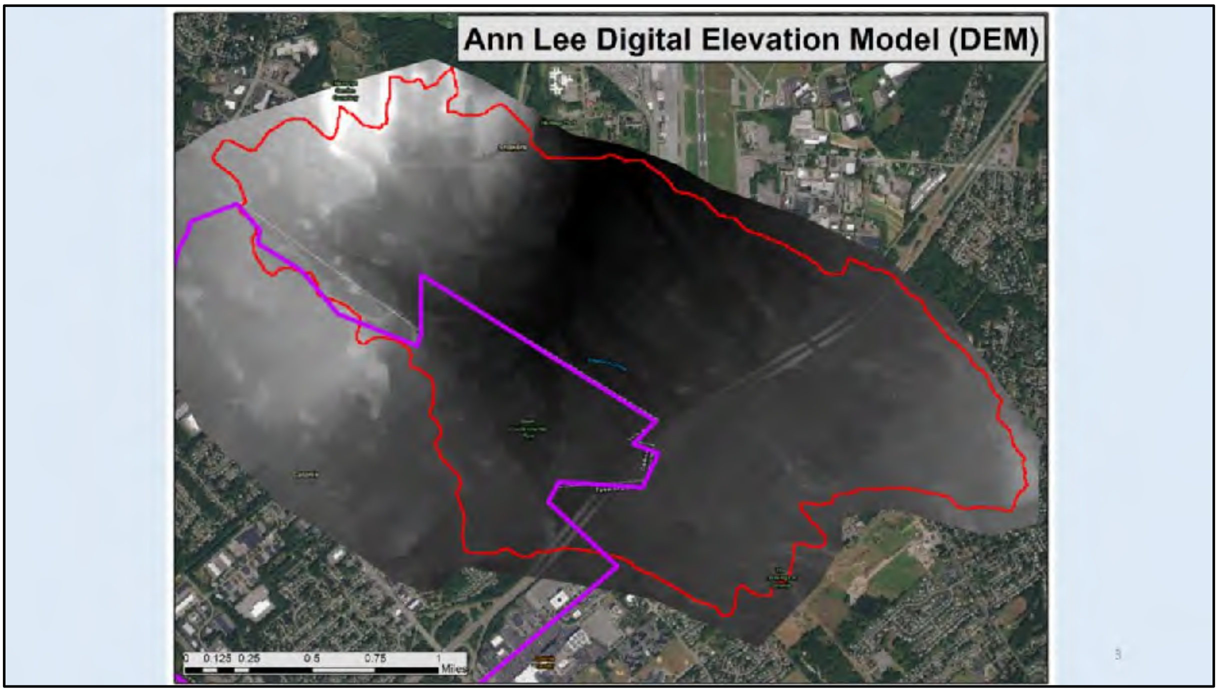
Sewershed Delineation and WinSLAMM Modeling

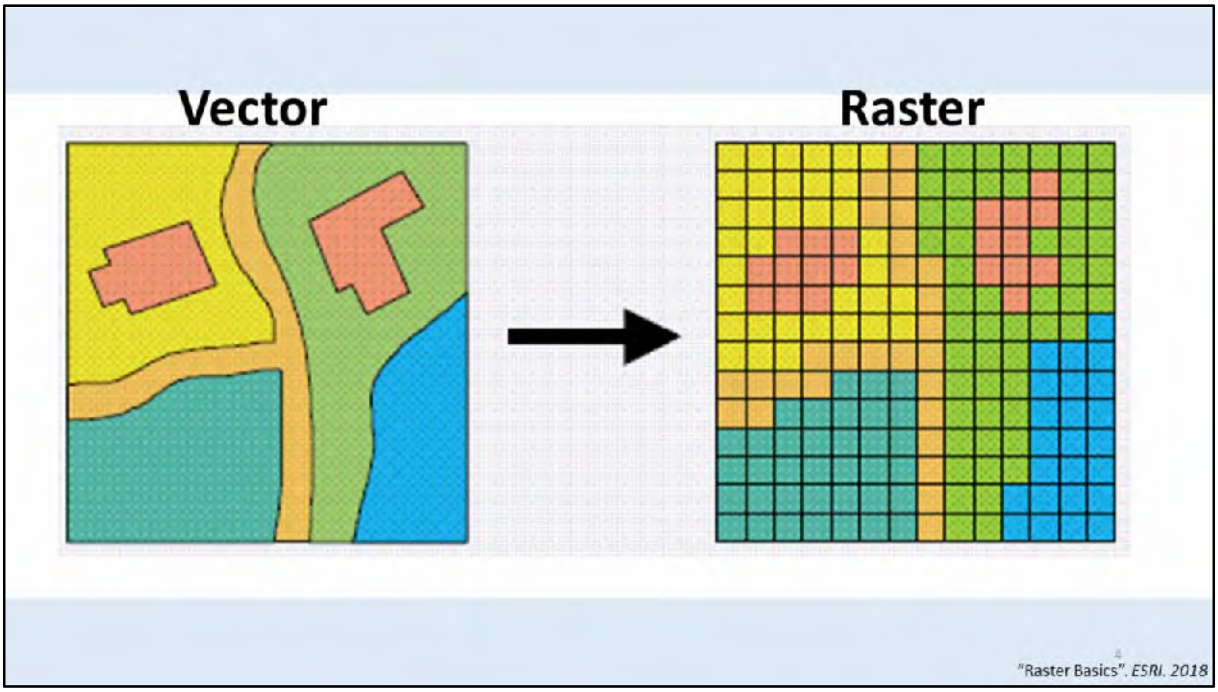
Stormwater Coalition of Albany County

January 25, 2018

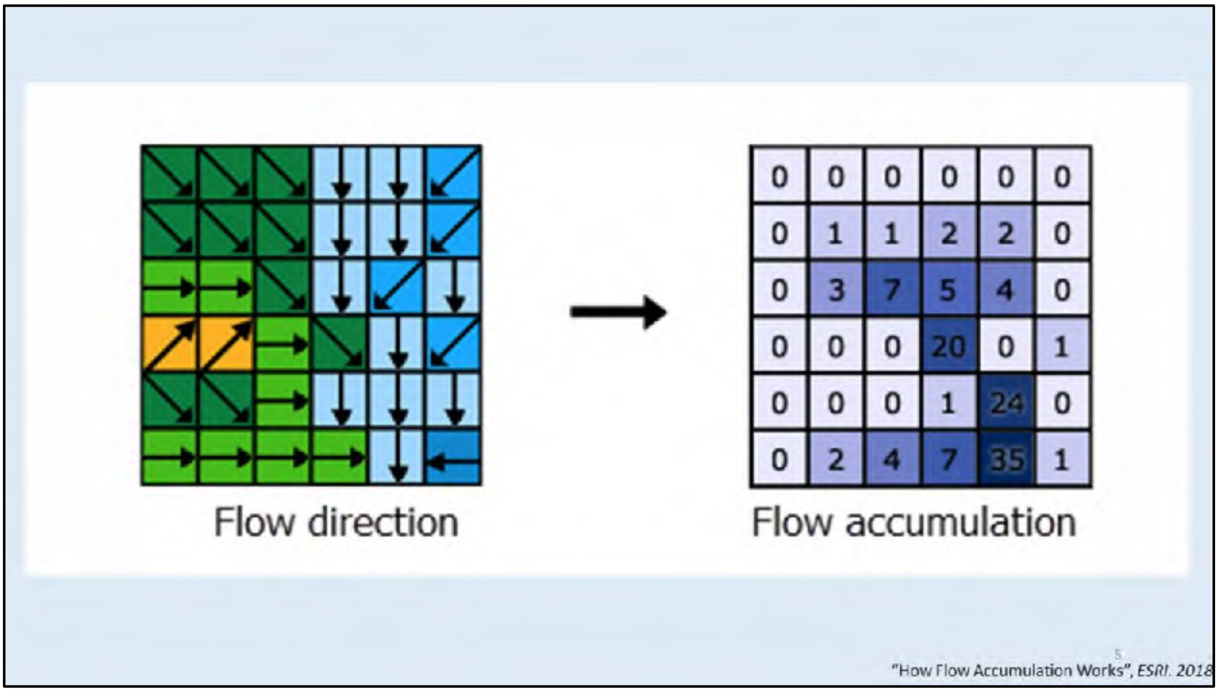
This is the Ann Lee Subwatershed with 2017 aerial imagery. The outlet of the watershed is marked with a green star. The border of the Village of Colonie is displayed in the purple outline. The rest of the subwatershed is in the Town of Colonie. This subwatershed was delineated by the Stormwater Coalition using USGS StreamStats



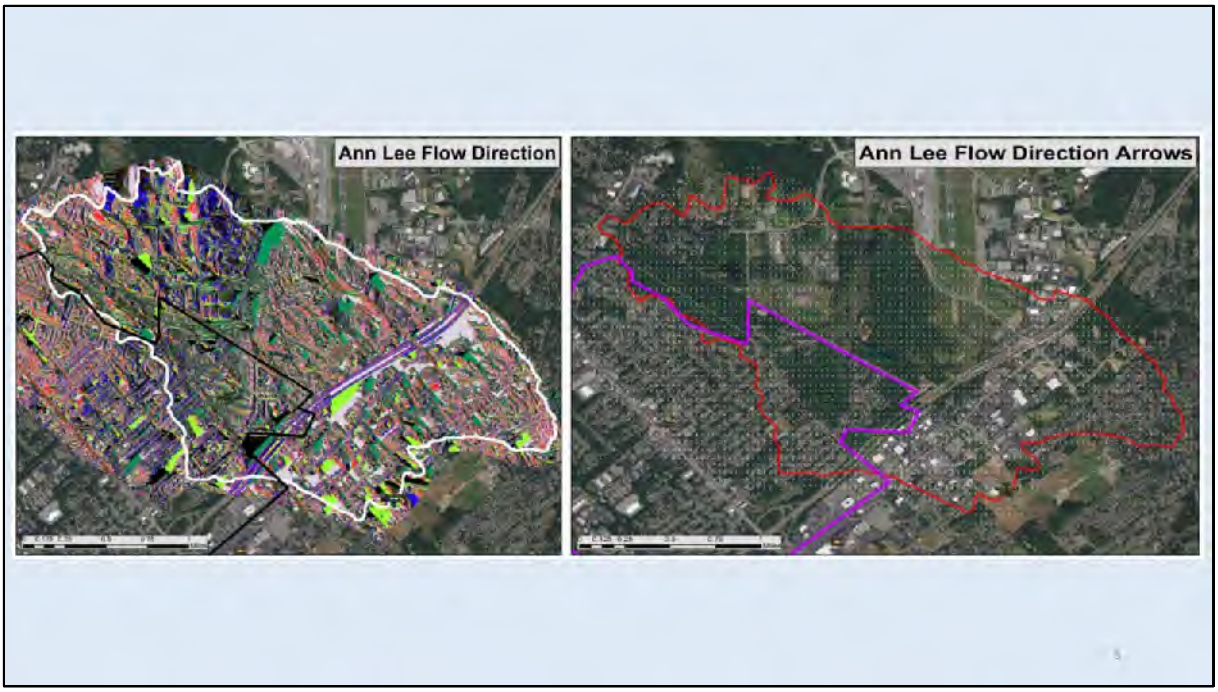
This is a digital elevation model (DEM). A DEM is a collection of raster pixels (explained on next slide) and each pixel has an elevation associated with it. In this particular DEM, each pixel represents a 3 foot by 3 foot area on the ground. The DEM is only shown for the area in and around the Ann Lee Subwatershed, but the Coalition has a DEM for all of Albany County. It is important to note that this DEM has been preprocessed using the “Fill” function. This tool corrects errors in the DEM, and will also help prevent “sinks” or pixels that would have no direction from them since they are the lowest relative elevation compared to the adjacent cells. This DEM was made using LiDAR data, the Stormwater Coalition and Albany County funded the collection of this data through a Department of Homeland Security grant



