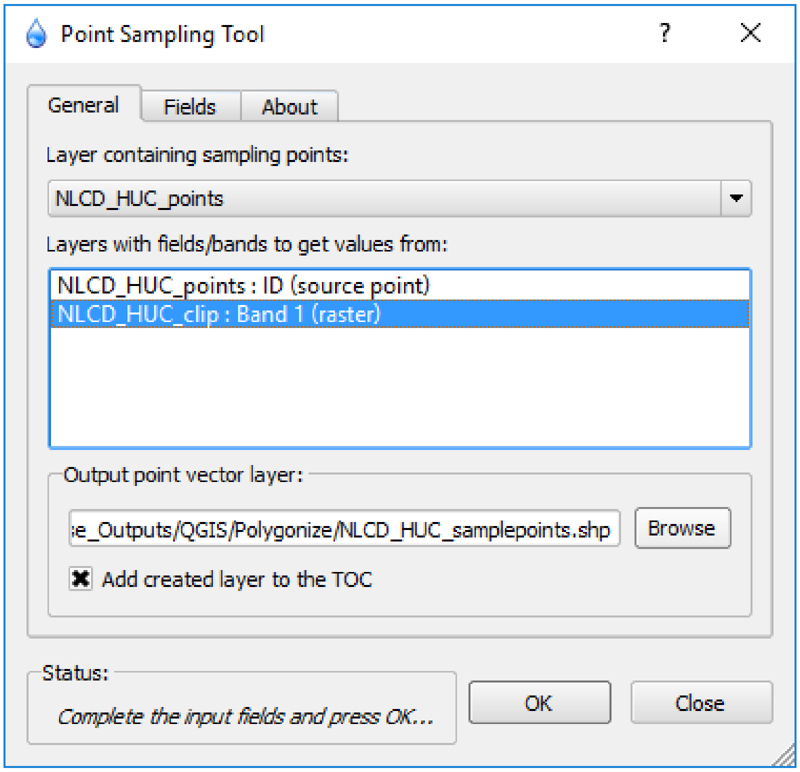


Figure 157 Point Sampling Tool window, with NLCD_HUC_clip selected in blue

Depending on the size of the AOI this tool may take a few hours to process. The window may say *Not Responding* while the tool is still actively processing.

25. After the output shapefile appears in the Layers panel, click *Close* to close the *Point Sampling Tool* window.
26. From the *Vector* menu, open the *Join attributes by location* tool (*Main Menu > Vector > Data Management Tools > Join attributes by location*, Figure 158).

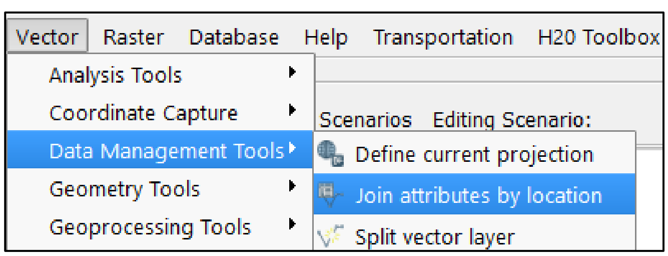


Figure 158 Location of the Join attributes by location tool in EPA H2O

27. In the *Join attributes by location* window (Figure 159):
    a. From the *Target vector layer* dropdown list, select the polygon vector grid (the output from the *Vector grid* tool in step 15, e.g. *NLCD_HUC_poly).*
    b. From the *Join vector layer* dropdown list, select the sampled points layer (the output from the *Point sampling tool* in step 24, e.g. *NLCD_HUC_samplepoints).*
    c. In the *Attribute Summary* section, toggle *Take attributes of first located feature.*
    d. In the *Output Shapefile* text box, specify the file path and name for the output polygon layer (e.g. *NLCD_HUC_poly_spoints_join.shp).*
    e. In the *Output table* section, toggle *Only keep matching records.*
    f. Click *OK.*

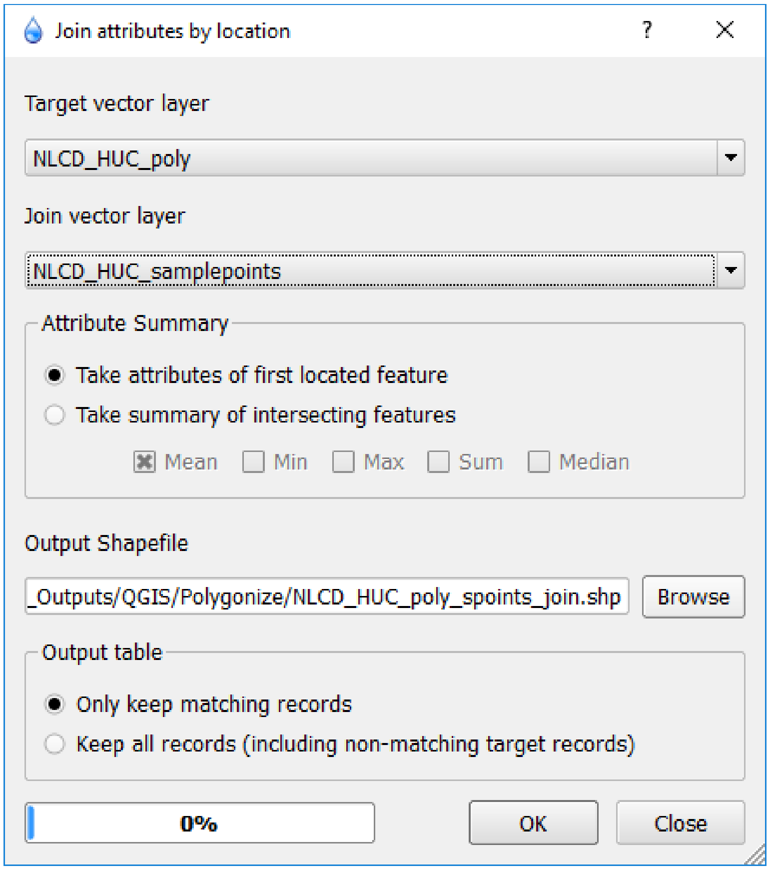
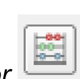


Figure 159 Join attributes by location window

28. A *Join attributes* message may appear when processing is almost complete. Click *Yes*.
29. After the output shapefile appears in the Layers panel, and the *Join attributes by location* tool progress bar returns to 0%, click *Close* to close the *Join attributes by location* window.
30. Double click on the NLCD polygon layer (e.g. *NLCD_HUC_poly_spoints_join*) to open *Layer Properties*.
31. Under the *Fields* tab, click the *pencil*  icon to toggle editing mode.
32. Click the *New Column*  icon to add a new gridcode field to the attribute table.
33. In the *Add Column* window (*Figure 160*):
    a. In the *Name* text box, type *gridcode.*
    b. In the *Type* dropdown list, select *Text (string).*
    c. In the *Width* text box, enter 2.
    d. Click *OK.*
34. Click the *Field Calculator*  icon in *Layer Properties* to open the *Field Calculator* window.
35. In the *Field Calculator* window (*Figure 161*):

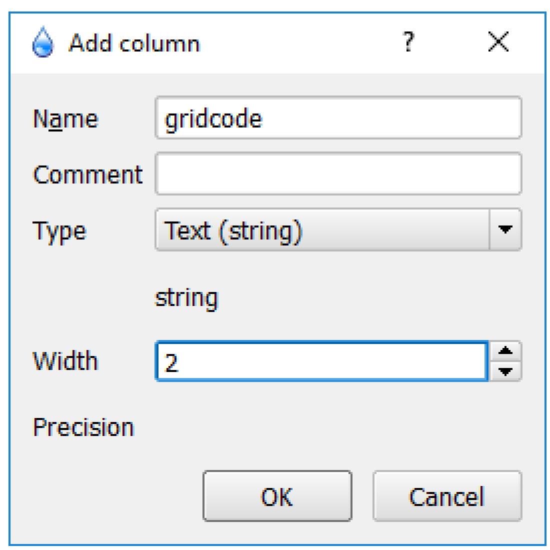


Figure 160 Add column window, to add a new field in the land use polygon layer

a. Toggle the *Update existing field* option, and from the dropdown list, select the “gridcode” field.
b. In the *Function List*, find and expand *Fields and Values*. Double click the joined field from this list (e.g. “NLCD_HUC_c”).
c. The name of the joined field should appear in the *Expression* box.
d. Click *OK.*

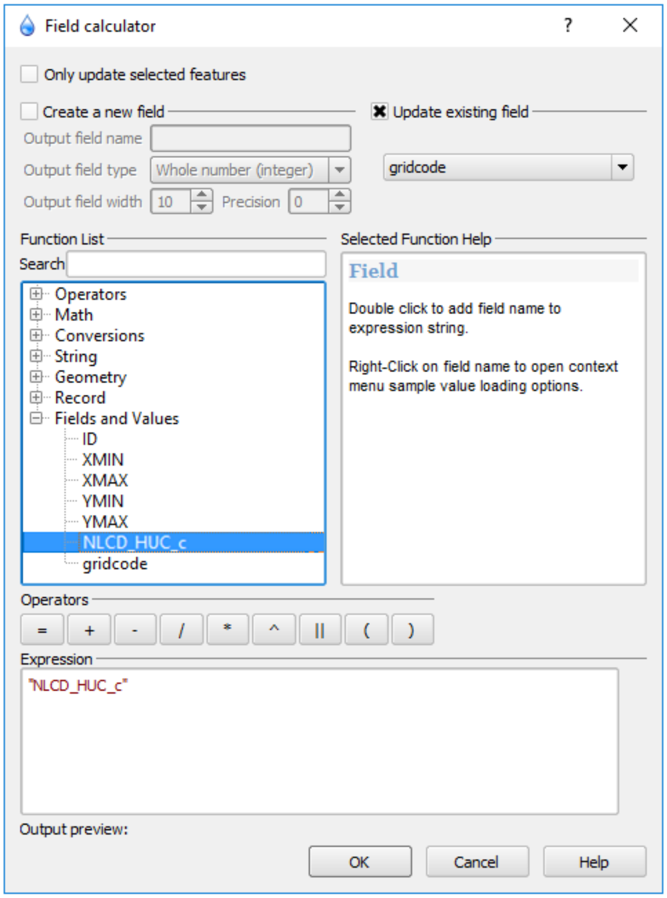


Figure 161 Field Calculator, with NLCD_HUC_c entered as the expression

36. Click the *pencil*  icon in the *Fields* tab of *Layer Properties* to toggle editing off. In the *Stop editing* window that appears, click *Save* to save the *Field Calculator* edits.

Troubleshooting Common Errors:

Problem:

While processing the field calculation an error may appear that states the program has stopped working (*Figure 162*). Depending on the size of the user’s AOI, EPA H2O may not be able to process the full field calculation.

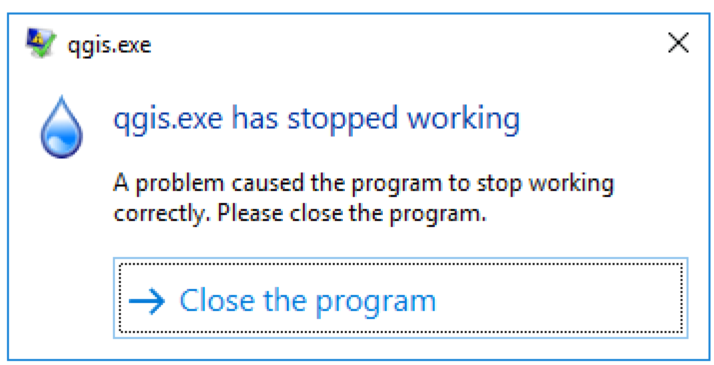


Figure 162 QGIS error message, which appears when the program has stopped working

Solution:

If this occurs, reopen the EPA H2O program, and load the NLCD polygon layer (e.g. *NLCD_HUC_poly_spoints_join).* Open the attribute table to determine if the “gridcode” field and the joined field (e.g. “NLCD_HUC_c”) match completely. Double click on the joined field header (e.g. “NLCD_HUC_c”) to sort the field in **descending order**. If the “gridcode” field did not fully populate, click the *pencil* icon in the attribute table to toggle editing on. Select the first row with a blank “gridcode” field and drag down the attribute table to highlight the subsequent rows. If there are many rows that did not update it is recommended that the user highlight rows in sections, to avoid having the error repeat. For each selection of rows, click the *Field Calculator* icon and populate the “gridcode” field using the *Field Calculator* window as shown in step 35 (*Figure 161*). Toggle editing off and save (step 36) after all values in the created field match those in the joined field.

37. In the Layers panel, right-click on the NLCD polygon layer (e.g. *NLCD_HUC_poly_spoints_join*) and open the attribute table.
38. In the *Look for* text box at the bottom of the attribute table, type *NULL* and from the *in* dropdown list, select the “gridcode” field. Click *Search.*
39. At the bottom of the attribute table, click the *Invert Selection*  icon. This may take **significant** time to process.
40. From the *Vector* menu, open the *Dissolve* tool (*Main Menu* > *Vector* > *Geoprocessing tools* > *Dissolve*).
41. In the *Dissolve* window (*Figure 163*):
    a. In the *Input vector layer* dropdown list, select the NLCD polygon layer (e.g. *NLCD_HUC_poly_spoints_join).*
    b. Check the *Use only selected features* option if not automatically checked.
    c. In the *Dissolve field* dropdown list, select “gridcode”.
    d. In the *Output shapefile* text box, specify the file path and name for the output shapefile (e.g. *NLCD_HUC_dissolve.shp*).
    e. Click *OK*.

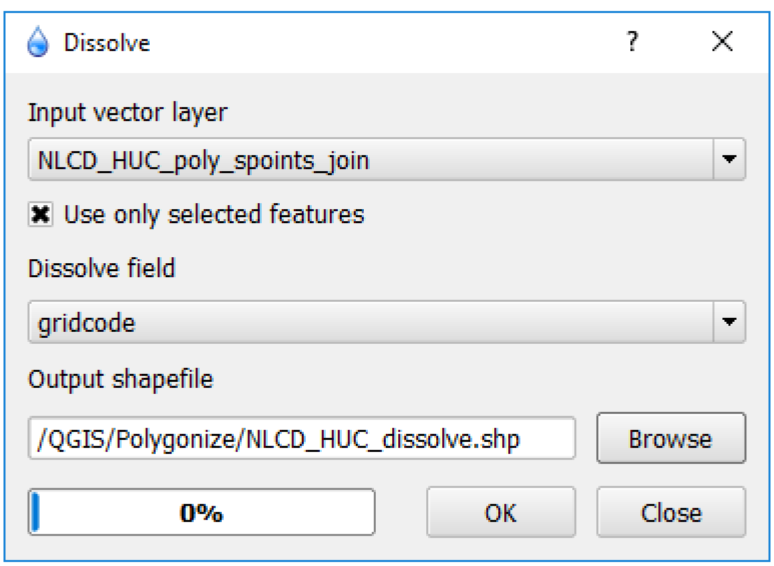


Figure 163 Dissolve window, used to merge common land use polygons together

Depending on the size of the area being processed, this step may take significant time to process. Do not close out of EPA H2O.

42. Once the tool is finished, click *Close* to exit the *Dissolve* window.

43. From the *Vector* menu, open the *Multipart to singleparts* tool (*Main Menu > Vector > Geometry Tools > Multipart to singleparts*).
44. In the *Multipart to singleparts* window (*Figure 164*):
    a. In the *Input line or polygon vector layer* dropdown list, select the dissolved polygon layer (e.g. *NLCD_HUC_dissolve*).
    b. In the *Output shapefile* text box, specify the file path and name for the output shapefile (e.g. *NLCD_HUC_parts.shp*)
    c. Click *OK.*

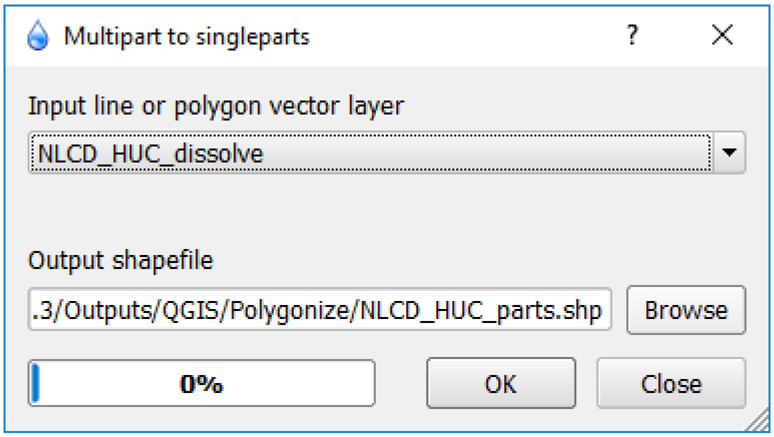
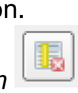


Figure 164 Multipart to singleparts window in EPA H2O

45. In the Layers panel, double click on the land use layer (e.g. *NLCD_HUC_parts*) to open *Layer Properties.*
46. From the *Fields* tab of *Layer Properties,* click the *pencil*  icon to toggle editing on.
47. Select all fields except the “gridcode” field and remove them using the *Delete column*  icon.
48. Click the *pencil*  icon under the *Fields* tab to toggle *Editing mode* off. In the *Stop editing* window that appears, click *Save*.

If the user had to clip the NLCD raster into smaller areas, steps 15 through 48 must be repeated for each NLCD clip. The following steps explain how to recombine NLCD shapefiles generated for each smaller area into one land use layer. If the NLCD raster was not split into smaller areas the NLCD shapefile is complete and the following steps can be skipped.

49. Use File Explorer to move the shapefile output for each NLCD clip to a common folder if not already. This common folder should only contain the final NLCD shapefile outputs (from step 44).
50. From the *Vector* menu, open the *Merge shapefiles to one* tool (*Main Menu > Vector > Data Management Tools > Merge shapefiles to one, Figure 165).*

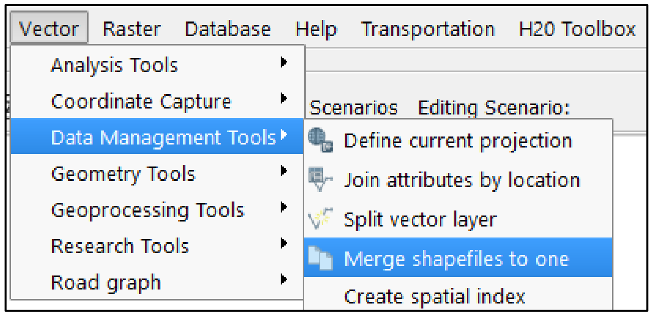


Figure 165 Location of the Merge shapefiles to one tool in QGIS

51. In the *Merge shapefiles* window (*Figure 166*):
    a. In the *Shapefile type* dropdown list, select *Polygon*.
    b. For the *Input directory* text box, click *Browse* and locate the common folder where each NLCD clip output was saved (e.g. *Polygonize).*
    c. In the *Output shapefile* text box, specify the file path and name for the output shapefile (e.g. *NLCD_Tampa_poly_reproj.shp)*.
    d. Check *Add result to map canvas.*
    e. Click *OK*.

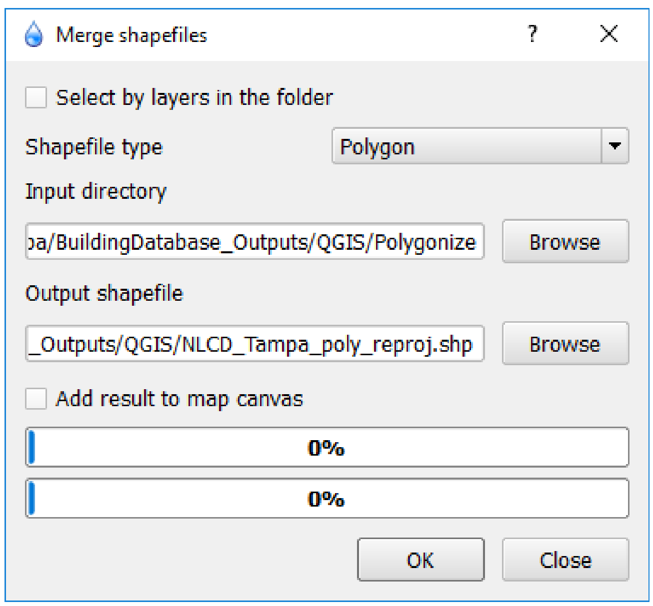


Figure 166 Merge shapefiles window in QGIS, with Polygonize folder indicated as the Input directory

52. Repeat steps 40-44 on the merged land use layer to combine any land use polygons that have been split when processing the raster by section; however, un-check the *Use only selected features* option when running the *Dissolve* tool (Step 41b).

The output layer is a vector (polygon) representation of the NLCD raster data layer. This layer has not been simplified, resulting in land use polygon boundaries with vertices that follow the jagged outlines of their former raster cells. In reality these land use areas will rarely follow straight lines like this and removing some of the vertices to smooth and simplify the polygons is an option in ArcGIS.

The layer created in this section is used in a spatial join with the soil dataset in the Spatially Join Soils to Land Use section. Database creation is continued in the Create Land Use Comparison Data section

Create Land Use Comparison Data

The original Tampa Bay database contains land use prediction datasets for the years 2020, 2040, and 2060. These datasets can be used to create and compare scenarios with current land use; however, the datasets are specific to the Tampa Bay area. The user can manipulate these tables in EPA H2O for use in new areas in multiple ways:

1. The user may remove these datasets from the Qspatialite plugin in EPA H2O, and not include created land use comparison data in their database.
2. The user may remove these datasets and insert their own future land use prediction data into the Qspatialite plugin. This data must be created or obtained by the user.
3. The user may create past land use comparison data from previously published NLCD data years and insert this comparison data into the Qspatialite plugin.

This section outlines how to process past NLCD data for EPA H2O scenario comparisons. Example input and output layers are given for processing the NLCD 2001 land use layer.

1. Past land use data was previously downloaded in the Download Land Use Data section (*Figure* 135 - *Figure* 138).
    a. If the *All Land Cover Years* option was toggled during data download, NLCD land cover for years 2001, 2003, 2006, 2008, 2013, and 2016 were unzipped into the same location as NLCD 2011.
    b. Note: only 3 land use comparison datasets can be inserted into a new database at one time.
2. Process the land use data as shown in Create Land Use Data Layer, Using ArcGIS or Using QGIS sections.
    a. Clip each land use raster to the AOI boundary.
        i. In this example, the *NLCD_2001_Land_Cover_L48_20190424_umtxeyAuXzMnsc7vNE8j.tiff* raster is clipped to the *HUC_Tampa* AOI shapefile, with the output named *NLCD2001_clip.tif.*
    b. Convert clipped land use raster data to polygon data.
        i. In this example, the *NLCD2001_clip.tif* raster is converted to a shapefile, with the output named *NLCD2001_clip_poly.shp.*
    c. Reproject each land use shapefile into the *WGS 1984 Web Mercator Auxiliary Sphere* (ArcGIS) or *WGS 84 Pseudo Mercator* (QGIS) coordinate system.
        i. In this example, the *NLCD2001_clip_poly* shapefile is re-projected, with the output named *NLCD2001_clip_poly_reproj.shp.*

The remaining steps outline the rest of the requirements for creating land use comparison data. Similar steps for processing of the land use layer (e.g. NLCD 2011) are in the Create Soil Data Layer, Update ES Coefficients, and Joining Lookup Table sections. However, if completing sections of this manual in sequential order, these have not been performed for the land use layer. The reader may wish to continue processing the land use layer and then come back to the remaining land use comparison data steps after.

3. Spatially join each land use layer (e.g. *NLCD2001_clip_poly_reproj.shp*) with the soil shapefile created in Create Soil Data Layer (e.g. *Max_Type_N.shp*), and continue the processing shown in Spatially Join Soils to Land Use (ArcGIS) or Spatially Join Soils to Land Use (QGIS).

a. After each join, create a new "Max_Type_N" field in the new land use attribute table (e.g. *NLCD2001_MaxTypeN_join.shp*). Populate "Max_Type_N" with integer values based on the averaged values in the "Avg_Max_Ty" field.
b. Calculate the most common soil type in the land use layer (e.g. *NLCD2001_MaxTypeN_join.shp*) and populate the "Max_Type_N" value for the NULL soil polygons (i.e. *"Avg_Max_Ty" = 0)*.

4. Join each land use layer with the lookup table, as shown in either the Using ArcGIS or Using QGIS sections. Then update the ES coefficients and continue with field calculations.
   a. Join the land use layer (e.g. *NLCD2001_MaxTypeN_join.shp*) with the lookup table (e.g. *lookUPvars*) and export the updated land use layer (e.g. *LandUse_2001.shp*).
   b. Update the "Canopy" field in the final land use layer (e.g. *LandUse_2001.shp*), as shown in the Tree Canopy section (Using ArcGIS or Using QGIS). However, the final land use layer (e.g. *LandUse_2001.shp*) will be used as the input, rather than the soil/land use layer.
      i. In ArcGIS, continue following the steps outlined in the Tree Canopy Using ArcGIS section; however, right-click on each land use layer (e.g. *LandUse_2001.shp*), rather than the lookup table, to join by attributes.
      ii. In QGIS, continue following the steps outlined in the Tree Canopy Using QGIS section. However, the field calculations will occur in each land use attribute table (e.g. *LandUse_2001.shp*), rather than the lookup table. The user must also select all rows for each gridcode value (not just the first row) and complete the appropriate calculations. This selection can be completed by clicking and dragging to highlight rows, or by creating a query for each gridcode in the *Look for* search box.
   c. The % canopy cover may differ between years because the land use changes. The carbon burial rate for "Developed" land use types incorporates the % canopy values. The user may choose to update the "CarbonFixe" field for the "Developed" land use in each layer, as explained in the Carbon Sequestration section.
   d. After the "Canopy" fields have been updated, the calculations in the Joining Lookup Table section can be completed as written for each land use layer.

The Importing Layers into QGIS section details how to upload the land use layers into the user database in QGIS. Database creation is continued in the Create Soil Data Layer section.

Create Soil Data Layer

The soil data layer defines soil types in EPA H2O. Soil types, along with land cover classes, are used to characterize Curve Number (CN) values in the land use layer. These CN values are then used to compute the dollar value of flood protection, one of the ecosystem services EPA H2O evaluates. This section illustrates the step-by-step method used to obtain and prepare the soil data. The Joining Lookup Table section describes how to calculate CN values for the land use data layer using the soil data layer that results from this section.

Either Esri ArcMap software or QGIS can be used to prepare the soil data. The procedure for both software applications is explained in this section.

Download Soil Data

This section illustrates the step-by-step procedure for downloading soil shapefiles by county from the USDA Soil Survey Website.

1. Navigate to https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx as shown in *Figure* 167.

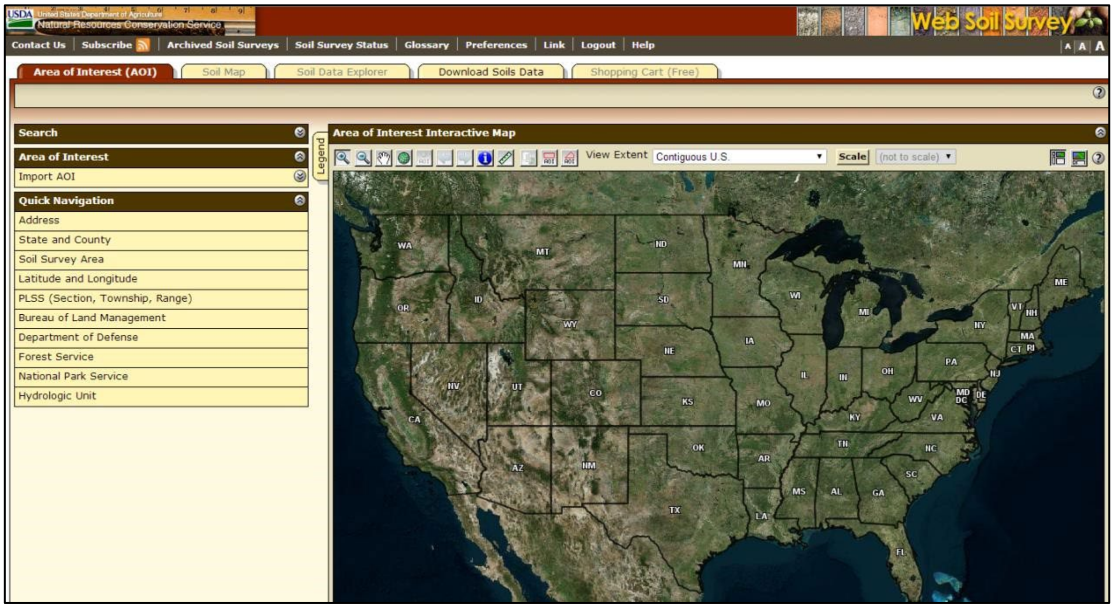


Figure 167 USDA Soil Data download website

2. Click on the *Download Soils Data* tab (*Figure* 168).

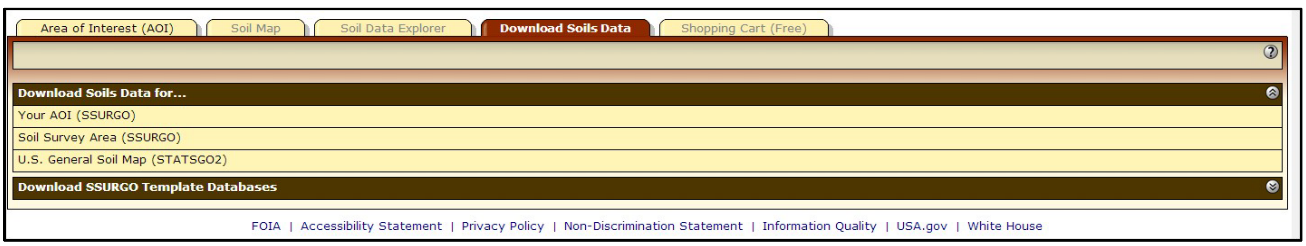


Figure 168 *Download options located under the Download Soils Data tab*

3. Under the *Download Soils Data for….* section click *Soil Survey Area (SSURGO)* to expand this section (*Figure 169*).
4. In the newly expanded *Options* section, select the desired *State* and *County* from the appropriate dropdown lists (*Figure 169*).
5. Check the *Include Template Database* option and click *Update.*

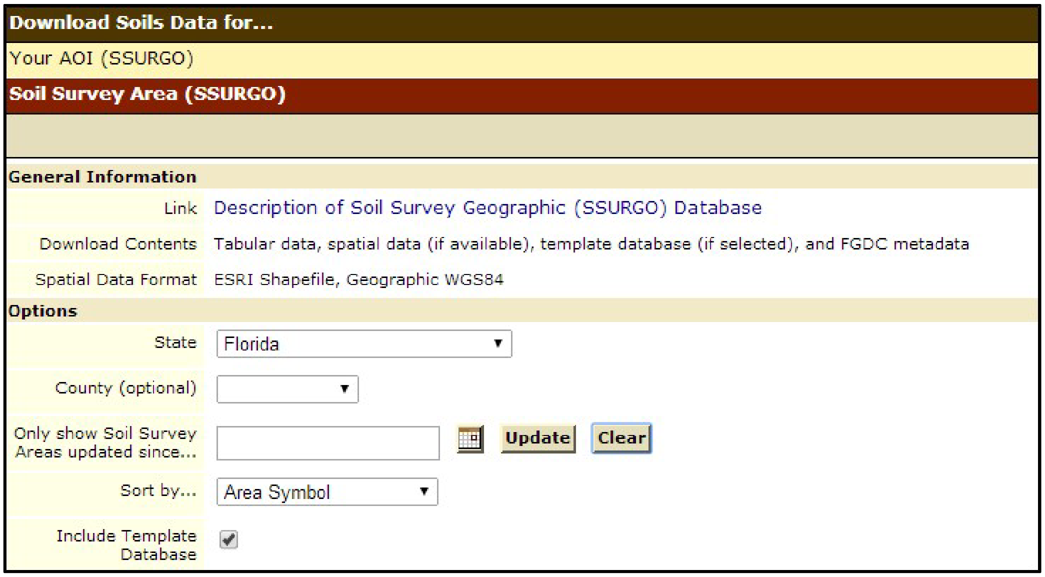
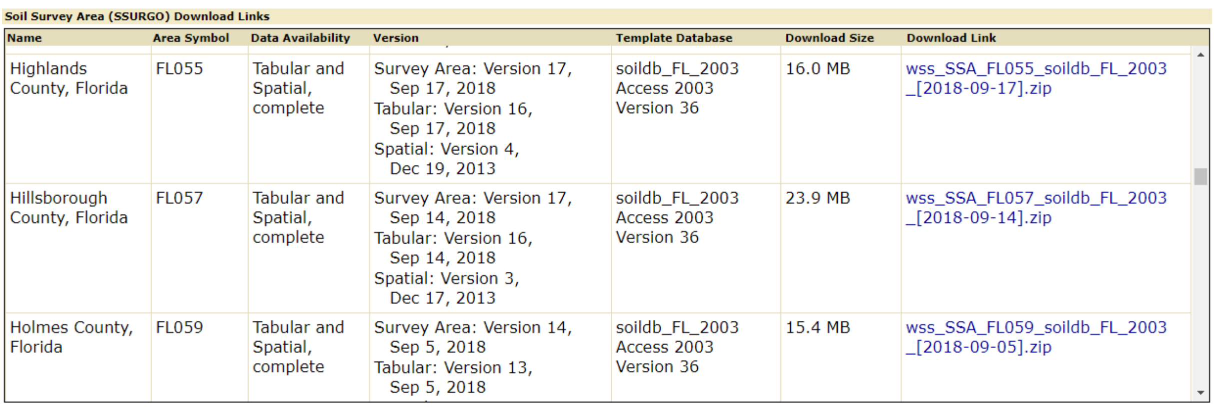


Figure 169 Soil datasets are downloaded by the counties the user's area of interest is in

6. From the *Soil Survey Area Download Links* section, find the desired county dataset and download it by clicking the hyperlink in the *Download Link* column (e.g. *wss_SSA_FL057_soildb_FL_2003_[2018-09-14].zip*, *Figure 170*). Multiple county datasets may need to be downloaded to cover all parts of the user's Area of Interest.



Soil Survey Area (SSURGO) Download Links

Name	Area Symbol	Data Availability	Version	Template Database	Download Size	Download Link
Highlands County, Florida	FL055	Tabular and Spatial, complete	Survey Area: Version 17, Sep 17, 2018 Tabular: Version 16, Sep 17, 2018 Spatial: Version 4, Dec 19, 2013	soildb_FL_2003 Access 2003 Version 36	16.0 MB	wss_SSA_FL055_soildb_FL_2003_[2018-09-17].zip
Hillsborough County, Florida	FL057	Tabular and Spatial, complete	Survey Area: Version 17, Sep 14, 2018 Tabular: Version 16, Sep 14, 2018 Spatial: Version 3, Dec 17, 2013	soildb_FL_2003 Access 2003 Version 36	23.9 MB	wss_SSA_FL057_soildb_FL_2003_[2018-09-14].zip
Holmes County, Florida	FL059	Tabular and Spatial, complete	Survey Area: Version 14, Sep 5, 2018 Tabular: Version 13, Sep 5, 2018	soildb_FL_2003 Access 2003 Version 36	15.4 MB	wss_SSA_FL059_soildb_FL_2003_[2018-09-05].zip

Figure 170 Link to download soil data is provided by county

7. Save the zip file to the computer and unzip the contents to a known location on the C:\ drive. It may be helpful to create a special directory for the soil data (an example directory is shown in *Figure 171*). By default, unzipped files for each download are saved in a folder named after their Area Symbol, as listed in the Area Symbol column in *Figure 170*.

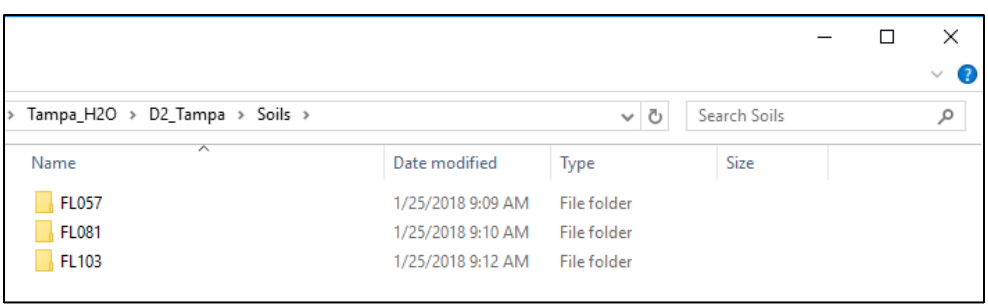


Figure 171 Recommended workspace for Soil data

The next section illustrates the pre-processing of spatial soil data using Microsoft Access.

Pre-processing Soil Data

This section illustrates pre-processing of the spatial soil data using Microsoft Access. These steps are also detailed in the *readme.txt* file located in each unzipped soil data folder. Users must complete these steps before creating the soil data layer using either Esri ArcGIS software (Using ArcGIS) or QGIS (Using QGIS).

1. Download and unzip the SSURGO soil data, as shown in the Download Soil Data section.
2. Each unzipped soil data folder contains a ".mdb" database file. Locate the ".mdb" file in File Explorer, right-click and choose *Open* to open the file in MS Access.
3. When MS Access opens the ".mdb" file a *Macro Single Step* window may appear (*Figure 172*). Click the X button to close the window and click *Enable Content* to fully enable the program.

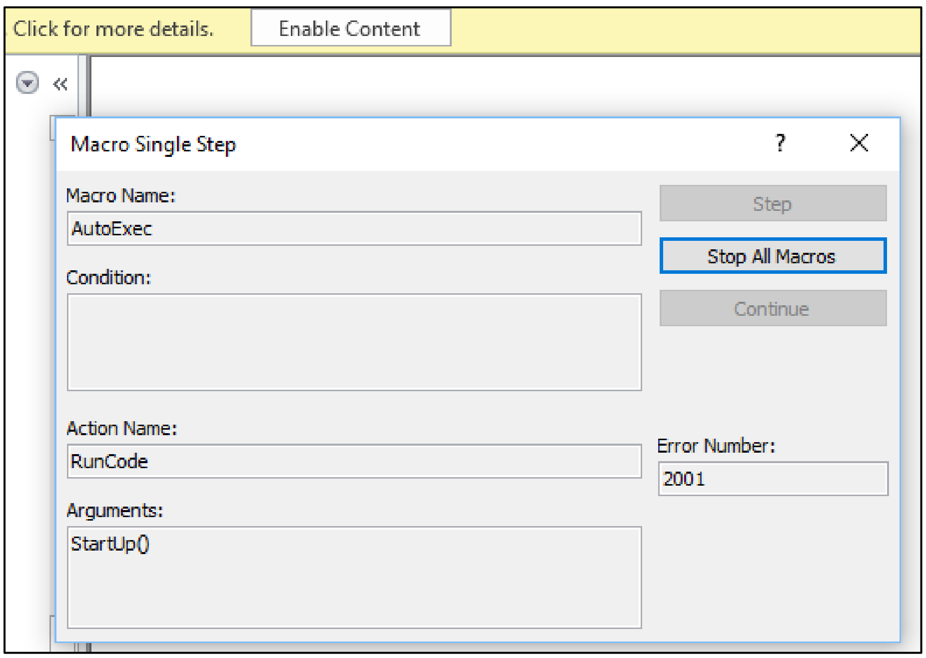


Figure 172 Macro Single Step pop-up window in Microsoft Access

4. A *SSURGO Import* window will appear when MS Access is fully enabled (*Figure* 173).

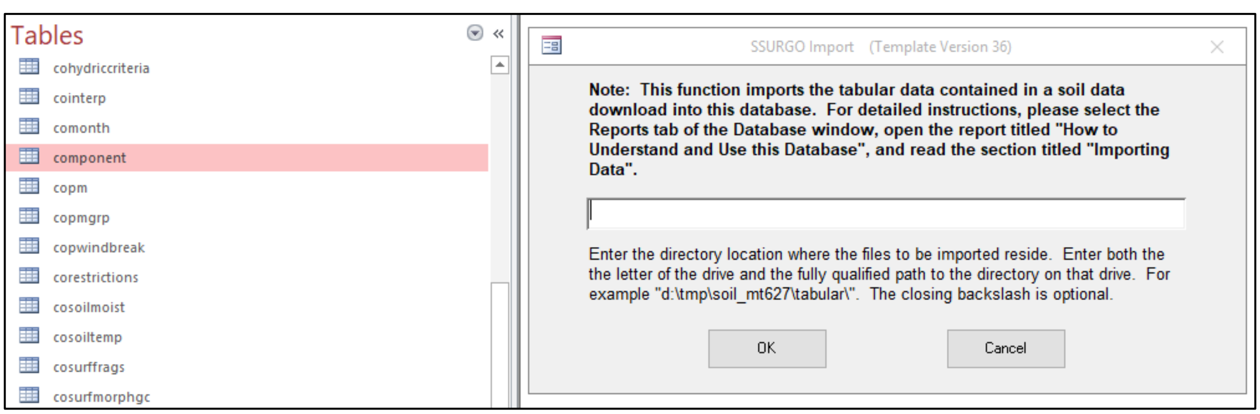


Figure 173 Macro requesting the tabular folder path

5. In File Explorer, locate the *tabular* folder within the unzipped soil data folder on the C:\ drive, and copy the file path (e.g. *C:\Users\USER\.qgis\0.0.3\Tampa_H2O\D2_Tampa\Soils\FL057\tabular*).
6. In the *SSURGO Import* window, paste the file path in the blank text box and click *OK.*
7. After the tabular data is imported into MS Access, the user will gain access to the *Tables* column on the left sidebar (*Figure* 173). If *Tables* is not showing at the top of the sidebar, click on the column dropdown button, and choose *Tables* (*Figure 174*).

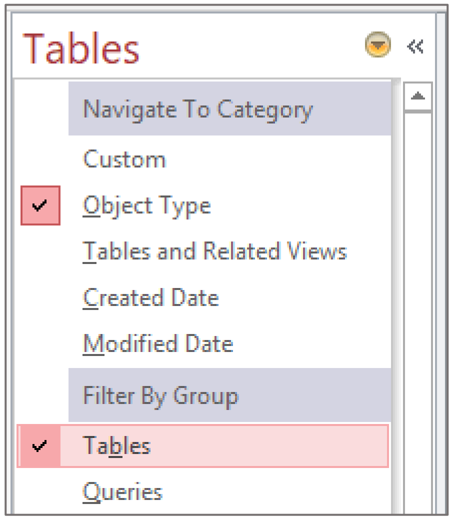


Figure 174 List of Access Objects in MS Access; Tables has been selected

8. The *Tables* column contains a list of tables; locate the *component* table and right-click on the table name to choose *Export* > *Text File* (*Figure 175*).

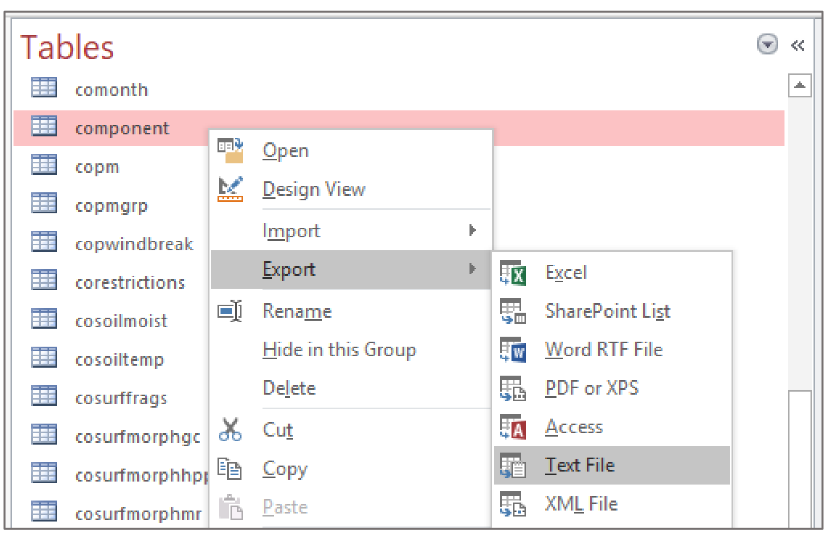


Figure 175 Tables column in Microsoft Access, used to export the component table as a Text File

9. The *Export -Text File* window will appear (*Figure 176*). Click the *Browse* button to navigate to the soils folder and export as *Component_AreaSymbol* (e.g. *Component_FL057.csv*), **with the extension ".csv"**, then click *OK.*

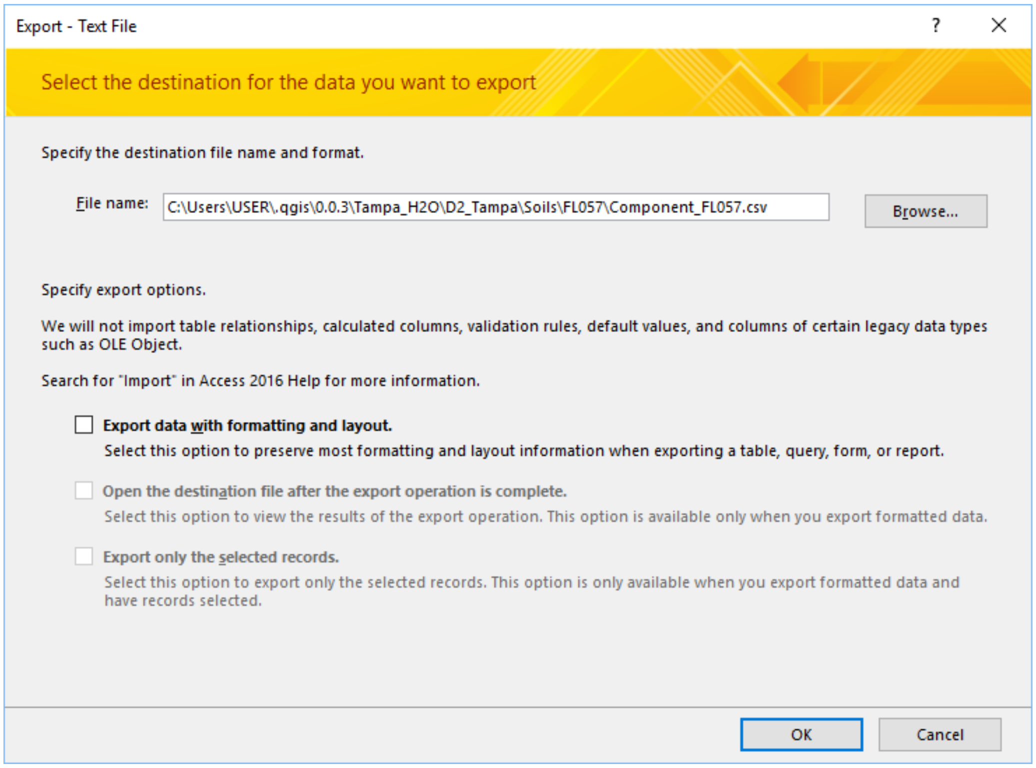


Figure 176 Export – Text File window, with Component_FL057.csv and the file path in the File name box

10. The *Export Text Wizard* window will appear (*Figure 177*). Check *Delimited* as the format type if not checked by default and click *Next >*.

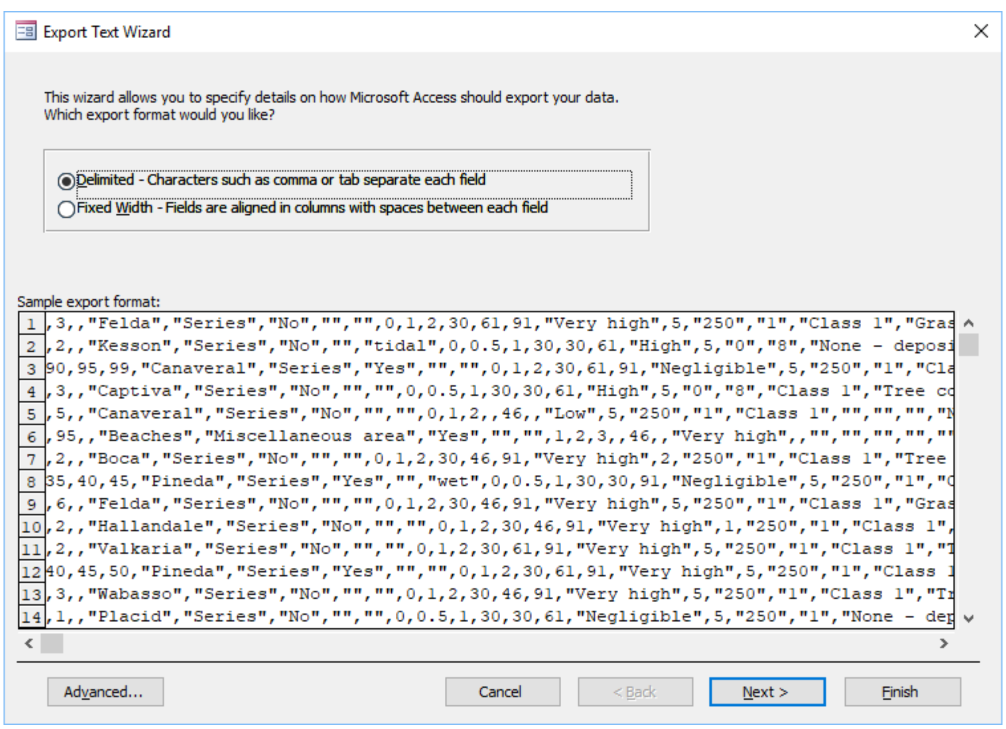


Figure 177 Export Text wizard, with Delimited format type

11. In the next *Export Text Wizard* window, select *Comma* as the delimiter and mark the box *Include Field Names on First Row* (*Figure 178*).

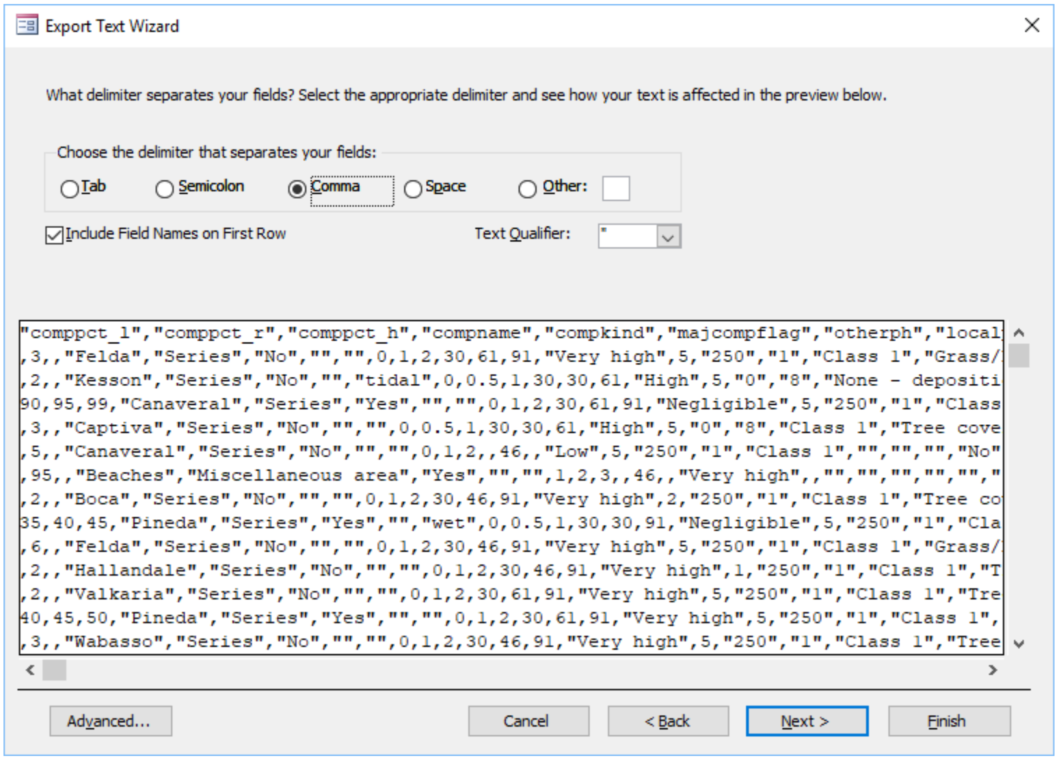


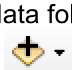
Figure 178 Export Text wizard, with Comma as the delimiter and field names included on first row

12. Click *Finish* to begin exporting the table.
13. Repeat steps 1-12 above to export component tables for all downloaded soil data.
14. Once all component tables are exported the user can exit Access. The tables in the *tabular* folder are now ready for use within ArcMap or QGIS.

The next section illustrates the creation of EPA H2O compatible soil data from the unzipped download file(s), using either Esri ArcGIS software (Using ArcGIS) or QGIS (Using QGIS).

Using ArcGIS

This section illustrates the creation of EPA H2O compatible soil data using Esri ArcGIS software.

1. Download and pre-process the soil data, as shown in the Download Soil Data and Pre-processing Soil Data sections.
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. Each county soil data folder (named by Area Symbol, e.g. *FL057*) contains a *Spatial* folder. Use the *Add Data*  icon to navigate to one of these *Spatial* folders. Select the soil shapefile (i.e. *soilmu_a…shp)* and add the layer to the Table of Contents of the map document.
4. Use the *Add Data* icon to locate and add the corresponding component table(s) (e.g. *Component_FL057.csv),* to the map document.
5. In the Table of Contents, right-click on the county soil shapefile (i.e. *soilmu_a…)* and open the attribute table.

6. In the attribute table, click on the *Table Options*  icon and choose *Add Field* (*Figure 179*).

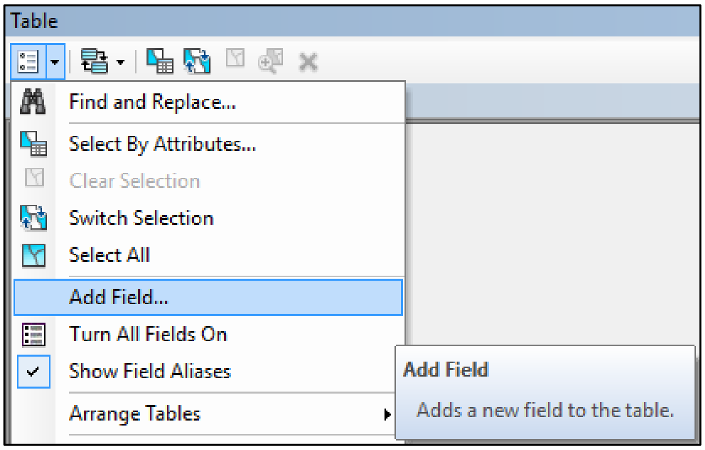


Figure 179 Location of Add Field icon in attribute table

7. In the *Add Field* window (*Figure 180*):
    a. In the *Name* text box, enter *MUKEY2*.
    b. In the *Type* dropdown list, select *Long Integer*.
    c. Click *OK*.

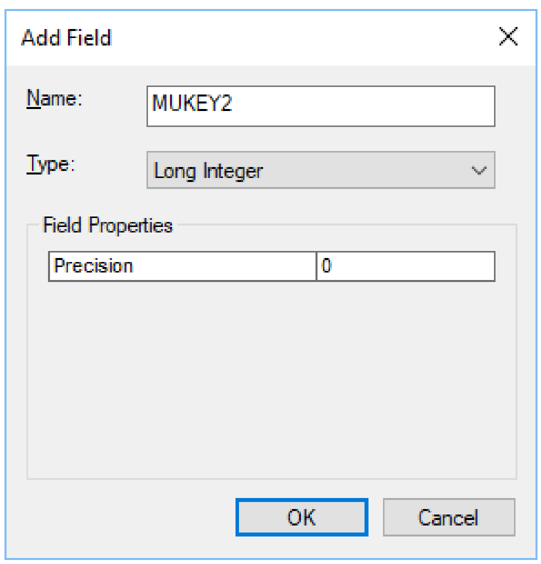


Figure 180 Add Field window in ArcMap

8. The “MUKEY2” field will appear in the attribute table. Right-click on the field header name and choose *Field Calculator* (*Figure 181*).

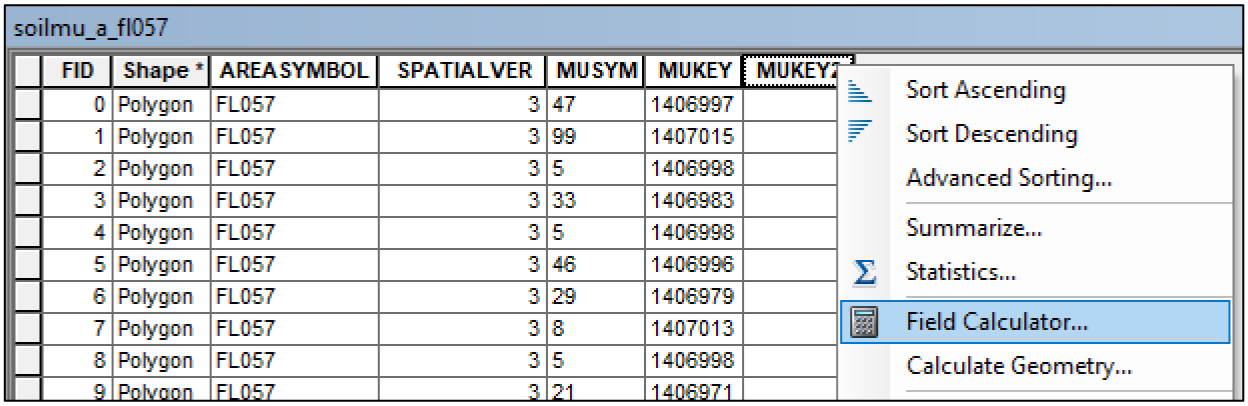


Figure 181 Field Calculator tool, accessed with a right-click on the field name

9. In the *Field Calculator* window (*Figure 182*):
   a. In the *Fields* list box, double click on “MUKEY”. The field name will appear in the *Expression* box as *[MUKEY].*
   b. Click *OK.*

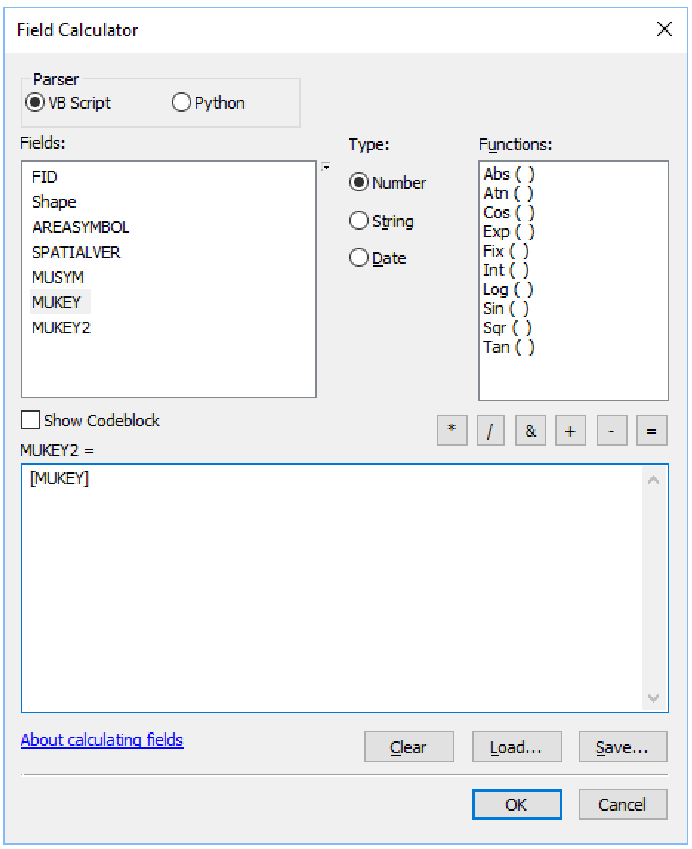


Figure 182 Field Calculator window, with [MUKEY] entered as the expression

10. In the Table of Contents, right-click on the county soil layer (e.g. *soilmu_a_fl057*) and choose *Joins and Relates > Join…* (*Figure 183*).

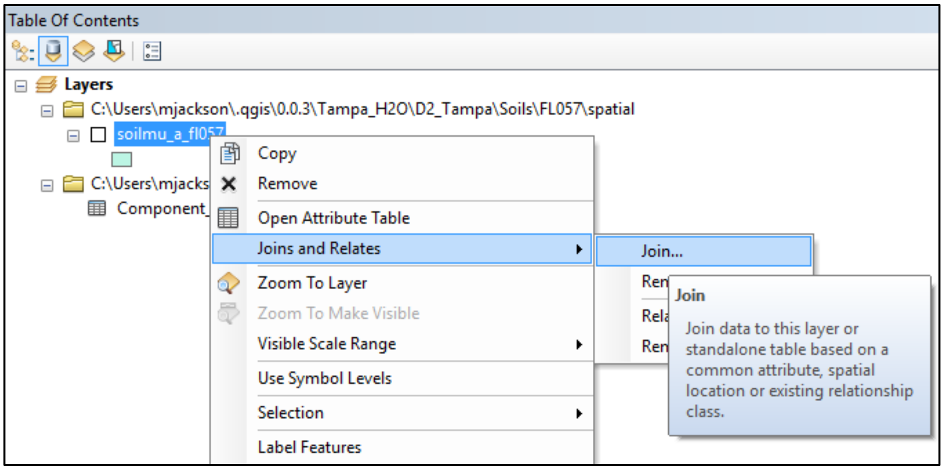


Figure 183 Location of the Join feature in ArcMap

11. In the *Join Data* window (*Figure 184*):
    a. In the first dropdown list, select *Join attributes from a table*.
    b. In the *Choose the field in this layer that the join will be based on* dropdown list, select "MUKEY2".
    c. In the *Choose the table to join to this layer* dropdown list, select the corresponding *Component* table (e.g. *Component_FL057.csv*).
    d. In the *Choose the field in the table to base the join on* dropdown list, select "mukey".
    e. Toggle *Keep all records*
    f. Click *OK*.

