SLAMM – GIS Development Model

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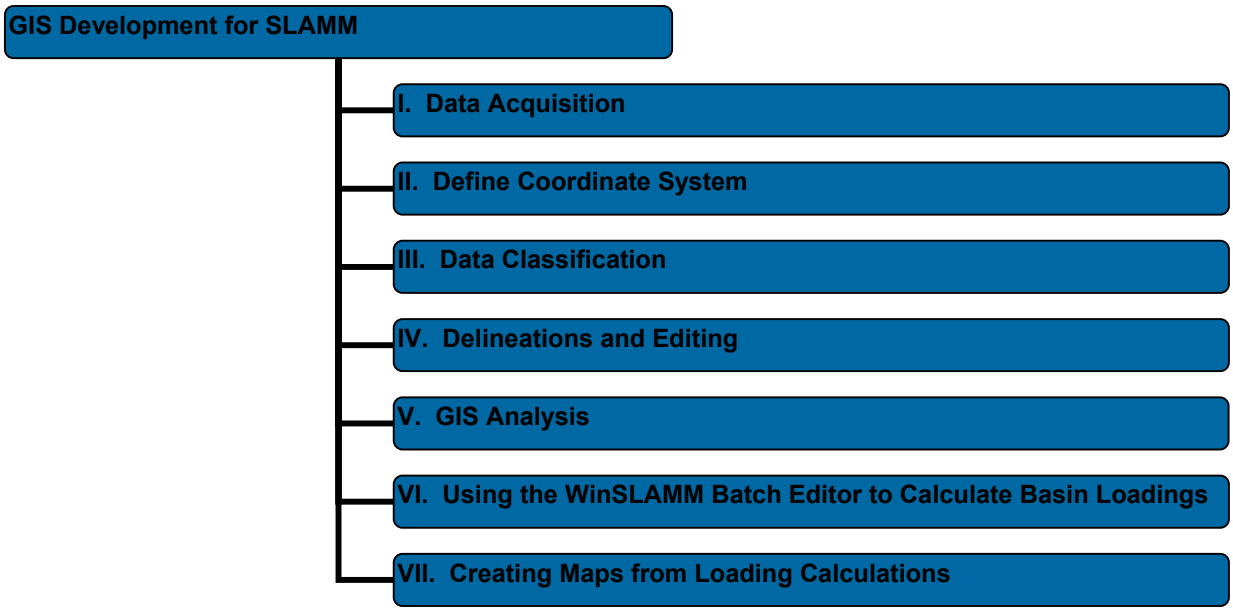
Introduction

GIS (geographic information systems) is an integral part of the SLAMM process for analyzing City-wide loads. The use of both graphical and tabular data helps to define the drainage characteristics that apply to the study area. The resulting analysis produces a tabular spreadsheet that can be incorporated into the SLAMM model.

There are several stages involved in developing a GIS model for SLAMM. This report describes these stages and is based on the use of ESRI's ArcGIS platform and file formats. These file formats may include shapefiles, ArcInfo coverage, geodatabases, and CAD.



I. DATA ACQUISITION

A variety of geographic data sets must be obtained to utilize the analytical capabilities of GIS. Most data comes from multiple sources that have to be identified prior to acquisition. Typically, local SLAMM studies will require data from municipal or county level agencies. These could include land information offices, planning departments, zoning departments, and public works. Regional SLAMM studies more commonly utilize county, state, and federal data.

Data sources should be identified by data extent and accuracy. In other words, land use data may be available from a municipal source and a state source. The municipal land use data may be classified at a parcel-based scale and the state land use data may be classified at a less accurate scale. It is preferable to obtain the municipal-based land use rather than the state based land use. The extent of the land use data is also important. The municipal based data may have to be combined with the state based data to get the most accurate information and coverage of the study area.

It is also important to obtain geographic data sets that cover the extent of the project limits or beyond. Otherwise there may be holes in that data that will need to be filled in, which can be time consuming.

Geographic Data Sets

The following is a preferred list of data you must acquire. Not all data will be available digitally or as GIS information. In these instances, some editing may be required to get the data into these formats.