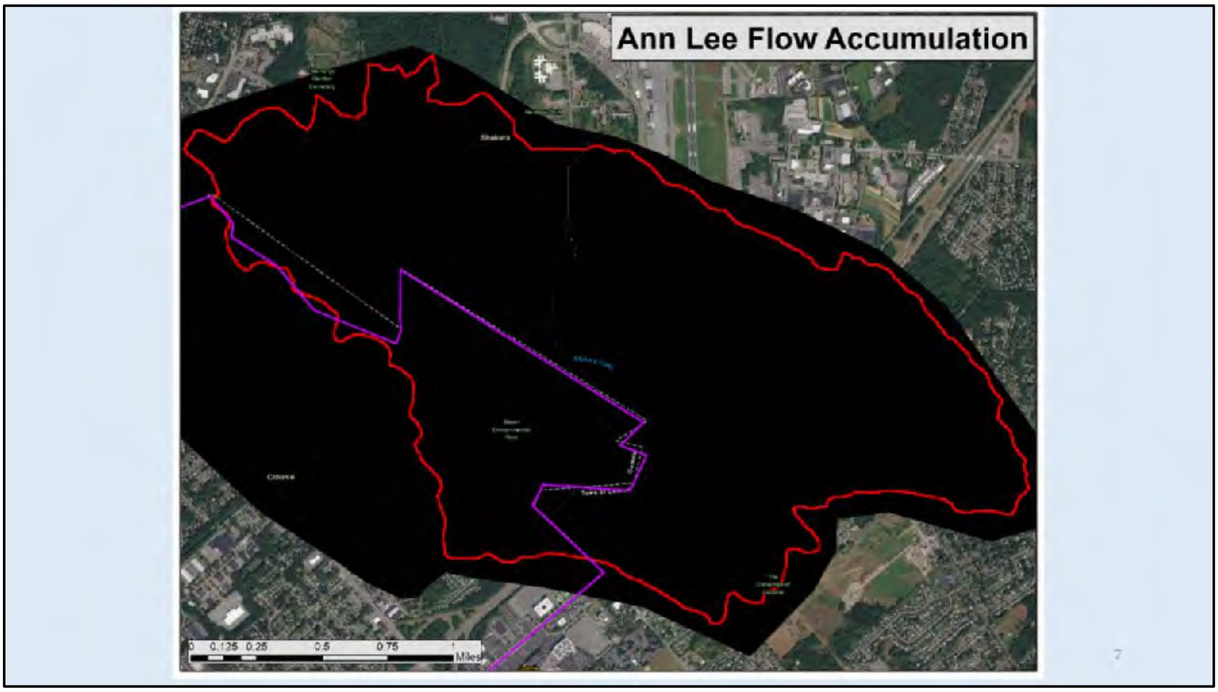
This graphic shows the differences between "Vector" and "Raster" data formats. These are the two ways that data can be represented in GIS. Vector data consists of points, lines, or polygons and are useful for storing and displaying data that have discrete boundaries, such as county borders. Raster data, the data format of the DEM, is comprised of "pixels" of a given, uniform size on the ground (in our DEM each pixel is 3 feet by 3 feet) and each pixel is assigned a value representing some attribute, so in the case of the DEM, each pixel has the elevation of that area associated with it.



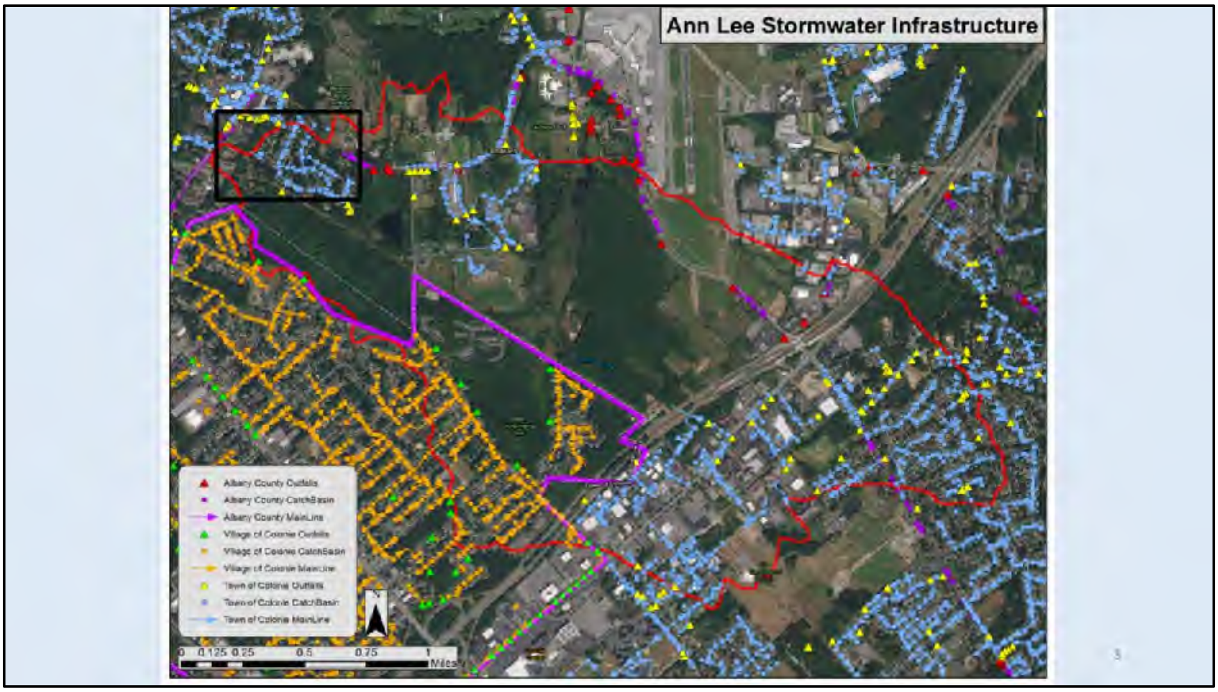
These graphics represent the "Flow Direction" and subsequent "Flow Accumulation" that are derived from our DEM. Using the "Flow Direction" tool, the GIS software finds the direction that water would flow based on the relative elevation of a cell compared to adjacent cells. Flow can move in 8 directions (through any of the 4 sides of the pixel, or any of the 4 corners), and the direction of flow will be toward an adjacent cell with the lowest elevation. Once "Flow Direction" is derived, "Flow Accumulation" can then be found by running the "Flow Accumulation" tool. If no unique value is specified then each pixel is assigned a default value of "1". A cell with a "Flow Accumulation" value of "2" means that this cell has 2 other cells flowing into it. In the above matrix the highest cell value is "35", meaning that 35 of the 36 cells are flowing into this cell, if this matrix represents a watershed, this cell would be the watershed outlet. It's important to note that "Flow Accumulation" is really the relative flow accumulation based on the direction of flow. The flow direction and flow accumulation in the Ann Lee watershed are displayed on the following 2 slides.



These are maps of flow direction for the Ann Lee Subwatershed. The map on the left has flow direction displayed as a raster format, and the map on the right is the generalized flow direction displayed as vector arrows, with each arrow representing the average flow direction for 35 pixels. Flow direction was processed for an area larger than the watershed boundary to include storm infrastructure connected within the Ann Lee Subwatershed.

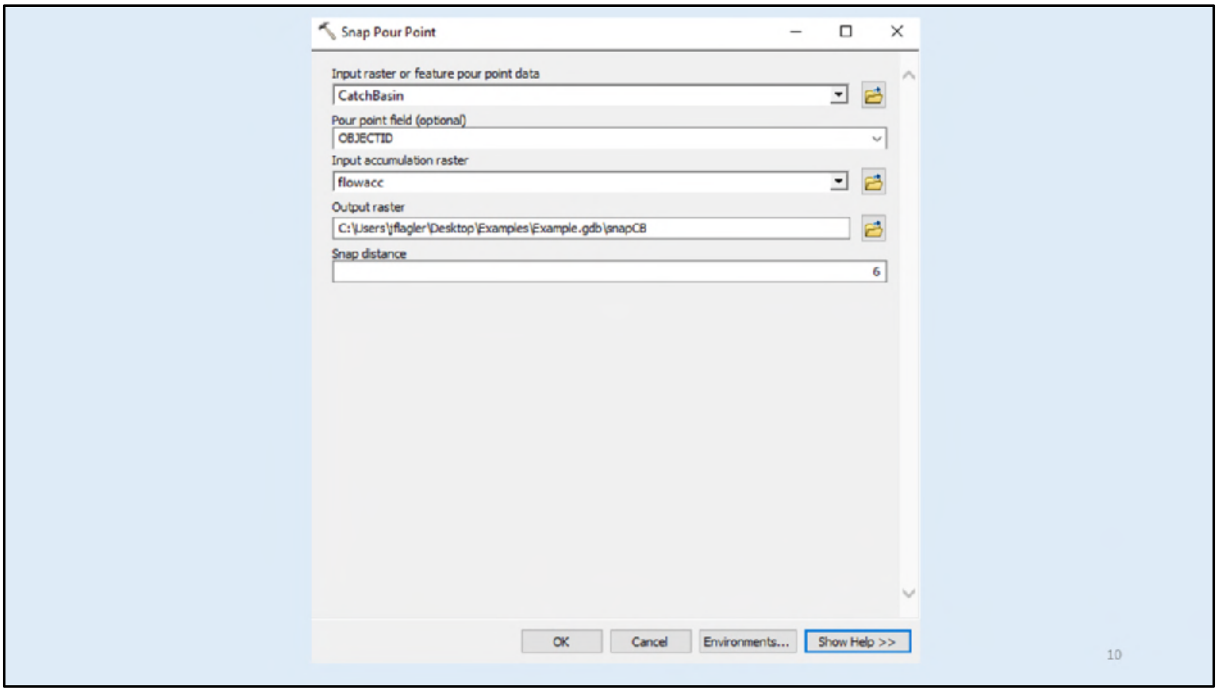


From the flow direction, the relative flow accumulation is pictured above. Pixels in white have relatively high flow accumulation.

