

# WinTR-55 for Plan Reviewers

Small Watershed Hydrology  
**Intermediate WinTR-55 Training**  
*Modeling Multiple Sub-area Watersheds*

## Course Outline

- Overview
- Review of Hydrology Terms
- Modeling Single Sub-area Watersheds
- Modeling Single Sub-area Watersheds
- **Multiple Sub-area Watersheds**
- Modeling Structures
- Advanced Features of WinTR-55



WinTR-55 Multiple Sub-Areas

We're next going to move on to modeling multiple sub-area watersheds. We will deal with structures in the next lesson. The concepts regarding sub-areas and reaches may be new to some users, so we'll spend time explaining those concepts. We'll look at the data requirements for multiple sub-area watersheds and how to enter data so that WinTR-55 understands you are working with multiple sub-areas. Through some examples and exercises we'll actually enter the data and run the program. And finally, we'll also talk about interpreting output as the output interpretation is more complicated when working with multiple sub-areas than when working with single sub-areas.

## Lesson Objectives

Upon completion of this lesson you will be able to :

- Describe the relationship between reaches and sub-areas in the modeling process
- Interpret Output



WinTR-55 Multiple Sub-Areas

The objectives for this lesson are that you be able to:

Describe the relationship between reaches and sub-areas in the modeling process;

Develop input data for multiple sub-area watersheds including stream reaches;

Input stream reach data into WinTR-55;

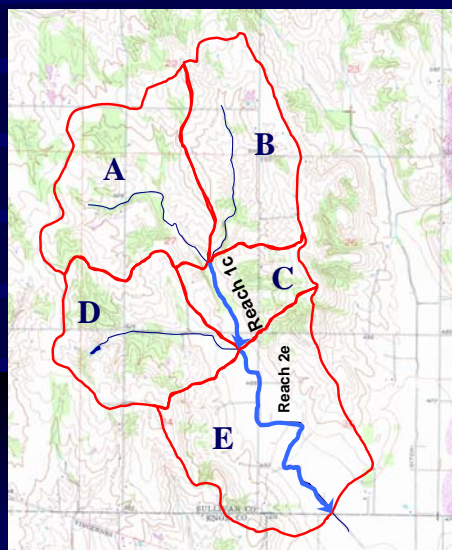
Run WinTR-55; and finally, as always

Interpret the output in order to find the particular piece of data you may be interested in or to be able to make adjustments to your input data if necessary.

## Sub-Area and Reach Concepts

**The first thing we want to do is look at the concept of sub-areas and reaches. Some of this may be new to some of you, so it's important you understand how the model handles multiple sub-areas and links them together as well as how reach routings are handled. This should help us achieve the first objective of this lesson.**

## Sub-area/Reach Concepts



WinTR-55 Multiple Sub-Areas

- **Watershed** - system of sub-areas and reaches
- **Sub-areas** - watersheds that generate runoff
- **Reaches** - represent watershed flow paths (stream channels) or structures

Look closely at our watershed map and notice how the parts of the watershed are identified.

☞ A watershed can be split up into multiple sub-areas and reaches.

☞ Sub-areas are those land areas that can be thought of as generating runoff. The watershed illustrated here consists of 5 sub-areas. Rain falling on each of those individual sub-areas flows to the outlet of that particular sub-area and is then conveyed downstream through the stream reaches to the watershed outlet.

☞ Reaches are watershed flow paths within the watershed through which runoff is conveyed in a concentrated manner. In the example shown here, the runoff from sub-areas A and B is conveyed to the watershed outlet by flowing through reach 1c and reach 2e. The runoff from sub-areas C and D is conveyed to the watershed outlet by flowing through reach 2e. The runoff from sub-area E is not conveyed through any reach as the outlet of sub-area E coincides with the watershed outlet.

One question that arises frequently is, how come some sub-areas contain a reach while others do not? In this case, sub-areas C and E have a Reach identified as flowing through them while sub-areas A, B and D do not even though there is a segment of stream in those sub-areas.