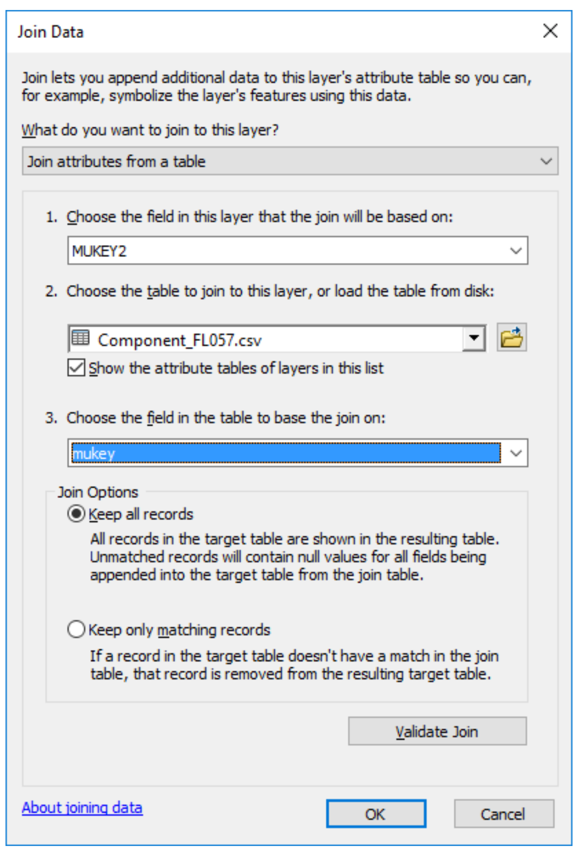


Figure 184 Join Data window in ArcMap

12. Right-click on the county soil layer (e.g. *soilmu_a_fl057*) in the Table of Contents and choose *Data* > *Export Data*, as shown in *Figure 123*.
13. In the *Export Data* window (as shown in *Figure 124*):
    a. In the *Export* dropdown list, select *All features.*
    b. Under *Use the same coordinate system as*, toggle *the data frame* option.
    c. In the *Output feature class* text box, navigate to the preferred file path and name the shapefile; ensure the output name will be both recognizable and distinguishable by basing names on the county or *soilmu_a_* file (e.g. *soilmu_fl057_join.shp)*.
14. A window may appear that asks: “Do you want to add the export data to the map as a layer?” (*Figure 125*). If so, click *Yes.*
15. From the *ArcToolbox* window, navigate to and open the *Delete Field* tool (*ArcToolbox* > *Data Management Tools* > *Fields* > *Delete Field*, *Figure 185*).

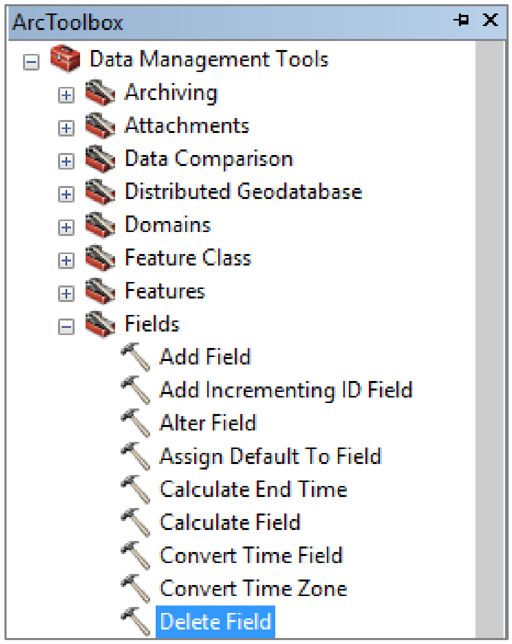


Figure 185 Location of the Delete Field tool in ArcMap

16. In the *Delete Field* window (*Figure 186*):
    a. In the *Input Table* dropdown list, select the exported shapefile (e.g. *soilmu_fl057_join)*.
    b. Under the *Drop Field* section, click the *Select All* button to check all the boxes. Uncheck the boxes next to “hydgrp” and "MUKEY2".
    c. Click *OK* to delete all checked fields from the attribute table.

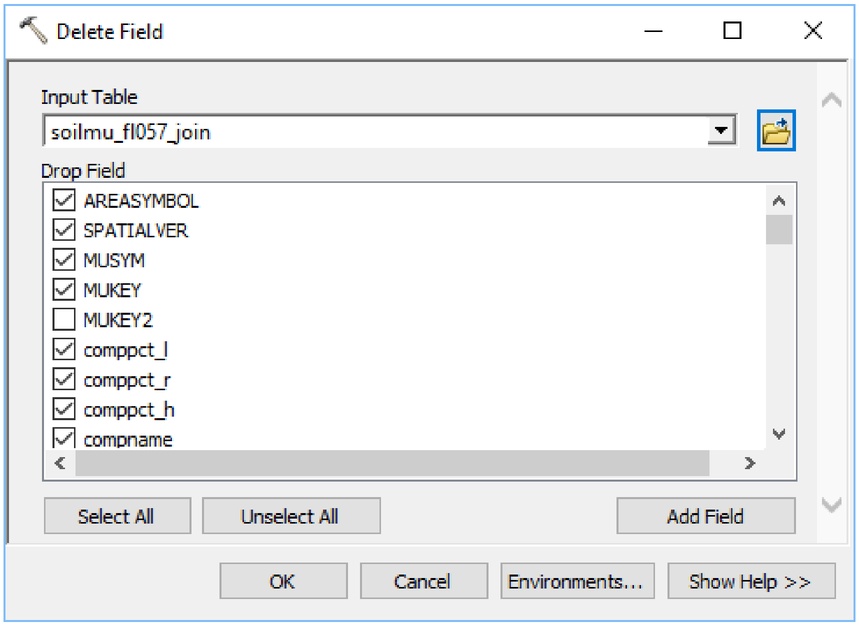


Figure 186 Delete Field tool window, with MUKEY2 field and hydgrp (not shown) field unselected

17. **Repeat steps 3-16, joining the component table to the shapefile, exporting the shapefile and deleting extra fields, for each county soil shapefile**.
18. All prepared soil shapefiles will be combined into one feature layer. In the *ArcToolbox* window, navigate to and open the *Append* tool (*ArcToolbox > Data Management Tools > General > Append*, *Figure 187*).

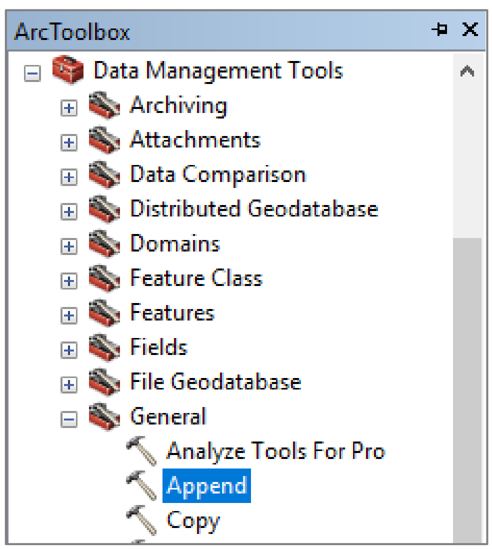


Figure 187 Location of the Append tool in ArcMap

19. In the *Append* window (*Figure 188*):
    a. In the *Target Dataset* dropdown list, choose any one soil shapefile to append the others to (e.g. *soilmu_fl057_join*).
    b. In the *Input Datasets* dropdown list, select all other soil shapefiles (e.g. *soilmu_fl081_join, soilmu_fl103_join*). As shapefiles are added they will appear in the list box.
    c. Keep the *Schema Type* set to *TEST* and do not select a field map or subtype.
    d. Click *OK*.

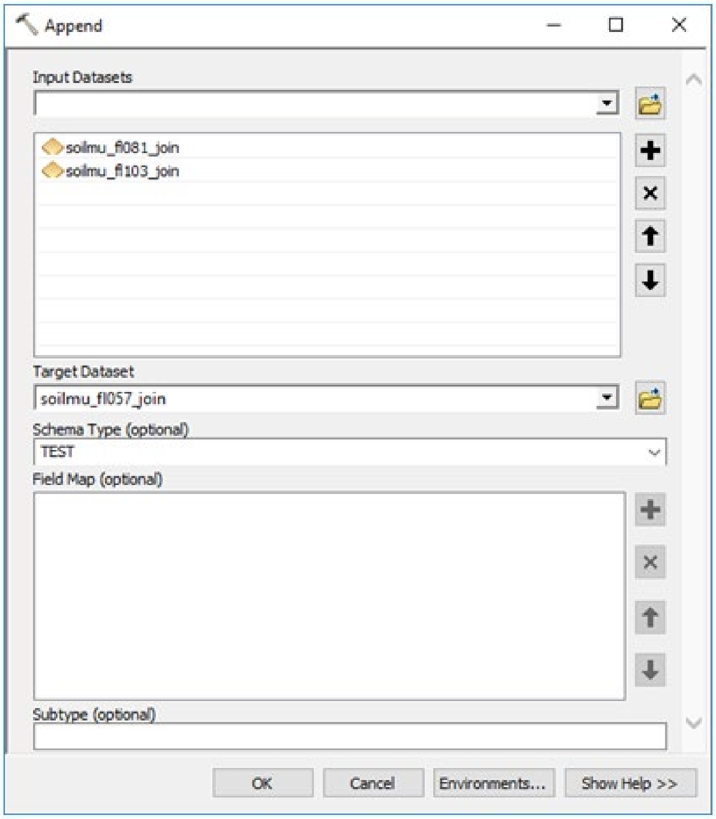


Figure 188 *Append tool window in ArcMap*

Note: If the newly appended dataset (e.g. *soilmu_fl057_join*) doesn't appear to contain the other input datasets (e.g. *soilmu_fl081_join* and *soilmu_fl103_join*), right-click and *Remove* the dataset from the Table of Contents and re-add the layer into the map.

20. In the Table of Contents, right-click on the newly appended dataset (*Target Dataset* from the append tool, e.g. *soilmu_fl057_join*) and open the attribute table.

21. In the attribute table, click on the *Table Options*  icon, and choose *Add Field* (*Figure 179*).
22. In the *Add Field* window (example shown in *Figure 180*):
    a. In the *Name* text box, enter the preferred name for the new field (e.g. "Max_Type_N").
    b. In the *Type* dropdown list, select *Short Integer*.
    c. Click *OK.*

The new field (e.g. "Max_Type_N") will appear in the attribute table. This field is populated based on the "hydgrp" field, which may contain dual soil codes, such as 'A/D', 'B/D', or 'C/D'. These codes denote that the water table can be close to the surface, causing the soil to act as 'D' type. However, when drained, these act as 'A', 'B', or 'C' type soils and therefore should be coded according to the first letter of the dual code.

23. From the main menu, choose *Selection* > *Select By Attributes.*
24. In the *Select By Attributes* window (*Figure 189*):
    a. In the *Layer* dropdown list, select the soil shapefile (e.g. *soilmu_fl057_join*).
    b. From the fields list box, select the "hydgrp" field and click *Get Unique Values.* The soil codes will load in the values list box above.
    c. Enter the following selection in the *Expression* box: *"hydgrp" = 'A' OR "hydgrp" = 'A/D'*
    d. Click *Apply.*

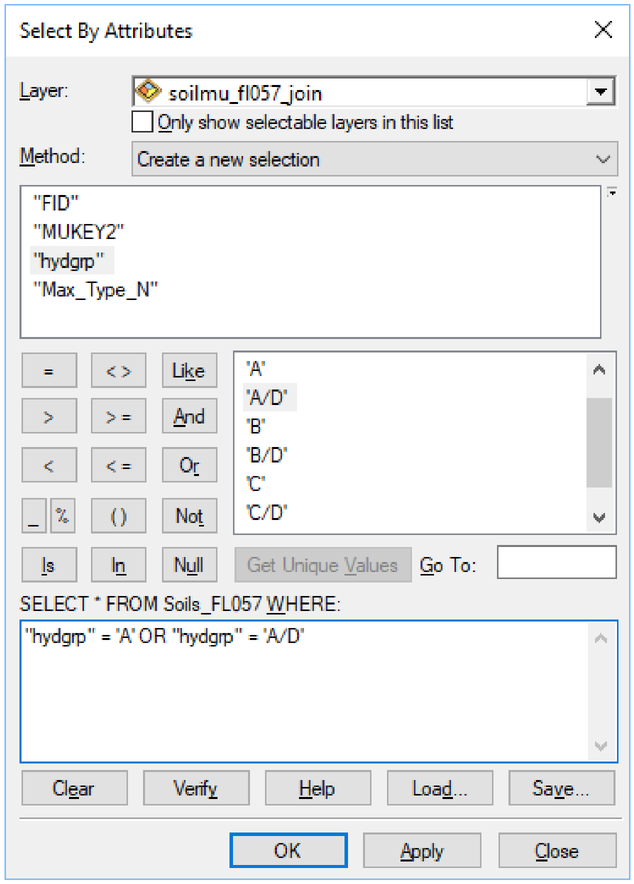


Figure 189 Select By Attributes window, used to select hydgrp values A and A/D

25. In the soil attribute table, rows with "hydgrp" values 'A' and 'A/D' will be selected. Right-click on the "Max_Type_N" field and choose *Field Calculator* (example shown in *Figure 181*).
26. In the *Field Calculator* window (example shown in *Figure 182*):
    a. In the *Expression* box, type *1*.
    b. Click *OK.*
27. Repeat step 23-26 to change the new field values to 2, 3, and 4, for the respective "hydgrp" field values 'B' (and 'B/D'), 'C' (and 'C/D'), and 'D'.
    a. The selection for "hydgrp" value 'D' will not contain a dual code. Therefore, the selection expression will be *"hydgrp" = 'D'.* Please note that not all AOIs will contain all possible "hydgrp" values.
28. In the Table of Contents, right-click the updated soil shapefile and choose *Data* > *Export Data* (example shown in *Figure 123*).
29. In the *Export Data* window (example shown in *Figure 124*):
    a. In the *Export* dropdown list, select *All features.*
    b. Under the *Use the same coordinate system as* section, toggle *the data frame* option on.
    c. In the *Output feature class* text box, specify the file path and name the output *Max_Type_N.shp.*
    d. Click *OK.*
30. In the Table of Contents, right-click on the *Max_Type_N* layer and open the attribute table
31. Delete all fields from the attribute table except "Max_Type_N", "Shape" and the ID field ("FID"):
    a. To delete each field, right-click on the field header and select *Delete Field* (*Figure 190*). Note: the "Shape" field cannot be deleted.

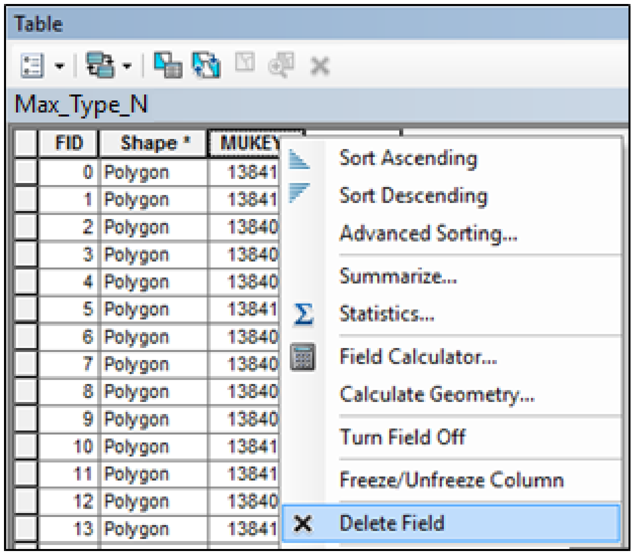


Figure 190 Right-click to access the Delete Field tool in ArcMap

32. Soil polygons in the *Max_Type_N* layer that do not have *Max_Type_N* field values will be deleted using the *Editor* tool. If the *Editor* toolbar is not enabled, right-click anywhere on the main menu bar at the top of the ArcMap program. From the list of optional toolbars that appear select *Editor* (*Figure 191*).

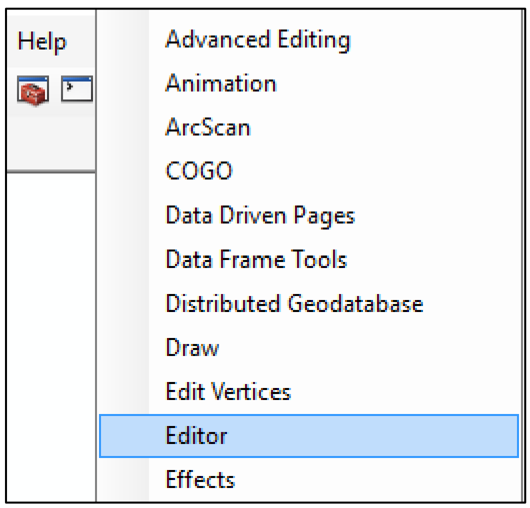


Figure 191 List of extensions and toolbars in ArcMap, with the Editor toolbar highlighted in blue

33. In the *Editor* toolbar, click the *Editor* dropdown list and choose *Start Editing* (*Figure 192*).

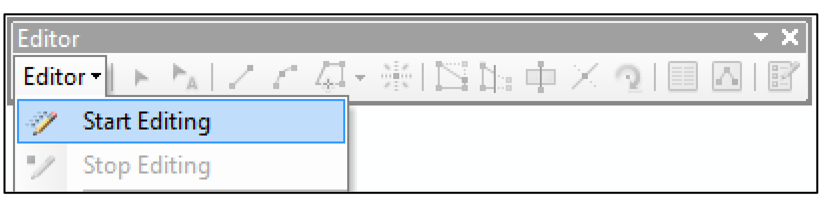


Figure 192 Editor toolbar, with the Start Editing option selected

34. If the *Start Editing* window appears, select the *Max_Type_N layer* and click *OK*.
35. From the main menu, choose *Selection > Select By Attributes.*
36. In the *Select By Attributes* window (example shown in *Figure 189*):
    a. In the *Layer* dropdown list, select *Max_Type_N.*

b. In the *Expression* box, type the following expression: *"Max_Type_N" = 0*
c. Click *OK.*

37. In the Table of Contents, right-click and open the *Max_Type_N* attribute table.
38. Click the *Delete* icon to delete the selected soil polygons.
39. In the *Editor* toolbar, click the *Editor* dropdown and choose *Save Edits,* and then *Stop Editing* (*Figure 193*).

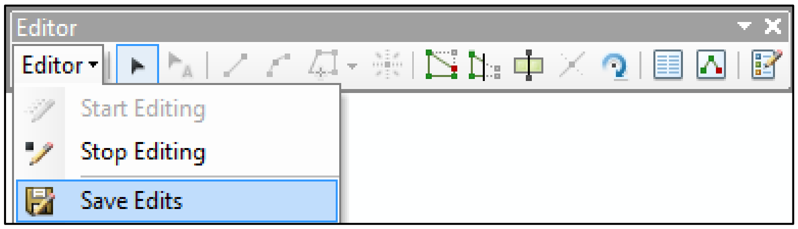


Figure 193 Editor toolbar, with the Save Edits option selected

The *Max_Type_N* layer is now complete; next, the values in this layer will be joined to the land use layer.

Spatially Join Soils to Land Use

After the soil shapefile (e.g. *Max_Type_N.shp*) is created it must be spatially joined to the land use layer created in the Create Land Use Data Layer section.

1. If using a new map document, use the *Add Data* icon to navigate to the land use shapefile created in the Create Land Use Data Layer section and add the layer to the Table of Contents.

2. In the Table of Contents panel, right-click on the land use layer. Under the *Joins and Relates* option, select *Join…* (*Figure 194*).

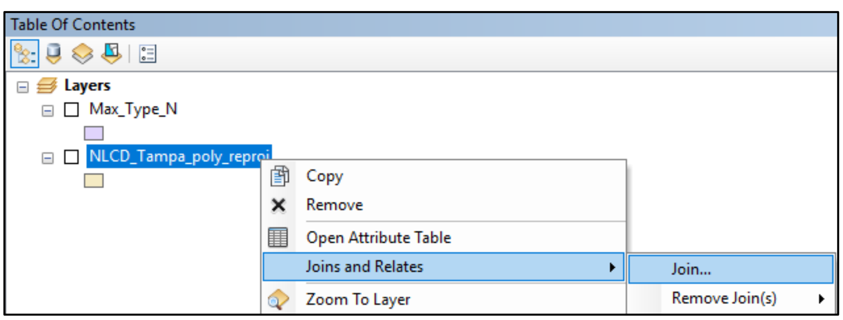


Figure 194 Location of the Join tool in ArcMap

3. In the *Join Data* window (*Figure 195*):
   a. In the first dropdown list, select *Join data from another layer based on spatial location.*
   b. In the *Choose the layer to join to this layer* dropdown list, select the updated soil layer (e.g. *Max_Type_N).*
   c. Toggle on the *Each polygon will be given a summary of the numeric attributes of the polygons in the layer being joined that intersect it* option*.*
   d. In the *How do you want the attributes to be summarized* section, check *Average*.
   e. In the *Specify output shapefile* text box, designate a file path and new name for the output shapefile (e.g. *NLCD_MaxTypeN_join.shp)*.
   f. Click *OK*.

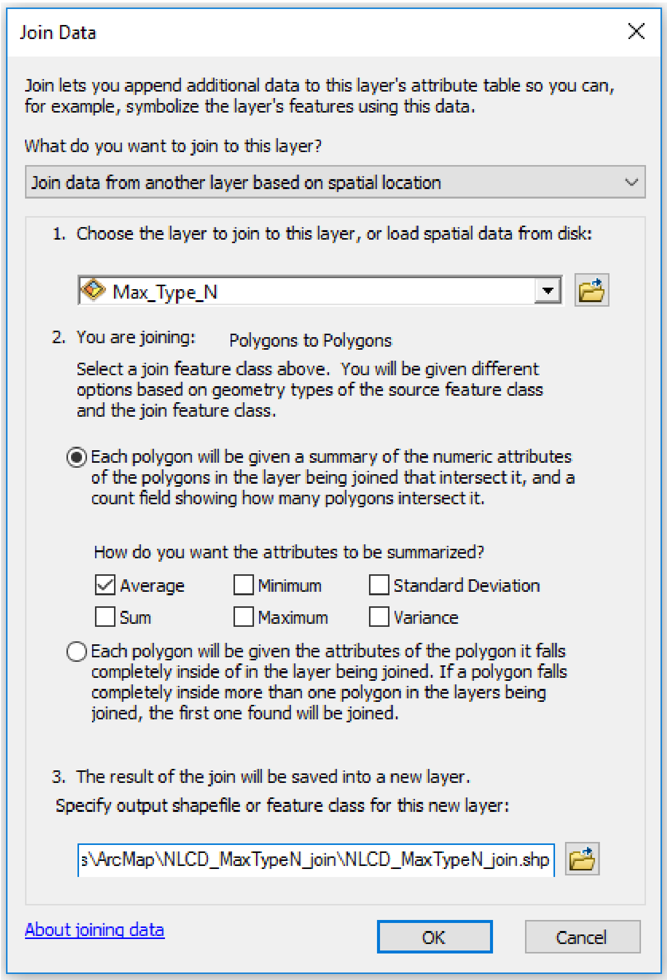


Figure 195 Join land use data to soils layer (e.g. Max_Type_N), summarizing by Average

After the spatial join is complete, the "Max_Type_N" field in the spatially joined layer will be renamed to "Avg_Max_Ty" and will contain average attribute values for each land use polygon. Where a land use polygon does not overlap any soil polygons, either because they were missing or were deleted, the "Avg_Max_Ty" value will be 0. These NULL polygons will be assigned the value for the most prominent soil type (largest area) in the AOI. To determine the most prominent soil type in the AOI:

4. In the Table of Contents, right-click on the spatially joined layer (e.g. *NLCD_MaxTypeN_join*) and open the attribute table.
5. In the attribute table, click on the *Table Options* icon and choose *Add Field* (as shown in *Figure 179*).
6. In the *Add Field* window (example shown in *Figure 180*):
   a. In the *Name* text box, type "Max_Type_N".
   b. In the *Type* dropdown list, select "Short Integer".
   c. Click *OK.*
7. Click on the *Table Options* icon and choose *Add Field* again to add a second field in the attribute table. This time in the *Add Field* window:
   a. In the *Name* text box, type "Area".
   b. In the *Type* dropdown list, select "Double".
   c. Click *OK.*
8. In the attribute table, locate the new "Area" field, right-click on the field name and choose *Calculate Geometry* (*Figure 196*).

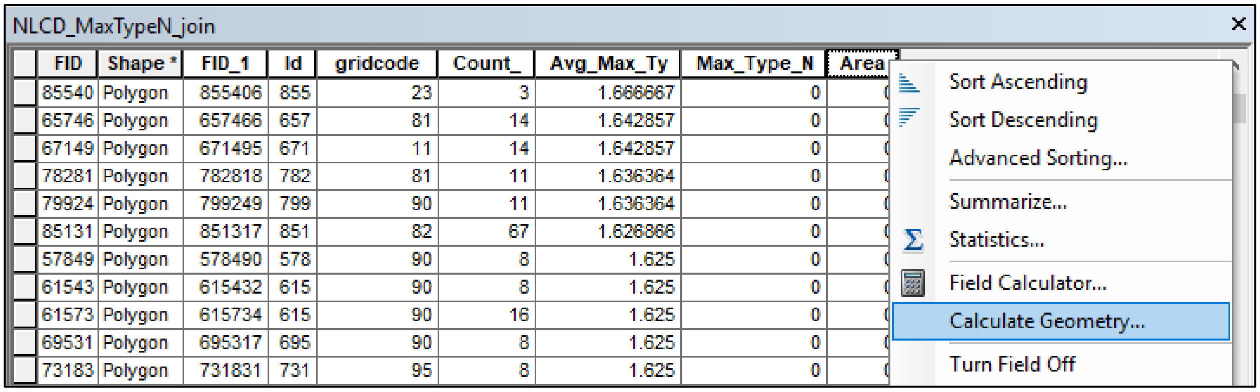


Figure 196 Right-click to access the Calculate Geometry option in NLCD_MaxTypeN_join attribute table

9. The *Calculate Geometry* window will open. In the window (*Figure 197*):
   a. In the *Property* dropdown list, choose *Area.*
   b. Under the *Coordinate System* section, toggle *Use coordinate system of the data frame.*
   c. In the *Units* dropdown list, choose *Acres US [ac].*
   d. Click *OK.*

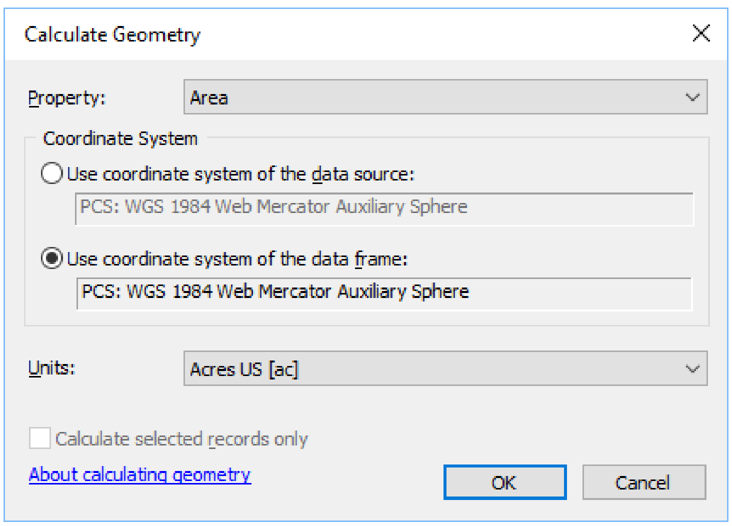


Figure 197 Calculate Geometry window in ArcMap

The new "Max_Type_N" field is populated based on the averaged values in the “Avg_Max_Ty” field. However, values in “Avg_Max_Ty” must be rounded to the nearest integer for the “Max_Type_N” field. For example, for *0* < *"averaged values"* < *1.5, “Max_Type_N”* = *1*. This is completed by:

10. From the main menu, choose *Selection* > *Select By Attributes.*
11. In the *Select By Attributes* window (example shown in *Figure 189*):
    a. In the *Layer* dropdown list, select *NLCD_MaxTypeN_join.*
    b. In the *Expression* box, type the following expression: *"Avg_Max_Ty"* > *0 AND "Avg_Max_Ty"* < *1.5*
    c. Click *Apply.*
12. In the Table of Contents, right-click on the spatially joined layer (e.g. *NLCD_MaxTypeN_join.shp*) and open the attribute table.
13. Locate the “Max_Type_N” field, right-click on the field name and choose *Field Calculator.*
14. In the *Field Calculator* window:
    a. In the *Expression* box, type *1*.
    b. Click *OK.*

15. With the selection still highlighted, right-click on the "Area" field and choose *Statistics...*
16. From the *Statistics* window, copy/write down the *Sum* value (*Figure 198*). This is the total area (acres) of the first soil type in the soil/land use layer.

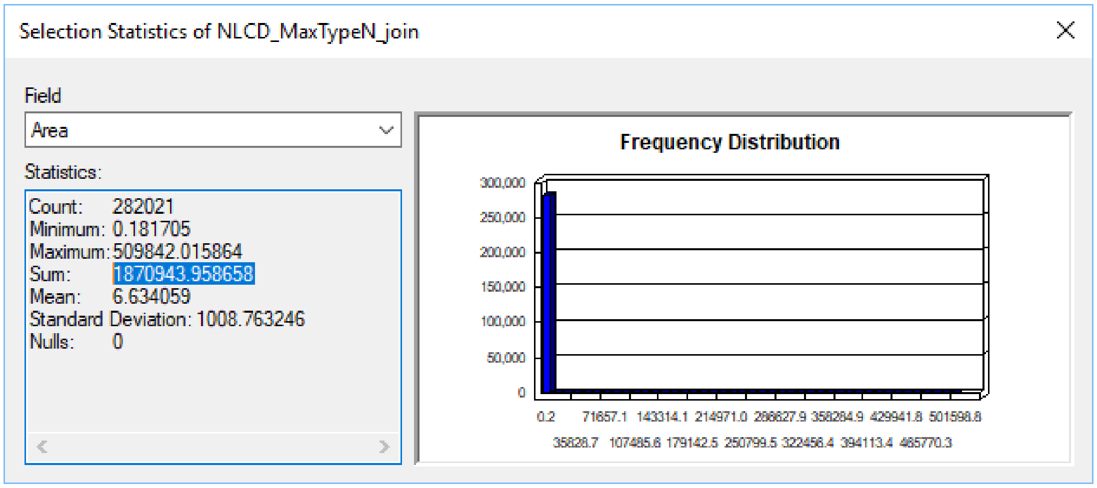


Figure 198 Selection Statistics window, with Sum of the Area (acres) highlighted in blue

17. Close the *Statistics* window and clear the selection in the attribute table.
18. For each selection in *Table 7*, repeat steps 10-17, setting the selection using the expression in *Select By Attributes* and the "Max_Type_N" field value using *Field Calculator.* Then find the total area of each selection using *Statistics* and write down the sums for comparison.

Table 7 Expressions for selections and corresponding field calculations

Expression for Selection	**"Max_Type_N" Value**
"Avg_Max_Ty" > 0 AND "Avg_Max_Ty" < 1.5	1
"Avg_Max_Ty" >= 1.5 AND "Avg_Max_Ty" < 2.5	2
"Avg_Max_Ty" >= 2.5 AND "Avg_Max_Ty" < 3.5	3
"Avg_Max_Ty" >= 3.5 AND "Avg_Max_Ty" <= 4	4

19. Compare the areas for each soil type, and determine which classification is most prominent. In this example, the total area for each soil type ("Max_Type_N" value) is as follows:
    a. 1 = 1,870,943.6 acres
    b. 2 = 102,619.9 acres
    c. 3 = 7,033.8 acres
    d. 4 = 4,220.2 acres

    In this example, the most common soil type is "Max_Type_N" = 1. This soil type will be used as the "Max_Type_N" values for the NULL land use polygons.
20. From the main menu, choose *Selection* > *Select By Attributes.*
21. In the *Select By Attributes* window (example shown in *Figure 189*):
    a. Under the *Layer* dropdown list, select *NLCD_MaxTypeN_join.*
    b. Enter the following expression in the *Expression* box: *"Avg_Max_Ty" = 0*
    c. Click *Apply.*
22. In the Table of Contents, right-click on the spatially joined layer (e.g. *NLCD_MaxTypeN_join*) and open the attribute table.
23. Locate the "Max_Type_N" field, right-click on the field name and choose *Field Calculator.*
24. In the *Field Calculator* window:
    a. In the *Expression* box, type the most common soil type found in the user's AOI from step19 (in the example this was 1).

b. Click *OK.*

Database creation is continued in the Update ES Coefficients section.

Using QGIS

This section illustrates the creation of EPA H2O compatible soil data using QGIS software.

1. Download and pre-process the soil data, as shown in the Download Soil Data and Pre-processing Soil Data sections.
2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. Add each soil shapefile to the Layers panel:
    a. From the *Layer* menu (*Figure 126*) open the *Add Vector Layer* window (*Main Menu* > *Layer* > *Add Vector Layer*).
    b. Each county soil data folder (named by Area Symbol, e.g. *FL057)* contains a *Spatial* folder. In the *Add Vector* layer window (*Figure 127*), click *Browse* to locate this folder and select the soil shapefile (i.e. *soilmu_a…shp),* then click *Open*.
4. Open File Explorer and locate each corresponding *Component* table. Click and drag the ".csv" files into the QGIS Layers panel.

Imported files will be displayed in the Layers panel, as shown in *Figure 199*.

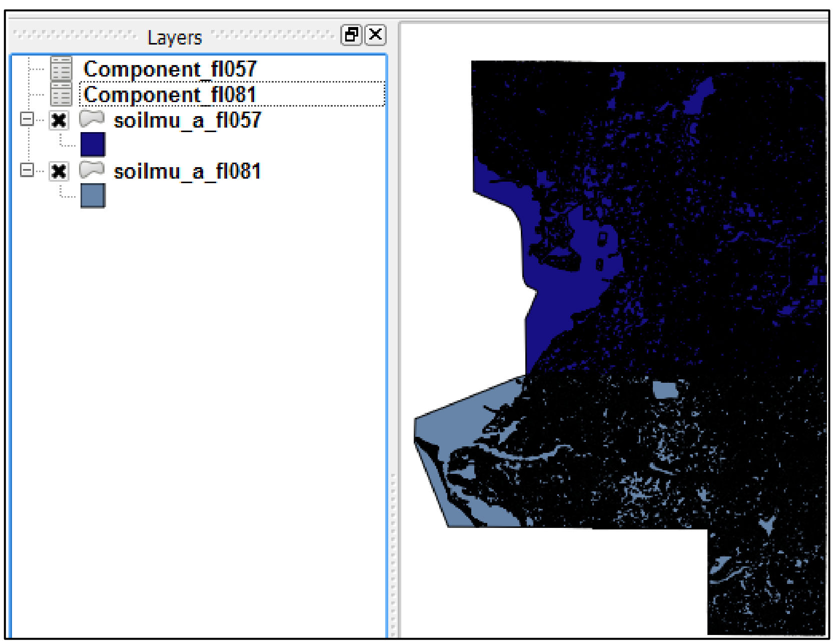


Figure 199 Soil shapefiles and component tables displayed in the Layers panel in EPA H2O

5. Double click the first *soilmu_a...* layer to open the *Layer Properties* window. Within *Layer Properties,* click the *Joins* tab.
6. In the *Joins* tab, click the *Add Join*  icon to open the *Add vector join* window (*Figure 200*).
    a. In the *Join layer* dropdown list, select the *Component* table corresponding to that soil layer (e.g. *Component_FL057).*
    b. In the *Join field* dropdown list*,* select "mukey"*.*
    c. In the *Target field* dropdown list, choose "MUKEY"*.*

d. Check *Cache join layer in virtual memory.*
e. Click *OK*.

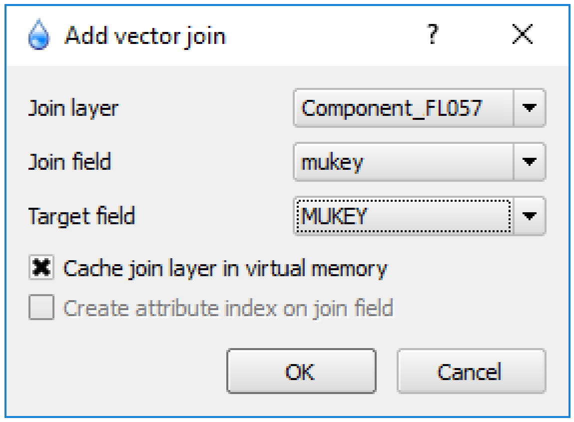


Figure 200 Add Vector Join window in Joins tab, within soil layer properties

7. Right-click on the *soilmu_a…* layer and select the *Save as…* option (as shown in *Figure 130*).
8. In the *Save as* window (example shown in *Figure 133*):
   a. In the *Format* dropdown list, select *ESRI Shapefile.*
   b. In the *Save as* text box, browse to or type the desired output shapefile name and file path.
   c. In the *CRS* dropdown list, choose *Selected CRS,* and click the *Browse* button to locate *WGS 84 / Pseudo Mercator.*
   d. Check the *Add saved file to map* option.
   e. Do not check the *Skip attribute creation* option.
   f. Click *OK.*
9. Double click on the exported soil layer to open the *Properties* window, and click the *Fields* tab.
10. Toggle the *editing*  button to start an edit session.
11. Click and drag to select all fields except “hydgrp” and “MUKEY”.

Please note: field names may get lost during the join; if this occurs, “hydgrp” becomes “Component_78”. Make a new field named “hydgrp” and use the Field Calculator to populate the new field from the original “hydgrp” data.

12. Click the *Delete Column*  button to delete all fields except “hydgrp” and “MUKEY” (*Figure 201*).
13. Click *OK*.

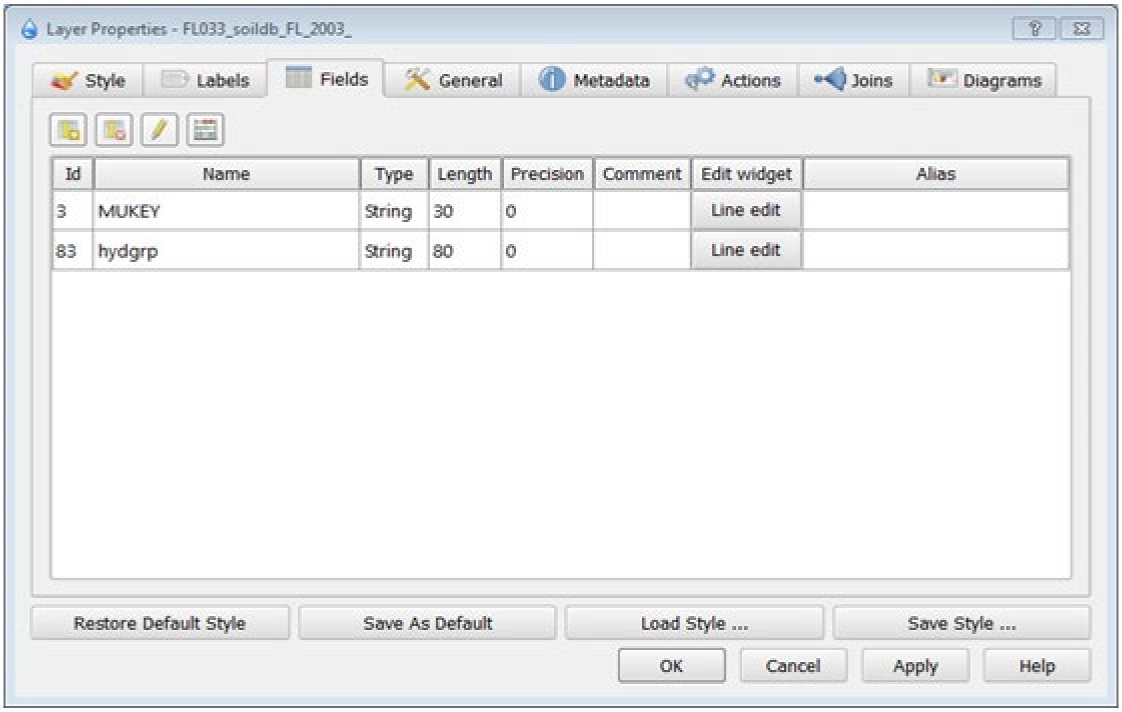


Figure 201 Layer Properties for joined soil layer, with required fields MUKEY and hydgrp

Repeat steps 3-13, joining the component table to the soil shapefile, exporting the shapefile and deleting extra fields, for each county soil shapefiles. All prepared soil shapefiles will be combined into a single layer.

14. Right-click on the first *soilmu_a…* layer and open the attribute table.
15. Click the *Invert Selection*  icon, and then click the *Copy rows to clipboard*  icon at the bottom of the attribute table (*Figure 202*).
16. Close this attribute table.

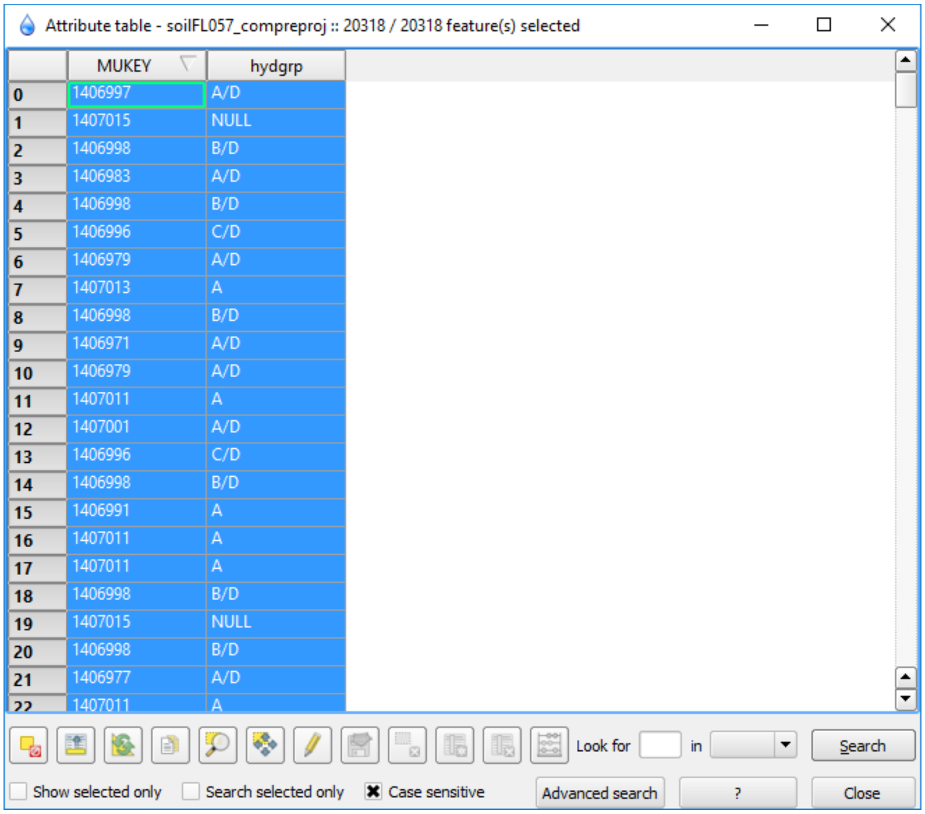


Figure 202 Soil layer attribute table, with all attributes selected and copied to clipboard

17. Click on a second *soilmu_a…* layer to highlight it in the Layers panel.
    Note: the second layer will become the combined shapefile from all the soils layers. The user must remember which soil layer was highlighted.
18. From the main menu, select *Layer > Toggle editing* (Figure 203).

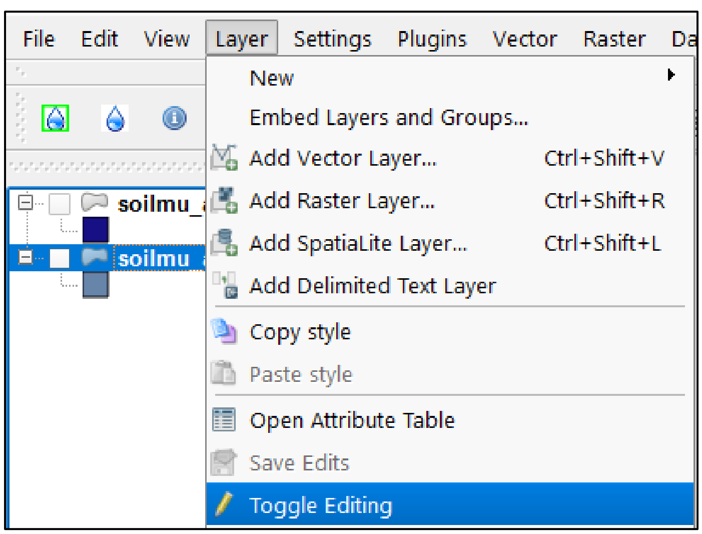


Figure 203 Toggle editing for the other soil layer in the Layers panel

19. With the second *soilmu_a…* shapefile still highlighted, from the main menu select *Edit > Paste Features* (Figure 204).

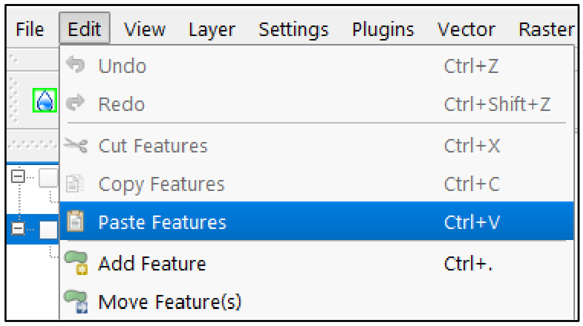


Figure 204 Paste Features tool located in the Edit menu

20. Repeat steps 14-16, copying rows, and step 19, pasting them into the selected layer, for the remaining soil shapefiles.
21. Click *Layer* > *Toggle editing* again to stop editing.
22. Click *OK* when prompted to save changes.
23. In the Layers panel, double click on the combined soil layer to open *Layer Properties*.
24. From the *Fields* tab, click the *pencil* icon to enable *Editing* mode.
25. Click on the *New Column* icon to add a new field.
26. In the *Add column* window (*Figure 205*):
    a. In the *Name* text box, enter a field name that is **6 characters or less** (e.g. "MaxTy").
    b. In the *Type* dropdown list, select *Whole number (integer).*
    c. In the *Width* text box, enter 1.
    d. Click *OK.*
27. Click *OK* to close *Layer Properties*.

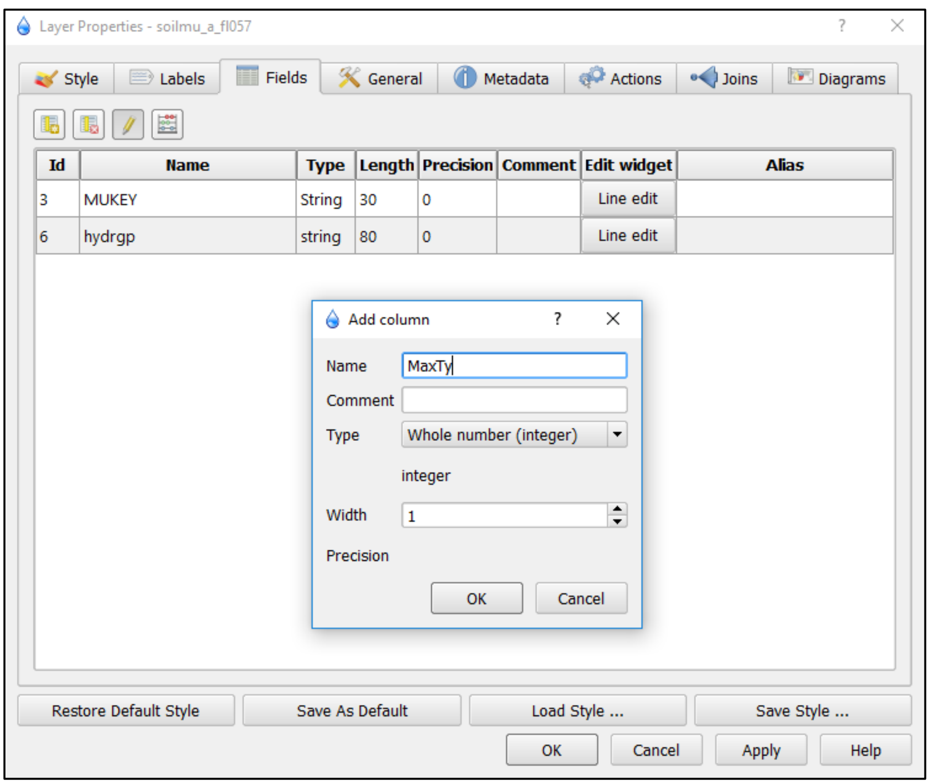


Figure 205 Create a new field in the updated attribute table with the Add column button

The new field (e.g. “MaxTy”) will appear in the combined soil layer attribute table. This field is populated based on the “hydgrp” field, which may contain dual soil codes, such as ‘A/D’, ‘B/D’, or ‘C/D’. These codes denote that the water table can be close to the surface, causing the soil to act as ‘D’ type. However, when drained, these act as ‘A’, ‘B’, or ‘C’ type soils and therefore should be coded according to the first letter of the dual code. To avoid assigning these dual codes a “MaxTy”’ value of 4, assign the “MaxTy” value for “hydgrp” ‘D’ first, and then go back to do ‘A’, ‘B’, and ‘C’.

28. Open the combined soil layer attribute table.
29. In the *Look for* text box, at the bottom of the attribute table, enter the letter ‘D’.
30. From the *in* dropdown list, choose “hydgrp”, and click the *Search* button (*Figure 206*).

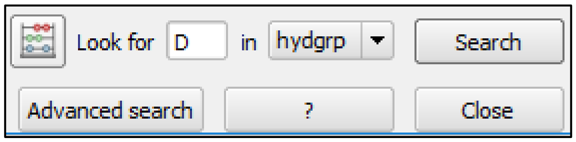


Figure 206 Search for letter D in the hydgrp field

Note: it may take a few moments for QGIS to select the attributes. Do not close the attribute table during this time.

31. Open the *Field Calculator* by clicking the *Field Calculator*  icon in the attribute table.
32. In the *Field Calculator* window (*Figure 207*):
    a. Check the box next to *Only update selected features.*
    b. Check the box next to *Update existing field.*
    c. Choose the newly created field (e.g. “MaxTy”) from the dropdown list.
    d. Under the *Expression* section, type the value 4.
    e. Click *OK.*

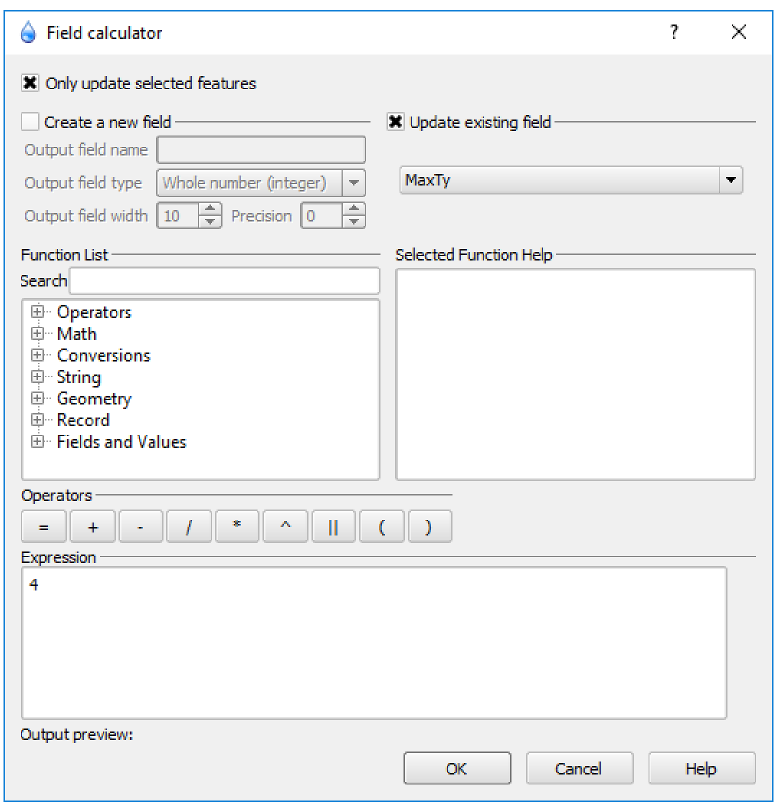


Figure 207 Field Calculator window, updating Max_Type_N field with a value of 4

33. Repeat steps 30 through 32 to find records with values ‘A’, ‘B’, and ‘C’ in the “hydgrp” field, and assign the corresponding values 1, 2, and 3 to the “MaxTy” field.
34. Click the *pencil* icon to toggle *Editing mode* off and save the edits.
35. Right-click on the soil layer with updated “MaxTy” values and choose *Save as*.
36. In the *Save as* window (example shown in Figure 133):
    a. In the *Format* dropdown list, select *ESRI Shapefile.*
    b. In the *Save as* text box, browse to the desired file path, and name the file *Max_Type_N.shp*.
    c. In the *CRS* dropdown list, choose *Selected CRS,* and click the *Browse* button to locate *WGS 84 / Pseudo Mercator.*
    d. Check the *Add saved file to map* option.
    e. Do not check the *Skip attribute creation* option.
    f. Click *OK.*
37. In the Layers panel, right-click on *Max_Type_N* and open the attribute table.
38. Click the *pencil* icon to enable *Editing* mode.
39. In the *Look for* text box, type *NULL*, and from the *in* dropdown list, choose “hydgrp”.
40. Click the *Search* button (example shown in Figure 206).
41. All the soil polygons without a soil classification are selected. Click the *Delete Selected Features* icon to delete these polygons.
42. Close the attribute table.
43. In the Layers panel, double click on *Max_Type_N* to open *Layer Properties.*
44. From the *Fields* tab, select all fields except “MaxTy” and remove them using the *Delete column* icon.
45. Click the *pencil* icon to toggle *Editing mode* off and save edits.
46. Click *OK* to close *Layer Properties*.

The *Max_Type_N* layer is now complete; next, the values in this layer will be joined to the land use layer.

Spatially Join Soils to Land Use

After the soil shapefile (e.g. *Max_Type_N.shp*) is created it must be spatially joined to the land use layer created in the Create Land Use Data Layer section.

1. If not in the Layers panel, add the land use layer created in the Create Land Use Data Layer section to the project using the *Add vector layer* tool (example shown in Figure 126 and Figure 127).
2. Open the *Join attributes by location* tool (*Main Menu* > *Vector* > *Data Management Tools* > *Join attributes by location,* Figure 158).
3. In the *Join attributes by location* window (Figure 208):
    a. In the *Target vector layer* dropdown list*,* select the land use layer (e.g. *NLCD_Tampa_poly_reproj).*
    b. In the *Join vector layer* dropdown list, select the updated soils layer (*Max_Type_N).*
    c. In the *Attribute Summary* section*,* toggle on *Take summary of intersecting features,* and check *Mean.*
    d. In the *Output Shapefile* text box, browse to or type the file path and desired shapefile name (e.g. *NLCD_MaxTypeN_spatial.shp*).
    e. Toggle on the *Keep all records* option.
    f. Click *OK.*

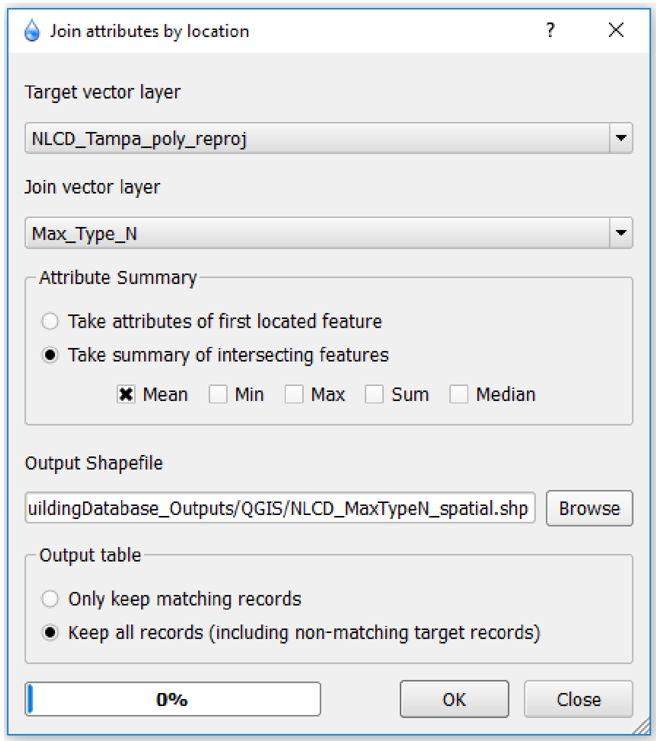


Figure 208 Join attributes by location, and summarize by Mean

Note: depending on the size of the datasets and the computer processing them this spatial join may take a few hours to complete. Do not close the EPA H2O program during this time.

Troubleshooting Common Errors:

Problem:

A common error in this step results in an *Incorrect field names* error (*Figure 209*). Three pieces of information help to understand the cause of this error: (1) Field names cannot be longer than 10 characters (2) Attribute Summary by Mean renames fields by adding MEAN in front of the original field name (3) This results in field names with more than 10 characters when the original is more than 6 characters.

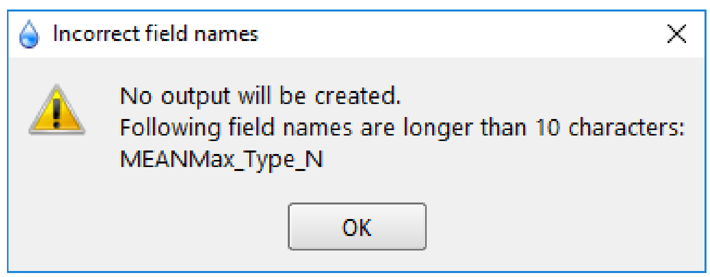


Figure 209 Incorrect field names error message in QGIS

Solution:

The user must replace each of the fields listed in the error message with a new field. Open the *Layer Properties* window for the layer and click the *pencil*  icon to start editing. Click on the *New Column*  icon to add a new field to the fields list (example shown in *Figure 205*). The new field name must have 6 or less characters (e.g. "MaxTy") and have the same *Type* as the field it is replacing. Open *Field Calculator*  and choose *Update Existing Field* from the dropdown list. Select the newly created field (e.g. "MaxTy", example shown in *Figure 207*). From the *Field and Values* dropdown list, double click on the field to be replaced (e.g. "Max_Type_N"). After the field appears in the *Expression* box, click *OK.* Delete the old field from *Layer Properties*, using the *Delete Column*  icon. Repeat these steps for each of the fields listed in the error. Save the changes made to the *Layer Properties* and retry the *Join attributes by location* tool.

4. A message box will appear when *Join attributes by location* is finished. After this message appears click *Close* to close the tool.

After the spatial join, the “MaxTy” field in the spatially joined layer will be renamed to “MEANMaxTy” and will contain average attribute values for each land use polygon. Where a land use polygon does not overlap any soil polygons, either because they were missing or because they were deleted, the “MEANMaxTy” value will be NULL. The soil classification type of these NULL polygons is assigned the most prominent soil type (largest area) in the AOI.