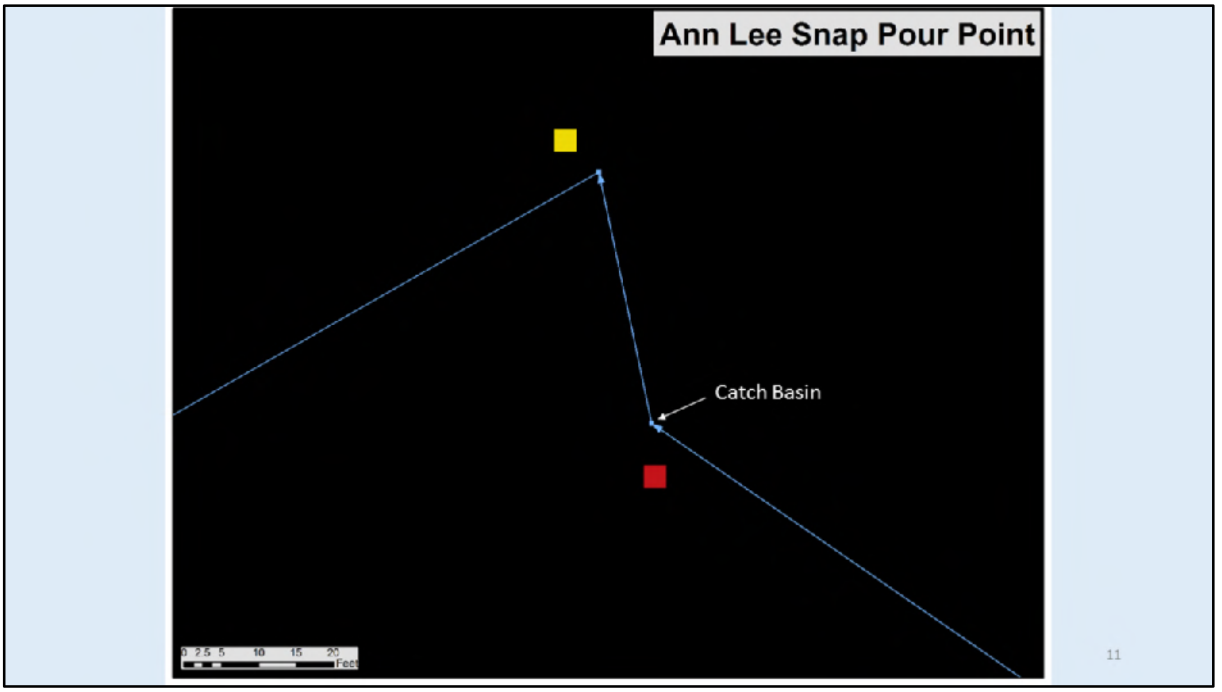


Based on System Mapping, this is the whole MS4 system for the Town of Colonie with an emphasis on the infrastructure within the Ann Lee Subwatershed. The most important infrastructure are “Catch Basins”, “Main Lines” and “Outfalls”, PCSMPs can be added later for subsequent “WinSLAMM” modeling. The black box in the northwestern part of the watershed is the isolated system that will be focused on in the following slides. The Town of Colonie data has not yet been finalized, but was provided by Rob Mateja, the town’s GIS Coordinator, on 1/9/2018. The Albany County dataset has also not yet been finalized

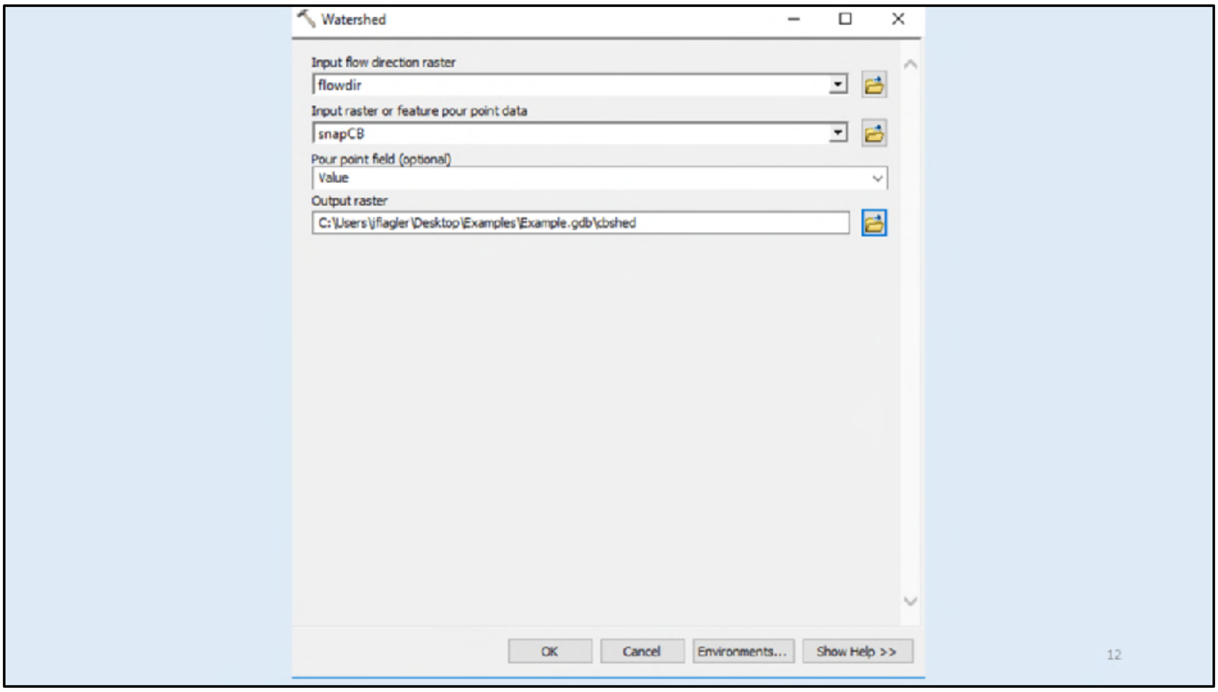
This is one part of the Town of Colonie system. In order to delineate the Sewershed, one must find an outfall, determine what pipes, catch basins, and other infrastructure are connected to that outfall and select these features and assess it as an isolated system. This is an example of this isolated infrastructure from the northwestern Ann Lee Subwatershed.



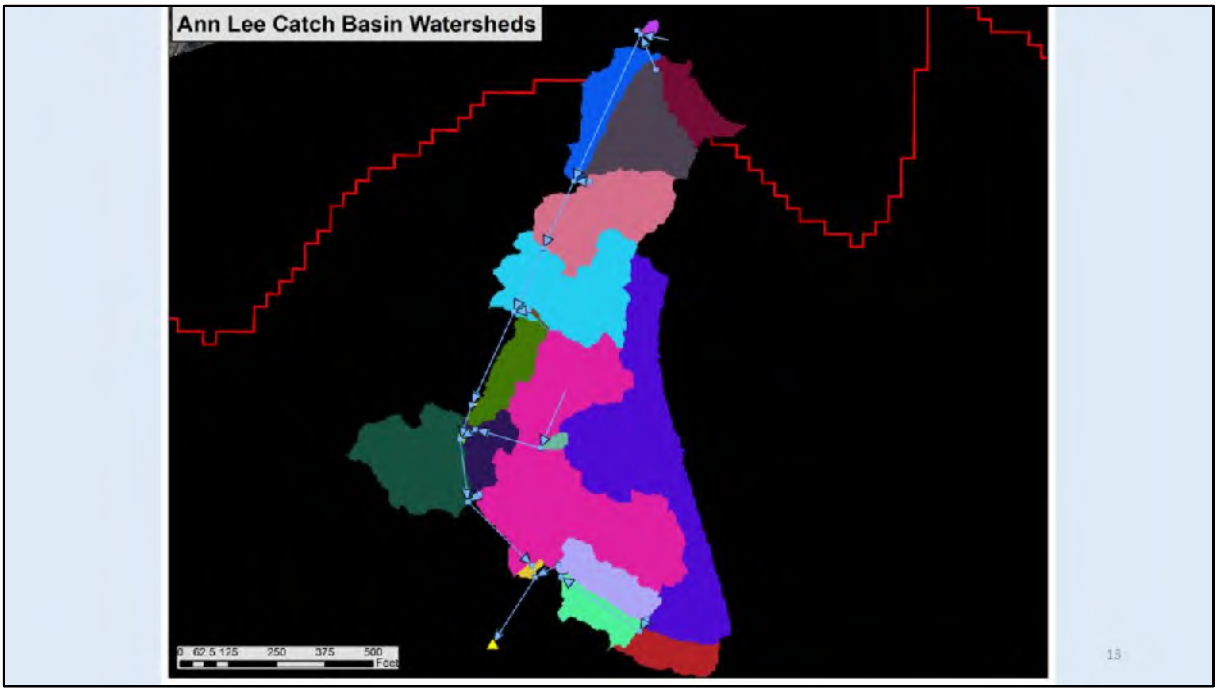
Now that the flow direction and flow accumulation have been found, and we have selected out the infrastructure connected to one outfall, we can begin delineating the source areas contributing water to the system ending at our selected outfall. The delineation is based on the topographic area contributing water to the catch basins in the system. The first step, shown here, is to “Snap Pour Point”. In this case the “pour points” are the catch basins in the system, therefore we input these as our “feature pour point data”, we also input the derived flow accumulation, and use a “Snap Distance” of 6, in this case our map units are feet, so our snap distance is 6 feet. With these inputs, the software searches a 6 foot radius around each catch basin to find the point of greatest flow accumulation. The purpose of this step is to account for any offset in the location where the catch basins were mapped and where they actually are, and also to mitigate assumptions in deriving flow accumulation from a DEM. By snapping to a pour point, our “outlet” of the small “watersheds” around each catch basin will be generalized to the highest flow accumulation to provide the best representation of source areas contributing to the catch basin. The value of a 6 foot snap distance was determined by FSI, now VHB, when delineating storm sewersheds for the Coalition in 2013. This distance had the best accuracy and therefore this value has been kept consistent.



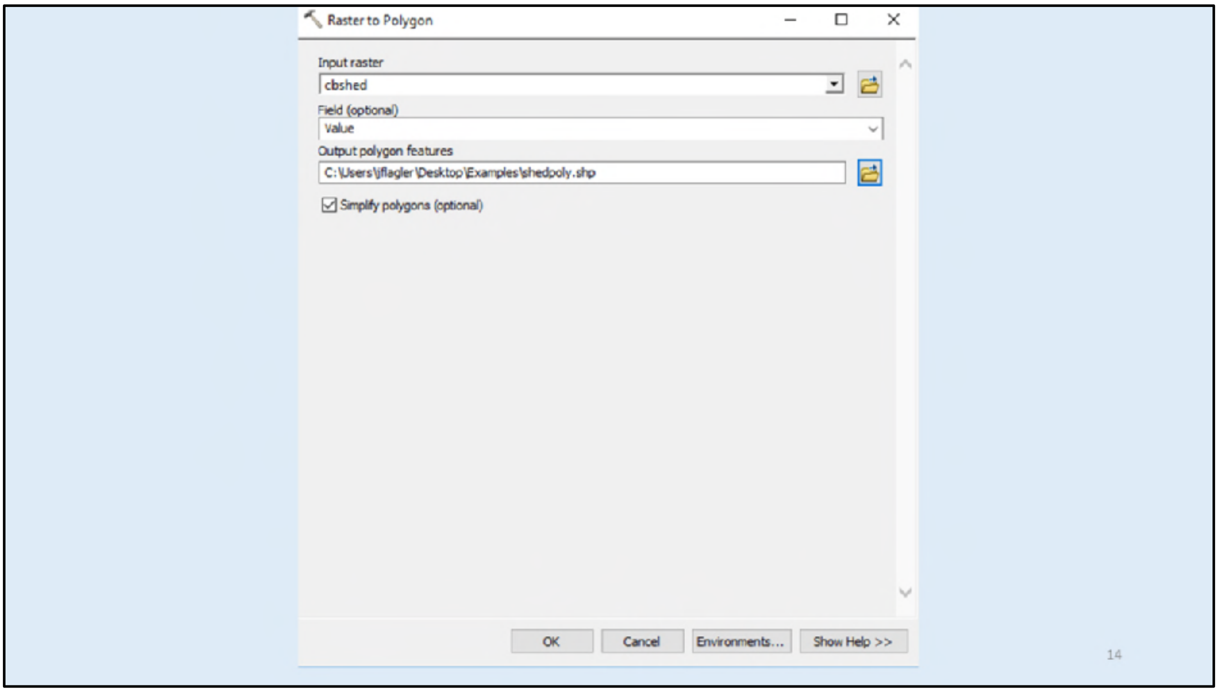
This is the result of the “Snap Pour Point” tool. The yellow and red squares represent the area within a 6 foot radius around the respective catch basins that have the highest flow accumulation. Take note of the offset, and also note that the offset is not always this dramatic.



