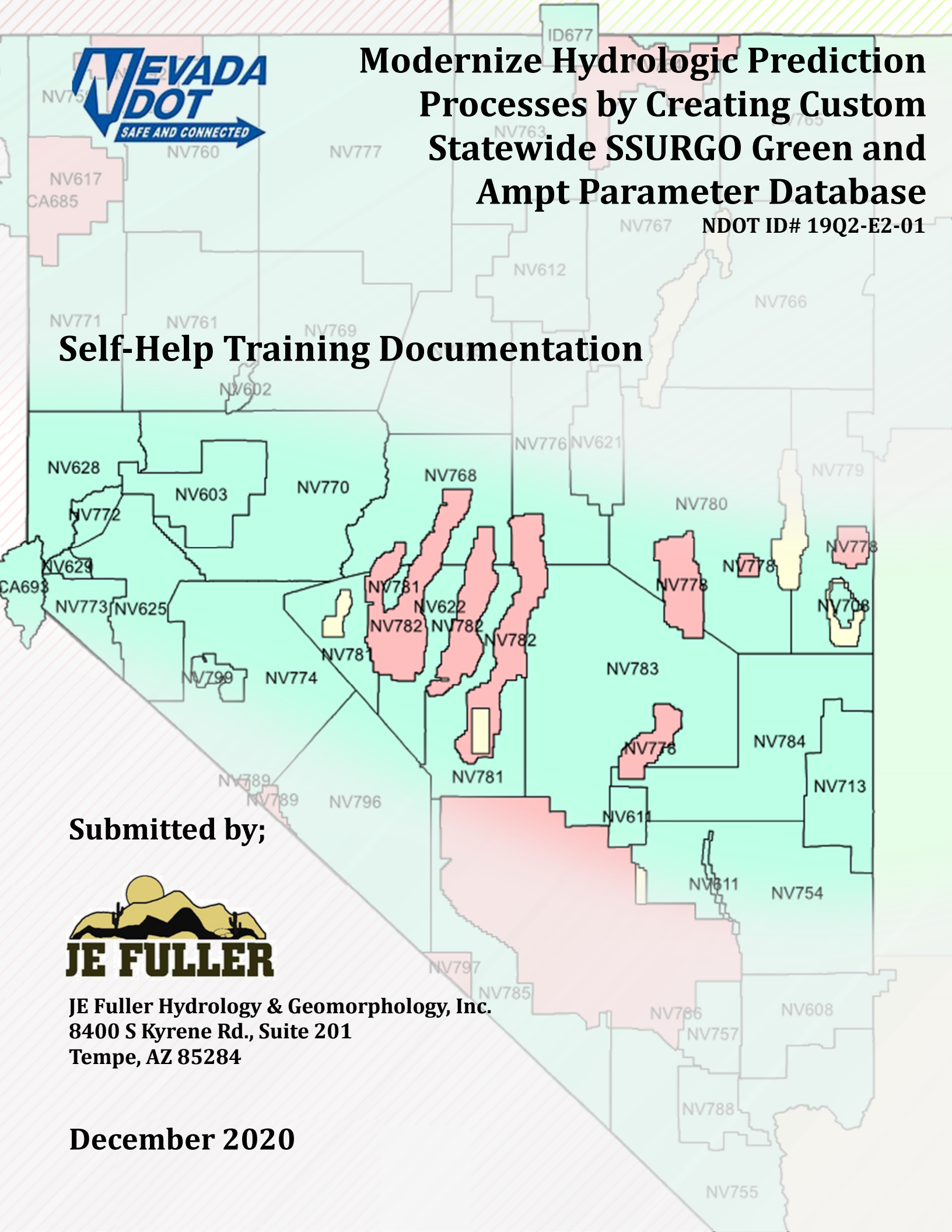




# Modernize Hydrologic Prediction Processes by Creating Custom Statewide SSURGO Green and Ampt Parameter Database

NDOT ID# 19Q2-E2-01

## Self-Help Training Documentation



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## Table of Contents

<u>Section</u>	<u>Page</u>
1. Introduction .....	1
2. Original Hydrologic Study .....	1
3. Example Model using Green and Ampt Methods .....	3
3.1 Processing NDOT polygon shapefiles using ArcMap and Excel .....	3
3.2 Determining hydrologic parameters for HEC-HMS loss modeling.....	7
4. Datasets for Rainfall.....	11
5. Developing a HEC-HMS Model.....	11
5.1 Getting Started .....	12
5.2 Creating a Project .....	12
5.3 Creating a Basin Model.....	13
5.4 Creating a Meteorologic Model .....	15
5.5 Entering Rainfall Losses .....	17
5.6 Developing Unit Hydrograph Data .....	18
5.7 Entering Unit Hydrograph Parameters into HEC-HMS .....	19
5.8 Creating Model Junctions .....	20
5.9 Creating Routing Reaches .....	20
5.10 Linking model elements.....	21
5.11 Adding data to each reach in the basin model.....	22
5.12 Adding a Diversion .....	23
5.13 Define Control Specifications.....	26
5.14 Run Model .....	26
5.15 View & Review the Results .....	27
6. Additional Modeling Considerations.....	28
6.1 Initial Abstraction using Canopy or Surface Methods .....	28
6.2 Depth Area Rainfall Reduction.....	29
7. References .....	29

## List of Figures

Figure 1 Project Location and Vicinity.....	2
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## List of Tables

Table 1 Subbasin 035 Data .....	7
Table 2 Assigned Land Use with Initial Moisture and % Impervious Assumptions.....	8
Table 3 Subbasin Effective Imperviousness .....	9
Table 4 Subbasin 035 Initial Content Values .....	10
Table 5 Green and Ampt Soil Parameter per Subbasins .....	11
Table 6 Subbasin Lag .....	19
Table 7 Junctions .....	20
Table 8 Routing Reaches.....	20



Table 9 Linking Junctions ..... 21

Table 10 Linking Subbasins ..... 21

Table 11 Reach Routing Parameters (Muskingum-Cunge)..... 22

Table 12 Diversion Rating Table ..... 24

Table 13 Point Rainfall Values for 100-year recurrence interval..... 29

**List of Appendices**

- Appendix A. Glossary
- Appendix B. HEC-HMS Model Support Data

## 1. Introduction

This document is intended to function as a Nevada Department of Transportation (NDOT) internal Self help guide for developing a simple hydrologic model using HEC-HMS. The model was developed based on the functions available in HEC-HMS Version 4.6. The example does not explain all the functions within HEC-HMS but makes use of the common functions available within the model software. The example was developed using an example watershed model (Section 2) supplied by NDOT. Within the example, notes are added where the modeling methods deviate from the Original Hydrologic Study and where NDOT specific methods were utilized.

## 2. Original Hydrologic Study

The reference Bailey Canyon Hydrologic Study was completed for the Washoe County Regional Transit Commission (RTC) in 2011. The project location and vicinity are shown in **Figure 1**. The hydrologic analysis consisted of a HEC-1 model with 11 subbasins, 6 routing reaches, 1 flow diversion, and 9 concentration points (Junctions). Rainfall losses were originally calculated using the Natural Resources Conservation Service (NRCS) curve number methodology and utilized soil, vegetation, and land use data. Flows were developed using the unit-hydrograph methodology. The precipitation depth was specified using NOAA Atlas 14 data with a fixed areal reduction of 0.98 of the point rainfall applied to all subbasins. The precipitation hyetograph was specified in the HEC-1 model using a JR record for a balanced storm distribution.



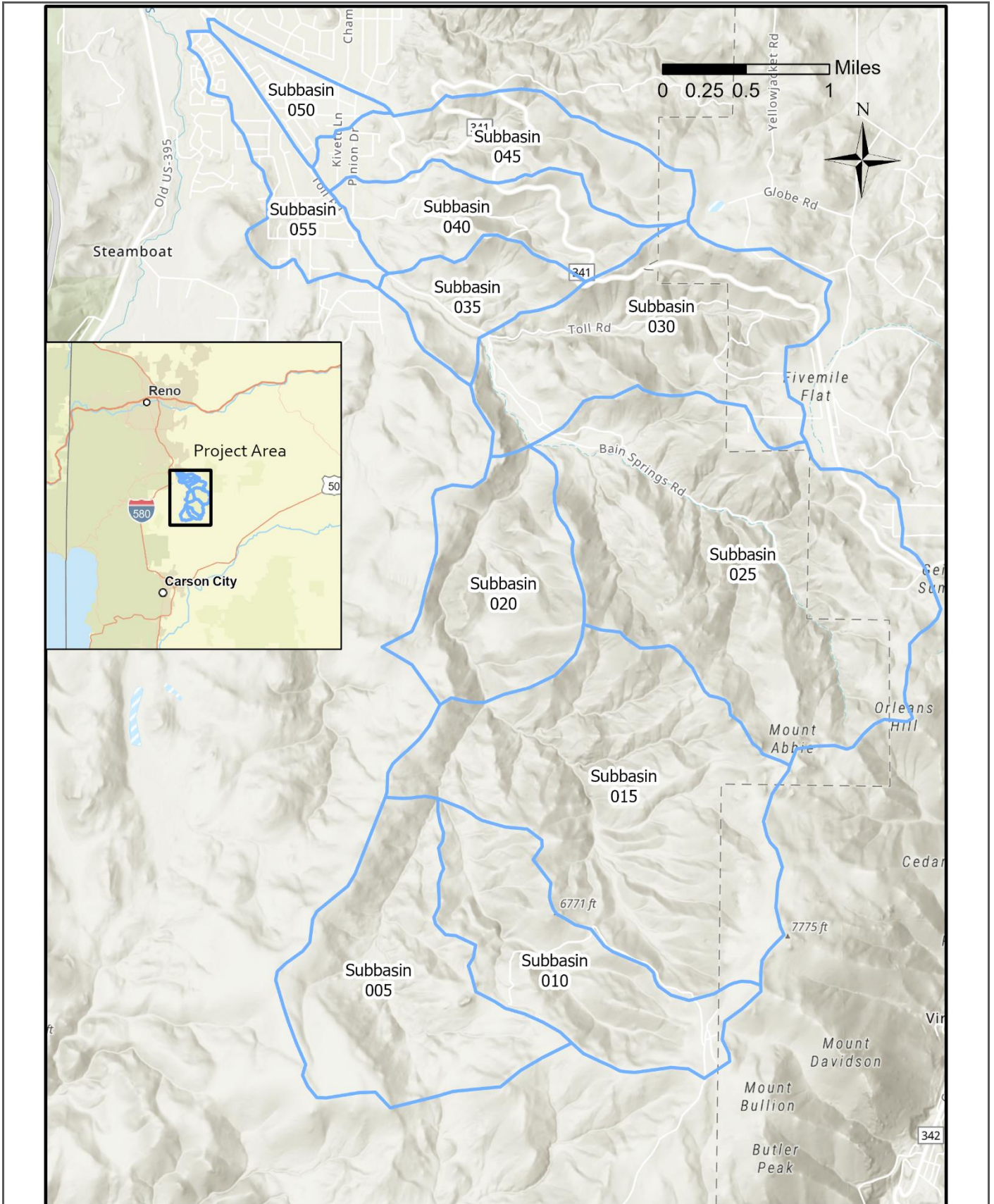


Figure 1 Project Location and Vicinity

### 3. Example Model using Green and Ampt Methods

The original hydrologic study was updated using the Green and Ampt methods/data processed as part of the overall project. Calculation of Green and Ampt parameters was accomplished using Nevada Department of Transportation (NDOT) Geographic Information System (GIS) data derived from NRCS soils surveys. The project watersheds fall within soil survey areas for Nevada (NV) NV628 And NV772 and data was calculated for the most restrictive layer within the top three inches of the soil column.

Green and Ampt parameters for use in HEC-HMS are defined as follows:

Initial Content	Dry - Volumetric soil moisture content expressed as Wilting Point (WPOINT) at start of rainfall, in inches,  Normal - Volumetric soil moisture content expressed as Field Capacity (FCAPAC) at start of rainfall, in inches,
Saturation (SAT)	Volumetric soil moisture content at saturation, in inches,
Suction (PSIF)	Wetting front capillary suction, in inches,
Conductivity (XKSAT)	Bare ground effective hydraulic conductivity at natural saturation, in inches/hour, and
Impervious %	Effective impervious area including soils and land use imperviousness, in percent.

Polygons of the subbasins were intersected with NDOT soils data to determine Green and Ampt parameter subareas within each subbasin. For subbasins with multiple soil map units present, Saturation (SAT), and Initial Content (Wpoint/FCapac) values were calculated via simple area weighted average of the soil map units in each of the subbasins. Suction (PSIF) and Conductivity (XKSAT) were calculated based upon a logarithmic area weighted average of the soil map units in each of the subbasins. Polygon intersection can be conducted using standard ArcMap routines. The Excel file provided in the example data includes all the soils/subbasins intersected values.