Graphical layer	Tabular	Source
Parcels (polygon)	Attributes with owner information	Municipal or County agency
Land use (polygon)	Attributes with land use classifications	Municipal or County agency
Soils (polygon)	Attributes with soil type, hydrologic soil unit	Municipal, County, or Federal agency (NRCS)
Drainage basins (line or polygon)	Attributes with unique drainage basin Id's	Municipal or County agency
Surface water (line)	Attributes with water type	Municipal or County agency
Storm sewer (line)	Attributes with pipe sizes	Municipal agency
Municipal Limits (line or polygon)	Attributes with municipal id	Municipal or County agency
Topographic Contours (line)	Attributes with elevations	Municipal or County agency
BMP Map schedule (line or polygon)	Attributes with scheduled BMP practices	Municipal agency
Roadside Drainage (line or polygon)	Attributes identifying drainage types	Municipal agency
Digital Air Photos (Ortho-rectified)	None	Municipal, County, State, or other source

Additional Data Editing

If not all of these datasets are readily available, it may be necessary to create or modify existing datasets. This is covered in step 4.

II. DEFINING COORDINATE SYSTEM AND PROJECT LIMITS

Once the data for the project has been obtained, you must identify the common coordinate system the data will reside in. Some data may come with defined coordinate projection files. Since ArcGIS can work with multiple file formats it is important to determine if the files received contain the proper coordinate information.

For example, if shapefiles were acquired, a .prj file extension would accompany the shapefile. Below is a table that lists the type of coordinate projection files that would accompany an example data set called SLAMM. If a projection file does not exist, define a coordinate projection for the file.

ArcGIS file type	Associated files	Coordinate projection file
Shapefile	Slamm.shp, .shx, .dbf	.prj (eg. Slamm.prj)
ArcInfo coverage	Slamm and Info folders – containing multiple files	A prj.adf file will reside in the Slamm folder
Geodatabase	Slamm.mdb	See properties list
CAD	Slamm.dxf	See properties list

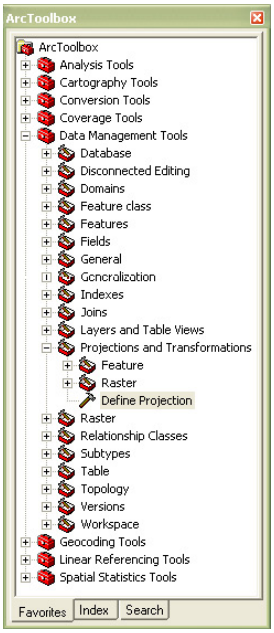
**coordinate information for geodatabase and CAD formats will show up in the files properties listing in ArcGIS – if present.*

Some files may contain different coordinate systems. In these instances it's important to determine the most logical coordinate system to use as the base coordinates. This may require input from the client. If the study area covers multiple counties, a state plane coordinate system may be preferred to a county coordinate system in order to maintain a seamless map environment.

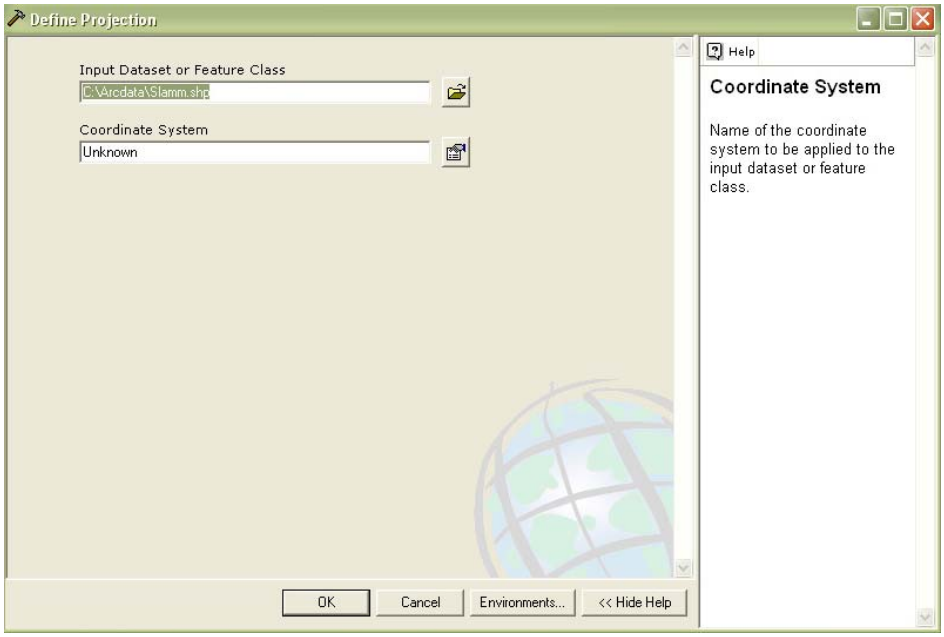
Assigning Coordinate Projection files

If no coordinate projection is associated with the data, it will be necessary to define the coordinate system for the data that has been acquired.