5. From the main menu, select *Plugins* > *Manage Plugins.*
6. In the *QGIS Plugins Manager* window will (*Figure 210*):
   a. In the *Filter* box, type *Statist.*
   b. The *Statist (1.0.0)* plugin will appear in the list of plugins. Check the box next to the plugin name if it is not already checked.
   c. Click *OK.*

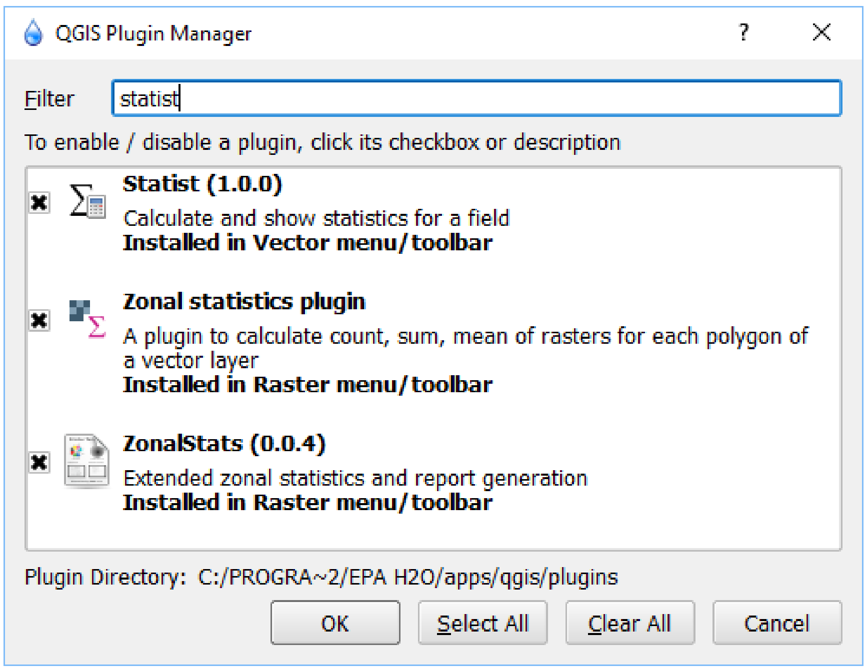


Figure 210 QGIS Plugin Manager window, with the Statist plugin enabled

7. In the layers panel, double click on the spatial join layer (e.g. *NLCD_MaxTypeN_spatial*) to open *Layer Properties*.
8. From the *Fields* tab, click the *pencil* icon to enable *Editing* mode.
9. Click the *New Column* icon. In the *Add column* window (*Figure 205*):
   a. In the *Name* text box, enter “Max_Type_N”.
   b. In the *Type* dropdown list, select *Whole number (integer).*
   c. In the *Width* text box, enter 1.
   d. Click *OK.*
10. Click the *New Column* icon again to add a second field. In the *Add column* window (*Figure 205*):
    a. In the *Name* text box, enter “Area”.
    b. In the *Type* dropdown list, select *Decimal number (real).*
    c. In the *Width* text box, enter 10, and in the *Precision* text box, enter 2.
    d. Click *OK.*

11. Close *Layer properties* and open the spatial join layer attribute table.

12. Click the *Field Calculator*  icon. In the *Field Calculator* window (*Figure 211*):
    a. Check the *Update existing field* option.
    b. In the existing field dropdown list, select “Area”.
    c. In the *Function List* list box, expand the *Geometry* option, and double click on *$area.*
    d. The expression *$area* will appear in the *Expression* box.
    e. Click *OK.*

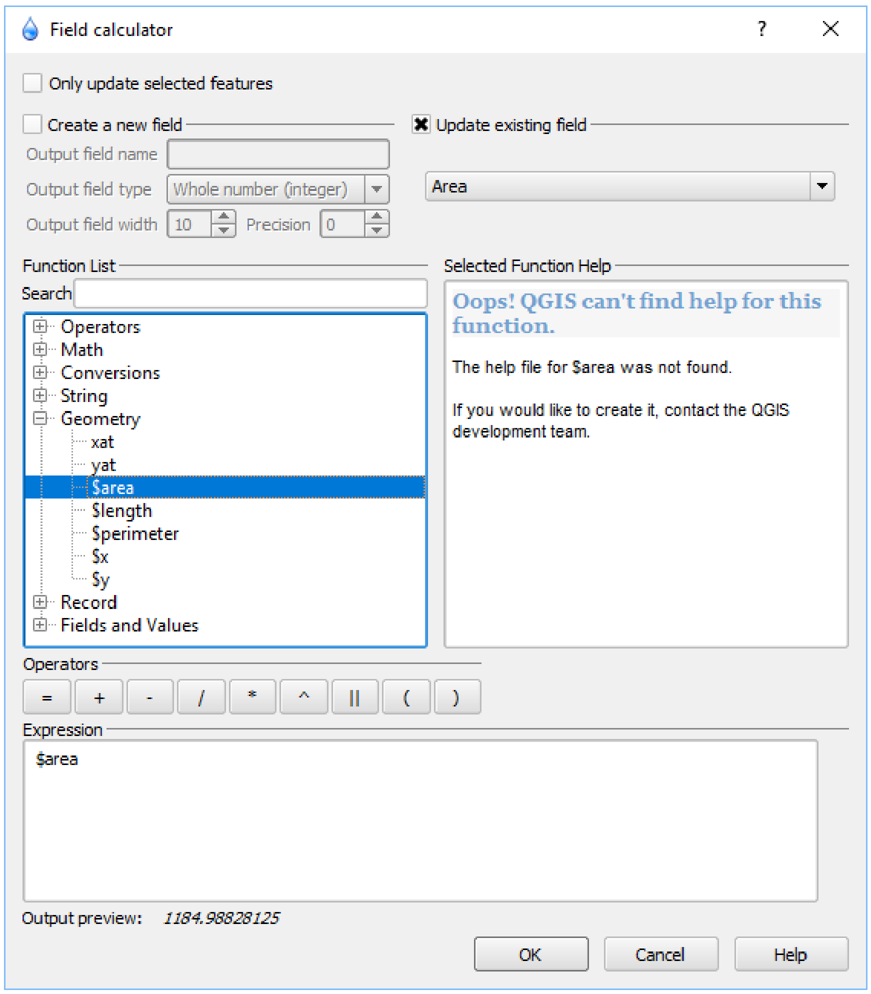


Figure 211 Field Calculator window, used to calculate the area of each polygon

The new "Max_Type_N" field is populated based on the averaged values in the “MEANMaxTy” field. However, values in “MEANMaxTy” must be rounded to the nearest integer for the “Max_Type_N” field. For example, for *0* < *"averaged values"* < *1.5, “Max_Type_N”* = *1*. This is completed by:

13. In the Layers panel, right-click the spatial join layer and open the attribute table.
14. In the attribute table click on the *Advanced Search* button (*Figure 212*).

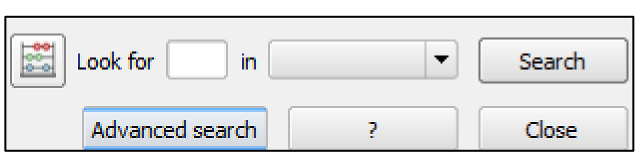


Figure 212 Advanced search button in attribute table

15. The *Search Query Builder* window will open. In the *Search Query Builder* window (*Figure 213*):
    a. In the *SQL where clause* text box, type the expression: *MEANMaxTy > 0 AND MEANMaxTy< 1.5*
    b. Click *OK.*

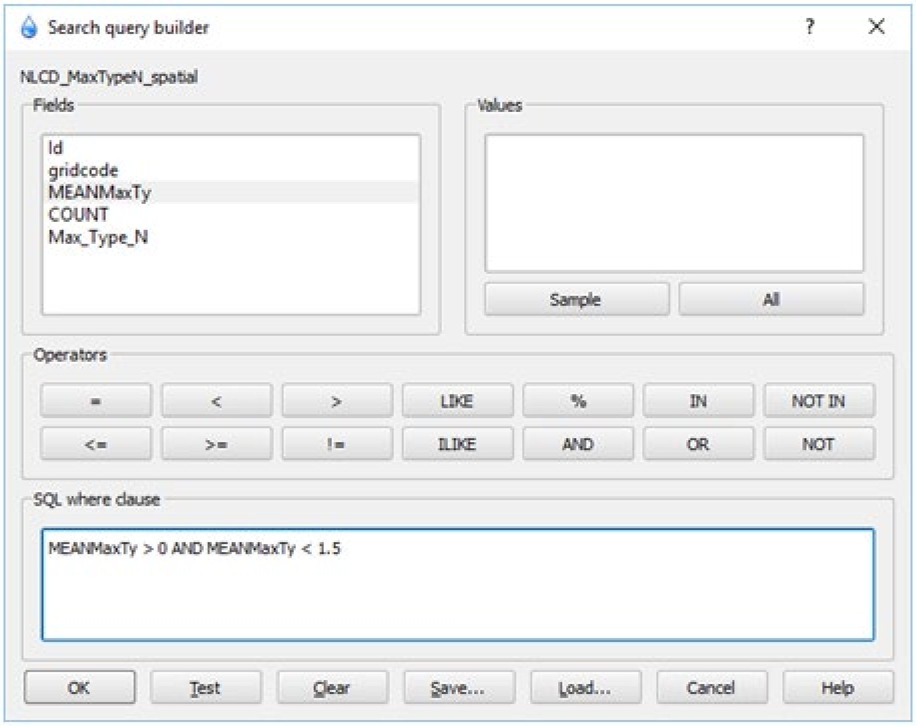


Figure 213 Search query builder in EPA H2O, used to select averaged values between 0 and 1.5

Please note, this selection may take a long time to process. Do not close the attribute table/program.

16. From the spatial join layer attribute table, open the *Field Calculator* window (example shown in *Figure 207*):
    a. Check the *Only update selected features* option.
    b. Check the *Update existing field* option and select “Max_Type_N” from the dropdown list.
    c. Type 1 in the *Expression* box.
    d. Click *OK.*
17. With the selection still highlighted, from the main menu select *Vector* > *Statist* > *Statist.*
18. In the *Statist: Field statistics* window (*Figure 214*):
    a. In the *Input vector layer* dropdown list, select *NLCD_MaxTypeN_spatial.*
    b. Check the *Use only selected features* option if not already checked.
    c. In the *Target field* dropdown list, select *Area.*
    d. Click *OK.* The statistics for the selection will generate within the window.
    e. From the *Statistics output,* copy down the *Sum* value (e.g. 7.5714e9).

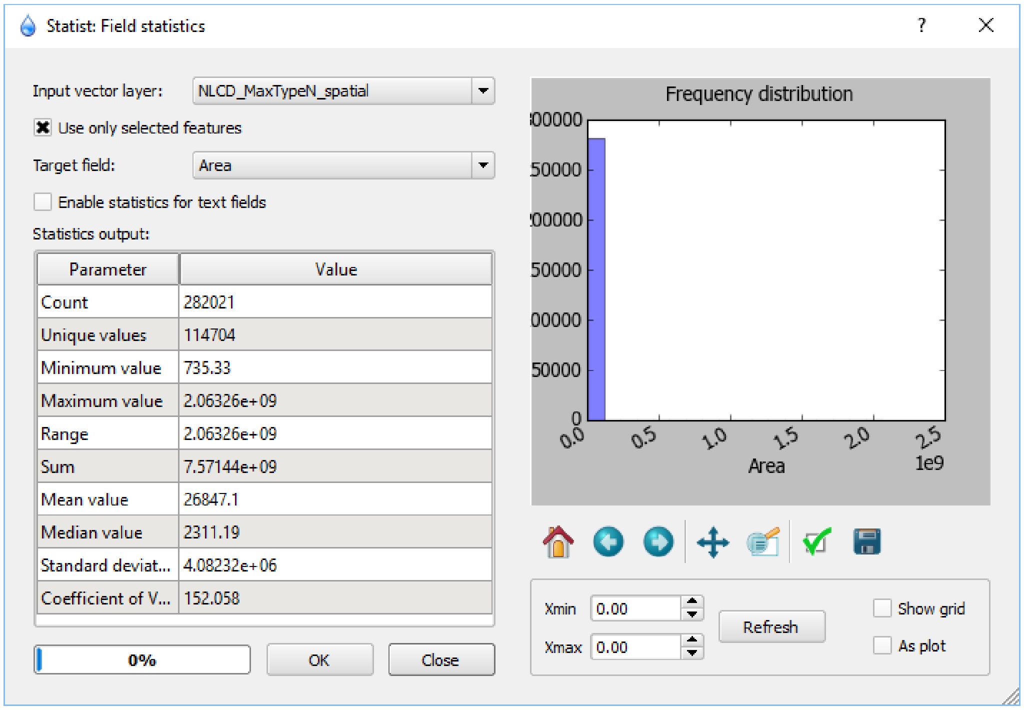


Figure 214 Statist: Field statistics window displaying the Area statistics for the first selection

19. Close the *Statist* window and clear the current attribute table selection.
20. For each selection in *Table 8*, repeat steps 13-18, setting the selection using the expression in *Search Query Builder* and the “Max_Type_N” field value using *Field Calculator*. Then find the total area of each selection using *Statist* and write down the sums for comparison.

Table 8 Expressions for selections and corresponding field calculations

Expression for Selection	“Max_Type_N” Value
MEANMaxTy > 0 AND MEANMaxTy < 1.5	1
MEANMaxTy >= 1.5 AND MEANMaxTy " < 2.5	2
MEANMaxTy >= 2.5 AND MEANMaxTy < 3.5	3
MEANMaxTy >= 3.5 AND MEANMaxTy <= 4	4

21. Compare the areas for each soil type, and determine which classification is most prominent. The sum is expressed in scientific notation, and the units are in meters (i.e. units of the coordinate system). In this example, the total area for each soil type (“Max_Type_N” value) is as follows:
    a. 1 = 7,571,440,000 m
    b. 2 = 415,287,000 m
    c. 3 = 28,464,900 m
    d. 4 = 17,078,600 m

    In this example, the most common soil type is “Max_Type_N” = 1. This soil type will be used to assign the “Max_Type_N” values where “MEANMaxTy” is NULL.
22. In the Layers panel, right-click the *NLCD_MaxTypeN_spatial* layer and open the attribute table.
23. In the attribute table (*Figure 215*):
    a. In the *Look for* text box, type *NULL.*
    b. In the *in* field dropdown list, select “MEANMaxTy”.
    c. Click *Search.*

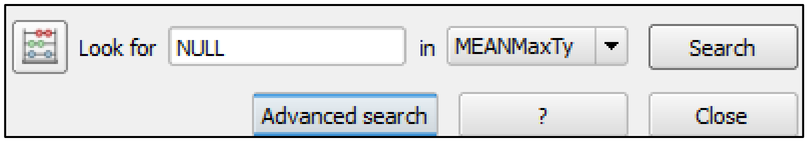


Figure 215 Look for NULL values in the MEANMaxTy field

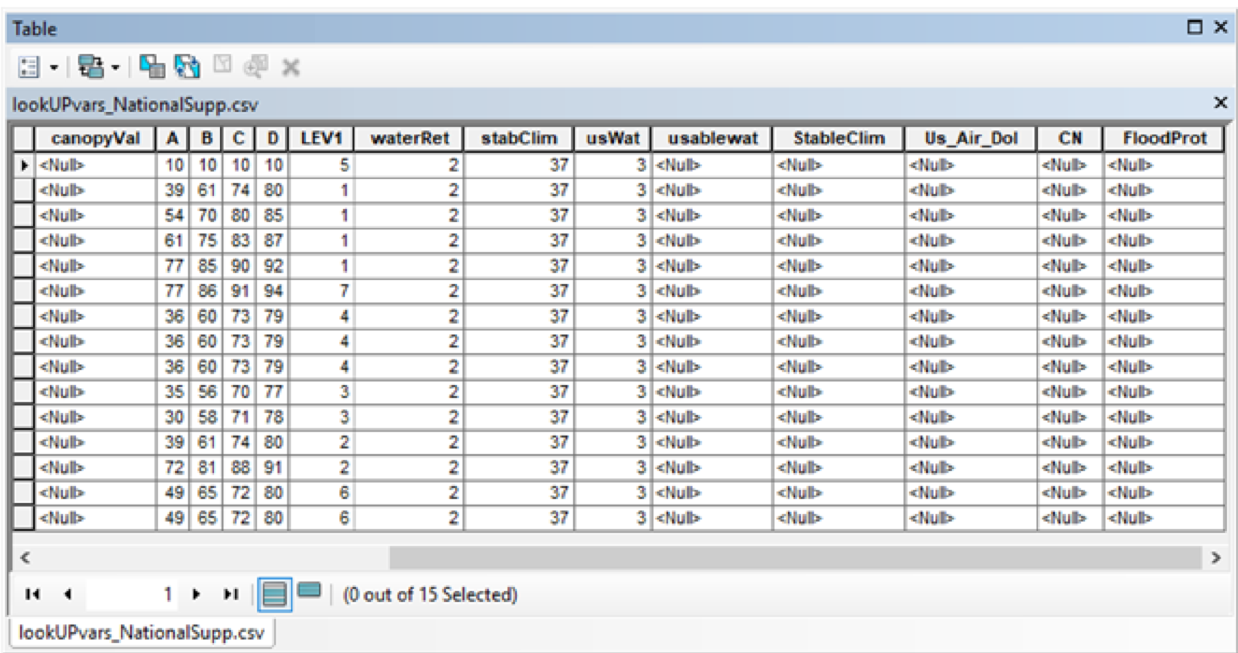
24. Click the *Field Calculator*  icon (example shown in *Figure 207*):
    a. Check the *Only update selected features* option.
    b. Check the *Update existing field* option and select “Max_Type_N” from the dropdown list.
    c. In the *Expression* box, enter the number corresponding to the most prominent soil from step 21 (in the example this was 1).
    d. Click *OK.*

Database creation is continued in the Update ES Coefficients section.

Update ES Coefficients

EPA H2O incorporates Tree Canopy, Air Quality, Carbon Sequestration, and Denitrification coefficients for each land use type. These coefficients are used to calculate ES values for air pollution removal, carbon sequestration, and nitrogen removal from water.

The land use layer attribute table (*Figure 216*) will include fields for ES coefficients ("Canopy", "CarbonFixe", and "denitrific") and ES values ("waterRet", "stabClim", and "usWat"). These fields are populated by joining the land use layer to a lookup table with the same land use classification (e.g. NLCD); as described in the Joining Lookup Table section. The fields for ES monetary values can be updated by *Modifying ES Algorithm Values;* as described in the Edit Scenarios section. National averages for each ES coefficient are provided in the supplemental lookup table (Appendix A: Supplemental NLCD Lookup Table) and may be imported to create a database from NLCD classified land use. However, user database accuracy may be improved if the default national averages are updated on a more local scale. To update coefficients, changes are first made to the lookup table, then changes are joined to the land use layer. The ES coefficients in the lookup table and land use table must match. Either Esri ArcMap software or QGIS can be used to update the ES coefficients. The procedure for both software applications is explained in this section.



Table

lookUPvars_NationalSupp.csv

canopyVal	A	B	C	D	LEV1	waterRet	stabClim	usWat	usablewat	StableClim	Us_Air_Dol	CN	FloodProt
<Null>	10	10	10	10	5	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	39	61	74	80	1	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	54	70	80	85	1	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	61	75	83	87	1	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	77	85	90	92	1	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	77	86	91	94	7	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	36	60	73	79	4	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	36	60	73	79	4	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	36	60	73	79	4	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	35	56	70	77	3	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	30	58	71	78	3	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	39	61	74	80	2	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	72	81	88	91	2	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	49	65	72	80	6	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>
<Null>	49	65	72	80	6	2	37	3	<Null>	<Null>	<Null>	<Null>	<Null>

1 (0 out of 15 Selected)

lookUPvars_NationalSupp.csv

Figure 216 Supplemental lookup table, with ES National Average fields; these fields may be updated to represent more local values

Tree Canopy

Download Tree Canopy Data

This section illustrates the step-by-step procedure for downloading NLCD 2011 Percent Tree Canopy (cartographic) data from the USGS National Map. This data is used to update the "Canopy" field in the lookup table, which is needed to calculate the "Us_Air_Dol" field in the Joining Lookup Table section.

1. Navigate to https://www.mrlc.gov/viewer/ as shown in *Figure 217*.

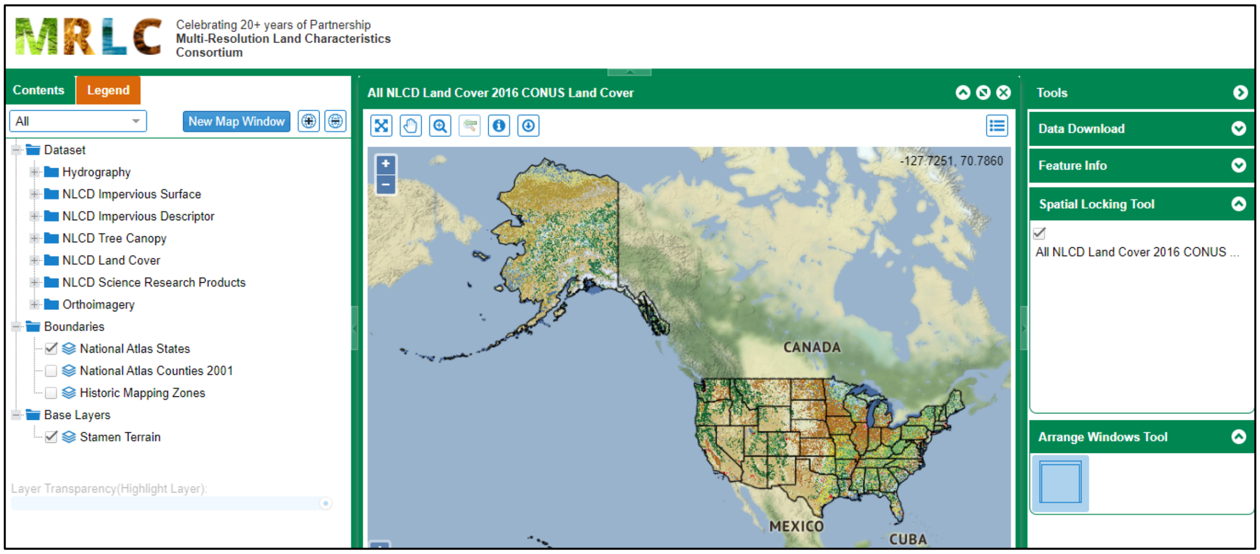


Figure 217 MRLC website, download NLCD Canopy Cover by AOI

2. Click-and-drag on the National Map to pan and use the *Zoom in* icon to zoom in to the user's AOI (e.g. Tampa Bay).

3. In the *Contents* section, under the *NLCD Tree Canopy* dropdown list, check the *2011 CONUS Tree Canopy* option (or the preferred display year).

4. From the map viewer toolbar, click the *Open Data Download Tool* icon and click to draw a bounding box around the user's AOI (*Figure 218*).

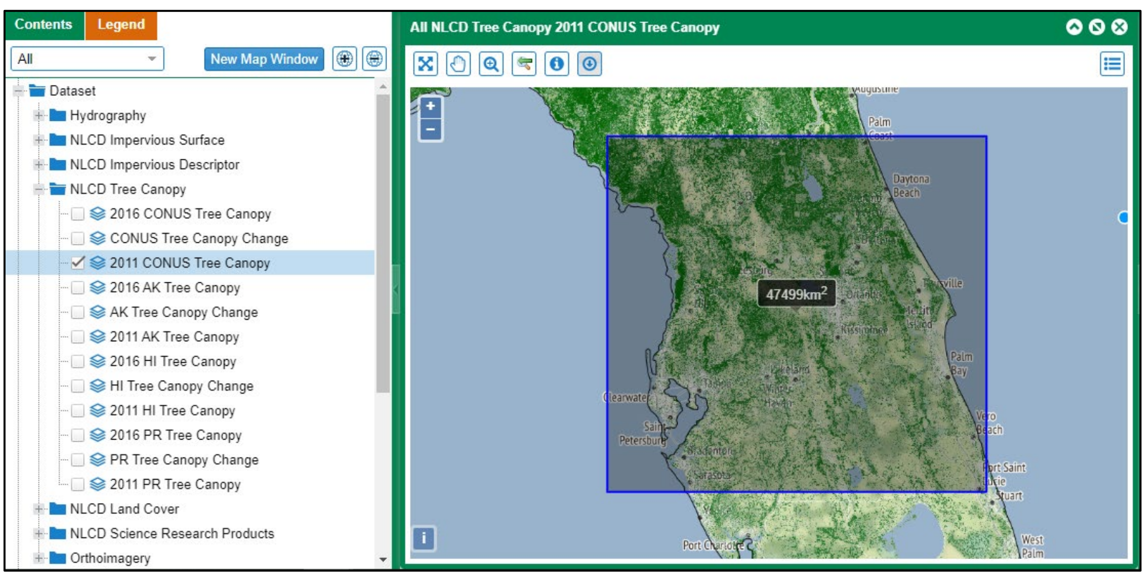


Figure 218 MRLC viewer with bounding box drawn around Tampa Bay AOI

5. Under the *Data Download* dropdown list, check the *Tree Canopy* option and toggle *All Tree Canopy Years* (*Figure 219*).

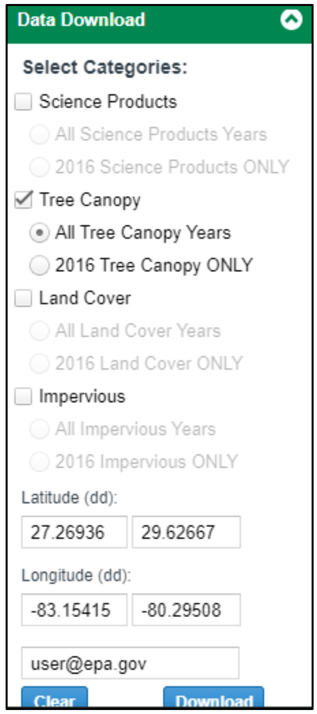


Figure 219 Data Download dropdown list

6. In the *Email* text box, enter the user's email address (e.g. user@epa.gov), then click *Download.*
7. A notification will appear indicating the download request has been sent. Click *OK* (*Figure 220*).

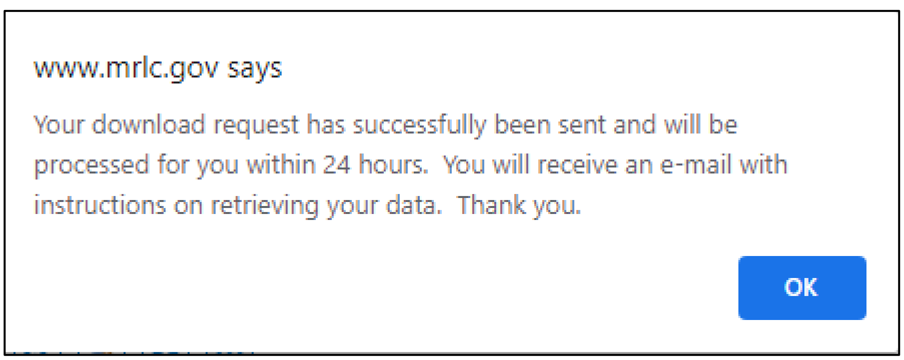


Figure 220 MRLC request notification

8. The download link will be emailed to the user by the USGS server. Click the first link in the email to download the NLCD Canopy Cover zip file.

9. Save the zip file to the computer and unzip the contents to a known location.

NLCD Canopy cover raster values represent the percent canopy cover for each 30m x 30m raster cell. EPA H2O requires average canopy cover for each land use classification. If using a land use classification other than NLCD the land use classification may have a different resolution (e.g. the FLUCCS 2006 classification used in the Tampa Bay dataset has a 5-meter resolution) resulting in a difference in canopy cover sampling. The next section illustrates the averaging of percent canopy cover for each land use type, using either Esri ArcGIS (Using ArcGIS) or QGIS (Using QGIS). Averaging canopy cover over larger areas better accounts for local variability and helps to limit errors due to differences in sampling.

Using ArcGIS

This section illustrates how to update the % Canopy Cover (“Canopy” field) for the user’s area of interest using Esri ArcGIS.

Note: this step requires the *Spatial Analyst* extension in ArcMap. If the user’s ArcGIS license does not include this extension, the user will skip this step and use the default national averages already in the “Canopy” field for calculations. These average canopy cover values come from overlaying NLCD land use and cartographic canopy cover. It is important to note that the cartographic canopy cover differs from the analytical, in that it has already been corrected for impervious surfaces.

Although the following process is shown using an NLCD land use dataset, the same steps can be performed using an alternative land use vector dataset (e.g. FLUCCS). Simply replace the “gridcode” field with the appropriate land use code field where required.

1. Download and unzip the Canopy Cover data to a known location, as shown in the Download Tree Canopy Data section.
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document**.**
3. Use the *Add Data*  icon to navigate to the Canopy Cover 2011 .tif dataset (or most recent year). Select it and click *Add* to add it as a layer in the Table of Contents.
4. If using a new map document, the shapefile created in the Spatially Join Soils to Land Use section (e.g. *NLCD_MaxTypeN_join*) must be located and added in the same way.
5. From the *ArcToolbox* window, navigate to and open the *Project Raster* tool, (*ArcToolbox > Data Management Tools > Projections and Transformations > Raster > Project Raster, Figure 221*).
6. In the *Project Raster* window (*Figure 222*):
   a. In the *Input Raster* dropdown list, select the NLCD canopy cover .tif (e.g. *NLCD_2011_Tree_Canopy_L48_20190831_RTDBmKOdx72K3rodhLUd.tiff*).
   b. In the *Output Raster Dataset* text box, name the output with a .tif extension (e.g. *Canopy_reproj.tif*) and the file path.
   c. Click the *Spatial Reference*  icon to set the *Output Coordinate System* to *WGS_1984_Web_Mercator_Auxiliary_Sphere*, located under the *World* folder in *Projected Coordinate Systems*. Alternatively, search for it by typing *3857* into the search box.
   d. A *Geographic Transformation* is required to reproject the land use dataset. In the dropdown list, choose *WGS_1984_(ITRF00)_To_NAD_1983*, if not already listed in the box.
   e. If the wrong *Geographic Transformation* is listed, click on the name, and click the X button to remove it.
   f. Click *OK* to run *Project Raster*.

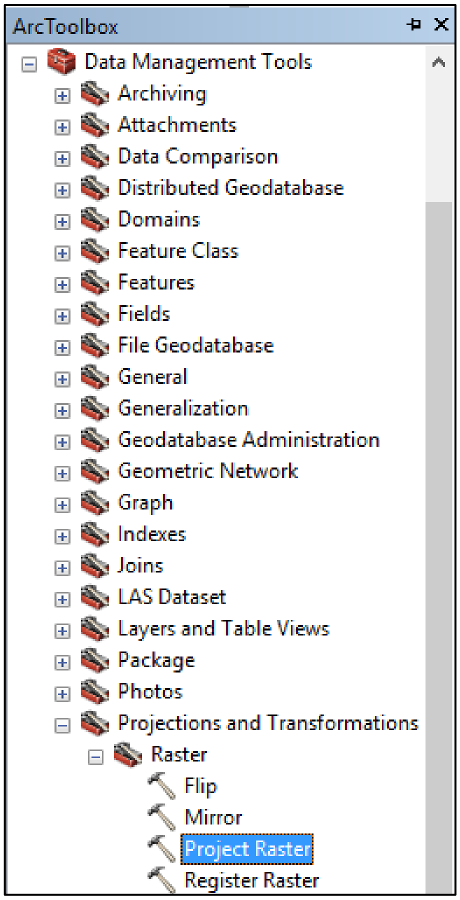


Figure 221 Location of the Project Raster tool in ArcToolbox

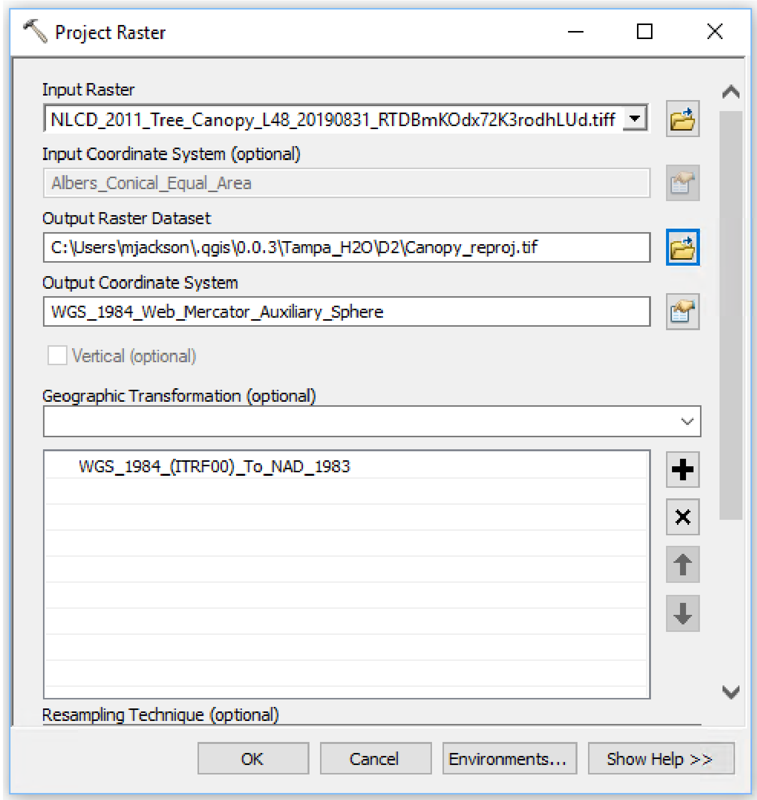


Figure 222 Project Raster tool window

7. Check that the *Spatial Analyst* extension is enabled. From the main menu, click *Customize > Extensions…,* and confirm that the *Spatial Analyst* option is checked. Click *Close.*
8. Use the *Tabulate Area* tool to create a table summarizing the re-projected canopy cover layer (e.g. *Canopy_reproj)* by the classification in the soil/land use layer (e.g. *NLCD_MaxTypeN_join).* From the *ArcToolbox* window, navigate to and open the *Tabulate Area* tool (*ArcToolbox > Spatial Analyst Tools > Zonal > Tabulate Area, Figure 223*).
9. In the *Tabulate Area* window (*Figure 224*):
    a. In the *Input raster or feature zone data* dropdown list, select the soil/land use layer (e.g. *NLCD_MaxTypeN_join).*
    b. In the *Zone field* dropdown list, select “gridcode”.
    c. In the *Input raster or feature class data* dropdown list, select the re-projected canopy layer (e.g. *Canopy_reproj).*
    d. In the *Class field* dropdown list, select “Value”.
    e. In the *Output table* text box, name the output table (e.g. *Canopy_TabArea)* and file path.
    f. Click *OK* to run *Tabulate Area*.

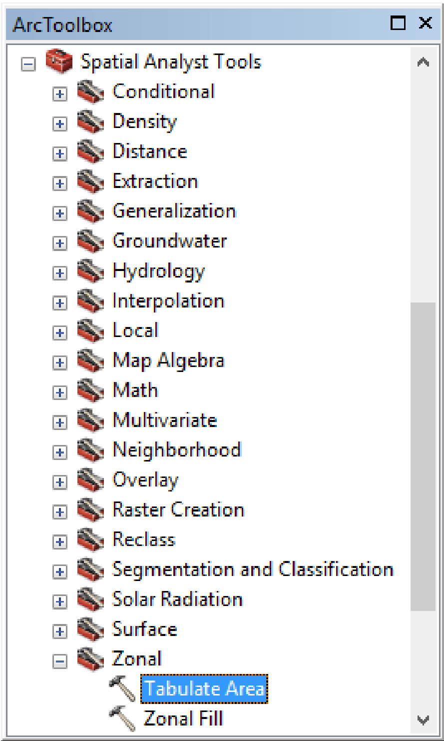


Figure 223 Location of the Tabulate Area tool in ArcToolbox

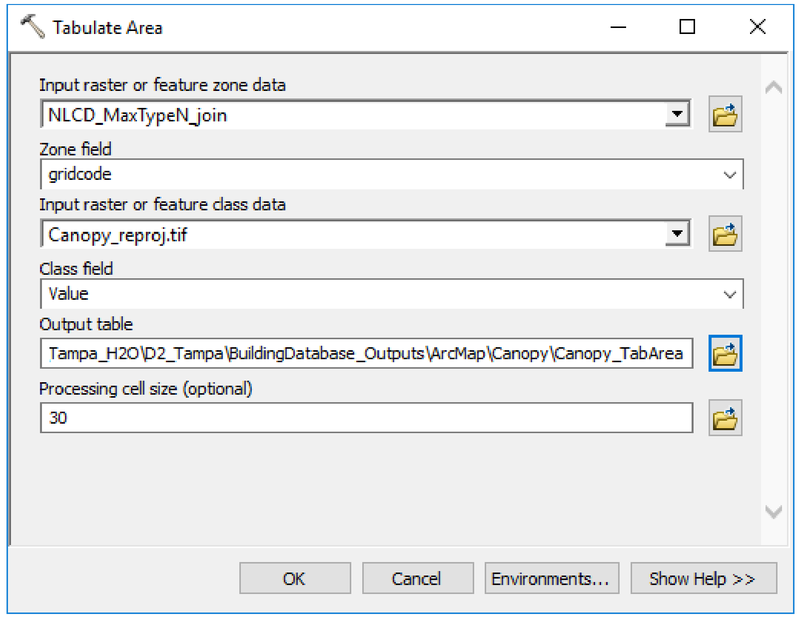


Figure 224 Tabulate Area tool window in ArcMap

10. In the Table of Contents, right-click to open the output table (e.g. *Canopy_TabArea*).
11. Add a new field in the table (example shown in *Figure 179* and *Figure 180)*:
    a. In the *Name* text box, type the preferred field name (e.g. "AvgCC").
    b. In the *Type* dropdown list, select *Short Integer.*
    c. Click *OK.*
12. In the attribute table, right-click on the new field, and choose *Field Calculator.*
13. In the expression box, copy and paste the following equation, then click *OK* (*Figure 225*):

(([VALUE_1] * 1) + ([VALUE_2] * 2) + ([VALUE_3] * 3) + ([VALUE_4] * 4) + ([VALUE_5] * 5) + ([VALUE_6] * 6) + ([VALUE_7] * 7) + ([VALUE_8] * 8) + ([VALUE_9] * 9) + ([VALUE_10] * 10) + ([VALUE_11] * 11) + ([VALUE_12] * 12) + ([VALUE_13] * 13) + ([VALUE_14] * 14) + ([VALUE_15] * 15) + ([VALUE_16] * 16) + ([VALUE_17] * 17) + ([VALUE_18] * 18) + ([VALUE_19] * 19) + ([VALUE_20] * 20) + ([VALUE_21] * 21) + ([VALUE_22] * 22) + ([VALUE_23] * 23) + ([VALUE_24] * 24) + ([VALUE_25] * 25) + ([VALUE_26] * 26) + ([VALUE_27] * 27) + ([VALUE_28] * 28) + ([VALUE_29] * 29) + ([VALUE_30] * 30) + ([VALUE_31] * 31) + ([VALUE_32] * 32) + ([VALUE_33] * 33) + ([VALUE_34] * 34) + ([VALUE_35] * 35) + ([VALUE_36] * 36) + ([VALUE_37] * 37) + ([VALUE_38] * 38) + ([VALUE_39] * 39) + ([VALUE_40] * 40) + ([VALUE_41] * 41) + ([VALUE_42] * 42) + ([VALUE_43] * 43) + ([VALUE_44] * 44) + ([VALUE_45] * 45) + ([VALUE_46] * 46) + ([VALUE_47] * 47) + ([VALUE_48] * 48) + ([VALUE_49] * 49) + ([VALUE_50] * 50) + ([VALUE_51] * 51) + ([VALUE_52] * 52) + ([VALUE_53] * 53) + ([VALUE_54] * 54) + ([VALUE_55] * 55) + ([VALUE_56] * 56) + ([VALUE_57] * 57) + ([VALUE_58] * 58) + ([VALUE_59] * 59) + ([VALUE_60] * 60) + ([VALUE_61] * 61) + ([VALUE_62] * 62) + ([VALUE_63] * 63) + ([VALUE_64] * 64) + ([VALUE_65] * 65) + ([VALUE_66] * 66) + ([VALUE_67] * 67) + ([VALUE_68] * 68) + ([VALUE_69] * 69) + ([VALUE_70] * 70) + ([VALUE_71] * 71) + ([VALUE_72] * 72) + ([VALUE_73] * 73) + ([VALUE_74] * 74) + ([VALUE_75] * 75) + ([VALUE_76] * 76) + ([VALUE_77] * 77) + ([VALUE_78] * 78) + ([VALUE_79] * 79) + ([VALUE_80] * 80) + ([VALUE_81] * 81) + ([VALUE_82] * 82) + ([VALUE_83] * 83) + ([VALUE_84] * 84) + ([VALUE_85] * 85) + ([VALUE_86] * 86) + ([VALUE_87] * 87) + ([VALUE_88] * 88) + ([VALUE_89] * 89) + ([VALUE_90] * 90) + ([VALUE_91] * 91) + ([VALUE_92] * 92) + ([VALUE_93] * 93) + ([VALUE_94] * 94) + ([VALUE_95] * 95) + ([VALUE_96] * 96) + ([VALUE_97] * 97) + ([VALUE_98] * 98) + ([VALUE_99] * 99) + ([VALUE_100] *

100))/([VALUE_0] + [VALUE_1] + [VALUE_2] + [VALUE_3] + [VALUE_4] + [VALUE_5] + [VALUE_6] + [VALUE_7] + [VALUE_8] + [VALUE_9] + [VALUE_10] + [VALUE_11] + [VALUE_12] + [VALUE_13] + [VALUE_14] + [VALUE_15] + [VALUE_16] + [VALUE_17] + [VALUE_18] + [VALUE_19] + [VALUE_20] + [VALUE_21] + [VALUE_22] + [VALUE_23] + [VALUE_24] + [VALUE_25] + [VALUE_26] + [VALUE_27] + [VALUE_28] + [VALUE_29] + [VALUE_30] + [VALUE_31] + [VALUE_32] + [VALUE_33] + [VALUE_34] + [VALUE_35] + [VALUE_36] + [VALUE_37] + [VALUE_38] + [VALUE_39] + [VALUE_40] + [VALUE_41] + [VALUE_42] + [VALUE_43] + [VALUE_44] + [VALUE_45] + [VALUE_46] + [VALUE_47] + [VALUE_48] + [VALUE_49] + [VALUE_50] + [VALUE_51] + [VALUE_52] + [VALUE_53] + [VALUE_54] + [VALUE_55] + [VALUE_56] + [VALUE_57] + [VALUE_58] + [VALUE_59] + [VALUE_60] + [VALUE_61] + [VALUE_62] + [VALUE_63] + [VALUE_64] + [VALUE_65] + [VALUE_66] + [VALUE_67] + [VALUE_68] + [VALUE_69] + [VALUE_70] + [VALUE_71] + [VALUE_72] + [VALUE_73] + [VALUE_74] + [VALUE_75] + [VALUE_76] + [VALUE_77] + [VALUE_78] + [VALUE_79] + [VALUE_80] + [VALUE_81] + [VALUE_82] + [VALUE_83] + [VALUE_84] + [VALUE_85] + [VALUE_86] + [VALUE_87] + [VALUE_88] + [VALUE_89] + [VALUE_90] + [VALUE_91] + [VALUE_92] + [VALUE_93] + [VALUE_94] + [VALUE_95] + [VALUE_96] + [VALUE_97] + [VALUE_98] + [VALUE_99] + [VALUE_100])

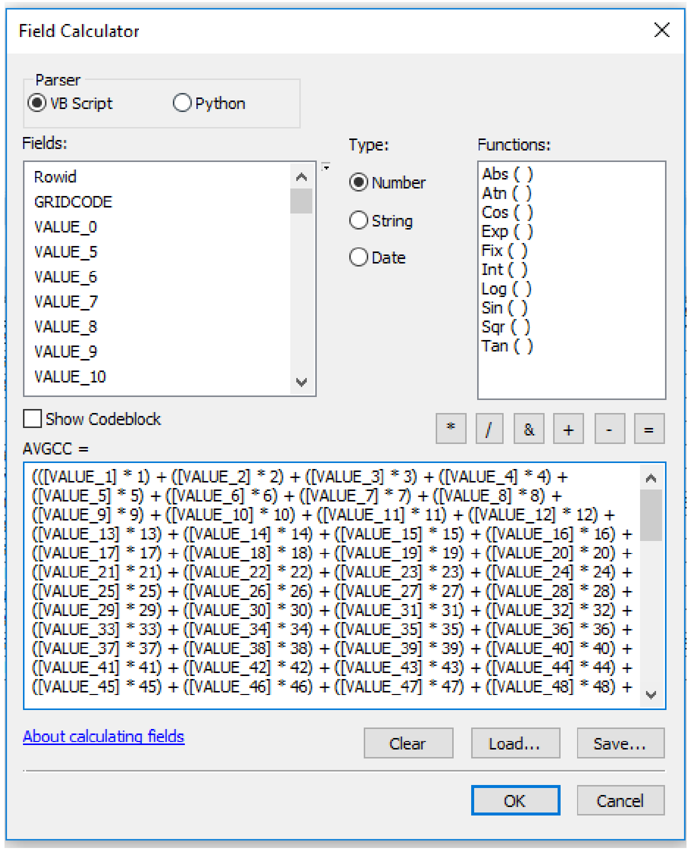


Figure 225 Field Calculator, with % Canopy equation entered

The new field should contain values between 0 and 100%, indicating the average percent tree canopy cover in each land use type.

Troubleshooting Common Errors:

Problem:

An error may occur during field calculation as shown in *Figure 226*. The message references the *Geoprocessing Results* window, to open this window from the main menu click *Geoprocessing* > *Results.* The *Results* window may list an error message that states *A field name was not found or there were unbalanced quotation marks* (*Figure 227*). This may occur if the canopy cover for the user's area of interest does not contain all values from 0 to 100. It may also appear if one “Value” field contains all zeros.

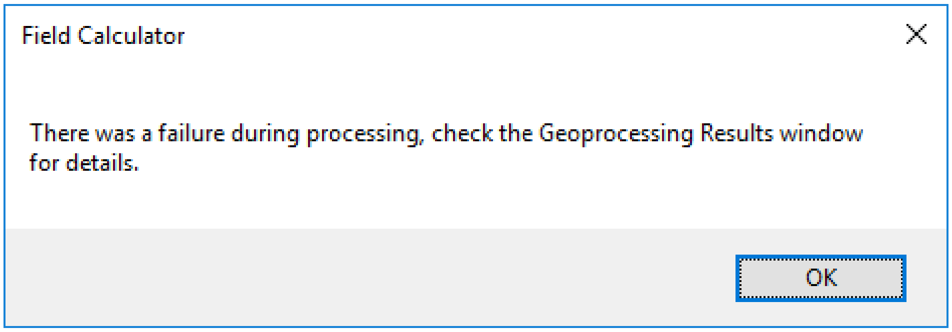


Figure 226 Field Calculator processing error window, referencing the Geoprocessing Results window

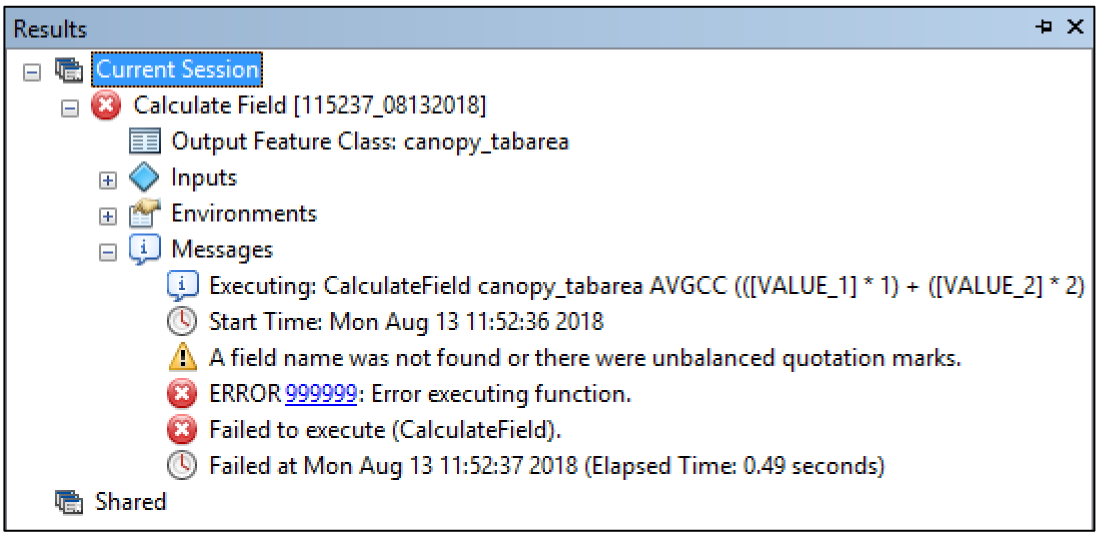


Figure 227 Results window in ArcMap, with the Messages error shown

Solution:

Open the *Tabulate Area* table and confirm that fields “Value_0” through “Value_100” appear. If a field is missing, it must be removed from both parts of the Field Calculator equation. For example, the NLCD canopy cover for Tampa Bay does not contain values 1-4. These values must be removed from the equation above. The expression for Tampa Bay will start with *(([VALUE_5] * 5) + …* and will divide by */([VALUE_0] + [VALUE_5] + …* in the second half of the equation.

14. Use the *Add Data*  icon to navigate to the lookup table with .dbf extension (e.g. supplemental lookup table exported from Appendix A: Supplemental NLCD Lookup Table) and add the table to the Table of Contents.
15. Right click on the lookup table and open the *Join* tool (example shown in *Figure 183*).
16. In the *Join Data* window (example shown in *Figure 184*):
    a. In the first dropdown list, select *Join attributes from a table*.
    b. In the *Choose the field in this layer that the join will be based on* dropdown list, select “GRIDCODE”.
    c. In the *Choose the table to join to this layer* dropdown list, select the *Tabulate Area* table (e.g. *Canopy_TabArea).*
    d. In the *Choose the field in the table to base the join on* dropdown list, select “GRIDCODE”.
    e. Under *Join Options,* toggle the *Keep all records* option on*.*
    f. Click *OK.*

17. Open the lookup table, locate the “Canopy” field, and open the *Field Calculator.*
18. In the *Field Calculator* window (*Figure 228*):
    a. In the *Fields* list box, double click on the new field name (e.g. *Canopy_TabArea:AVGCC*).
    b. The new field should appear in the expression box. Click *OK.*

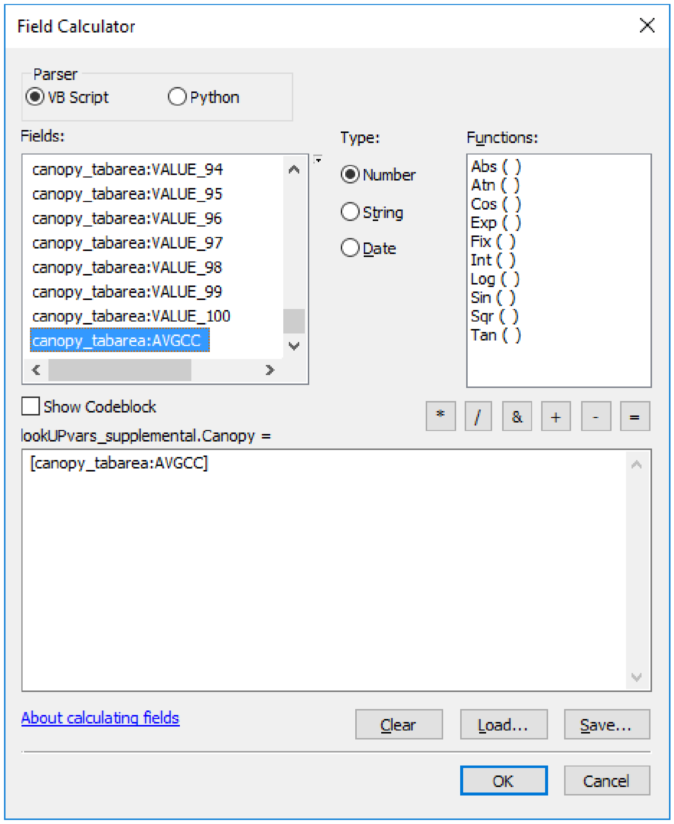


Figure 228 Field Calculator window, with the AvgCC field as the expression

19. Right click on the lookup table and choose *Joins and Relates > Remove Join(s) >Tabulate Area* table (e.g. *Canopy_TabArea, Figure 229*).

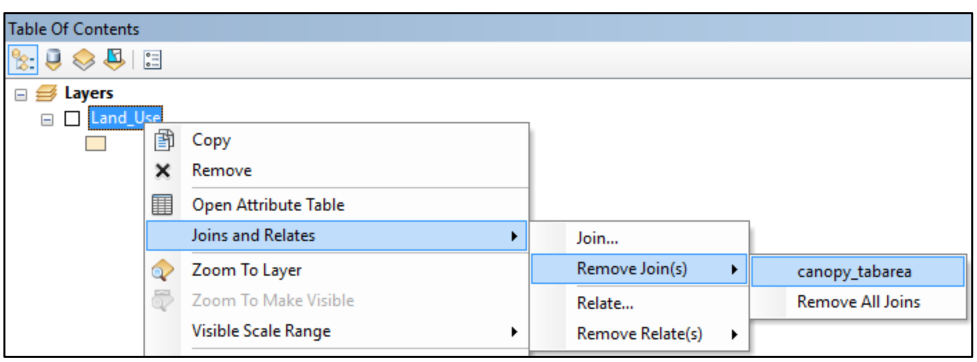


Figure 229 Location of the Remove Join tool, in the Table of Contents

Although averaging canopy cover helps to limit errors, some manual corrections may be necessary. One common instance of this is seen with aquatic land use types. Whereas aquatic areas are known to be covered in water bordering areas with trees may cause the land use type to be assigned a small percent canopy cover, especially when there are differences in resolution. These errors were corrected in the lookup table by adjusting the canopy cover value to zero. The following steps illustrate how to zero out the “Canopy” value for NLCD *Open Water.*

20. Open the supplemental lookup table, locate the row for *Open Water*, and click the to the left of that row to select it (the entire row will be highlighted in blue when selected).
21. With *Open Water* selected, right-click the "Canopy" field and open the *Field Calculator.*
22. In the *Field Calculator* window (example shown in *Figure 228*):
    a. In the expression box, type *0*
    b. Click *OK.*

The average percent canopy cover for the user's AOI has replaced the national averages in the "Canopy" field of the lookup table, and the canopy cover for *Open Water* has been corrected. This updated field will be used to calculate the "Us_Air_Dol" field in the Field Calculations section.

Using QGIS

This section illustrates how to update the % Canopy Cover ("Canopy" field) for the user's area of interest using QGIS.

Although the following process is shown using an NLCD land use dataset, the same steps can be performed using an alternative land use vector dataset (e.g. FLUCCS) and a lookup table with corresponding land use classes (e.g. the original Qspatialite lookup table). Simply replace the "gridcode" field with the appropriate land use code field where required.

1. Download and unzip the Canopy Cover data, as shown in the Download Tree Canopy Data section.
2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. From the *Layer* menu open the *Add Raster Layer* window (*Main Menu* > *Layer* > *Add Raster Layer*, *Figure 145*).
4. Navigate to the cartographic canopy cover data and add the 2011 .tif file (or most recent year) to the Layers panel (e.g. *NLCD_2011_Tree_Canopy_L48_20190831_RTDBmKOdx72K3rodhLUd.tiff)*.
5. From the *Layer* menu open the *Add Vector Layer* window (*Main Menu* > *Layer* > *Add Vector Layer*, *Figure 126*).
6. In the *Add vector layer* window, click *Browse* to locate and select the soil/land use layer (e.g. *NLCD_MaxTypeN_spatial*) previously created in the Spatially Join Soils to Land Use section. Click *Open* to add this layer to the map document.
7. From the *Raster* menu, open the *Warp (Reproject)* tool (*Main Menu* > *Raster* > *Projections* > *Warp (Reproject), Figure 146*).
8. In the *Warp (Reproject)* window (example shown in *Figure 148*):
    a. In the *Input file* dropdown list, select the NLCD canopy raster (e.g. *NLCD_2011_Tree_Canopy_L48_20190831_RTDBmKOdx72K3rodhLUd.tiff).*
    b. Next to the *Output file,* click *Select* to select a file path and name for the output (e.g. *Canopy_reproj.tif)*. Be sure to name the output with a **.tif extension**.
    c. Check the *Source SRS* box, and click *Select* to open the *Select the source SRS window.*
        i. Under the *Recently used coordinate reference systems* section, choose the * Generated CRS (+proj = aea…) SRS (*Figure 147*).
        ii. Click *OK*.
    d. Check the *Target SRS* box and click *Select* to open the *Select the target SRS window*.
    e. In the *Filter* box, type *3857,* and under *Coordinate reference systems of the world,* choose *WGS 84/ Pseudo Mercator*. Click *OK*.
    f. Check *Load into canvas when finished*.
    g. Click *OK.*

9. From the *Raster* menu, open the *Zonal Statistics* tool (*Main Menu > Raster > Zonal Statistics > Zonal Statistics*).
10. In the *Dialog* window (*Figure 230*):
    a. In the *Raster layer* dropdown list, select the re-projected canopy raster (e.g. *Canopy_reproj*).
    b. In the *Polygon layer containing the zones* dropdown list, select the soil/land use layer (e.g. *NLCD_MaxTypeN_spatial*).
    c. In the *Output column prefix* text box, enter *LU.*
    d. Click *OK.*

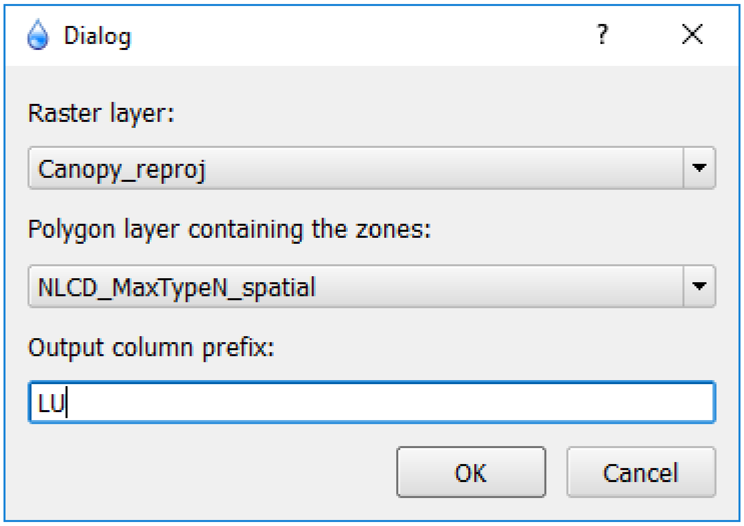
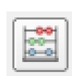


Figure 230 Zonal Statistics Dialog window, with LU designated as the Output column prefix

This tool may take some time to process. Do not close the *Dialog* window until processing is complete. Once finished, the soil/land use layer (e.g. *NLCD_MaxTypeN_spatial)* will contain three new fields: "LUcount", "LUsum", and "LUmean".

11. Open the soil/land use attribute table and click the *pencil* icon  to start an edit session.
12. Click the *Add column* icon  to add a new field in the attribute table.
13. In the *Add column* window (example shown in *Figure 205*):
    a. In the *Name* field, type *Area*.
    b. In the *Type* dropdown list, select *Decimal number (real).*
    c. In the *Width* text box enter 20 and in the *Precision* text box enter 2.
    d. Click *OK.*
14. Click the *Field Calculator* icon  to open the *Field Calculator* window.
15. In the *Field Calculator* window (example shown in *Figure 161*):
    a. Check *Update existing field* option.
    b. In the *Field* dropdown list, select the "Area" field.
    c. Click the *Geometry* option to open the dropdown list, and double click on *$area*.
    d. *$area* will appear in the *Expression* box. Click *OK.*
16. Click the *Add column* icon again to add a second field.
17. In the *Add column* window:
    a. In the *Name* field, enter the desired field name (e.g. *new_field)*
    b. In the *Type* dropdown list, select *Decimal number (real).*
    c. In the *Width* text box enter 20, and in the *Precision* text box enter 2.
    d. Click *OK.*
18. Click the *Field Calculator* icon again to open the *Field Calculator.*
19. In the *Field Calculator* window:

   a. Select the *Update existing field* option.
   b. In the *Field* dropdown list, select the new field (e.g. “new_field”).
   c. Click the *Fields and Values* option to open the dropdown list.
   d. Double click on the “Area” field from the list; the name should appear in the *Expression* box.
   e. Click on the *multiply (*)* operator; it should appear in the *Expression* box.
   f. Double click on the “LUmean” field from the list; the name should appear in the *Expression* box. The full expression is: *"Area" * "LUmean"*
   g. Click *OK.*

20. Click the *pencil* icon to turn off editing and save changes to the attribute table.
21. In the soil/land use attribute table (e.g. *NLCD_MaxTypeN_spatial),* click on the *Advanced search* tool (as shown in *Figure 212*).
22. In the *Search query builder* window (example shown in *Figure 213*):
    a. In the *Fields* list, double click the “gridcode” field*;* the name should appear in the *Expression* box.
    b. Click the *Equals (=)* operator; it should appear in the *Expression* box.
    c. Under the *Values* option, click the *All* button*;* the list of all gridcode values will appear.
    d. Double click on the first code (this is gridcode 11 with NCLD data). The full expression is: *gridcode = 11*
    e. Click *OK.*
23. In the attribute table, click the *Move selection to top* icon  to view the selected features.
24. While leaving the attribute table open, open the *Basic Statistics* tool (*Main Menu >Vector > Analysis Tools > Basic statistics).*
25. In the *Basic statistics* window (*Figure 232*):
    a. In the *Input Vector Layer* dropdown list, select the soil/land use layer (e.g. *NLCD_MaxTypeN_spatial).*
    b. Check the *Use only selected features* option if not already checked.
    c. In the *Target field* dropdown list, select the field created in step 19 (e.g. “new_field”).
    d. Click *OK.*

The statistics output will be listed in the *Basic statistics* window after the tool is run (*Figure 231*).

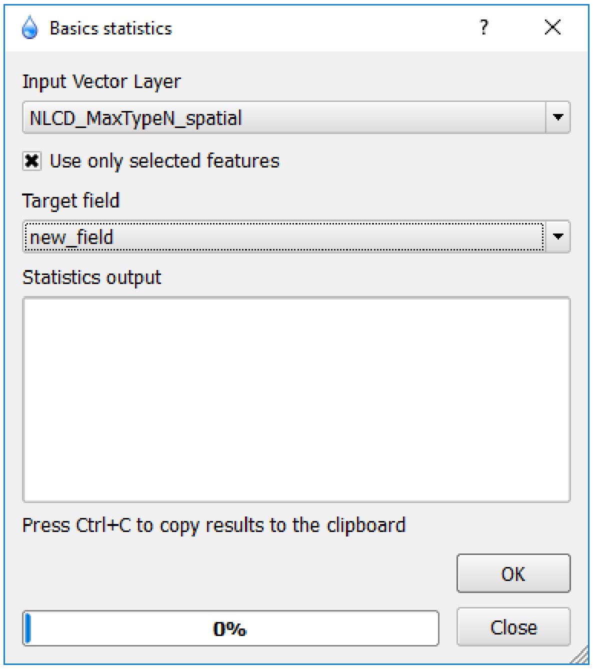


Figure 232 Basic statistics window before the Statistics output is run

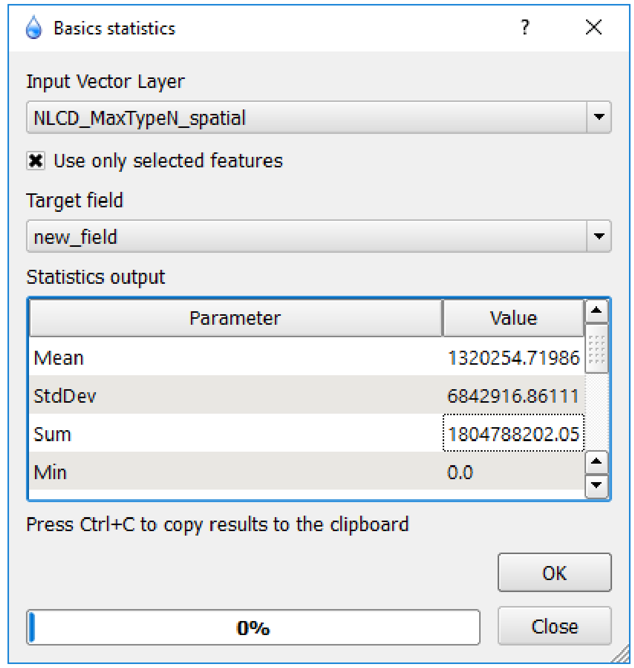
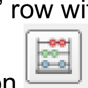


Figure 231 Basic statistics window, with Statistics output gridcode 11 in new_field

26. Copy down the *Sum* value (e.g. *1,804,788,202.05*) into a spreadsheet. This value will be used in a later field calculation.
27. In the same *Basic statistics* window, change the *Target field* to "Area".
28. Click *OK* to run a new statistical output.
29. Copy down the *Sum* value into the same spreadsheet. This value will be used in a later field calculation.
30. Repeat steps 21-29 above for each gridcode value:
    a. Select each gridcode individually in the *Search query builder* window.
    b. Copy the *Sum* value for the "new_field" and "Area" fields in the *Basic statistics* window for each selection.
    c. It is recommended that the user create a table of the gridcodes and sums, to keep the values organized for later calculations.