For the watershed illustrated here, sub-areas A, B, and D do not have water from OTHER sub-areas passing through them to reach the watershed outlet. Indeed, a portion of that runoff will flow through the stream in those sub-areas, but those stream channels are not conveying water from other sub-areas.

In the case of sub-area, C, the runoff hydrographs generated from sub-areas A and B are added at the top of Reach 1c and conveyed to the downstream end of Reach 1c which coincides with the outlet of sub-area C. At the outlet of sub-area C, the routed hydrograph is added to the runoff hydrograph generated from sub-area C AND the runoff hydrograph generated from sub-area D.

This forms the total watershed hydrograph at the outlets of sub-areas C and D, or the top of Reach 2e. That water is then conveyed (the hydrograph routed) through Reach 2e where it is added to the runoff hydrograph generated from sub-area E to form the total hydrograph at the watershed outlet.

**Note: WinTR-55 REQUIRES an alphabetic character in the reach name.**

## Sub-area/Reach Concepts

- **Watershed** - system of sub-areas and reaches
- **Sub-areas** - generate runoff
  - feed into the upstream end of reaches
- **Reaches** or Routing Elements- represent watershed stream flow paths or structures
  - Channel Routing elements - Stream Reaches
  - Structure Routing elements - Reservoir/Structure Reaches
- **Watershed Outlet** - downstream end of the watershed (required for all watersheds)

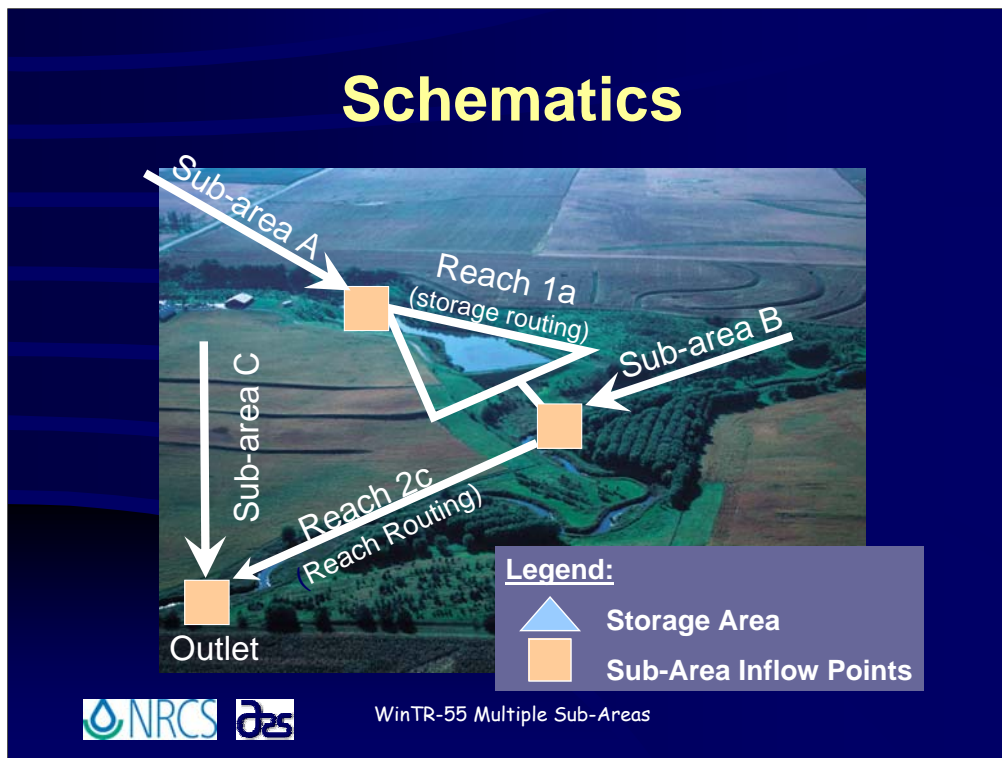


WinTR-55 Multiple Sub-Areas

To emphasize the important points.