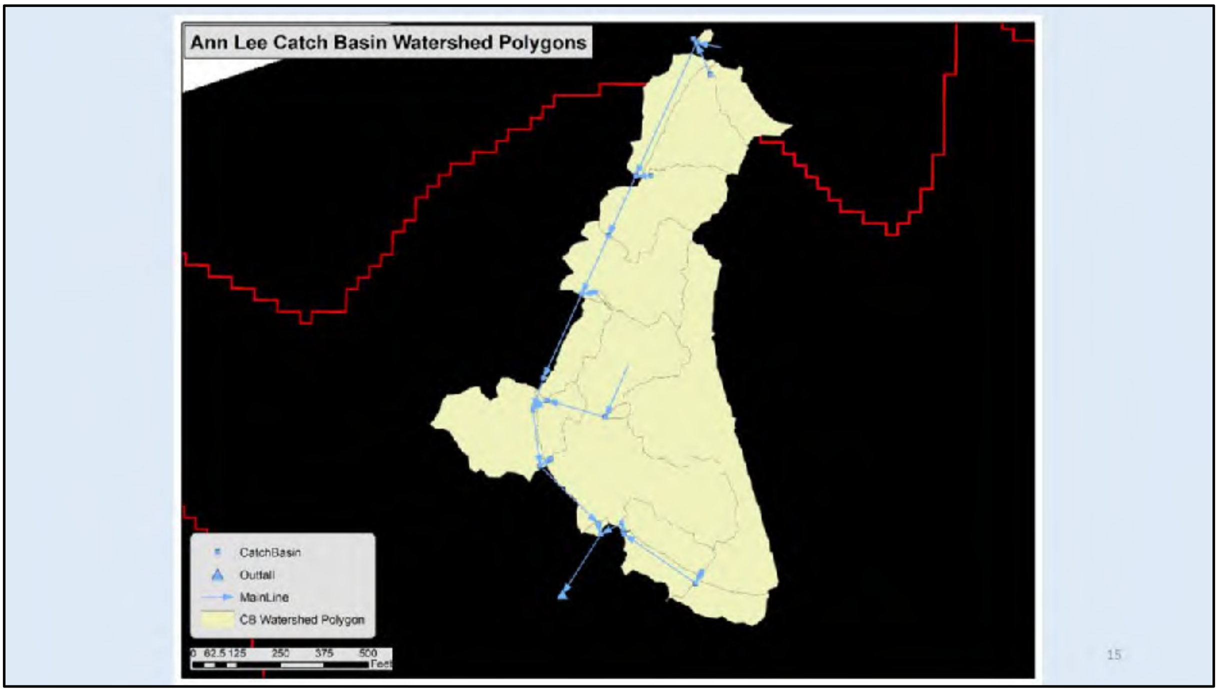
Once we’ve snapped to pour points, we want to delineate the watersheds around each catch basin (now snapped, so instead of inputting our “CatchBasins” as the “feature pour point data” we actually input the “snapCB”, which is the result of the “Snap Pour Point” tool). We also input the flow direction derived from the DEM, and this will delineate the source area around each catch basin



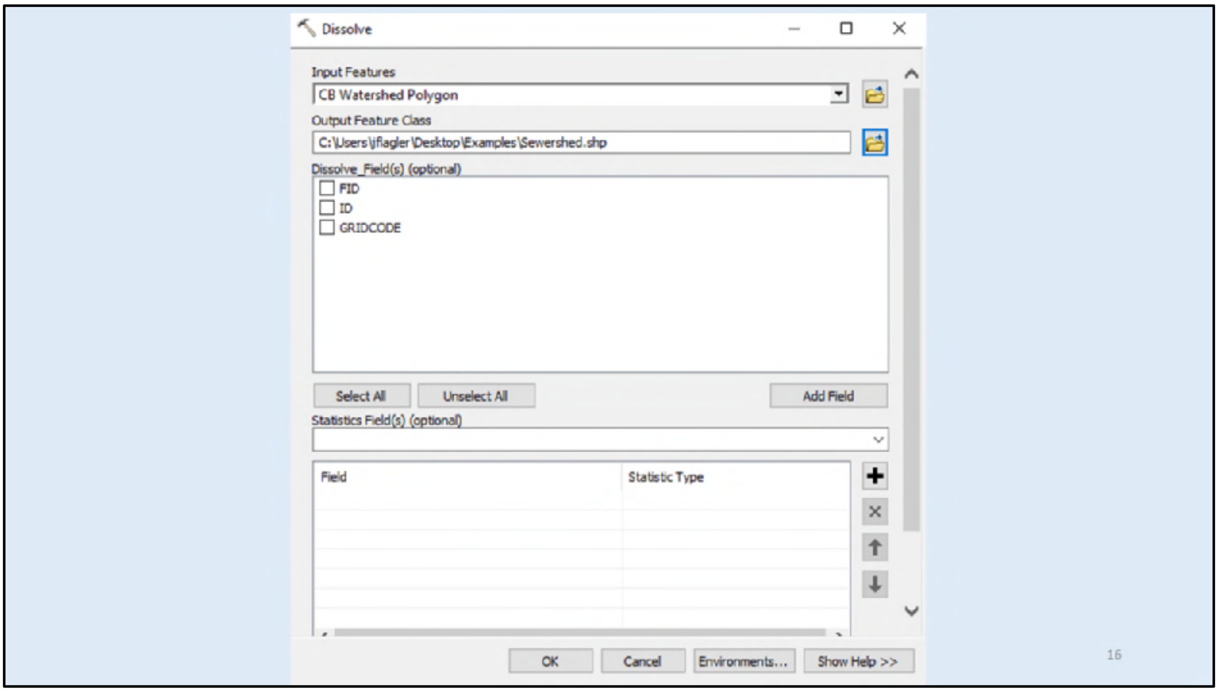
This is the result of the “Watershed” tool. The output is a raster format, and the different colored areas represent the source area pouring into a given catch basin



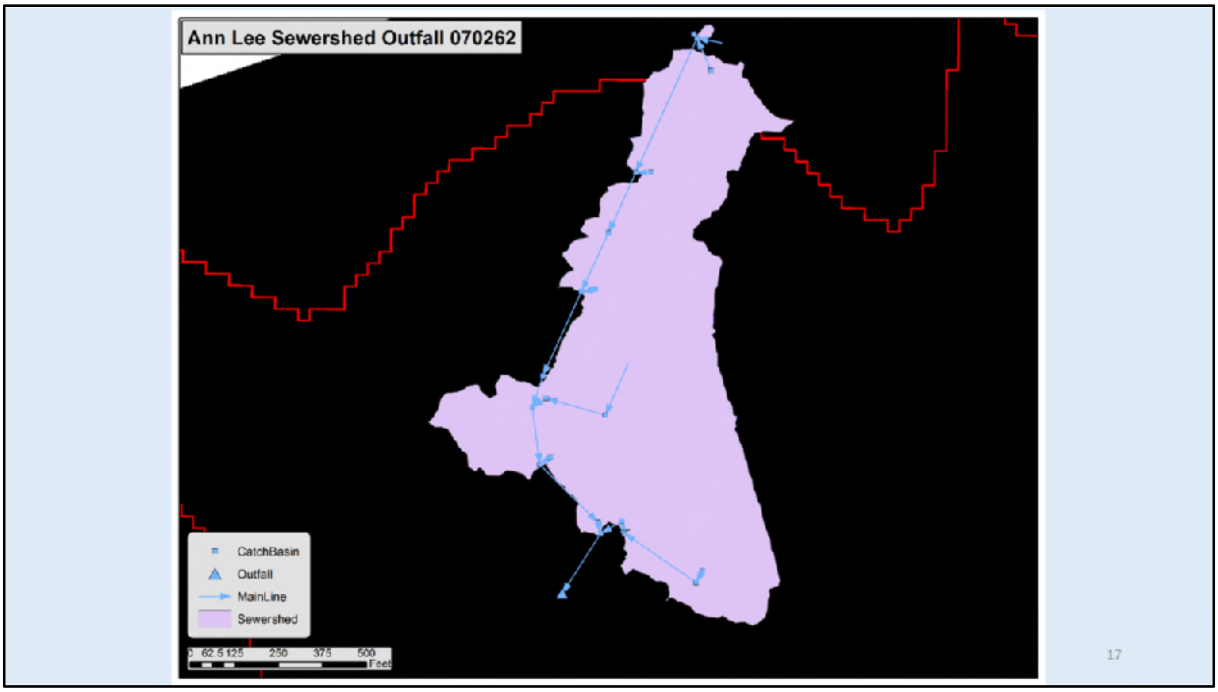
For representational purposes and for simplicity working with GIS data we now want to convert our output raster watersheds to a polygon layer using the “Raster to Polygon”. We input the watershed raster and let the program convert the data.



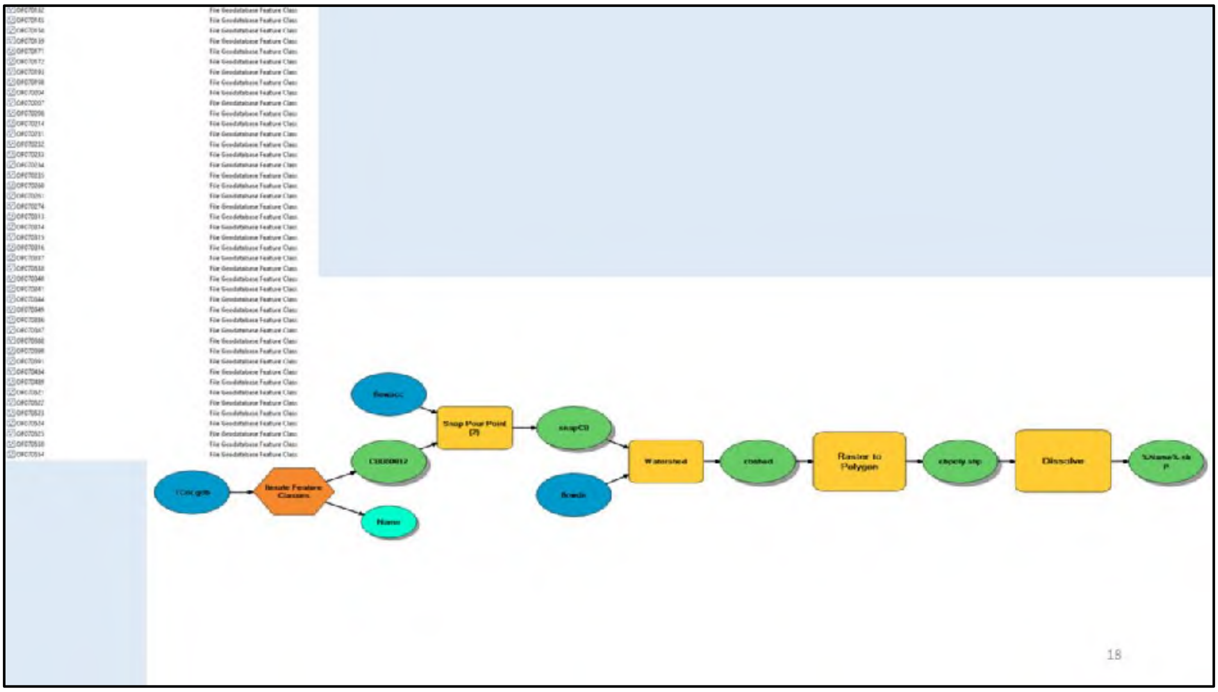
This is the result of the “Polygon to Raster” tool. Notice the lines separating the sewershed. These are still the individual source areas contributing to each catch basin. However, we want one shape to have a good representation of the aggregated sewershed, this also makes is easier to manipulate the sewershed.



