Culvert Design Tool 1.0
User Guide
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I. Introduction

The Culvert Design Tool is a Python Add-in developed specifically for ESRI ArcMap 10.4. The tool employs the Rational Method as the basis for designing a singular submerged, circular, concrete culvert at a user-specified location. This automated technique displays an average time savings of greater than 95% over traditional hand calculations for watershed delineation and culvert design. The tool can be used to design a new proposed culvert or to simply confirm design results of an existing culvert. This instructional guide contains the methodology for installation and use of the Culvert Design Tool.

II. System Requirements

The Culvert Design Tool is compatible with ESRI ArcMap version 10.4 or higher. ArcMap must contain licenses for the Spatial Analyst toolbox
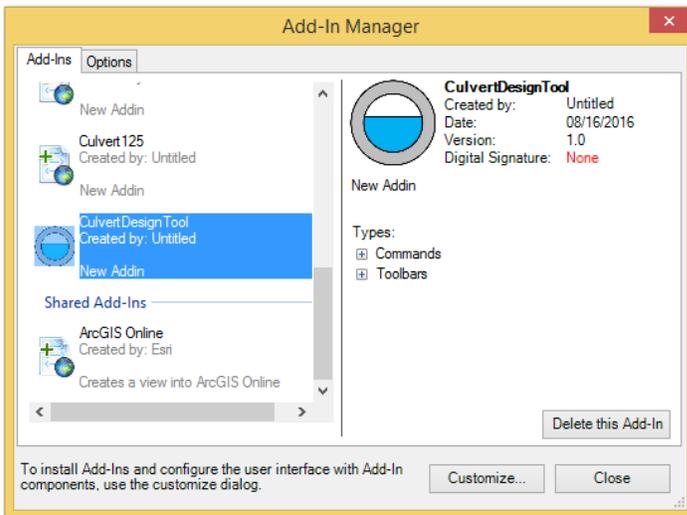
II. Installation

1. Installation of Python Add-in

a. Download the culvert design tool, which is an `.esridaddin` file, from the appropriate source

b. Once the `.esriaddin` file has been downloaded, double-click on the file. This will open the ESRI ArcGIS Add-In Installation Utility

c. Click the **Install Add-In** button at the bottom of the ESRI ArcGIS Add-In Installation Utility. Upon doing so, the utility will copy the add-in to the default add-in folder. On a Windows machine, the default add-in folder for ArcGIS 10.4 is: `C:\Users\<username>\Documents\ArcGIS\AddIns\Desktop10.4.`

d. If ArcMap is not running, the culvert design toolbar should open upon starting the program. If ArcMap is already running, you can add the toolbar to your window through the **Add-in Manager**.

e. To access the **Add-In Manager**, locate it under the **Customize** menu. Select the Culvert Design Tool from the list under **My Add-Ins**, and click the **Customize** button at the bottom of the window. Under **Toolbars** check the box beside the Culvert Design Tool. The tool will display itself in the ArcMap window. **Close** the Add-In Manager Window, and drag the Culvert Design Tool to its desired location within the ArcMap window.

Further instructions on installing an ESRI Python Add-In can be found here: http://desktop.arcgis.com/en/arcmap/10.3/guide-books/python-addins/sharing-and-installing-add-ins.htm

2. Installation of Appropriate Python Libraries

Some of the Python libraries employed by the Culvert Design Tool are already available within ArcMap. However, there are a couple of third-party libraries that must be downloaded in order to successfully run the design tool: **Requests** and **wxPython**. Both libraries are available for download online and must be downloaded to the user's ArcGIS site package library, which can be found in the location that Python was originally installed through ArcGIS. On a Windows machine, this is usually: `C:\Python27\ArcGIS10.4\Lib\site-packages`.

a. WxPython Download:

WxPython can be found at https://www.wxpython.org/download.php and can be installed using the instructions on the website. The version for 32-bit Python 2.7 should be downloaded. During the download, when prompted for the download folder, the user should choose the site package library folder described previously.

b. Requests Download:

Requests can be found at http://docs.python-requests.org/en/master/user/install/ and can be installed using the instructions on the website. Like wxPython, Requests should also be downloaded to the site package library folder described previously

III. Use

1. Acquisition of Required Data:

The culvert design tool designs a culvert based on a user-specified point by analyzing the land-cover and elevation changes around that point. In order for the program to

function, the user must provide a 1/3 arc-second digital elevation model (DEM) from the National Elevation Dataset (NED) as well as a land cover raster from the National Land Cover Database (NLCD).