Please note: the sum of the "Area" field for each gridcode is also needed to update the Carbon Sequestration (Using QGIS section) and Denitrification coefficients. It is strongly recommended to save the *Sum* values for each gridcode in Excel to avoid repeating the steps above.

31. Add the supplemental lookup table to the QGIS Layers panel following the QGIS directions in Appendix A: Supplemental NLCD Lookup Table.
32. Right-click and open the lookup table from the Layers panel.
33. Click the *pencil* icon  to start an edit session.
34. Click the "GRIDCODE" field name, to sort the field values in Ascending order.
35. Select the first "GRIDCODE" row with a value. For NLCD, the first gridcode value is 11.
36. Click the *Field Calculator* icon  to open the *Field Calculator.*
37. In the *Field Calculator* window (Figure 233):
    a. Check the *Only update selected features* option.
    b. Check the *Update existing field* option.
    c. In the dropdown list, select the "Canopy" field.

d. In the *Expression* box, type the "new_field" sum for the first gridcode, divided by the "Area" sum for that gridcode. The expression should read *"new_field" sum / "Area" sum* (e.g. 1804788200.58 / 73515068.6)

e. Click *OK.*

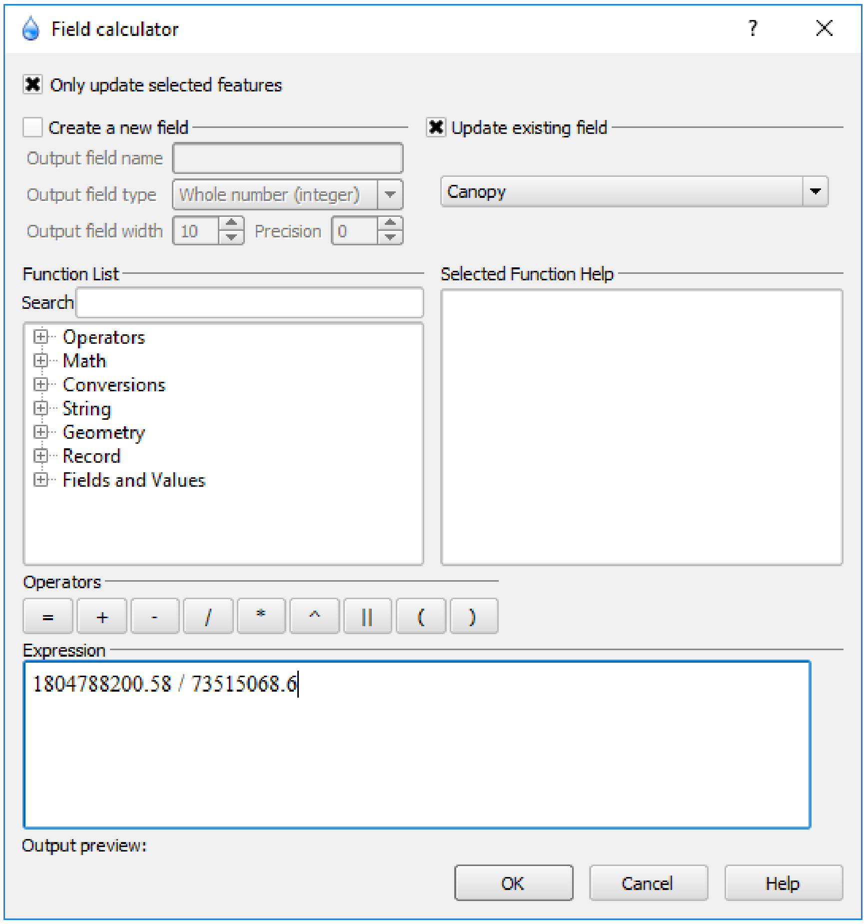


Figure 233 Field Calculator window, with 1804788200.58 / 73515068.6 entered as the expression

38. Repeat field calculation steps 35-37 for each gridcode row, with the appropriate "new_field" sum and "Area" sum.

Once the calculations are complete, the "Canopy" field in the lookup table will contain the average % Canopy Cover for each land use type in the AOI. This updated field will be used to calculate the "Us_Air_Dol" field in the Field Calculations section.

Air Quality

This section illustrates how to update the air quality value ("canopyVal") for an area of interest. The "canopyVal" field will be used to calculate the "Us_Air_Dol" field in the Joining Lookup Table section.

Average removal rates for carbon monoxide (CO), ozone (O_3), particulate matter (PM_{10}), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2) have been previously estimated for 55 metropolitan areas in the continental United States (Nowak et al., 2006; *Figure 234*). If the area of interest is within the continental United States or Hawaii, the removal rates for each pollutant in the nearest city can either be selected from the Air Quality Reference table (Appendix B: Air Quality Reference Table), or by spatially referencing the Air Quality Reference table and determining the nearest city in either ArcGIS or QGIS. The total Air Quality value of canopy cover ($/m²/yr) has been calculated in the Air Quality Reference table as described in the ES Calculations Theory section.

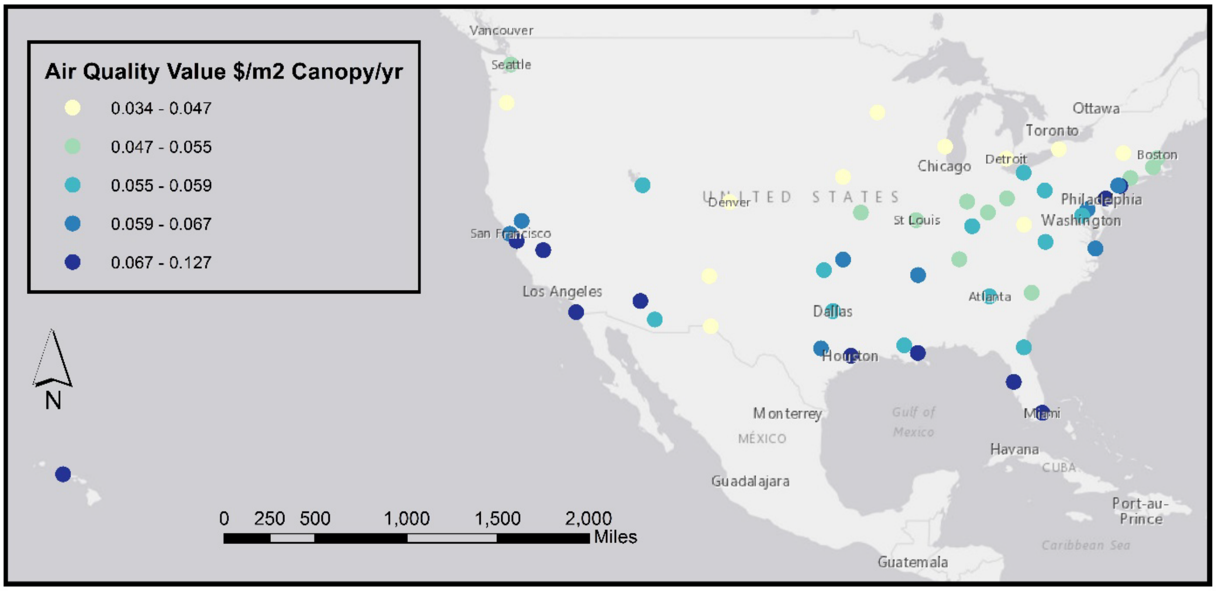
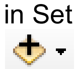


Figure 234 Total value ($/m2/yr) of canopy cover for each metropolitan area in Nowak et al., 2006

Using ArcGIS

This section outlines the calculation of land use air pollution removal rates based on the nearest city, using the Air Quality Reference table as a shapefile in ArcGIS. This process is suggested if the user is unsure which city from Appendix B: Air Quality Reference Table is closest to their AOI. However, if the user knows which city from the table is closest, the shapefile is not required. The user can skip to step 9 and enter the appropriate "Value/m²/yr" value into Field Calculator.

1. Create a shapefile (*AirQualityReference.shp*) from the Air Quality Reference table as shown in Appendix B: Air Quality Reference Table.
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. Use the *Add Data*  icon to navigate to and add the *AirQualityReference* shapefile as a layer in the Table of Contents.
4. If using a new map document, the AOI shapefile created in the Using ArcGIS section must be added in the same way.

5. Right click on the layer representing the AOI and select *Joins and Relates > Join…* (*Figure 194*).
6. In the *Join Data* window (*Figure 235*).
    a. From the first dropdown list, select *Join data from another layer based on spatial location*.
    b. In the *Choose the layer to join to this layer* dropdown list, select *AirQualityReference.*
    c. Toggle the second join option, to join only the attributes of the nearest point.
    d. In the *Specify output shapefile* text box, enter the desired file path and shapefile name (e.g. *AOI_Join_AQ.shp).*

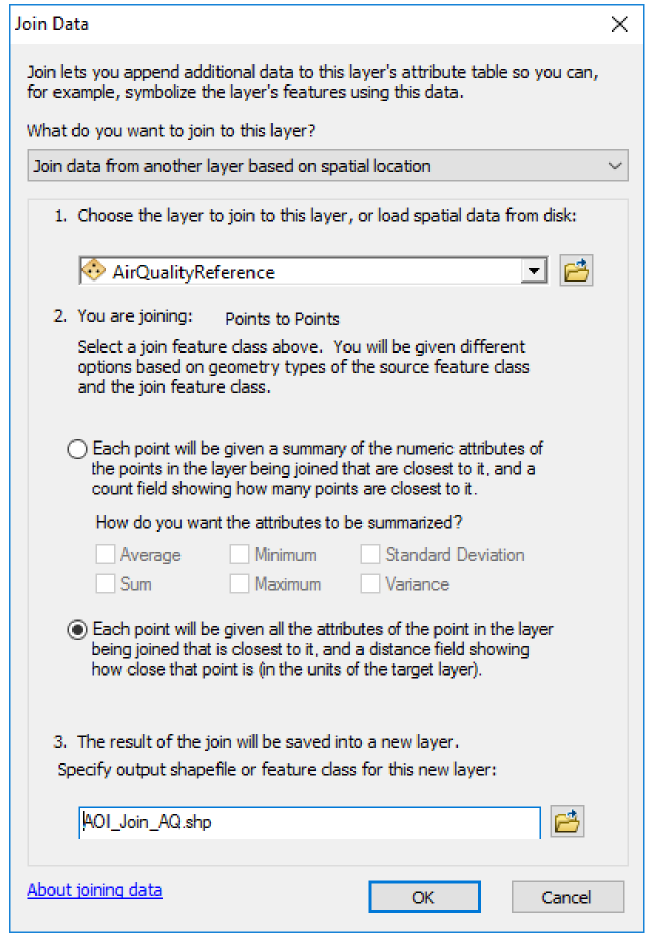


Figure 235 Join Data window filled out as described in the text, with the result nearest join table saved as AOI_Join_AQ.shp

7. In the Table of Contents, right-click on the output layer (e.g. *AOI_Join_AQ*) and open the attribute table.
8. Find the "Value_m2" field in the attribute table and write down or copy the value in this field. The value will be used to populate the "canopyVal" field in the lookup table in step 9.

    Note**:** if the AOI includes multiple features, for example when multiple HUCs or counties are analyzed at once, then the values in the "Value_m2" field may differ across features/rows in the nearest join table, if those features are closer to different cities. It is recommended to choose one value to use throughout. Alternatively, separate lookup tables and land use layers can be created for the different AOI features, each using their own unique "Value_m2" and "canopyVal" fields.
9. In the Table of Contents, right-click on the supplemental lookup table (e.g. *lookUPvars*) and open the attribute table.
    a. Right-click on the "canopyVal" field in the attribute table and open the *Field Calculator*.
    b. In the "canopyVal" *Field Calculator* window:
        i. Enter the value (e.g. 0.0713215) from the "Value_m2" field in the output layer (e.g. *AOI_Join_AQ*).
        ii. Type */ 100* after the coefficient value in the *Expression* box (e.g. *0.0713215 / 100).*
        iii. Click *OK*.

The lookup table "canopyVal" field contains the air pollutant removal value coefficient. This coefficient will be multiplied by the land use average canopy cover to get values for air pollution removal for the "Us_Air_Dol" field in the Field Calculations section.

Using QGIS

This section outlines the calculation of land use air pollution removal rates based on the nearest city, using the Air Quality Reference table as a shapefile in QGIS. This process is suggested if the user is unsure which city from Appendix B: Air Quality Reference Table is closest to their AOI. However, if the user knows which city from the table is closest, the shapefile is not required. The user can skip to step 22 and enter the appropriate “Value/m^2/yr” value into Field Calculator.

1. Create a shapefile (*AirQualityReference.shp*) from the Air Quality Reference table as shown in Appendix B: Air Quality Reference Table.
2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. From the *Layer* menu open the *Add Vector Layer* window (*Main Menu > Layer > Add Vector Layer*, *Figure 126*).
4. In the *Add vector layer* window (example shown in *Figure 127*), click *Browse* to locate and select the *AirQualityReference* shapefile, then click *Open*.
5. If using a new map document, the AOI shapefile created in the Using QGIS section must be added in the same way.
6. From the *Vector* menu open the *Polygon centroids* tool (*Vector > Geometry tools > Polygon centroids*, *Figure 236*).

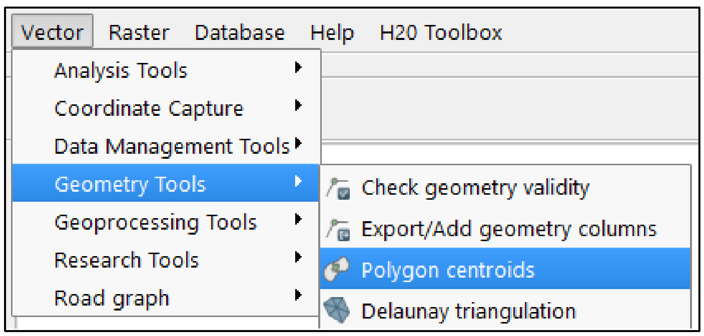


Figure 236 Polygon centroids tool in QGIS, located in Vector menu > Geometry tools

7. In the *Polygon centroids* window (*Figure 238*):
   a. In the *Input polygon vector layer* dropdown list, select the AOI shapefile (e.g. *HUC_Tampa).*
   b. In the *Output point shapefile* text box, indicate the file path and shapefile name (e.g. *HUC_Tampa_points.shp).*
   c. Click *OK.*

The output is a point shapefile, with one point for the center of each watershed polygon (*Figure 237*).

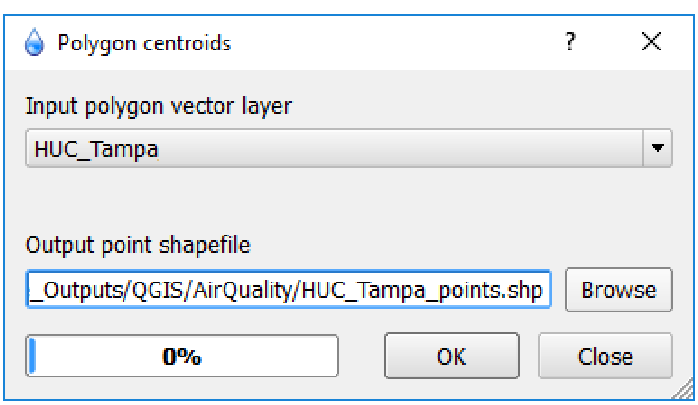


Figure 238 Polygon centroids window, with HUC shapefile as input

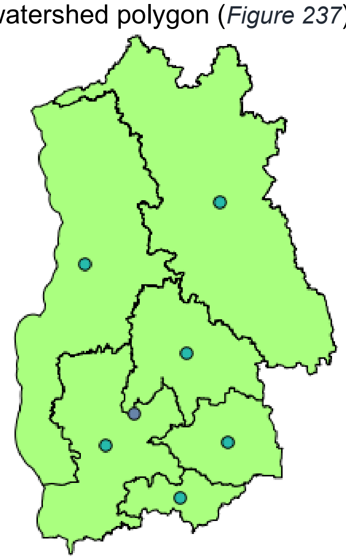


Figure 237 HUC shapefile with centroid points in blue; closest Air Quality Reference City represented by purple point

8. From the *Vector* menu open the *Distance matrix* tool (*Vector* > *Analysis tools* > *Distance matrix*, *Figure 239*).

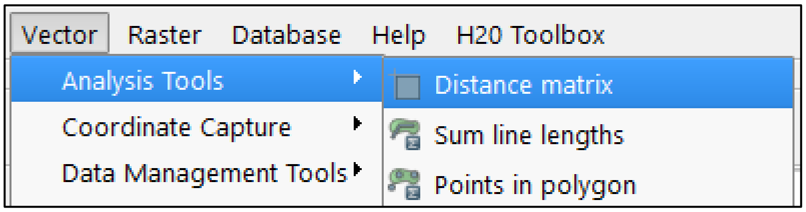


Figure 239 Distance matrix tool in QGIS, located in Vector menu > Analysis tools

9. In the *Distance matrix* window (*Figure 240*):
   a. In the *Input point layer* dropdown list, select the HUC centroid points shapefile (e.g. *HUC_Tampa_points*).
   b. In the *Input unique ID field* dropdown list, choose "NAME".
   c. In the *Target point layer* dropdown list, select the *AirQualityReference* shapefile.
   d. In the *Target unique ID field* dropdown list, select "City".
   e. Under *Output matrix type*, toggle on the *Linear* option if not on by default.
   f. Check *Use only the nearest (k) target points* and enter 1 in the text box.
   g. In the *Output distance matrix* text box, indicate the file path and output name (e.g. *DistanceMatrix_HUC.csv*).
   h. Click *OK*.
10. A popup window may appear, telling the user that the output matrix was created. Click *OK.*
11. Click *Close* to close the *Distance matrix* window.
12. Locate the output matrix in *File Explorer* and click and drag the .csv file into the Layers panel.
13. In the Layers panel, double click on the matrix .csv layer to open *Layer Properties.*
14. In the *Layers Properties* window, click on the *Joins* tab and click the *Add Join*  icon.
15. In the *Add vector join* window (example shown in *Figure 200*):
   a. In the *Join layer* dropdown list, select the *AirQualityReference* shapefile.
   b. In the *Join field* dropdown list, select "City".
   c. In the *Target field* dropdown list, select "TargetID".
   d. Check *Cache join layer in virtual memory.*
   e. Click *OK.*
16. Click *OK* to close *Layer Properties.*
17. In the Layers panel, right click on the matrix .csv layer and choose *Open Attribute Table.*
18. Locate the "Value_m2" field in the attribute table.

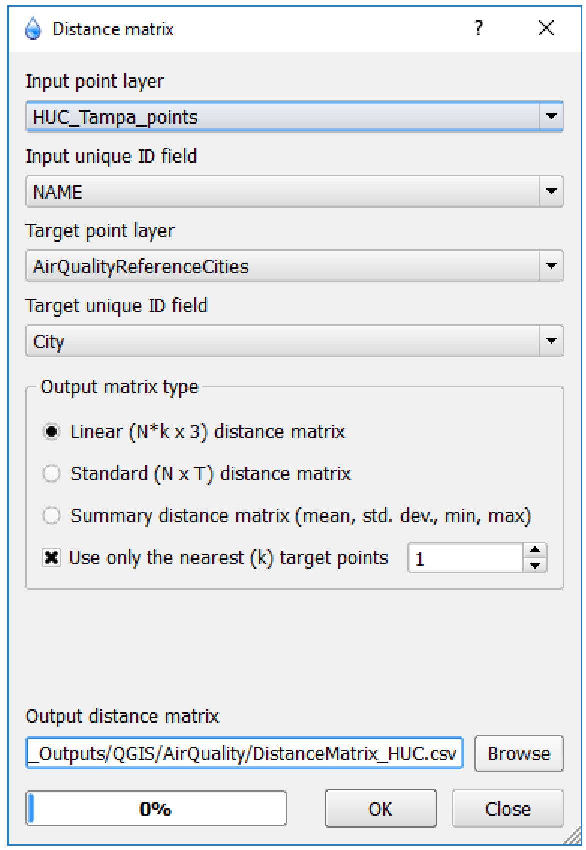
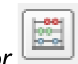


Figure 240 Distance matrix window, with output as a .csv file

a. Take note of the value in this field, as it will need to be typed into the *Field Calculator* in the following steps.

Note: if the AOI includes multiple features, for example when multiple HUCs or counties are analyzed at once, then the values in the "Value_m2" field may differ across features/rows in the nearest join table, if those features are closer to different cities. It is recommended to choose one value to use throughout. Alternatively, separate lookup tables and land use layers can be created for the different AOI features, each using their own unique "Value_m2" and "canopyVal" fields.

19. Load the supplemental lookup table from Appendix A: Supplemental NLCD Lookup Table or the most recently updated lookup table (e.g. if updated in the Tree Canopy section) into the Layers panel.
20. In the Layers panel, double click on the lookup table to open *Layer Properties.*
21. Under the *Fields* tab, click the *Pencil*  icon to start editing.
22. Click the *Field Calculator*  icon, and in the *Field Calculator* window (*Figure 241*):
    a. Check the *Update existing field.*
    b. From the dropdown list, select the "canopyVal" field.
    c. In the *Expression* box, type the value from the "Value_m2" field in step 18 (e.g. 0.0713215).
    d. Type */ 100* after the coefficient value in the *Expression* box (e.g. *0.0713215 / 100).*
    e. Click *OK.*

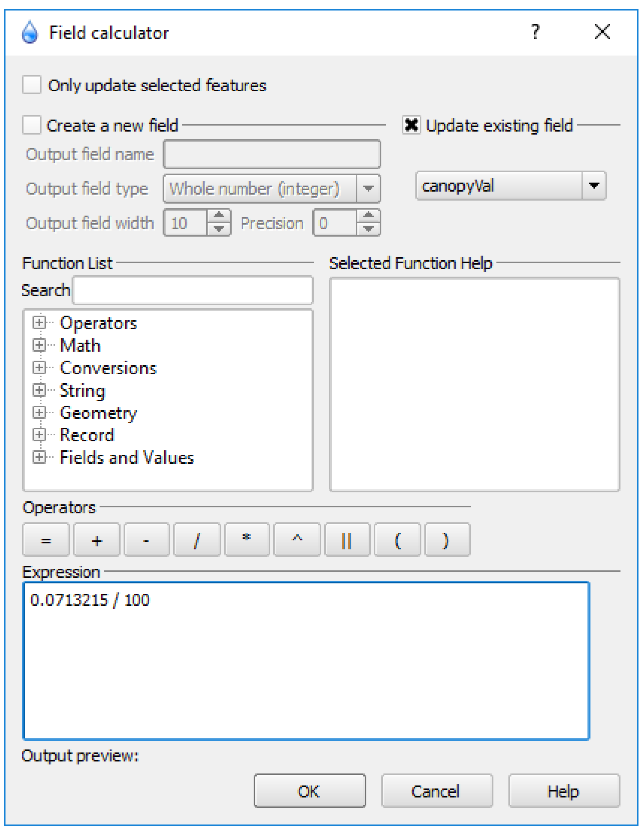


Figure 241 Field Calculator in QGIS, used to update the canopyVal field

23. Click the *Pencil* icon to toggle editing off and save changes made to the attribute table.
24. Click *OK* to close *Layer Properties.*

The lookup table “canopyVal” field now contains the air pollutant removal value coefficient. This coefficient will be multiplied by the land use average canopy cover to get values for air pollution removal for the “Us_Air_Dol” field in the Field Calculations section.

Carbon Sequestration

This section details how the carbon fixation rate was established for each land use type in the Supplemental NLCD Lookup Table (Appendix A) and how rates can be further refined for an area of interest. These rates, found in the “CarbonFixe” field (g C/m2/yr), will be used to calculate the “StableClim” field in the Joining Lookup Table section. Carbon fixation coefficients (g C/m^2/yr) will differ significantly depending on if the carbon is being fixed into biomass or buried. The literature values used to calculate each NLCD carbon burial rate are listed in Appendix A. These rates differ from the FLUCCS carbon fixed into biomass listed in *Table 3* and described in the ES Calculations Theory section.

When updating carbon fixation rates, it is suggested that the user first calculate the percent of each land use type found in the Area of Interest (AOI). This helps identify the land use types where the model will be most sensitive to the “CarbonFixe” rates. It is possible that an AOI will not include some land use types from the classification. When this occurs, the rate will have no impact on results and would not need to be updated. Steps for determining the percent of each land use type in the AOI are illustrated in the Carbon Fixation Rates from Literature Review

The following summarizes the process and criteria used to determine carbon burial rates for all NLCD land use classes that were not “Developed” land use types from reviewed literature.

- An extensive literature review was conducted. The values obtained from these reviews were ranked based on specificity to land use type, location, and reliability of the source.
- After the values were selected, a land use type average was calculated; this average value is the final Carbon Burial Rate for each land use type.
- The available literature varies between land use types, location, units, and sampling duration, as well as the method of carbon storage (sequestered, fixed, or buried). This results in some values being more reliable than others.
- Where no carbon burial rates are available, they may be inferred from similar land use types. This approach was used for the “Mixed Forest” land use type, where values were an average from “Deciduous Forest” and “Evergreen Forest” rates, two land use types with reliable rates in the literature. Likewise, when rates are available but not reliable, it may be helpful to compare the rate against rates for other similar land use types.

Once new carbon burial rates are determined for the user’s AOI, these rates must be updated in the NLCD lookup table using Field Calculator to replace the national averages in the “CarbonFixe” field.

Using ArcGIS or Using QGIS sections.

Carbon fixation rates either come from rates in reviewed literature or are calculated for developed land use classes based on the average characteristics (i.e. percent canopy and impervious surfaces). Steps for calculating carbon fixation rates for developed land use types are illustrated for ArcGIS in the Rates for Developed Classes section or for QGIS in the Rates for Developed Classes section. Determining rates for all other land use types from literature values is detailed in the Carbon Fixation Rates from Literature Review section.

Carbon Fixation Rates from Literature Review

The following summarizes the process and criteria used to determine carbon burial rates for all NLCD land use classes that were not “Developed” land use types from reviewed literature.

- An extensive literature review was conducted. The values obtained from these reviews were ranked based on specificity to land use type, location, and reliability of the source.
- After the values were selected, a land use type average was calculated; this average value is the final Carbon Burial Rate for each land use type.
- The available literature varies between land use types, location, units, and sampling duration, as well as the method of carbon storage (sequestered, fixed, or buried). This results in some values being more reliable than others.
- Where no carbon burial rates are available, they may be inferred from similar land use types. This approach was used for the “Mixed Forest” land use type, where values were an average from “Deciduous Forest” and “Evergreen Forest” rates, two land use types with reliable rates in the literature. Likewise, when rates are available but not reliable, it may be helpful to compare the rate against rates for other similar land use types.

Once new carbon burial rates are determined for the user’s AOI, these rates must be updated in the NLCD lookup table using Field Calculator to replace the national averages in the “CarbonFixe” field.

Using ArcGIS

The following steps summarize how to calculate the percent of each land use type using Esri ArcGIS. If the user does not have a *Spatial Analyst* license, the user may be able to estimate the most prominent land use types from the raster attribute table after clipping the raster to the AOI.

1. Tabulate the area between the NLCD raster and the AOI shapefile. In the *ArcToolbox* window, navigate to the *Tabulate Area* tool (ArcToolbox > *Spatial Analyst Tools* > *Zonal*, *Figure 223*).
2. In the *Tabulate Area* window (example shown in *Figure 224*):
   a. In the *zone data* dropdown list, select the NLCD raster.
   b. In the *class data* dropdown list, select the AOI shapefile (i.e. the HUC boundary shapefile).
3. The output table will list each area in the land use layer units (for NLCD this in meters). Percent of total area is calculated by:
   a. Add the area of each gridcode together to find the total area of the AOI.
   b. Divide each gridcode area by the total area and multiply the value by 100. This will provide the percent land use out of 100%.
4. When listed in descending order, the percent land use table will outline which land use types are most prominent (highest percentage) in the user’s AOI.

It is strongly recommended that the user evaluate the values selected in the literature review, with a focus on the most prominent land use types.

Carbon Fixation Rates for Developed Classes

The following steps summarize how the carbon burial rate is calculated for the NLCD “Developed” land use types (e.g. “Developed, Open Space” through “Developed, High Intensity”) using Esri ArcGIS.

1. Calculate the % Canopy Cover and populate the “Canopy” field, as shown in the Tree Canopy section.
2. Calculate the Canopy based Carbon Burial Rate for each “Developed” land use type:
   a. Copy the “Canopy” value for each “Developed” land use type into a spreadsheet.

b. Determine an average Carbon Burial Rate for trees in developed areas. For NLCD carbon burial rates listed in Appendix A, the average value for “Evergreen Forest” and “Deciduous Forest” (i.e. “Mixed Forest”) was 28.
c. *Canopy Carbon Burial Rate = (% canopy / 100) * 28*

3. Calculate % impervious surface for the user’s specific area of interest, following the same steps outlined in the Tree Canopy section:
    a. Navigate to https://www.mrlc.gov/viewer/ as shown in *Figure 217,* and download the *Impervious* data using the *All Impervious Years* option.
    b. Reproject the NLCD 2011 Impervious .tif dataset (or most recent year), as shown in the Using ArcGIS section.
    c. Run the *Tabulate Area* tool between the soil/land use layer and the re-projected impervious layer.
        i. In the *Input raster zone data* dropdown list, select the soil/land use layer (e.g. *NLCD_MaxTypeN_join*) and in the *Zone field* dropdown list, select “gridcode”.
        ii. In the *Input raster class data* dropdown list, select the re-projected impervious layer, and in the *Class field* dropdown list, select “Value”.
        iii. In the *Output table* text box, name the output table (e.g. *Imp_TabArea*) and file path.
        iv. Click *OK.*
    d. In the output *Tabulate Area* table (e.g. *Imp_TabArea*) add a new field (e.g. “avgImp”) with type *Short Integer*.
    e. Right-click on the new field (e.g. “avgImp”) and open *Field Calculator.*
        i. In the *Expression* box, paste the same equation used to calculate the % canopy in step 13 of the Tree Canopy (Using ArcGIS) section (example shown in *Figure 225*) to calculate % impervious surface.
4. Calculate the Lawn Carbon Burial Rate for each “Developed” land use type:
    a. Copy the “Impervious” (e.g. “Imp” field) value for each “Developed” land use type into a spreadsheet.
    b. Determine an average Carbon Burial Rate for lawns in developed areas. For NLCD carbon burial rates listed in Appendix A the average lawn rate from the literature review was 100 (*Table 4*).
    c. *Lawn Carbon Burial Rate = 100 * ((100 - % impervious) / 100)*
5. The final Carbon Burial Rate for the “Developed” land use types are calculated as:
   Final Carbon Burial Rate = Lawn Carbon Burial Rate + Canopy Carbon Burial Rate.
6. In the lookup table use *Field Calculator* to update the “CarbonFixe” field value for each “Developed” land use type to equal the new corresponding *Final Carbon Burial Rate*.

The lookup table “CarbonFixe” field now contains the updated carbon burial rates, which will be used to calculate the “StableClim” field in the Field Calculations section. The database creation is continued in the Denitrification section.

Using QGIS

The following steps summarize how to calculate the percent of each land use type using QGIS. If the user saved the *Sum* of the “Area” field for each gridcode in a separate spreadsheet (Using QGIS section), skip to step 5.

1. From the soil/land use attribute table, open the *Advanced search* tool (as shown in *Figure 212*).
2. Select all polygons representing the first land use type. In the *Search query builder* window:
    a. In the *Expression* box, enter *gridcode =*

   b. Under the *Values* option, click the *All* button; the list of all gridcode values will appear. Double click on the first gridcode value (e.g. 11).
3. With the selection highlighted, open the *Basic Statistics* tool (*Main Menu >Vector > Analysis Tools > Basic statistics*).
   a. In the *Input Vector Layer* dropdown list select the soil/land use layer.
   b. Check *Use only selected features*.
   c. In the *Target field* dropdown list select "Area".
4. Copy down the *Sum* value for the first gridcode into a spreadsheet. Repeat the selection and *Basic Statistics* analysis to obtain the total area for each gridcode type.
5. Add the area of each gridcode together to find the total area of the AOI.
6. Divide each gridcode area by the total area and multiply the value by 100. This will provide the percent land use out of 100%.
7. When the percent land use is listed in descending order in the spreadsheet, the land use types at the top are most prominent (highest percentage) in the user's AOI.

It is strongly recommended that the user evaluate the values selected in the literature review, with a focus on the most prominent land use types.

Carbon Fixation Rates for Developed Classes

The following steps summarize how the carbon burial rate was calculated for the NLCD "Developed" land use types (e.g. "Developed, Open Space" through "Developed, High Intensity") using QGIS.

1. Calculate the % Canopy Cover and populate the "Canopy" field, as shown in the Tree Canopy section.
2. Calculate the Canopy Carbon Burial Rate for each "Developed" land use type:
   a. Copy the "Canopy" value for each "Developed" land use type into a spreadsheet.
   b. Determine an average Carbon Burial Rate for trees in developed areas. For NLCD carbon burial rates listed in Appendix A, the average value for "Evergreen Forest" and "Deciduous Forest" (i.e. "Mixed Forest") was 28.
   c. *Canopy Carbon Burial Rate = (% canopy / 100) * 28*
3. Calculate % impervious surface for the user's specific area of interest, following the same steps outlined in the Tree Canopy section:
   a. Navigate to https://www.mrlc.gov/viewer/ as shown in *Figure 217*, and download the *Impervious* data using the *All Impervious Years* option.
   b. Reproject the NLCD 2011 Impervious .tif dataset (or most recent year), as shown in the Using QGIS section.
   c. Run the *Zonal Statistics* tool between re-projected impervious layer and the soil/land use layer with a new output column prefix (e.g. *IMP)*.
      i. In the *Raster layer* dropdown list, select the re-projected impervious layer.
      ii. In the *Polygon layer containing the zones* dropdown list, select the soil/land use layer.
      iii. In the *Output column prefix* text box, enter *IMP,* then click *OK.*
   d. In the soil/land use layer, create a new field (e.g. "avgImp") with *Whole number (integer)* type. Then use *Field Calculator* to populate the new field using the expression *"Area" * "IMPmean".*
   e. Follow the steps outlined in the Using QGIS section to select each "Developed" gridcode value and use the *Basic Statistics* tool to find the *Sum* values for the newly created field and the "Area" field.
      i. Open the attribute table and use the *Search query builder* to select the first "Developed" gridcode (e.g. *gridcode = 21*).
      ii. Open the *Basic Statistics* tool and select the following inputs: in the *Input Vector Layer* dropdown list, select the soil/land use layer, check *Use only selected features,* and in the *Target field* dropdown list, choose "avgImp". Click *OK.*

iii. Copy down the *Sum* value for the “avgImp” field, then change the *Target field* to “Area” and click *OK* to run another statistical output. Copy down the *Sum* value for the “Area” field.
iv. Repeat step e for each “Developed” gridcode”.

f. In the spreadsheet, complete the following calculation to determine the % impervious surface for each “Developed” gridcode value: *“newest_field” sum / “Area” sum*

4. Calculate the Lawn Carbon Burial Rate for each “Developed” land use type:
   a. Each “Developed” land use type will have a % impervious in the spreadsheet calculated in the previous step.
   b. Determine an average Carbon Burial Rate for lawns in developed areas. For NLCD carbon burial rates listed in Appendix A the average lawn rate from the literature review was 100 (*Table 4*).
   c. *Total Carbon Burial Rate = 100 * ((100 - % impervious) / 100)*
5. The final Carbon Burial Rate for the “Developed” land use types are calculated as: *Final Carbon Burial Rate = Lawn Carbon Burial Rate + Canopy Carbon Burial Rate.*
6. In the lookup table use *Field Calculator* to update the “CarbonFixe” field value for each “Developed” land use type to equal the new corresponding *Final Carbon Burial Rate*.

The lookup table “CarbonFixe” field now contains the updated carbon burial rates, which will be used to calculate the “StableClim” field in the Field Calculations section. The database creation is continued in the Denitrification section.

Denitrification

This section details how the Denitrification rate was established for each land use type in the Supplemental NLCD Lookup Table (Appendix A) and how rates can be further refined for an area of interest. These rates, found in the “denitrific” field (g N/m2/yr), will be used to calculate the “usablewat” field in the Joining Lookup Table section.

Average nitrogen removal values have been provided for each NLCD land use type, based on an extensive literature review (Appendix A). These values may differ from the FLUCCS denitrification values listed in *Table 3* and described in the ES Calculations Theory section.

When updating denitrification rates, it is suggested that the user first calculate the percent of each land use type found in the user’s Area of Interest (AOI). This helps identify the land use types where the model will be most sensitive to the “denitrific” rates. It is possible that an AOI will not include some land use types from the classification. When this occurs, the rate will have no impact on results and would not need to be updated. Steps for determining the percent of each land use type in the AOI are illustrated in the Carbon SequestrationCarbon Fixation Rates from Literature Review

The following summarizes the process and criteria used to determine carbon burial rates for all NLCD land use classes that were not “Developed” land use types from reviewed literature.

An extensive literature review was conducted. The values obtained from these reviews were ranked based on specificity to land use type, location, and reliability of the source.
After the values were selected, a land use type average was calculated; this average value is the final Carbon Burial Rate for each land use type.
The available literature varies between land use types, location, units, and sampling duration, as well as the method of carbon storage (sequestered, fixed, or buried). This results in some values being more reliable than others.
Where no carbon burial rates are available, they may be inferred from similar land use types. This approach was used for the “Mixed Forest” land use type, where values were an average from

“Deciduous Forest” and “Evergreen Forest” rates, two land use types with reliable rates in the literature. Likewise, when rates are available but not reliable, it may be helpful to compare the rate against rates for other similar land use types.

Once new carbon burial rates are determined for the user’s AOI, these rates must be updated in the NLCD lookup table using Field Calculator to replace the national averages in the “CarbonFixe” field.

Using ArcGIS or Using QGIS sections.

Denitrification rates either come from rates in reviewed literature or are calculated for developed land use classes based on the average characteristics (i.e. percent canopy and impervious surfaces). The Determine Nitrogen Removal Rates section describes how to update rates using both these methods. The steps for calculating denitrification rates are very similar to those illustrated for ArcGIS in the Carbon Fixation Rates for Developed Classes section or for QGIS in the Carbon Fixation Rates for Developed Classes section.

Nitrogen Removal Rates from Literature Review

The following summarizes the process and criteria used to determine nitrogen removal rates for all NLCD land use classes that were not “Developed” land use types from reviewed literature.

- An extensive literature review was conducted. The values obtained from these reviews were ranked based on specificity to land use type, location, and reliability of the source.
- After the values were selected, a land use type average was calculated; this average value is the final Nitrogen Removal Rate for each land use type.
- The available literature varies between land use types, location, units, and sampling duration. This results in some values being more reliable than others.
- Where no nitrogen removal rates are available they may be inferred from similar land use types. This approach was used for the “Mixed Forest” land use type, where values were an average from “Deciduous Forest” and “Evergreen Forest” rates, two land use types with reliable rates in the literature. Likewise, when rates are available but not reliable, it may be helpful to compare the rate against rates for other similar land use types.

Once new denitrification rates are determined for the user’s AOI, these rates must be updated in the NLCD lookup table using Field Calculator to replace the national averages in the “denitrific” field.

Determine Nitrogen Removal Rates

The following steps summarize how the nitrogen removal rate was calculated for the NLCD “Developed” land use types (e.g. “Developed, Open Space” through “Developed, High Intensity”).

Calculate % impervious surface for the user’s specific area of interest, as illustrated in the Carbon Sequestration Carbon Fixation Rates from Literature Review

The following summarizes the process and criteria used to determine carbon burial rates for all NLCD land use classes that were not “Developed” land use types from reviewed literature.

- An extensive literature review was conducted. The values obtained from these reviews were ranked based on specificity to land use type, location, and reliability of the source.
- After the values were selected, a land use type average was calculated; this average value is the final Carbon Burial Rate for each land use type.

- The available literature varies between land use types, location, units, and sampling duration, as well as the method of carbon storage (sequestered, fixed, or buried). This results in some values being more reliable than others.
- Where no carbon burial rates are available, they may be inferred from similar land use types. This approach was used for the “Mixed Forest” land use type, where values were an average from “Deciduous Forest” and “Evergreen Forest” rates, two land use types with reliable rates in the literature. Likewise, when rates are available but not reliable, it may be helpful to compare the rate against rates for other similar land use types.

Once new carbon burial rates are determined for the user’s AOI, these rates must be updated in the NLCD lookup table using Field Calculator to replace the national averages in the “CarbonFixe” field.

Using ArcGIS or Using QGIS sections.

1. Calculate the final Nitrogen Removal Rate for each “Developed” land use type:
    a. Use the “Impervious” (e.g. “avgImp” field) value for each “Developed” land use type.
    b. Determine an average Nitrogen Removal Rate for lawns in developed areas. For NLCD denitrification rates listed in Appendix A: Supplemental NLCD Lookup Table the average rate from the literature review was 1.4 N/m2/yr (Raciti et al. 2011).
    c. *Final Nitrogen Removal Rate = ((100 - % impervious) / 100) * 1.4*
2. In the lookup table, use *Field Calculator* (in ArcGIS or QGIS) to update the “denitrific” field value for each “Developed” land use type to equal the new corresponding *Final Nitrogen Removal Rate*.
3. In the lookup table, use *Field Calculator* to also update the “dni” field to match the values in the “denitrific” field.

The lookup table “denitrific” field now contains the updated nitrogen removal rates, which will be used to calculate the “usablewat” field in the Field Calculations section. The “dni” field is not directly used during field calculations; however, this field is used to recalculate the “usablewat” field in the H2O tool and must match the “denitrific” field values exactly. The database creation is continued in the Joining Lookup Table section.

Joining Lookup Table

This section illustrates the joining of the Supplemental NLCD lookup table with the land use layer using ArcGIS or QGIS. The lookup table contains the parameter values for each land use type that are required to compute Ecosystem Service values. After the join, field calculations are required to update these parameter values.

The NLCD lookup table must be joined to the land use layer as part of database creation even if ES Coefficients were not updated in the Update ES Coefficients section. If the NLCD lookup table ES Coefficients were updated the updated lookup table should be joined, not the original found in Appendix A: Supplemental NLCD Lookup Table. If FLUCCS data were used in the Create Land Use Data Layer section instead of NLCD the corresponding lookup table from Appendix D: Extracting and Updating the Original FLUCCS Lookup Table may be joined by the “FLUCCS” field instead of the “GRIDCODE” field.

Using ArcGIS

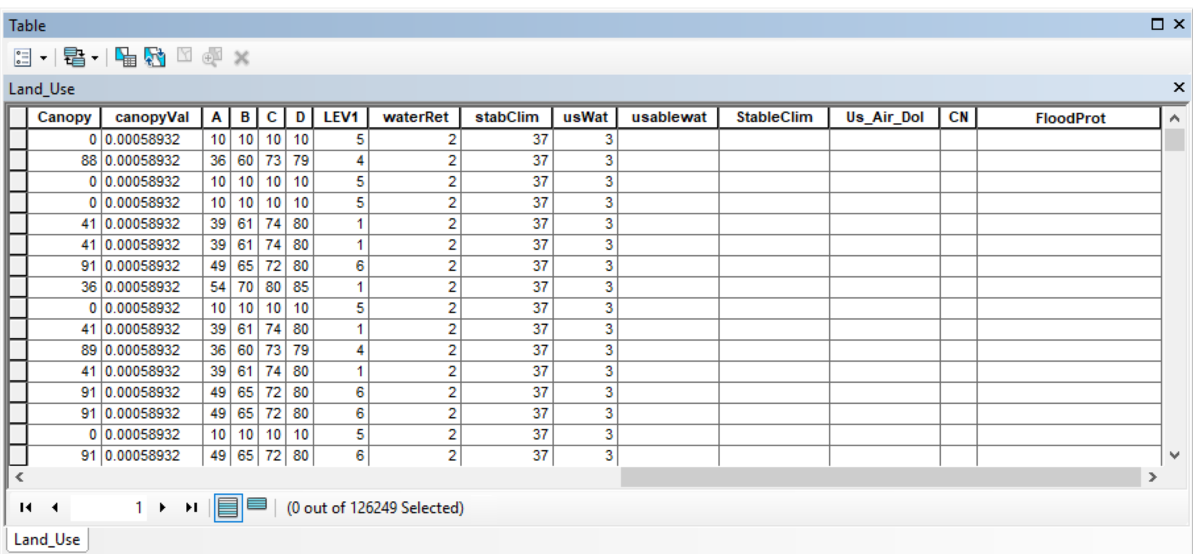
This section illustrates how to join the lookup table and complete field calculations using Esri ArcGIS.

1. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.

2. If using a new map document, use the *Add Data*  icon to navigate to and add both the soil/land use layer created in the Spatially Join Soils to Land Use section and the lookup table updated in the Update ES Coefficients section or from Appendix A: Supplemental NLCD Lookup Table.
3. Right-click on the soil/land use layer (e.g. *NLCD_MaxTypeN_join)* and open the *Join* tool (as shown in *Figure 183*).
4. In the *Join Data* window (example shown in *Figure 184*):
    a. In the first dropdown list, select the *Join attributes from a table* option.
    b. In the *field in this layer that the join will be based on* dropdown list, select "gridcode".
    c. In the *table to join to this layer* dropdown list, select the lookup table (i.e. *lookUPvars*).
    d. In the *field in the table to base the join on* dropdown list, select "GRIDCODE".
    e. Under *Join Options,* toggle the *Keep all records* on.
    f. Click *OK*.
5. Right-click on the land use layer and open the *Export Data* tool (*Figure 123*).
6. In the *Export Data* window (example shown in *Figure 124)*:
    a. In the *Export* dropdown list, select *All features*.
    b. Under the *Use the same coordinate system as* section, toggle *the data frame* option on.
    c. In the *Output feature class* text box, specify the file path and name the output *Land_Use.shp.*
    d. Click *OK.*

Field Calculations

This section illustrates how to update the blank fields joined from the lookup table (*Figure 242*). In the expressions, "denitrific" is the denitrification rate (g N/M2/yr), "CarbonFixe" is the carbon sequestration rate (g C/m2/yr), "Canopy" is percent canopy cover (%), and "CN" is Curve Number.



Canopy	canopyVal	A	B	C	D	LEV1	waterRet	stabClim	usWat	usablewat	StableClim	Us_Air_Dol	CN	FloodProt
0	0.00058932	10	10	10	10	5	2	37	3					
88	0.00058932	36	60	73	79	4	2	37	3					
0	0.00058932	10	10	10	10	5	2	37	3					
0	0.00058932	10	10	10	10	5	2	37	3					
41	0.00058932	39	61	74	80	1	2	37	3					
41	0.00058932	39	61	74	80	1	2	37	3					
91	0.00058932	49	65	72	80	6	2	37	3					
36	0.00058932	54	70	80	85	1	2	37	3					
0	0.00058932	10	10	10	10	5	2	37	3					
41	0.00058932	39	61	74	80	1	2	37	3					
89	0.00058932	36	60	73	79	4	2	37	3					
41	0.00058932	39	61	74	80	1	2	37	3					
91	0.00058932	49	65	72	80	6	2	37	3					
91	0.00058932	49	65	72	80	6	2	37	3					
0	0.00058932	10	10	10	10	5	2	37	3					
91	0.00058932	49	65	72	80	6	2	37	3					

Figure 242 Land_Use attribute table, with blank fields from lookup table join

The following steps detail how to update the "usablewat" field. Similar steps need to be followed to update the "StableClim", "Us_Air_Dol", "CN" and "FloodProt" fields.

1. Right-click on the *Land_Use* layer and open the attribute table.
2. Right-click on the "usablewat" field and choose *Field Calculator.*
3. In the *Field Calculator* window (*Figure 243*)*:*
    a. In the *Fields* list box, locate "denitrific" and double click on the field name; [denitrific] will appear in the *Expression* box.

b. In the *Expression* box, type * .018 after the field name; the full expression is *[denitrific] * .018*.

c. Click *OK*.

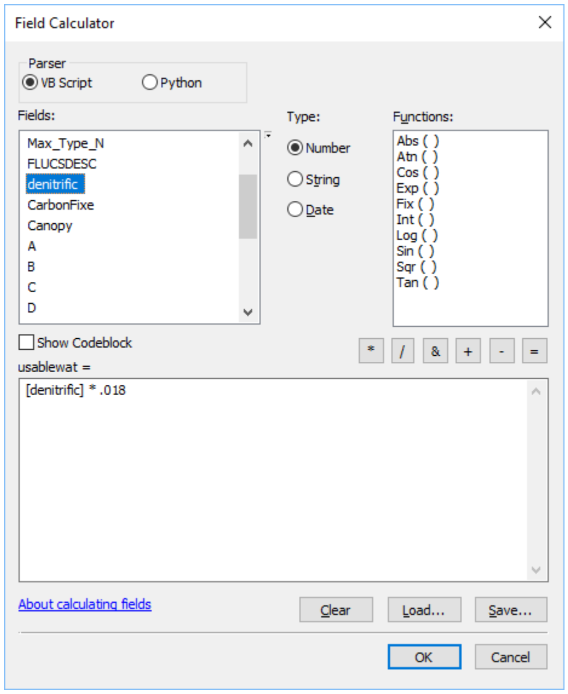


*Figure 243 Field Calculator window, with [denitrific] * .018 as the expression*

For each field name listed in *Table 9*, repeat steps 2 and 3 to populate each field based on the corresponding Field Calculator expression.

Table 9 Field Calculator expressions for each blank field in the Land_Use attribute table

Field Name	Field Calculator Expression
usablewat	[denitrific] * .018
StableClim	1.3542e-4 * [CarbonFixe]
Us_Air_Dol	[canopyVal] * [Canopy]
CN	See Calculation Explanation Below
FloodProt	(0.05 * (25400.00 / [CN] - 254.00)) / 1000.00 * 70.629265

The following steps detail how to calculate Curve Number (CN). Please note that the "CN" field must be calculated prior to calculating "FloodProt" field values.

4. From the main menu, choose *Selection* > *Select By Attributes* (*Figure 244*).

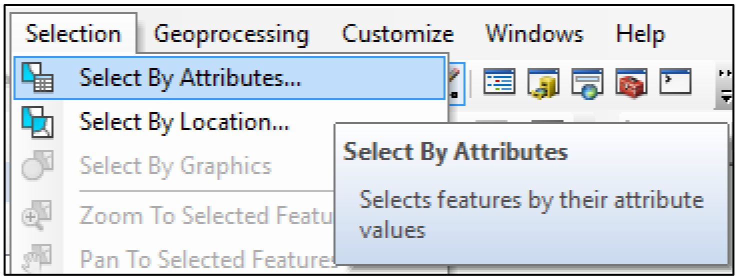


Figure 244 Select By Attributes tool, located under the Selection menu in ArcMap

5. In the *Select By Attributes* window (*Figure 245*):
   a. In the *Layer* dropdown list, select *Land_Use.*
   b. In the *Expression* box, type the following expression: *"Max_Type_N" =1*
   d. Click *OK.*

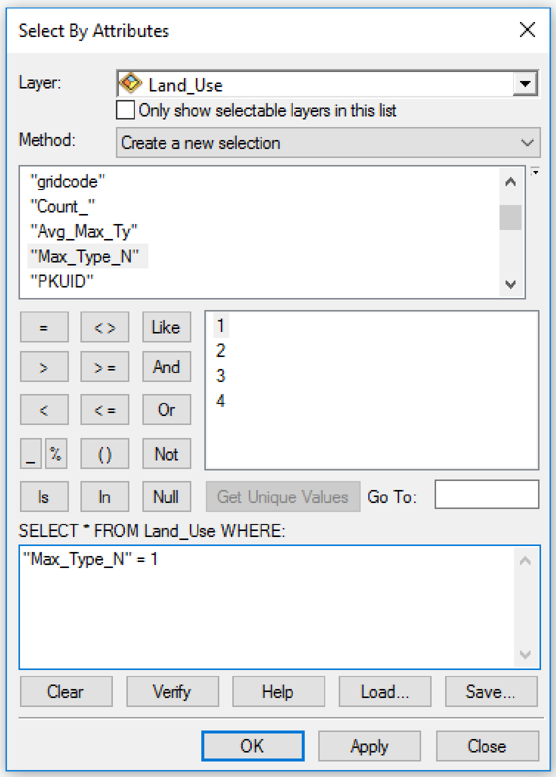


Figure 245 Select By Attributes window, with Max_Type_N = 1 entered as the expression

6. Right-click on the *Land_Use* layer in the Table of Contents and open the attribute table.
7. Right click on the "CN" field and choose *Field Calculator.*
8. In the *Field Calculator* window (example shown in *Figure 243*):
   a. In the *Fields* list box, double click on the "A" field. The expression *[A]* should appear in the box below.
   b. Click *OK.*
9. Repeat steps 4-8 to select records with "Max_Type_N" field values of 2, 3, and 4, and to assign corresponding "CN" field values of B, C, and D (1=A, 2=B, 3=C, 4=D) using the *Field Calculator*.

Regardless of the land use data used, field headers from the original Tampa database must be present in the land use layer and lookup table. If using NLCD instead of FLUCCS, it is still necessary to include a field titled "FLUCSDESC” and “FLUCCS” for EPA H2O to function properly. In the supplemental lookup table in Appendix A: Supplemental NLCD Lookup Table, “FLUCSDESC” should already be set equal to “NLCDDesc”. If other land use data were used, the user must populate the “FLUCSDESC” field with the appropriate descriptions. Both the land use layer and the lookup table must be updated.

The Importing Layers into QGIS section details how to upload the land use layer into the user database in QGIS. Although the NLCD data detailed in the Download Land Use Data section is from 2011, the naming scheme in Qspatialite must match the original Tampa Bay database (i.e. *Land_Use_2006*). Database creation is continued in the Create NHDPlus V2 Data Layers section.

Using QGIS

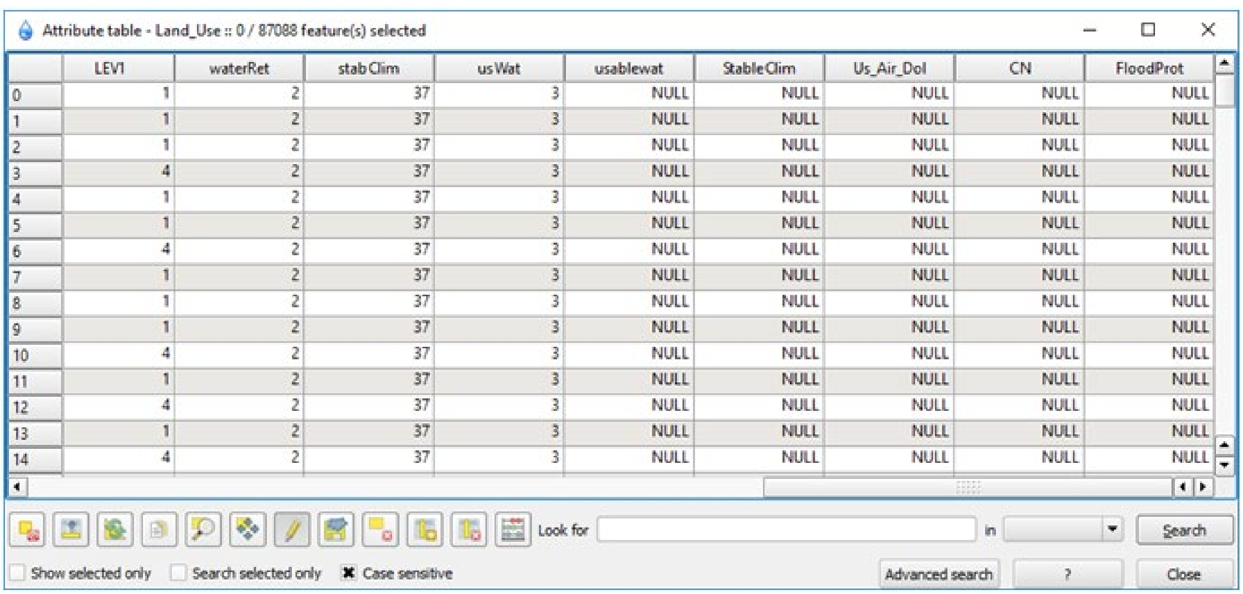
This section illustrates how to join the lookup table and complete field calculations using QGIS.

1. Locate the soil/land use layer (e.g. *NLCD_MaxTypeN_join*) created in the Spatially Join Soils to Land Use section and locate the lookup table updated in the

2. Update ES Coefficients section or from Appendix A: Supplemental NLCD Lookup Table.
3. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
4. If using a new map document, use the *Add Vector Layer* window (*Main Menu* > *Layer* > *Add Vector Layer*) to add the soil/land use layer and lookup table.
5. In the Layers panel, double click on the land use layer to open the *Properties* menu.
6. In the *Properties* window, click on the *Joins* tab, then click the *Add join* icon.
7. In the *Add vector join* window (example shown in *Figure 200*):
   a. In the *Join layer* dropdown list select the lookup table.
   b. In the *Join field* dropdown list select "gridcode".
   c. In the *Target field* dropdown list, select "Gridcode".
   d. Check *Cache join layer in virtual memory.*
   e. Click *OK.*
8. In the Layers panel, right-click on the land use layer and select the *Save as* option (*Figure 132*).
9. In the *Save vector layer as...* window (example shown in *Figure 133*):
   a. In the *Format* dropdown list, select *ESRI Shapefile.*
   b. In the *Save as* text box, indicate the file path, and name the output *Land_Use.*
   c. From the *CRS* dropdown list, select *Selected CRS,* and click the *Browse* button.
   d. In the *Filter* box, type *3857*, choose *WGS 84/ Pseudo Mercator* and click *OK.*
   e. Check *Add saved file to map.* Do not check *Skip attribute creation.*
   f. Click *OK.*

Field Calculations

This section illustrates how to update the *NULL* fields joined from the supplemental lookup table (*Figure 246*). In the expressions, "denitrific" is the denitrification rate (g N/M2/yr), "CarbonFixe" is the carbon sequestration into biomass rate (g C/m2/yr), "Canopy" is percent canopy cover (%), and "CN" is Curve Number.



	LEV1	waterRet	stabClim	usWat	usablewat	StableClim	Us_Air_Dol	CN	FloodProt
0	1	2	37	3	NULL	NULL	NULL	NULL	NULL
1	1	2	37	3	NULL	NULL	NULL	NULL	NULL
2	1	2	37	3	NULL	NULL	NULL	NULL	NULL
3	4	2	37	3	NULL	NULL	NULL	NULL	NULL
4	1	2	37	3	NULL	NULL	NULL	NULL	NULL
5	1	2	37	3	NULL	NULL	NULL	NULL	NULL
6	4	2	37	3	NULL	NULL	NULL	NULL	NULL
7	1	2	37	3	NULL	NULL	NULL	NULL	NULL
8	1	2	37	3	NULL	NULL	NULL	NULL	NULL
9	1	2	37	3	NULL	NULL	NULL	NULL	NULL
10	4	2	37	3	NULL	NULL	NULL	NULL	NULL
11	1	2	37	3	NULL	NULL	NULL	NULL	NULL
12	4	2	37	3	NULL	NULL	NULL	NULL	NULL
13	1	2	37	3	NULL	NULL	NULL	NULL	NULL
14	4	2	37	3	NULL	NULL	NULL	NULL	NULL

Figure 246 Land_Use attribute table, with NULL fields from lookup table join

The fields with *NULL* values (i.e. "usablewat", "StableClim", "Us_Air_Dol", "CN" and "FloodProt") were added by joining to the lookup table. Values for these fields will be calculated using *Field Calculator*.

The following steps show the procedure to calculate the land use layer “usablewat” field. Similar steps need to be followed to update the rest of the fields as well.

1. In the Layers panel, double click on the *Land_Use* layer to open *Layer Properties*.
2. From the *Fields* tab, click the *pencil* icon to enable *Editing* mode. Click the *Field Calculator* icon to open the *Field Calculator* window.
3. In the *Field Calculator* window (*Figure 247*):
   a. Check *Update existing field*
   b. From the dropdown list, select “usablewat”.
   c. Under the *Function List* heading, locate the *Fields and Values* list box, and double click on the “denitrific” field. “denitrific” will appear in the *Expression* box.
   d. Type ** .018* in the *Expression* box after “denitrific”. The full expression is *“denitrific” * .018*.
   e. Click OK.

