

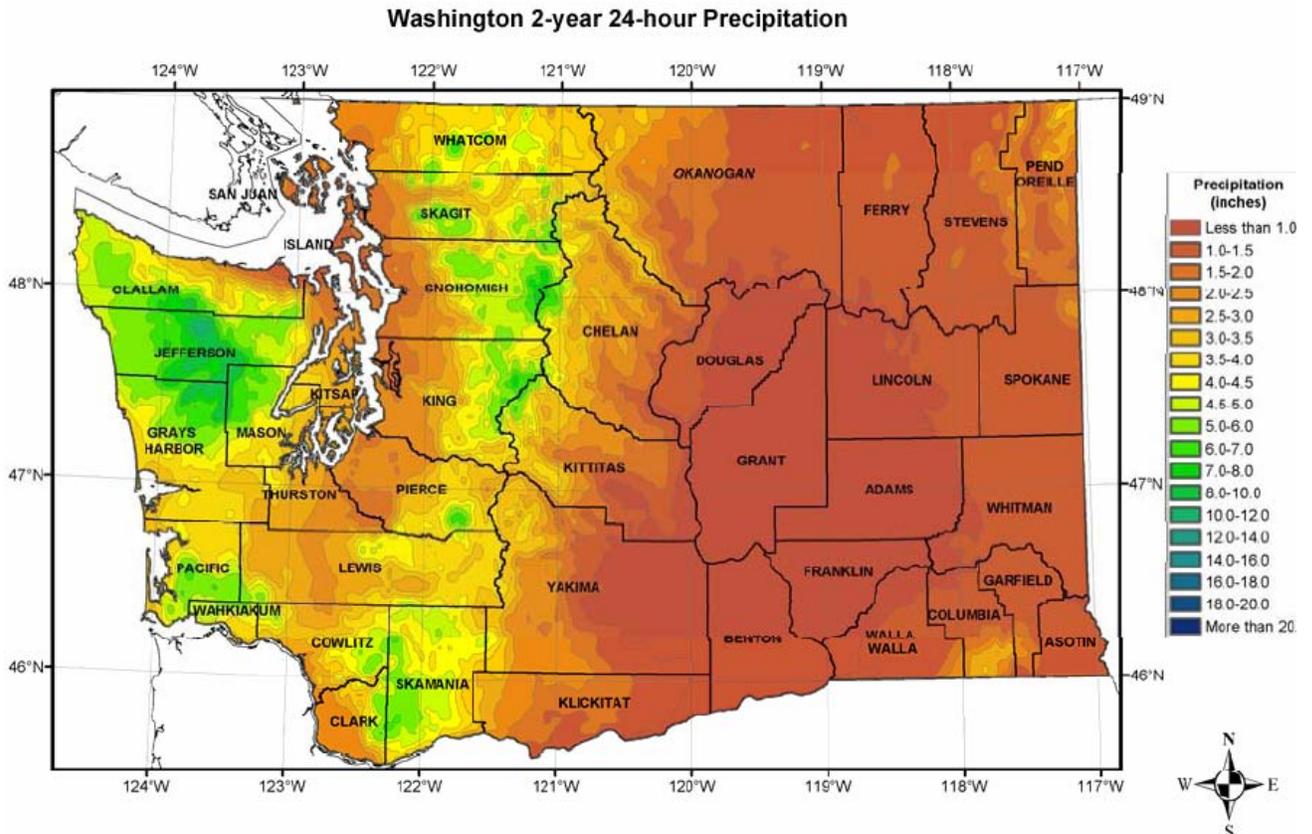
In this example you will learn about:

- How to determine the applicable storm duration for a project location.
 - Creating a basin, the different basin options, and how to estimate runoff from a basin.
 - How to transfer basin information to a report.
 - The Slope Calculator.
-

WWA – Storm Duration

Western Washington utilizes the Type 1A 24 hour storm to design conveyance systems. The precipitation values are much simpler to determine than for EWA, as noted below.