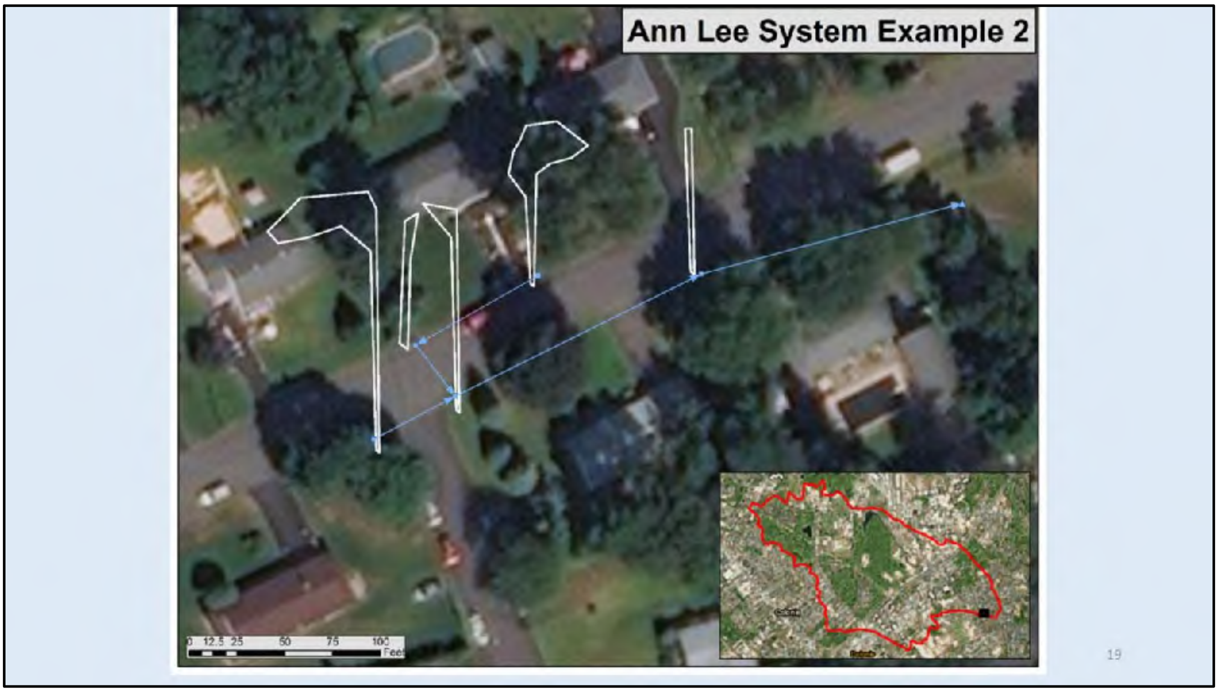
Since we want one shape, we use the “Dissolve” tool, this takes the smaller watersheds for each catch basin and aggregates is into one shape, which is our final “Sewershed”



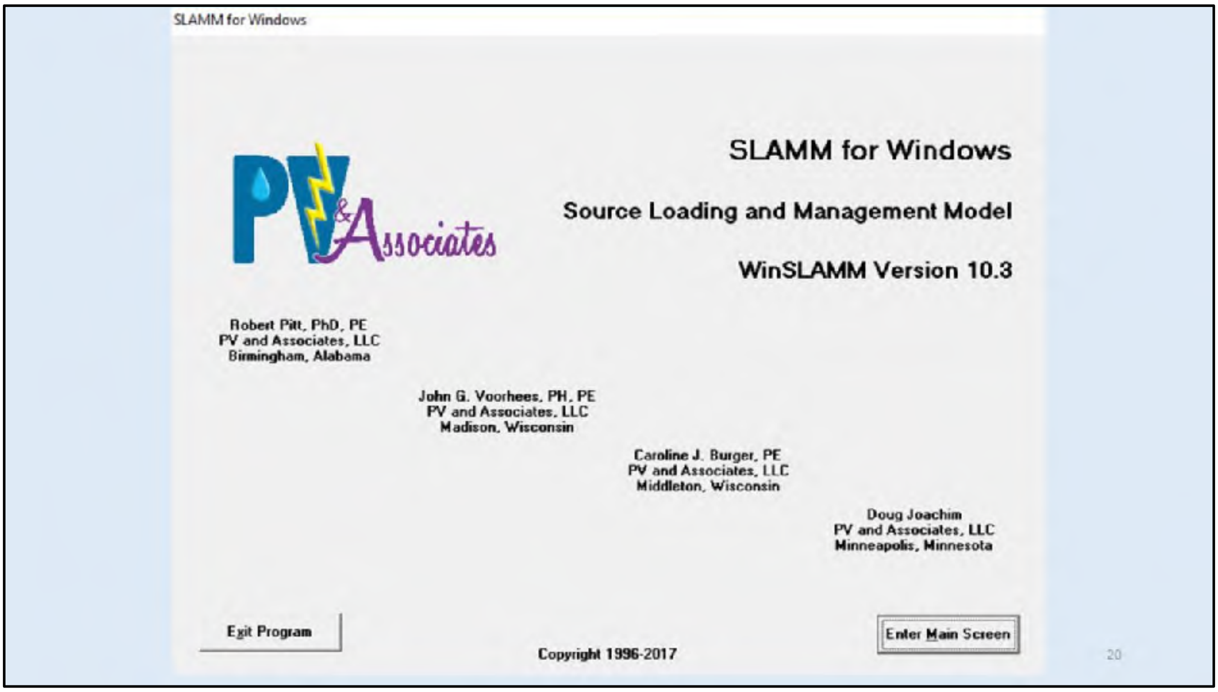
Here is our 16.5 acre sewershed in the Ann Lee Subwatershed. The areas in purple is the entire area that will spill into the catch basins contributing to the identified outfall.



This is a screenshot of the model used to execute this process. As noted, one must go through the area of interest (in this case the Ann Lee subwatershed), select the catch basins contributing to a single outfall, and group those together. The grouped catch basins are labeled using the outfall ID for the outfall they are connected to. In the list above we see the groups of catch basins contributing to the respective outfalls for Town of Colonie outfalls within the Ann Lee Subwatershed. These catch basins are stored in a geodatabase labeled “Tcol.gdb” and this is shown as the blue oval in the model (blue ovals are input features, yellow rectangles are tools, green ovals are outputs of processes, and as will be discussed, the orange figure is an “iterator”). The grouped catch basin feature classes and the flow accumulation “flowacc” (blue oval) are input into the yellow rectangle labeled “Snap Pour Point”. The green oval “snapCB” is the output of this tool, and this, along with flow direction (“flowdir” in the blue oval) serve as the inputs in the yellow rectangle labeled “Watershed”. The output of this process is in the green oval labeled “cbshed” and is the raster of the small watersheds around each catch basin. This is then used as the input for the “Raster to Polygon” (yellow rectangle) and the output “cbpoly.shp” (green oval) is the small watersheds converted to a shapefile (vector format). This shape is then input into the “Dissolve” tool (yellow rectangle), and the output is our final sewershed, labeled as “%Name%.shp”. This label is between “%” because this tells the program that the name of this final output will be the same as the name of the input, meaning each sewershed receives the name of the outfall ID that it is a sewershed for. Once this process is complete, we go back to the beginning with the orange figure labeled “Iterate Feature Classes”. This iterator makes it so that once the model processes are completed and the sewershed is delineated, the model, and all processes, will repeat on the next group of catch basins for the next outfall. So, once the catch basins are selected and grouped the model can automatically run on many sets of catch basins.



This is an example of a sewershed, derived from the same process, but is in the eastern portion of the Ann Lee Subwatersehd. The reason that this image is included is to show that there might not be a large, “neat”, source area contributing to an outfall based on the topography in the DEM, whether or not this is the case .in the reality would need to be field verified

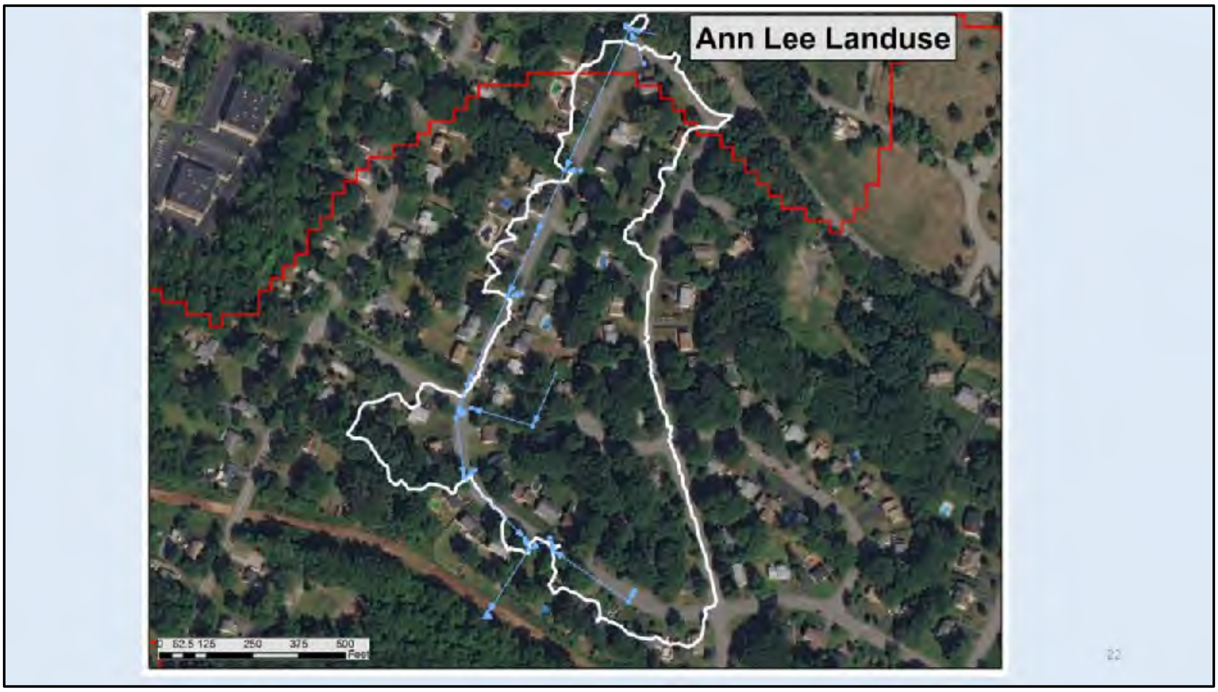


Now that the sewersheds are delineated we can model the system using WinSLAMM (Source Loading and Management Model for Windows) by PV associates. This mathematical model allows us to calculate pollutant concentrations, flow to the outfall, sediment delivery, and simulate various PCSMPs using stormwater infrastructure information