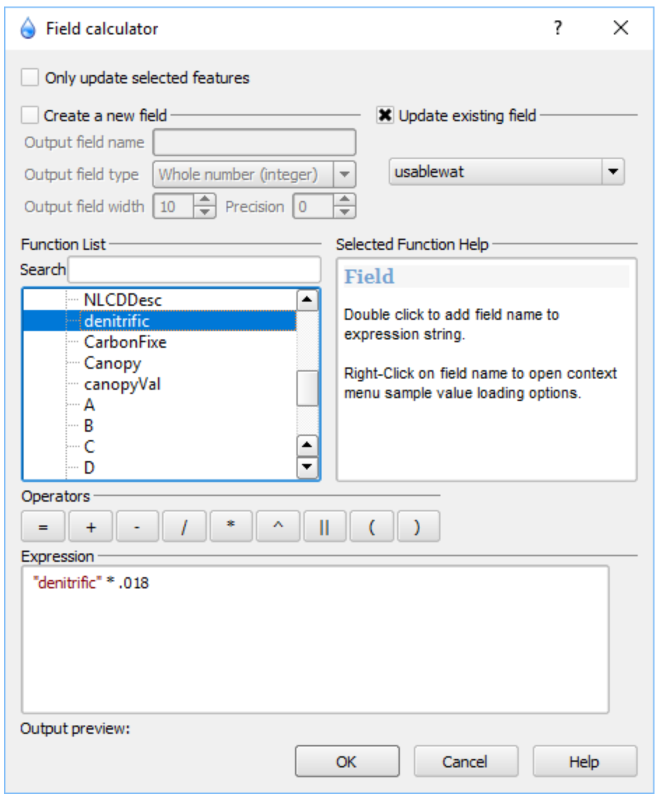


*Figure 247 Field Calculator window, with “denitrific” * .018 entered as the expression*

4. Use *Field Calculator* to populate the other *NULL* fields. The expressions used in step 3.d. will be different for each field, as shown in *Table 10*.

Table 10 Expression for the calculation of each field

Field Name	Expression
usablewat	"denitrific" * .018
StableClim	1.3542e-4 * "CarbonFixe"
Us_Air_Dol	“canopyVal” * "Canopy"

CN	See Calculation Explanation Below
FloodProt	(0.05 * (25400.00 / "CN" - 254.00)) / 1000.00 * 70.629265
waterRet	2
stabClim	37
usWat	3

The following steps detail how to calculate Curve Number (CN). Please note that the "CN" field must be calculated prior to calculating "FloodProt" field values.

5. In the Layers panel, right-click the *Land_Use* layer, open the attribute table, and locate the *Look for* search option at the bottom of the table (*Figure 248*).
6. In the search box, type *1*, and from the *in* dropdown list select the field created in the Spatially Join Soils to Land Use section (e.g. "Max_Type_N").

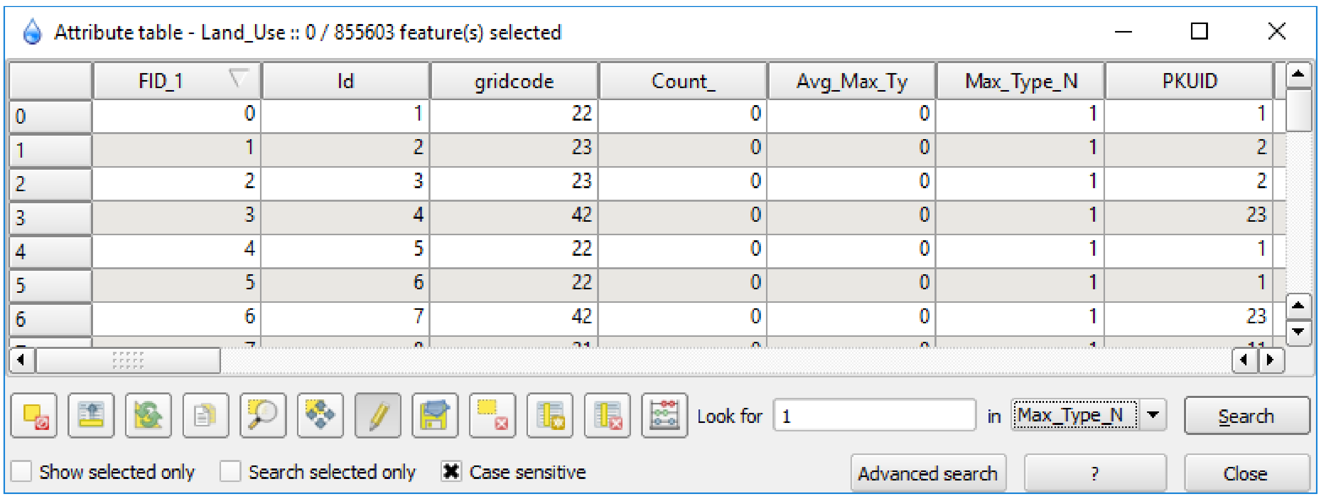


Figure 248 Land_Use attribute table, searching for value 1 in Max_Type_N field

7. Click *Search* to select all attributes that have a value of 1 in the "Max_Type_N" field.
8. Click the *Field Calculator*  icon in the attribute table.
9. In the *Field Calculator* window (example shown in *Figure 247*):
   a. Check the *Only update selected features* option.
   b. Check the *Update existing field* option.
   c. In the dropdown list, select "CN".
   d. In the *Fields and Values* list box*,* double click on the "A" field. "A" should appear in the *Expression* box.
   e. Click *OK.*
10. Repeat steps 5-9 to select records with *Max_Type_N* field values of 2, 3, and 4 and assign the corresponding values B, C, and D using the *Field Calculator* (1=A, 2=B, 3=C, 4=D).

Regardless of the land use data used, field headers from the original Tampa database must be present in the land use layer. If using NLCD instead of FLUCCS, it is still necessary to include a field titled "FLUCSDESC" and "FLUCCS" for EPA H2O to function properly. In the supplemental lookup table in Appendix A: Supplemental NLCD Lookup Table, "FLUCSDESC" should already be set equal to "NLCDDesc".

The Importing Layers into QGIS section details how to upload the land use layer into the user database in QGIS. Although the NLCD data detailed in the Download Land Use Data section is from

2011, the naming scheme in Qspatialite must match the original Tampa Bay database (i.e. *Land_Use_2006*). Database creation is continued in the Create NHDPlus V2 Data Layers section.

Create NHDPlus V2 Data Layers

The National Hydrography Dataset (NHD) defines the flowlines, catchments and waterbodies necessary for EPA H2O functionality. The NHD data is used to determine the upstream areas of interest in the EPA H2O report. This section illustrates the step-by-step method used to obtain and prepare the NHD data.

Either Esri ArcMap software or QGIS can be used to prepare the NHD data. The procedure for both software applications is explained in this section.

Download NHDPlus Data

This section illustrates the step-by-step procedure for downloading NHD data by region from the NHDPlus Version 2 website.

1. Navigate to https://nhdplus.com/NHDPlus/NHDPlusV2_data.php, as shown in *Figure 249*.

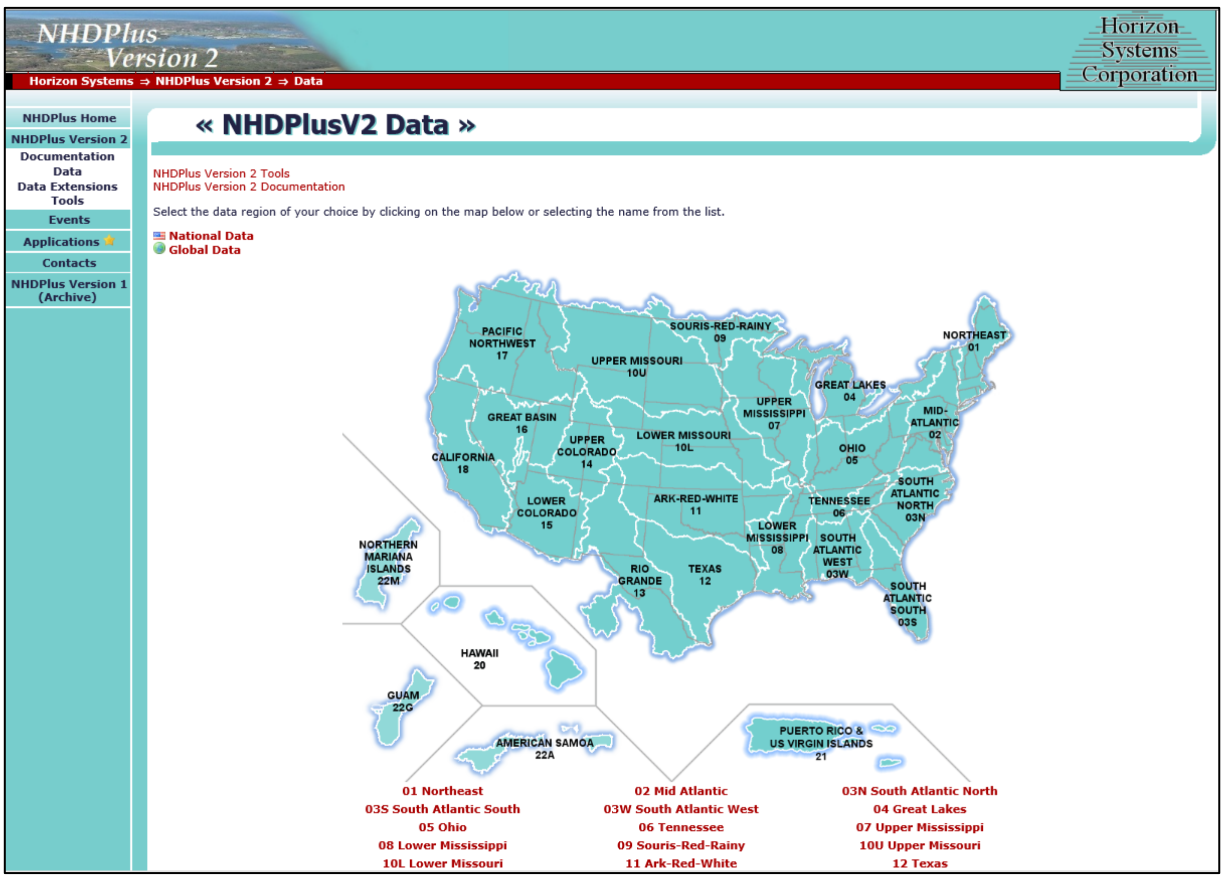


Figure 249 NHDPlus Version 2 website, published by Horizon Systems Corporation

2. On the interactive map, click on the region where the user's area of interest is located (e.g. *South Atlantic South (03S)*).
   Note: NHDPlus hydrological regions are similar to 2-digit HUC regions (*Figure 118*).

3. In the next page, scroll down to locate the *File Name* download table for the selected region.
4. From the *File Name* table, find the following files and download each by clicking on the *HTTP* button (Figure 250):
   a. *NHDPlusV21_SA_03S_NHDPlusAttributes_06.7z*
   b. *NHDPlusV21_SA_03S_NHDPlusBurnComponents_02.7z*
   c. *NHDPlusV21_SA_03S_NHDPlusCatchment_01.7z*
   d. *NHDPlusV21_SA_03S_NHDSnapshot_06.7z*

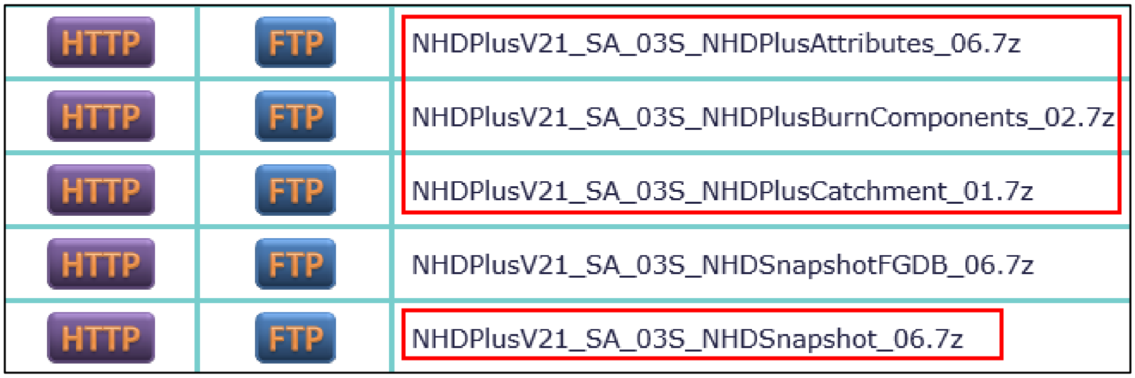


Figure 250 South Atlantic South File Names, with HTTP or FTP download available

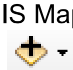
Please note: the number at the end of the file name is the version number and changes as it is updated. The “SA” and “03S” in the file name are specific to the South Atlantic region and South subregion, respectively; these abbreviations will change based on the user’s AOI location.

5. Save the zip file to the computer and unzip the contents to a known location.

The next section illustrates the creation of EPA H2O compatible NHD data from the unzipped download files, using either Esri ArcGIS software (Using ArcGIS) or QGIS (Using QGIS).

Using ArcGIS

This section illustrates the creation of EPA H2O compatible NHDPlus V2 data using Esri ArcGIS software.

1. Download and unzip the NHD datasets, as shown in the Download NHDPlus Data section.
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. Click the *Add Data* icon , and navigate to the unzipped NHD folder (i.e. *NHDPlusREGION*). Select the following files and click the *Add* button to add each layer to the Table of Contents.
   a. NHDPlusSA\NHDPlusCatchment*Catchment.shp*
   b. NHDPlusSA\NHDPlusSnapshot\Hydrography*NHDFlowline.shp*
   c. NHDPlusSA\NHDPlusSnapshot\Hydrography*NHDWaterbody.shp*
   d. NHDPlusSA\NHDPlusAttributes*PlusFlowlineVAA.dbf*
   e. NHDPlusSA\NHDPlusAttributes*PlusFlow.dbf*
   f. NHDPlusSA\NHDPlusAttributes*MegaDiv.dbf*
4. Reproject the *Catchment* layer using the *Project* tool. From the *ArcToolbox* window, navigate to and open the *Project* tool (*ArcToolbox > Data Management Tools > Projections and Transformations > Project* Figure 143).
5. In the *Project* tool window (example shown in Figure 144):
   a. In the *Input Dataset or Feature Class* box, select *Catchment.shp*.

b. In the *Output Dataset or Feature Class* text box, browse to or type the desired file name (e.g. *Catchment_reproj*) and file path.

c. Click the *Spatial Reference*  icon to set the *Output Coordinate System* to *WGS_1984_Web_Mercator_Auxiliary_Sphere*, located under the *World* folder in *Projected Coordinate Systems*. Alternatively, search for it by typing *3857* into the search box.

a. A *Geographic Transformation* is required to reproject the land use dataset. In the dropdown list, choose *WGS_1984_(ITRF00)_To_NAD_1983* if not already selected.

d. Click *OK.*

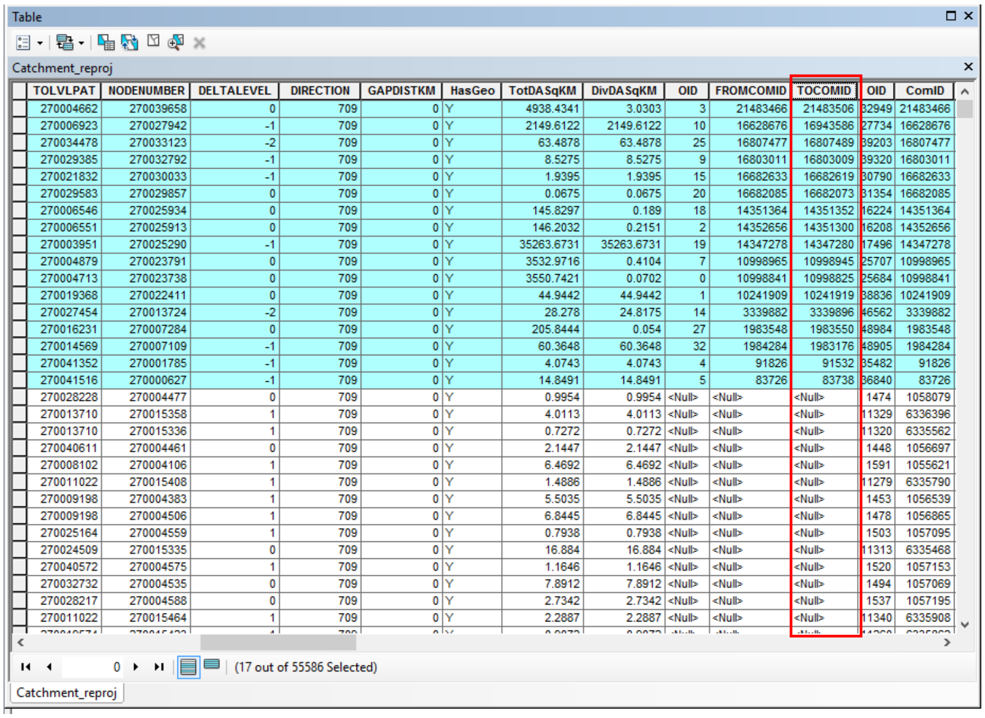
6. **Repeat steps 4 and 5 to reproject *NHDWaterbody.shp* and *NHDFlowline.shp*.**

7. In the Table of Contents, right-click on the re-projected *Catchment* layer and choose *Joins and Relates > Join…* (*Figure 183*).
8. In the *Join Data* window (example shown in *Figure 184*).
   a. In the first dropdown list, select *Join attributes from a table*.
   b. In the *Choose the field in this layer that the join will be based on* dropdown list, select "FEATUREID".
   c. In the *Choose the table to join to this layer* dropdown list, select *PlusFlow.*
   d. In the *Choose the field in the table to base the join on* dropdown list, select "FROMCOMID".
   e. Under *Join Options,* toggle *Keep all records.*
   f. Click *OK.*
9. Right-click on the re-projected *Catchment* layer again and choose *Joins and Relates > Join…* to add a second join, this time with the *MegaDiv* table.
   a. In the *Choose the table to join to this layer* dropdown list, select *MegaDiv*.
   b. Repeat all other inputs from step 8.
10. Right-click on the re-projected *Catchment* layer a third time and choose *Joins and Relates > Join…* to add a third join, this time with the *PlusFlowlineVAA* table.
    a. In the *Choose the table to join to this layer* dropdown list, select *PlusFlowlineVAA*.
    b. In the *Choose the field in the table to base the join on* dropdown list select "ComID".
    c. Repeat all other inputs from step 8.
11. **Repeat steps 7-10 to join the re-projected *NHDFlowline* layer with the *PlusFlow, MegaDiv* and *PlusFlowlineVAA* tables.**
    a. In the Table of Contents, right-click on the *NHDFlowline* layer and choose *Joins and Relates > Join…* (*Figure 183*).
    b. In the *Join Data* window, for the *Choose the field in this layer that the join will be based on* dropdown list, select "COMID".
    c. Repeat all other inputs from steps 8-10.

12. In the Table of Contents, right-click on the re-projected *Catchment* layer and open the attribute table.
13. In the attribute table, click on the *Table Options* icon and choose *Add Field* (*Figure 179).*
14. In *Add Field* window (example shown in *Figure 180*):
    a. In the *Name* text box, type *HUC_14.*
    b. In the *Type* dropdown list, select "Text".
    c. Click *OK.*
15. In the *Catchment* attribute table, right-click on the newly created *HUC_14* field and choose *Field Calculator.*
16. In the *Field Calculator* window:
    a. From the *Fields* list box, double click the "FEATUREID" field (e.g. *Catchment_reproj.FEATUREID)*. The name of the field should appear in the *Expression* box.
    b. Click *OK.*
17. In the *Catchment* attribute table, add a second new field.
    a. In the *Name* text box, type *HU_14_DS.*
    b. In the *Type* dropdown list, select "Text".

c. Click *OK.*

18. There are two fields in the *Catchment* attribute table named "TOCOMID", one from the joined *PlusFlow* table and one from the *MegaDiv* table.
    a. Right-click on each “TOCOMID” field and choose properties to see the full field names, until finding the "TOCOMID" with “MegaDiv.TOCOMID” as it’s full field name.
    b. Right-click on the correct "TOCOMID" field again and choose *Sort Descending*.
    c. Click and drag to select the rows that contain the non-NULL “TOCOMID” values (*Figure 251*). There should only be a relatively small amount of non-NULL features at the top of this “TOCOMID” field.



TOLVLPAT	NODENUMBER	DELTALEVEL	DIRECTION	GAPDISTKM	HasGeo	TotDASqKM	DivDASqKM	OID	FROMCOMID	TOCOMID	OID	ComID
270004662	270039658	0	709	0	Y	4938.4341	3.0303	3	21483466	21483506	32949	21483466
270006923	270027942	-1	709	0	Y	2149.6122	2149.6122	10	16628676	16943586	27734	16628676
270034478	270033123	-2	709	0	Y	63.4878	63.4878	25	16807477	16807489	39203	16807477
270029385	270032792	-1	709	0	Y	8.5275	8.5275	9	16803011	16803009	39320	16803011
270021832	270030033	-1	709	0	Y	1.9395	1.9395	15	16682633	16682619	30790	16682633
270029583	270029857	0	709	0	Y	0.0675	0.0675	20	16682085	16682073	31354	16682085
270006546	270025934	0	709	0	Y	145.8297	0.189	18	14351364	14351352	16224	14351364
270006551	270025913	0	709	0	Y	146.2032	0.2151	2	14352656	14351300	16208	14352656
270003951	270025290	-1	709	0	Y	35263.6731	35263.6731	19	14347278	14347280	17496	14347278
270004879	270023791	0	709	0	Y	3532.9716	0.4104	7	10998965	10998945	25707	10998965
270004713	270023738	0	709	0	Y	3550.7421	0.0702	0	10998841	10998825	25684	10998841
270019368	270022411	0	709	0	Y	44.9442	44.9442	1	10241909	10241919	38836	10241909
270027454	270013724	-2	709	0	Y	28.278	24.8175	14	3339882	3339896	46562	3339882
270016231	270007284	0	709	0	Y	205.8444	0.054	27	1983548	1983550	48984	1983548
270014569	270007109	-1	709	0	Y	60.3648	60.3648	32	1984284	1983176	48905	1984284
270041352	270001785	-1	709	0	Y	4.0743	4.0743	4	91826	91532	35482	91826
270041516	270000627	-1	709	0	Y	14.8491	14.8491	5	83726	83738	36840	83726
270028228	270004477	0	709	0	Y	0.9954	0.9954	<Null>	<Null>	<Null>	1474	1058079
270013710	270015358	1	709	0	Y	4.0113	4.0113	<Null>	<Null>	<Null>	11329	6336396
270013710	270015336	1	709	0	Y	0.7272	0.7272	<Null>	<Null>	<Null>	11320	6335562
270040611	270004461	0	709	0	Y	2.1447	2.1447	<Null>	<Null>	<Null>	1448	1056697
270008102	270004106	1	709	0	Y	6.4692	6.4692	<Null>	<Null>	<Null>	1591	1055621
270011022	270015408	1	709	0	Y	1.4886	1.4886	<Null>	<Null>	<Null>	11279	6335790
270009198	270004383	1	709	0	Y	5.5035	5.5035	<Null>	<Null>	<Null>	1453	1056539
270009198	270004506	1	709	0	Y	6.8445	6.8445	<Null>	<Null>	<Null>	1478	1056865
270025164	270004559	1	709	0	Y	0.7938	0.7938	<Null>	<Null>	<Null>	1503	1057095
270024509	270015335	0	709	0	Y	16.884	16.884	<Null>	<Null>	<Null>	11313	6335468
270040572	270004575	1	709	0	Y	1.1646	1.1646	<Null>	<Null>	<Null>	1520	1057153
270032732	270004535	0	709	0	Y	7.8912	7.8912	<Null>	<Null>	<Null>	1494	1057069
270028217	270004588	0	709	0	Y	2.7342	2.7342	<Null>	<Null>	<Null>	1537	1057195
270011022	270015464	1	709	0	Y	2.2887	2.2887	<Null>	<Null>	<Null>	11340	6335908

Figure 251 Catchment attribute table, with non-NULL values in TOCOMID field highlighted

19. Right-click on the new *HU_14_DS* field and choose *Field Calculator.*
20. In the *Field Calculator* window:
    a. Clear any previous text from the expression box.
    b. From the *Fields* list box, double click on the “*MegaDiv.TOCOMID*” field. The name of the field should appear in the *Expression* box.
    c. Click *OK.*
21. In the attribute table, invert the current selection with the *Switch Selection*  icon.
22. Right click on the new *HU_14_DS* field again and choose *Field Calculator.*
23. In the *Field Calculator* window:
    a. Clear any previous text from the expression box.
    b. From the *Fields* list box, double click on the “*PlusFlow.TOCOMID*” field. The name of the field should appear in the *Expression* box.
    c. Click *OK.*
24. Clear the current selection in the attribute table and open the *Select by Attributes* tool.
25. In the *Select by Attributes* window:
    a. Clear any previous text from the expression box.
    b. From the *Fields* list box, double click on the “*PlusFlowlineVAA.TerminalFl* ” field. The name of the field should appear in the *Expression* box.
    c. Type *= 1* after the name of the field. The full expression is *"PlusFlowlineVAA.TerminalFl" = 1*.
    d. Click *OK.*

26. In the attribute table, right-click on the *HU_14_DS* field and choose *Field Calculator.*
27. In the *Field Calculator* window:
    a. Clear any previous text from the expression box.
    b. In the *Expression* box, type *"NULL"*.
    c. Click *OK.*
28. **Repeat steps 12-27 for the re-projected *NHDFlowline* layer, using the "COMID" field in place of the "FEATUREID" field when using field calculator on the "HUC_14" field (step 16).**

29. After finishing updating the *NHDFlowline* layer, clear all selected features by clicking the clear selection icon on the tools toolbar.
30. From the main menu, choose *Selection > Select By Attributes.*
31. In the *Select by Attributes* window:
    a. From the *Fields* list box, double click on the "*NHDFlowline_reproj.FTYPE* " field. The name of the field should appear in the *Expression* box.
    b. Type *LIKE 'Coastline'* after the name of the field. The full expression is *"NHDFlowline_reproj.FTYPE" LIKE 'Coastline'*.
    c. Click *OK.*
32. The selected flow lines must be deleted, which requires the user to be in an edit session. If the *Editor* toolbar is not enabled, right-click anywhere on the main menu bar at the top of the ArcMap window. From the list of optional toolbars that appear select *Editor* (*Figure 252*).

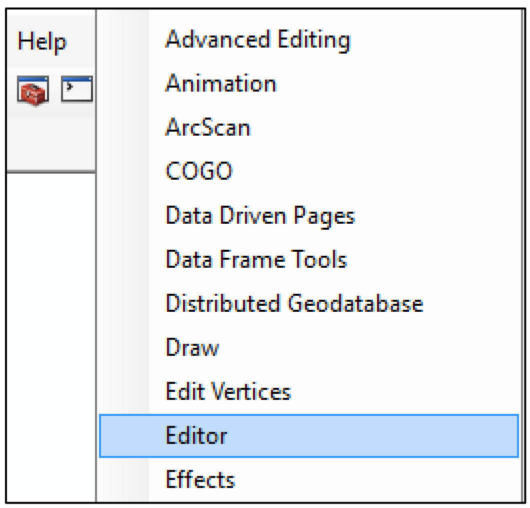
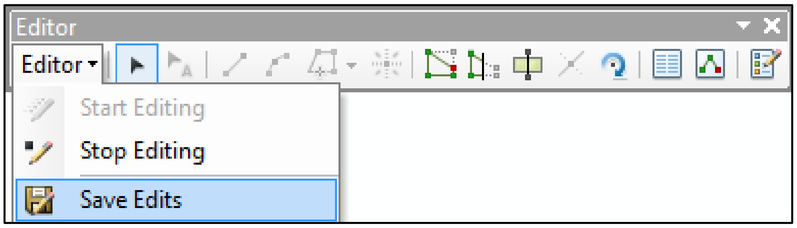


Figure 252 List of extensions and toolbars in ArcMap, with the Editor toolbar selected

33. In the *Editor* toolbar, click the *Editor* dropdown list and choose *Start Editing* (*Figure 253*).

Figure 253 Editor toolbar, with the Start Editing option selected

34. If the *Start Editing* window appears, select the *NHDFlowline* layer and click *OK.*
35. In the Table of Contents, right-click and open the *NHDFlowline* attribute table.
36. Click the *Delete* icon to delete the selected flow lines (*"FTYPE" LIKE Coastline*).
37. In the *Editor* toolbar, click the *Editor* dropdown and choose *Save Edits,* and then *Stop Editing* (*Figure 254*).



<table>
<tr><th></th><th colspan="2">Catchment Layer</th><th colspan="2">NHDFlowline Layer</th></tr>
<tr><td>Joined Tables</td><td colspan="2">PlusFlow.dbf, MegaDiv.dbf, and PlusFlowlineVAA.dbf</td><td colspan="2">PlusFlow.dbf, MegaDiv.dbf, and PlusFlowlineVAA.dbf</td></tr>
<tr><td colspan="5">HUC_14 Field</td></tr>
<tr><td>Field Type</td><td colspan="2">“Text”</td><td colspan="2">“Text”</td></tr>
<tr><td rowspan="2">Field Calculator</td><td>Attribute Selection</td><td>New Value</td><td>Attribute Selection</td><td>New Value</td></tr>
<tr><td>All</td><td>“FEATUREID”</td><td>All</td><td>“COMID”</td></tr>
<tr><td colspan="5">HU_14_DS Field</td></tr>
<tr><td>Field Type</td><td colspan="2">“Text”</td><td colspan="2">“Text”</td></tr>
<tr><td rowspan="6">Field Calculator</td><td>Attribute Selection</td><td>New Value</td><td>Attribute Selection</td><td>New Value</td></tr>
<tr><td>“MegaDiv.TOCOMID” IS NOT NULL</td><td>“MegaDiv.TOCOMID”</td><td>“MegaDiv.TOCOMID” IS NOT NULL</td><td>“MegaDiv.TOCOMID”</td></tr>
<tr><td>*Invert Selection or: “MegaDiv.TOCOMID” IS NULL</td><td>“PlusFlow.TOCOMID”</td><td>*Invert Selection or: “MegaDiv.TOCOMID” IS NULL</td><td>“PlusFlow.TOCOMID”</td></tr>
<tr><td rowspan="2">“PlusFlowlineVAA.TerminalFl” = 1</td><td rowspan="2">“NULL”</td><td>“PlusFlowlineVAA.TerminalFl” = 1</td><td>“NULL”</td></tr>
<tr><td>“NHDFlowline_proj.FTYPE” LIKE ‘COASTLINE’</td><td>*Delete selected fields</td></tr>
</table>

Figure 254 Editor toolbar, with the Save Edits option selected

38. In the Table of Contents, right-click on the *Catchment* layer and choose *Joins and Relates* > *Remove Join(s)* > *Remove All Joins.* Repeat this for the *NHDFlowline* layer.

A summary of the calculations used to prepare the NHDPlus data using Esri ArcGIS software is listed in *Table 11*.

Table 11 Fields added and calculations required to prepare the Catchment and NHDFlowline layers in ArcMap

The Importing Layers into QGIS section details how to upload the NHD Catchment, Waterbodies and Flowlines layers into the user database in QGIS. Database creation is continued in the Grid Water Bodies section.

Using QGIS

This section illustrates the creation of EPA H2O compatible NHDPlus V2 data using QGIS software.

1. Download and unzip the NHD datasets, as shown in the Download NHDPlus Data section.

2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. In File Explorer, locate the unzipped NHD folder (i.e. *NHDPlusREGION*). Drag and drop each of the following files into the QGIS Layers panel (*Figure 255*):
   a. NHDPlusSA\NHDPlusCatchment*Catchment.shp*
   b. NHDPlusSA\NHDPlusSnapshot\Hydrography*NHDFlowline.shp*
   c. NHDPlusSA\NHDPlusSnapshot\Hydrography*NHDWaterbody.shp*
   d. NHDPlusSA\NHDPlusAttributes*PlusFlowlineVAA.dbf*
   e. NHDPlusSA\NHDPlusAttributes*PlusFlow.dbf*
   f. NHDPlusSA\NHDPlusAttributes*MegaDiv.dbf*

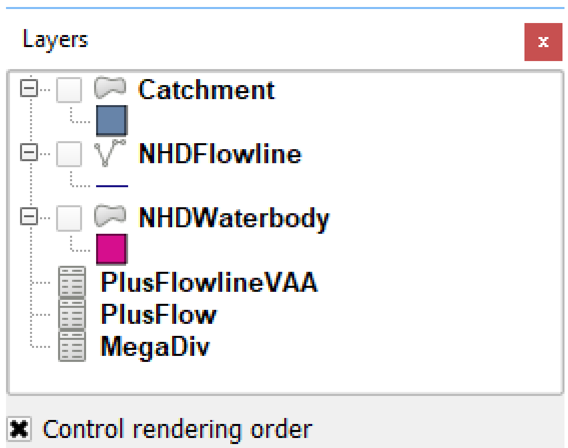


Figure 255 Layers panel in EPA H2O, listing the hydrological tables and shapefiles

4. In the Layers panel, right-click on the *Catchment* layer and select the *Save as* option (*Figure 132*).
5. In the *Save vector layer as...* window (example shown in *Figure 133*):
   g. In the *Format* dropdown list, select *ESRI Shapefile.*
   h. In the *Save as* text box, browse to or type the desired file path and name the output *Catchment_reproj.*
   i. In the *CRS* dropdown list, choose *Selected CRS,* and click the *Browse* button.
   d. In the *Filter* box, type *3857*, choose *WGS 84/ Pseudo Mercator* and click *OK*.
   e. Check *Add saved file to map.* Do not check *Skip attribute creation.*
   f. Click *OK.*
6. **Repeat steps 4 and 5 to reproject *NHDWaterbody.shp* and *NHDFlowline.shp*.**
7. In the Layers panel, double click the re-projected *Catchment* layer to open *Layer Properties*.
8. From the *Joins* tab, click the *Add Join*  icon to open the *Add vector join* window. (example shown in *Figure 200*):
   a. In the *Join layer* dropdown list, select *PlusFlow*.
   b. In the *Join field* dropdown list, select "FROMCOMID*"*.
   c. In the *Target field* dropdown list, select "FEATUREID".
   d. Check *Cache join layer in virtual memory*.
   e. Click *OK.*
9. Click the *Add Join* icon again. In the *Add vector join* window:
   a. In the *Join layer* dropdown list, choose *MegaDiv.*
   b. In the *Join field* dropdown list, choose "FROMCOMID".
   c. In the *Target field* dropdown list, choose "FEATUREID".
   d. Check *Cache join layer in virtual memory*.
   e. Click *OK.*
10. Click the *Add Join* icon a third time. In the *Add vector join* window:

a. In the *Join layer* dropdown list, choose *PlusFlowlineVAA*.
b. In the *Join field* dropdown list, choose “ComID”.
c. In the *Target field* dropdown list, choose “FEATUREID”.
d. Check *Cache join layer in virtual memory*.
e. Click *OK.*

The completed joins are listed under the *Joins* tab, as shown in *Figure 256.*

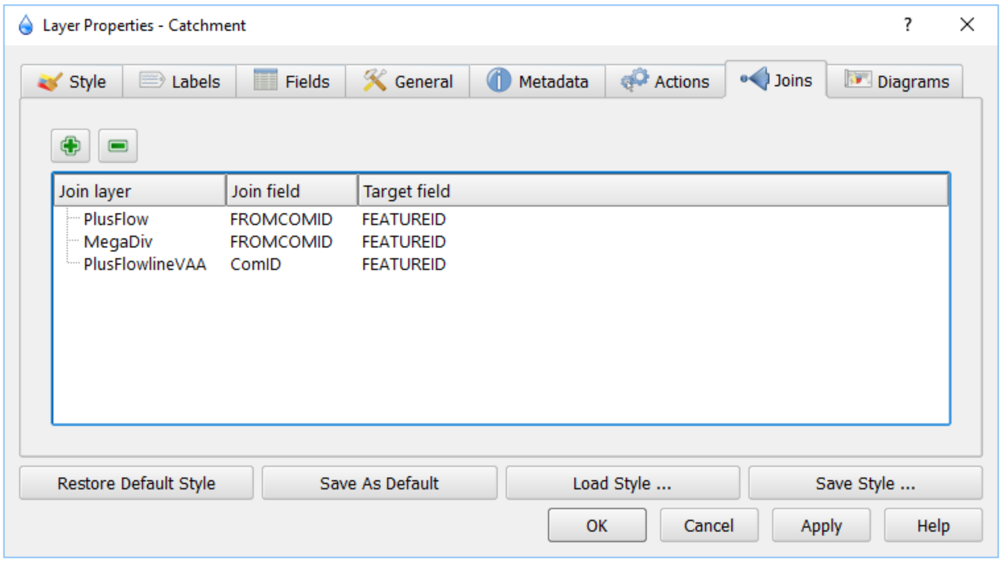


Figure 256 Layer Properties > Joins tab, listing tables joined to Catchment layer

11. **Repeat steps 7-10 to join the re-projected NHDFlowline layer with the PlusFlow, MegaDiv and PlusFlowlineVAA tables.**
    a. In the Layers panel, double click on the *NHDFlowline* layer to add the joins.
    b. In the *Target field* dropdown list, choose “COMID”.
    c. Repeat all other inputs from steps 7-10.

12. In the Layers panel, right-click the *Catchment* layer and choose *Open Attribute Table.*

13. In the attribute table window, toggle editing on by clicking the *pencil* icon .

14. Click the *Field Calculator* icon  to open the *Field Calculator* window.
15. In the *Field Calculator* window (*Figure 257*):
    a. Check *Create a new field*.
    b. In the *Output field name* text box, type *HUC_14.*
    c. In the *Output field type* dropdown list, select *Text (string).*
    d. In the *Function List,* expand the *Fields and Values* option and double click the “FEATUREID” field. The name of the field will appear in the *Expression* box.
    e. Click *OK.*

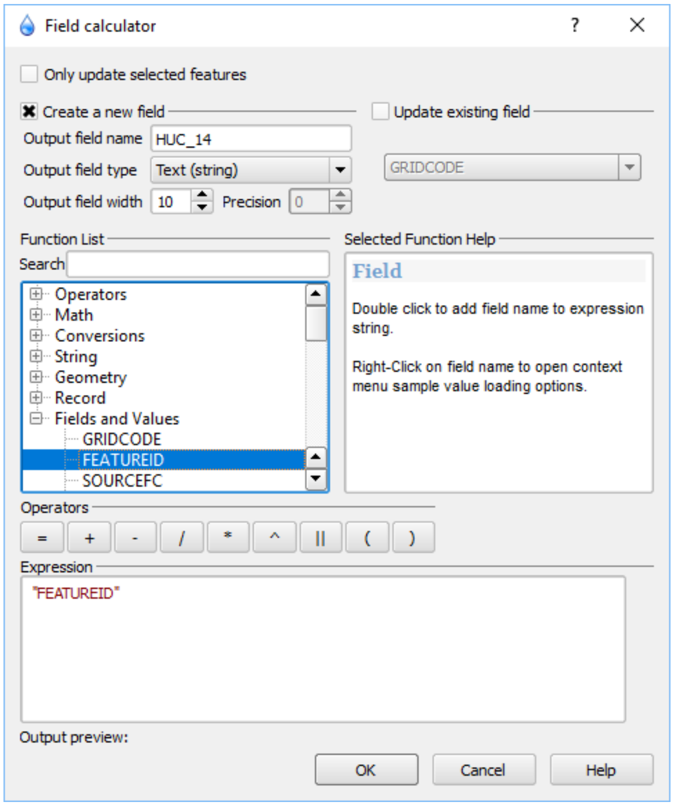
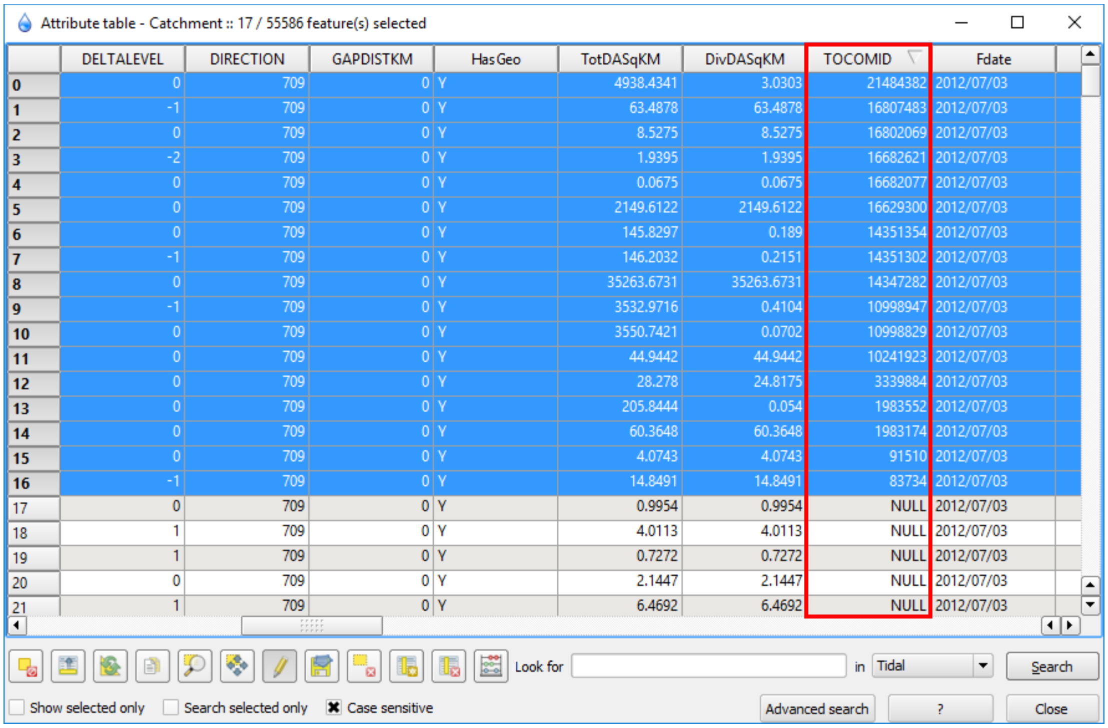


Figure 257 Field Calculator window, used to create and populate the HUC_14 field

16. In the *Attribute table* window, click the *Save Edits*  icon.
17. There are two fields in the attribute table named "TOCOMID". Locate the second or rightmost column.
    a. Click the “TOCOMID” column header twice to sort the attribute table in *Descending* order. There should only be a relatively small amount of non-NULL features.
    b. Click on row number 0 and drag to select the rows that contain the non-NULL “TOCOMID” values (*Figure 258*).



	DELTALEVEL	DIRECTION	GAPDISTKM	HasGeo	TotDASqKM	DivDASqKM	TOCOMID	Fdate
0	0	709	0	Y	4938.4341	3.0303	21484382	2012/07/03
1	-1	709	0	Y	63.4878	63.4878	16807483	2012/07/03
2	0	709	0	Y	8.5275	8.5275	16802069	2012/07/03
3	-2	709	0	Y	1.9395	1.9395	16682621	2012/07/03
4	0	709	0	Y	0.0675	0.0675	16682077	2012/07/03
5	0	709	0	Y	2149.6122	2149.6122	16629300	2012/07/03
6	0	709	0	Y	145.8297	0.189	14351354	2012/07/03
7	-1	709	0	Y	146.2032	0.2151	14351302	2012/07/03
8	0	709	0	Y	35263.6731	35263.6731	14347282	2012/07/03
9	-1	709	0	Y	3532.9716	0.4104	10998947	2012/07/03
10	0	709	0	Y	3550.7421	0.0702	10998829	2012/07/03
11	0	709	0	Y	44.9442	44.9442	10241923	2012/07/03
12	0	709	0	Y	28.278	24.8175	3339884	2012/07/03
13	0	709	0	Y	205.8444	0.054	1983552	2012/07/03
14	0	709	0	Y	60.3648	60.3648	1983174	2012/07/03
15	0	709	0	Y	4.0743	4.0743	91510	2012/07/03
16	-1	709	0	Y	14.8491	14.8491	83734	2012/07/03
17	0	709	0	Y	0.9954	0.9954	NULL	2012/07/03
18	1	709	0	Y	4.0113	4.0113	NULL	2012/07/03
19	1	709	0	Y	0.7272	0.7272	NULL	2012/07/03
20	0	709	0	Y	2.1447	2.1447	NULL	2012/07/03
21	1	709	0	Y	6.4692	6.4692	NULL	2012/07/03

Figure 258 Catchment attribute table, with non-NULL TOCOMID rows highlighted

18. Click the *Field Calculator* icon to open the *Field calculator* window.
19. In the *Field Calculator* window (example shown in *Figure 257*):
    a. Check *Only update selected features*.
    b. Check *Create a new field*.
    c. In the *Output field name* text box, type *HU_14_DS*.
    d. In the *Output field type* dropdown list, select *Text (string).*
    e. Under the *Function List,* expand the *Fields and Values* option and double click the second listed "TOCOMID" field name. The field name "TOCOMID" will appear in the *Expression* box.
    f. Click *OK*.
20. In the attribute table, click the *Invert Selection* icon to select all the *NULL* values in the second "TOCOMID" field.
21. Click the *Field Calculator* icon and in the *Field Calculator* window:
    a. Check *Only update selected features*.
    b. Check *Update existing field.*
    c. In the field dropdown list, select "HU_14_DS".
    d. Under the *Function List,* expand the *Fields and Values* option and double click the **first** "TOCOMID" field. The first "TOCOMID" field should appear in the *Expression* box.
    e. Click *OK*.
22. In the attribute table, click the *Save Edits* icon, then click the *Advanced Search* Advanced search button to open a search query window.
23. In the *Search query builder* window (*Figure 259*):
    a. In the *Fields* list box, double click on the "TerminalFl" field. The name of the field will appear in the *SQL where clause* box.
    b. Type *= 1* after the name of the field. the full expression is *TerminalFl = 1.*

c. Click *OK*.

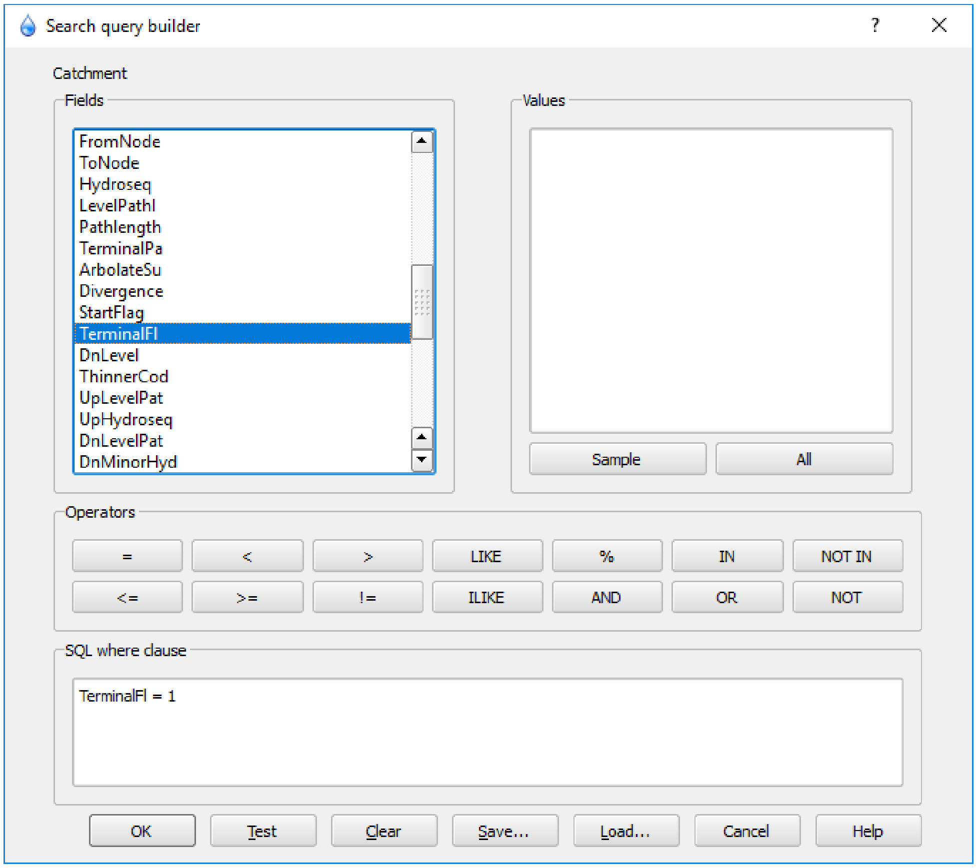
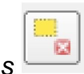
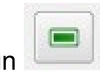


Figure 259 Search query builder window, with TerminalFl = 1 entered in the Search box

24. Click the *Field Calculator* icon to open the *Field Calculator* window.
25. In the *Field Calculator* window:
    a. Check *Only update selected features*.
    b. Check *Update existing field.*
    c. In the fields dropdown list, select "HU_14_DS".
    d. In the *Expression* box, type *NULL.*
    e. Click *OK.*
26. Toggle editing off by clicking the pencil icon and save edits when prompted.
27. **Repeat steps 12-26 for the re-projected *NHDFlowline* layer, replacing "FEATUREID" with "COMID" during "HUC_14" field calculation.**

28. After completing updated to the *NHDFlowline* layer, open the *NHDFlowline* attribute table and click the *Advanced search* button.
29. In the *Search query builder* window (example shown in *Figure 259*):
    a. In the *Fields* list box, double click on the "FTYPE" field. The name of the field will appear in the *SQL where clause* box.
    b. In the *Values* box, click the *All* button. All values found in the "FTYPE" field are listed in the *Values* box.
    c. In the *Operators* list, click the *LIKE* button.
    d. Back in the *Values* list box, double click on the 'Coastline' attribute. The full expression in the search box should read *FTYPE LIKE 'Coastline'.*
    e. Click *OK.*

30. In the *NHDFlowline* attribute table, click the *Delete selected features*  icon.
31. Toggle editing off by clicking the *pencil* icon  and save edits when prompted.
32. Deleting the joins made in the beginning of this section is not required but will save disk space and reduce memory usage when using EPA H2O.
    a. In the Layers panel, double click on the *Catchment* and *NHDFlowline* layers to open the *Properties* window.
    b. In the *Join* tab, highlight each join and click the green minus sign  to remove it.
    c. Click *OK* when all joins have been removed.

A summary of the calculations used to prepare the NHDPlus layers using QGIS is listed in *Table 12*.

Table 12 Fields added and the calculations required to prepare the Catchment and NHDFlowline layers in QGIS

	***Catchment* Layer**		***NHDFlowline* Layer**	
Joined Tables	*PlusFlow.dbf, MegaDiv.dbf,* and *PlusFlowlineVAA.dbf*		*PlusFlow.dbf, MegaDiv.dbf,* and *PlusFlowlineVAA.dbf*	
HUC_14 Field				
Field Type	Text (string)		Text (string)	
Field Calculator	Attribute Selection	New Value	Attribute Selection	New Value
	All	"FEATUREID"	All	"COMID"
HU_14_DS Field				
Field Type	Text (string)		Text (string)	
Field Calculator	Attribute Selection	New Value	Attribute Selection	New Value
	"TOCOMID" IS NOT NULL	(MegaDiv) 2nd "TOCOMID"	"TOCOMID" IS NOT NULL	(MegaDiv) 2nd "TOCOMID"
	*Invert Selection or: "TOCOMID" IS NULL	(PlusFlow) 1st "TOCOMID"	*Invert Selection or: "TOCOMID" IS NULL	(PlusFlow) 1st "TOCOMID"
	(PlusFlowlineVAA) "TerminalFl" = 1	"NULL"	(PlusFlowlineVAA) "TerminalFl" = 1	"NULL"
			(NHDFlowline_proj) "FTYPE" LIKE 'COASTLINE'	*Delete selected fields

The Importing Layers into QGIS section details how to upload the NHD Catchment, Waterbodies and Flowlines layers into the user database in QGIS. If using QGIS, database creation is continued in the Create Road Layer section.

Grid Water Bodies

The EPA H2O tool uses the *NHD_flowlines* and *Subwatershed* layers to trace data from upstream. Upstream data are used to calculate the ES values in the Ecosystem Valuation Reports. However, the catchments in the *Subwatershed* layer do not overlap large bodies of water, such as Tampa Bay. If the user's AOI extends into a large body of water, it may be unclear what data are upstream.

The user may create an interior bay hexagon layer to link upstream data to these large bodies for Ecosystem Valuation Reports. This grid will "fill in" the water bodies in the *Subwatershed* layer with hexagonal polygons.

This section illustrates the creation of an interior bay hexagon layer using Esri ArcGIS software.

1. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
2. If using a new map document, use the *Add Data*  icon to navigate to the AOI shapefile (e.g. *HUC_Tampa.shp)*, and add the layer to the Table of Contents.
3. If not already in the Table of Contents, the re-projected NHD catchment layer (e.g. *Catchment_reproj.shp*) must be added in the same way.
4. In the Table of Contents, right-click on *Catchment_reproj* and open the attribute table.
5. Click the *Table Options*  icon in the attribute table and select *Add Field* (*Figure 179*).
6. In the *Add Field* window (example shown in *Figure 180*):
   a. In the *Name* text box, type "AreaKM2".
   b. Under the *Type* dropdown list, select *Float.*
   c. Click *Ok.*
7. In the attribute table, right-click on the "AreaKM2" field and select *Calculate Geometry.*
8. In the *Calculate Geometry* window (*Figure 260*):
   a. In the *Property* dropdown list, select *Area.*
   b. Under *Coordinate System,* confirm *Use coordinate system of the data source* is toggled and lists *PCS: WGS 1984 Web Mercator Auxiliary Sphere.*
   c. In the *Units* dropdown list, select *Square Kilometers [sq km].*
   d. Click *OK.*

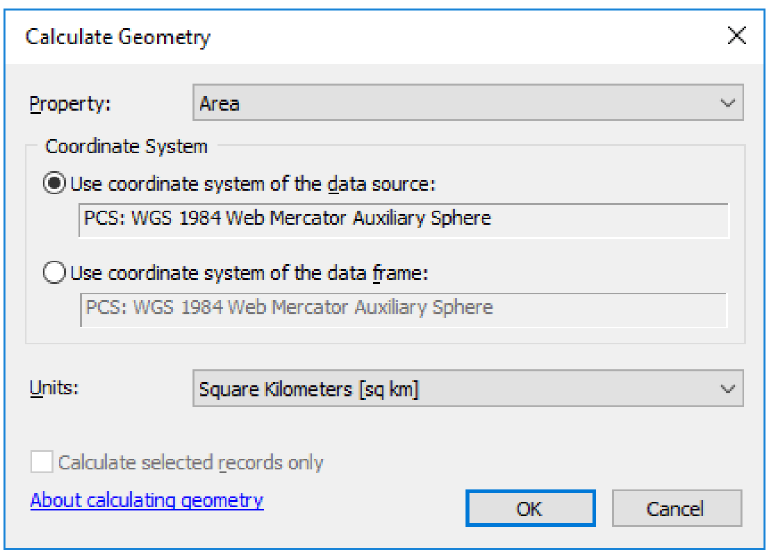


Figure 260 Calculate Geometry window in ArcMap, used to calculate area

9. From the main menu, click *Selection > Select By Location.*
10. In the *Select By Location* window (*Figure 261*):
    a. In the *Selection method* dropdown list, choose *select features from.*
    b. In the *Target layer(s)* box, check the NHD catchment layer (e.g. *Catchment_reproj).*
    c. In the *Source layer* dropdown list, select the AOI shapefile (e.g. *HUC_Tampa).*
    d. In the *Spatial selection method for target layer feature* dropdown list, select *intersect the source layer feature.*

e. Click *OK.*

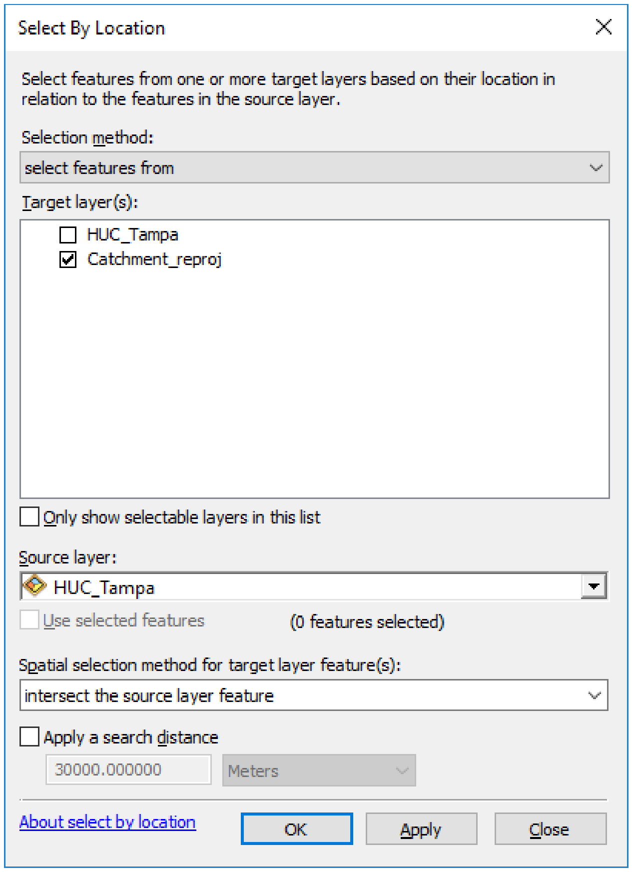


Figure 261 Select By Location window in ArcMap

11. Do not clear the selection. Right-click on *Catchment_reproj* and open the attribute table.
12. Right-click on the “AreaKM2” field and choose *Statistics.*
13. In the *Selection Statistics* window (*Figure 262*):
    a. In the *Field* dropdown list, confirm “AreaKM2” is displayed.
    b. From the *Statistics* box, write down the *Mean* value (e.g. 6.215708 km^2). This value is used in later calculations.

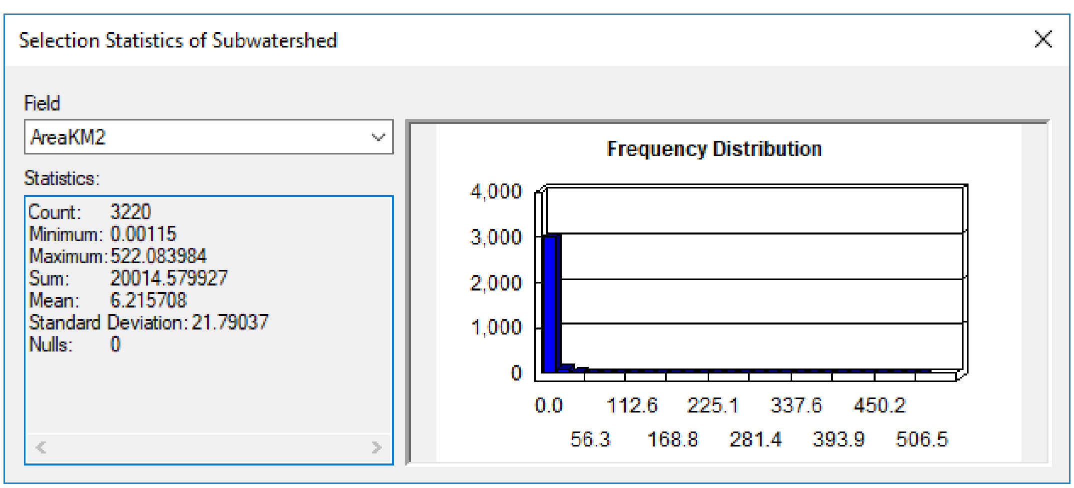


Figure 262 Selection Statistics for the Catchment_reproj AreaKM2 field

14. Various calculations are required to create the area-specific hexagonal grid. It is suggested that the user copy values and calculations into a spreadsheet or record them on paper to organize and track work.
15. Hexagon area will be set equal to the average catchment area. However, hexagons will be created based on their width and height. Width is determined using the equation:

    Hex width = 2.0*sqrt(***Mean* value**/6*sqrt(3))

    Where the example **Mean value** = **6.215708**,

    Hex width = 2.0 * sqrt(**6.215708** / 6 * sqrt(3))

    Hex width = 2.0 * sqrt(**6.215708** / 6 * 1.73205080757)

    Hex width = 2.67904485964

    Please note: **all decimals listed are required** throughout each calculation for accurate hexagons.
16. The height of each hexagon is calculated using the hexagon width. Height is determined using the equation:

    Hex height = Hex width * sqrt(3)

    Where the example hex width = 2.67904485964,

    Hex height = 2.67904485964 * 1.73205080757

    Hex height = 4.64024181265
17. To determine vertices for hexagon sides the orientation of the height and width values are swapped. In this example, height is now 2.67904485964 km, and width is now 4.64024181265 km.
18. The new height and width values must be converted from kilometers into meters. In this example, height is 2679.04485964 meters, and width is 4640.24181265 m.
19. In the Table of Contents, right-click on the AOI shapefile (e.g. *HUC_Tampa)* and select *Properties.*
20. Under the *Source* tab, the *Extent* is listed for the *Left, Bottom, Right,* and *Top* coordinates (*Figure 263*). Copy down each of these extents, indicating the specific location of each.