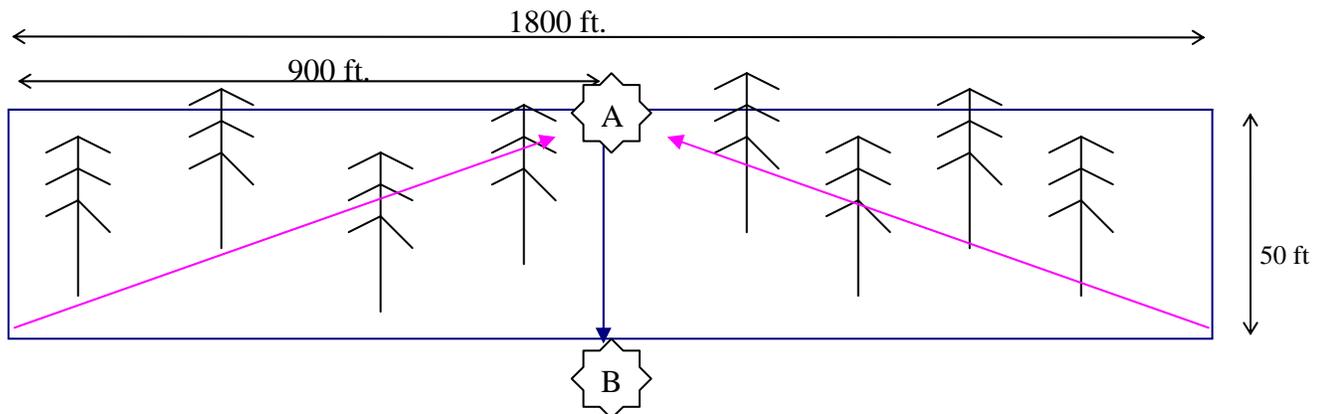
1. From the HQ Hydraulics web page, select Links.
(<http://www.wsdot.wa.gov/Design/Hydraulics/links.htm>)
2. Select the [Washington 24-hour Isopluvial Maps](#) link and a set of maps for Washington will open including the one shown below.
3. Locate the project on the map and determine the precipitation values for the 6 month, 2, 10, and 25 year storms.
4. Input these values into the Project Precipitation table, on the **Project Defaults** tab, in the **Project Configuration** dialog box. *For this example, we will assume the values are the same as in EWA.*



Example Problem

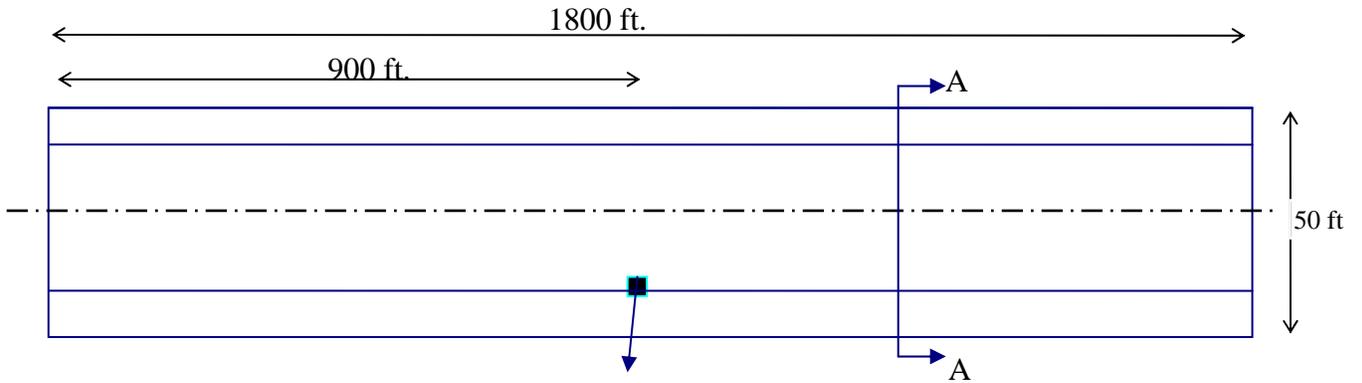
Develop basins for the before and after conditions using the following description:

- A new two-lane roadway section is to be constructed near Seattle, which is in **Climatic Region 3**.
- The SCS soil type for the entire project is **Type C** and the ground cover is primarily forest in fair conditions.
- The existing site condition currently sags in the middle of its length (approximately **1800 feet**). It is also about **50 feet** wide. Water generally collects at point A and then runs down the basin to point B in a semi-defined ditch. The ground cover is all forested. The ground generally slopes
- The calculated time of concentration should be assumed for the forested conditions to be **50 feet** of sheet flow with the remaining **900 feet** as shallow concentrated flow to point A. Finally, runoff concentrates and flows to **50 feet** to point B. The average slope of the ground before the construction was **1%**.
- The proposed conditions for the new impervious roadway will be slightly elevated and will utilize curb and gutter to control the flow. The developed site will have a sag in the profile (see Figure 3). See the plan and cross section view below in Figures 1 and 2 below.