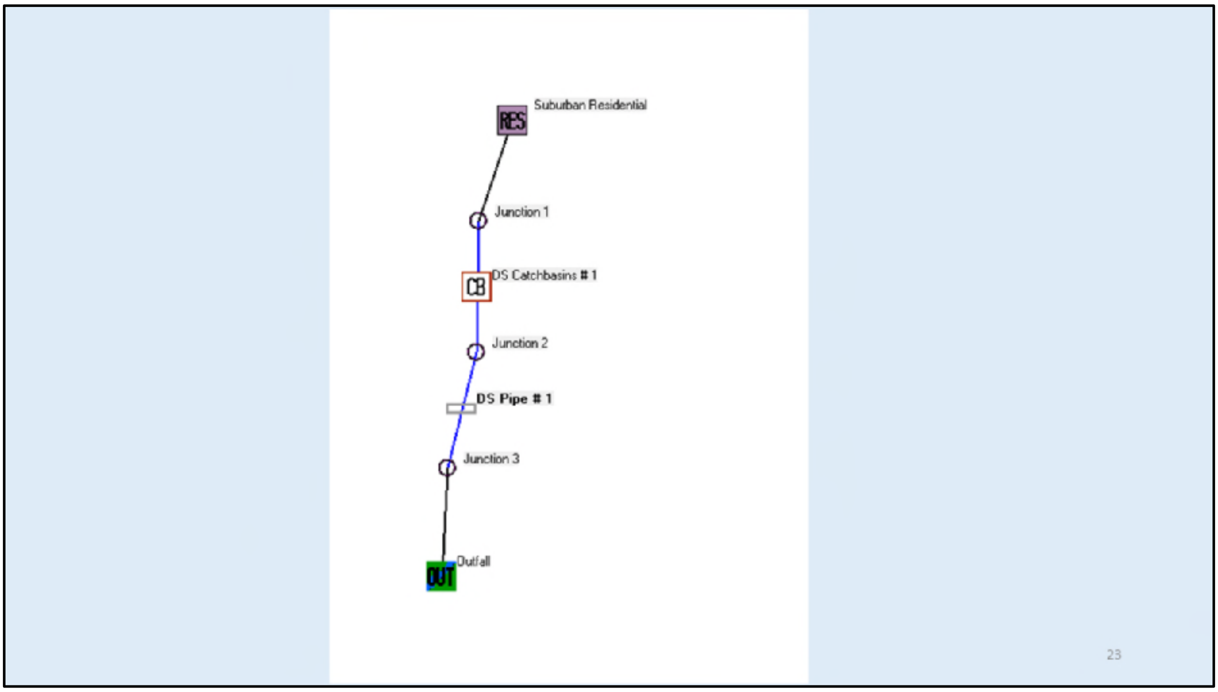
MODEL VS REALITY

- Model as a tool to simulate and represent real scenarios, but models are NOT reality
  - Modeled systems with relatively high pollutant concentrations may only have minimal pollution when field checked. Conversely, modeled systems with low pollutant concentrations may have high pollutant levels when field checked
- Models are useful for a basic understanding of what might happen in a drainage area over a year, 2 years, 10 years, etc

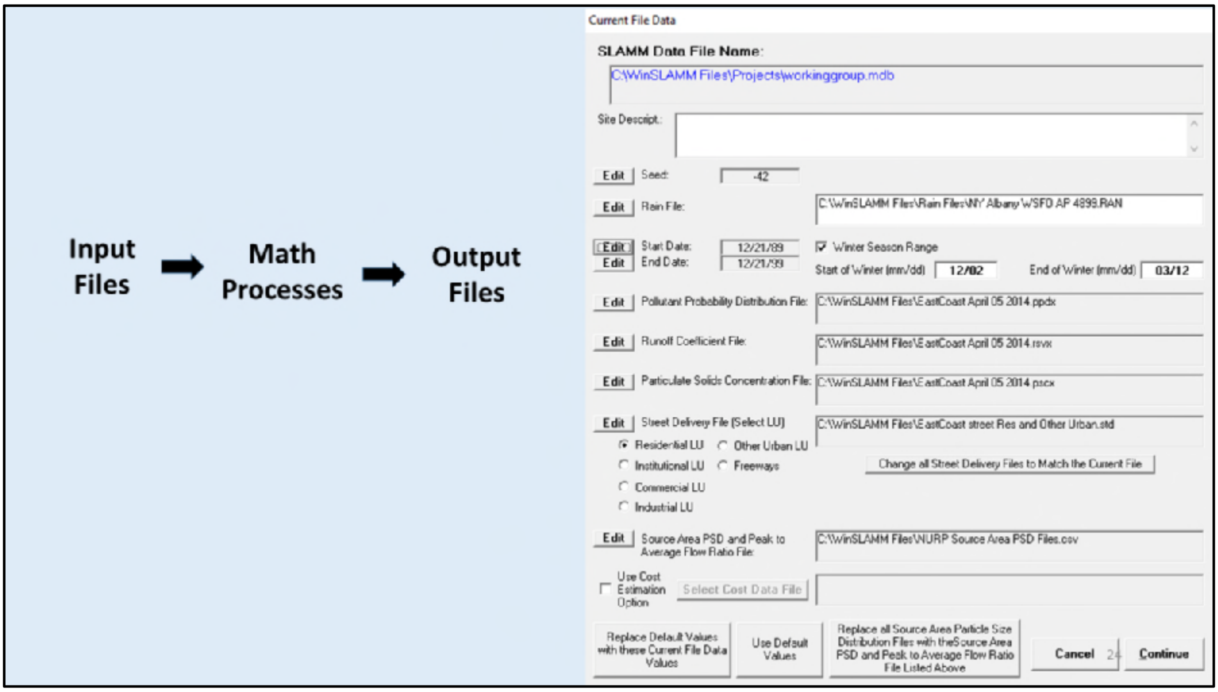
When discussing modeling we need to start with these caveats. Models are important representations that assist users in understanding processes at a landscape scale, but these are not definitive, and models cannot account for things like illicit discharges. Models cannot determine that someone is dumping oil in a catch basin, but can describe what happens if the land area is mostly parking lots, driveways, etc.



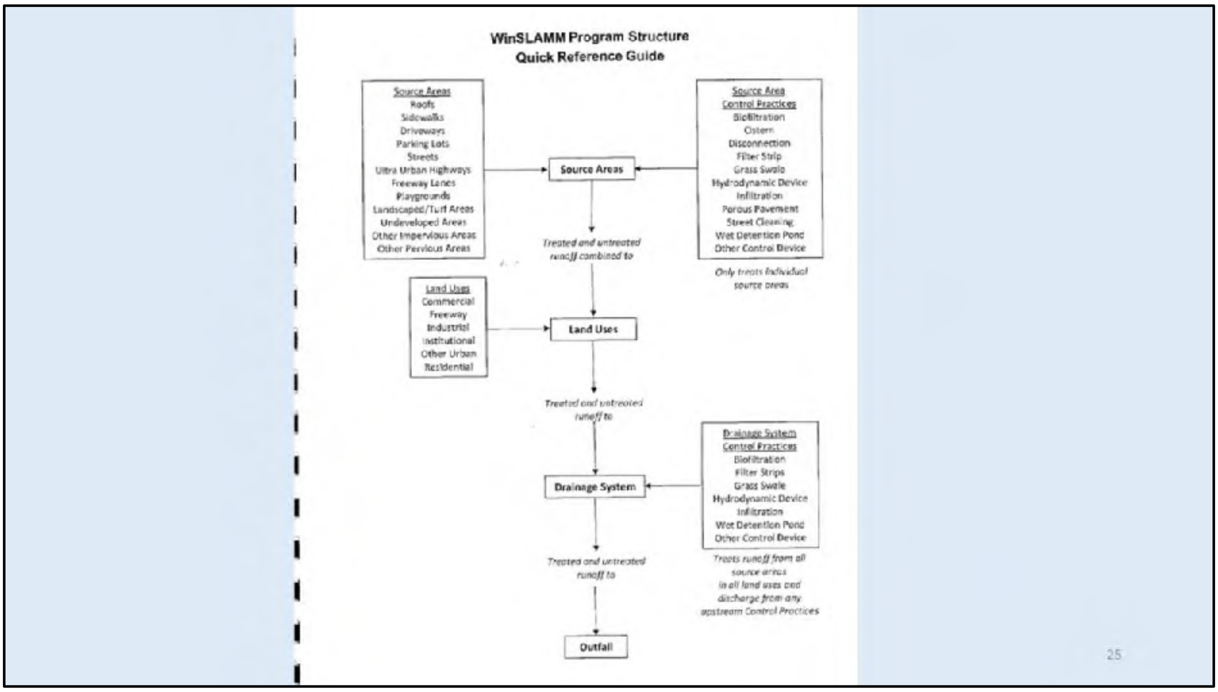
This is our original sewershed, delineated in the white line, take note of the aerial imagery and the land use that we see in the watershed. This land use is classified as “Suburban Residential”



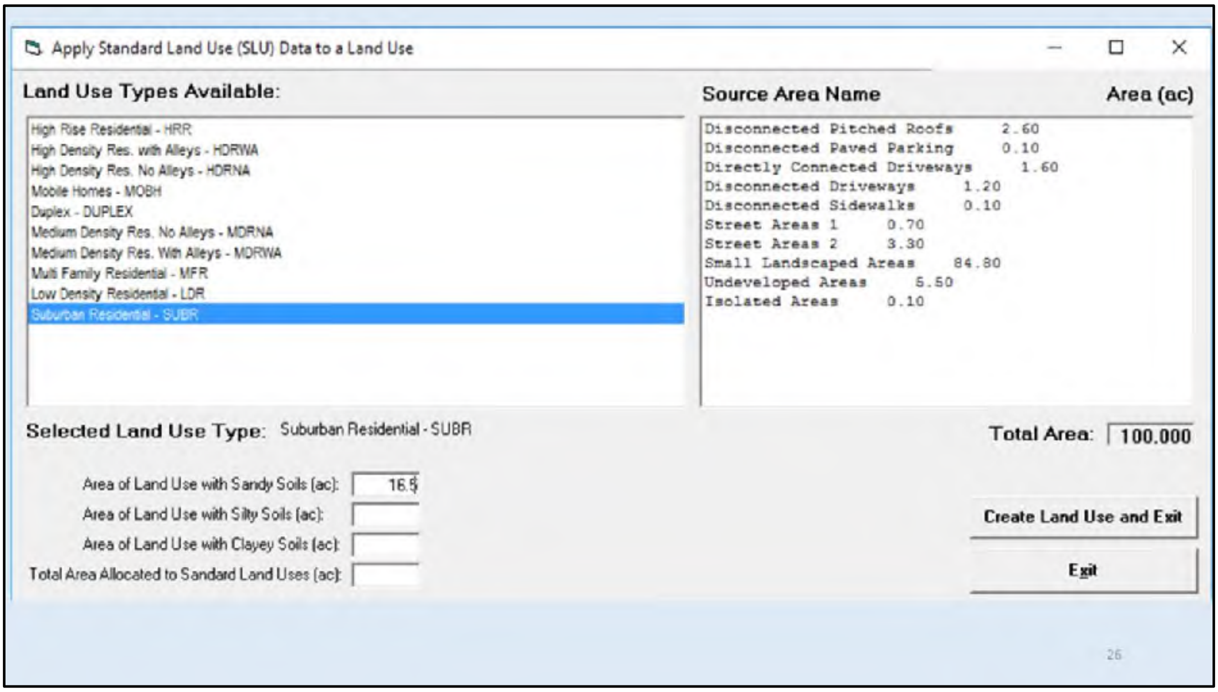
This is a visual representation of the model. The purple box labeled “Suburban Residential” is the land use area, this is connected to our Catch Basins, where stormwater then enters the pipes (“DS Pipe #1), and makes its way to the outfall. The inputs will be elaborated on in subsequent slides.



These are the input data files for the WinSLAMM model. They include precipitation (we have data until 2005), pollutant probability, runoff coefficient, particulate solids, 6 different files for source areas, and peak to average flow ratios. These inputs have been calculated based on studies done by the USGS, and by members of PV Associates, and they are calculated for the northeast generally, and precipitation data comes from Albany Airport.