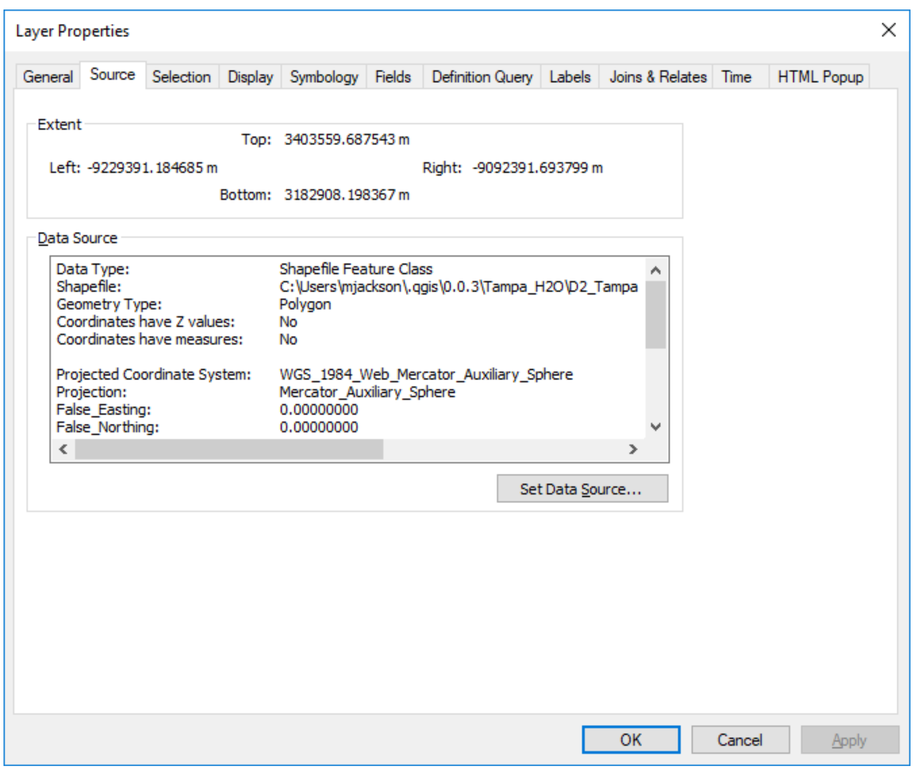


Figure 263 Layer Properties window, under the Source tab, which displays the extents of the AOI

21. New extents must be calculated for the hexagon layer by adding the width and height of the hexagons to the original extents. *Table 13* shows formulas and example calculations for the new Left, Bottom, Right, and Top extent, where *XMin* is the original *Left* extent, *YMin* is the original *Bottom* extent, *XMax* is the original *Right* extent, and *YMax* is the original *Top* extent.

Table 13 Formulas used to calculate the new area extents, using the original area extents, hex width, and hex height

Extent Location	Base Formula	Example Formula	Example New Extent
LEFT	XMin + width * -2	-9229391.184685 + 4640.24181265* -2	-9238671.66831
BOTTOM	YMin + height * -2	3182908.198367 + 2679.04485964 * -2	3177550.10865
RIGHT	XMax + width * 2	-9092391.693799 + 4640.24181265* 2	-9083111.21017
TOP	YMax + height * 2	3403559.687543 + 2679.04485964 * 2	3408917.77726

22. In ArcMap, click the *ArcToolbox*  icon to open *ArcToolbox.*
23. In the *ArcToolbox* window, navigate to the *Create Fishnet* tool (*Data Management Tools > Sampling > Create Fishnet*)
24. In the *Create Fishnet* window (*Figure 264*):
    a. In the *Output Feature Class,* name the output (e.g. *Tampa_Fishnet1*) and indicate the file path.
    b. Below the *Template Extent* option are blank fields for the *Left, Bottom, Right,* and *Top* extents. In each text box, enter the corresponding newly calculated extent (e.g. *Example New Extent* values in *Table 13*). Please note, the *Bottom* value may need to be entered last.
    c. In the *Cell Size Width* text box, enter the calculated hex width (e.g. 4640.24181265).
    d. In the *Cell Size Height* text box, enter the calculated hex height (e.g. 2679.04485964).
    e. In the *Number of Rows* text box, enter 0.
    f. In the *Number of Columns* text box, enter 0.
    g. The *Opposite corner of Fishnet* coordinates will populate automatically.
    h. Confirm the *Create Label Points* option is checked.
    i. In the *Geometry Type* dropdown list, confirm *POLYLINE* is selected.
    j. Click *OK.*

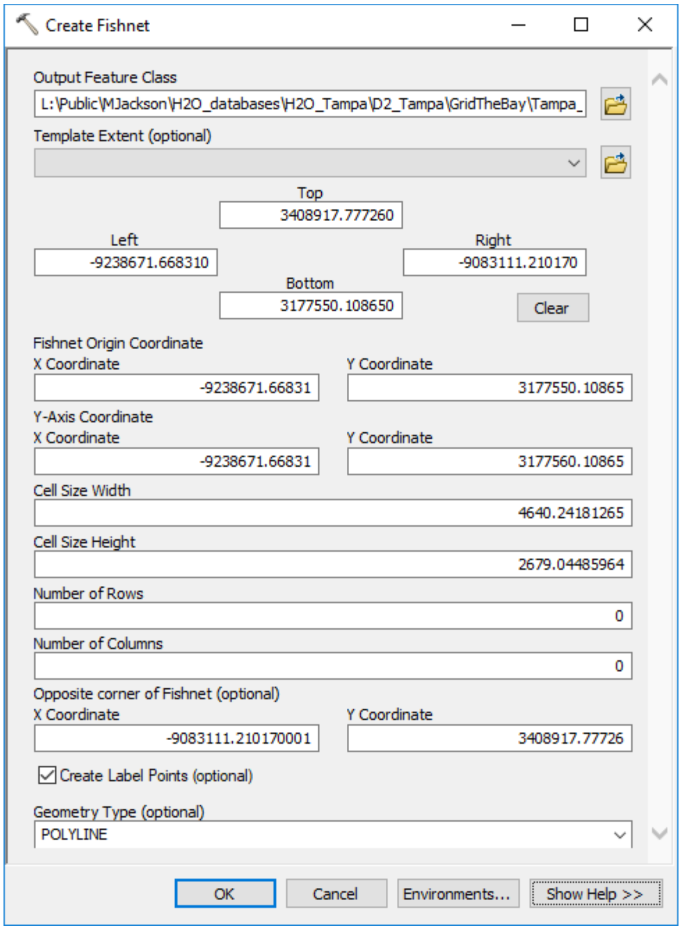


Figure 264 Create Fishnet window in ArcMap, using the newly calculated extents

25. A second Fishnet layer must be created using offset extents. This will create an alternating pattern of points, allowing the hexagons to fit together exactly. Formulas are similar to those used to calculate the offset extents shown in *Table 14*. However, the newly created Fishnet1 extents are used as the initial extent in the calculations, instead of the original AOI extents.

Table 14 Formulas used to calculate the offset area extents, using the Fishnet1 extents, hex width, and hex height

Extent Location	Base Formula	Example Formula	New Offset Extent
LEFT	newXMin + width * 0.5	-9238671.66831 + 4640.24181265 * 0.5	-9236351.5474
BOTTOM	newYMin + height * 0.5	3177550.10865 + 2679.04485964 * 0.5	3178889.63108
RIGHT	newXMax + width * 0.5	-9083111.21017 + 4640.24181265 * 0.5	-9080791.08926
TOP	newYMax + height * 0.5	3408917.77726 + 2679.04485964 * 0.5	3410257.29969

26. Open the *Create Fishnet* tool (*ArcToolbox >Data Management Tools > Sampling > Create Fishnet).*
27. In the *Create Fishnet* window (example shown in *Figure 264*):
    a. In the *Output Feature Class*, name the output (e.g. *Tampa_Fishnet2*) and indicate the file path.

b. Below the *Template Extent* option are blank fields for the *Left, Bottom, Right,* and *Top* extents. In each text box, enter the corresponding newly calculated offset extent (e.g. *New Offset Extent* values in *Table 14*). Please note, the *Bottom* value may need to be entered last.
c. In the *Cell Size Width* text box, enter the calculated hex width (e.g. 4640.24181265).
d. In the *Cell Size Height* text box, enter the calculated hex height (e.g. 2679.04485964).
e. In the *Number of Rows* text box, enter 0.
f. In the *Number of Columns* text box, enter 0.
g. The *Opposite corner of Fishnet* coordinates will populate automatically.
h. Confirm the *Create Label Points* option is checked.
i. In the *Geometry Type* dropdown list, confirm *POLYLINE* is selected.
j. Click *OK.*

28. Toggle both *_label* point layers (e.g. *Tampa_Fishnet1_label* and *Tampa_Fishnet2_label)* on in the Table of Contents. The *_label* point layers should create a rectangle of points around the user's AOI in a zig-zag pattern, as shown in *Figure 265*. The user may right-click and remove the Fishnet line layers (e.g. *Tampa_Fishnet1* and *Tampa_Fishnet2).*

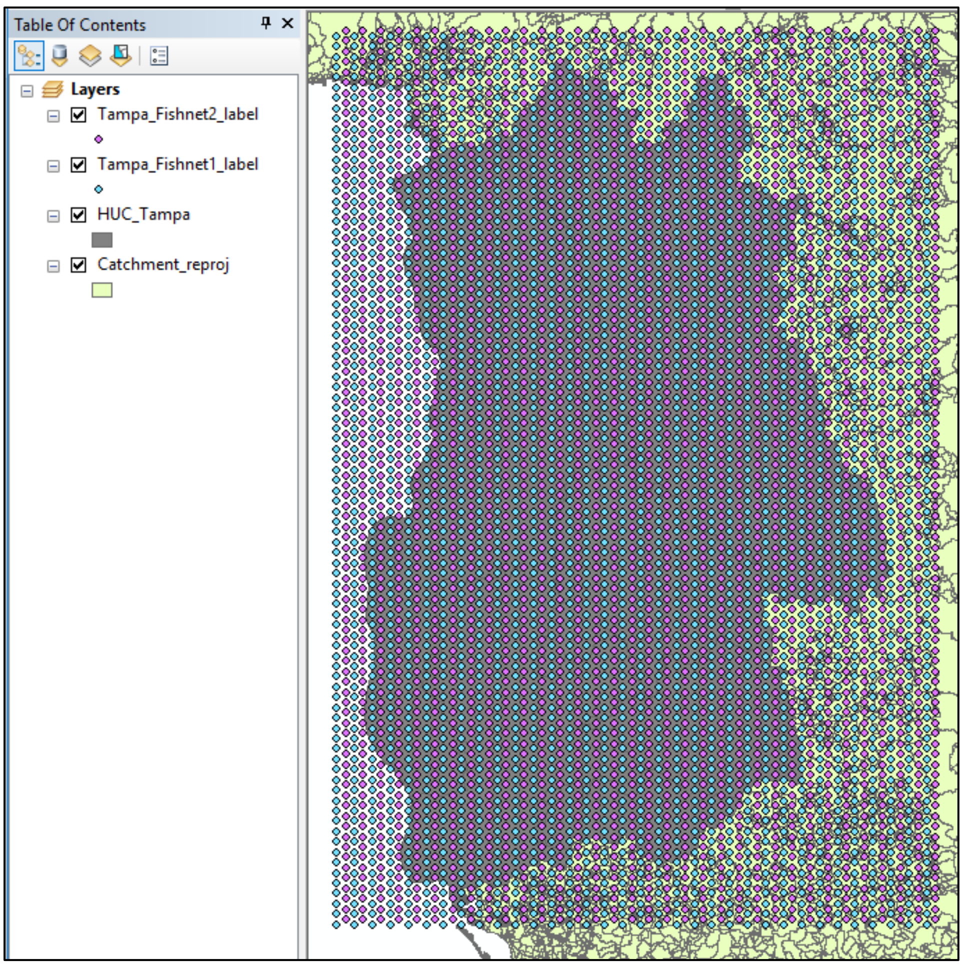


Figure 265 ArcMap project displaying Fishnet label layers over Tampa AOI and NHD catchments

29. Open *ArcToolbox* and navigate to the *Define Projection* tool (*Data Management Tools > Projections and Transformations > Define Projection*).
30. In the *Define Projection* window (*Figure 266*):
    a. In the *Input Dataset or Feature Class* dropdown list, select the first Fishnet label layer (e.g. *Tampa_Fishnet1_label).*

b. Click the *Coordinate System*  icon and enter *3857* into the search box. Select *WGS 1894 Web Mercator (auxiliary sphere)* and click *OK.*
c. In the *Coordinate System* text box, *WGS_1984_Web_Mercator_Auxiliary_Sphere* will appear*.* Click *OK.*

31. Repeat steps 29-30 to define the projection for the second Fishnet label layer (e.g. *Tampa_Fishnet2_label).*

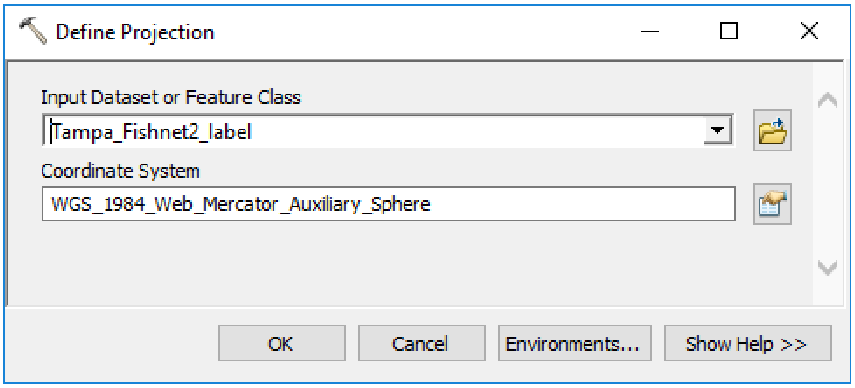


Figure 266 Define Projection window, setting the coordinate system for the Fishnet layer

32. Use the *Append* tool to combine both Fishnet label layers into one layer (*ArcToolbox* > *Data Management Tools* > *General* > *Append, Figure 187*).
33. In the *Append* window (example shown in *Figure 188*):
    a. In the *Input Datasets* dropdown list, select *Tampa_Fishnet2_label.*
    b. In the *Target Dataset* dropdown list, select *Tampa_Fishnet1_label.*
    c. Click *OK.*
34. Open the *ArcToolbox* window and locate the *Create Thiessen Polygons* tool (*ArcToolbox* > *Analysis Tools* > *Proximity* > *Create Thiessen Polygons, Figure 267*).

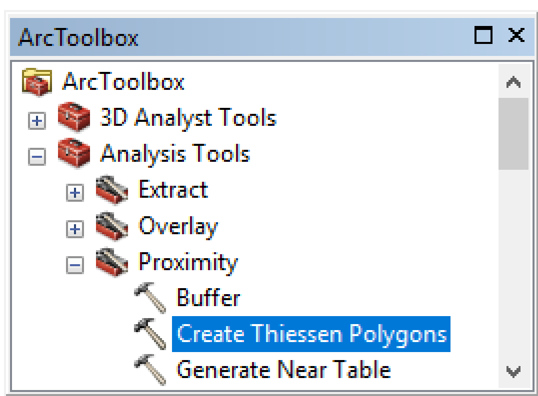


Figure 267 ArcToolbox window, showing the location of the Create Thiessen Polygons tool

35. In the *Create Thiessen Polygons* window (*Figure 268*):
    a. In the *Input Features* dropdown list, select the appended Fishnet layer (e.g. *Tampa_Fishnet1_label).*
    b. In the *Output Feature Class* text box, name the file path and shapefile (e.g. *Tampa_Thiessen.shp)*.
    c. In the *Output Fields* dropdown list, select *ONLY_FID.*
    d. Click *OK.*

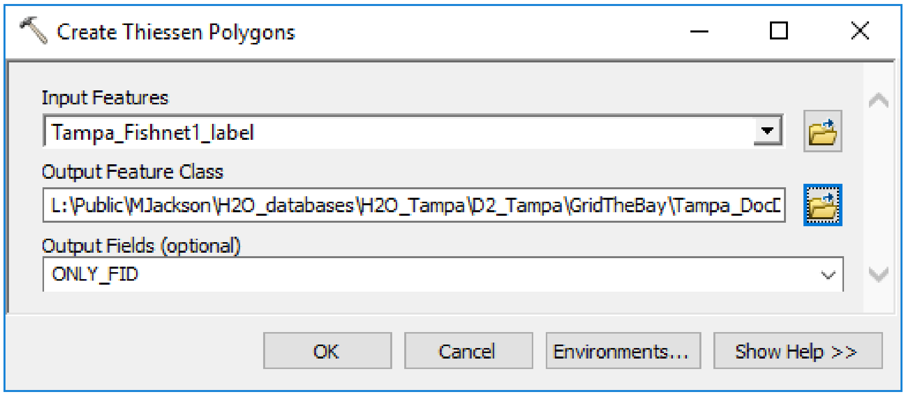


Figure 268 Create Thiessen Polygons window, used to create Thiessen polygons for the Fishnet points

36. Open *ArcToolbox* and navigate to the *Minimum Bounding Geometry* tool (*Data Management Tools > Features > Minimum Bounding Geometry*).
37. In the *Minimum Bounding Geometry* window (*Figure 269*):
    a. In the *Input Features* dropdown list, select the AOI shapefile (e.g. *HUC_Tampa).*
    b. In the *Output Feature Class* text box, name the file path and layer name (e.g. *Tampa_Envelope.shp).*
    c. In the *Geometry Type* dropdown list, select *ENVELOPE.*
    d. Click *OK.*

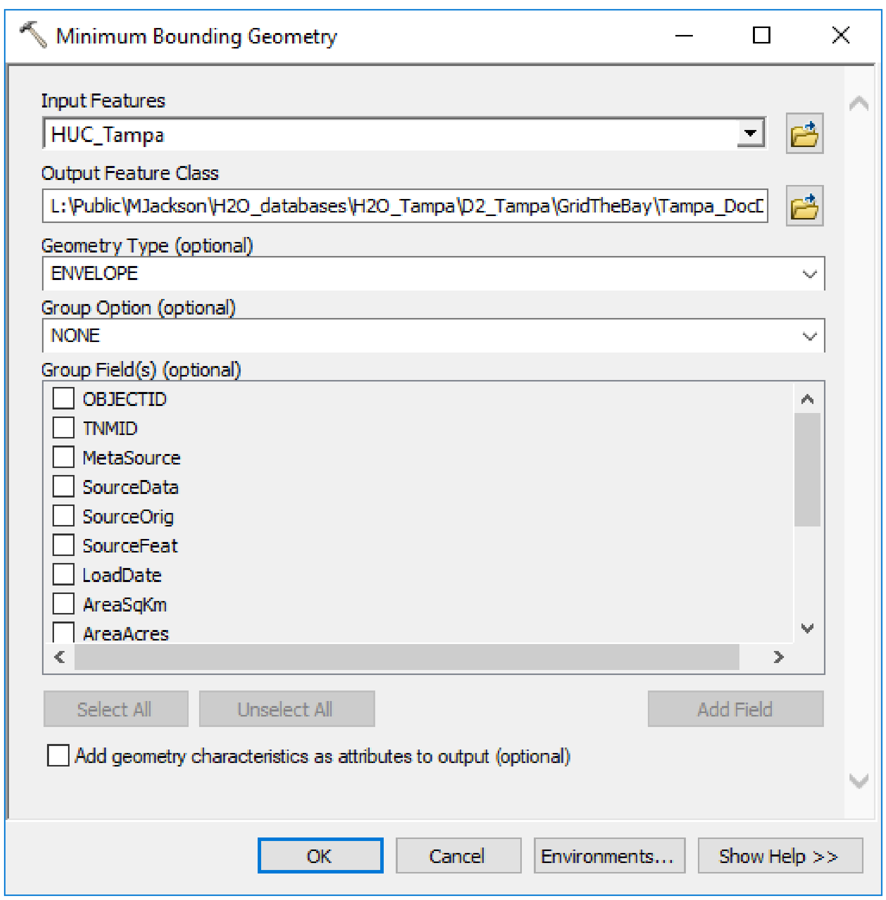


Figure 269 Minimum Bounding Geometry window, used to create an envelope around the AOI extent

38. From the main menu, choose *Selection > Select By Location.*

39. In the *Select By Location* window (example shown in *Figure 261*):
    a. In the *Selection method* dropdown list, choose *select features from.*
    b. In the *Target layer(s)* section, check *Tampa_Thiessen.*
    c. In the *Source layer* dropdown list, select *Tampa_Envelope.*
    d. In the *Spatial selection method for target layer feature(s)* dropdown list, select *intersect the source layer feature.*
    e. Click *OK.*
40. In the Table of Contents, right-click on *Tampa_Thiessen* and choose *Data > Export Data.*
41. In the *Export Data* window:
    a. In the *Export* dropdown list, choose *Selected features.*
    b. Under the *Use the same coordinate system as* option, toggle *the data frame.*
    c. In the *Output feature class* text box, name the file path and shapefile (e.g. *Tampa_ThiessenEnvelope.shp.*
    d. Click *OK.*
42. Open *ArcToolbox* and locate the *Erase* tool (*ArcToolbox > Analysis Tools > Overlay > Erase).*
43. In the *Erase* window (*Figure 270*):
    a. In the *Input Features* dropdown list, select the Thiessen Envelope (e.g. *Tampa_ThiessenEnvelope).*
    b. In the *Erase Features* dropdown list, select the NHD Catchment layer (e.g. *Catchment_reproj).*
    c. In the *Output Feature Class* text box, name the file path and output (e.g. *TampaThiessen_Erase.shp*)
    d. Click *OK.*

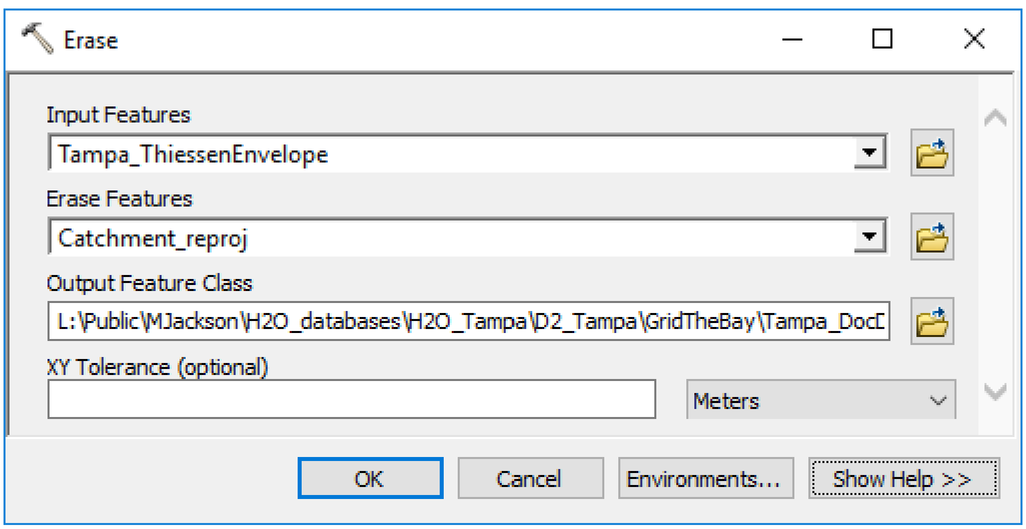


Figure 270 Erase window, used to remove Thiessen polygons that overlap the Catchment layer

44. Open *ArcToolbox* and locate the *Merge* tool (*ArcToolbox > Data Management Tools > General > Merge).*
45. In the *Merge* window (*Figure 271*):
    a. In the *Input Datasets* dropdown list, select the NHD Catchment layer (*Catchment_reproj*), then select the erased Thiessen layer (e.g. *TampaThiessen_Erase).* Both layers will appear in the box.
    b. In the *Output Dataset* text box, name the file path and shapefile (e.g. *Catchment_GridBay.shp*).
    c. In the *Field Map* section, select the "Id (Long)" field and click the *Remove*  icon.
    d. Click *OK.*

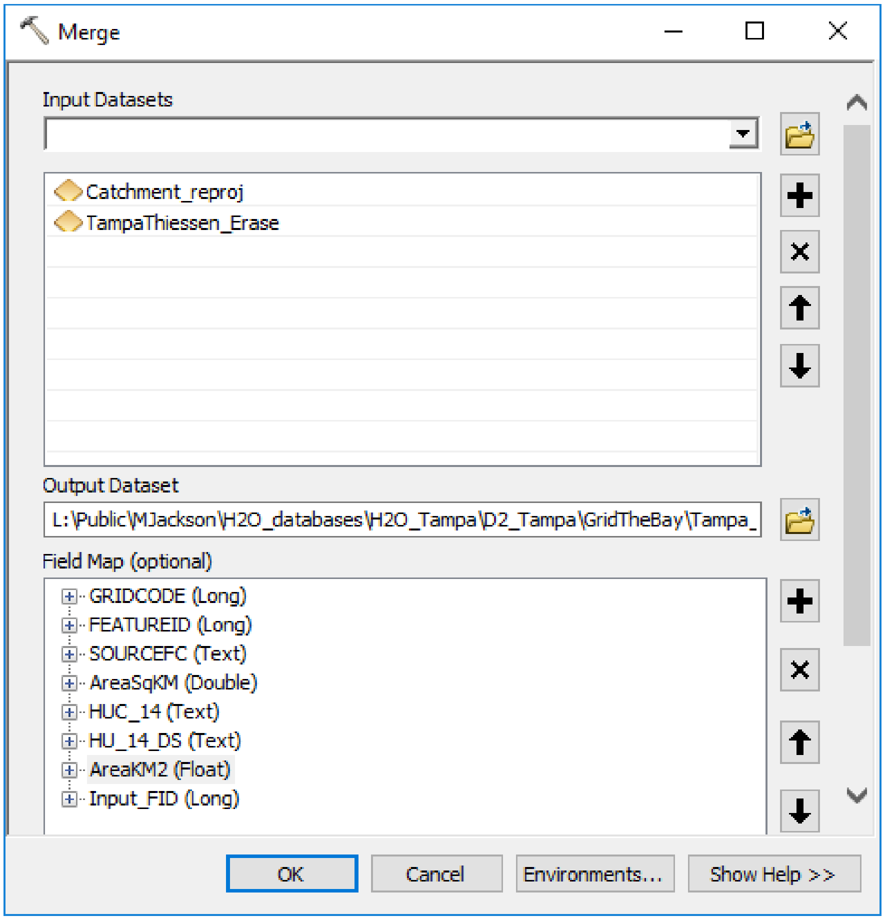


Figure 271 Merge window, used to combine the Catchment layer with the hexagonal grid

46. From the main menu, select *Selection* > *Select By Attributes.*
47. In the *Select By Attributes* window:
    a. In the *Layer* dropdown list, select the merged layer (e.g. *Catchment_GridBay).*
    b. In the list of fields, double click “FEATUREID”. The field name will appear in the *Expression* box below.
    c. In the *Expression* box, type = 0 after the field name. The full expression is "FEATUREID" = 0.
    d. Click *OK.*
48. In the Table of Contents, right-click on the merged layer (e.g. *Catchment_GridBay* and open the attribute table.
49. In the attribute table, click the *Show Selected Records*  icon. The attributes for each hexagon polygon will be listed.
50. Locate the “FID” field, right-click on the name, and choose *Sort Ascending.* Make note of the first FID value (e.g. *55586);* this value is used in the next *Field Calculator* calculation.
51. Right-click on the “FEATUREID” field and open the *Field Calculator.*
52. In the *Field Calculator* window (*Figure 272*):
    a. In the *Expression* box, type the following equation: (([FID] - **first “FID” value**) * -1) - 1000000
    b. In this example, the entered expression is: (([FID] - 55586) * -1) - 1000000
    c. Click *OK.*

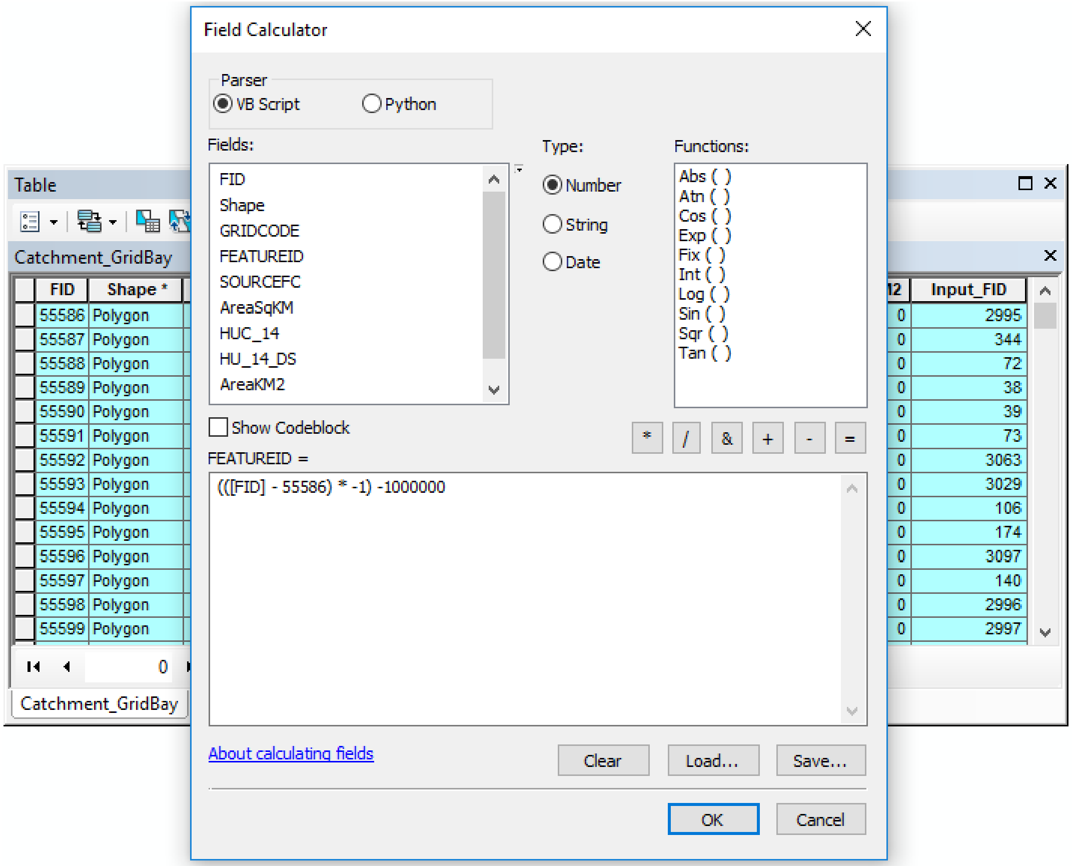


Figure 272 Field Calculator window with Catchment_GridBay attribute table

53. In the merged shapefile attribute table, right-click on “HUC_14” and open the *Field Calculator.*
54. In the *Field Calculator* window:
    a. Clear the previous expression if it appears in the *Expression* box.
    b. In the *Fields* list, double click on the “FEATUREID” field. The field name will appear in the *Expression* box.
    c. Click *OK.*
55. In the attribute table, locate the “SOURCEFC” field, and right-click to open the *Field Calculator.*
56. In the *Field Calculator* window:
    a. In the *Expression* box, type "Hex" (Please note, the quotation marks are required).
    b. Click *OK.*

The hexagonal grid has been added to the NHD Catchment layer. The Importing Layers into QGIS section details how to upload the updated NHD Catchment layer into the user database in QGIS. Database creation is continued in the Create Road Layer section.

Create Road Layer

Download TIGER/Line data

This section shows the step-by-step procedure for downloading the roads data for the Transportation Tool (Advanced Module Only) in EPA H2O. The Road layer is only used for the Transportation Tool and the rest of EPA H2O functionality is available without this layer.

1. Navigate to https://www.census.gov/cgi-bin/geo/shapefiles/index.php to open the US Census Bureau website (*Figure 273*).
2. In the *Select year* dropdown list, choose the most recently published year. In this example, 2018 has been selected.
3. In the *Select a layer type* dropdown list, select *Roads.*
4. Click the *Submit* button.

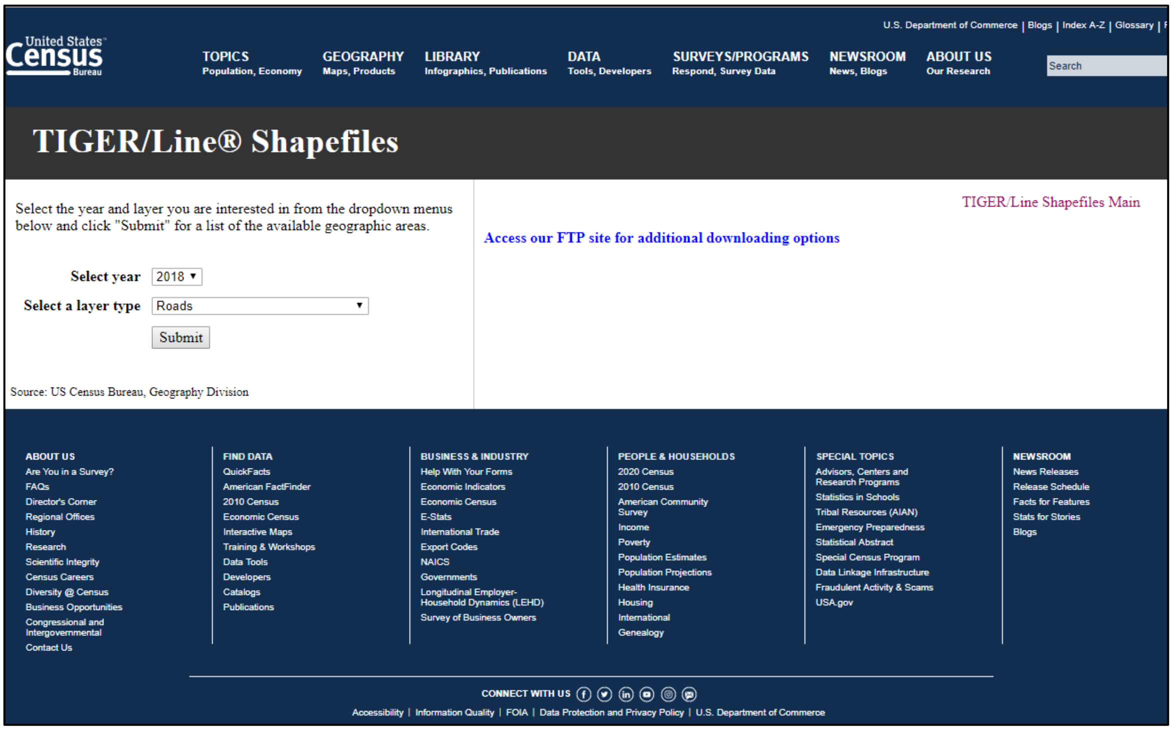


Figure 273 US Census Bureau TIGER/Line Shapefiles download website

5. The website will navigate to the next page, as shown in *Figure 274*.
6. Under the *All Roads* option, select the state containing the user's AOI (e.g. *Florida*).
7. Once a state is selected, a *Select a County* dropdown list will appear. Select the desired county from the dropdown list (e.g. *Hillsborough County)*.
8. Under the *Select a County* dropdown list, click the *Download* button.

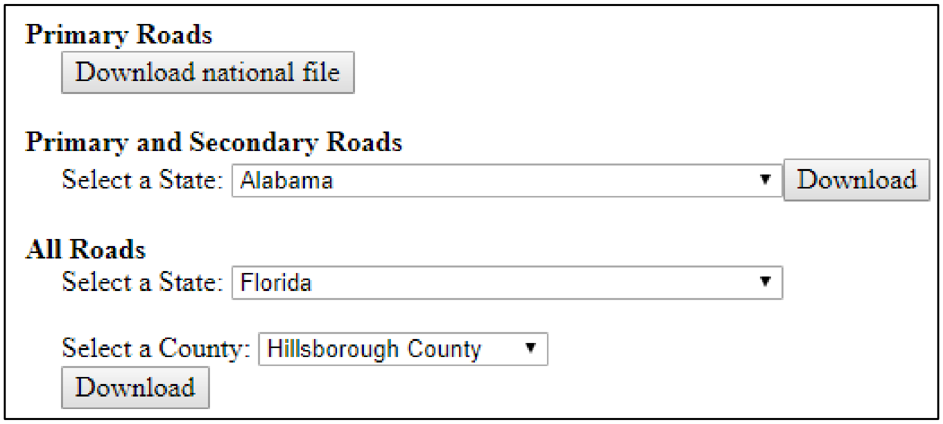


Figure 274 TIGER/Line All Roads menu, with Florida selected from the dropdown box

9. Save the zip file and unzip the contents to a known location.
10. If the user's AOI is located across multiple counties or multiple states, the user must repeat these steps to download all necessary data.

Download Max Speed data

The Transportation Tool (Advanced Module Only) in EPA H2O requires TIGER/Line road data include maximum speeds. TIGER does not supply this information, but there are several ways users can generate it. Appendix C: Roads Speeds Table provides a lookup table of maximum speed national averages for the different MTFCC codes in the TIGER/Line road data. The process for adding this information to the Roads shapefile(s) is outlined in the ArcGIS Create Max Speed Dataset and QGIS Create Max Speed Data sections. Maximum speeds vary from one area to the next, making local sources that are more specific to the area of interest preferable to using the national averages. Each state's Department of Transportation (DOT) may be a useful source of more locally specific max speeds data. The following section outlines how a Max Speed shapefile was obtained for the state of Florida.

A Max Speed shapefile can be downloaded for the state of **Florida** at:

1. Navigate to https://www.arcgis.com/home/item.html?id=4a61f17ab4784202ae10d7d5fb3bf9de#overview to open the ArcGIS website (*Figure 275*).
2. Under *Description > Download Data,* click the hyperlink to open the login screen.

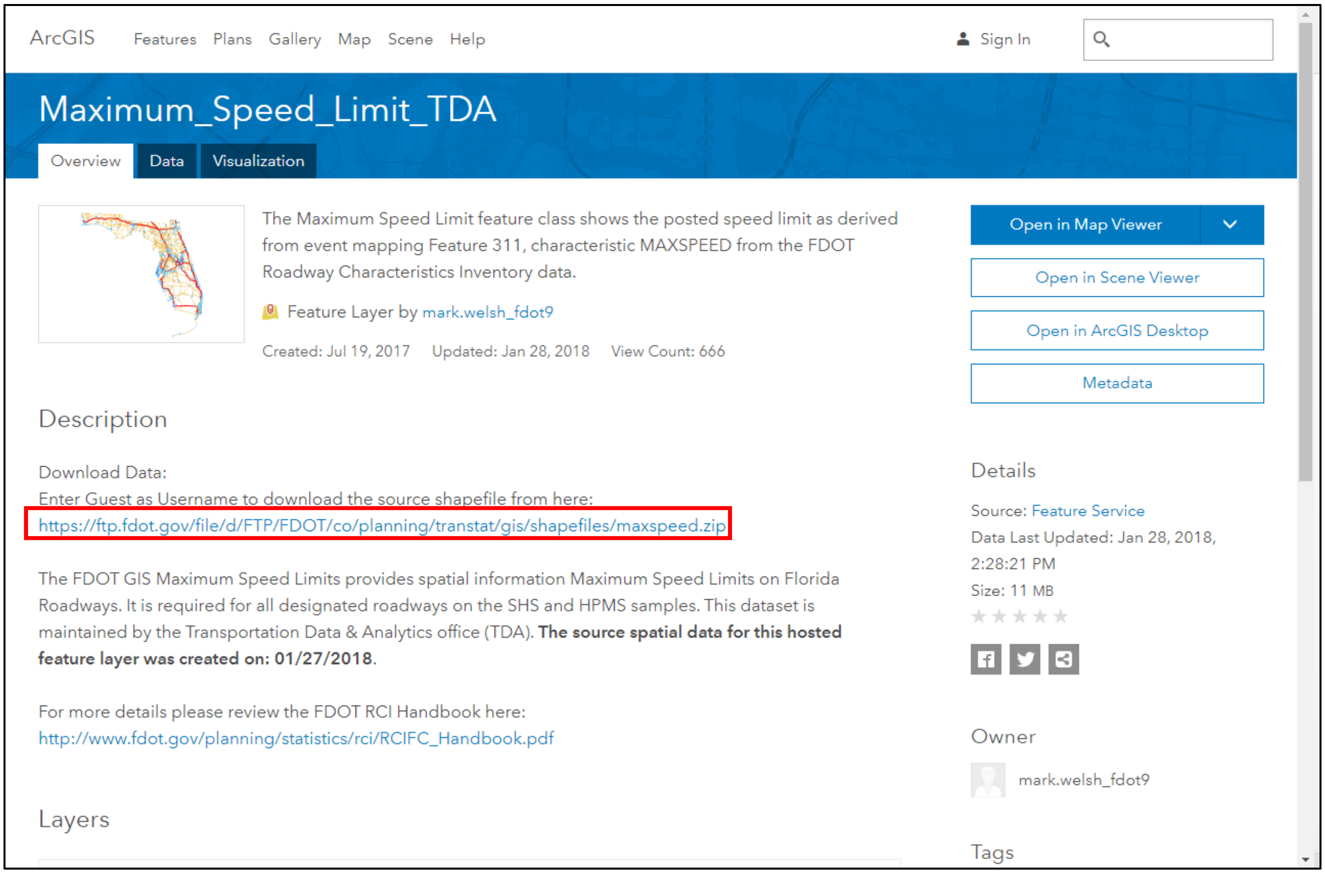


Figure 275 ArcGIS website, which contains FDOT MAXSPEED data for the state

3. Under *Client Login,* in the *Username* text box, enter *Guest.* No password is required.
4. Click *Sign In.*

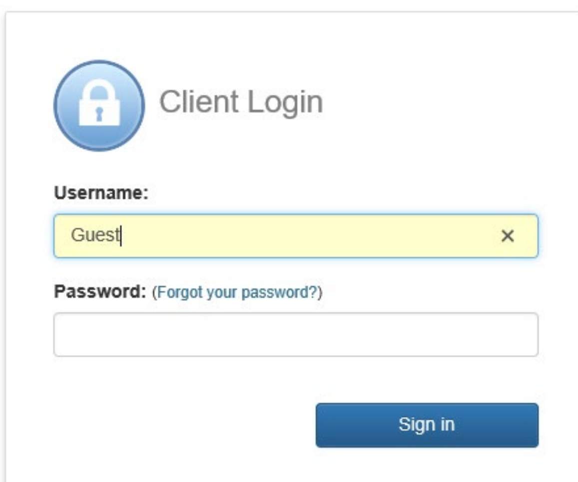


Figure 276 Client Login, with Guest entered as the username

5. Save the *maxspeed.zip* file and unzip the contents to a known location.

Using ArcGIS

This section illustrates the creation of EPA H2O compatible road data using Esri ArcGIS software.

1. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
2. Use the *Add Data*  icon to navigate to the TIGER/Line shapefile(s) and add it as a layer in the Table of Contents.
3. If using a previously created Max Speed dataset, the layer must be added in the same way.
4. In the *ArcToolbox* window, navigate to and open the *Project* tool (*ArcToolbox > Data Management Tools > Projections and Transformations > Project, Figure 143*).
5. In the *Project* window (example shown in *Figure 144*):
   a. In the *Input Dataset or Feature Class* dropdown list, select the first TIGER/Line shapefile (e.g. *tl_2013_12057_roads).*
   b. The *Input Coordinate System* automatically lists the coordinate system of the selected dataset (e.g. *GCS North American 1983).*
   c. In the *Output Dataset or Feature Class* text box, browse to or type the desired file path and name (e.g. *Roads057.shp*).
   d. Click the *Spatial Reference*  icon to set the *Output Coordinate System* to *WGS_1984_Web_Mercator_Auxiliary_Sphere*, located under the *World* folder in *Projected Coordinate Systems*. Alternatively, the user may type *3857* into the search box.
   e. A *Geographic Transformation* is required to reproject the land use dataset. In the dropdown list, choose *WGS_1984_(ITRF00)_To_NAD_1983* if not already selected.
   f. Click *OK*.
6. Repeat steps 4-5 to reproject any other TIGER/Line roads or max speed datasets.

If multiple Roads shapefiles were required for the AOI, the user must combine the TIGER/Line layers.

7. Open the *Append* tool in *ArcToolbox* (location shown in *Figure 187).*
8. In the *Append* window (example shown in *Figure 188*):
   a. In the *Target Dataset* dropdown list, choose any one road shapefile to append the others to (e.g. *Roads057*).
   b. In the *Input Datasets* dropdown list, select all other road shapefiles.
   c. Keep the *Schema Type* set to *TEST* and do not select a field map or subtype.
   d. Click *OK*.

Create Max Speed Dataset

This section illustrates the creation of Maximum Speed data using the supplemental lookup table (Appendix C: Roads Speeds Table). If the user obtained a Max Speed shapefile dataset, skip to the User-Obtained Max Speed Data section.

1. Load the *MaxSpeed_lookup.csv* table into ArcMap, exported from Appendix C: Roads Speeds Table.
2. Right-click on the appended Roads shapefile in the Table of Contents and choose *Joins and Relates > Join* (*Figure 183).*
3. In the *Join Data* window (example shown in *Figure 184*):
   a. In the first dropdown list, select *Join attributes from a table*.
   b. In the *Choose the field in this layer that the join will be based on* dropdown list, choose "MTFCC".
   c. Under the *Choose the table to join to this layer* dropdown list, select *MaxSpeed_lookup.csv*.
   d. In the *Choose the field in the table to base the join on* dropdown list, select "MTFCC".
   e. Toggle *Keep all records*

f. Click *OK.*

6. Right click on the appended Roads shapefile and select *Data* > *Export Data.*
7. In the *Export Data* window (example shown in *Figure 124*):
   a. In the *Export* dropdown list, select *All features.*
   b. Under the *Use the same coordinate system as* option, toggle *the data frame.*
   c. In the *Output feature class* text box, navigate to the preferred file path and name the shapefile *Roads.shp.*
   d. Click *OK.*

The *Roads.shp* output will contain the maximum speed data in miles per hour and kilometers per hour. Database creation is continued in the Importing Layers into QGIS section.

User-Obtained Max Speed Data

This section describes steps for using a Max Speed shapefile dataset.

1. Navigate to the *Spatial Join* tool in *ArcToolbox,* located in *ArcToolbox* > *Analysis Tools* > *Overlay* (*Figure 277*).

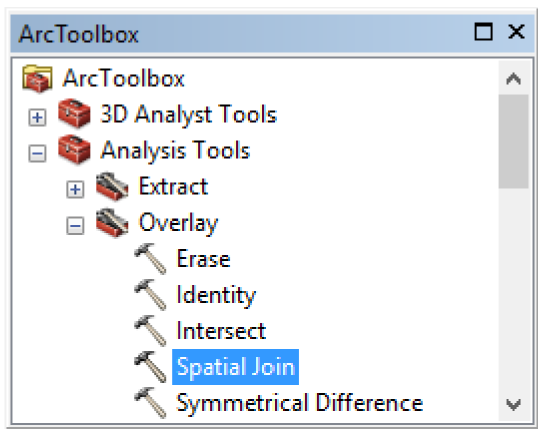


Figure 277 Location of the Spatial Join tool in ArcToolbox

2. In the *Spatial Join* window (*Figure 278*):
   a. In the *Target Features* dropdown list, select the appended Roads shapefile (e.g. *Roads057).*
   b. In the *Join Features* dropdown list, select the max speed dataset (e.g. *maxspeed_reproj).*
   c. In the *Output Feature Class* text box, browse to or type the desired file name (e.g. *Roads_spatialjoin.shp*) and file path.
   d. From the *Join Operation* dropdown list, choose *JOIN_ONE_TO_MANY.*
   e. Check *Keep All Target Features.*
   f. In the *Match Option* dropdown list, select *INTERSECT.*
   g. Click *OK.*

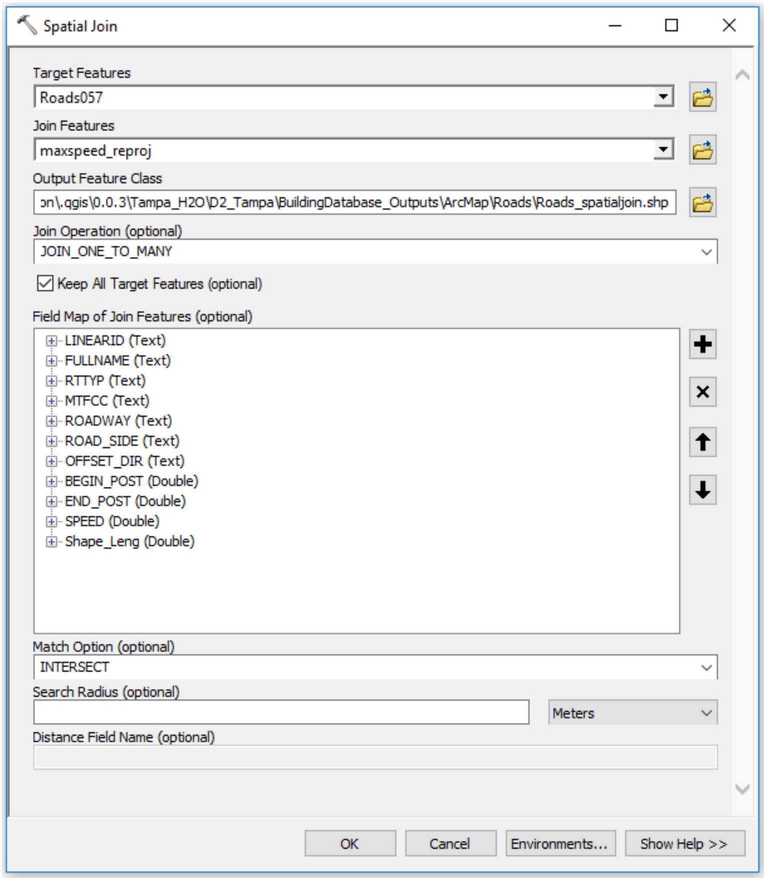


Figure 278 Spatial Join window, creating a join between the Roads shapefile and max speed

Once max speeds have been successfully added to the Roads shapefile these speeds may need to be updated to meet the requirements of EPA H2O. The field must be named “SPEED”, cannot contain zero values and should be in both miles per hour (MPH) and kilometers per hour (KMH).

3. To rename the field with the maximum speed data to “SPEED”:
    a. Create a new field in the Roads attribute table named “SPEED”, with *Short Integer* type.
    b. Populate this field with the maximum speed data using *Field Calculator.*
4. To update speeds with zero values to 25:
    a. Right click on the spatially joined layer (e.g. *Roads_spatialjoin)* and open the attribute table.
    b. From the main menu, choose *Selection* > *Select By Attributes* (*Figure 244*).
    c. In the *Select By Attributes* window (example shown in *Figure 245*):
        i. Under the *Layer* dropdown list, choose the spatial join layer (e.g. *Roads_spatialjoin).*
        ii. From the list of fields, double click on the “SPEED” field.
        iii. In the *Expression* box, type *=0* after the field name, to search for *“SPEED” = 0.*
        iv. Click *OK.*
    d. Right click on the “SPEED” field and choose *Field Calculator.*
    e. In the *Field Calculator* window:
        i. In the *Expression* box, type *25.*
        ii. Click *OK.*
    f. Clear the previous selection by clicking the *Clear Selection*  icon in the attribute table.
5. If the max speed data are only in miles per hour:

a. Add a new field in the attribute table (*Table Options*  > *Add Field*.
b. In the *Add Field* window:
    i. In the *Name* text box, type *SPEED_kmh*.
    ii. In the *Type* dropdown list, choose *Double*.
    iii. Click *OK.*
c. Right click on *SPEED_kmh* in the attribute table and choose *Field Calculator.*
d. In the *Field Calculator* window:
    i. From the *Fields* list, double click on the "SPEED" field.
    ii. In the *Expression* box, type ** 1.60934* after the field name.
    iii. The full expression is *[SPEED] * 1.60934*
    iv. Click *OK.*

The spatially joined layer (e.g. *Roads_spatialjoin.shp*) contains the maximum speed limit for the TIGER/Line roads in miles per hour and kilometers per hour. The database creation is continued in the Create User Point of Interest (POI) Layer section.

Using QGIS

This section illustrates the creation of EPA H2O compatible road data using QGIS software.

1. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
2. From the *Layer* menu (*Figure 126*) open the *Add Vector Layer* window (*Main Menu > Layer > Add Vector Layer*).
3. In the *Add vector layer* window (example shown in *Figure 127*), click *Browse* to locate each TIGER/Line roads shapefile, then click *Open*.
4. If using a previously created Max Speed dataset, the layer must be added in the same way.
5. Right-click on each layer, including the Max Speed layer (if available), and select the *Save as…* option.
6. In the *Save vector layer as…* window (example shown in *Figure 131*):
    a. In the *Format* dropdown list, select *ESRI Shapefile.*
    b. In the *Save as* text box, browse to or type the desired output shapefile name (e.g. *Roads057.shp)* and file path. The TIGER/Line outputs must be saved together in a new folder, and the Max Speed dataset must be saved under a different file path.
    c. In the *CRS* dropdown list, choose *Selected CRS,* and click the *Browse* button to locate *WGS 84 / Pseudo Mercator.*
    d. Check *Add saved file to map.*
    e. Do not check *Skip attribute creation.*
    f. Click *OK.*
7. In the *Layers* panel, right-click on the original road shapefiles and choose *Remove.*
8. Open the *Merge shapefiles* tool to combine all TIGER/Line shapefiles (*Vector > Data Management Tools > Merge shapefiles to one* (*Figure 279*)).

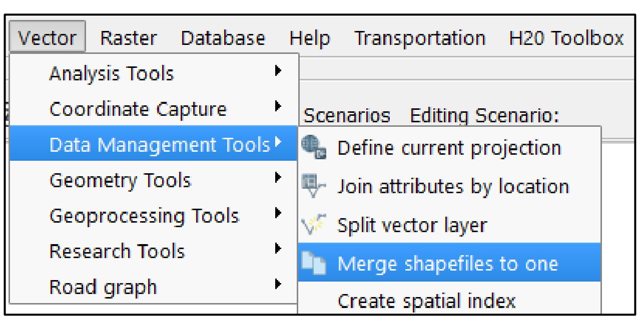


Figure 279 Location of the Merge shapefiles to one tool in EPA H2O

9. In the *Merge shapefiles* window (*Figure 280*):
   a. In the *Shapefile type* dropdown list, choose *Line*.
   b. Under *Input directory*, click *Browse* to navigate to the new TIGER/Line shapefile folder created to hold the outputs from the step 6.
   c. In the *Output shapefile* text box, name the output shapefile (e.g. *TIGER_join.shp*) and file path.
   d. Check *Add result to map canvas*.
   e. Click *OK.*

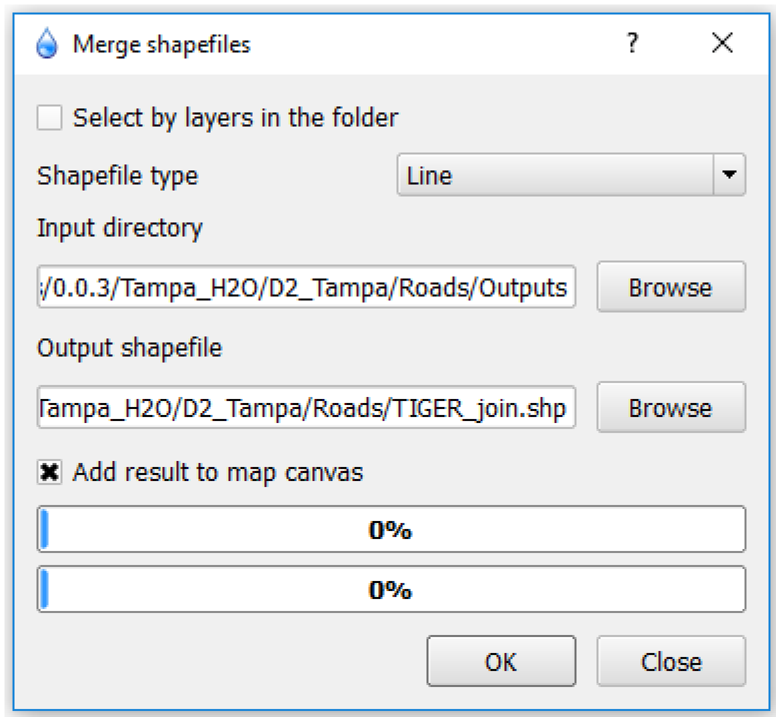


Figure 280 Merge shapefiles window, with the Roads/Outputs as the Input directory

Create Max Speed Data

This section illustrates the creation of Maximum Speed data using the supplemental lookup table (Appendix C: Roads Speeds Table). If the user obtained a Max Speed shapefile dataset, skip to the User-Obtained Max Speed Data section.

1. Load the *MaxSpeed_lookup.csv* table into the Layers panel, exported from Appendix C: Roads Speeds Table.
2. In the Layers panel, double click on the merged Roads shapefile (e.g. *TIGER_join)* to open *Layer Properties.*
3. Under the *Joins* tab, click the *Add Join*  icon.
4. In the *Add vector join* window (example shown in *Figure 200*):
   a. In the *Join layer* dropdown list, select *MaxSpeed_lookup*.
   b. In the *Join field* dropdown list, choose “MTFCC”.
   c. From the *Target field* dropdown list, select “MTFCC”.
   d. Check *Cache join layer in virtual memory.*
   e. Click *OK.*
5. Right click on the merged Roads shapefile (e.g. *TIGER_join)* and select *Save as* (*Figure 132*).

6. In the *Save vector layer as…* window (example shown in *Figure 133*):
   b. In the *Format* dropdown list, select *ESRI Shapefile.*
   c. In the *Save as* text box, browse to or type the desired file path and name the output *Roads.shp*.
   d. In the *CRS* dropdown list, choose *Selected CRS,* and click the *Browse* button to locate *WGS 84 / Pseudo Mercator.*
   e. Check *Add saved file to map.*
   f. Do not check *Skip attribute creation.*
   g. Click *OK.*

The *Roads.shp* output will contain the maximum speed data in miles per hour and kilometers per hour. The database creation is continued in the Importing Layers into QGIS section.

User-Obtained Max Speed Data

This section describes steps for using a Max Speed shapefile dataset.

1. Open the *Join attributes by location* tool, as shown in *Figure 158.*
2. In the *Join attributes by location* window (example shown in *Figure 159*).
   a. Under the *Target vector layer* dropdown list, choose the merged TIGER/Line shapefile (e.g. *TIGER_join.shp*).
   b. In the *Join vector layer* dropdown list, select the saved Max Speed layer (e.g. *maxspeed_reproj)*.
   c. Under *Attribute Summary*, toggle *Take summary of intersecting features,* and check *Mean.*
   d. In the *Output Shapefile* text box, browse to or type the file path and name the shapefile *Roads.shp.*
   e. Under *Output table*, choose *Keep all records (including non-matching target records)*
   f. Click *OK.*

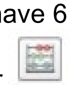
Please note that this spatial join may take a few moments to process.

Troubleshooting Common Errors:

Problem:

A common error in this step results in an *Incorrect field names* error (*Figure 209*). Three pieces of information help to understand the cause of this error: (1) Field names cannot be longer than 10 characters (2) Attribute Summary by Mean renames fields by adding MEAN in front of the original field name (3) This results in field names with more than 10 characters when the original is more than 6 characters.

Solution:

The user must create a new field for each of the fields listed in the error message. Open the *Layer Properties* window for the corresponding layer and click the *pencil*  icon to start editing. Click on the *New Column*  icon to add a new field to the fields list (example shown in *Figure 205*). The new field name must have 6 or less characters and have the same *Type* as the field it is replacing. Open *Field Calculator*  and choose *Update Existing Field*; from the dropdown list, select the newly created field. From the *Field and Values* dropdown list, double click on the field to be replaced. After the field appears in the *Expression* box, click *OK.* Delete the old field from *Layer Properties*, using the *Delete Column*  icon. Repeat these steps for each of the fields listed in the error. Save the changes made to the *Layer Properties* and retry the *Join attributes by location* tool.

Once max speeds have been successfully added to the Roads shapefile these speeds may need to be updated to meet the requirements of EPA H2O. The field must be named “SPEED”, cannot contain zero values and should be in both miles per hour (MPH) and kilometers per hour (KMH).

3. To rename the field with the maximum speed data to “SPEED”:
   a. Create a new field in the attribute table named “SPEED”, with *Whole number (integer)* type.
   b. Populate this field with the maximum speed data using *Field Calculator.*
4. To update speeds with zero values to 25:
   a. In the Layers panel, locate *Roads* and toggle the display off, then right-click to open the attribute table.
   b. In the *Roads* attribute table, locate the *Look for* option:
      i. In the *Look for* text box, type *NULL* (as shown in *Figure 248*).
      ii. In the field dropdown list, select “SPEED”.
      iii. Click *SEARCH*.
      Please note that the selection may take a few moments. Do not close the attribute table.
   c. After the *NULL* values are selected, click the *pencil* icon to start editing.
   d. Click the *Field Calculator* icon to open *Field Calculator.* In the *Field Calculator* window (example shown in *Figure 247*):
      i. Check the *Only update selected features* option.
      ii. Check the *Update existing field* option.
      iii. In the field dropdown list, select the “SPEED” field.
      iv. In the *Expression* box, type 25.
      v. Click *OK.*
   e. Click the *Clear Selection* icon to clear the current selection.
   f. Toggle editing off by clicking the *pencil* icon and save the edits.
5. If the max speed data are only in miles per hour:
   a. In the Layers panel, right-click on the *Roads* layer and open the attribute table.
   b. Click the *pencil* icon to start editing.
   c. Click the *Field Calculator* icon to open *Field Calculator.* In the *Field Calculator* window (example shown in *Figure 247*):
      i. Check the *Create New Field* option.
      ii. In the *Output field name* text box, type *SPEED_kmh*
      iii. From the *Output field type* dropdown list, select *Decimal number (real)*.
      iv. Leave the *Output field width* and *precision* set to the default.
      v. From the *Fields and Values* dropdown list, double click on the “SPEED” field.
      vi. In the *Expression* box, type ** 1.60934* after the field name. The full expression is *"SPEED” * 1.60934*
      vii. Click *OK*.
   d. Toggle editing off by clicking the *pencil* icon and save the edits.

The *Roads.shp* output will contain the maximum speed data in miles per hour and kilometers per hour. The database creation is continued in the Create User Point of Interest (POI) Layer section.

Create User Point of Interest (POI) Layer

This section illustrates the step- by -step procedure to create a user-defined *Point of Interest* layer. Point features in the *Point of Interest* layer define the destinations in the Transportation Tool (Advanced Module Only). The user can modify the existing transportation network based on these points of interest.

1. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
2. Use the QGIS Plugin Manager (*Main Menu* > *Plugins* > *Manage Plugins*) to make sure the Qspatialite plugin is enabled, as shown in *Figure* 290. If not already enabled, check the box next to *QSpatiaLite (Version 6.0.3)* to activate the plugin, and click OK.
3. Open the Qspatialite plugin (*Main Menu* > *Database* > *SpatiaLite* > *Qspatialite*, *Figure 291*).
4. The Qspatialite window will open (*Figure* 292). Click the database dropdown list and locate the user database. If the name of the database is not listed, it must be connected to the Qspatialite plugin.
5. If the user-created database is not connected:
   a. Connect to the *UserDatabase.sqlite* database by clicking the *Open/Create new Database* icon . *UserDatabase.sqlite* is a renamed copy of *TampaBay.sqlite,* created in the Setting Up a Project Directory section.
   b. A warning message may appear that states “UserDatabase.sqlite already exists. Do you want to replace it?” If this appears click *Yes.*
6. The name of the active database appears in the dropdown box. Make sure this is the user-created database.
7. In the *Tables* list, right-click on *User_POIs*, and select *Drop Table.*
8. From the main menu, select *Layer* menu > *New* > *New Spatialite Layer…*, as shown in *Figure 281*.

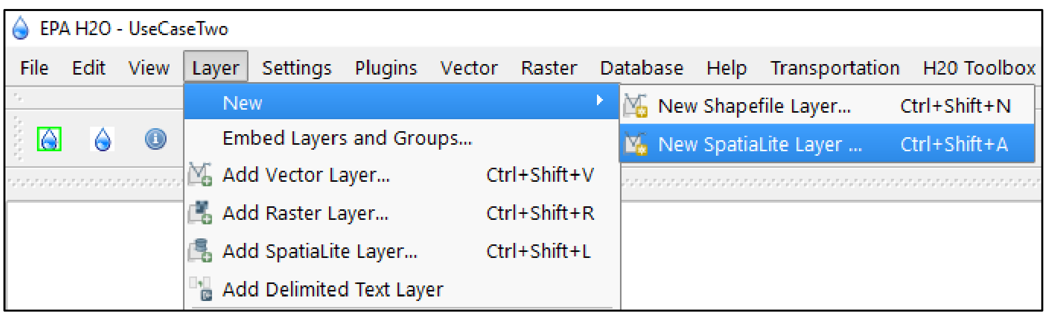


Figure 281 Add a new Spatialite layer in EPA H2O Power Mode

9. The *New Spatialite Layer* window will appear as shown in *Figure 282*. In the *New Spatialite Layer* window:
   a. Under the *Database* option, click the *Choose a new database* icon, and navigate to the new database created in Setting Up a Project Directory. This database does not contain POIs for areas outside of Tampa, but using it as a template ensures the new user-defined POIs are structured to work with the Transportation Tool (Advanced Module Only).
   b. In the *Layer name* text box, enter *User_POIs*.
   c. In the *Type* option box, select *Point*.
   d. Click the *Specify CRS* button and in the *Filter* box, type *3857.* Select *WGS 84 / Pseudo Mercator* and click *OK.*
   e. Check the *Create an autoincrementing primary key* check box.
   f. Within the *New Attribute* section:

    i. In the *Name* text box enter "NAME".
    ii. From the *Type* dropdown list, select "Text data".
    iii. Click *Add to attributes list* button. The “NAME” attribute will appear in the *Attributes list* section.

g. Repeat to add the following attributes:
    i. In the *Name* text box enter "TYPE_DESC", and in the *Type* dropdown list, select “Text data”.
    ii. In the *Name* text box enter "REC_USE", and in the *Type* dropdown list, select “Text data”.
    iii. In the *Name* text box enter "XCOORD", and in the *Type* dropdown list, select “Decimal number”.
    iv. In the *Name* text box enter "YCOORD", and in the *Type* dropdown list, select “Decimal number”.
    v. In the *Name* text box enter "xUTM", and in the *Type* dropdown list, select “Decimal number”.
    vi. In the *Name* text box enter "yUTM", and in the *Type* dropdown list, select “Decimal number”.
    vii. In the *Name* text box enter "Cost", and in the *Type* dropdown list, select “Decimal number”.

h. After the eight new attributes are listed in the *Attributes list* section (*Figure 282*), click *OK*.

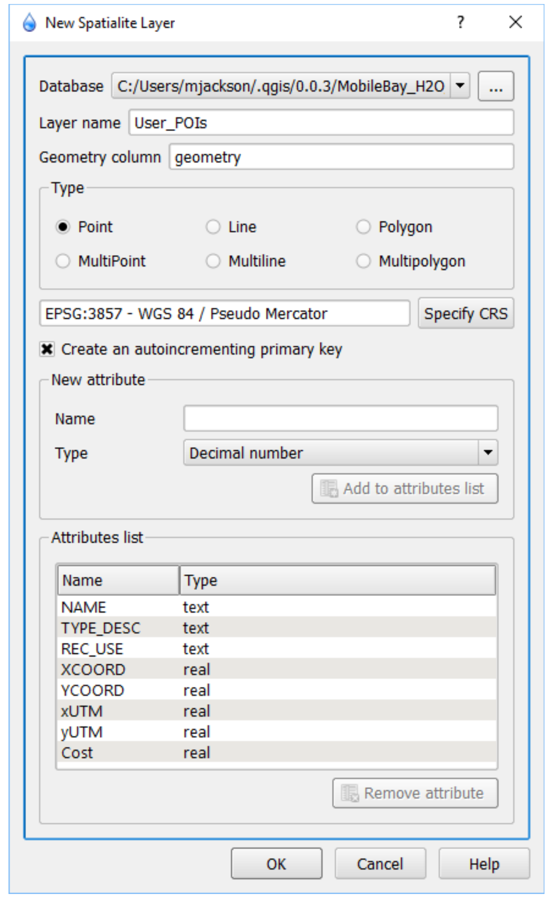


Figure 282 New Spatialite Layer window

An empty point layer has been added to the new QSpatialite database, which will be populated with the points of interest when using the Transportation Tool (Advanced Module Only) in EPA H2O.

The database creation steps are complete. The Importing Layers into QGIS section details how to import the finals layers into the user database using the QGIS Qspatialite plugin.

Importing Layers into QGIS

Each of the final layers created throughout Database Creation must be imported into the QGIS Qspatialite plugin. Updating the Qspatialite table removes the Tampa-specific data from the user database and replaces it with AOI-specific data. This section details how to upload the AOI shapefile (HUC watershed boundary layer) into Qspatialite. The same steps must be followed to import the other updated layers; *Table 15* outlines the updated layers that need to be uploaded, and the naming scheme required for each.

1. Open EPA H2O in Power Mode.
2. In the *Choose a Module* window, click *OK* (*Figure 283*).

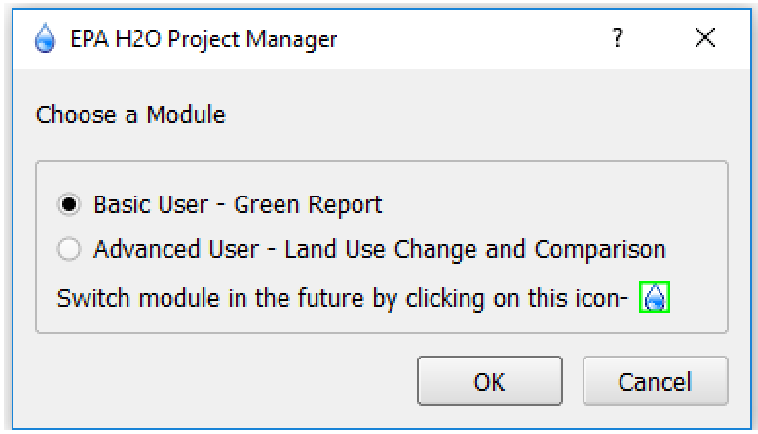


Figure 283 EPA H2O Choose a Module window

3. In the *Select Project* window, select *Open existing project* or *Create new project*. For first time Power Mode users, choose *Create new project* (*Figure* 284).

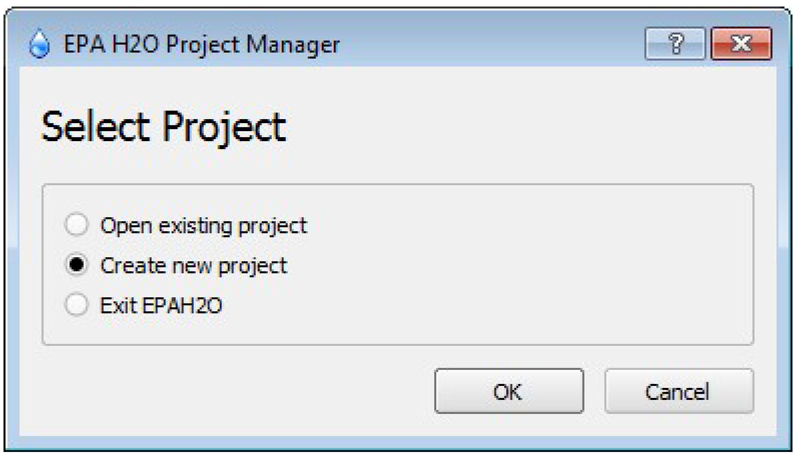


Figure 284 EPA H2O Select Project window

4. In the *Project Configuration* window (*Figure 285*):
    a. Confirm that the *Source Database Name* is referencing the original *TampaBay.sqlite*. If the source database is not the original *TampaBay.sqlite*, click the *Select* button, and navigate to the original "0.0.3" folder.
    b. In the *Name Your Project Database* text box, enter the preferred project name (e.g. *Demo)*, and click *OK.*

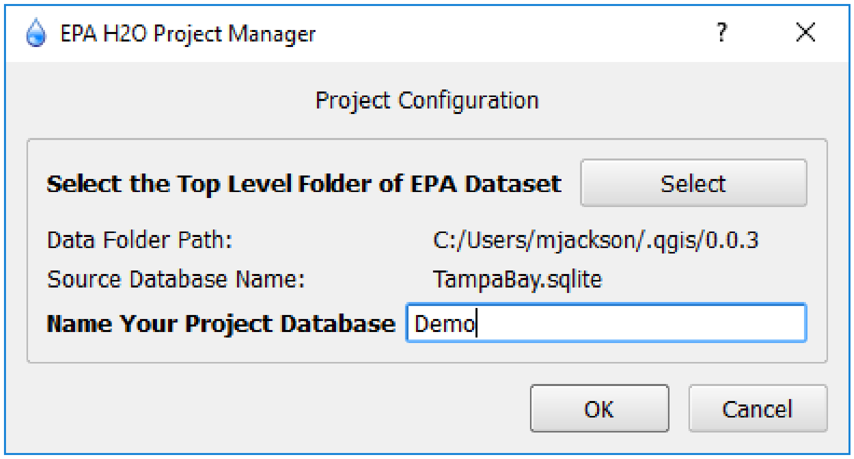


Figure 285 Project Configuration window

5. In the *Select Area of Interest* window, click *Cancel*.
6. From the *Settings* menu (*Figure 116*), open the *Project Properties* window (*Main Menu > Settings > Project Properties*).
7. In the *Project Properties* window (*Figure 286*):
   a. Click the *Coordinate Reference System (CRS)* tab and check the box labeled *Enable 'on the fly' CRS transformation*.
   b. In the *Filter* text box, type *3857*.
   c. Under the *Coordinate reference systems of the world* section, select *WGS 84 / Pseudo Mercator*.
   d. Click *OK* to apply these changes and close the *Project Properties* window.

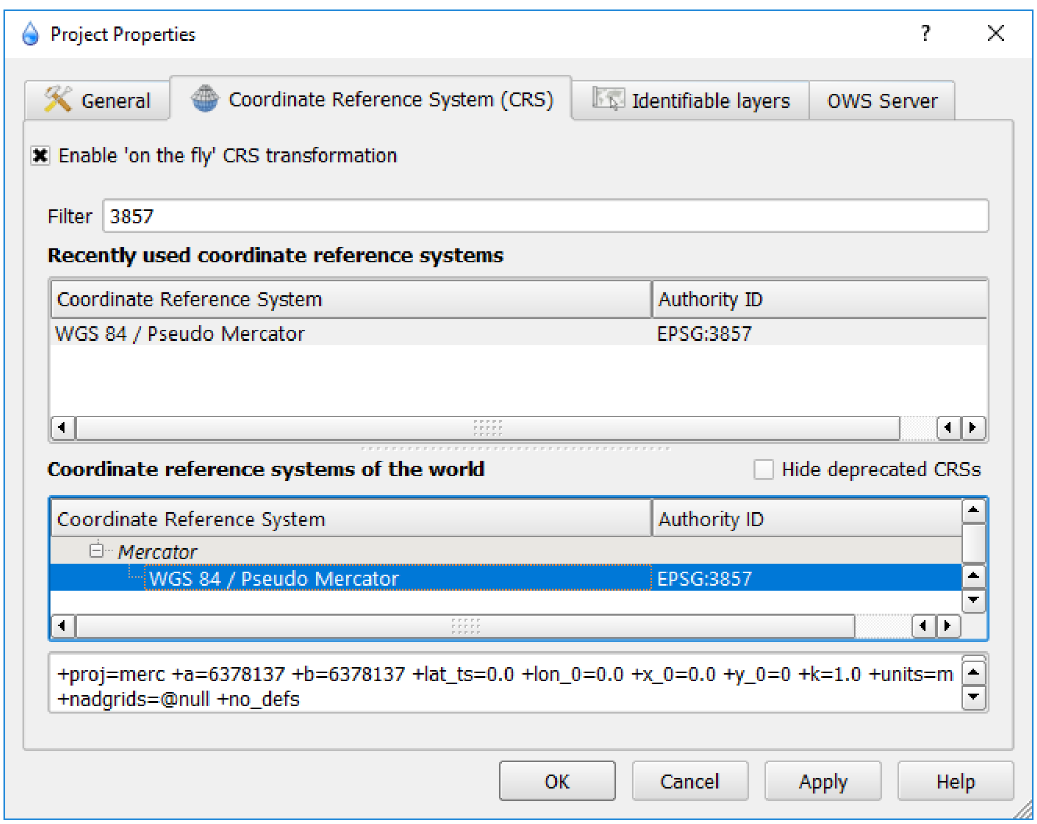


Figure 286 Project Properties window in EPA H2O

8. From the *Layer* menu (*Figure 287*) open the *Add Vector Layer* window (*Main Menu > Layer > Add Vector Layer*).

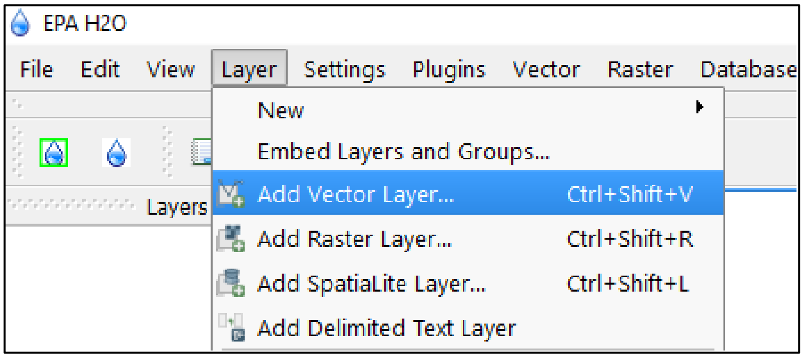


Figure 287 Location of the Add Vector Layer tool in EPA H2O

9. In the *Add vector layer* window (*Figure* 288), click *Browse* to locate and select the layer being added (e.g. the HUC watershed boundaries layer, *HUC_Tampa.shp*), then click *Open*.

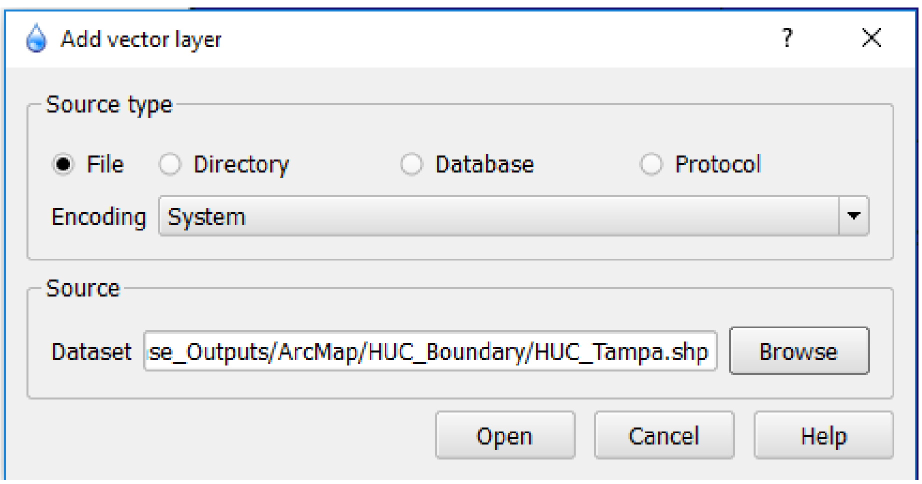


Figure 288 *EPA H2O Add Vector Layer window*

10. In the Layers panel, right-click on the added layer (e.g. *HUC_Tampa*) and choose *Set Layer CRS* (*Figure* 289).

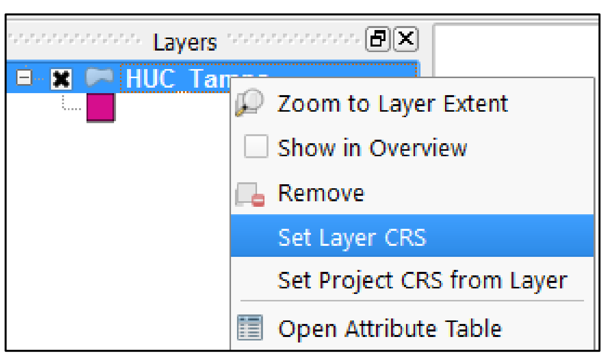


Figure 289 *Set Layer CRS in EPA H2O*

11. In the *Filter* box, type *3857* and under the *Coordinate reference systems of the world* section, choose *WGS 84 / Pseudo Mercator*. Click *OK*.
12. In the Layers panel, right-click on the added layer again, choose *Rename*, and type the Required Qspatialite Name from *Table 15* that corresponds to the layer. For the HUC boundaries layer, *Watersheds* is required as the new layer name, and the layer must be renamed "Watersheds" to function correctly in the database.
13. Use the QGIS Plugin Manager (*Main Menu > Plugins > Manage Plugins*) to make sure the QSpatialite plugin is enabled, as shown in *Figure* 290. If not already enabled, check the box next to *QSpatiaLite (Version 6.0.3)* to activate the plugin, and click OK.

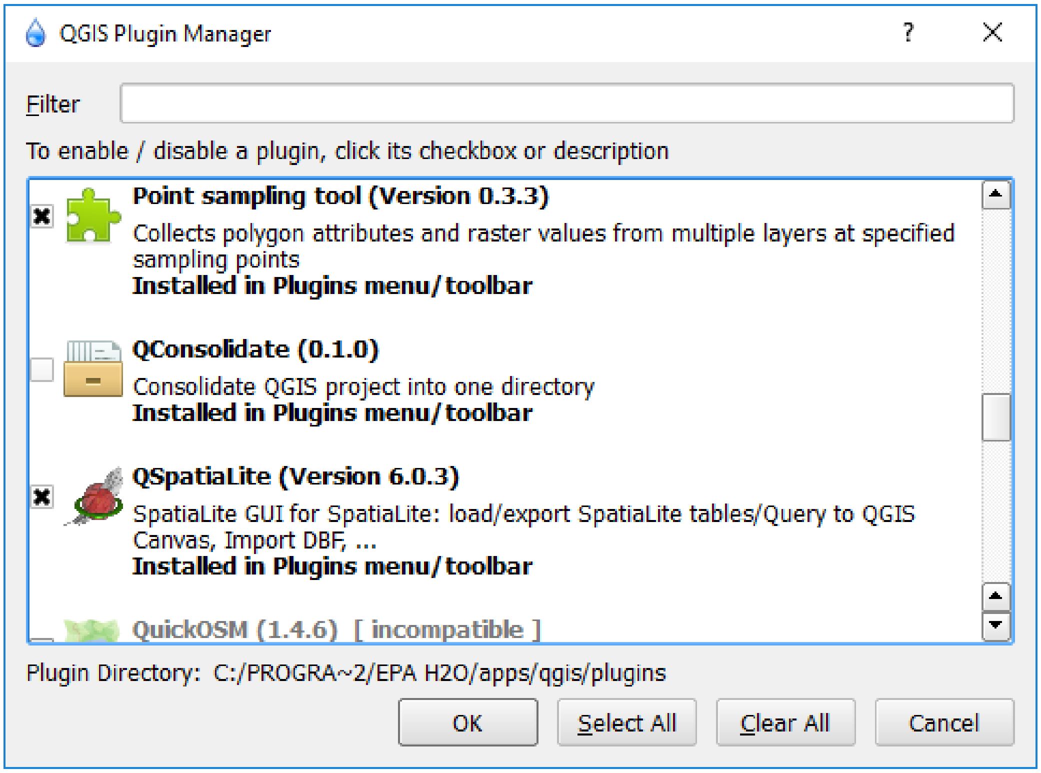


Figure 290 Confirm the box next to Qspatialite plugin in checked

14. Open the Qspatialite plugin (*Main Menu > Database > SpatiaLite > Qspatialite*, *Figure 291*).

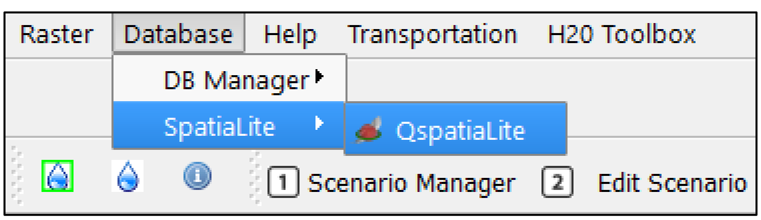


Figure 291 Location of the Qspatialite plugin in EPA H2O

15. When the Qspatialite window opens (*Figure* 292), the name of the active database appears in the database box (i.e. *TampaBay.sqlite* in *Figure* 292). Click the database dropdown (downward arrow beside database box) to see the full dropdown list of connected databases. Both the original *TampaBay.sqlite* database and the user-created database must be listed in the database dropdown list.

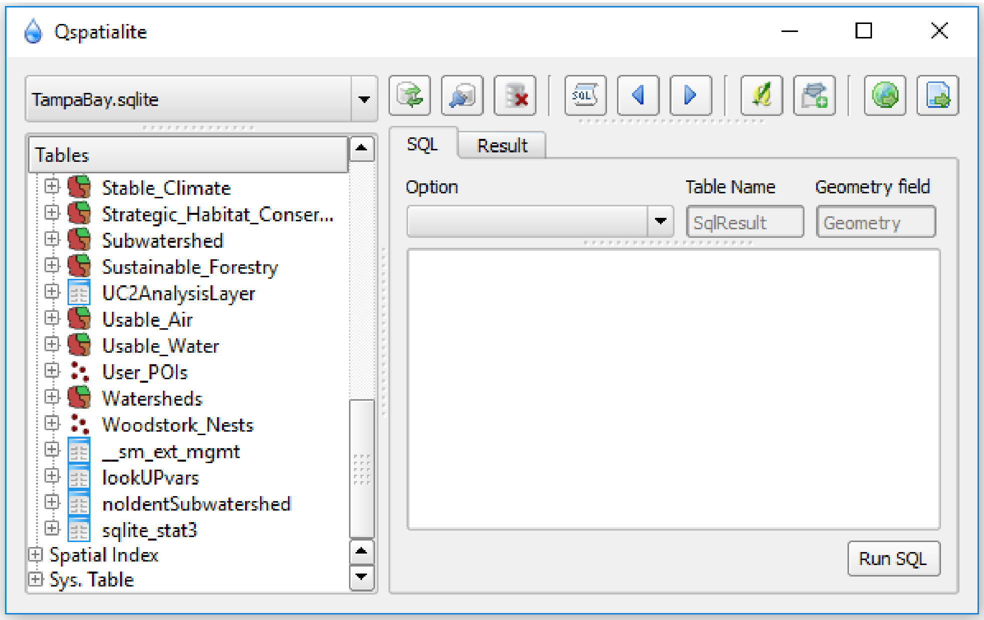


Figure 292 Qspatialite plugin window in EPA H2O

16. If the original *TampaBay.sqlite* database is not listed:
    a. Connect to the *TampaBay.sqlite* database by clicking the *Open/Create new Database* icon . The database is placed in the following directory during installation: (~\.qgis\0.0.3\data\database\TampaBay.sqlite).
    b. A warning message may appear that states "TampaBay.sqlite already exists. Do you want to replace it?" If this appears click *Yes.*
17. If the user-created database is not listed:
    a. Connect to the *UserDatabase.sqlite* database by clicking the *Open/Create new Database* icon . *UserDatabase.sqlite* is a renamed copy of *TampaBay.sqlite,* created in the Setting Up a Project Directory section.
    b. A warning message may appear that states "UserDatabase.sqlite already exists. Do you want to replace it?" If this appears click *Yes.*
18. Make the user-created database the active database by selecting it from the database dropdown list (*Figure 293*).
19. Tables in the active database are listed in the *Tables* box, below the active database name. Before a new layer can be added to a database, tables with the same name as the layer (e.g. the *Watersheds* table*),* must be removed by right-clicking the table name and choosing *Drop Table* (*Figure 293*).

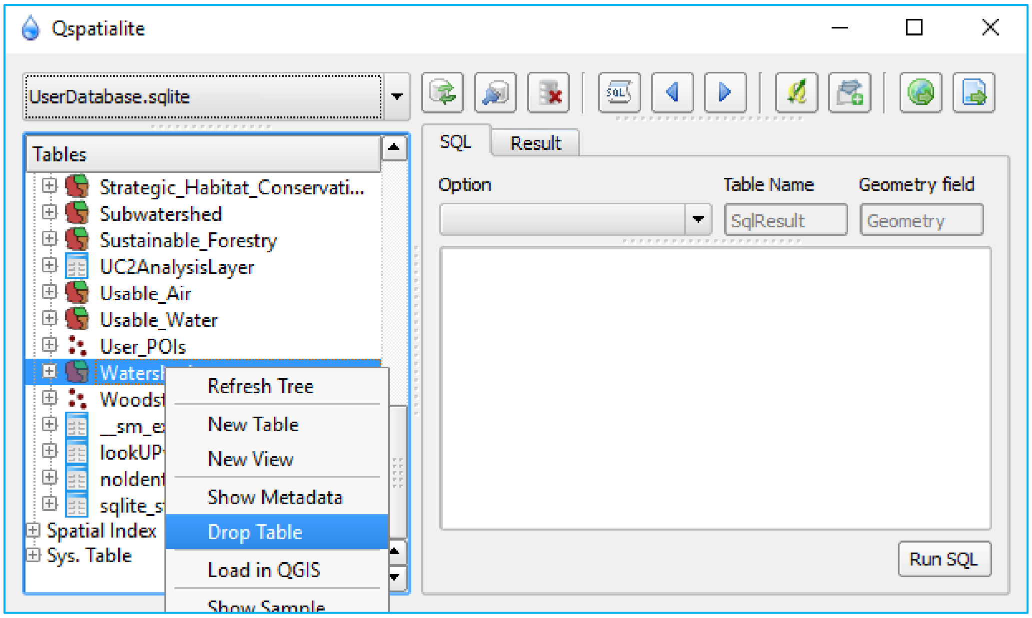


Figure 293 Drop the original Watersheds table in Qspatialite with a right-click

20. To add the new layer in the database, click on the *Import QGIS Layers* icon  in the Qspatialite window. In the *Import QGIS Layers* window (Figure 294):

    a. Highlight the layer to be added (e.g. Watersheds) from the list of layers in the current map.

    b. Check the box next to *Destination SRID* and type *3857* into the text box.

    c. Click OK

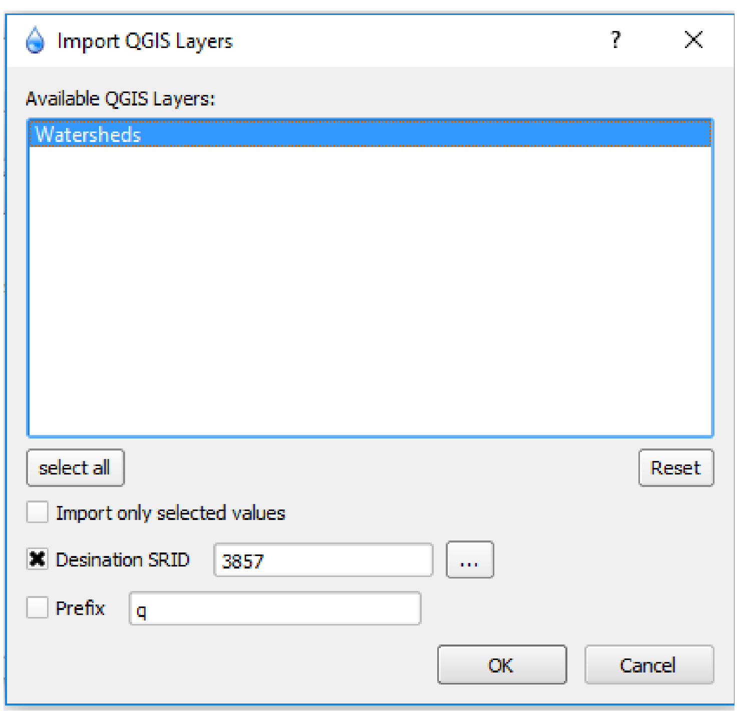


Figure 294 Import Watersheds layer into Qspatialite

The final Qspatialite table in QGIS should contain the updated tables for Watersheds, Land Use, Roads, and Hydrology, as well as the updated lookup table. Please note, the final lookup table must be updated in Qspatialite, even if FLUCCS land use and the original lookup table were used for database creation. The name and description of each updated layer is detailed in *Table 15*, with the name required for the user database.

Table 15 Final Qspatialite table inputs, with the description of each layer, and links to each creation section

Example File	**Layer Description**	**Required Qspatialite Name**	**Creation Section(s)**
HUC_Tampa.shp	Shapefile of user-specific HUC watershed boundaries	*Watersheds*	Create HUC Watershed Boundaries
Land_Use.shp	Shapefile with spatially joined land use and soil data, updated ES coefficients, and has been joined with the lookup table with complete field calculations	*Land_Use*	Create Land Use Data Layer Create Soil Data Layer Update ES Coefficients Joining Lookup Table
Roads.shp	Shapefile with spatially joined TIGER/Line roads (appended) and Max Speed data	*Roads*	Create Road Layer
Catchment_reproj.shp OR *Catchment_GridBay.shp*	NHD Catchment shapefile, OR with hexagon layer added (Esri ArcGIS only)	*Subwatershed*	Create NHDPlus V2 Data Layers
NHDFlowline_reproj.shp	NHD Flowline shapefile	*NHD_flowlines*	
NHDWaterbody_reproj.shp	NHD Waterbody shapefile	*NHD_Waterbody*	
lookUPvars.dbf	supplemental lookup table with updated ES coefficients	*lookUPvars*	Updated throughout Database Creation

For full functionality the Qspatialite table must contain the default tables copied from the original Tampa Bay database.

After the tables created throughout Database Creation have been input into the Qspatialite plugin, the user's database is functional in the Advanced Module setting of EPA H2O. The user may select their AOI By Shapefile By Drawing on Map, or By River Basin (Advanced Module Only).

To select an AOI By County in the new database, the *Counties* layer must be updated in the Qspatialite plugin. This requires a *Counties* shapefile, containing the county boundaries from the area of interest. The shapefile must also list the name of each county in a "NAME" field (the field name "NAME" is required for functionality).

Update Land Use Comparison Datasets in Qspatialite

The user may choose to replace the original *FUTUREtwenty*, *FUTUREforty* and/or *FUTUREsixty* tables with their own scenarios, as explained in the Create Land Use Comparison Data section. The new land use comparison dataset(s) must be input into the Qspatialite plugin under the names created within the Tampa Bay database. The user may add up to three land use comparison datasets, and must rename their layer(s) *FUTUREtwenty, FUTUREforty,* and/or *FUTUREsixty.* These will appear as *Land_Use_2020, Land_Use_2040,* and *Land_Use_2060* (respectively) in EPA H2O, even if data from other years were inserted. The user may change these display names by updating the *UC2AnalysisLayer* table:

1. Open the Qspatialite plugin and locate *UC2AnalysisLayer* within the user database.
2. Right-click on the table and choose *Load in QGIS.*
3. In the Layers panel, right-click on *UC2AnalysisLayer* and choose *Save As.*
    a. In the *Format* dropdown list, select *Comma Separated Value.*
    b. Click *Browse* to save the output in a known location and name the output *UC2AnalysisLayer.*
    c. Click *OK.*
4. Locate the *UC2AnalysisLayer* in File Explorer, right-click, and open the file with Notepad or the preferred text editor.
    a. The user may change *Land_Use_2020, Land_Use_2040,* and/or *Land_Use_2060* to display a different year. For example, *Land_Use_2020* can be changed to *Land_Use_2001.* However, the name must start with *Land_Use_20*; only the last two digits can be changed.
    b. Please note, the *Land_Use_2006* name **cannot be changed**, and therefore other comparison layers cannot be named *Land_Use_2006.*
    c. Save the updated CSV file.
5. From File Explorer, drag and drop the updated file into the EPA H2O Layers panel.
6. Using the Qspatialite plugin, remove the previous *UC2AnalysisLayer* table from the user database and add the new *UC2AnalysisLayer* (as shown in Importing Layers into QGIS).

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Appendices

Appendix A: Supplemental NLCD Lookup Table

This section contains the supplemental NLCD lookup table (*Table 16*), which is updated throughout database creation. The lookup table contains NLCD land use descriptions, as well as the coefficients required for EPA H2O functionality. The table must be exported as a .csv and converted to a .dbf to make changes using Esri ArcGIS or QGIS. *Table 17* lists the references used to determine the Denitrification and Carbon Buried coefficients for each NLCD land use class in the lookup table.

Using ArcGIS

1. Copy both sections of *Table 16* ("PKUID" through "FloodProt" fields) into a new Excel spreadsheet. Save the file to a known location and name the output with a .csv extension (e.g. *lookUPvars_supplemental.csv*).
   a. Note: if an error occurs while importing the .csv file into ArcMap, resave the Excel spreadsheet with a .txt extension.
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. Use the *Add Data*  icon to navigate to and add the lookup .csv file (e.g. *lookUPvars_supplemental.csv*) as a layer in the Table of Contents.
4. In the Table of Contents, right-click on the lookup table and choose *Data* > *Export.* In the *Export Data* window:
   a. In the *Export* dropdown list, select *All records*.
   b. Next to the *Output table* text box, click the *Browse* button and navigate to the preferred file path. In the *Save as type* dropdown list, select *dBASE Table,* and in the *Name* text box, enter *lookUPvars**.dbf**.* Click *Save.*
   c. Click OK.

The exported lookup table should be edited to update the coefficients for the user's specific area of interest following the steps outlined in the Update ES Coefficients section. The "canopyVal", "usablewat", "StableClim", "Us_Air_Dol", "CN" and "FloodProt" fields will be populated in the Joining Lookup Table section. Once the table has been updated for the specific area of interest, it is imported into the Qspatialite plugin as described in the Importing Layers into QGIS section.

Using QGIS

1. Copy both sections of *Table 16* ("PKUID" through "FloodProt" fields) into a new Excel spreadsheet. Save the file to a known location and name the output with a .csv extension (e.g. *lookUPvars_supplemental.csv*).
2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. From the main menu, select *Layer* > *Add Delimited Text Layer.*
4. In the *Create a Layer from a Delimited Text File* window:
   a. Click the *Browse* button to locate the lookup .csv table.
   b. Under the *Selected Delimiter* option, select *Comma*.
   c. In the *X field* and *Y field* dropdown list, leave the default fields.
   d. Click *OK*.
5. QGIS may try to map the attributes, this can be disregarded. In the Layers panel, right-click on the lookup table and choose *Save as.*
6. In the *Save vector layer as* window:
   a. In the *Format* dropdown list, select *ESRI Shapefile.*
   b. In the *Save as* text box, browse to the desired location and name the output *lookUPvars.shp.*

    c. In the *CRS* dropdown list, choose *Selected CRS,* and click the *Browse* button to locate *WGS 84 / Pseudo Mercator.*
    d. Click *OK.*
7. In File Explorer, locate the .dbf file that coincides with the lookup shapefile (*lookUPvars.dbf*) and click and drag the file into the Layers panel.

Although the exported lookup table is saved as a “shapefile”, the output is an editable table (*lookUPvars.dbf*), which is updated throughout database creation to change the coefficients for the user’s specific area of interest. The “canopyVal”, “usablewat”, “StableClim”, “Us_Air_Dol”, “CN” and “FloodProt” fields will be populated in the Joining Lookup Table section. Once the table has been updated for the specific area of interest, it is imported into the Qspatialite plugin as described in the Importing Layers into QGIS section.

Table 16 Supplemental NLCD lookup table, with land use descriptions and coefficients needed for EPA H2O

PKUID	FLUCCS	FLUCSDESC	GRIDCODE	NLCDDesc	denitrific	CarbonFixe	Canopy	canopyVal
32	5400	Open Water	11	Open Water	8.3	155	0	
11	1900	Developed Open Space	21	Developed Open Space	1.27	105	22	
1	1100	Developed Low Intensity	22	Developed Low Intensity	0.98	78	10	
2	1200	Developed Medium Intensity	23	Developed Medium Intensity	0.6	45	3	
3	1300	Developed High Intensity	24	Developed High Intensity	0.24	17	1	
6	1600	Barren Land (Rocks/Sand/Clay)	31	Barren Land (Rocks/Sand/Clay)	1.1	0	1	
26	4200	Deciduous Forest	41	Deciduous Forest	0.2	8	71	
23	4100	Evergreen Forest	42	Evergreen Forest	0.1	47	57	
27	4340	Mixed Forest	43	Mixed Forest	0.1	28	75	
21	3200	Shrub/Scrub	52	Shrub/Scrub	0.9	20	5	
20	3100	Grassland/ Herbaceous	71	Grassland/Herbaceous	0.1	30	3	
12	2100	Pasture/Hay	81	Pasture/Hay	1.4	49	6	
16	2400	Cultivated Crops	82	Cultivated Crops	0.9	43	1	
41	6300	Woody Wetlands	90	Woody Wetlands	17.2	194	67	
42	6400	Emergent Herbaceous Wetlands	95	Emergent Herbaceous Wetlands	12.9	187	8	

A	B	C	D	LEV1	dni	waterRet	stabClim	usWat	usablewat	StableClim	Us_Air_Dol	CN	FloodProt
100	100	100	100	5	8.3	2	37	3					
39	61	74	80	1	1.27	2	37	3					
54	70	80	85	1	0.98	2	37	3					
61	75	83	87	1	0.6	2	37	3					
77	85	90	92	1	0.24	2	37	3					
77	86	91	94	7	1.1	2	37	3					
36	60	73	79	4	0.2	2	37	3					
36	60	73	79	4	0.1	2	37	3					
36	60	73	79	4	0.1	2	37	3					
35	56	70	77	3	0.9	2	37	3					
30	58	71	78	3	0.1	2	37	3					
39	61	74	80	2	1.4	2	37	3					
72	81	88	91	2	0.9	2	37	3					
49	65	72	80	6	17.2	2	37	3					
49	65	72	80	6	12.9	2	37	3					

Table 17 References used to determine Denitrification and Carbon Buried coefficients for each NLCD land use class

NLCD Land Use Classes	Denitrification References	Carbon Buried References
Open Water	An et al. 2001; An and Gardner 2002; Bianchi et al. 1999; Brenner et al., 2001; DeLaune et al. 2005; Fennel et al. 2009; Gardner et al. 2006; Gihring et al. 2010; Heffernan and Cohen 2010; James et al., 2011; Joye and Anderson 2008; Messer and Brezonik 1983; Mortazavi et al. 2000; Pina-Ochoa and Alvarez-Cobelas 2006; Pina-Ochoa and Alvarez-Cobelas 2006; Seitzinger 1988; Seitzinger et al. 2006; Smith et al. 1985	Boyd et al. 2010; Brenner et al. 2001; Craft and Richardson 1993; Munsiri et al. 1995; Tepe and Boyd 2002
Developed Open Space	Calculated as explained in the Determine Nitrogen Removal Rates section	Calculated as explained in the Carbon Fixation Rates for Developed Classes section
Developed Low Intensity		
Developed Medium Intensity		
Developed High Intensity		
Barren Land (Rocks/Sand/Clay)	Jackson et al. 1990	N/A

Deciduous Forest	Barton et al 1999; Chestnut et al. 1999	Downing et al. 2008; Johnston et al. 1996; Laffoley and Grimsditch 2009; Mcleod et al. 2011; Vesterdal et al. 2002
Evergreen Forest	Barton et al 1999; Henrich and Haselwandter 1997; Robertson et al. 1987	Garten Jr 2002; Hooker and Compton 2003; Huntington 1995; Richter et al 1999; Schiffman and Johnson 1989
Mixed Forest	Barton et al. 1999; Dutch and Ineson 1990; Goodroad and Keeney 1984	Calculated average based on “Deciduous Forest” and “Evergreen Forest” references
Shrub/Scrub	Jackson et al. 1990	Lawrence et al. 2012
Grassland/Herbaceous	Frank and Groffman 1998; Robertson et al. 1987; Tsai 1989	Burke et al. 1995; Downing et al. 2008; Gebhart et al 1994; Knops and Tilman 2000; Laffoley and Grimsditch 2009; Post and Kwon 2000
Pasture/Hay	Barton et al. 1999; Espinoza 1997; Seitzinger et al. 2006	Downing et al. 2008
Cultivated Crops	Barton et al. 1999, Espinoza 1997, Tsai 1989	Pacala et al. 2001; Houghton 1999
Woody Wetlands	Bowden 1987; DeLaune et al. 1998; Gale et al. 1993; Lindau et al. 2008; Seitzinger 1994; Walbridge and Lockaby 1994	Breithaupt et al. 2012; Engle 2011; Hanson and Nestlerode 2014
Emergent Herbaceous Wetlands	Craft et al. 2009; DeLaune et al. 1989; Dodla et al. 2008; Gale et al. 1993; Morris 1991; Nixon and Lee 1986; Reddy et al. 1989; Seitzinger 1988; Wigand et al. 2004	Brenner et al. 2001; Chmura et al. 2003; Day et al. 2004; DeLaune et al. 1981; Downing et al. 2008; Duarte et al. 2005; Laffoley and Grimsditch 2009

Appendix B: Air Quality Reference Table

This section contains the supplemental Air Quality reference table (*Table 18*), which details the average pollutant removal rates for 55 metropolitan areas in the continental United States (Nowak et al., 2006). The "TOTgm2" field contains the sum of the pollutant rates, and "Value_m2" is the sum of each monetary value multiplied by that total. The estimated values ($) for removal of each pollutant were $959/ton Carbon Monoxide, $6752/ton Ozone, $1653/ton Sulfur Dioxide, $4508/ton Particulate Matter (PM10), and $6752/ton Nitrogen Dioxide (Murray et al., 1994).

The user may locate the city nearest their area of interest and use the appropriate "Value_m2" value in the Air Quality section. If the user is unsure which city is closest to their area of interest, the user may alternatively copy *Table 18* into an Excel spreadsheet, and export the table to create a shapefile using Esri ArcGIS or QGIS.

Using ArcGIS

1. Copy *Table 18* into a new Excel spreadsheet. Save the file to a known location and name the output with a .csv extension (e.g. *AQ_AttributeTable.csv*).
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. From the main menu choose *File > Add Data > Add XY Data.* In the *Add XY Data* window:
   a. In the *Choose a table from the map or browse for another table* dropdown list, click the *Browse* button and navigate to the exported .csv file. The file name will appear in the dropdown list.
   b. In the *X Field* dropdown list select the "X" field, and in the *Y Field* dropdown list, select the "Y" field (if not already populated).
   c. Under the *Coordinate System of Input Coordinates* box, click the *Edit* button. In the *XY Coordinate System* search box, type *4326* and select *WGS 1984.* Click *OK.*
   d. Click *OK.*
4. A message will appear that explains "Table Does Not Have Object-ID Field". Click *OK.*
5. The table will appear in the Table of Contents. Right-click on the table and choose *Data > Export Data* (as shown in *Figure 123* and *Figure 124*).
6. In the *Export Data* window:
   a. In the *Export* dropdown list, select *All features*.
   b. Under the *Use the same coordinate system as* section, toggle *the data frame* option.
   c. In the *Output feature class* text box, name the output *AirQualityReference.shp.*
   d. Click *OK.*

The exported shapefile can be used in the Air Quality section, to calculate the land use air pollution removal rates based on the nearest city.

Using QGIS

1. Copy *Table 18* into a new Excel spreadsheet. Save the file to a known location and name the output with a .csv extension (e.g. *AQ_AttributeTable.csv*).
2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. From the main menu, select *Settings > Project Properties.*
4. In the *Project Properties* window:
   a. Toggle on the *Enable 'on the fly' CRS transformation* option if not already on by default.
   b. In the *Filter* box, type *4326,* and under *Coordinate reference systems of the world,* select *WGS 84.*
   c. Click *OK.*

5. From the main menu, select the *Layer* > *Add Delimited Text Layer.*
6. In the *Create a Layer from a Delimited Text File* window:
   a. Click the *Browse* button to locate the exported .csv file (e.g. *AQ_AttributeTable.csv*).
   b. Under the *Selected Delimiter* option, select *Comma*.
   c. In the *X field* dropdown list select the "X" field, and in the *Y field* dropdown list, select the "Y" field (if not already populated).
   e. Click *OK*.
7. In the Layers panel, right-click on the Air Quality table and choose *Save as.*
8. In the *Save vector layer as* window:
   a. In the *Format* dropdown list, select *ESRI Shapefile.*
   b. In the *Save as* text box, browse to the desired location and name the output *AirQualityReference.shp.*
   c. In the *CRS* dropdown list, choose *Selected CRS,* and click the *Browse* button to locate *WGS 84 / Pseudo Mercator.*
   d. Check *Add saved file to map.*
   e. Click *OK.*
9. **Repeat steps 3 and 4 to change the project coordinate system back to *WGS 84/ Pseudo Mercator.***

Note: after the coordinate system is changed back, layers that were previously in the Layers panel may need to be removed and re-added into the map to draw correctly.

The exported shapefile can be used in the Air Quality section, to calculate the land use air pollution removal rates based on the nearest city.

Table 18 Average removal rates for carbon monoxide (CO), ozone (O3), particulate matter (PM10), sulfur dioxide (SO2), and nitrogen dioxide (NO2) for 55 U.S. cities

FID	X	Y	City	State	COgm2	O3gm2	SOgm2	PMgm2	NOgm2	TOTgm2	Value_m2
0	-73.7562	42.65258	Albany	NY	0.1	3.4	0.5	2.4	1	7.4	0.04145
1	-106.606	35.0853	Albuquerque	NM	0.3	2.4	1.1	2.6	1.2	7.6	0.038134
2	-84.3863	33.75374	Atlanta	GA	0.3	4.6	0.8	3.8	1.2	10.7	0.057902
3	-97.7505	30.26693	Austin	TX	0.6	5.2	1.7	3.1	2	12.6	0.065975
4	-76.6094	39.29923	Baltimore	MD	0.3	4	1.3	3.7	2.7	12.1	0.064355
5	-91.1474	30.47116	Baton Rouge	LA	0.5	4.8	0.9	3.5	1.3	11	0.058932
6	-71.0571	42.36114	Boston	MA	0.3	3.8	1.1	2.8	2.1	10.2	0.054565
7	-73.1952	41.18649	Bridgeport	CT	0.3	3.4	0.8	2.8	1.6	9	0.047993
8	-78.8787	42.88023	Buffalo	NY	0.2	3.7	1.5	2.1	1	8.5	0.043873
9	-81.6326	38.34981	Charleston	WV	0.1	2.7	1	1.9	0.9	6.7	0.034621
10	-84.512	39.10312	Cincinnati	OH	0.3	3	1.2	3.3	1.8	9.5	0.049557
11	-81.6813	41.50549	Cleveland	OH	0.3	3.7	1.4	4.7	1.5	11.6	0.0589
12	-81.0348	34.0007	Columbia	SC	0.4	4.1	1.3	3	0.7	9.6	0.048466
13	-82.9988	39.96119	Columbus	OH	0.2	3.7	0.6	3	1.8	9.2	0.051844
14	-96.797	32.7767	Dallas	TX	0.5	4.7	0.4	3.6	1.2	10.5	0.057206

15	-104.99	39.73919	Denver	CO	0.2	2.1	0.7	3.1	1.8	7.9	0.041656
16	-83.0458	42.3314	Detroit	MI	0.2	3.1	0.9	3.4	1.1	8.7	0.045365
17	-106.485	31.7619	El Paso	TX	0.4	3.1	1.1	4	0.4	9	0.043866
18	-119.773	36.7468	Fresno	CA	0.3	5.1	0.6	6.7	1.6	14.3	0.076721
19	-157.858	21.3069	Honolulu	HI	0.6	6.6	0.5	5	0.5	13.3	0.071881
20	-95.3698	29.7604	Houston	TX	0.4	4.5	1.8	4.7	2	13.4	0.068435
21	-86.1581	39.7684	Indianapolis	IN	0.2	4.5	1.1	3.4	1	10.3	0.054473
22	-81.6557	30.33219	Jacksonville	FL	0.3	5	0.9	3.4	1.1	10.7	0.05829
23	-74.0776	40.7282	Jersey City	NJ	0.7	3.6	1.6	4.1	2.7	12.7	0.064337
24	-94.5786	39.09969	Kansas City	MO	0.3	4	0.8	3.3	0.7	9.2	0.048221
25	-118.244	34.0522	Los Angeles	CA	1.2	6.9	0.6	8	6.3	23.1	0.127333
26	-85.7585	38.25269	Louisville	KY	0.3	4.3	1.9	3.5	1.4	11.3	0.057693
27	-90.049	35.1495	Memphis	TN	0.4	4.8	1	3.6	2.3	12.1	0.066205
28	-80.1918	25.7617	Miami	FL	0.5	5.5	0.4	4.6	1.7	12.7	0.070492
29	-87.9065	43.0389	Milwaukee	WI	0.2	3.3	0.5	2.2	1.2	7.4	0.04132
30	-93.265	44.9778	Minneapolis	MN	0.3	3.1	0.2	1.1	1.5	6.2	0.036636
31	-86.7816	36.1627	Nashville	TN	0.3	3.4	0.8	3.4	1.2	9.1	0.047996
32	-90.0715	29.9511	New Orleans	LA	0.6	4.8	1	4.8	1.6	12.8	0.06708
33	-74.006	40.71279	New York	NY	0.7	3.7	1.7	3.7	3.6	13.5	0.069451
34	-74.1724	40.7357	Newark	NJ	0.3	3.6	1.1	4.8	2.7	12.5	0.066282
35	-97.5164	35.4676	Oklahoma City	OK	0.3	5.7	0.8	2.8	0.8	10.4	0.05812
36	-95.998	41.25239	Omaha	NE	0.2	2.6	0.7	3.4	0.7	7.6	0.038958
37	-75.1652	39.9526	Philadelphia	PA	0.3	3.8	2	5.5	2	13.7	0.067549
38	-112.074	33.4484	Phoenix	AZ	0.9	4.3	0.2	7.2	2.3	15	0.078215
39	-79.9959	40.4406	Pittsburgh	PA	0.2	3.6	2.4	3.8	1.6	11.6	0.0564
40	-122.677	45.52309	Portland	OR	0.6	3	1	3.1	1.5	9.2	0.046587
41	-71.4128	41.82399	Providence	RI	0.2	3.7	1	3.7	1.2	9.8	0.051609
42	-79.9414	37.271	Roanoke	VA	0.2	4.6	1.1	4	1	11	0.057853
43	-121.494	38.58159	Sacramento	CA	0.4	4.9	0.3	3.8	1.4	10.8	0.060547
44	-111.891	40.76079	Salt Lake City	UT	0.3	3	0.5	5.2	1.6	10.5	0.055615
45	-117.161	32.7157	San Diego	CA	0.7	7.6	0.8	5.6	2.8	17.4	0.097459
46	-122.419	37.77489	San Francisco	CA	0.7	3.5	0.5	4.7	2.7	12.1	0.064548

47	-121.886	37.33819	San Jose	CA	0.5	4.6	0.4	3.7	2.8	12	0.067785
48	-122.332	47.6062	Seattle	WA	0.6	3.3	1.5	3.1	1.5	10	0.049439
49	-90.1994	38.62699	St. Louis	MO	0.3	3.3	1.8	3.8	1.5	10.7	0.052803
50	-82.4572	27.95059	Tampa	FL	0.5	5.8	2.4	4.5	1.1	14.2	0.071321
51	-110.927	32.2217	Tucson	AZ	0.4	4.6	0.3	3.8	1.3	10.3	0.057847
52	-95.9928	36.154	Tulsa	OK	0.4	5.3	1.2	3.6	0.9	11.4	0.060458
53	-75.978	36.85289	Virginia Beach-Norfolk	VA	0.2	5.8	1.2	2.8	1.5	11.5	0.064087
54	-77.0369	38.90719	Washington	DC	0.5	3.9	1.6	3.3	2	11.3	0.057838

Appendix C: Roads Speeds Table

This section contains the supplemental Max Speed reference table (*Table 19*) with the average speed limits for the various road types in shapefiles from TIGER roads. Speed data is required to create the road network in the Create Road Layer section and is implemented in the Transportation Module of EPA H2O. The table must be exported as a .csv to use in Esri ArcGIS or QGIS.

Using ArcGIS

1. Copy *Table 19* into a new Excel spreadsheet. Save the file to a known location and name the output with a .csv extension (e.g. *MaxSpeed_lookup.csv*).
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. Use the *Add Data*  icon to navigate to and add the lookup .csv file (e.g. *MaxSpeed_lookup.csv*) as a layer in the Table of Contents.

The imported table can be used in the Create Road Layer section, to calculate the speed limits for the road network.

Using QGIS

1. Copy *Table 19* into a new Excel spreadsheet. Save the file to a known location and name the output with a .csv extension (e.g. *MaxSpeed_lookup.csv*).
2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. In File Explorer, locate the Max Speed .csv table. Click and drag to load the table into the Layers panel.

The imported table can now be used to calculate the speed limits for the road network in the Create Road Layer section.

Table 19 Max Speed reference table, with speed limits in mph and kmh

MTFCC	Road_Desc	Speed	Speed_kmh
S1100	Primary Road	70	112.6538
S1200	Secondary Road	65	104.6071
S1400	Local Neighborhood Road/ Rural Road/ City Street	25	40.2335
S1500	Vehicular Trail (4WD)	0	0
S1630	Ramp	25	40.2335
S1640	Service Drive usually along a limited access highway	25	40.2335
S1710	Walkway/Pedestrian Trail	0	0
S1730	Alley	15	24.1401
S1740	Private Road for service vehicles (logging/ oil fields/ ranches/ etc.)	0	0
S1750	Drive for census use	0	0
S1780	Parking Lot Road	15	24.1401
S1820	Bike Path or Trail	0	0
S1830	Bridle Path	0	0
S2000	Road Median	0	0
S1720	Stairway	0	0

Appendix D: Extracting and Updating the Original FLUCCS Lookup Table

The steps outlined throughout database creation were written using a land use layer based on NLCD and the supplemental lookup table (Appendix A: Supplemental NLCD Lookup Table). The supplemental lookup table was intended for users creating a database extending outside of the Tampa Bay area, where the FLUCCS land use data and original coefficients may not apply.

However, if the user is creating a new database completely within the state of Florida, and intends to use FLUCCS land use data, the original lookup table may be used with a few modifications. This lookup table contains all available FLUCCS land use types for the Tampa Bay area. If the new FLUCCS data include additional land use types it is suggested that the user add each to the lookup table and update the rates accordingly. The FLUCCS classification codes are hierological (e.g. code 1110 is a subset of 1100) and joining the land use layer to the lookup table may require codes to be generalized. Depending on the software, different steps are required to modify the original lookup table (Using ArcGIS or Using QGIS).

Using ArcGIS

This section contains the original lookup table for Tampa, extracted from the *TampaBay.sqlite* database with some modifications (*Table 20*). The table must be exported as a .csv and converted to a .dbf to make changes using Esri ArcGIS.

1. Copy both sections of *Table 20* ("PKUID" through "FloodProt" fields) into a new Excel spreadsheet. Save the file to a known location and name the output with a .csv extension (e.g. *lookUPvars.csv*).
2. Open your existing ArcGIS map document file (.mxd), or create one following the steps outlined in Set Up ArcGIS Map Document.
3. Use the *Add Data* icon to navigate to and add the lookup .csv file (e.g. *lookUPvars.csv*) as a layer in the Table of Contents.
4. In the Table of Contents, right-click on the lookup table and choose *Data* > *Export.*
5. In the *Export Data* window:
   a. In the *Export* dropdown list, select *All records*.
   b. Next to the *Output table* text box, click the *Browse* button and navigate to the preferred file path. In the *Save as type* dropdown list, select *dBASE Table,* and in the *Name* text box, enter *lookUPvars**.dbf**.* Click *Save.*
   c. Click OK.

The exported lookup table should be edited to update the coefficients for the user's specific area of interest following the steps outlined in the Update ES Coefficients section. The "canopyVal", "usablewat", "StableClim", "Us_Air_Dol", "CN" and "FloodProt" fields will be populated in the Joining Lookup Table section. Once the table has been updated for the specific area of interest, it is imported into the Qspatialite plugin as described in the Importing Layers into QGIS section.

Using QGIS

1. Copy both sections of *Table 20* ("PKUID" through "FloodProt" fields) into a new Excel spreadsheet. Save the file to a known location and name the output with a .csv extension (e.g. *lookUPvars_supplemental.csv*).

2. Open your existing QGIS map document file (.qgs), or create one following the steps outlined in Set Up QGIS Map Document.
3. From the main menu, select *Layer > Add Delimited Text Layer.*
4. In the *Create a Layer from a Delimited Text File* window:
    a. Click the *Browse* button to locate the lookup .csv table.
    b. Under the *Selected Delimiter* option, select *Comma*.
    c. In the *X field* and *Y field* dropdown list, leave the default fields.
    d. Click *OK*.
5. QGIS may try to map the attributes, this can be disregarded. In the Layers panel, right-click on the lookup table and choose *Save as.*
6. In the *Save vector layer as* window:
    a. In the *Format* dropdown list, select *ESRI Shapefile.*
    b. In the *Save as* text box, browse to the desired location and name the output *lookUPvars.shp.*
    c. In the *CRS* dropdown list, choose *Selected CRS,* and click the *Browse* button to locate *WGS 84 / Pseudo Mercator.*
    d. Click *OK.*
7. In File Explorer, locate the .dbf file that coincides with the lookup shapefile (*lookUPvars.dbf*) and click and drag the file into the Layers panel.

Although the exported lookup table is saved as a “shapefile”, the output is an editable table (*lookUPvars.dbf*), which is updated throughout database creation to change the coefficients for the user’s specific area of interest. The “canopyVal”, “usablewat”, “StableClim”, “Us_Air_Dol”, “CN” and “FloodProt” fields will be populated in the Joining Lookup Table section. Once the table has been updated for the specific area of interest, it is imported into the Qspatialite plugin as described in the Importing Layers into QGIS section.

Table 20 Original lookup table for Tampa Bay with FLUCCS land use. The vital rates for H2O are denitrification rate (denitrific), carbon fixation rate (CarbonFixe), percent canopy cover(Canopy), and soil type categories (A, B, C).