PLAN VIEW - EXISTING CONDITION*Figure 1*

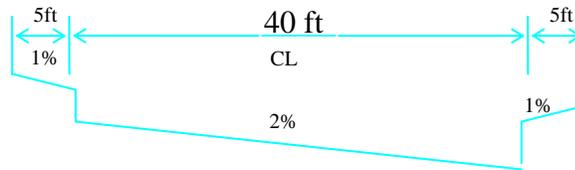
PLAN VIEW – DEVELOPED CONDITIONS

Figure 2



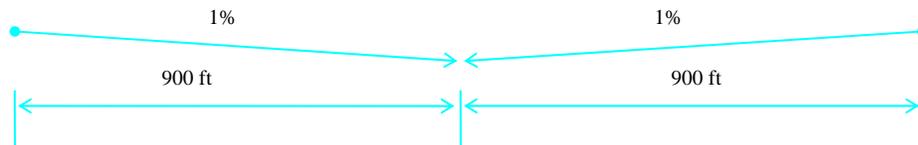
CROSS SECTION A-A

Figure 2



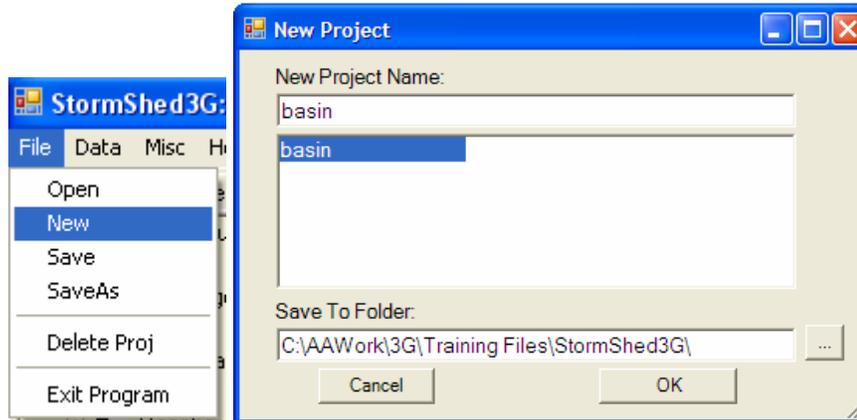
PROFILE

Figure 3

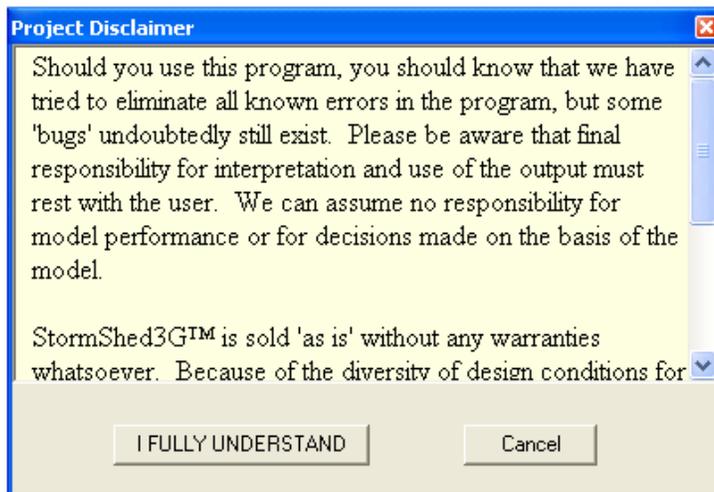


Creating a New File

When StormShed 3G is opened, it will automatically open to the last file used. The first step for this example is to create a new file. Select **File>New** and input a unique name that will easily remind you of the project. For this example, call the New Project Name: **basin**. Then click on Ok.



The 3G project disclaimer dialog will appear as shown below. This is just a reminder that this is technical software and while the software developer has made every effort to eliminate errors in the program, it is up to the designer to use engineering judgment when reviewing the results.

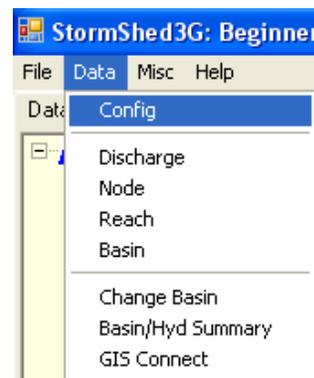


Select **I Fully Understand** and the box will close.