#### 3.1 Processing NDOT polygon shapefiles using ArcMap and Excel

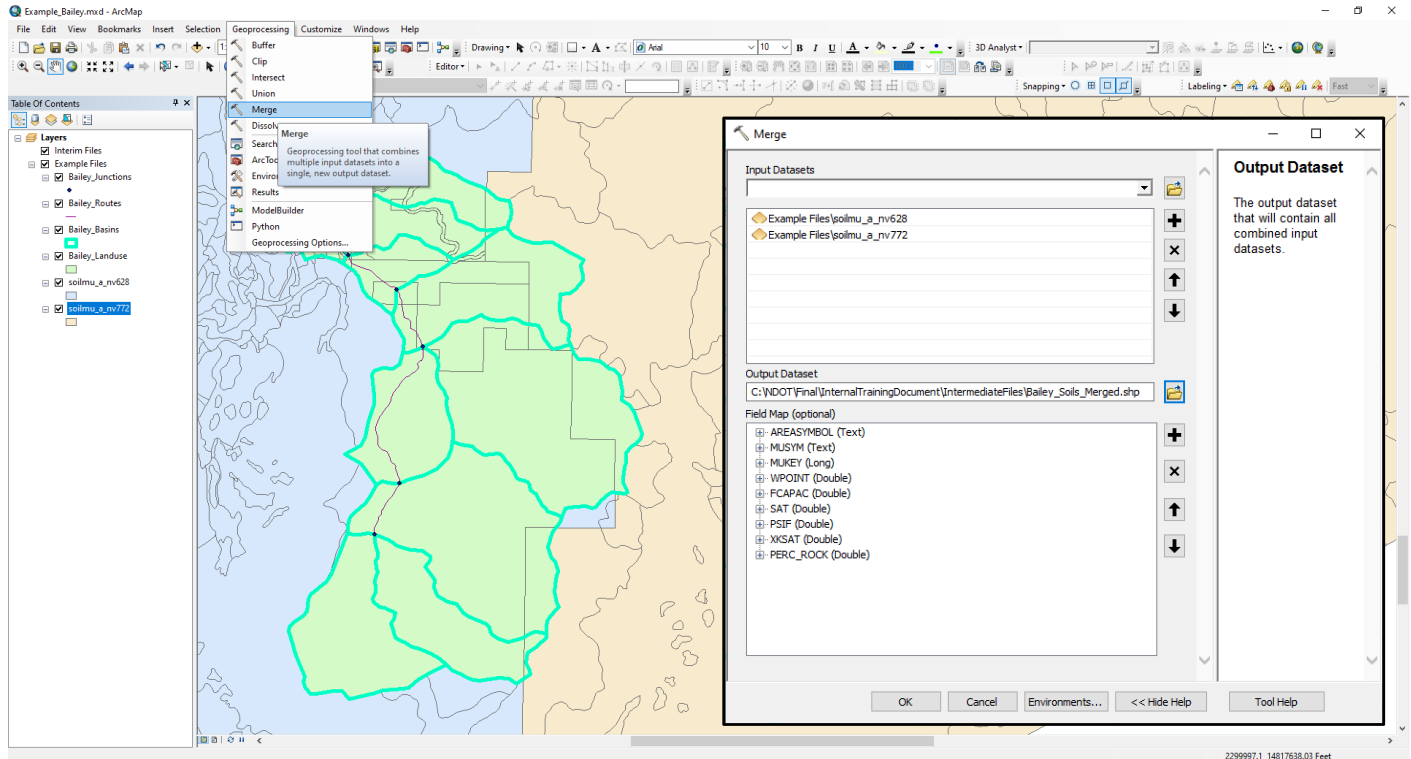
The following shape files have been provided for this example:

- soilmu\_a\_nv628 – Green and Ampt shapefile for Nevada Soils Survey 628
- soilmu\_a\_nv772 – Green and Ampt shapefile for Nevada Soils Survey 628
- Bailey\_Landuse – Land use data digitized from the original Bailey Canyon Study
- Bailey\_Basins – Subbasins for Bailey Canyon Watershed
- Bailey\_Junctions – Hydrologic modeling junctions for Bailey Canyon Watershed
- Bailey\_Routes – Hydrologic routing reaches for Bailey Canyon Watershed

##### 3.1.1 Merging Green and Ampt soils shapefiles

To develop basin specific Green and Ampt parameters, merging of the shapefiles soilmu\_a\_nv628 and soilmu\_a\_nv772 is recommended to facilitate further processing, this allows subsequent functions and calculations to be performed on a single soils dataset rather than multiple (two in this case). This can be accomplished using the “Merge” geoprocessing tool in ArcMap.

In the ArcMap menu bar, navigate to “Geoprocessing” → “Merge”. Within the merge dialogue box, under “Input Datasets” add both Green and Ampt soils shapefiles. Provide an output shapefile/feature class name and file location then select “OK”. If successful, after a few seconds the “Merged” Green and Ampt soils shapefile will be added to the map layers.

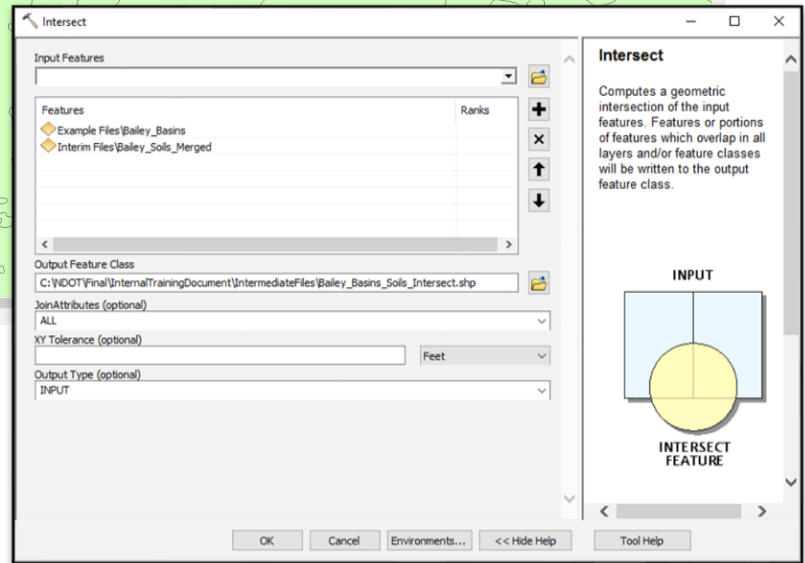
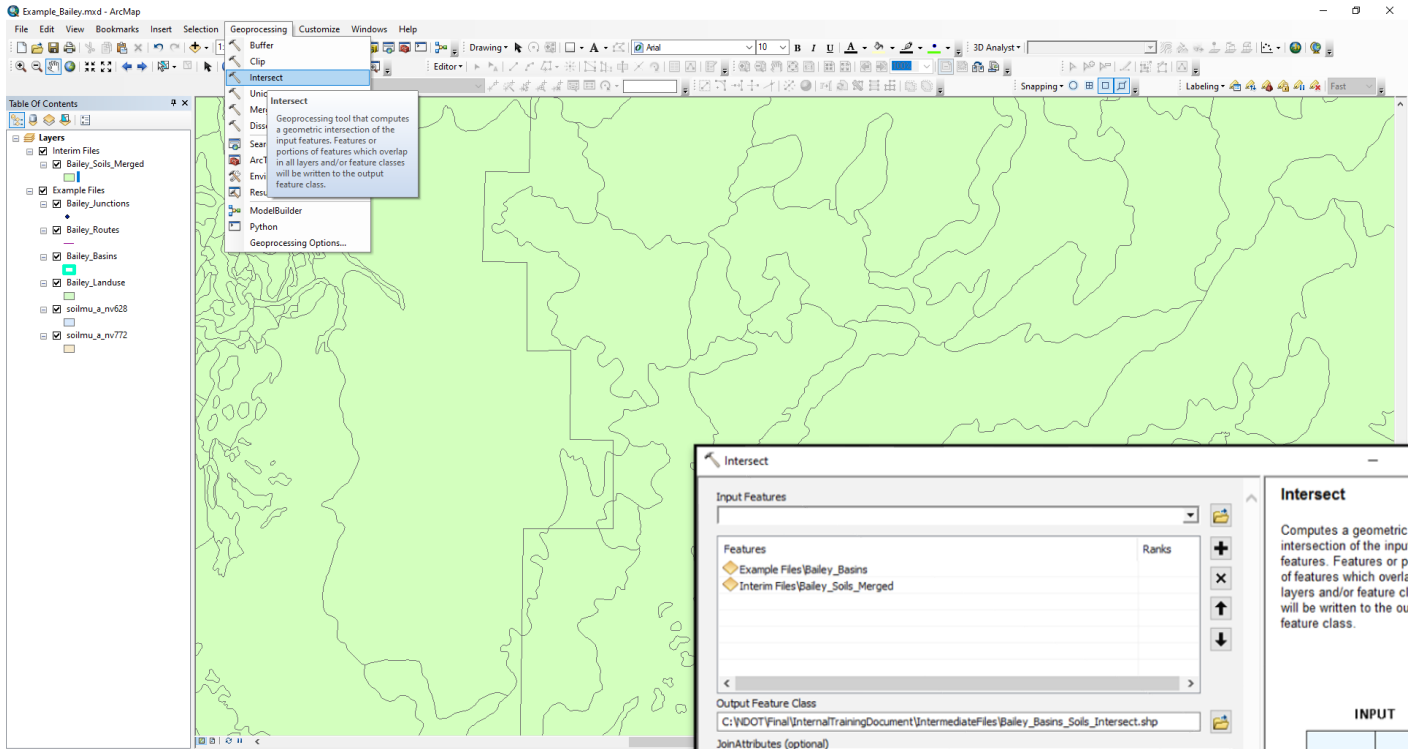


### 3.1.2 Intersecting Green and Ampt soils and Land Use shapefiles to develop subbasin specific parameters.

When developing subbasin specific Green and Ampt parameters the “Merged” Green and Ampt soils shapefile needs to be intersected with the subbasin shapefile then intersected with the land use shapefile. While Green and Ampt infiltration parameters are primarily based upon soils data, land use data is used to estimate antecedent moisture conditions, surface storage, and land use based imperviousness; an intersection step with the land use shapefile will be used to develop the effective impervious area and initial soil moisture content for each subbasin (See **Section 3.2**).

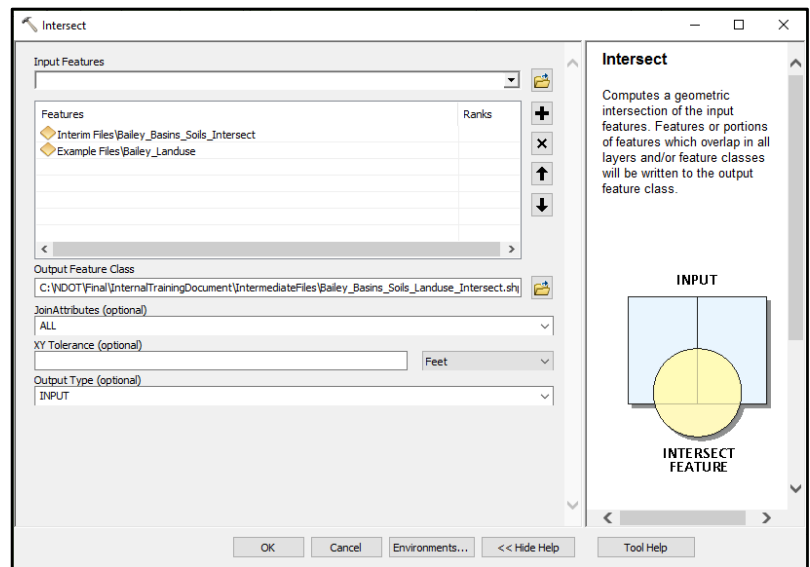


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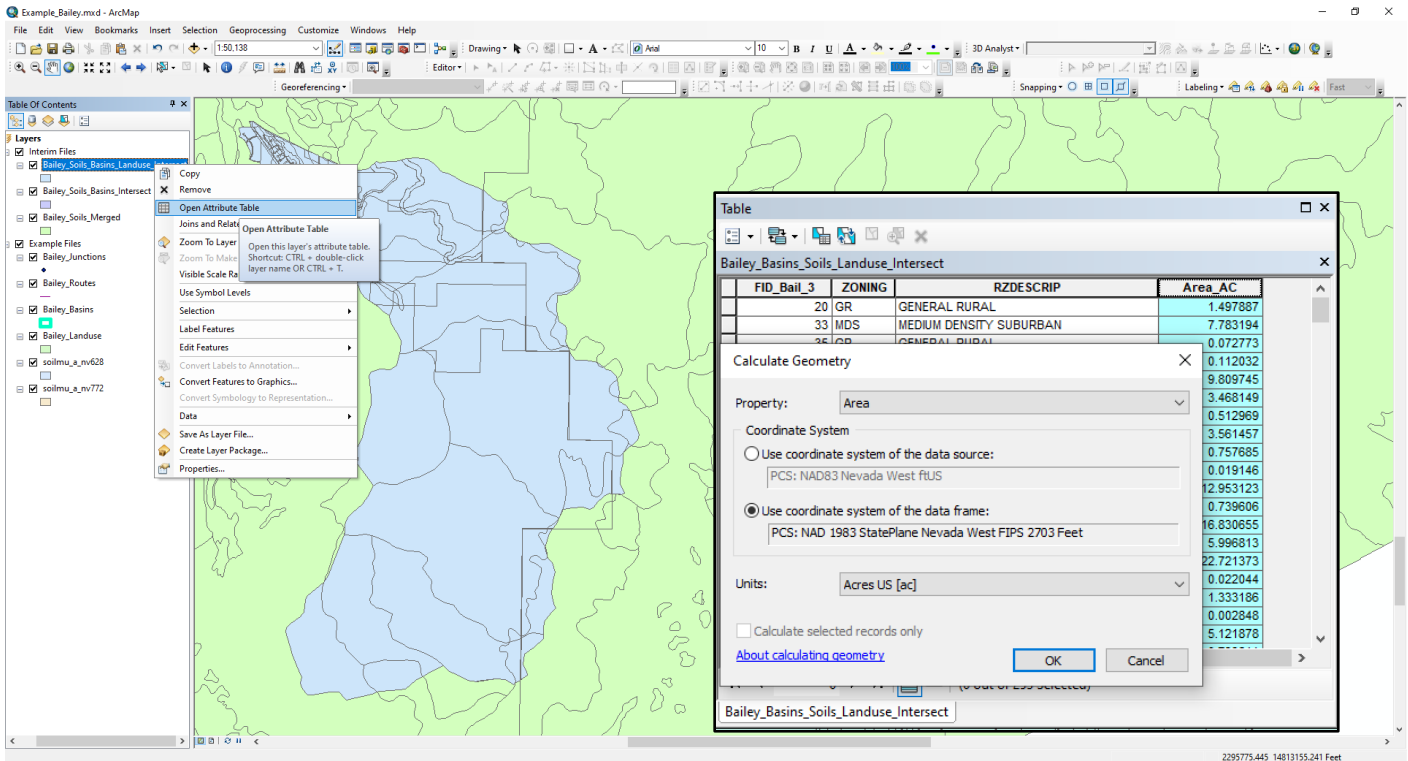
In the ArcMap menu bar, navigate to “Geoprocessing” → “Intersect”. Under “Input Datasets” add the Merged Soil shapefiles created in **Section 3.1.1** and subbasin boundaries (Bailey\_Basins.shp). Provide an output shapefile name and location then select “OK”. If successful, after a few seconds the intersected shapefile will be added to the map layers.