PKUID	FLUCCS	FLUCSDESC	denitrific	CarbonFixe	Canopy	A	B	C
1	1100	RESIDENTIAL LOW DENSITY < 2 DWELLING UNITS	1.3	148	22	54	70	80
2	1200	RESIDENTIAL MED DENSITY 2->5 DWELLING UNIT	1.13	138.5	23	61	75	83
3	1300	RESIDENTIAL HIGH DENSITY	0.85	91	12	77	85	90
4	1400	COMMERCIAL AND SERVICES	0.62	56.5	5	89	92	94
5	1500	INDUSTRIAL	0.6	50.5	3	81	88	91
6	1600	EXTRACTIVE	1.18	116.5	13	77	86	91
7	1650	RECLAIMED MINE LAND	1.18	116.5	13	39	61	74
8	1700	INSTITUTIONAL	0.87	73.11111	4	81	88	91
9	1800	RECREATIONAL	1.4	127.5	11	49	69	79
10	1820	GOLF COURSES	1.4	132.5	13	49	69	79

11	1900	OPEN LAND	1.4	132.5	13	39	61	74
12	2100	CROPLAND AND PASTURELAND	0.72	423.1256	7	39	61	74
13	2140	ROW CROPS	3.15	959.0622	3	67	78	85
14	2200	TREE CROPS	0.45	570.5556	16	43	65	76
15	2300	FEEDING OPERATIONS	0.06	423.1256	6	68	79	86
16	2400	NURSERIES AND VINEYARDS	0.45	570.5556	10	72	81	88
17	2500	SPECIALTY FARMS	0	0	6	68	79	86
18	2540	TROPICAL FISH FARM	0	0	19	81	88	91
19	2600	OTHER OPEN LANDS <RURAL>	0.82	673.3333	18	30	58	71
20	3100	HERBACEOUS	0.06	742.5	16	30	58	71
21	3200	SHRUB AND BRUSHLAND	0.06	945	28	35	56	70
22	3300	MIXED RANGELAND	0.82	540	31	48	67	77
23	4100	UPLAND CONIFEROUS FOREST	0.12	697.5	56	36	60	73
24	4110	PINE FLATWOODS	0.12	697.5	49	36	60	73
25	4120	LONGLEAF PINE - XERIC OAK	0.12	312.9	46	36	60	73
26	4200	UPLAND HARDWOOD FORESTS - PART 1	0.19	590	55	36	60	73
27	4340	HARDWOOD CONIFER MIXED	0.19	660	65	36	60	73
28	4400	TREE PLANTATIONS	0.45	730.8333	56	43	65	76
29	5100	STREAMS AND WATERWAYS	20.73	180	22	100	100	100
30	5200	LAKES	12.16	396.5722	0	100	100	100
31	5300	RESERVOIRS	6.73	367.7989	0	100	100	100
32	5400	BAYS AND ESTUARIES	5.66	195	0	100	100	100
33	5700	OCEAN AND GULF OF MEXICO	0	115.3367	0	100	100	100
34	5720	GULF OF MEXICO	6.89	115.3367	0	100	100	100
35	6100	WETLAND HARDWOOD FORESTS	25.5	808	76	49	65	72
36	6110	BAY SWAMPS	25.5	808	79	49	65	72
37	6120	MANGROVE SWAMPS	0.69	777.9744	76	49	65	72
38	6150	STREAM AND LAKE SWAMPS (BOTTOMLAND)	25.5	808	81	49	65	72
39	6200	WETLAND CONIFEROUS FORESTS	25.5	298.2	72	49	65	72

40	6210	CYPRESS	24.66	241.25	66	49	65	72
41	6300	WETLAND FORESTED MIXED	25.5	552.4	73	49	65	72
42	6400	VEGETATED NON-FORESTED WETLANDS	28.26	141.7	21	49	65	72
43	6410	FRESHWATER MARSHES	28.26	618	30	49	65	72
44	6420	SALTWATER MARSHES	4.52	492.2544	30	49	65	72
45	6430	WET PRAIRIES	25.48	141.7	20	49	65	72
46	6440	EMERGENT AQUATIC VEGETATION	26.22	141.7	29	49	65	72
47	6510	TIDAL FLATS	10	195	0	98	98	98
48	6520	SHORELINES	0	0	0	98	98	98
49	6530	INTERMITTENT PONDS	17.44	141.7	10	98	98	98
50	6600	SALT FLATS	0	0	10	98	98	98
51	7100	BEACHES NO SWIM	0	0	0	98	98	98
52	7200	SAND OTHER THAN BEACHES	0	0	0	98	98	98
53	7400	DISTURBED LAND	0	25	10	98	98	98
54	8100	TRANSPORTATION	1.2	96	4	98	98	98
55	8200	COMMUNICATIONS	1.16	105.5	9	98	98	98
56	8300	UTILITIES	1.4	132.5	9	98	98	98
57	9113	SEAGRASS PATCHY	5	813.6667	0	100	100	100
58	9116	SEAGRASS CONTINUOUS	5	813.6667	0	100	100	100
59	9121	ALGAE BEDS	5	0	0	100	100	100

D	LEV1	waterRet	stabClim	usWat	canopyVal	usablewat	StableClim	Us_Air_Dol	CN	FloodProt
85	1	2	37	3						
87	1	2	37	3						
92	1	2	37	3						
95	1	2	37	3						
93	1	2	37	3						
94	1	2	37	3						
80	1	2	37	3						

93	1	2	37	3						
84	1	2	37	3						
84	1	2	37	3						
80	1	2	37	3						
80	2	2	37	3						
89	2	2	37	3						
82	2	2	37	3						
89	2	2	37	3						
91	2	2	37	3						
89	2	2	37	3						
93	2	2	37	3						
78	2	2	37	3						
78	3	2	37	3						
77	3	2	37	3						
83	3	2	37	3						
79	4	2	37	3						
79	4	2	37	3						
79	4	2	37	3						
79	4	2	37	3						
79	4	2	37	3						
82	4	2	37	3						
100	5	2	37	3						
100	5	2	37	3						
100	5	2	37	3						
100	5	2	37	3						
100	5	2	37	3						
100	5	2	37	3						
80	6	2	37	3						
80	6	2	37	3						

80	6	2	37	3						
80	6	2	37	3						
80	6	2	37	3						
80	6	2	37	3						
80	6	2	37	3						
80	6	2	37	3						
80	6	2	37	3						
80	6	2	37	3						
80	6	2	37	3						
80	6	2	37	3						
98	6	2	37	3						
98	6	2	37	3						
98	6	2	37	3						
98	6	2	37	3						
98	7	2	37	3						
98	7	2	37	3						
98	7	2	37	3						
98	8	2	37	3						
98	8	2	37	3						
98	8	2	37	3						
100	9	2	37	3						
100	9	2	37	3						
100	9	2	37	3						

Appendix E: Additional Troubleshooting and Common Errors

New Project "No Such Table" Error

When starting a new project, an error window may appear while the selected AOI is processing (*Figure 295*). This error states "The SQL query seems to be invalid. No such table:" and lists the table name that cannot be found (e.g. *FUTUREsixty*). The error message may appear behind the progress bar.

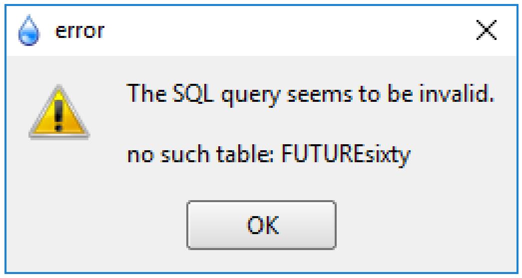


Figure 295 SQL no such table error message

This message occurs when a table has been deleted or doesn't have the expected name in the Qspatialite plugin. EPA H2O searches for each table name from the original Tampa Bay database; if a name does not appear, or it has been renamed incorrectly, the user will receive an error.

If the named table was deleted intentionally, the user only needs to click the *OK* button. The rest of the data layers will continue to process for the AOI. Please note, this error will appear every time a new project is created, and the rest of the data will not load until the *OK* button is clicked.

If the named table was deleted unintentionally, or the table was renamed incoretly, the user must make changes in the Qspatialite plugin. In a blank map project, the user must rename the table to match the Tampa Bay naming scheme or add a new table into Qspatialite with the correct name.

An exception may occur if the "no such table" name in the error message is *Land_Use* (*Figure 296*). This **may** occur if the land use layer was originally named *Land_Use_2006.*

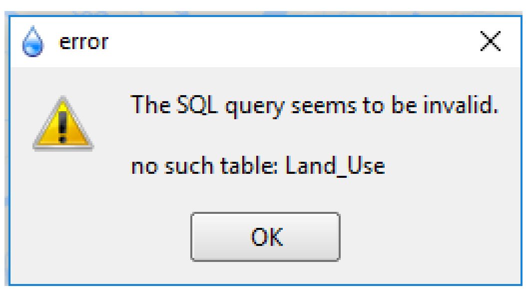


Figure 296 EPA H2O Land_Use error window

The user database requires the name *Land_Use_2006* the first time the land use layer is inserted into Qspatialite. However, if the user updates the land use layer later, and reuploads it into the Qspatliate plugin, the database **may** require the name *Land_Use.* Change the name of the land use layer to match that in the error message, reupload the table into Qspatialite, and the error should not appear again.

Cannot Run Advanced Comparison Report

EPA H2O requires that all layer names in the Qspatialite plugin maintain the naming scheme found in the Tampa Bay database. The program also requires that the layer names stay the same in the Layers panel. If the user right clicks on a layer in the Layers panel and renames it, two different errors may occur when running a comparison report.

The first error occurs if *Land_Use_2006* is renamed. A *No Project* error message appears that states “Please Create a Project, then run Scenario Manager” (*Figure 297*). The user must right-click on the appropriate layer in the Layers panel and rename the layer *Land_Use_2006* to run a comparison report.

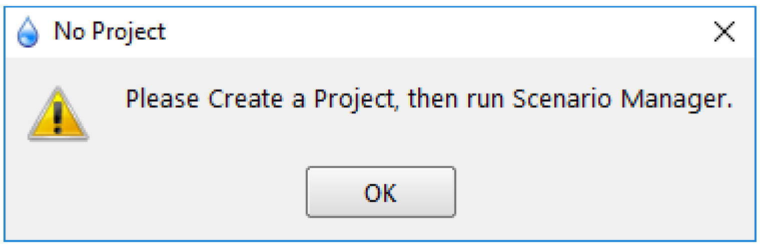


Figure 297 No Project error message when comparing scenarios

A second error may appear if the land use scenario layers (e.g. *Land_Use_2020, Land_Use_2040,* and *Land_Use_2060*) are renamed and the renamed layer is used in a comparison report. A *Python error* window appears that indicates one of the scenario layers (e.g. *scenarioLayerB*) is out of range (*Figure 298*).

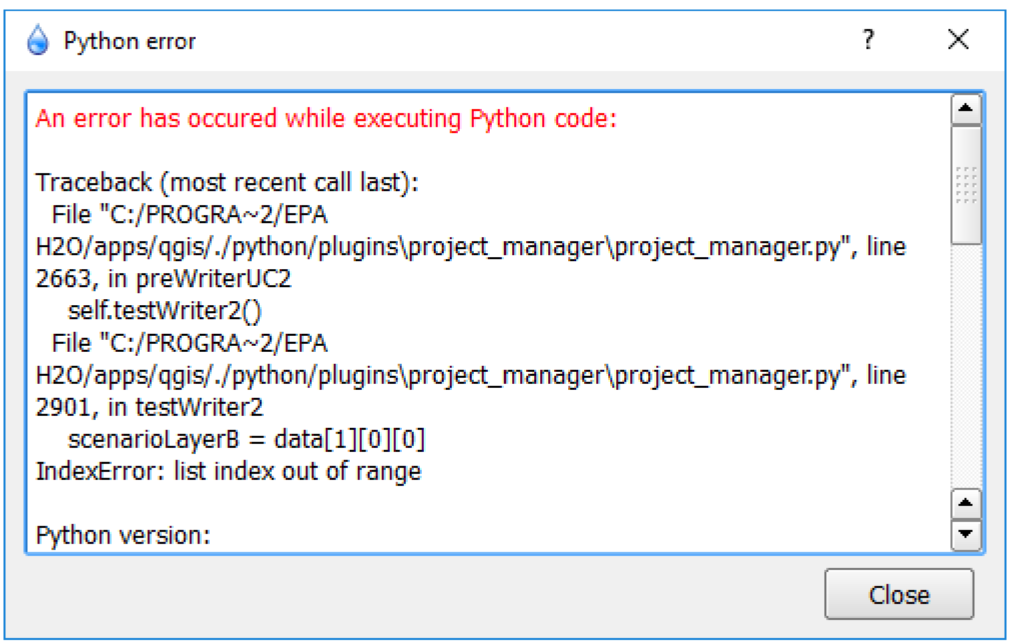


Figure 298 Python error window while running a comparison report

The user must rename the layer to match one of the original Future Scenario layer names, even if the layers represent NLCD data from a different time.

Cannot Update Polygons in Edit Scenario Tool

After a user database is created, the user can update land use polygons with the Edit Scenarios tool. A *Python error* may occur after the *Update* button is selected in the tool (*Figure 299*). The error window indicates that the CN Value is out of range.

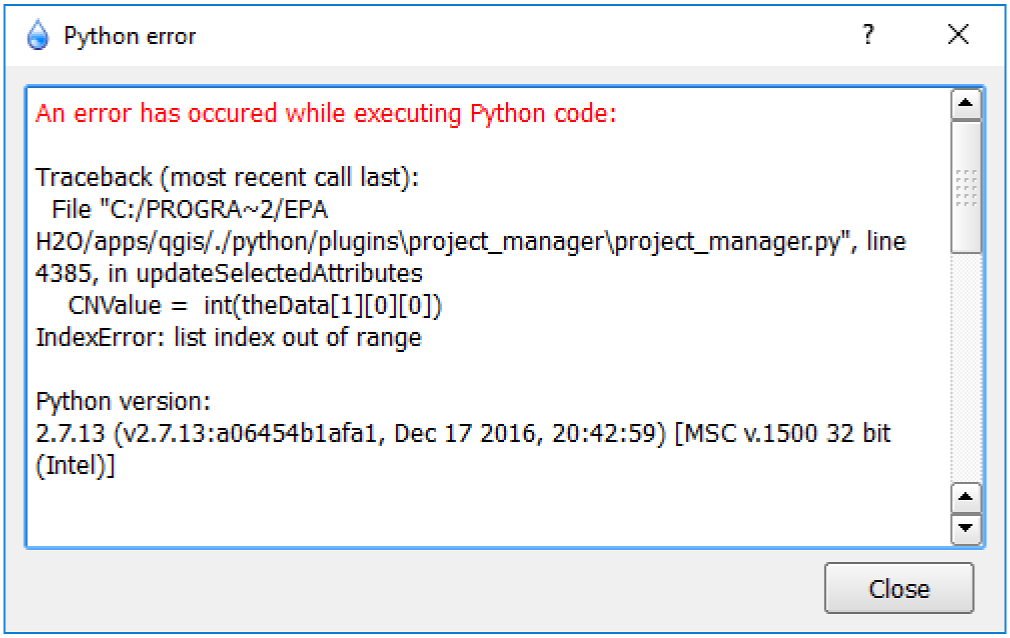


Figure 299 Python error window while updating land use polygons

This error occurs when the “FLUCSDESC” field in the land use layer does not match the attributes in the lookup table “FLUCSDESC” field. Both “FLUCSDESC” fields must contain the updated land use descriptions (e.g. “NLCDDesc”); this is explained in the Field Calculations sections.

To fix the error, the user must use Field Calculator to update the “FLUCSDESC” fields with the “NLCDDesc” attributes. The updated layer (land use or lookup table) must then be reuploaded into the Qspatialite plugin. Create a new project using the user database, and the Edit Scenario tool will be fully functional.

Report Legend Crossed Out in Advanced Report

When running an Ecosystem Valuation Report (as shown in the Compare Scenarios section), the output Legend may appear partially crossed out (*Figure 300*).

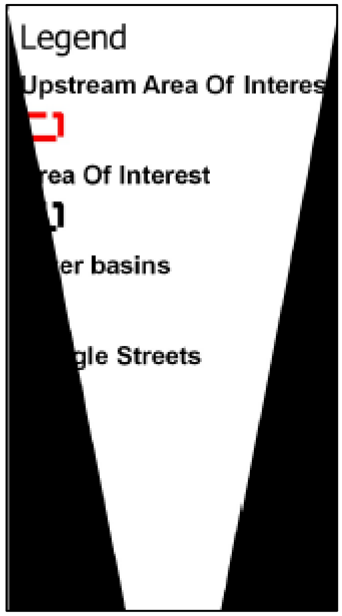


Figure 300 Advanced Report legend, with cross hatch error

This occurs when the layers were not "turned on" in the Layers panel before the comparison was run. Both layers must be toggled on prior to running a scenario comparison report; the report does not require the layers to stay turned on for the report, they simply must be turned on and off once.

The user must close the current project and create a new project for the AOI. Turn each land use layer on once before the first comparison report is run.

Flood Protection = 0 in Advanced Report

When running an Advanced report in a user-created database, the Flood Protection value for *Land_Use_2006* may equal zero (*Figure 301*).

STATISTICS FOR LAYERS IN DRAWN AREA
DRAWN AREA OF INTEREST: 3,963 Hectares

Usable Water: Human activities produce water pollutants. As water moves through a watershed it is filtered by wetlands, forests, and aquatic areas. Replacement costs for removing a pound of nitrogen from various sources range from less than $10 to as high as $855.Costs increase as the nitrogen becomes harder to route towards treatment areas and as simpler, more cost efficient mechanisms for removing nitrogen need to be replaced by more centralized advanced waste water treatment facilities.

Land_Use_2006	Scenario-test
Estimated total value ($) per year: 1,738,087	Estimated total value ($) per year: 1,749,379

Usable Air: Human activities produce air pollutants. Trees and other plants remove these harmful pollutants. Pollution removal results in healthier people with reduced health care costs. The loss of trees and other plants would result in increased health care costs and decreased human well-being.

Land_Use_2006	Scenario-test
Estimated total value ($) per year: 95,252,132	Estimated total value ($) per year: 91,502,472

Stable Climate: Stored carbon provides a more stable climate by keeping greenhouse gasses out of our atmosphere. Carbon dioxide (CO2) is the primary greenhouse gas emitted through human activities. Carbon sequestration helps reduce future social costs associated with a more unstable climate.

Land_Use_2006	Scenario-test
Estimated total value ($) per year: 2,380,473	Estimated total value ($) per year: 2,306,371

Flood Protection: Human activities alter the way water moves through the landscape. Natural landscapes retain and slow the movement of water offering protection from flooding. The loss of these natural landscapes would result in the need for more man made flood protection at much higher cost. Flood protection value below is summarized for the Area of Interest (AOI) that user has selected.

Land_Use_2006	Scenario-test
Estimated total value: 0	Estimated total value: 206,111

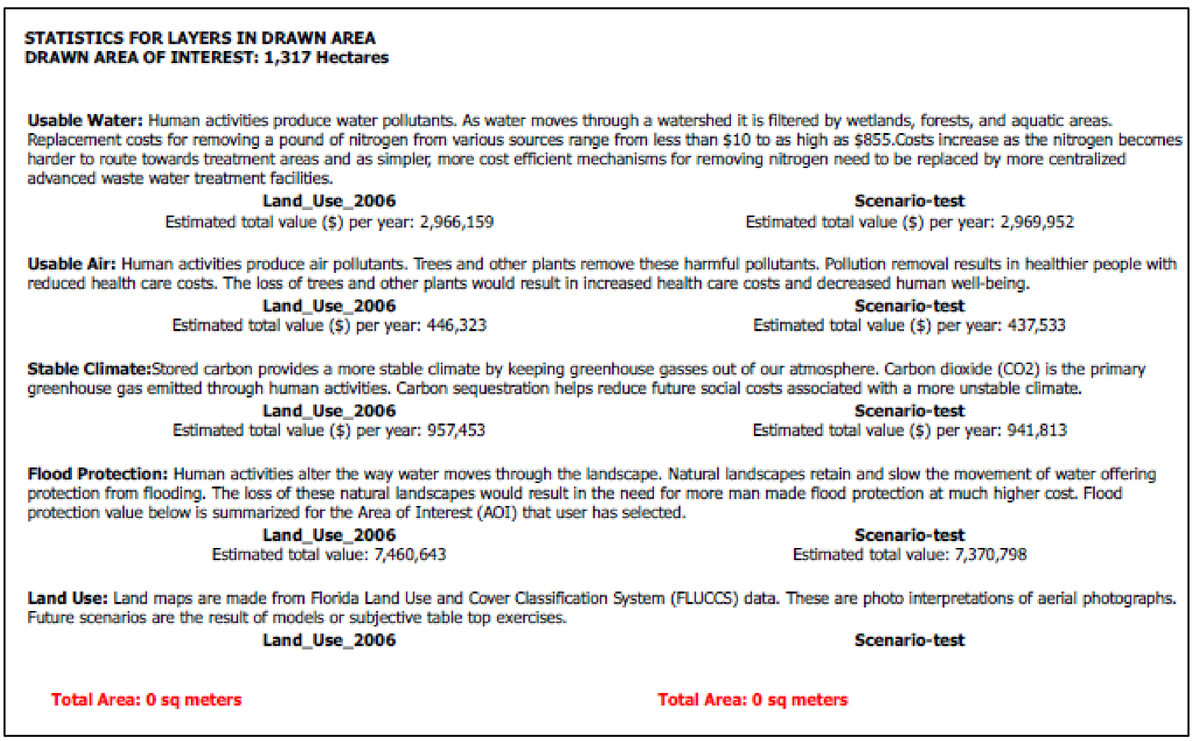
Figure 301 Statistics page of the Advanced Ecosystem Valuation Report

This issue may be rooted in an incorrect field calculation in the Joining Lookup Table section.

1. Open the *Land_Use_2006* attribute table and sort the “Max_Type_N” field in ascending order.
2. If the “Max_Type_N” field contains values of 0, this may be the source of the issue above.
   a. Recalculate the missing “Max_Type_N” values, as shown in the Spatially Join Soils to Land Use (ArcGIS) or Spatially Join Soils to Land Use (QGIS) section.
   b. Recalulate the “CN” field, then recalculate the “FloodProt” field, as shown in the Joining Lookup Table section.
3. Drop and re-add the updated *Land_Use_2006* table into Qspatialite.
4. When a comparison report is run in the user database, the Flood Protection value should no longer be zero.

Total Area: 0 sq meters in Advanced Report

When running an Advanced report, the Total Area may report as 0 sq meters, with no land use types listed.



STATISTICS FOR LAYERS IN DRAWN AREA
DRAWN AREA OF INTEREST: 1,317 Hectares

Usable Water: Human activities produce water pollutants. As water moves through a watershed it is filtered by wetlands, forests, and aquatic areas. Replacement costs for removing a pound of nitrogen from various sources range from less than $10 to as high as $855.Costs increase as the nitrogen becomes harder to route towards treatment areas and as simpler, more cost efficient mechanisms for removing nitrogen need to be replaced by more centralized advanced waste water treatment facilities.

Land_Use_2006	Scenario-test
Estimated total value ($) per year: 2,966,159	Estimated total value ($) per year: 2,969,952

Usable Air: Human activities produce air pollutants. Trees and other plants remove these harmful pollutants. Pollution removal results in healthier people with reduced health care costs. The loss of trees and other plants would result in increased health care costs and decreased human well-being.

Land_Use_2006	Scenario-test
Estimated total value ($) per year: 446,323	Estimated total value ($) per year: 437,533

Stable Climate: Stored carbon provides a more stable climate by keeping greenhouse gasses out of our atmosphere. Carbon dioxide (CO2) is the primary greenhouse gas emitted through human activities. Carbon sequestration helps reduce future social costs associated with a more unstable climate.

Land_Use_2006	Scenario-test
Estimated total value ($) per year: 957,453	Estimated total value ($) per year: 941,813

Flood Protection: Human activities alter the way water moves through the landscape. Natural landscapes retain and slow the movement of water offering protection from flooding. The loss of these natural landscapes would result in the need for more man made flood protection at much higher cost. Flood protection value below is summarized for the Area of Interest (AOI) that user has selected.

Land_Use_2006	Scenario-test
Estimated total value: 7,460,643	Estimated total value: 7,370,798

Land Use: Land maps are made from Florida Land Use and Cover Classification System (FLUCCS) data. These are photo interpretations of aerial photographs. Future scenarios are the result of models or subjective table top exercises.

Land_Use_2006	Scenario-test
Total Area: 0 sq meters	**Total Area: 0 sq meters**

Figure 302 Statistics page of the Advanced Ecosystem Evaluation Report

This is simply a processing error. Close the report and remove the *Upstream Area of Interest* and *Area of Interest* layers from the Layers panel (right-click > *Remove*). Run another report using the *Compare Scenarios* tool, with a new Report Name; the correct areas will be reported.

Cannot Open Qspatialite Plugin

An error may appear when trying to open the Qspatialite plugin in EPA H2O (*Database* menu > *SpatiaLite* > *QspatiaLite)*. The error message states “The SQL query seems to be invalid. No such table: geometry_columns”.

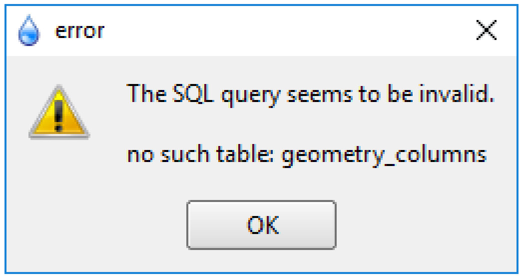


Figure 303 SQL error window when opening Qspatialite

This message may appear if a database was renamed or moved within the user's *.qgis* folder. All databases that were once opened in EPA H2O and/or Qspatialite are linked to the plugin. If a database is moved or renamed, the plugin searches for a database that is no longer there.

The user must delete the connection between Qspatialite and the database.

1. Close the error messages that appear.
2. Open the Qspatialite plugin and select the old database from the dropdown box.
3. Click the *Delete Link to Database*  icon.

The user should now be able to reopen the Qspatialite window with no errors.

If the user completely deleted a database folder from their C:/ drive, a different error will appear. This error message states "Can't connect to DataBase. Error unable to open database file". The error window also lists the file path of the missing database (*Figure 304*).

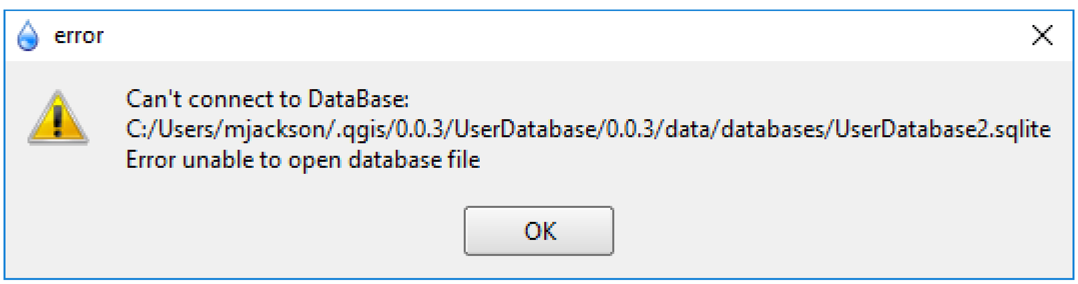


Figure 304 Missing database error window in EPA H2O

Qspatialite cannot be opened until a database is returned to the exact file path listed in the error.

1. Create a copy of the original Tampa Bay database, as shown in the Setting Up a Project Directory section.
2. The file path for the copied database must exactly match the file path listed in the error message received.
3. Rename the copied Tampa Bay database to match the deleted database name (e.g. *UserDatabase2.sqlite)*.
4. The Qspatialite plugin should now open in EPA H2O. Select the database from the dropdown box.
5. Click the *Delete Link to Database*  icon.
6. The user may then delete the copied database folder from their C:/ drive.

Python Error When Opening or Creating Project

A *Python error* may appear after selecting an AOI for a new project, or when opening a previously saved project (*Figure 305*). The error window states "*UnboundLocalError: local variable 'olRes'* *referenced before assignment".* After clicking the *Close* button, a second message may appear, explaining that the Google Streets layer cannot be drawn (*Figure 306*).

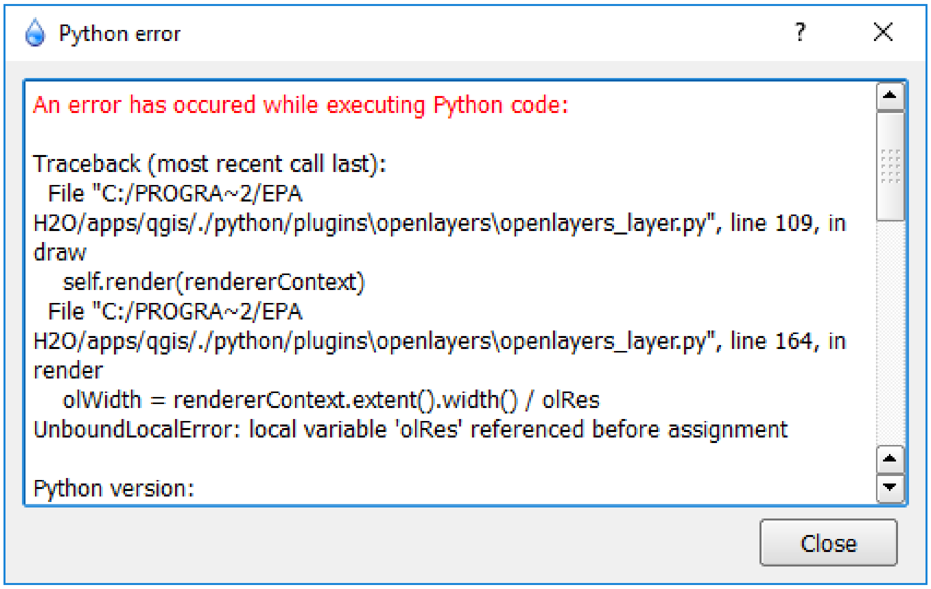


Figure 305 Python error while creating a new project, or opening a previous project

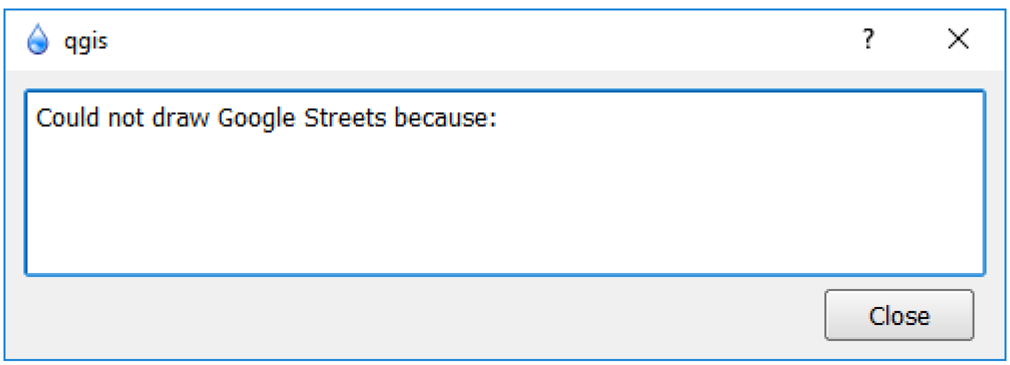


Figure 306 qgis message window, stating Google Streets cannot be drawn

These error messages appear together when there is an issue with the user's internet connection. A connection to the internet is required to display the Google Streets layer. The user must close the program, troubleshoot the internet connection, and reopen EPA H2O to draw Google Streets.

If the internet is connected and Google Streets continues to fail, right-click on the layer in the Layers panel and choose *Remove.* From the main menu select *Plugins > OpenLayers plugin > Add Road layer.* Google Streets may be experiencing a licensing issue, and the Bing road layer may be used instead.

Please note, the program is completely functional without the streets layer but may be desired when exporting reports.

FAQ: Frequently Asked Questions

This section addresses common questions users may have about the program, its use, and its development.

How do I get the EPA H2O?
EPA H2O is a free software distributed by US EPA's Gulf Ecology Division, and can be downloaded at the following link: https://www.epa.gov/water-research/ecosystem-services-scenario-assessment-using-epa-h2o
If you are unable to download EPA H2O, please contact US EPA's Gulf Ecology Division.

Do I need to pay for EPA H2O?
No. It is distributed free of charge by US EPA's Gulf Ecosystem Measurement and Modeling Division. For questions regarding commercial application, the license agreement can be found in the Setup Wizard of the EPA H2O Download and Installation section.

Are there any constraints on use of EPA H2O?
Yes. EPA H2O relies on the QGIS application, and inherits all QGIS use constraints (licensed under the GNU General Public License).

Where did the EPA H2O data come from? How up to date is the data?
The Tampa Bay database used in EPA H2O is comprised of data collected by various governmental agencies including Florida Natural Areas Inventory (FNAI), Florida Geographic Data Library (FGDL), and EPA. Please refer to source agency websites for more information on specific datasets (*Table 6*). Data were further processed for optimum use in EPA H2O. All data were downloaded from agency websites in July 2013. However, the last updated date of each data are different.

I am an advanced QGIS user, can I use QGIS functionality in EPA H2O?
Yes. Users can run EPA H2O with full QGIS functionality in power mode by changing the EPA H2O settings in the computer registry as shown under the Power Mode section of the help manual.

Can I use EPA H2O on any operating system?
No. EPA H2O is currently only compatible with Windows operating systems. Please check the System Requirements for further details.

Can I modify the report style and format in EPA H2O?
No. The current version of EPA H2O does not allow users to modify the report style and format.

What does the "EPA H2O version 1" popup box mean?
This box appears when a user action is not supported in the current EPA H2O mode. The functionality may be supported when the EPA H2O *power mode* is enabled, as described in the Power Mode section of the help manual.

Can I simultaneously and seamlessly work on Basic and Advanced Modules of the EPA H2O? No. Users can operate EPA H2O only in one mode at a given time. Please save your work as an EPA H2O project, and then switch modules using the "EPA H2O Module" tool, as shown in the Navigating EPA H2O section.

Can I save the EPA H2O project and share it with others?
Yes. Please refer to the Saving and Moving the Project section of the manual.

Appendix F: Updating QGIS Layer Symbologies

When starting a new project in the user's database, the symbology in the Layers panel will match that of the original Tampa Bay database. This legend incorporates the user's land use classifications but appears to display FLUCCS categories. *Table 21* shows how the Layers panel legend categorizes the NLCD descriptions.

Table 21 NLCD descriptions condensed into EPA H2O legend descriptions

Legend	NLCD Description
Urban and Built-Up	Developed, Open Space Developed, Low Intensity Developed, Medium Intensity Developed, High Intensity
Agriculture	Pasture/Hay Cultivated Crops
Rangeland	Shrub/Scrub Grassland/Herbaceous
Woodlands	Deciduous Forest Evergreen Forest Mixed Forest
Water	Open Water
Wetlands	Woody Wetlands Emergent Herbaceous Wetlands
Barren Land	Barren Land (Rocks/Sand/Clay)
Utilities and Transportation	N/A
Seagrass and Algae Beds	N/A
Tidal Flats	N/A

The original Tampa Bay database utilized FLUCCS land use data, which incorporated *Utilities and Transportation*, *Tidal Flats*, and *Seagrass and Algae Beds* as land use types. Although these land use types are not found in NLCD data, they are still listed in the Layers panel.

Only data that is present in the selected AOI will appear in the Advanced Module Scenario Comparison Report; therefore, *Utilities and Transportation*, *Tidal Flats,* and *Seagrass and Algae Beds,* as well as any other land use type not located in the AOI, will not appear in the report description.

Land use types and their symbology are condensed for a cleaner, more simplified map. However, the user may update the symbology to display the NLCD descriptions, rather than the condensed legend descriptions.

Note: if the symbology is changed in the land use layer and a comparison report is run, the AOI and Upstream AOI boundaries will draw behind the land use layer in the report. The AOI boundaries will therefore not display directly on the map in the report output.

1. In the Layers panel, double click on the *Land_Use_2006* layer.
2. From the *Layer Properties* window, click on the *Style* tab, and in the first dropdown box, choose *Categorized* (*Figure 307*).

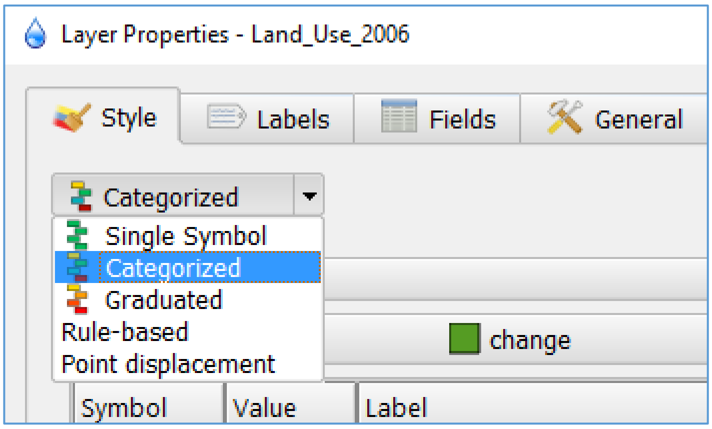


Figure 307 Land_Use_2006 Layer Properties, with Categorized selected in the Style tab

3. In the *Column* dropdown box, choose the "FLUCSDESC" field (*Figure 308*).
4. Click *Classify.* The land use descriptions from the user's land use layer will appear in an alphabetical list, as shown in *Figure 308*.

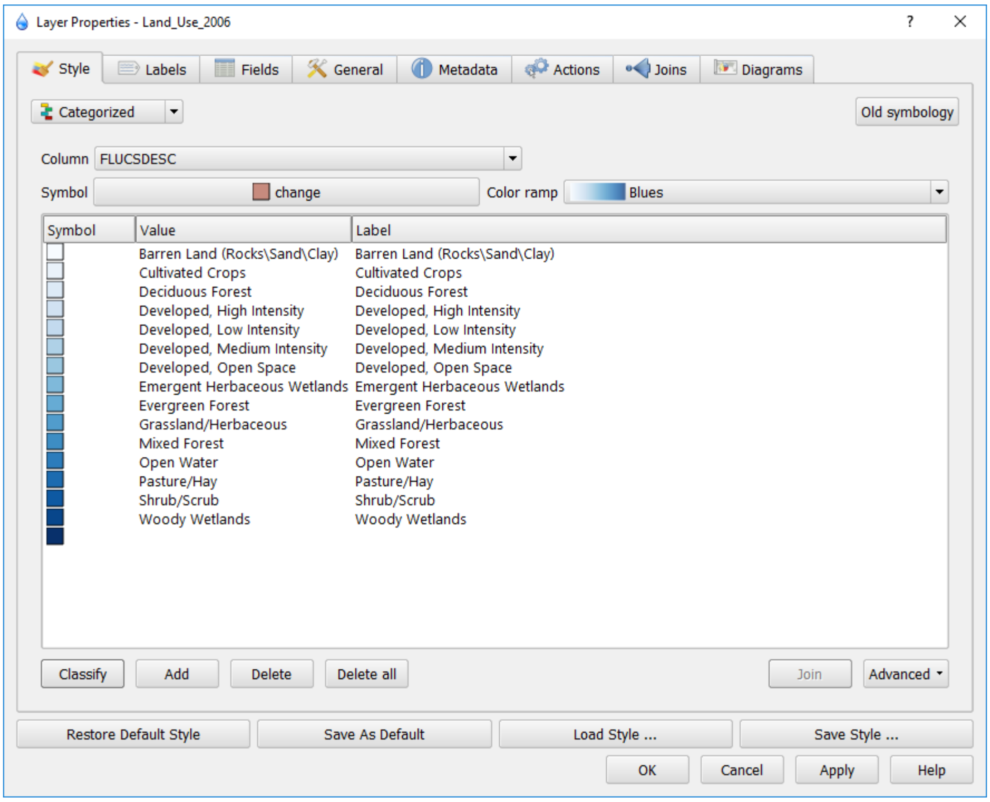


Figure 308 Land_Use_2006 Layer Properties window, with NLCD descriptions listed in the Style tab

5. Under the *Symbol* column, right-click on the first square, and choose *Change color*.
6. Select a new color to appropriately represent the first land use type and click *OK.*
7. Change the color of the symbol for each land use type, then click *OK.*
8. Repeat the same changes in symbology for any other land use comparison datasets the user input into the EPA H2O Qspatialite plugin.
9. The correct land use descriptions will appear in the Layers panel, and in any reports ran during the current project. These steps must be repeated with every new project created.

Appendix G: EPA H2O Development From QGIS

This section provides additional information for developers to understand the EPA H2O architecture and coding structure.

Development

The EPA H2O program is created by customizing the base QGIS program. There are different Integrated Development Environments (IDEs) to customize QGIS that are dependent on the development operation system platform used. For the EPA H2O tool, the platform used for development was a Windows 32bit operating system and the IDE used to customize QGIS was Microsoft Visual Studio 2008. The customization consists of creating a Plugin for QGIS developed using the Python language. The QGIS plugin is made with Python scripts combined into a package. These scripts follow an object-oriented methodology.

User interface creation:

The QGIS user interface is based on Qt and PyQt technology. It consists of Qt widgets and graphic tools that are generated by “QtDesigner” and compiled using Python code.

Qt and PyQt libraries are embedded in “OSGEO4W” and accessible by QGIS.

Spatialite database:

QGIS accesses the Project database using the “Spatialite” library. This library provides functions to access and read the main database, create user scenarios, and edit existing attributes.

QGIS Python package:

The QGIS python package has the necessary GIS functionalities required by EPA H2O and the ability to programmatically access the existing QGIS features.

Through the QGIS python package, the QGIS window can be customized by adding menus, toolbars, and QDockWidget.

Cmake and Microsoft Visual C++:

Customizations made to the QGIS program and plugins need to be compiled in order to create the executable file. Running a compilation can be done using Cmake. It will create the Project Solution, which can be compiled and released as the package.

Error catching and debugging QGIS

QGIS has a Python and PyQt debugger console that facilitates error catching.

QGIS Source Code Compilation

The compilation process of QGIS is listed below:

Set OSGEO4W and MVS environment variables.

To setup the necessary environment dependencies for the code compilation:

1. All the software below must be installed first.

a. Cmake
b. Flex
c. Bison
d. MS Server 2003 R2 SDK

2. Edit OSGeoMSC.bat in the QGIS source folder and set the right paths.
   a. Execute OSGeoMSC.bat in a Command console. It is preferable to execute OSGeoMSC.bat with administrative privileges.

Generate QGIS Microsoft Visual Studio solution

This step links all required QGIS libraries using Cmake. CMake Files define all the necessary rules for solution generation; however, paths linking the source to the libraries may be null or wrong. Please correct these paths if required.

3. Generate a build folder using the command << MKdir build>> the <<Cd build>>.
4. Execute <<Cmake-gui>> and set the source and the build folders path similar to what is shown in *Figure 309*.

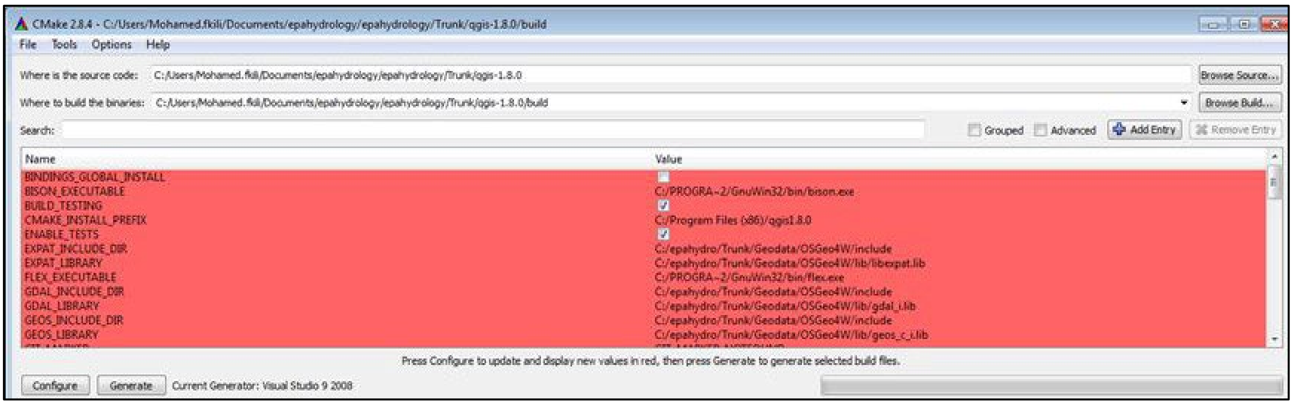


Figure 309 CMake 2.8.4 window

5. Set the appropriate value for every unknown path, e.g. library path, App folder, binary file.
6. The paths should resemble:
   a. Binary folders: OSGeo4W/bin.
   b. Include folder: OSGeo4W/include.
   c. App folder: OSGeo4W/apps.
   d. Libraries folder: OSGeo4W/lib.
7. Run *Configure*.
8. Check and fix any errors.
9. When the configuration is complete, run the *generate* command which will create the Microsoft Visual C++ solution <<QGIS1.8.0.sln>> and all related Visual C++ projects (*Figure 310*).

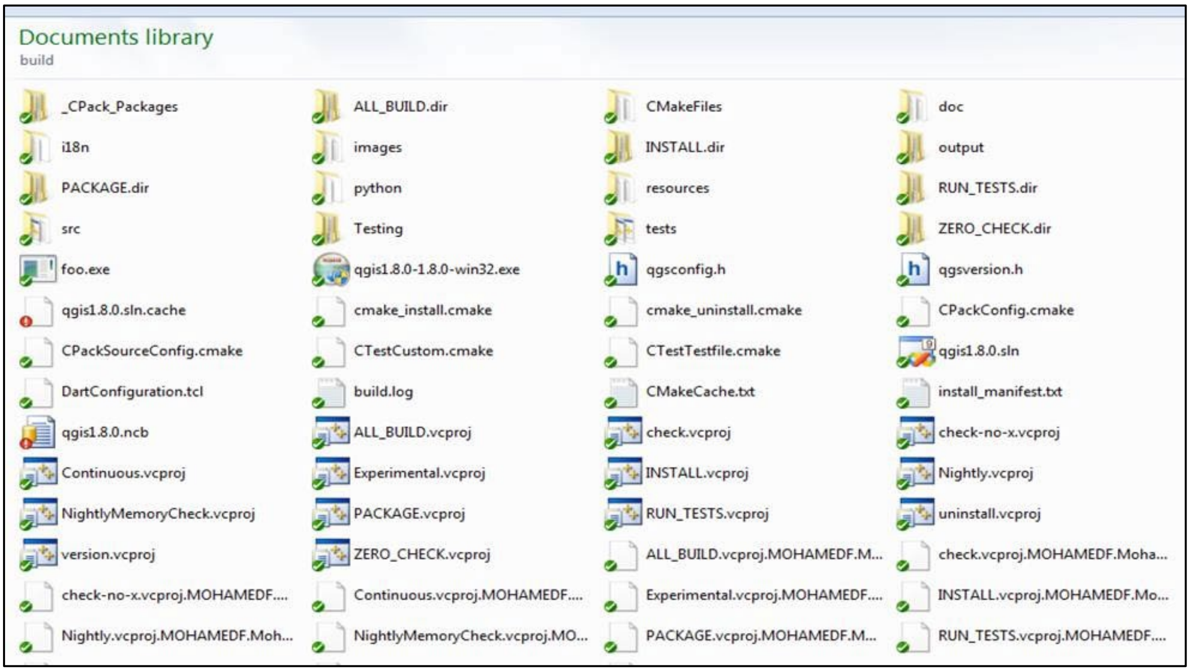


Figure 310 Documents library window after the source and build folders path have been set

Compile the source

Microsoft Visual Studio Solution Builder is used in this step.

1. Run the command <<MSbuild QGIS1.8.0.sln /p:Configuration=Release>>
2. **Please make sure the build is successfully done. Any kind of error might affect the compilation later.**
3. Run the command <<MSbuild INSTALL.vcproj /p:Configuration=Release>>

Generate the installer package

Installer package creation requires the installation of Cygwin (https://www.cygwin.com/).
To run the install:

1. Run a Cygwin console as an Administrator.
2. Locate to the path Trunk\QGIS-1.8.0\ms-windows\
3. Run the command << ./quickpackage.sh>>
4. The quickpackage.sh script could be edited to set installer name and version.
5. The installer file will be generated in a MS Windows folder.

Project Manager Plugin for EPAH2O

The Project Manager Plugin is a custom plugin that controls all the functions of the EPA H2O program. The sample in *Figure 311* shows the directory structure of a typical plugin (Source: https://docs.qgis.org/testing/en/docs/pyqgis_developer_cookbook/intro.html#python-plugins).

```
PYTHON_PLUGINS_PATH/
 MyPlugin/
 __init__.py  --> *required*  mainPlugin.py
--> *required*  metadata.txt --> *required*
resources.qrc --> *likely useful*
 resources.py --> *compiled version, likely useful*  form.ui
--> *likely useful*
 form.py    --> *compiled version, likely useful*
```

Figure 311 Python plugins path

Plugin files include:

1. *__init__.py* = The starting point of the plugin. It needs the classFactory() method and may have any other initialization code.
2. *mainPlugin.py* = The main working code of the plugin. It contains all the information about the actions of the plugin and the main code.
3. *resources.qrc* = The .xml document created by Qt Designer. It contains relative paths to resources of the forms.
4. *resources.py* = The translation of the .qrc file described above to Python.
5. *form.ui* = The GUI created by Qt Designer.
6. *form.py* = The translation of the form.ui described above to Python.
7. *metadata.txt* = Required for QGIS >= 1.8.0.

The Project Manager Plugin's components relate to other familiar components of EPA H2O (conceptual diagram shown in *Figure 312*).

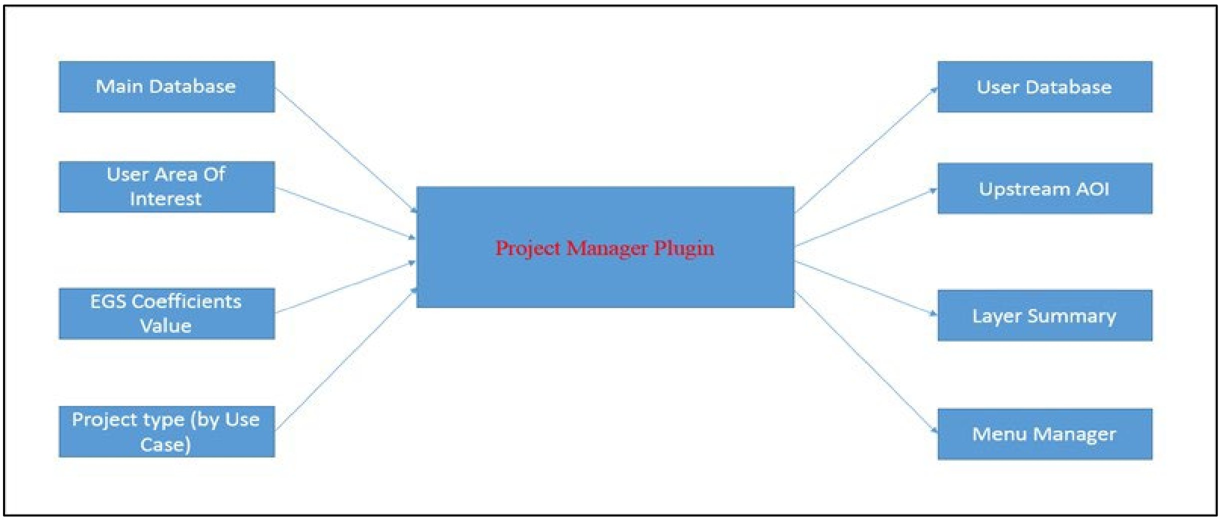


Figure 312 Conceptual diagram of the Project Manager Plugin's components

Project Creation and User Database

EPA H2O is based on the "Use Case". Each use case has a different user interface and functionality. The project creation has three major components:

1. Select the Main Database's and the user database's names. The main database path will be saved in the system registry in order to reload it for future use.
2. Select the AOI and clip the main database.
3. Load all layer in the Table of Contents.

Main Database and user database management

QGIS accesses the project database using the "Spatialite" library. This library provides functions to access and read the main database, creates the user database, and edits existing attributes.

AOI selection and clip using Spatialite

The function "runListIntersect" in project_manager.py presents the table creation from the intersection between AOI and Main Database. The intersection query is in SQL as shown in the sample query below.
Note: countyRect represents the extent of the county selected by the user. This example represents the intersection query for a county AOI selection.

```
"consSQL = ('create table '+theLayer+' as select * from '+theLayer+' where
MBRIntersects('+theLayer+'.geometry, GeomFromText(\'POLYGON(('+str(countyRect.xMinimum())+'
'+str(countyRect.yMinimum())+','+str(countyRect.xMinimum())+'
```

'+str(countyRect.yMaximum())+','+str(countyRect.xMaximum())+'
'+str(countyRect.yMaximum())+','+str(countyRect.xMaximum())+'
'+str(countyRect.yMinimum())+','+str(countyRect.xMinimum())+' '+str(countyRect.yMinimum())+'))\'))')"

Load Layers in the Table of Contents

The function "runSelectConservationLands" in project_manager.py loads a layer from the user spatialite database depending on parameters such as table name, symbology and user database path.

Clip and Summary Operations

Each use case has the appropriate clip and summarize operations for the calculation needed.

Use Case I:

A *Vector Clip* operation is performed in Use Case I in order to summarize the layer's statistics. The calculation requires going through different attributes in the data. Based on the specific operation to execute, the project manager will loop over features and read data attributes. The summary of a layer requires running specific operations to a particular attribute for the input AOI. *Figure 313* displays the conceptual diagram of the sequential steps to clip and summary operations.

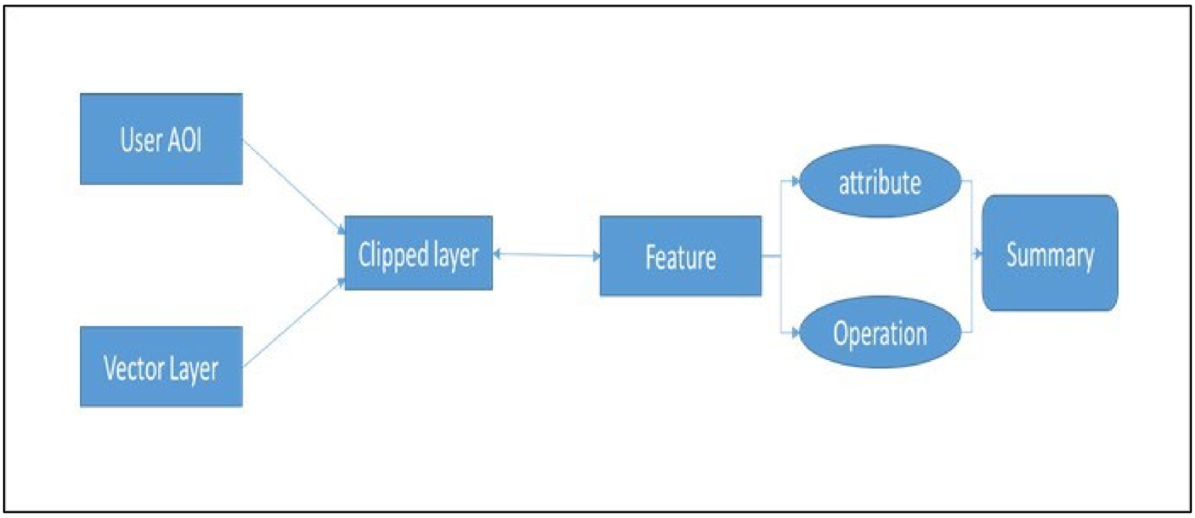


Figure 313 Conceptual diagram detailing the steps to clip and summary operations in Use Case I

A separate table named *AnalysisLayer* is used to determine the attributes used and the summary operation to be executed for the given layer. The list below shows the types of operations performed on layers:

1. Total area calculation
2. Total length calculation
3. Features count within the area
4. Dollar or dollar/area value summation
5. Total area categorized by feature description

The user can choose the AOI three different ways:

1. By County selection (Counties are listed in "Counties" layer).
2. By a Polygon shapefile (Shapefile should be loaded from the file system).
3. By drawing on the map (Drawing tools will appear in order to select the AOI)

"utils.ClipIt.clip" is the function responsible for the vector clip.
"runStats" function in Project Manager is responsible to run the summary statistic calculation for each layer.

Use Case II:

For Use Case II, a raster clip and summary operation are used. The summary operation calculates the mean of pixel values. *Figure 314* demonstrates the conceptual diagram of sequential steps to the clip and summary operations.

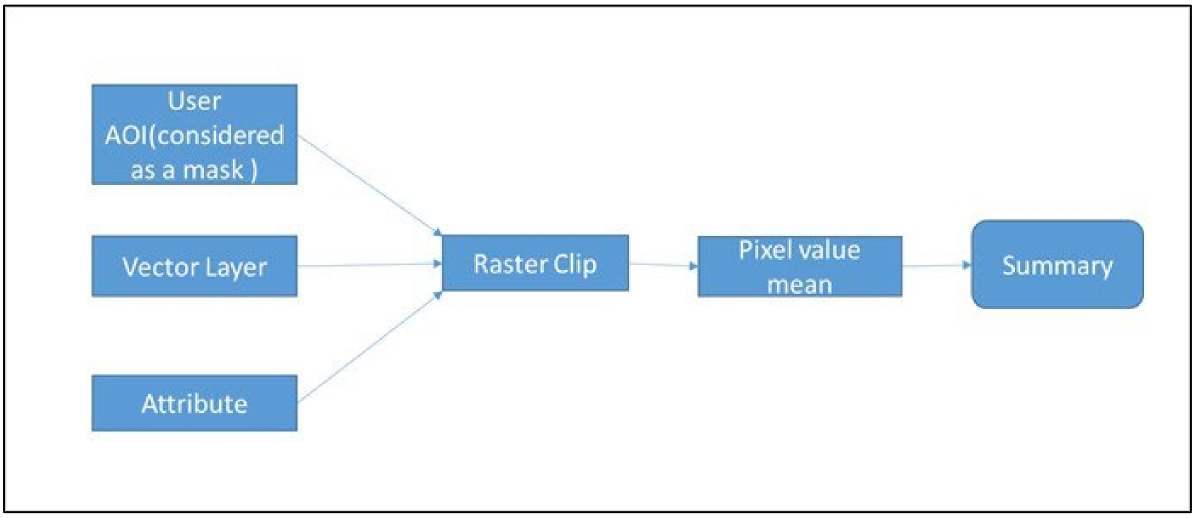


Figure 314 Conceptual diagram detailing the steps to clip and summary operations in Use Case II

A separate table named *UC2AnalysisLayer* is used to determine the attributes used and the summary operation to be executed for the given layer. The list below shows the types of operations performed on layers.

AOI selection choices for this use case are the same as Use Case I, with the addition of "Selection by river basins." River basins are listed in "River basins" layer.

"vectorToRasterGridClip" function lists layers to summarize from the UC2AnalysisLayer table.
"clipLandUseGrid" function runs the raster clip for a vector layer.

ES Coefficient Values and Edit User Scenarios

Editing ES coefficients affects the ES value calculations. A field's recalculation must be executed after every ES coefficient edit is complete. These coefficients are stored in the *scenario layer table* and are considered as default values for future edits. "EGSUpdateAttThread.py" is the source of the class responsible for ES coefficient edits and related recalculation executions.

The user can also edit the land use feature descriptions. EPA H2O will recalculate the ES values based on the new descriptions and attribute values found in the "LookUPvars" table. The recalculation is executed for all edited features. The "updateSelectedAttributes" function in "project_manager.py" performs all the ES values recalculations upon land use feature editing.

Reporting

Project Manager generates two different types of reports - one for each Use Case I and Use Case II. After calculating the summary statistics based on the use case, EPA H2O Project Manager generates the report. It combines the map, the legend, and the summarizing description of each ES variable within area of interest and its upstream area.

Below are the critical functions required for the report generation:

"writeMap" function in 'project_manager.py' exports the map and legend to a PNG image.
"writeReport" function in 'project_manager.py' generates the PDF report for Use Case I.

“writeReport2” function in 'project_manager.py' generates the PDF report for Use Case II.

Transportation Tool

The Transportation Tool is an additional functionality in Use Case II. It provides the user with ability to:
1. Customize the roads network
2. Check the change effects
3. Add new points of interest

Figure 315 shows the conceptual diagram for the Transportation Tool workflow.

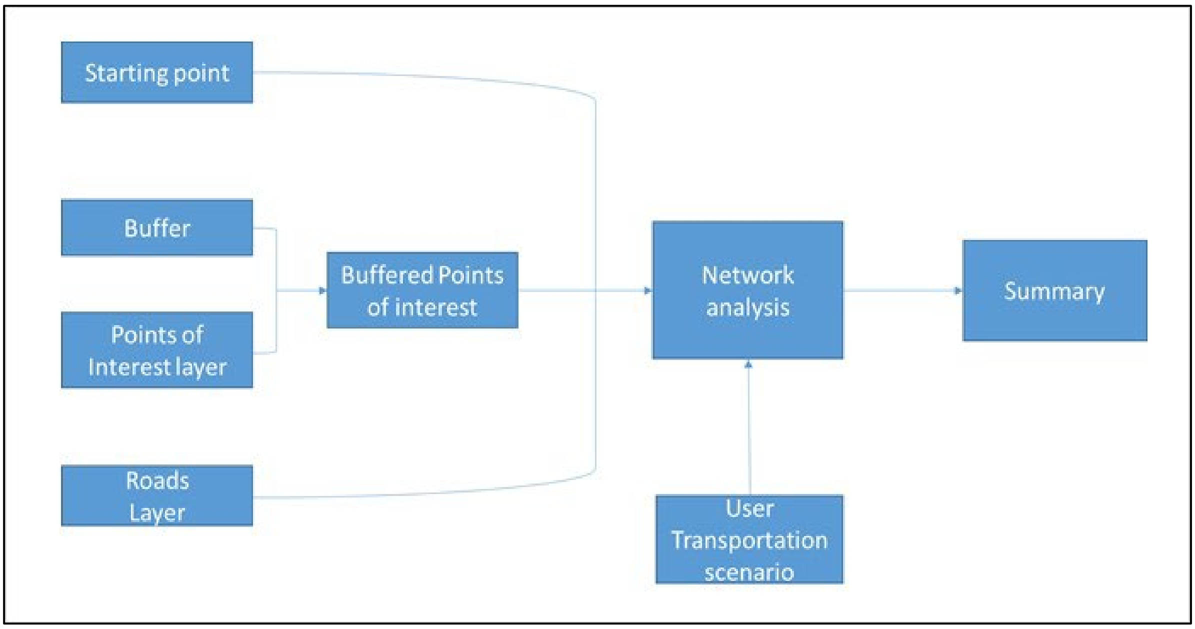


Figure 315 Conceptual diagram of the Transportation network workflow

Starting point

The user can choose the starting point two different ways:
1. By coordinate capture in the map
2. By geocoding an address

The “StPointCapButtonClick” function in 'project_manager.py' serves to capture a map point and set it as the starting point.
The “StPointGeocodeButtonClick” function in 'project_manager.py' serves to geocode an address and set it as the starting point.

Points of interest

EPA H2O lists standard points of interest and lets the user add extra points using three methods:
1. By coordinate capture
2. By geocoding an address
3. By loading a .csv file containing a list of addresses

User transportation scenario

The *User transportation scenario* is an exact copy of the *Roads* layer, but with user ability to edit.

“TrScenarioManager.py” is the UI class for the user transportation scenario’s creation and deletion.
“TransportationEditScenario.py” is the UI class responsible for editing the scenario.
“TrNewRoad.py” is the UI class responsible for adding new roads to the edited user scenario.

Network Analysis Library

Network Analysis Library from the QGIS API provides the functionality to build the topology and perform network analysis on it.

“SpeedProperter “class in 'ShortestPathCalculator.py' describes the strategy pattern based on road speed used by the network analysis.

Summary and reporting

The output of the network analysis updates the cost in time to reach each of the points of interest using the starting point as a reference. Upon running the analysis, Project Manager writes the cost in the buffered user points of interest layer. The report generated for the transportation module compares the main road network to a selected user transportation scenario.

“TrWriteReport” function in project_manager.py is used for writing the report.

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