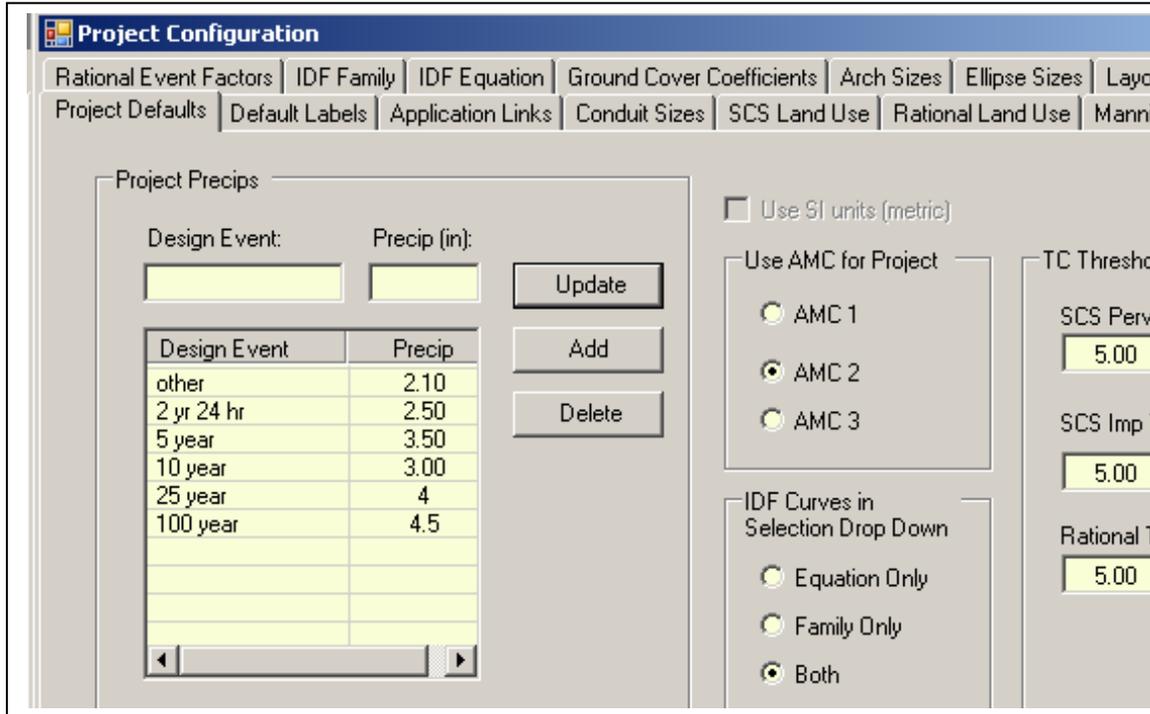
Set Project Defaults

After a project is created, the next step is to set the project defaults. In this tutorial we will only modify the items in the Project Defaults tab.

Select **Data>Config**.



The Project Configuration box will open as shown below.



Project Configuration

Rational Event Factors | IDF Family | IDF Equation | Ground Cover Coefficients | Arch Sizes | Ellipse Sizes | Layo
 Project Defaults | Default Labels | Application Links | Conduit Sizes | SCS Land Use | Rational Land Use | Manni

Project Precip

Design Event: Precip (in):

Design Event	Precip
other	2.10
2 yr 24 hr	2.50
5 year	3.50
10 year	3.00
25 year	4
100 year	4.5

Use SI units (metric)

Use AMC for Project

AMC 1

AMC 2

AMC 3

IDF Curves in Selection Drop Down

Equation Only

Family Only

Both

TC Thresho

SCS Perv

SCS Imp T

Rational T

To eliminate the Warning dialog box; the Design Event must be typed as '2 year 24 hour' or '2yr 24hr'. If '2 year' is typed, the warning will continue to appear.

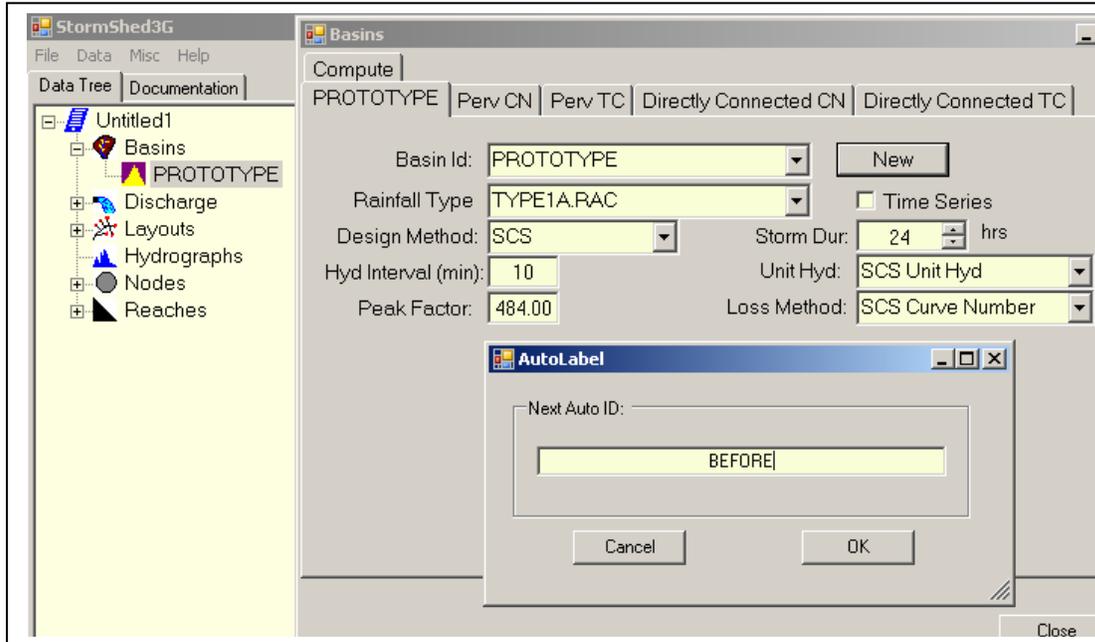
Project Precip – After determining the precipitation values (*see the applicable EWA or WWA storm determination sections of this tutorial*), input the values as shown above.