Run the process again by adding the newly created shape file (Bailey\_Soils\_Basins\_Intersect.shp) and Bailey\_Landuse. Again, provide an output shapefile name and location then select “OK”. If successful, after a few seconds the intersected shapefile will be added to the map layers.

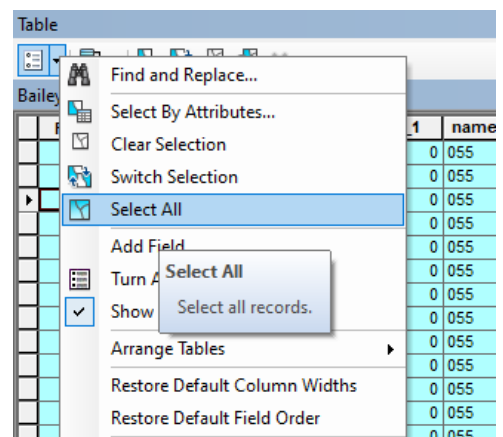


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As a final step before exporting the data and processing in the Excel spreadsheet, update the “ Area\_AC” column. This can be accomplished by highlighting the layer “Bailey\_Basins\_Soils\_Landuse\_Intersect”, right mouse click to “open attribute table”. Next highlight “Shape\_Area” column then select “Calculate Geometry” For this example select “Area” under top pull down menu, use coordinate system of the data frame and select “Acres US [ac]” under lower pull down menu.

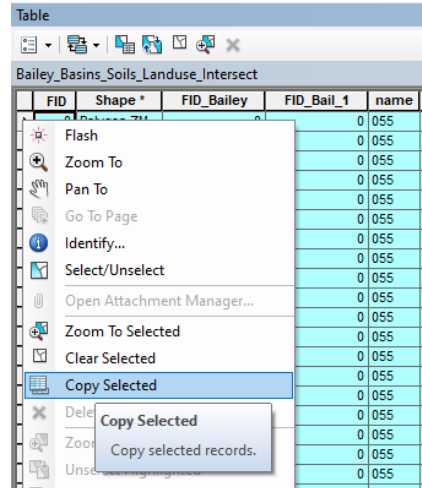


The next step in the process will extract the data from the shapefile Bailey\_Basins\_Soils\_Landuse\_Intersect.shp and add it to the spreadsheet prepared for this example. The spreadsheet, *Bailey\_3in\_Green&Ampt.xlsx*, located in folder *07\_DataFiles*, was created as one example of how to process Green and Ampt data for hydrologic modeling. Note: The modeler should use a process (GIS, Python, Excel etc. ) they are most comfortable with as long as the results match the values in **Table 5**.



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With the attribute table still open, select “Table Options” in the upper left corner and select “Select All” from the pull-down menu. Next, position the cursor anywhere along the left side of the table and right mouse click and a menu will pop up and select “Copy Selected”. Now the data is ready to “Paste” into the spreadsheet. Open the Excel spreadsheet, navigate to tab “Bailey\_G&A\_Data”, position cursor in cell A1 and paste shapefile data into spreadsheet. After the data is added to the spreadsheet, Sort the data in ascending order by the “name” column (Subbasin ID). If the data is pasted correctly, Table 5 on tab “Report Tables” should match **Table 5** below.



**3.2 Determining hydrologic parameters for HEC-HMS loss modeling**

All the data necessary to calculate Green and Ampt Loss parameters for input to HEC-HMS are now included in the shapefile data. For this example, the shapefile data that was added to the Excel spreadsheet for,

1. Determining Percent of Effective Impervious area for each Subbasin (**Section 3.2.1**)
2. Determining Controlling Initial Soils Moisture Content for each Subbasin (**Section 3.2.2**)
3. Determining Initial Content, Saturated Content, Suction and Conductivity for each Subbasin (**Section 3.2.3**)

For this example, subbasin 035, represented by 17 soils/land use subareas was extracted directly out of the relevant columns in *Bailey\_Basins\_Soils\_Landuse\_Intersect.shp* prepared in **Section 3.1 (Table 1)**.

Table 1 Subbasin 035 Data									
Subbasin	Soil Survey ID	Soil Map Unit	WPOINT [IN]	FCAPAC [IN]	SAT [IN]	PSIF [IN]	XKSAT [IN/HR]	Effective Impervious [%]	Subbasin Area [AC]
35	NV628	482	0.066	0.132	0.441	0.0720	1.0806	0.0000	4.40
35	NV628	482	0.066	0.132	0.441	0.0720	1.0806	0.0000	0.07
35	NV628	482	0.066	0.132	0.441	0.0720	1.0806	0.0000	1.12
35	NV628	482	0.066	0.132	0.441	0.0720	1.0806	0.0000	9.65
35	NV628	482	0.066	0.132	0.441	0.0720	1.0806	0.0000	1.50
35	NV628	1520	0.117	0.235	0.437	7.6430	0.2584	0.0000	1.78
35	NV628	1520	0.117	0.235	0.437	7.6430	0.2584	0.0000	0.27
35	NV628	1520	0.117	0.235	0.437	7.6430	0.2584	0.0000	31.63
35	NV628	1520	0.117	0.235	0.437	7.6430	0.2584	0.0000	105.51
35	NV628	1520	0.117	0.235	0.437	7.6430	0.2584	0.0000	137.82
35	NV628	1520	0.117	0.235	0.437	7.6430	0.2584	0.0000	8.73
35	NV628	251	0.093	0.182	0.431	3.1800	0.5021	0.0000	0.40
35	NV628	251	0.093	0.182	0.431	3.1800	0.5021	0.0000	9.80
35	NV628	251	0.093	0.182	0.431	3.1800	0.5021	0.0000	3.77
35	NV628	251	0.093	0.182	0.431	3.1800	0.5021	0.0000	0.77
35	NV628	251	0.093	0.182	0.431	3.1800	0.5021	0.0000	0.09
35	NV628	251	0.093	0.182	0.431	3.1800	0.5021	0.0000	13.73

Note: Abbreviations used in column headings match shapefile.

### 3.2.1 Determining Percent Effective Impervious Area for each Subbasin

In applying Green and Ampt methodology, the “Percent Impervious Area” attribute may be calculated through a composite of soils imperviousness and land use imperviousness.

Soils imperviousness is included in the NDOT soils data shapefiles as PERC\_ROCK or Percent Rock. This terminology is consistent with the original NRCS soils data. For the purposes of consistency with Green and Ampt reference documentation, Soils (Natural) Imperviousness is used in this document.

Land use imperviousness was determined using the land use composition within each subbasin. Land use composition for each area were then cross-referenced with **Table 2** to determine the approximate percent imperviousness for each land use category.

For this example, Initial Moisture content and % Imperviousness were set using the original hydrologic study land use categories and reference tables found in the ADOT Hydrology Manual (Arizona Department of Transportation, 2014) and Mohave County (Arizona) Drainage Design Manual (latest edition).

Table 2 Assigned Land Use with Initial Moisture and % Impervious Assumptions			
Land Use Code	Land Use Name	Initial Moisture Condition	Land use Imperviousness [% 0-100]
OS	Open Space	dry	0
GR	General Rural	dry	12
LDS	Low Density Suburban	dry	14
MDS	Medium Density Suburban	normal	22
MDR	Medium Density Rural	normal	6
PR	Parks and Recreation	dry	0
PSP	Public and Semi-Public Facilities	dry	0
GC	General Commercial	dry	85
HDS	High Density Suburban	normal	54

Note: For this example, values in **Table 2** are not included in the Bailey\_Landuse.shp file however the modeler may choose to add these values to simplify processing of Initial Soils Moisture Content and Percent of Effective Impervious area for each Subbasin.

Once values for percent impervious areas are determined for both soil and land use attributes, the two values are then composited using simple area weighted average for use within HEC-HMS. Calculated values for soils and land use imperviousness are shown in **Table 3** and can be found in *Bailey\_3in\_Green&Ampt.xlsx* on *All Subbasins* tab, columns “Soils % Imp” and “Land use % Imp” with effective imperviousness found on column “Effective % Impervious”. Effective Impervious percentage per subbasin assumes impervious area is hydraulically directly connected to the basin outlet.

**Table 3 Subbasin Effective Imperviousness**

Subbasin	Weighted Soils (Natural) Imperviousness [% 0-100]	Weighted Land use Imperviousness [% 0-100]	<sup>1</sup> Weighted Effective Imperviousness [% 0-100]
005	0.0%	0.0%	0.0%
010	0.0%	0.0%	0.0%
015	0.0%	0.0%	0.0%
020	0.0%	0.0%	0.0%
025	0.0%	1.4%	1.4%
030	0.0%	4.3%	4.3%
035	0.0%	6.0%	6.0%
040	0.0%	12.1%	12.1%
045	0.0%	10.7%	10.7%
050	0.0%	22.6%	22.6%
055	2.9%	21.4%	24.3%

Note 1: Weighted Effective Imperviousness is the sum of Weighted Soils (Natural) Imperviousness and Weighted Land use Imperviousness for each subbasin.

**3.2.2 Determining Controlling Initial Soils Moisture Content for each Subbasin**

Initial soil moisture or Initial Content (WPOINT, FCAPAC or SAT) within each subbasin is assigned based upon the soil parameters and land use. For example, for natural or non-irrigated landscapes, a dry condition, as represented by the Wilting Point (WPOINT), is utilized. For irrigated landscapes such as lawns, a normal condition saturated content, specified as the Field Capacity (FCAPAC) is assumed and for agricultural land uses, saturated initial conditions or Saturation (SAT) is assumed.

Average initial soil moisture values for use within HEC-HMS were calculated based upon the percent of each subarea represented by each moisture condition (dry, normal or saturated) and are calculated via simple area weighted average based upon the soil and land use composite data. Land use initial moisture assumptions for the example hydrologic model subbasins are shown in **Table 2**.

**3.2.3 Determining Initial Content, Saturated Content, Suction and Conductivity for each Subbasin**

Calculations for Initial Content (WPOINT, FCAPAC or SAT) can be accomplished by first determining the controlling initial conditions of either Wilting Point (WPOINT), Field Capacity (FCAPAC) and Saturation (SAT) values for each soil map unit based on land use representing dry, normal, and saturated conditions. For subbasin 035, these values are shown in **Table 4** below.



**Table 4 Subbasin 035 Initial Content Values**

Subbasin	Soil Survey ID	Soil Map Unit	WPOINT [IN]	FCAPAC [IN]	SAT [IN]	<sup>1</sup> Land Use Code]	Initial Moisture Conditions	Initial Content	Subbasin Area [AC]
35	NV628	482	0.066	0.132	0.441	GR	dry	0.066	4.40
35	NV628	482	0.066	0.132	0.441	LDS	dry	0.066	0.07
35	NV628	482	0.066	0.132	0.441	MDS	normal	0.132	1.12
35	NV628	482	0.066	0.132	0.441	OS	dry	0.066	9.65
35	NV628	482	0.066	0.132	0.441	MDR	normal	0.132	1.50
35	NV628	1520	0.117	0.235	0.437	OS	dry	0.117	1.78
35	NV628	1520	0.117	0.235	0.437	GR	dry	0.117	0.27
35	NV628	1520	0.117	0.235	0.437	GR	dry	0.117	31.63
35	NV628	1520	0.117	0.235	0.437	GR	dry	0.117	105.51
35	NV628	1520	0.117	0.235	0.437	OS	dry	0.117	137.82
35	NV628	1520	0.117	0.235	0.437	MDR	normal	0.235	8.73
35	NV628	251	0.093	0.182	0.431	OS	dry	0.093	0.40
35	NV628	251	0.093	0.182	0.431	GR	dry	0.093	9.80
35	NV628	251	0.093	0.182	0.431	LDS	dry	0.093	3.77
35	NV628	251	0.093	0.182	0.431	MDS	normal	0.235	0.77
35	NV628	251	0.093	0.182	0.431	LDS	dry	0.093	0.09
35	NV628	251	0.093	0.182	0.431	OS	dry	0.093	13.73

Note: Land use code per **Table 2**.

Depending upon the detail and accuracy of available soil and land use spatial datasets, an intersection of the land use initial moisture conditions with the soil moisture parameters can be used to subdivide the soil initial moisture capacity based upon different land use types (as described above and shown in **Table 4**), but for many studies, use of a single initial moisture condition per subbasin is acceptable. If the soil and land use spatial datasets are intersected, a simple area weighted average of the initial moisture conditions should be utilized to calculate the subbasin average value. Similarly, a simple area weighted average should be used based upon the selected initial moisture condition for the soils data if a land use/soils intersection is not performed.

For Subbasin 035, the land use for the subbasin varies and the initial content value will be calculated using a simple area weighted average assuming a “dry” or “normal” initial soils condition.

$$Initial\ Content = \frac{4.04*0.066+0.07*0.066+1.12*0.132+.....+13.73*0.093}{4.04+0.07+1.12+.....+13.73} = 0.116\ in.$$

Similar calculations using a simple area weighted average for Saturation (SAT) are needed to aggregate the data for HEC-HMS.

Calculation of the Conductivity (XKSAT) value for Subbasin 035 is then accomplished by taking the logarithmic area weighted average of the Conductivity (XKSAT) values for the applicable soils from **Table 1**.

$$\text{Conductivity (XKSAT)} = 10^{\left(\frac{4.04 \cdot \log_{10}(1.0806) + 0.07 \cdot \log_{10}(1.0806) + 1.12 \cdot \log_{10}(1.0806) \dots + 13.73 \cdot \log_{10}(0.5021)}{4.04 + 0.07 + 1.12 \dots + 13.73}\right)}$$

$$\text{Conductivity (XKSAT)} = 10^{-0.5314} = 0.2942 \text{ in/hr}$$

Similar calculations using logarithmic area weighted average for Suction (PSIF) are needed to aggregate the data for HEC-HMS. Green and Ampt soil-based parameters are summarized (for the top 3" soil horizon dataset) in **Table 5**. For this example, Excel was used to aggregate the Green and Ampt parameters for each subbasin. See *Bailey\_3in\_Green&Ampt.xlsx* in *07\_DataFiles* folder. Once hydrologic parameters are calculated for each subbasin, they can be added to the HEC-HMS model.