- ☞ A watershed can be thought of as a system of sub-areas and reaches.
- ☞ Sub-areas are those smaller subwatersheds that generate runoff and feed into the upstream end of reaches.
- ☞ Reaches are routing elements through which water is conveyed. There are two types of reaches.
- ☞ Channel routing elements or Stream reaches, and ☞ Structure routing elements or structure reaches.
- ☞ All watersheds are required to have an identified Watershed Outlet. Do not confuse the Watershed Outlet with outlets for individual sub-areas.

In this particular lesson, we'll focus on stream reaches and take a look at structure reaches in the next lesson.



Schematics are line drawings representing the elements of a watershed model. Remember we said that watersheds consist of a series of sub-areas and reaches. The idea behind drawing a schematic is to show how these elements are combined to represent the watershed as we build a computer model of that watershed. Taking the time to make a quick sketch of a schematic for a watershed model will help clarify how all the parts fit together when it comes time to enter your data. A schematic is also an incredibly helpful tool for anyone who might have to look at your work 10, 15, 20, or even 50 years from now and try to figure out what you did. I can't emphasize enough the importance of developing a simple schematic.

The sub-area/reach concepts utilized in WinTR-55 are one of the most important things you need to have a clear idea of in order to build good models and schematics will help with that understanding.

Again, a schematic is a simple line drawing representing the elements of a watershed model. Let's take a look at the watershed area in this photograph and develop a schematic for it.

☞ In this schematic blue triangles will represent storage areas (or STRUCTURE reaches) and orange squares represent sub-area inflow points. Other lines represent either sub-areas or stream reaches as labeled.

☞ First is a line representing SUB-AREA A. Sub-areas are those elements that generate runoff, so a runoff hydrograph would be developed for the runoff from that sub-area. The orange square shows us that this is where the inflow (runoff hydrograph) from SUB-AREA A enters the watershed system.

☞ The next step is to route the runoff from SUB-AREA A through the structure (blue triangle) and label it a structure reach. In this case, REACH 1a.

☞ Next a runoff hydrograph for SUB-AREA B is developed. SUB-AREA B is represented by a line and, an orange square shows the point at which this runoff enters the watershed system.

☞ At this stage, the water from REACH 1a (the structure) and SUB-AREA B are combined and a total hydrograph developed for that location.

☞ That total hydrograph is then reach routed through the channel below that point to the watershed outlet. This STREAM reach is represented by a line labeled REACH 2c.

There now exists a hydrograph at the top of REACH 2c representing all the runoff from above that point, and a hydrograph at the bottom of REACH 2c which represents the changes in the previous hydrograph due to the water flowing through the reach. Not yet accounted for is the runoff for that area below the top of REACH 2c.

☞ A line here represents SUB-AREA C. A runoff hydrograph for SUB-AREA C is developed to account for all that watershed area below the point at the top of REACH 2c.

☞ An orange square indicates the point where the runoff from SUB-AREA C enters the watershed system. This runoff from SUB-AREA C is then combined with the routed hydrograph from REACH 2c to represent a total runoff hydrograph at the WATERSHED OUTLET.

Since these concepts may be new to some of you, I'll give you a few moments to consider all this and ask questions....

## Data Requirements

- **Identification Data** - User, State, and County
- **Dimensionless Unit Hydrograph**
- **Storm Data** – for specific County/State
- **Sub-area Data** - Name, flows to reach/outlet, area, runoff curve number, & time of concentration
- **Reach Data** -Name, receiving reach/outlet, reach length, Manning's "n", friction slope, bottom width, average side slopes