- To modify an existing value, highlight the Design Event by LMB click on an item and then modify the values in the boxes above. Accept the change by selecting the **Update** button.
- To add a new value, input the design event and precip. into the blank boxes, then select the **Add** button.

For this tutorial we will leave the default selections for AMC, IDF and Tc as shown above.

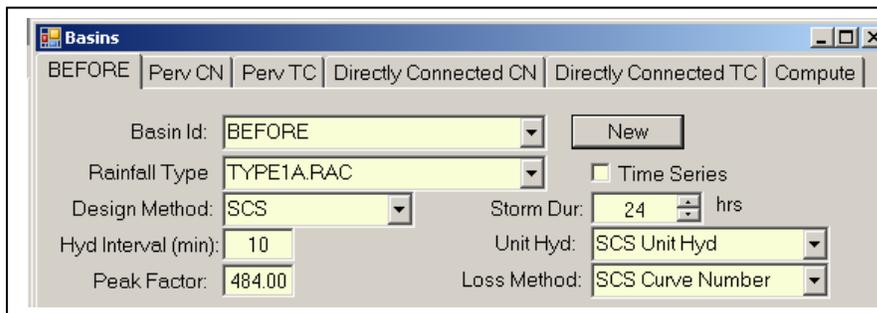
Create Basins

First, define the ‘before’ drainage basin conditions.



Expand the **Basin** option in the *Data Tree View* and then double click on *PROTOTYPE* to open the basin dialog box. The PROTOTYPE dialog box is the template for all other basin records. It will save time if repetitive options are set in the PROTOTYPE dialog box and saved before creating a new basin or use an existing basin to create a new basin.

Select the *New* button and input the basin name, for this tutorial use ‘**before**’. Then click **OK** to close the dialog box.



Next we will review the input boxes on the first tab, labeled the basin name ‘before’:

- **Rainfall Type** – This is where the design storm, as specified in Chapter 4 of the HRM, is selected. For this project, we were told to use the **Type1A.RAC for WWA**.
- **Storm Duration** – the length of a storm is set here and the program will either stretch or shrink a storm distribution to this time line. For this example, set the duration to **24 hours in WWA**.

- Design Method – designers have three methods to select from for the design analysis: SCS, SBUH, or the Rational Method. Either the **SCS or SBUH** is acceptable on WSDOT projects as both will yield similar results for most WSDOT project. For projects with more pervious surface or in a rural area, consider the SCS method and for projects with more impervious surface or in an urban area consider the SBUH method.
- Hyd Interval – or the hydrograph interval. This is the interval at which data is reported from the 3G analysis; this value does not affect the actual analysis. When the **Type 1A or Long Duration Storm** is used, the **10 minute default** is appropriate.
- Peak Factor – This feature is not modified for WSDOT projects from the default value of **484**. This is a customization feature that will either flatten or heighten the hydrograph.
- Unit Hydrograph – A unit hydrograph basically put represents the affect rainfall has on a particular basin. In 3G there are two options: SCS and Delmarva. The Delmarva only applies to projects in Maryland, so for all WSDOT projects the **SCS Unit Hydrograph** option should be selected.
- Loss Method – there are three options for determining precipitation losses on a project: SCS, Green Ampt, and Holtan. Generally all WSDOT projects use the **SCS CN Approach** which combines infiltration losses with the initial abstraction. The Green Ampt and Holtan method require more information than we usually have on a WSDOT project.

The **Perv CN** tab is where the pervious drainage basin area is defined by both the total area in acres and the Curve Number (CN). The CN values can be selected from the pull-down tab based on the land use selected, (Urban, Developing Urban, Cultivated Agriculture, Other Agriculture, and Arid Rangeland) and the HSG (Hydrologic Soils Group). Designers should verify these values are the same as found in Appendix 4B of the HRM, an example is shown on the next page. *Note there are separate CN tables for eastern and western Washington in the HRM, be sure to use the correct table.*

Notice there are values already set up in the PROTOTYPE basin; these are examples of how to input data and should be **deleted**. Next input the information from the example by typing the values in the boxes as shown below and then selecting the **Add** tab. To modify information already input, LMB click on the data and the information will appear in the upper boxes. Make the necessary changes and then select the **Update** button. The changes should appear in the lower box.