Table 5 Green and Ampt Soil Parameter per Subbasins					
Subbasin	Initial Content WPOINT or FCAPAC [IN]	Saturation SAT [IN]	Suction PSIF [IN]	Conductivity XKSAT [IN/HR]	Effective Imperviousness [% 0-100]
005	0.121	0.434	7.628	0.2516	0.0
010	0.114	0.438	7.022	0.2763	0.0
015	0.115	0.437	7.172	0.2717	0.0
020	0.117	0.437	7.644	0.2578	0.0
025	0.114	0.438	7.107	0.2760	1.4
030	0.116	0.437	7.622	0.2625	4.3
035	0.116	0.437	5.598	0.2942	6.0
040	0.130	0.437	5.314	0.2941	12.1
045	0.127	0.437	5.832	0.2875	10.7
050	0.130	0.426	0.841	0.7199	22.6
055	0.175	0.430	2.962	0.3703	24.3

#### 4. Datasets for Rainfall

The NOAA’s National Weather Service (NWS) provides the GIS datasets of NOAA Atlas 14 rainfall. The data is available from the NWS Hydrometeorological Design Studies Center website: [https://hdsc.nws.noaa.gov/hdsc/pfds/pfds\\_map\\_cont.html?bkmrk=nv](https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nv).

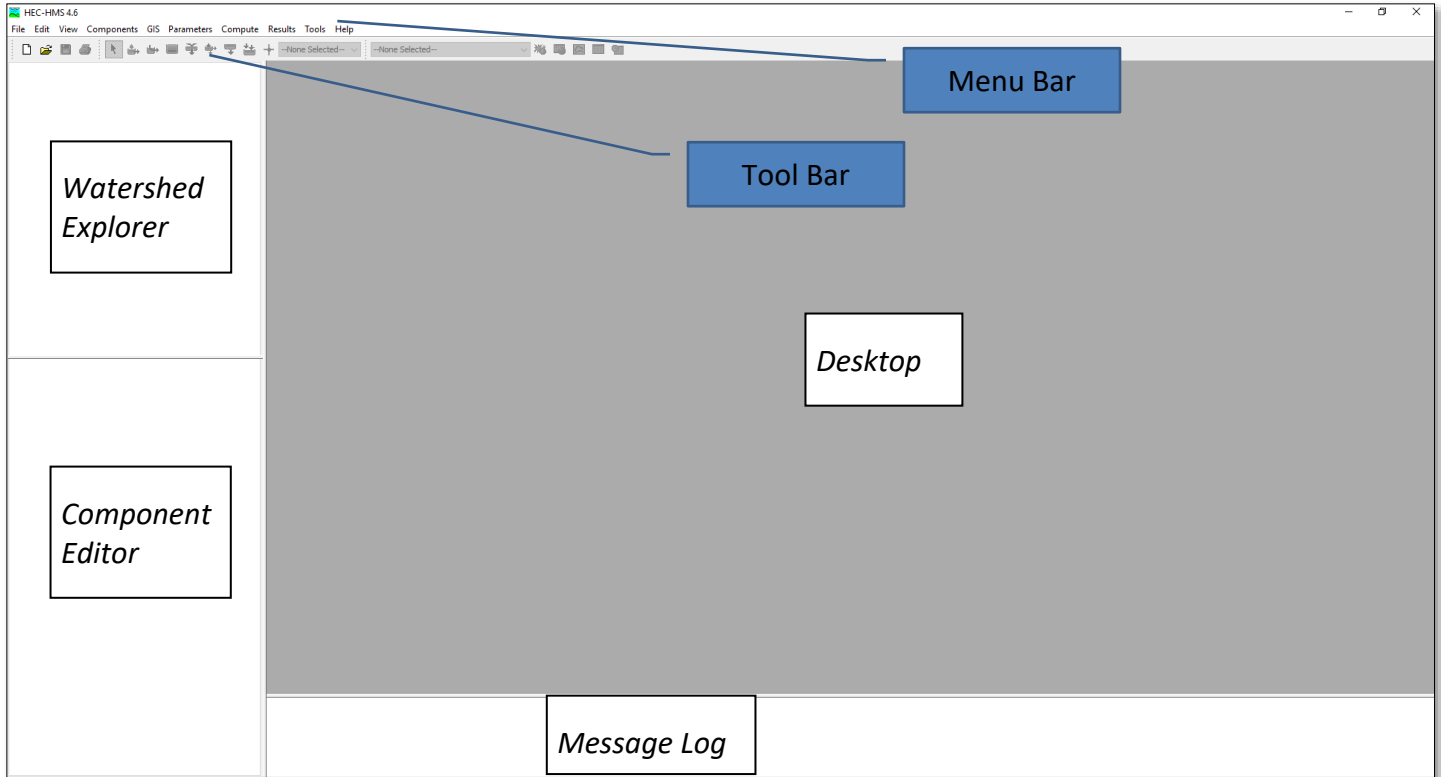
#### 5. Developing a HEC-HMS Model

This example will guide you through various steps to prepare a simple HEC-HMS hydrologic model using the NDOT Green and Ampt soils data. Modeling sequence is setup to input all the relevant data for the sub-basins and routing reaches then develop the model hydrologic order. Alternatively, the user may find it more desirable to prepare the model hydrologic order for each basin and concentration point as they enter the data. This is certainly an option, HEC-HMS Version 4.6 includes data summary tables that can be accessed by selecting **Parameters** in the Menu Bar and navigating to desired menu. Additional discussion and shortcuts are included in this example.

### 5.1 Getting Started

Start HEC-HMS by clicking on the HEC-HMS icon by going to Start → Programs → HEC-HMS → HEC-HMS 4.6.

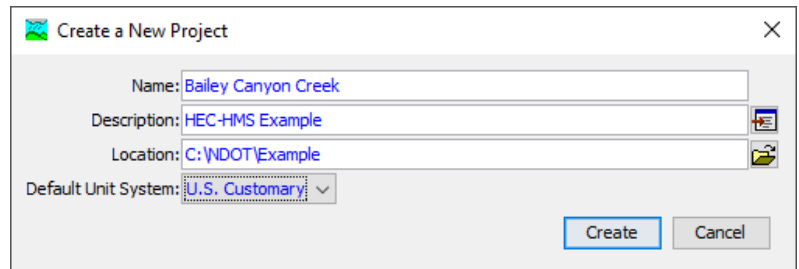
After a few seconds, the following should appear:



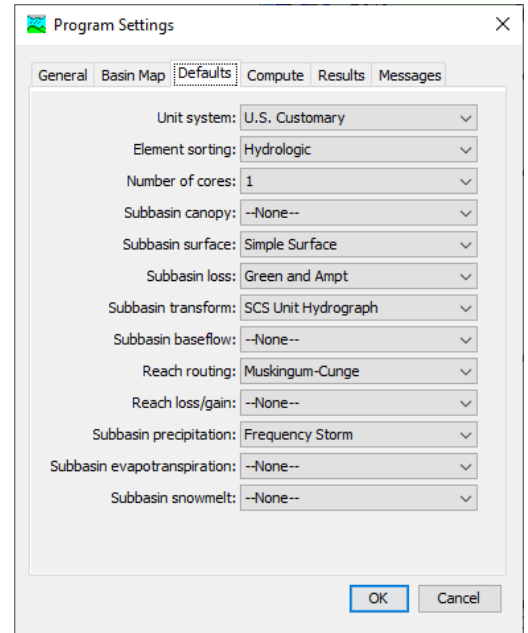
This window represents the HEC-HMS Interface. The HEC-HMS interface consists of a menu bar, tool bar, and four panes. These panes are referred to as the *Watershed Explorer*, the *Component Editor*, the *Message Log* and the *Desktop*. These panes are further discussed later in the example.

### 5.2 Creating a Project

1. Open a new project in HEC-HMS (**File** → **New**).
2. Enter the following in the “Create a New Project” dialog box:
  - a. Name: Bailey Canyon Creek
  - b. Description: HEC-HMS Example



- c. Location: Point the browser to the location you would like the project stored. Remember this location because you will need to retrieve the project later.
- d. Default Unit System: Select “US Customary” or prepare to do lots of metric conversions.
- e. Click on “Create”. Note that a file folder called “Bailey Canyon Creek” appears in *Watershed Explorer*.

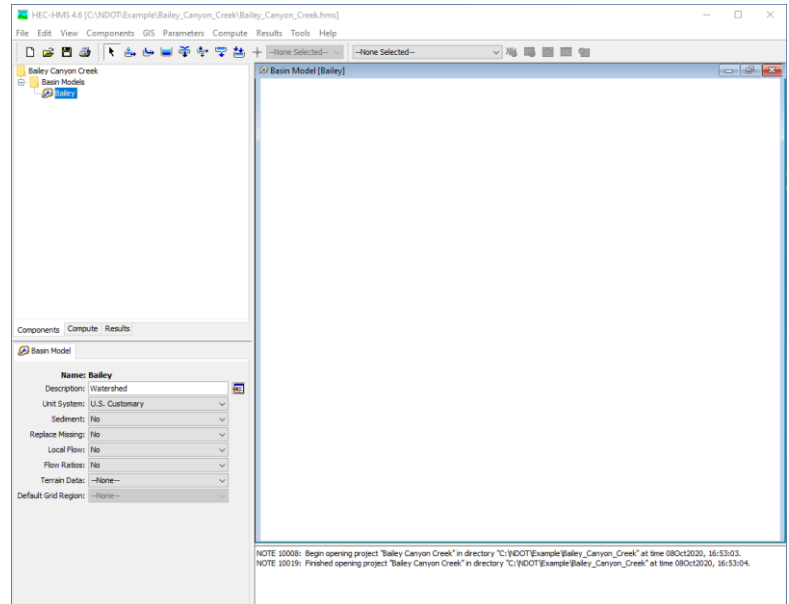


- 3. Set the program default settings (**Tools** → Program Settings → Defaults) to what you think they ought to be (we can update this later, but setting the defaults is a good habit).

### 5.3 Creating a Basin Model

- 1. Create a Basin Model (**Components** → Basin Model Manager). In the “Basin Model Manager” dialog box, create the Bailey Canyon Creek model by doing the following:

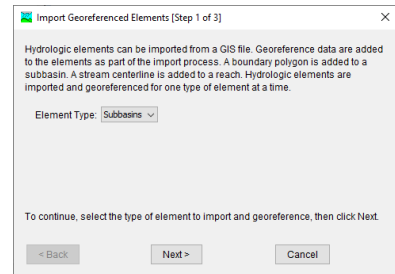
- a. Click “New”
- b. Enter “Bailey” for Name and a description of your choice.
- c. Click “Create.” Note that a file folder called “Basin Models” appears in the *Watershed Explorer*.
- d. Close the Basin Model Manager dialog box and expand the “Basin Models” file folder to reveal a subfolder called “Bailey”.



- e. Click on the Bailey folder – the basin model screen in the *Desktop* becomes active.

2. Setting coordinate system - Clicking GIS → Coordinate System. Select either Predefined or Browse.

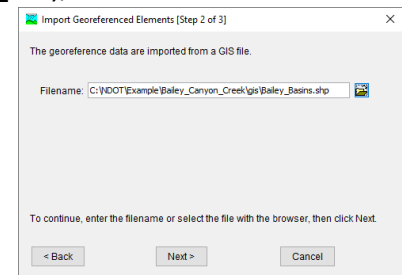
For this example, a coordinate system is provided. Select Browse and navigate to the folder (03\_Projections) location containing the projection file “NAD 1983 StatePlane Nevada West FIPS 2703 (US Feet).prj” then click set. This will set the coordinate system when importing georeferenced GIS files. Note: Don’t worry if this step is skipped, the model will use the coordinate system of the first imported GIS file from Step 3 below.



3. Importing GIS basin and routing reach shapefiles by clicking **GIS** → Import Georeferenced Elements. For this example, select

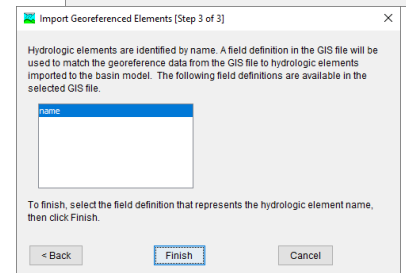
“Next” to go to step 2 of the import process. Navigate to the file location (04\_GIS), select “Bailey\_Basins.shp”. Select “Next” to go to step 3 of the import process.

Available shapefile column headers will appear for the subbasin names. For this example, select “name” and then “Finished”. Repeat process for routing reached. Each subbasin and routing reach imported will appear under “Basin Model” but will not include modeling data other than geographic location (Latitude and Longitude) and basin area. Using the same process, add Bailey\_Junctions.shp. this file will be useful in developing the hydrologic model in **Section 5.8**.