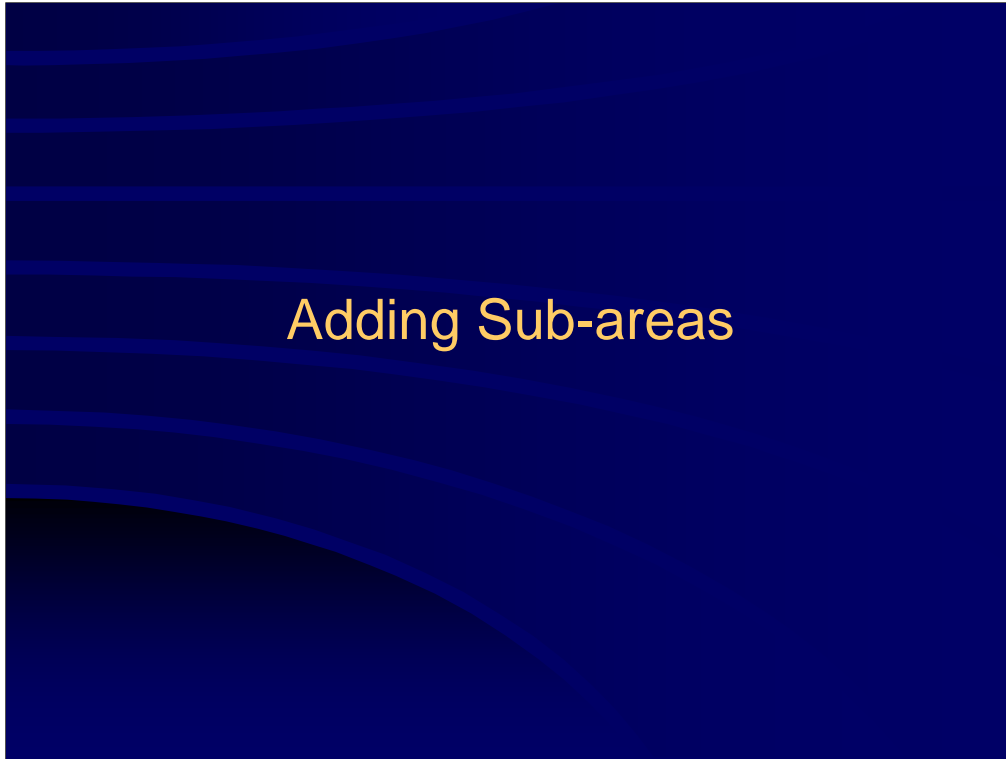


WinTR-55 Multiple Sub-Areas

When modeling multiple sub-area watersheds, most of the data requirements are the same as for single sub-area watersheds.

- ☞ The user must still fill in all the *Identification Data*,
- ☞ specify which *Dimensionless Unit Hydrograph* is appropriate,
- ☞ specify the appropriate *Storm Data*,
- ☞ and all the pertinent **Sub-area Data**.
- ☞ The new pieces of information required are the *Reach Data*. We'll take a look at reach data, specifically for stream/channel reaches shortly, but first let's talk about the addition of sub-areas.





**For multiple sub-area watersheds, adding sub-areas is as simple as typing the names of the sub-areas (up to 10) into the *Sub-area Entry and Summary* portion of the *WinTR-55 Main Window*.**

# Adding Sub-areas

The screenshot shows the WinTR-55 Main Window with the following settings:

- Project Identification Data:
  - User: jcs
  - State: Missouri
  - Project: Example 2
  - County: Franklin
  - Subtitle: test
  - Execution Date: 2/11/2003
- Sub-areas are expressed in:
  - Acres
  - Square Miles
- Dimensionless Unit Hydrograph: standard
- Storm Data Source: Franklin County, MO (NRCS)
- Rainfall Distribution Identifier: Type II

The Sub-area Entry and Summary table is as follows:

Sub-area Name	Sub-area Description	Sub-area Flows to Reach/ Outlet	Area (ac)	Weighted CN	Tc (hr)
UpperMain		MainStem1	175.00	77	0.423
CountyRoad		MainStem1	200.00	73	0.450
MiddleMain		MainStem2	70.00	66	0.211
UpperEast		EastReach	130.00	77	0.287
LowerEast		MainStem2	110.00	70	0.373
UpperWest		WestReach	65.00	77	0.342
LowerWest		MainStem2	75.00	81	0.189
LowerMain		Outlet	130.00	79	0.426