The 1/3 arc-second DEM can be located through the NED here: http://viewer.nationalmap.gov/basic/

The NLCD can be located here (NLCD 2011 Land Cover): http://www.mrlc.gov/nlcd11_data.php

The NLCD automatically includes data for the entire coterminous United States, while the NED allows a user to select the location of his or her choosing. The user should select the DEM encompassing the location of interest by either clicking on the map or entering latitude and longitude coordinates.

Note: Some of the geoprocessing tools employed by the Culvert Design Tool require intensive processing of the DEM and therefore can take a long time to complete if the DEM contains a large area. For best results, it is recommended to clip the DEM to a smaller area of interest with the Raster Clip tool before attempting to use it within the Culvert Design Tool.

2. Add Data to Map:

The Culvert Design Tool requires that the user add both the DEM and the NLCD to the map document. The tool also requires that the coordinate system of the data frame be set to the same coordinate system as the DEM. This can most easily be achieved by simply adding the DEM to a blank map document first, before other layers have been added. Once the DEM has been added and the coordinate system set, the user may add the NLCD and any other layers which the user would like to include in the map document. The layers may be arranged in whichever order that the user prefers.
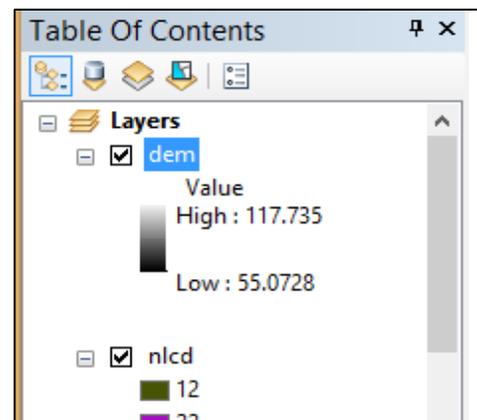
3. Run Design Tool:

a. Activate Toolbar:

The culvert design tool can be activated by clicking on its button in the toolbar. When the tool is activated, the cursor's appearance will change to a crosshair when it is hovering within the data frame.

b. Select Culvert Location:

Select the culvert location by clicking on its approximate location within the data frame.

c. Enter Culvert Design Constraints

Upon selecting the culvert location, the Culvert Design Form will appear. The user will be prompted to enter values for the following constraints:
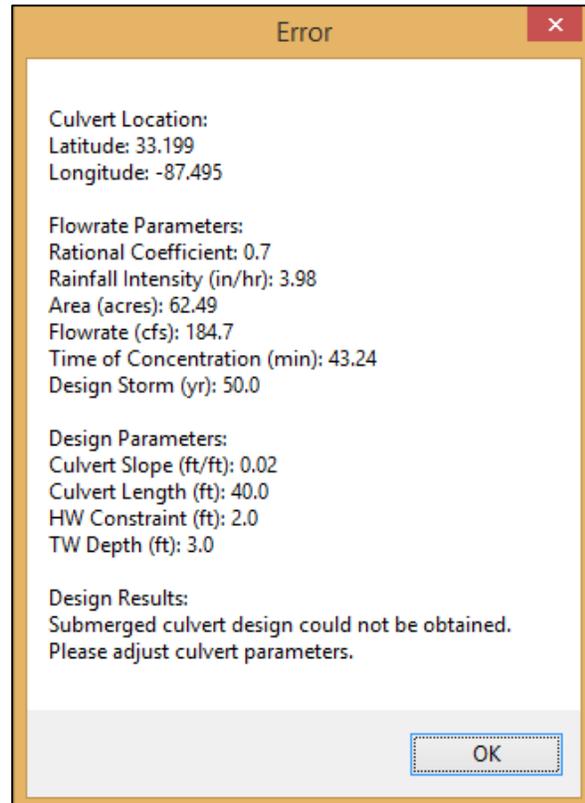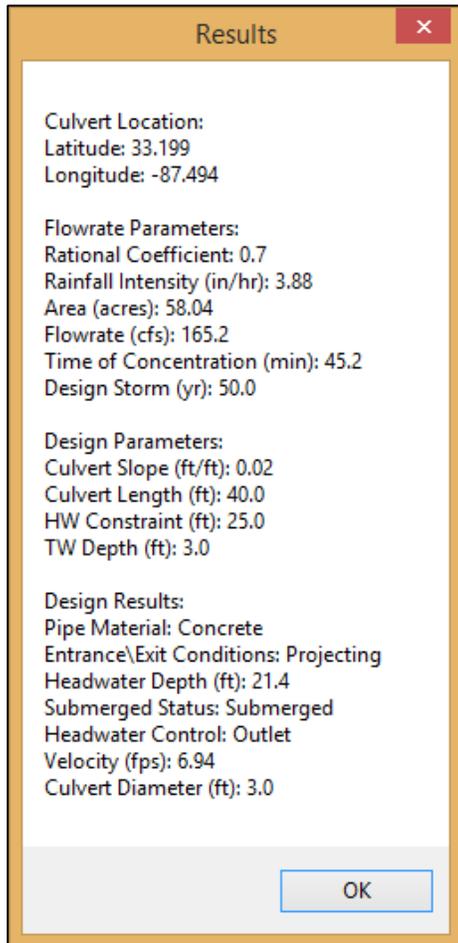
- **DEM Layer:** The user should select the DEM file from the dropdown list of layers within the map document.
- **NLCD Layer:** The user should select the NLCD file from the dropdown list of layers within the map document
- **Culvert Length:** This value can be described as the total length from the entrance of the culvert to the exit.
- **Culvert Slope:** This value can be described as the change in vertical height versus the length of the culvert. It is often the same as the natural slope of the stream.
- **Headwater (HW) Constraint:** This is the maximum allowable depth of water impounded upstream of the culvert.
- **Tailwater (TW) Value:** This is the depth of water at the outlet of a culvert.
- **Design Storm ARI:** This is defined as the Average Recurrence Interval for a storm, such as a 25-, 50-, or 100-year event.