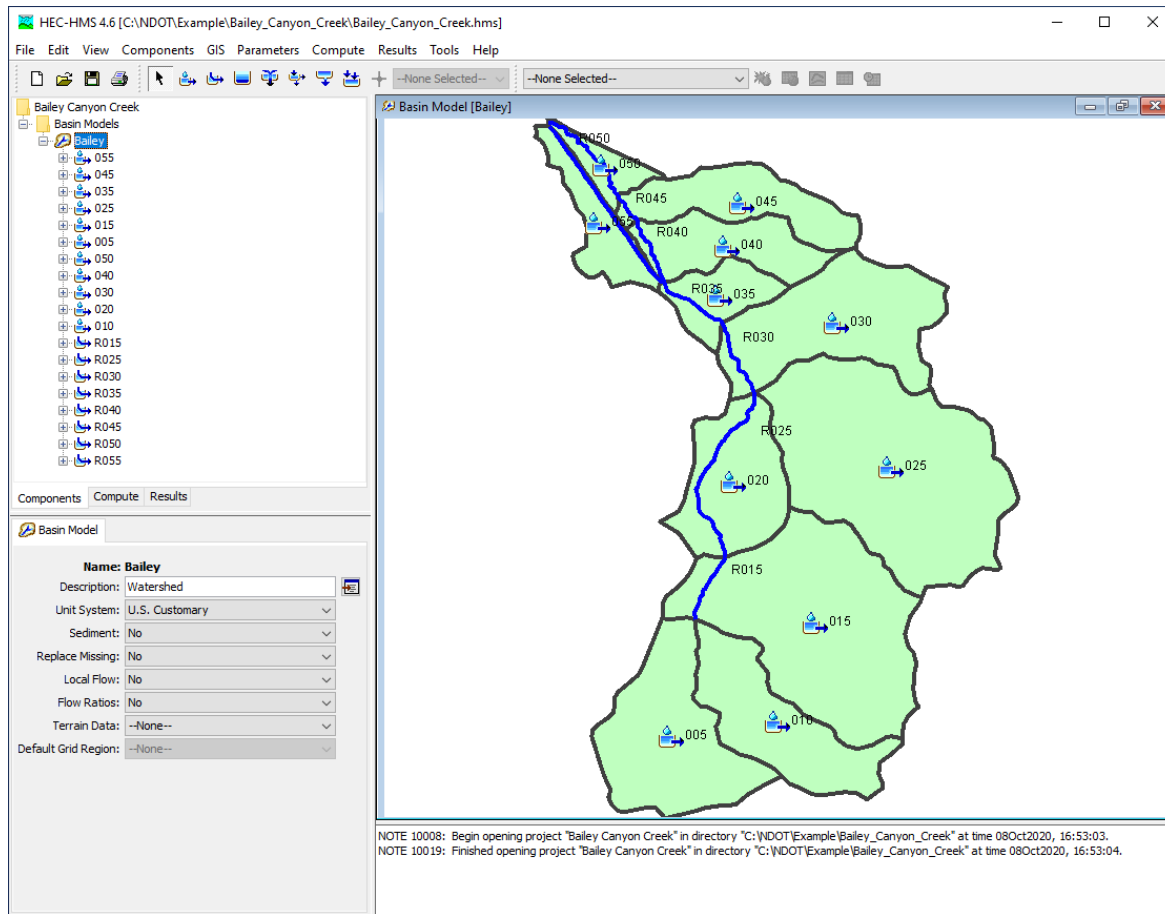
4. Note: In lieu of using subbasin shapefiles described in Step 3 above, each subbasin can be entered manually using the **Tool Bar**.

- a. To enter and label subbasins click on the subbasin icon
- b. Enter a description for each subbasin or leave it blank.
- c. Repeat for each subbasin in the watershed.





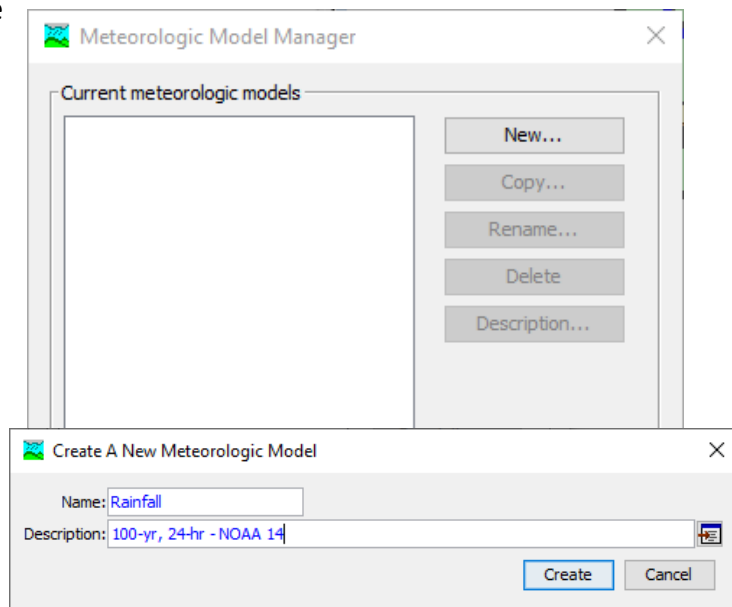
d. This example will continue from Step 3.



### 5.4 Creating a Meteorologic Model

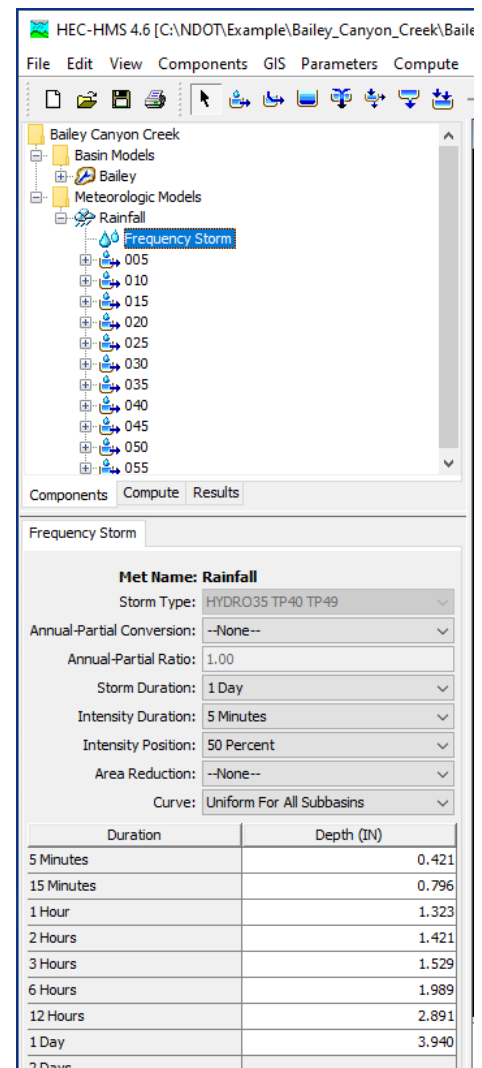
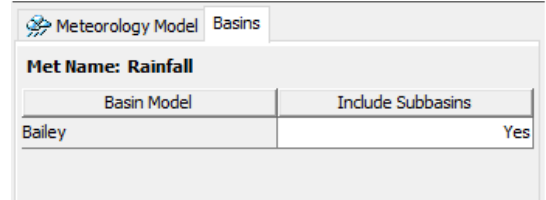
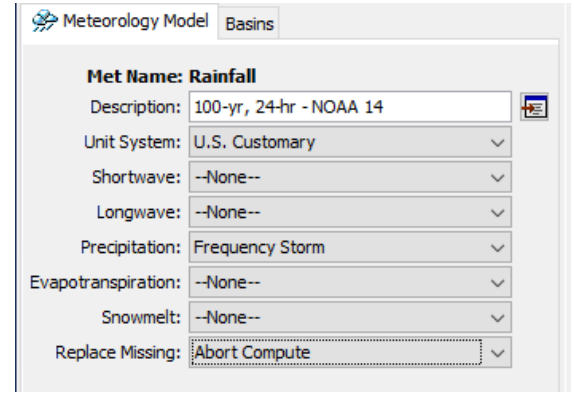
Create a Meteorologic Model (**Components** → Meteorologic Model Manager). In the “Meteorologic Model Manager” dialog box, create the model by doing the following:

1. Click “New”
2. Enter “Rainfall” for Name and a description of your choice.
3. Click “Create.” Note that a file folder called “Meteorologic Models” appears in the *Watershed Explorer*.
4. Close the “Meteorologic Model Manager” dialog box and expand the “Meteorologic Models” file folder to reveal a subfolder called “Rainfall.”



Modernize hydrologic prediction processes by creating custom statewide SSURGO Green and Ampt parameter database

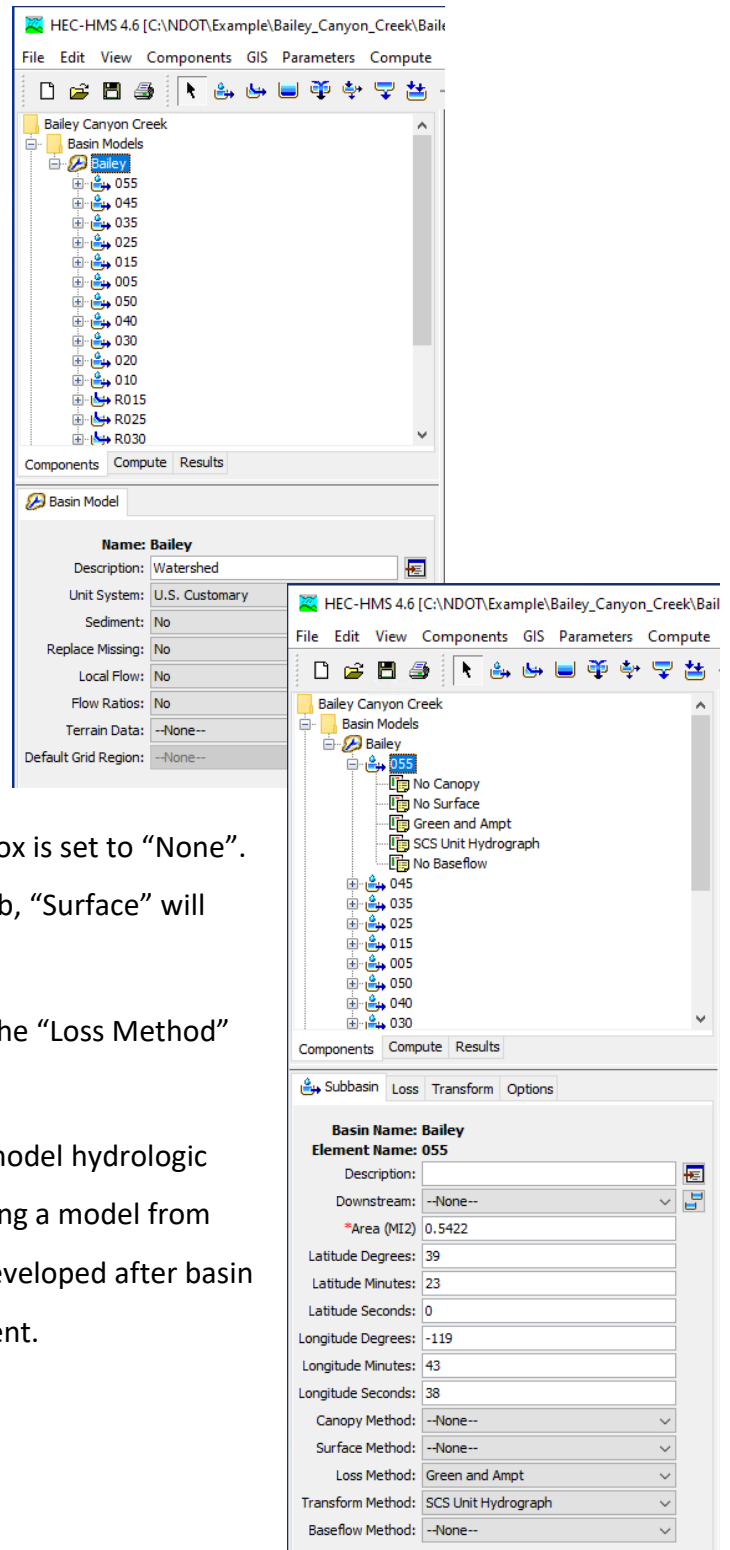
5. Click on the “Rainfall” folder – the Meteorology Model appears in the *Component Editor*.
6. Make sure the Precipitation is set to “Frequency Storm”. If you set up your project defaults the values should already be set. If not, set the values as shown in the image to the right.
7. Go to the “Basins” tab and set the Basin model to include subbasins by selecting “Yes” from the drop-down menu.
8. Click on the “Frequency Storm” folder below the Rainfall folder on the *Watershed Explorer*. The precipitation table will appear in the *Component Editor*.
9. Select “None” for Annual-Partial Conversion, “1 Day” Storm Duration, “5 Minutes” Intensity Duration, “50 Percent” Intensity Position, “None” for Area Reduction and “Uniform for All Subbasins” for Curve.
10. Type in the values for the rainfall durations from 5 minutes to 1 day from the original hydrologic study.  
  
Note: Rainfall depths entered were reduced to 98% of the point rainfall valued to mimic the use of the JR record in the HEC-1 from the Original Hydrologic Study.
11. For other studies, rainfall values for a watershed can be obtained online from the NOAA Precipitation Frequency Data Server (PFDS) noted in **Section 4**. Navigate to PFDS website then under 1) Manually, a) By Location, the user can manually enter the latitude and longitude for the watershed. Entering the watershed latitude/longitude will generate a Point Precipitation Frequency (PF) estimates which can be downloaded as an I-D-F (Intensity Duration Frequency) or a D-D-F (Depth Duration Frequency) comma separated value file (.csv). Appropriate values can then be entered in the



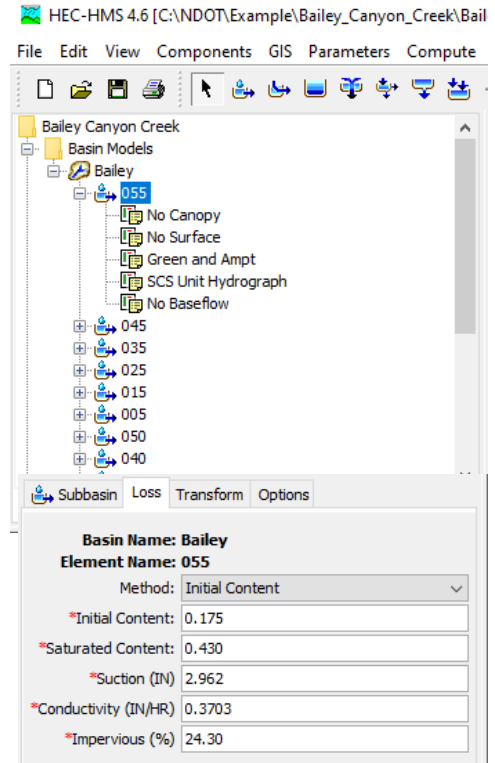
Frequency Storm tab for the desired storm event. See output example in folder *06\_Precipitation*.