- For this example, input the data as shown in the box below.

The screenshot shows the 'Basins' software window with the 'BEFORE' tab selected. The interface includes the following elements:

- Navigation tabs: BEFORE, Perv CN, Perv TC, Directly Connected CN, Directly Connected TC, Compute.
- Input fields: Description (dropdown), Area (ac) (0), CN (0), HSG (dropdown).
- Buttons: Update, Add, Delete, Move to DCIA.
- Radio buttons for land use types:
 - Urban
 - Developing Urban
 - Cultivated Agriculture
 - Other Agriculture
 - Arid Rangeland
- Table:

Description	Subarea	CN
BEFORE CONSTRUCTION	2.076	70.00

- **Move to DCIA** – This option allows designers to move pervious basins to the impervious basin tab, a time saver when basins are accidentally input on the wrong tab. Simply highlight the row, select this button, and the basin description, subarea, and CN will be moved to the Directly Connected CN tab.
- **Abstraction Coeff** – This value can only be modified when using the SCS CN for the loss method. Precipitation has to be greater than 0.2S (the maximum soil water retention parameter) before runoff is generated. While this number can be modified in the Pervious CN tabs only, it should be left as **0.2** for WSDOT applications.
- **Total Area** – The total pervious area entered for this basin is summed in this box.
- **Avg CN** – This is the average CN computed based on all the pervious surfaces reported.

Get CN values in Appendix 4B of the Highway Runoff Manual.

<http://www.wsdot.wa.gov/Design/Hydraulics/default.htm>

OR

Get CN values using drop down boxes and menus.

Table 4B-2. Runoff curve numbers for selected agricultural, suburban, and rural areas (western Washington).

Cover Type and Hydrologic Condition	CNs for hydrologic soil group			
	A	B	C	D
Curve Numbers for Predevelopment Conditions				
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Curve Numbers for Postdevelopment Conditions				
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.):¹				
Fair condition (grass cover on 50% to 75% of the area)	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds, etc.	100	100	100	100
Paved parking lots, roofs, ² driveways, etc. (excluding right-of-way)	98	98	98	98
Porous Pavers and Permeable Interlocking Concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	95	96	97	97
Good lawn condition (weighted average CNs)	94	95	96	97
Paved	98	98	98	98
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch)	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)	45	66	77	83
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77

Defining the Time of Concentration (TC) is the next step for the pervious surface. Select the *Perv TC* tab and modify the information as shown on the below using the example problem statement summarized below.

- For this example we have **50ft** of **sheet flow** on a **1%** and the land cover type is a **fair forest** condition. The best match for a sheet flow Kf from the pull down menu is, **wood or forest with dense under brush**.
- The second type of pervious flow is **shallow** for a length of **900ft** at a **1%** slope. Select **forest with heavy ground litter and meadows** for the ns value.
- The third type of pervious flow is intermittent channel flow for a length of **50ft** at **1%** (assumed). Select **forested swale with heavy ground litter** for the Kc value.

Again the default values in the PROTOTYPE description area are for example and need to be either deleted or updated.

The screenshot shows the 'Basins' software interface. At the top, there are tabs for 'before', 'Perv CN', 'Perv TC', 'Directly Connected CN', 'Directly Connected TC', and 'Compute'. Below the tabs, there are input fields for 'Flow Type', 'Description', 'Len (ft)', 's (%)', 'Coeff', and '2 yr Precip'. The 'Flow Type' dropdown is currently set to 'Sheet'. The 'Len (ft)' field contains '0', 's (%)' contains '0', 'Coeff' contains '0', and '2 yr Precip' contains '0'. There is a 'Select Coeff.' dropdown and a 'Slope Cal' button. Below these are 'Update', 'Add', and 'Delete' buttons. A 'Total TC (min):' field shows '80.42'. At the bottom, there is a table with the following data:

Type	Description	Length	Slope	Coeff	TT
Sheet	Woods or forest with dense un...	50.00	1.00	0.80	32.06
Shall...	Forest w/ heavy ground litter &...	900.00	1.00	0.10	46.73
intCh...	Forested swale w/ heavy grou...	50.00	1.00	0.10	1.64

Now let's review the options in the Flow Type pull-down menu. While there are many options we generally only use the ones noted below on WSDOT projects:

- Fixed – Rather than having the program calculate the travel time, the designer can manually input the value.
- Sheet Flow – Flow, over a relatively flat surface that does not concentrate more than 0.1' deep, and is less than 100' in length is considered sheet flow. This type of flow will be used to model runoff as it travels off the roadway to the shoulder.
- Shallow Flow – Once flow exceeds the depth and or length requirements for Sheet Flow, it begins to have a defined flow path and is assumed to be Shallow Flow. Runoff traveling along the curb line or in ditches should be modeled as Shallow Flow.
- Channel Flow – Is assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where lines indicating streams are shown on US Geological Survey Maps. There are two options for Channel Flow in 3G: **intermittent and continuous**. The difference between the two is intermittent flow has a lower Hydraulics Radius (0.2) than continuous flow (0.4).