A schematic containing the parameters can be found in Section 4 of this user guide. Once the desired parameters have been set, the user should click the "Calculate Culvert Design" button.
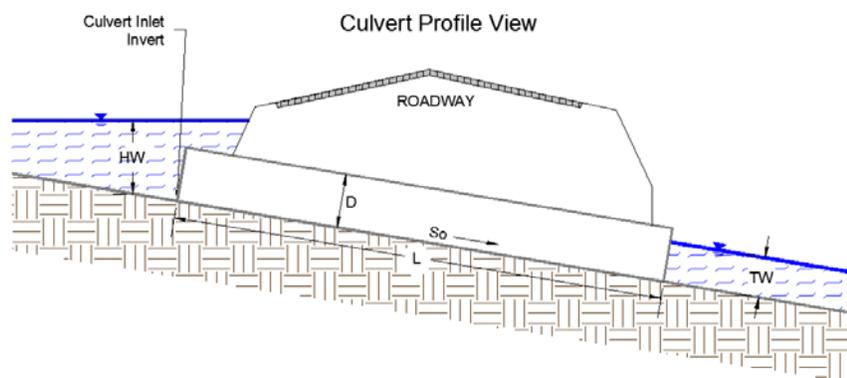
d. View Design Results

The resulting design calculations will appear to the user in a message box. A successful design will result in a message box containing all of the design results calculated through the tool. In the event that the given parameters produce a situation in which the design constraints could not be met, a message will be provided advising the user to adjust the design parameters.

Results ×

Culvert Location:
Latitude: 33.199
Longitude: -87.494

Flowrate Parameters:
Rational Coefficient: 0.7
Rainfall Intensity (in/hr): 3.88
Area (acres): 58.04
Flowrate (cfs): 165.2
Time of Concentration (min): 45.2
Design Storm (yr): 50.0

Design Parameters:
Culvert Slope (ft/ft): 0.02
Culvert Length (ft): 40.0
HW Constraint (ft): 25.0
TW Depth (ft): 3.0

Design Results:
Pipe Material: Concrete
Entrance\Exit Conditions: Projecting
Headwater Depth (ft): 21.4
Submerged Status: Submerged
Headwater Control: Outlet
Velocity (fps): 6.94
Culvert Diameter (ft): 3.0

OK

Error ×

Culvert Location:
Latitude: 33.199
Longitude: -87.495

Flowrate Parameters:
Rational Coefficient: 0.7
Rainfall Intensity (in/hr): 3.98
Area (acres): 62.49
Flowrate (cfs): 184.7
Time of Concentration (min): 43.24
Design Storm (yr): 50.0

Design Parameters:
Culvert Slope (ft/ft): 0.02
Culvert Length (ft): 40.0
HW Constraint (ft): 2.0
TW Depth (ft): 3.0

Design Results:
Submerged culvert design could not be obtained.
Please adjust culvert parameters.

OK

4. Interpret Design Results:

Results of the design as well as the parameters are displayed in the following diagrams:

- Culvert Diameter: D
- Headwater: HW
- Culvert Length: L
- Tailwater: TW
- Culvert Slope: S_o

Culvert Profile View

Culvert Cross-Section View