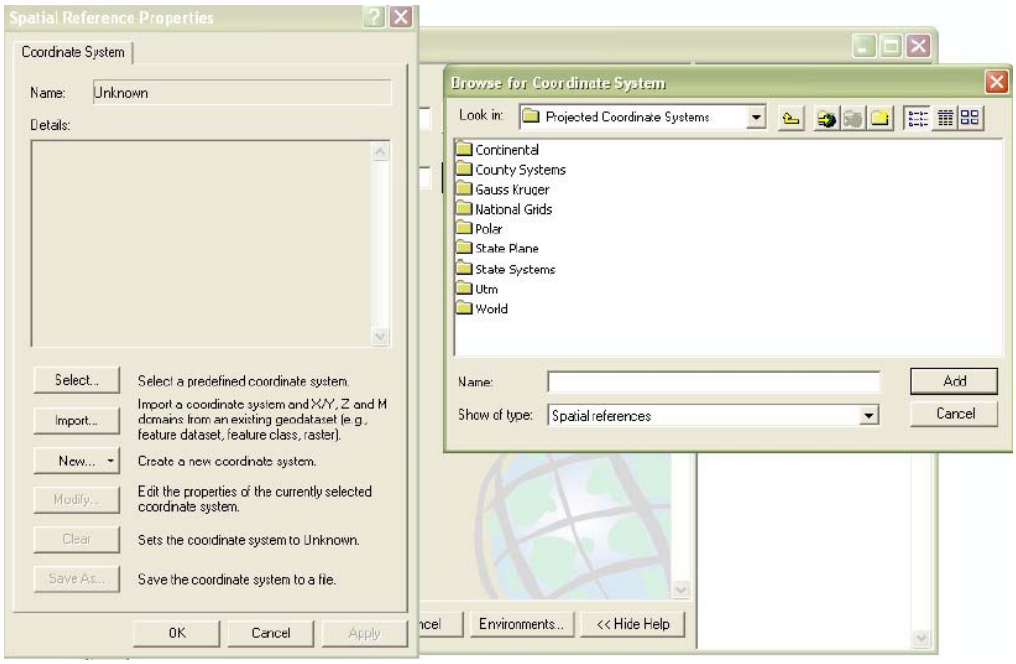
1) Open the ArcToolbox module of ArcGIS and select from Data Management Tools. Next select Projections and Transformations - select the Define Projection tool *(as illustrated below)*:



2) Select the browse button beside Dataset or Feature Class to assign coordinates. Select Coordinate System button to associate a coordinate projection.



3) Browse to Coordinate System using the "Select" button. Locate the coordinate system to be used for the base mapping environment.



III. DATA CLASSIFICATION

The tabular portion of the data must be classified properly for use with the SLAMM model. The datasets that may require re-classification to meet these needs include: land use, soils, drainage basins, BMP's, and roadside drainage.

For example, a land use dataset received from a local municipality may need to have residential properties re-classified into low density (ldr), medium density (mdr), and high density residential (hdr) land uses to conform to the SLAMM standard land use files. Non-residential properties may require changes to SLAMM standard land use classifications such as strip commercial, light and medium industrial, multi-family, office buildings, parking lots, and so on.

Similarly, soils data received from the NRCS may need a hydrologic soil unit assigned to each soil type. This would involve creating a new field in the soils database and populating that field with the appropriate hydrologic soil value (A, B, C, or D).

Drainage basins need to be coded with a unique identifier that will make each record distinguishable in the SLAMM model.

Best Management Practices (BMP's) may be identified by management type: No BMP, Street sweeping, Catch Basin cleaning, etc.

Roadside drainage could be identified as curb and gutter, swale, or undeveloped.