Project Area: 955 (ac)

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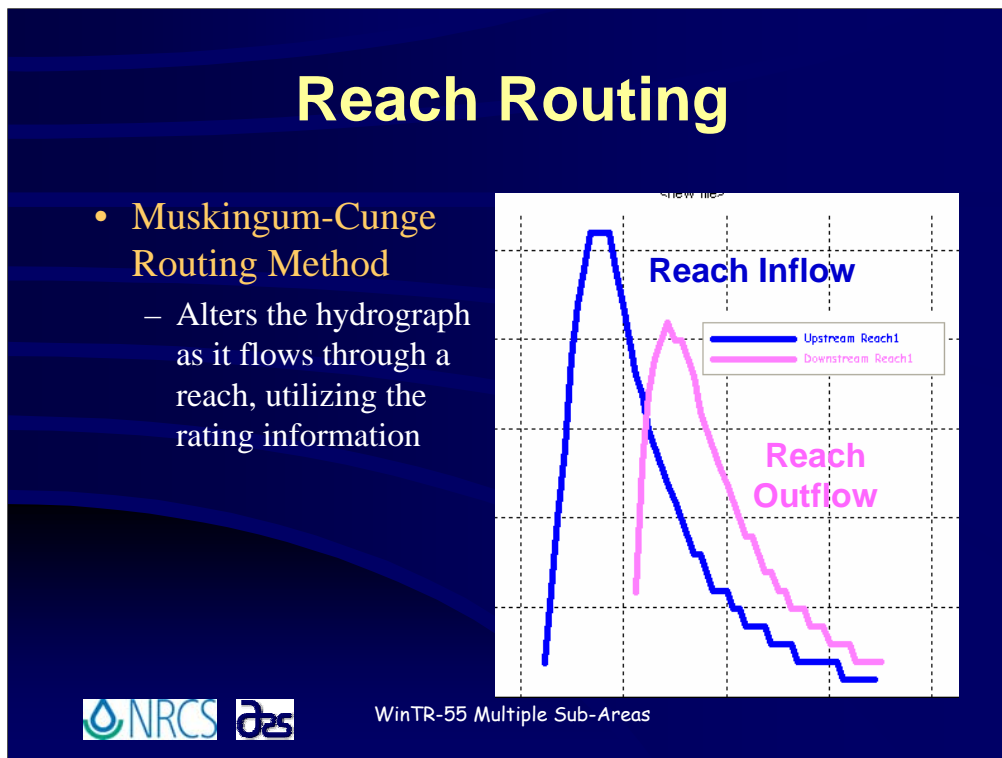


WinTR-55 Multiple Sub-Areas

In the example shown here you'll notice that this watershed has a total of 8 sub-areas. (Remember that the maximum number of sub-areas is 10).

 You will also notice that each sub-area has the Drainage Area, Curve Number and Time of Concentration specified.

So, adding additional sub-areas is as simple as specifying the names here and supplying the appropriate area, CN and Tc if they were computed elsewhere, or working through the *Land Use Details Window* for each sub-area to compute runoff curve numbers; and through the *Time of Concentration Details Window* for each sub-area to compute time of concentration.



Reach routings within the WinTR-20 computational routine are performed using the Muskingum-Cunge method of channel routing (Chow, Maidment, and Mays, 1988; Maidment, ed., 1993; or Ponce, 1989).

Channel or floodrouting estimates how the hydrograph changes as it flows through a reach, utilizing the rating information. Typically reach storage reduces and delays the peak discharge. In addition, the hydrograph becomes more rounded.

The rating table generated by WinTR-55 for each reach is used to represent flow in that reach.