### 5.5 Entering Rainfall Losses

1. Expand the “Basin Models” folder so that each of the 11 subbasins are shown.
2. Highlight subbasin 055 and note that the *Component Editor* changes to show four tabs (Subbasin – Loss – Transform – Options).
3. On the “Subbasin” Tab:
  - a. For this example, the drainage area field was populated from the Basin shapefile imported earlier as well as the Latitude/Longitude of the centroid of each basin.
  - b. Make sure the Canopy Method is set to “None.”
  - c. Make sure the Surface Method drop down box is set to “None”. Note: if you select “Simple Surface” a fifth tab, “Surface” will appear in the *Component Editor*.
  - d. Make sure “Green and Ampt” is selected in the “Loss Method” drop down box.
  - e. Note: At this time “Downstream” (used for model hydrologic order) is not populated. For ease of developing a model from scratch, modeling hydrologic order will be developed after basin and routing data is populated for each element.



4. On the “Loss” Tab
  - a. “Initial Content”: Use Initial Content value from **Table 5**.
  - b. “Saturated Content”: Use the Saturation (Sat) value from **Table 5**.
  - c. “Suction”: Use the Suction (PSIF) value from **Table 5**.
  - d. “Conductivity”: Use the Conductivity (XKSAT) value from **Table 5**.
  - e. “Impervious”: Use the Effective Imperviousness value from **Table 5**.
5. Do not enter any information on the “Transform” or “Options” Tabs for now.
6. Repeat process for all subbasins.



Note: Navigating to **Parameters** → Loss → Green and Ampt produces a summary table to enter all subbasin Green and Ampt parameters. Enter Green and Ampt Loss parameters from **Table 5**.

### 5.6 Developing Unit Hydrograph Data

SCS Unit Hydrograph. The SCS Unit Hydrograph method was used in the example project provided by NDOT staff and will be used in this example.

1. The time of concentration (Tc) equation was selected from the Truckee Meadows Regional Drainage Manual (2009).

$$T_{lag} = 22.1K_n \left( \frac{L L_c}{S^{0.5}} \right)^{0.33}$$

EQUATION 710 (TRUCKEE MEADOWS REGIONAL DRAINAGE MANUAL (2009))

where;

- $T_{lag}$  = Lag Time (hrs)
- $K_n$  = Manning's Roughness Factor for the Basin Channels
- $L$  = Length of the watercourse to the hydraulically most distant point (mi)
- $L_c$  = Length Along Longest Watercourse Measured Upstream to a Point Opposite the Centroid of the sub-basin (mi)
- $S$  = Representative (Average) slope of the Longest Watercourse (ft/mi)

Table 6 Subbasin Lag

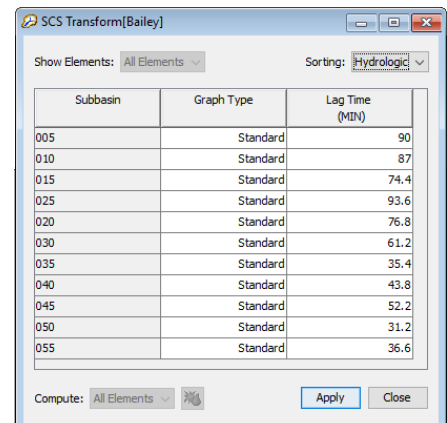
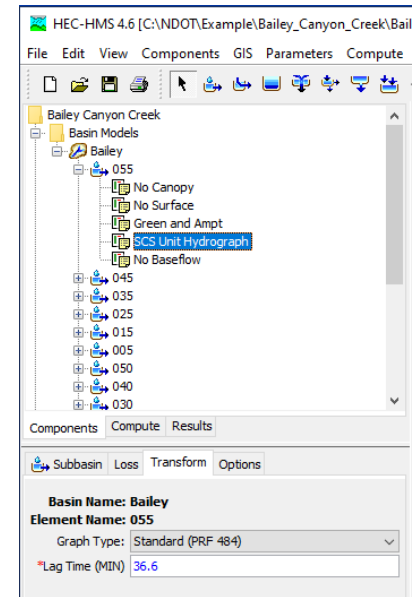
HEC-HMS ID	$K_n$	L [mi]	$L_c$ [mi]	S [ft/mi]	$T_{lag}$ [MIN]
005	0.12	2.64	1.22	329	90
010	0.12	2.78	1.42	617	87
015	0.12	2.64	0.98	693	74.4
020	0.12	2.36	0.89	360	76.8
025	0.12	2.99	1.66	615	93.6
030	0.10	2.29	1.03	603	61.2
035	0.08	1.41	0.5	395	35.4
040	0.07	2.36	1.09	620	43.8
045	0.07	2.71	1.44	510	52.2
050	0.05	1.25	0.74	81	31.2
055	0.05	1.89	1.02	133	36.6

Note: Roughness factor  $K_n$  interpolated from Table 703 in City of Sparks Hydrologic Criteria and Drainage Design Manual.

### 5.7 Entering Unit Hydrograph Parameters into HEC-HMS

Now that you have estimated unit hydrograph parameter, enter the information in the HEC-HMS model.


1. Expand the “Basin Models” folder so that each of the 11 subbasins are shown.
2. Highlight subbasin 055 and note that the *Component Editor* changes to show four tabs (Subbasin – Loss – Transform – Options).
3. On the “Transform” Tab:
  - a. Enter the  $T_{lag}$  from **Table 6** for subbasin 055 in “LagTime (MIN)”.
  - b. To aid in entering data for multiple subbasins, go to the Parameters → Transform → SCS Unit Hydrograph. The SCS Transform window will open.
  - c. Change the selection on “Show Elements” to “All Elements”. You can now enter the SCS Unit Hydrograph parameter for the rest of the subbasins here. When finished, click “Apply”



You have now completed the data entry for the subbasins. For this example, we won't be using the “Options” tab.



### 5.8 Creating Model Junctions

1. Expand the “Basin Models” folder so that each of the 11 sub-basins are shown.
2. Select the Junction Tool from the Tool bar.  Drag the Junction Tool to the Junction Point at the outlet of subbasin 010/015 and click to add. (Note: Make sure background map for Junctions is active. To check this, go to View → Map Layers and verify that the box is checked for Junctions shapefile imported earlier).
3. Type in Name (CP010) and Description then click enter. Repeat until all Junctions in **Table 7** are added to the model.

Junction Name	Basin Outlet/Combination Point
CP010	005/010
CP015	015
CP025	020/025
CP030	030
CP035	035
CP040	040
CP045	045
CP050	050
CP055	055
CP055B	050/055

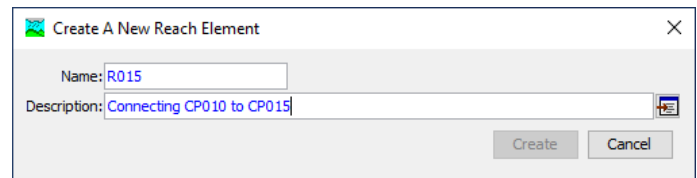
### 5.9 Creating Routing Reaches

Routing reaches elements were created in **Section 5.3** when importing shapefile using the **GIS** → Importing Georeferenced Elements.

Alternatively, the routing reaches could be entered into the model using the following process.

1. Select Reach Creation Tool  on the Menu Bar.

Click first at CP010 (outlet to subbasin 005 and 010) and then again at CP015. A pop-up window



will appear. Type in the Reach “Name” from **Table 8** and Reach “Description” if desired. When finished, click “Create”. The routing reach will be created. Continue for all routing reaches listed in

**Table 8.**

Routing Reach	Upstream Connection	Downstream Connection
R015	CP010	CP015
R025	CP015	CP025
R030	CP025	CP030
R035	CP030	CP035
R040	CP035	CP040
R045	CP040	CP045
R050	CP045	CP050
D055	D040 ( <b>Section 5.12</b> )	CP055

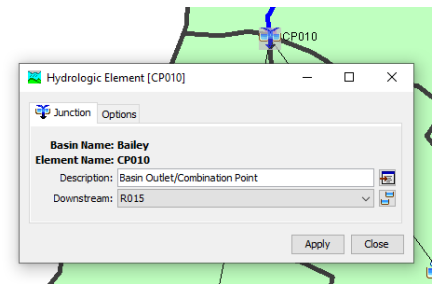
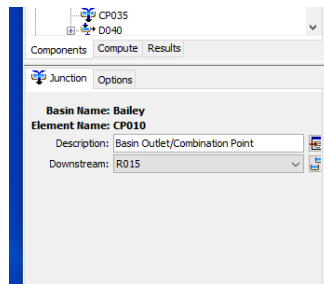
### 5.10 Linking model elements

1. Link **Junctions/Diversions** to Downstream model elements

- a. Highlight/double click “CP010”. A *Component Editor* box will appear. Data can be entered in this menu or in the standard *Component Editor* menu. For the “Downstream” link, select “R015” from the dropdown menu.
- b. No data will be entered on the “Options” tab.
- c. Continue for all junctions listed in **Table 9**.
- d. Diversion D040. More about Diversions in **Section 5.12**.

Table 9 Linking Junctions	
Junction Name	Basin Outlet/Combination Point
CP010	R015
CP015	R025
CP025	R030
CP030	R035
CP035	See <b>Section 5.12</b>
CP040	R045
CP045	R050
CP050/CP055	CP055B

- e. Note: Once you select the “Downstream” link, the routing reach will move in the list directly below the Junction when another element is selected. You can right mouse click on “Bailey” and select to lock current element order by selecting “Lock Element Locations” or “Lock Hydrologic Order” if you prefer the model hydrologic order. For this example nothing is selected until all elements have been linked then “Lock Hydrologic Order” will be selected.



2. Link Subbasins to Downstream model elements.

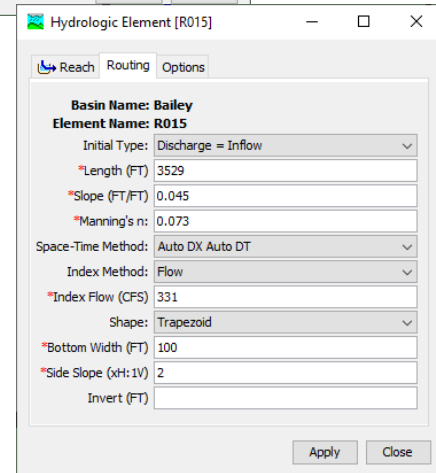
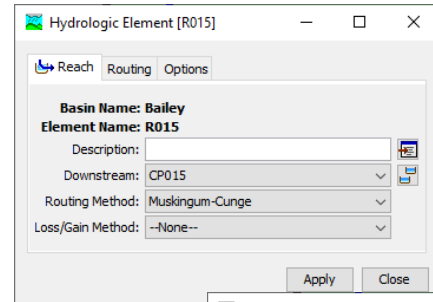
- a. Similar to Junctions, highlight subbasins either by double clicking on the element in the *Desktop* or through the *Watershed Explorer*.
- b. Continue for all subbasins listed in **Table 10**.
- c. Note: As you complete the link you will notice a connection line appear in the Basin model between the subbasin and the downstream element.

Table 10 Linking Subbasins	
Sub-basin	Downstream Connection
005/010	CP010
015	CP015
020/025	CP025
030	CP030
035	CP035
040	CP040
045	CP045
050	CP050
055	CP055
050/055	CP055B

### 5.11 Adding data to each reach in the basin model

#### 1. Inputting Routing Data

- a. With model links completed for each subbasin, diversion and junction, next step is to add the links for the routing reaches and inputting the routing data.
- b. To begin, highlight Routing Reach R015 either by double clicking on the element in the *Desktop* or through the *Watershed Explorer*.
- c. Select “Downstream” element per **Table 8**.
- d. For all Routes, the “Routing Method” will be “Muskingum-Cunge”.
- e. “Loss/Gain Method” will remain “--None--”.
- f. Add routing data from **Table 11** for each routing reach.
- g. “Time Step Method” will be set to “Automatic Fixed Interval” for all reaches.
- h. “Invert (ft)” to be left blank.
- i. After all data in entered, Save Model
- j. Data can be entered in each individual routing reach or by using a summary table through **Parameters** → Routing → Muskingum-Cunge.




**Table 11 Reach Routing Parameters (Muskingum-Cunge)**

HEC-HMS ID	Length (ft.)	Energy Slope (ft./ft.)	Manning’s N Values	Index Flow	Shape	Bottom Width (FT)	Side Slope (xH:1V)
R015	3529	0.045	0.073	347	Trapezoid	100	2
R025	9817	0.045	0.078	676	Trapezoid	50	2
R030	4069	0.039	0.1	1188	Trapezoid	25	3
R035	3714	0.034	0.108	1374	Trapezoid	70	4
R040	3539	0.029	0.073	1144	Trapezoid	30	50
R045	1734	0.023	0.086	1182	Trapezoid	30	50
R050	5748	0.018	0.053	1234	Trapezoid	20	2
D055	9490	0.026	0.045	246	Trapezoid	8	10

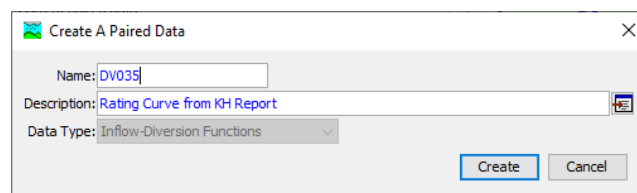
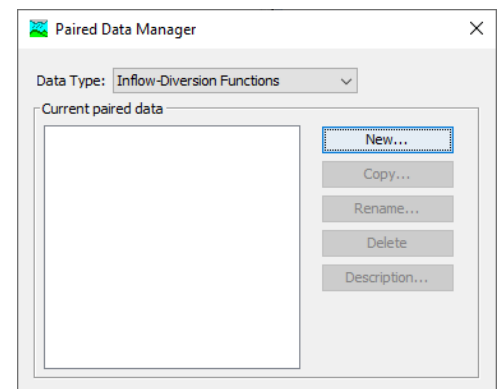
- k. Note: For this example, “Initial Type” is set to “Discharge=Inflow”, “Space-Time Method” is set to “Auto DX Auto DT”, and “Index Method” is set to “Flow”.
- l. Index Flow = (Peak Incoming Flow + Baseflow)/2. Where the peak incoming flow (for the connected subbasins to be modeled) is determined by preprocessing each subbasin watershed separately as a non-connected independent subbasin and then recording the peak flow outputs of each non-connected watershed. These non-connected output results will then be used as the peak incoming flows for the connected sub-watersheds model.
- m. Options tab to remain unchanged.