An example SLAMM classification system:

SLAMM Standard Land Use File Names

Starting Letter Based On Land Use

A	LDR	Low Density Residential
B	MDR	Medium Density Residential
C	HDR	High Density Residential
D	MFR	Multifamily Residential
H2	WTR	Water
L	MFR50	Multifamily Residential with 50% Rooftop Connection
M	MFR90	Multifamily Residential with 90% Rooftop Connection
N	STR	Strip Mall Commercial
O	SHP	Shopping Center Commercial
OP	OPN	Open Parcels (parcels slated for future development)
P	LIN	Light Industrial
Q	MIN	Medium Industrial
R	INS	Institutional (Office and Schools)
		Office Buildings (use Institutional unless otherwise indicated)
T	PRK	Parks (recreational uses eg. tennis, softball diamonds)
U	CEM	Cemetery (gives higher loads)
V	FRE	Freeway

Starting Letter Based On Land Use cont.

CEM	CEM1	Cemetery as defined by WinSLAMM (gives lower loads)
UDV	UDV	Undeveloped (use for nature parks, etc.) - values for swale and no bmp
X	HDR50	HDR w/ 50% of Rooftops Connected
XX	HDR90	HDR w/ 90% of Rooftops Connected
Y	LDR50	LDR w/ 50% of Rooftops Connected
YY	LDR90	LDR w/ 90% of Rooftops Connected
Z	MDR50	MDR w/ 50% of Rooftops Connected
ZZ	MDR90	MDR w/ 90% of Rooftops Connected

Second Letter of File Name based on Soil Type

A	A	A Soils (Sandy Soils)
B	B	B Soils (Silty Soils)
C	CD	C/D Soils (Clayey)

Third Letter of File Name Based on Drainage Condition

g	CG	Curb and Gutter Drainage
w	SW	Swaled Drainage

Fourth and Fifth Characters are the Management Type

01	NoBMP	No BMP
02	S1	Street sweeping 1/week
03	S2	Street sweeping every 2 weeks
04	S4	Street sweeping every 4 weeks
05	S12	Street sweeping every 12 weeks
06	C1	Catch Basin Cleaning 1/year
07	C2	Catch Basin Cleaning 2/year
08	S1C1	Sweeping 1/week, Catch Basin 1/year
09	S1C2	Sweeping 1/week, Catch Basin 2/year
10	S2C1	Sweeping every 2 weeks, Catch Basin 1/year
11	S2C2	Sweeping every 2 weeks, Catch Basin 2/year
12	S4C1	Sweeping every 4 weeks, Catch Basin 1/year
13	S4C2	Sweeping every 4 weeks, Catch Basin 2/year
14	S12C1	Sweeping every 12 weeks, Catch Basin 1/year
15	S12C2	Sweeping every 12 weeks, Catch Basin 2/year

Example file name

BAg07.dat - Medium Density Residential, A type soil, Curb and Gutter, Catch Basin cleaning 2/year (no street sweeping).

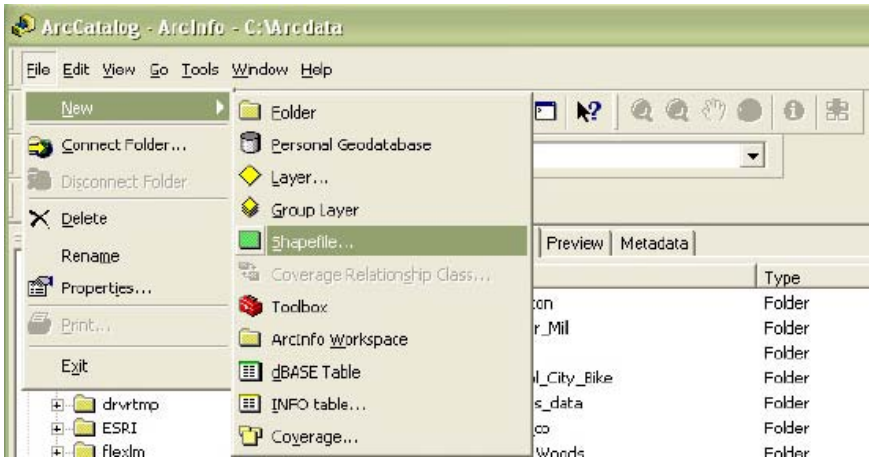
IV. DELINEATIONS AND EDITING

Drainage basins, BMP's, and roadside drainage are often unavailable in a digital format. As a result, it will be necessary to delineate or edit the data to complete the GIS model. By utilizing the other datasets acquired in Part I. Data Acquistion, these layers can be completed.

For example, you may need to create a new layer to represent drainage basins that were not available digitally. Use topographic contours, storm sewer, and surface water data as references in ArcMap to delineate drainage basins and roadside drainage layers. Consultation with the client may be required to identify BMP locations and schedules.