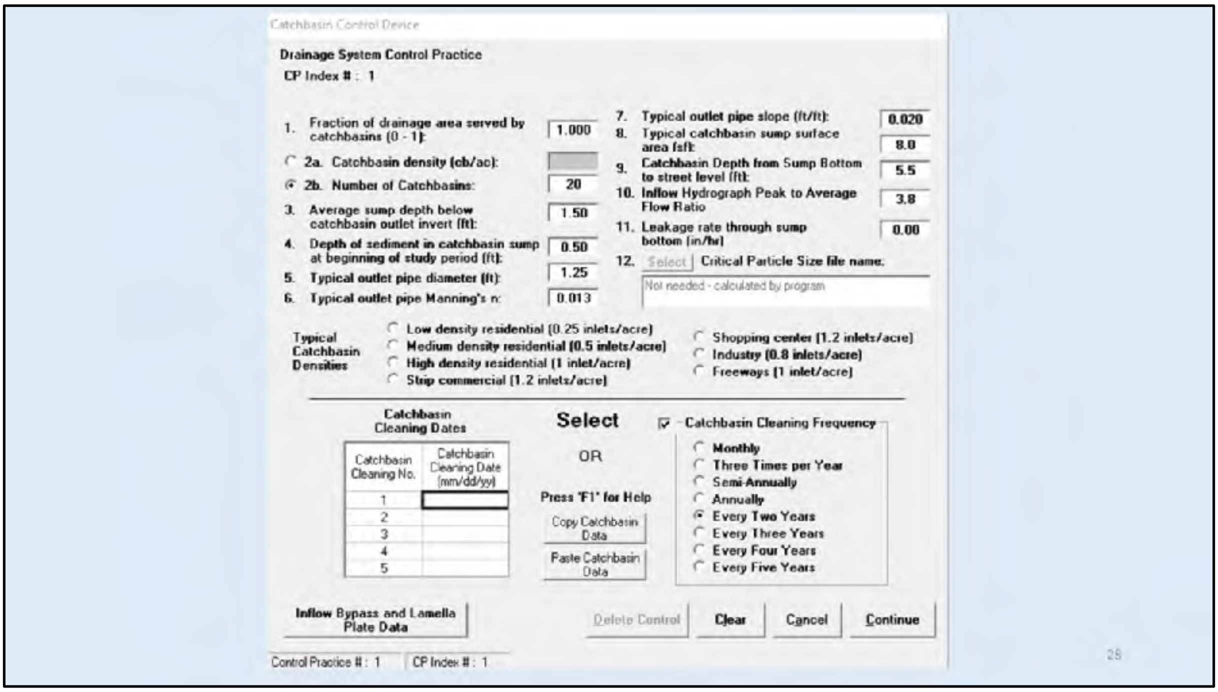


This is the WinSLAMM flowchart of the various source areas and land uses, which contribute to the drainage system, and ultimately result in the outputs at the outfall

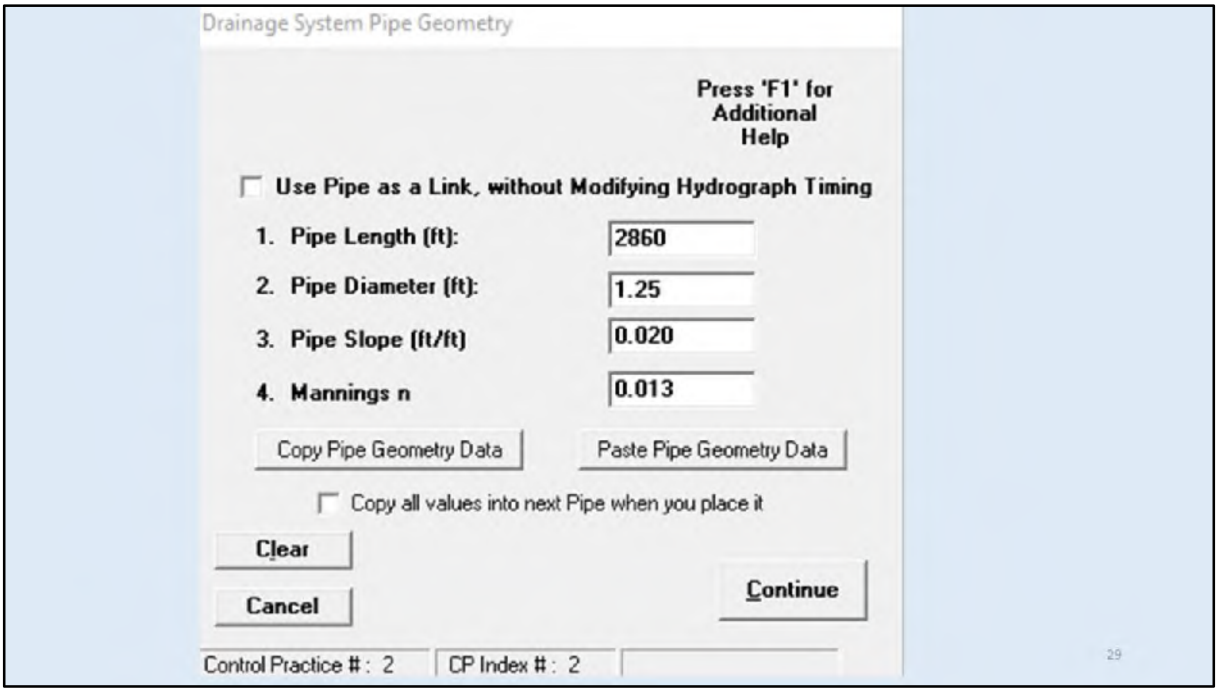


These are the generalized land use types with source areas (roofs, parking, undeveloped areas, etc.) attributes described. And the soil texture taken from the SSRGO database. In this sewershed the entire 16.5 acres are on sandy soils.

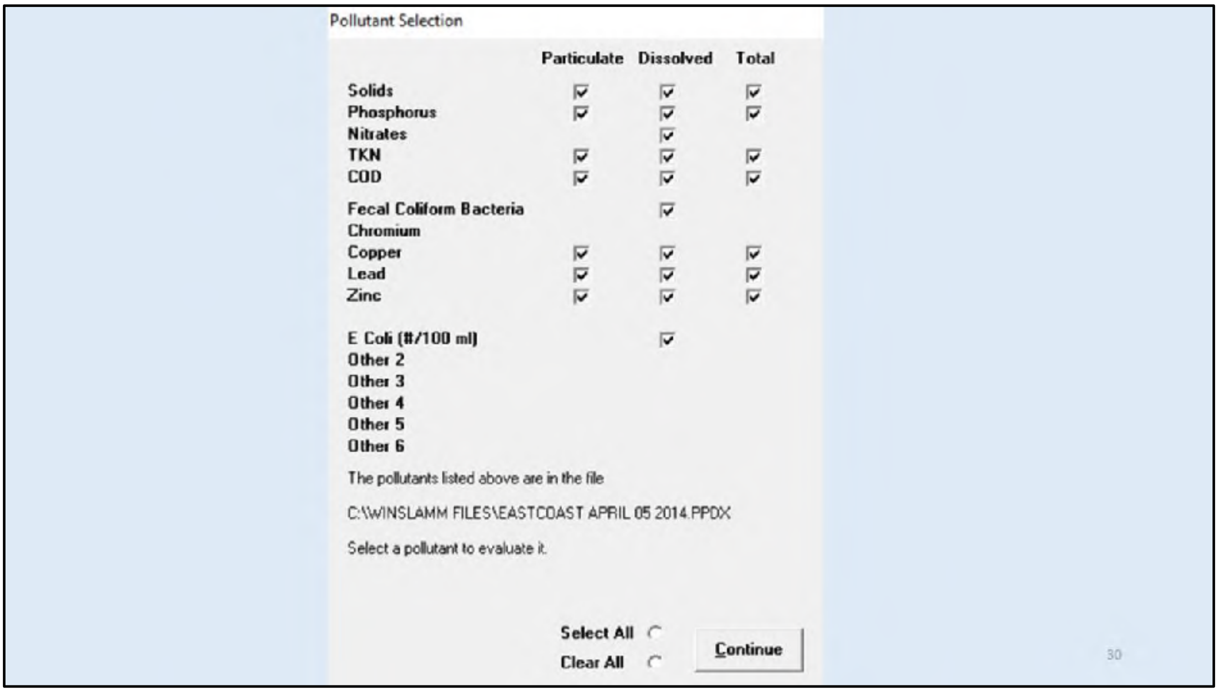
This is an example of digitization that can be done to focus on describing the area and attributes of the source areas within the sewershed. In most cases the generalized parameters and source area size will be “good enough”, as this method of digitization is time consuming and inefficient



This is the input file for Catch Basin attributes. In this area we know that there are 20 catch basins, and that the entire area is served by the catch basins (this is because our delineation method is focused on the area contributing runoff to the catch basins). Note that cleaning frequency and pipe attributes are among some of the inputs that can be described here.



This is the input describing the pipe attributes once stormwater enters a catch basin. The pipe length is simply the sum of the pipes connecting the system to the outfall, the pipe diameter is averaged based on information we have from system mapping, Manning's number can be derived from the pipe type, and the slope is left at 0.020, which is a default model value.



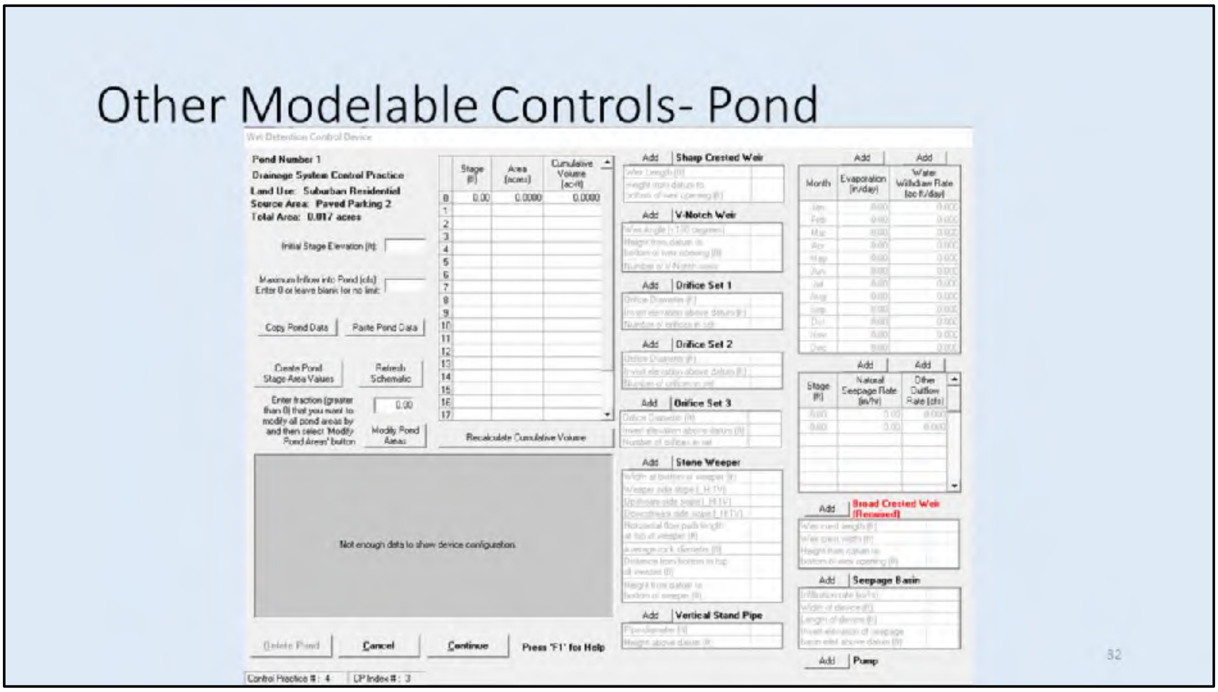
This is the file where one can select the pollutants they are interested in. For this simulation all possible pollutants were calculated in the output