Since in the before condition there is no impervious surface, the next two *Directly Connected* tabs should be left blank.

The screenshot shows the 'Basins' software interface with the 'Compute Design Event' tab selected. The 'Select Design Event' dropdown menu is set to '25 year'. Below it, the 'AMC for this Computation' section has three radio buttons: AMC 1, AMC 2 (which is selected), and AMC 3. To the right of these buttons, it says 'Project AMC: 2'. In the 'Results' section, the following data is displayed: Peak Rate: 0.4679 cfs, Time to Peak: 535.97 min / (8.93 hrs) from start, and Hyd Vol: 13128.30 cf / 0.301384 acft.

The last tab, **Compute Design Event**, can be used to quickly compute a flow rate and volume of the runoff based on this basins characteristic.

- The **Select Design Event** pull-down menu references the precipitation values input into the **Program Defaults** tabs. For this example, select **25 year**.
- The AMC group can be changed for just this computation when using the compute command; it is not a permanent change. This will only give the designer an idea of how a different AMC could affect runoff from this basin. Note the Project AMC that was set in the **Project Defaults** tab, is also noted here.
- Select the **Compute** button for a quick look at the runoff generated from the basin. Using this command does not report the data to the history view; instructions for reporting this data are described at the end of this tutorial.

Next, the **After** drainage basin site conditions will be defined (the new impervious roadway with curb and gutters).

- Click on the **New** button, to create a new basin and then type '**after**'. *To save time reselecting the settings, select the '**before**' basin instead of the prototype basin.*

Next, delete any entries in the **Perv** tabs since in the after condition; the pervious surfaces are replaced with pavement. **Or to save time, highlight the pervious basin and hit the Move DCIA button.** This will automatically move the basin to the **Directly Connected CN** tab. Remember to update the **Description** and **CN** to reflect an impervious area.

Description	Area (ac)	CN	HSG
AFTER CONSTRUCTION	2.076	98	

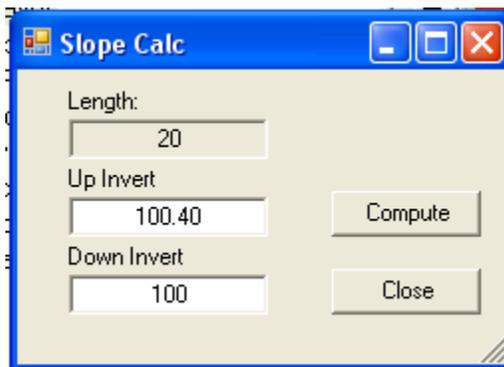
Directly Connected CN and TC – These tabs were formally known as **Impervious CN and TC** in the older versions of StormSHED. This is still the location to input impervious areas; however the name has changed. The new name simply describes what is happening, that is runoff from impervious areas is directly connected to runoff from pervious areas within that basin. When pervious runoff and impervious runoff are input into separate tabs, the program generates two separate hydrographs (one for the Directly Connected and one for the Pervious areas) and then the two hydrographs are added together. If a composite CN is more representative of a project site runoff, this can still be done by entering both the pervious and impervious areas into the **Perv CN and TC** tabs. Then StormSHED will generate one hydrograph based on the composite CN. Generally two separate hydrographs summed as one, will provide a more accurate representation of a project site runoff. Consider a project with 9 acres of pervious runoff directly connected to 1 acre of impervious runoff. The runoff from the 1 acre of impervious area is going to have a faster travel time than the pervious area.

Type	Description	Length	Slope	Coeff	TT
Sheet	Smooth Surfaces.	5.00	1.00	0.011	0.16
Sheet	Smooth Surfaces.	40.00	2.00	0.011	0.66
Shall...	Paved and gravel areas (n=0....	900.00	1.00	0.012	5.61

Next, select the **Directly Connected TC** tab. Each flow path must be defined for the impervious area, below is a summary of the example description.