### 5.12 Adding a Diversion

As part of the original hydrologic study, a diversion was added at Junction CP035 that diverts a portion of the flow through a culvert structure and along the road embankment. Flow eventually recombines at the model outlet (CP055B). To add a Diversion,

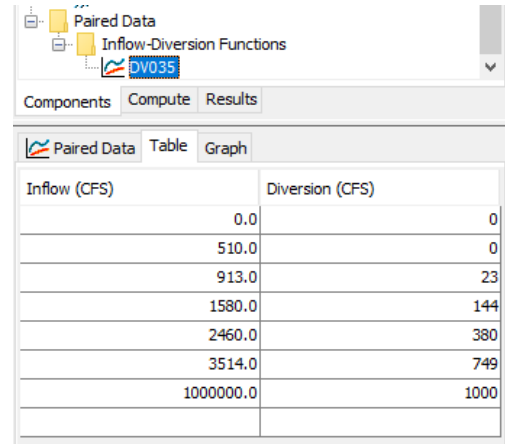
1. Select **View** → Zoom In to navigate to CP035.
2. Select the Diversion Tool from the Menu bar.  Drag the Diversion Tool to the Junction Point CP035 at the outlet of subbasin 035 and click to add.
3. Type in “Name” (D040) and “Description” then click enter. At this point the Diversion is entered but is not associated with any data.
4. **Entering Paired Data** - For this example, the diversion is represented by an rating curve that is entered in HEC-HMS as paired data.

- a. Select **Components** → Paired Data Manager and for “Data Type” select “Inflow-Diversion Functions” from the pull-down menu then select New. Enter name and Description as shown then select Create and close Time-Series Data Manager by selecting X in the upper right corner.



- b. In the *Watershed Explorer*, navigate to the Paired Data – Inflow-Diversion Function – DV035 created above. Under the “Table” tab enter in the values from **Table 12**.

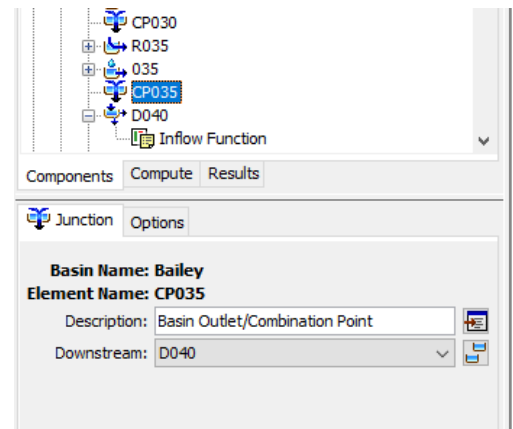
Table 12 Diversion Rating Table	
Inflow (cfs)	Diversion (CFS)
0.0	0
510.0	0
913.0	23
1580.0	144
2460.0	380
3514.0	749
1000000.0	1000



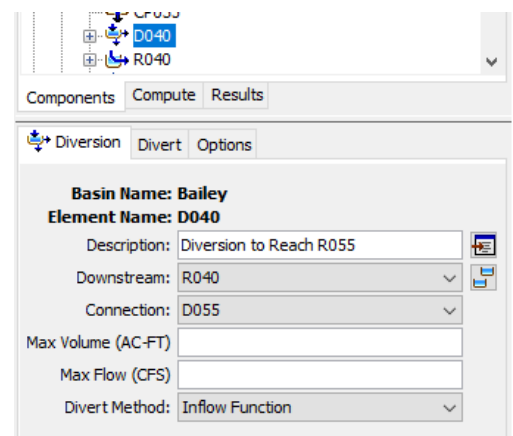
Note: Diversion rating table values reported from the Original Hydrologic Study.

5. Linking Diversion

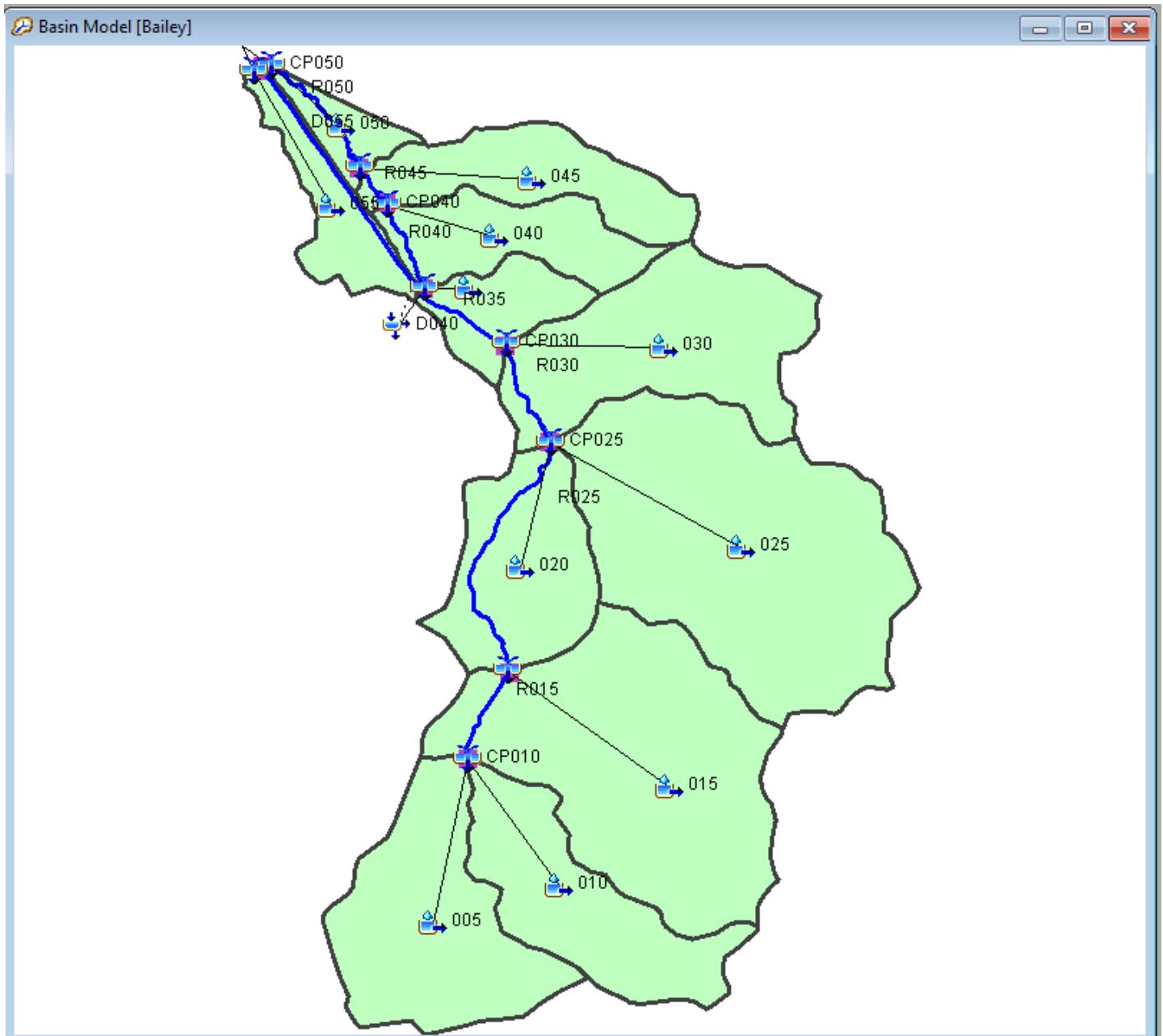
- a. Under “Basin Model”, highlight “CP035” and add “D040” from the pull down menu, as the downstream connection.



- b. Next, highlight “D040” and add “R040” as “Downstream” link and “D055” as “Connection”. Select “Inflow Function” from the pull down menu as the “Divert Method”.



When complete your basin model should look similar to this →

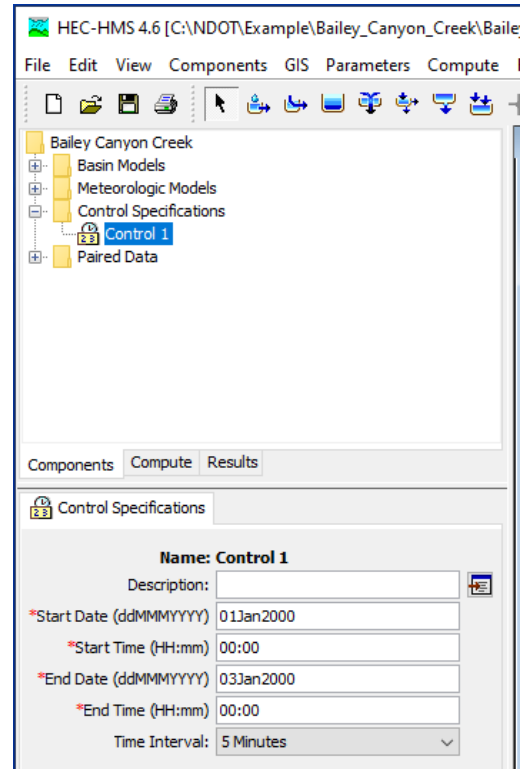




### 5.13 Define Control Specifications

Now, set up the control specifications for the first run.

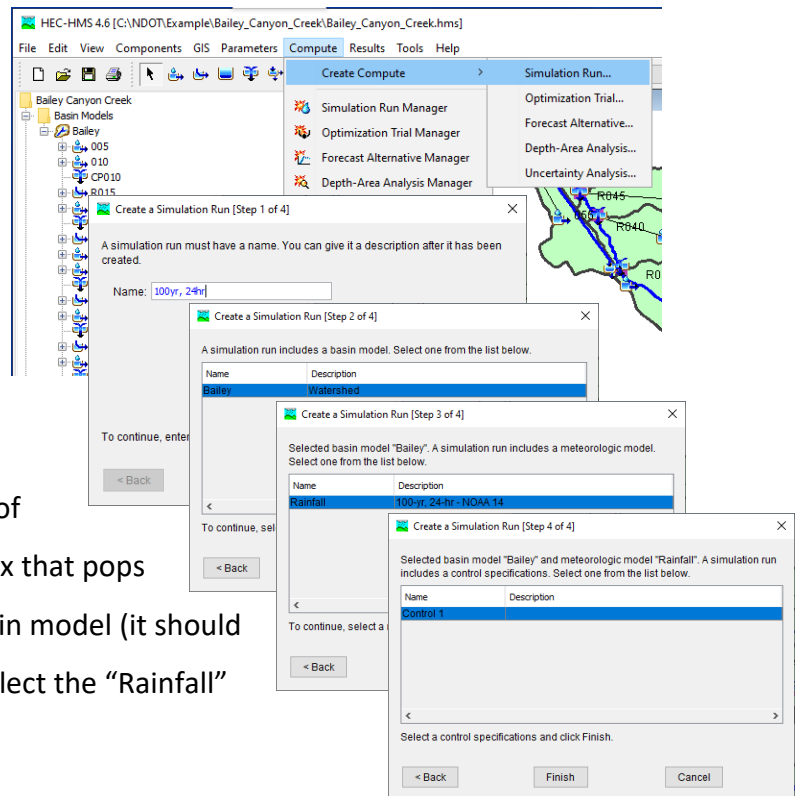
1. Open the Control Specifications Manager (**Components** → Control Specifications Manager) and select “New”.
2. Keep the Default name suggested by HMS or create your own name. It is not necessary to create a description. Click “Create”.  
Note: New Control Specifications folder appears in the *Watershed Explorer*.
3. Expand the “Control Specifications” file folder to reveal a subfolder called “Control 1”.
4. Click on the “Control 1” folder – the Control Specifications appears in the *Component Editor*.
5. Enter “01Jan2000” for the “Start Date” and “03Jan2000” for the “End Date”. This is from the Original Hydrologic Study model. Enter “Start Time” and “End Time” of “00:00”.
6. Set the “Time Interval” to “5 Minutes”. General guidance for selecting a time interval is given in the HEC-HMS Applications Guide online.
7. Save your file.





### 5.14 Run Model

Let’s get some answers by running the model.

1. Set up the Run for the first time by selecting **Compute** → Simulation Run Manager → New at the top of the HEC-HMS menu bar. Use the default name as “Run 1” or type “100yr,24hr” for the Name in the first screen of the “Create a Simulation Run [Step 1 of 4]” box that pops up. Then click “Next.” Select the “Bailey” basin model (it should be the only one available) and click “Next.” Select the “Rainfall”




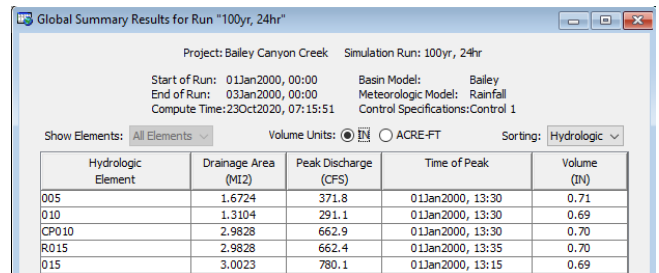
meteorologic model (again, the only choice) and click “Next.” Finally select the “Control 1” specifications and click “Finish.” Close the Simulation Run Manager dialog box.