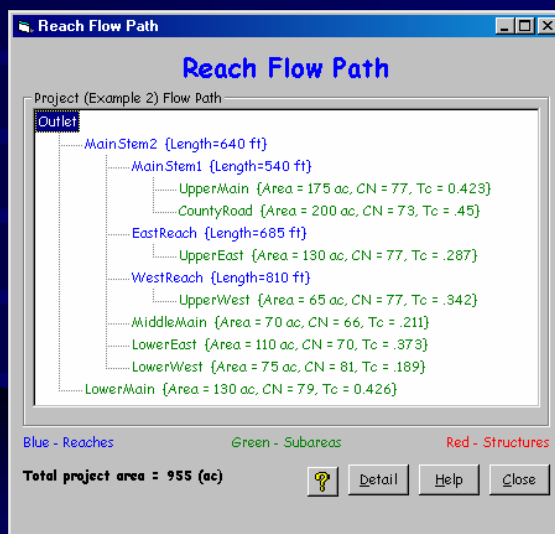
The unique feature of the Muskingum-Cunge routing is the calculation of the length of a routing reach step based on inflow peak discharge and cross section information.

If the routing reach step length is shorter than the reach length, the reach is sub-stepped.

For example, if there are two steps, the routing is accomplished by solving the routing equation twice: the outflow hydrograph for the upper half of the reach becomes the inflow hydrograph for the lower half of the reach.

If there are less than ten points from the beginning of the hydrograph to the peak of the inflow hydrograph, the inflow hydrograph is interpolated at a time interval to allow ten points, the routing computed, and the outflow hydrograph interpolated to return it to the original time increment.

## Reach Flow Path Window



WinTR-55 Multiple Sub-Areas

This slide shows the watershed schematic or reach flow path for the watershed example problem that has been illustrated in the last few slides. As you can see, this watershed consists of 8 sub-areas and 4 reaches. This illustrates how important it is to study this drawing carefully to make sure all the sub-areas are flowing to the proper reaches and all the reaches are flowing to the proper reaches.

## Capabilities and Limitations

**We spoke about capabilities and limitations so far as guidelines on the number of sub-areas and reaches during the Overview portion of the training. Right now, we want to review only those that pertain to multiple sub-area watersheds.**

## Capabilities & Limitations

- Number of sub-areas    1 - 10
- Number of reaches      0-10
- Types of reaches        Channel or Structure
- Channel Reach  
Routing Procedure        Muskingum-Cunge



WinTR-55 Multiple Sub-Areas

As mentioned previously, many of the capabilities and limitations in WinTR-55 were carried over from the original TR-55. This was done to limit its use to approximately the same types of watersheds that were being modeled using the original TR-55. TR-20 is capable of handling extremely large and complex watersheds, but the philosophy and focus of the original TR-55 was geared towards modeling smaller, simpler watersheds. The modeling team wished to retain this focus. The result is a model that is fairly simple and straightforward to use.

☞ Up to 10 sub-areas may be modeled using WinTR-55. Obviously 1 sub-area represents a single sub-area watershed and no reach data is used. Therefore, it is possible to have zero reaches in a run. Remember that it is also possible to have more than one sub-area if all sub-areas flow to the watershed outlet, in which case there would also be no reaches in the model.

☞ Up to 10 reaches. This is a new limitation. The philosophy or reach routing is revised in the new TR-20 computation routine. We'll talk about this later, however, the limitation of 10 reaches was intended to match up with the maximum number of sub-areas limitation.

☞ Reaches may be comprised of channel reaches or structure reaches. Channel reaches are those where hydrographs are routed through a length of stream channel, while structure reaches are those where hydrographs are routed through a structure. We'll talk about structure reaches in the next lesson later.

☞ Reach routings are performed using the Muskingum-Cunge procedure. NRCS made changes in the TR-20 computation routine to now utilize Muskingum-Cunge as opposed to the previously utilized Att-Kin (Attenuation-Kinematic) Method.