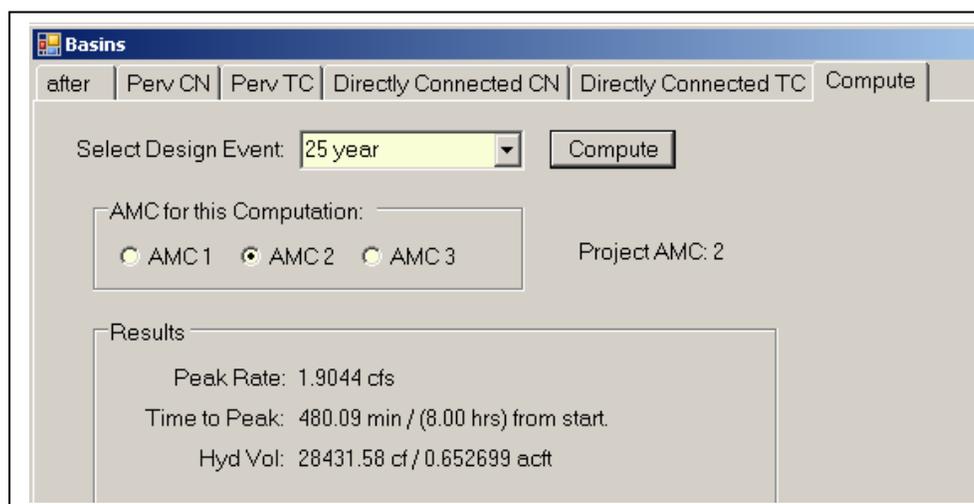
- For this example we were told there is **45ft** of **sheet flow** at a **2%** and the land cover type is a **paved** condition. Thus when defining the coefficient for sheet flow, select **smooth surfaces** from the pull down menu.
- The second type of flow we have on the site is **shallow** for a length of **900ft** at a **1%** slope. From the pull down menu select **paved and gravel areas** as the coefficient value.

*Need to calculate the slope? Select the **Slope Calc** button below the Coeff. box and the calculator to the left will open. Next input the runoff length and the up and down elevations and select the **Compute** button. 3G will automatically transfer the resulting slope to the slope box for the tab that is open in the basin dialog box.*



The image shows a dialog box titled "Slope Calc". It has a blue title bar with standard Windows window controls. The main area is light gray and contains three input fields: "Length:" with the value "20", "Up Invert" with the value "100.40", and "Down Invert" with the value "100". To the right of the "Up Invert" field is a "Compute" button, and below it is a "Close" button.

Select the last tab, **Compute**, to quickly compute a flow rate and volume based on the after construction basin runoff as shown below.



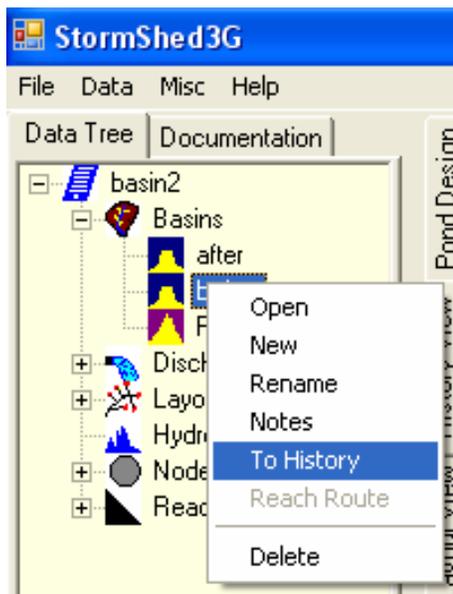
The image shows a dialog box titled "Basins" with several tabs: "after", "Perv CN", "Perv TC", "Directly Connected CN", "Directly Connected TC", and "Compute". The "Compute" tab is active. It features a "Select Design Event" dropdown menu set to "25 year" and a "Compute" button. Below this is a section for "AMC for this Computation" with three radio buttons: "AMC 1", "AMC 2" (which is selected), and "AMC 3". To the right of these buttons is the text "Project AMC: 2". At the bottom, a "Results" box displays the following information: "Peak Rate: 1.9044 cfs", "Time to Peak: 480.09 min / (8.00 hrs) from start", and "Hyd Vol: 28431.58 cf / 0.652699 acft".

Create a Report

Once information for each basin is entered, the designer will need to provide this data in the hydraulic report. There is no formal report writing command in 3G, however information can be sent to the History View and then copied into a word document. This can be done by:

- LMB click to select the basin in the *Data Tree View*.
- RMB click to open the menu.
- Then LMB click to select the 'To History' option.

This process should be repeated for each basin.



The *History View* will open and should look as shown below. Notice there is information on each precipitation value that was entered in the *Project Configuration* tab as well as all the information input into each basin.

Repeat the process for the 'after' basin. Each item (basin, reach, node, etc) will need to be selected individually as described above and copied from the *History View* into a word document. For larger projects there is a quicker method that will be reviewed in the Layout Tutorial.