2. Along the menu bar, in the pull down window, select the “Run” just setup. For this example, select “Run 1”.
3. Note that the “RUN” icon  is no longer grayed out on the tool bar. Click the  to run your model. A progress bar will appear to show the computational progress, or a series of red error messages will appear in the *Message Component* and the dialog box will be titled “Failed Computing [filename].” To debug your model:
  - a. Read the error messages and take action.
  - b. Consult the User’s Manual for additional guidance.
4. If all goes well, the dialog box will read “Finished Computing “Run 1” and the progress bar will go to 100%. Close the progress dialog box.

Read the Notes and Warnings in the Messages Component of the view screen and respond to any notes or warnings that require action.

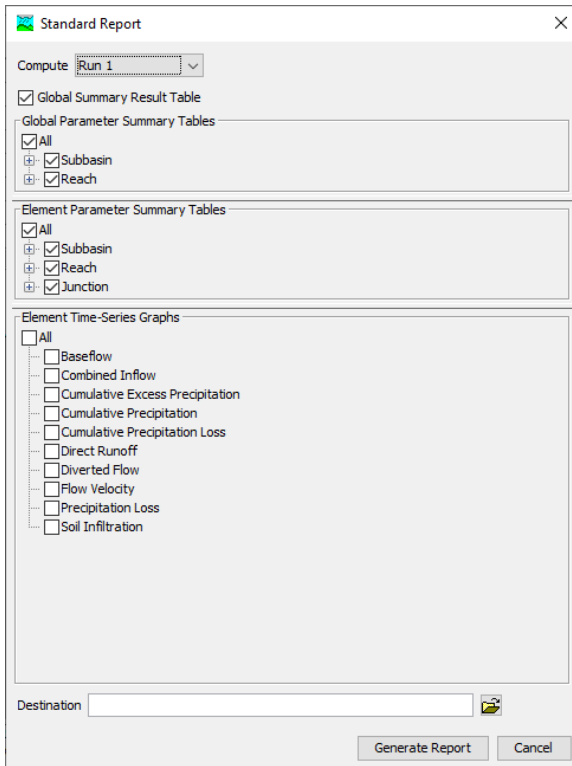
### 5.15 View & Review the Results

Global summary results can be viewed by clicking on the Global Summary  icon. There are several other ways to view the model results. Hover your mouse over one of the basin elements in the *Desktop Component* area and right click the mouse. Click “View Results” and look at the graphical, summary table, and time-series table. Next, click on the Results Tab in the *Watershed Explorer*. Click on the one of the model elements and scroll the various types of output. Finally, try plotting two graphs on a single figure by holding the control key and selecting two (or more) elements (suggest looking at an inflow and routed hydrograph). Note which results plot in the *Desktop* and which plot in the *Components Editor*.



Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (IN)
005	1.6724	371.8	01Jan2000, 13:30	0.71
010	1.3104	291.1	01Jan2000, 13:30	0.69
CP010	2.9828	662.9	01Jan2000, 13:30	0.70
R015	2.9828	662.4	01Jan2000, 13:35	0.70
015	3.0023	780.1	01Jan2000, 13:15	0.69

Custom reports in HTML format can also be created by going to **Tools** → **Reports** → **Standard Report**.



Other model runs were included in the Example HEC-HMS model.

Run: Run 2 – Basin Model: Bailey and Meteorologic Model: DARF (See **Section 6.2**)

Run: Run 3 - Basin Model: Bailey -IA (See **Section 6.1**) and Meteorologic Model: DARF (See **Section 6.2**)

Run: Run 4 - Basin Model: Bailey -IA (See **Section 6.1**) and Meteorologic Model: Rainfall.

## 6. Additional Modeling Considerations

Green and Ampt infiltration, in the absence of other considerations, models a soil percolation process and does not account for other relevant rainfall loss aspects such as initial abstraction, precipitation point-rainfall reduction, canopy loss, vegetative impacts on conductivity, and surface imperviousness. In the example above, land use based imperviousness is discussed and applied, but these other aspects are not addressed in detail in this document.

### 6.1 Initial Abstraction using Canopy or Surface Methods

#### 6.1.1 Canopy Method

Vegetative cover effects on rainfall losses may be expressed in multiple ways. Canopy loss may be utilized to represent initial abstraction effects on rainfall applied to the soil prior to infiltration calculations. In special circumstances where interception losses are believed to be significant and separable from surface depression losses, the “Canopy Method” may also be applied. These circumstances might include heavily forested areas where significant tree canopy captures additional rainfall preventing it from reaching the ground. Select

guidance for arid vegetative cover adjustments may be found in the ADOT Hydrology Manual (Arizona Department of Transportation, 2014) and Mohave County (Arizona) Drainage Design Manual (latest edition).

**6.1.2 Surface Method**

Consideration has not been included in the Green and Ampt analyses in this document to account for initial abstraction in the form of surface storage loss. Surface storage loss is typically implemented within HEC-HMS using the “Surface” component of a subbasin and allows an initial and maximum surface storage depth to be included in the analysis. Additional information and guidance regarding “surface storage” and selection of appropriate initial abstraction values may be found in the ADOT Hydrology manual (Arizona Department of Transportation, 2014) and Mohave County (Arizona) Drainage Design Manual (latest edition).

**6.2 Depth Area Rainfall Reduction**

Rainfall depths entered were reduced to 98% of the point rainfall valued to mimic the use of the JR record in the original HEC-1 Bailey Canyon hydrologic model. Depth Area Reduction Factors (DARFs) were developed by NDOT for use in areas outside of Clark County. Updated equations are included below.

$$DARF_{6hr} = 1 - \frac{0.89A^{0.76}}{45.37 + A^{0.76}} \quad DARF_{24hr} = 1 - \frac{0.85A^{0.72}}{45.37 + A^{0.72}} \quad \text{Eqns. 3.2.3}$$

Where:

A = Watershed Area (mi<sup>2</sup>)

DARF = Depth Area Reduction Factor

For an additional exercise, replace the point rainfall valued in **Step 10**, under **Section 5.4** with DARF values in **Table 13** rerun and compare the results with the current model.

Table 13 Point Rainfall Values for 100-year recurrence interval			
Duration Min or Hr	100-year (No Reduction) [in]	Reduced to 98% per Bailey Canyon hydrologic model [in]	Reduced to 88% per NDOT DARF <sub>24hr</sub> Equation [in]
5-min	0.43	0.42	0.38
15-min	0.81	0.80	0.71
60-min	1.35	1.32	1.19
2-hr	1.45	1.42	1.28
3-hr	1.56	1.53	1.37
6-hr	2.03	1.99	1.79
12-hr	2.95	2.89	2.60
24-hr	4.02	3.94	3.54

**7. References**

Arizona Department of Transportation. (2014). Highway Drainage Design Manual Vol 2: Hydrology. Phoenix: Arizona Department of Transportation.

Flood Control District of Maricopa County. (2018). Drainage Design Manual Hydrology. Phoenix.

Mohave County Flood Control District. (May 2018). Drainage Design Manual for Mohave County, 3rd Edition

Washoe County Regional Transportation Commission, Geiger Grade Road Realignment Project, Kimley Horn and Associates, Inc. (2011).

United States Geological Survey. (1999). The National Flood-Frequency Program -- Methods for Estimating Flood Magnitude and Frequency in Rural Areas in Nevada. US Department of the Interior, US Geological Survey.



# Appendix A. Glossary



**attenuate** - To reduce the flood peak discharge and lengthen the time base of the flood wave.

**base flow** - Discharge in a river prior to the onset of direct runoff from a rainfall event.

**concentration point** - A physical location in a watershed where all surface runoff must pass to exit the watershed.

**direct runoff** - The same as rainfall excess.

**distribution** - Function describing the frequency with which random events of various magnitudes occur.

**drainage area** - The total area contributing to surface runoff at a point of interest (flow concentration point).

**duration** - Used either as the length of time for rainfall, such as a 24-hour storm, or as the length of time for rainfall excess, such as used to specify the duration of rainfall excess for a unit hydrograph.

**effective impervious area** - The portion of a land area, expressed in percent of total land area, which will drain directly to the outlet of the drainage area without flowing over pervious area. This is often called directly connected impervious area.

**exceedance probability** - Probability that a flood discharge will exceed a specified magnitude in a given time period, usually one year unless otherwise indicated.

**field capacity** - Amount of soil moisture or water content held in soil after excess water has drained away and the rate of downward movement has materially decreased, which usually takes place within 2–3 days after a rain or irrigation in pervious soils of uniform structure and texture.

**frequency** - The measure of the probability of occurrence or exceedance of a flood magnitude in a number of observations.

**hydraulic conductivity** – A description of the ease with which a water can move through pore spaces or fractures.

**hydrograph** - A continuous plot of instantaneous discharge versus time.

**hydrologic soil group** - A classification system developed by the NRCS to place soils into one of four groups based on runoff potential.

**impervious area** - The portion of a land area, expressed in percent of total land area, which has a negligible infiltration rate. Impervious area can be natural, such as rock outcrop (soils (natural) impervious area) and the surface of permanent water bodies; or man-made, such as paved areas, roofs, and so forth (land use impervious area).

**infiltration** - The rate of movement, in inches per hour, of rainfall from the land surface into and through the surface soil.

- initial abstraction** - The accumulative loss, due to all mechanisms, of all rainfall from the start of rainfall to the point in time when surface runoff begins. This is equivalent to the initial loss in the “Initial and Constant Loss” method.
- percolation** - The rate of movement, in inches per hour, of water through the underlying soil or geologic strata subsequent to infiltration.
- physiography** - The physical geography of a watershed.
- population** - The entire (usually infinite) number of data from which a sample is taken or collected. The total number of past, present, and future floods at a location on a river is the population of floods for that location even if the floods are not measured or recorded. The frequency distribution of the population defines the underlying probability model from which the sample of annual floods arises.
- rainfall excess** - The equivalent uniform depth of runoff, in inches, that drains from the land surface. Rainfall excess equals rainfall minus rainfall losses.
- rainfall losses** - The sum of rainfall that is lost to surface runoff due to interception, depression storage, evaporation, infiltration, and other mechanisms. Rainfall loss is expressed as an equivalent uniform depth, in inches.
- reach** - A relatively short length of channel or watercourse.
- return period** - The average number of years between occurrences of a hydrological event of a given or greater magnitude. In an annual flood series, the average number of years in which a flood of a given size is exceeded as an annual maximum.
- routing** - A procedure by which an inflow hydrograph is modified by the effects of flow resistance and storage to simulate an outflow hydrograph from the system.
- soil** - The layer of inorganic particulate matter covering the Earth's surface. It can and does contain organic matter and often supports vegetation. For the purpose of estimating rainfall losses, only the upper horizon (generally about the top 3 inches of soil) will be considered. Underlying soil horizons or other strata will generally not affect rainfall losses in Nevada for storms of 100-year magnitude or less.
- soil texture** - The classification of soil into groups according to percentage of sand, silt, and clay, as used by the U.S. Department of Agriculture.
- sand** - Soil composed of particles in the 0.05 mm to 2.0 mm size range.
- silt** - Soil composed of particles in the 0.002 mm to 0.05 mm size range.
- clay** - Soil composed of particles smaller than 0.002 mm.
- soil map unit** – A collection of areas defined and named the same in terms of their components (e.g., series) or miscellaneous areas or both. The basic unit of a soil map.

- subarea** - A portion of a drainage area or subbasin that is delineated according to a physical feature such as soil texture or land use.
- subbasin** - A portion of a drainage area or watershed that is determined according to the internal surface drainage pattern. A drainage area can often be divided into subbasins for modeling purposes.
- surface retention loss** - The depth of rainfall loss, in inches, due to all factors other than infiltration.
- time of concentration** - The travel time, during the corresponding period of most intense rainfall excess, for a flood wave to travel from the hydraulically most distant point in the watershed to the point of interest (concentration point).
- topography** - The surface features of a watershed.
- unit hydrograph** - The hydrograph of one inch of direct runoff from a storm of a specified duration for a particular watershed.
- vegetation cover** - The percentage of land surface that is covered by vegetation. Vegetation cover is evaluated on plant basal area for grasses and forbs, and on canopy cover for trees and shrubs.
- watershed** - The area within definable boundaries in which all direct runoff drains to a common outlet.
- wetting front suction** – Portion of the total head driving infiltration at the wetting front (interface between saturated soil above and drier soil beneath).
- wilting point** - The point at which, through heat or drought, a plant loses turgidity and becomes limp and flaccid.

## Appendix B. HEC-HMS Model Support Data

Supporting Data Folders and Files Include:

### 01\_BailyCanyonCreekStudy

- Includes referenced document - Washoe County Regional Transportation Commission, Geiger Grade Road Realignment Project, Kimley Horn and Associates, Inc. (2011).

### 02\_SoilsData

- Includes Green and Ampt soils data shapefiles used in model example.
  - NV628
  - NV772

### 03\_Projections

- Includes ArcView projection file for GIS data.
  - NAD 1983 StatePlane Nevada West FIPS 2703 (US Feet).prj

### 04\_GIS

- Includes GIS files used in the model example.
  - Bailey\_Basins.shp
  - Bailey\_Junctions.shp
  - Bailey\_Routes.prj
  - Bailey\_Landuse.shp
  - Bailey\_Soils\_Merged.shp
  - Bailey\_Basins\_Soils\_Intersect.shp
  - Bailey\_Basins\_Soils\_Landuse\_Intersect.shp

### 05\_MXD

- Example\_Bailey.mxd

### 06\_Precipitation

- Includes NOAA precipitation files used in model example.
  - PF\_Depth\_English\_PDS.csv
  - Precipitation Frequency Data Server.pdf

### 07\_DataFiles

- Datafiles used to process lumped basin parameters
  - Bailey\_3in\_Green&Ampt.xlsx – Spreadsheet used to determine Green and Ampt parameters with adjustments for subbasin average Initial Content and land use imperviousness.