Freeway Street Delivery file name: C:\WinSLAMM Files\EastCoast Freeway.std
Pollutant Relative Concentration file name: C:\WinSLAMM Files\EastCoast April 05 2014.ppdx
Start of Winter Season: 12/02 End of Winter Season: 03/12
Model Run Start Date: 12/21/89 Model Run End Date: 12/21/99
Date of run: 01-11-2018 Time of run: 15:52:52
Total Area Modeled (acres): 16.500
Years in Model Run: 9.99

	Runoff Volume (cu ft)	Percent Runoff Volume Reduction	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Total of all Land Uses without Controls:	919591	-	215.3	12360	-
Outfall Total with Controls:	919592	0.00%	136.0	7809	36.82%
Annualized Total After Outfall Controls:	92060			781.7	

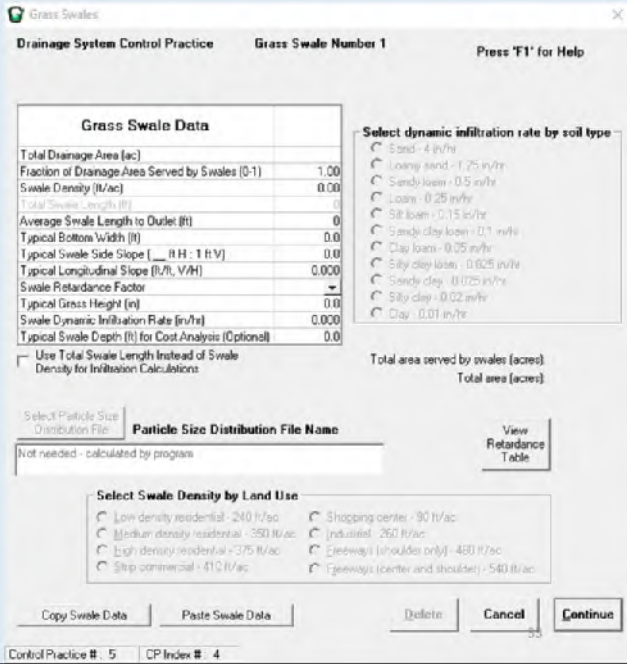
Pollutant	Concentration - No Controls	Concentration - With Controls	Conc. Units	Pollutant Yield No Controls	Pollutant Yield With Controls	Pol. Yield Units	Percent Reduction
Particulate Solids	215.3	136.0	mg/L	12360	7809	lbs	36.82 %
Filterable Solids	428.0	0	mg/L	24570	0	lbs	100.00 %
Total Solids	643.3	136.0	mg/L	36930	7809	lbs	78.86 %
Particulate Phosphorus	0.4042	0	mg/L	23.20	0	lbs	100.00 %
Filterable Phosphorus	0.1684	0	mg/L	9.670	0	lbs	100.00 %
Total Phosphorus	0.5726	0	mg/L	32.87	0	lbs	100.00 %
Nitrate	0.7297	0	mg/L	41.89	0	lbs	100.00 %
Particulate TKN	1.394	0	mg/L	80.04	0	lbs	100.00 %
Filterable TKN	0.5980	0	mg/L	34.33	0	lbs	100.00 %
Total TKN	1.992	0	mg/L	114.4	0	lbs	100.00 %
Particulate Chemical Oxygen D	52.90	0	mg/L	3037	0	lbs	100.00 %
Filterable Chemical Oxygen De	21.58	0	mg/L	1239	0	lbs	100.00 %
Total Chemical Oxygen Demand	74.49	0	mg/L	4276	0	lbs	100.00 %
Fecal Coliform Bacteria	239514	0	#/100 ml	6.233E+13	0	Count	100.00 %
Particulate Copper	23.53	0	ug/L	1.351	0	lbs	100.00 %
Filterable Copper	19.13	0	ug/L	1.098	0	lbs	100.00 %
Total Copper	42.66	0	ug/L	2.449	0	lbs	100.00 %
Particulate Lead	61.39	0	ug/L	3.524	0	lbs	100.00 %
Filterable Lead	5.149	0	ug/L	0.2956	0	lbs	100.00 %
Total Lead	66.54	0	ug/L	3.820	0	lbs	100.00 %
Particulate Zinc	85.76	0	ug/L	4.923	0	lbs	100.00 %
Filterable Zinc	57.24	0	ug/L	3.286	0	lbs	100.00 %
Total Zinc	143.0	0	ug/L	8.210	0	lbs	100.00 %
Filterable E Coli	3465	0	#/100 ml	9.016E+11	0	Count	100.00 %

This is the general model output text file. The general attributes are at the top of the page. The model run was simulated for a 10 year period. Note the pollutants modeled, and we can see the pollutant yield at the outfall with the controls (Catch Basins in this case) and without the controls.



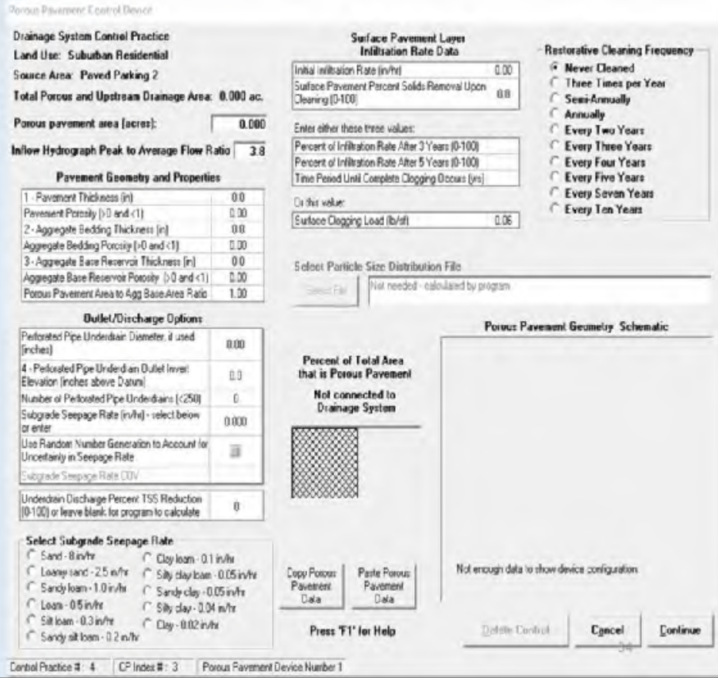
This slide and the next 2 are example input forms for other PCSMPs that can be modeled. Included are ponds, grassy swales, and porous pavement. These PCSMPs can be added if they are actually in the field, or added in a computer simulation to achieve a relative understanding of how pollutants, and discharge would be impacted if these controls were included in the system. Again, these are model outputs meant to provide a general understanding of these systems, but field studies are best at documenting the effectiveness and efficiency of any control practice.

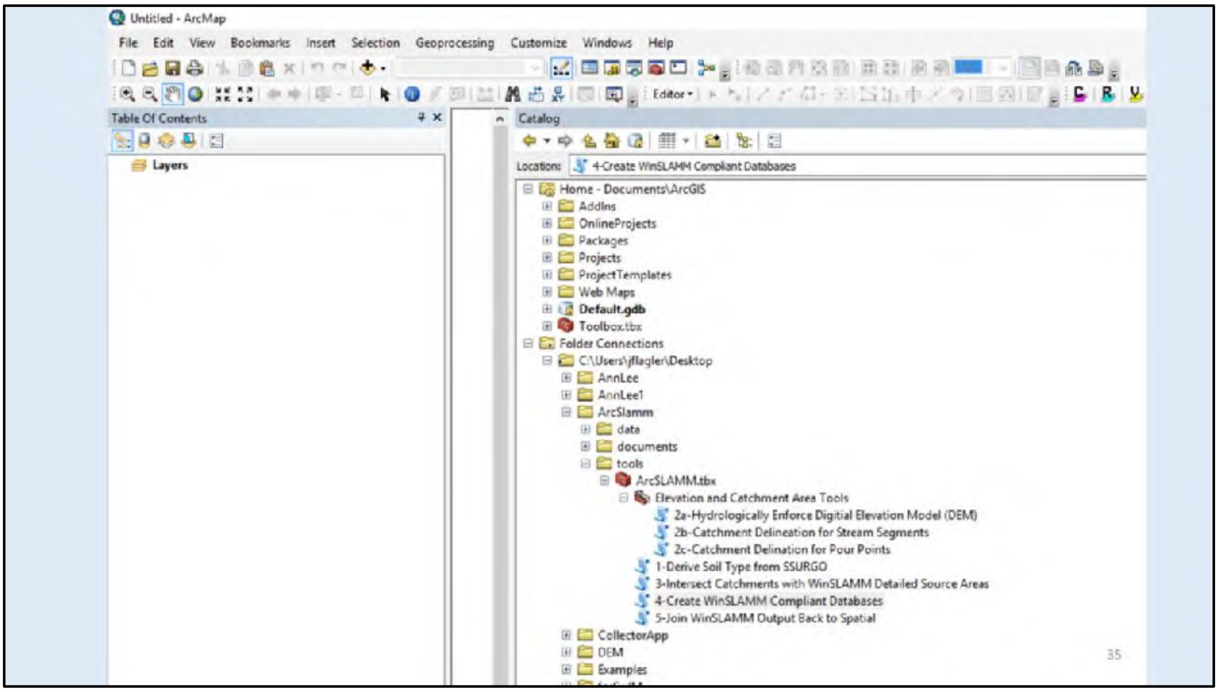
Swale



Grass Swales
Drainage System Control Practice
Grass Swale Number 1
Press 'F1' for Help
Grass Swale Data
Total Drainage Area (ac)
Fraction of Drainage Area Served by Swales (0-1) 1.00
Swale Density (ft/ac) 0.00
Total Swale Length (ft) 0
Average Swale Length to Outlet (ft) 0
Typical Bottom Width (ft) 0.0
Typical Swale Side Slope (__ ft H : 1 ft V) 0.0
Typical Longitudinal Slope (ft/ft, V/H) 0.000
Swale Retardance Factor
Typical Grass Height (in) 0.0
Swale Dynamic Infiltration Rate (in/hr) 0.000
Typical Swale Depth (ft) for Cost Analysis (Optional) 0.0
Use Total Swale Length Instead of Swale Density for Infiltration Calculations
Select dynamic infiltration rate by soil type
Sand - 4 in/hr
Loamy sand - 1.25 in/hr
Sandy loam - 0.5 in/hr
Loam - 0.25 in/hr
Silt loam - 0.15 in/hr
Sandy clay loam - 0.1 in/hr
Clay loam - 0.05 in/hr
Silty clay loam - 0.025 in/hr
Sandy clay - 0.025 in/hr
Silty clay - 0.02 in/hr
Clay - 0.01 in/hr
Total area served by swales (acres)
Total area (acres)
Select Particle Size Distribution File
Particle Size Distribution File Name
Not needed - calculated by program
View Retardance Table
Select Swale Density by Land Use
Low density residential - 240 ft/ac
Medium density residential - 350 ft/ac
High density residential - 375 ft/ac
Strip commercial - 410 ft/ac
Shopping center - 90 ft/ac
Industrial - 260 ft/ac
Freeways (shoulder only) - 480 ft/ac
Freeways (center and shoulder) - 540 ft/ac
Copy Swale Data
Paste Swale Data
Delete
Cancel
Continue
Control Practice # : 5
CP Index # : 4

Porous Pavement





ArcSLAMM software/toolbox for use of WinSLAMM in ESRI’s ArcGIS