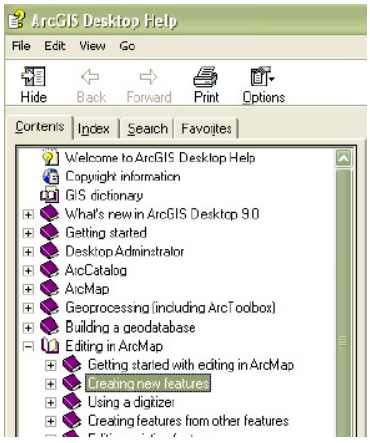
To create drainage basins, BMP, or roadside drainage basin layers, perform the following steps:

1) Create new layers (i.e. Basins.shp) using the ArcCatalog module of ArcGIS



It is important to assign a coordinate system to any new layers created with ArcCatalog *(See steps 1-3 under II. Defining Coordinate Systems)*

2) Once the new layer is created, editing can begin using the ArcMap module of ArcGIS. *(See ArcMap's help system for editing new layers)*



Upon completion of the data editing, perform a quick review on all graphical and tabular datasets prior to analysis.

- Graphical: All datasets should be topologically updated – using the BUILD or CLEAN function within ArcToolbox.
- Graphical: All datasets should geographically extend to the project study limits
- Tabular: All datasets should be populated with the appropriate SLAMM codes

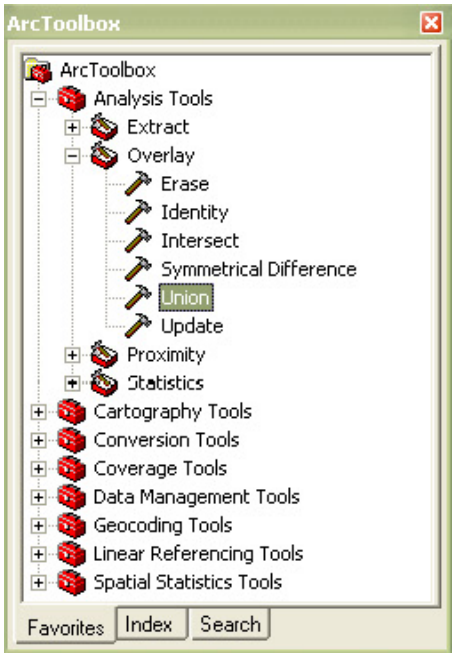
V. GIS ANALYSIS – DATA OVERLAY

When all datasets have been updated, overlay them with one another to create the final SLAMM definitions. The datasets to overlay will be:

- Land Use (with SLAMM land use classifications)
- Soils (with Hydrologic soil values)
- Drainage Basins (with unique drainage basin Id's)
- BMP map (with management type)
- Roadside Drainage (with condition type)

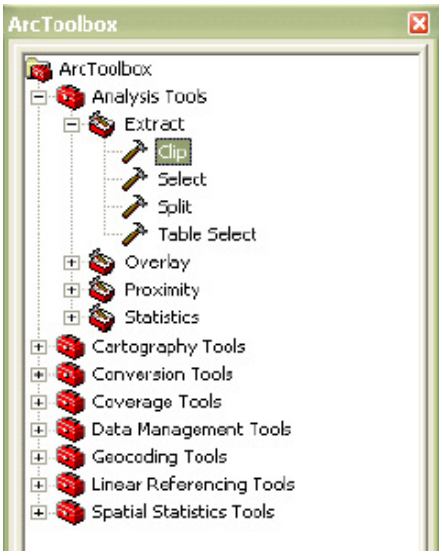
**If a municipal boundary represents the study limits, this dataset may be required to clip all of the other datasets to its boundary.*

All of the datasets should be graphically represented as polygon features. Use the **Union** tool in ArcToolbox to overlay the polygon features into one common dataset. The resulting dataset will contain all of the SLAMM definitions for each record in the database. (*The illustration below shows the overlay function to use – Union)*



Once the datasets have been "Union'd", check the database to make sure a unique SLAMM value has been assigned to each record and make sure there are no non-unique duplicate records. If there are any missing SLAMM values in the database they will have to be updated.

The result of the union function may create a dataset that extends beyond the study limits. If this is the case, clip the dataset using a study limits (e.g. Municipal limits) layer. Use the CLIP function in ArcToolbox :



The resulting shapefile database might look something like the example below:

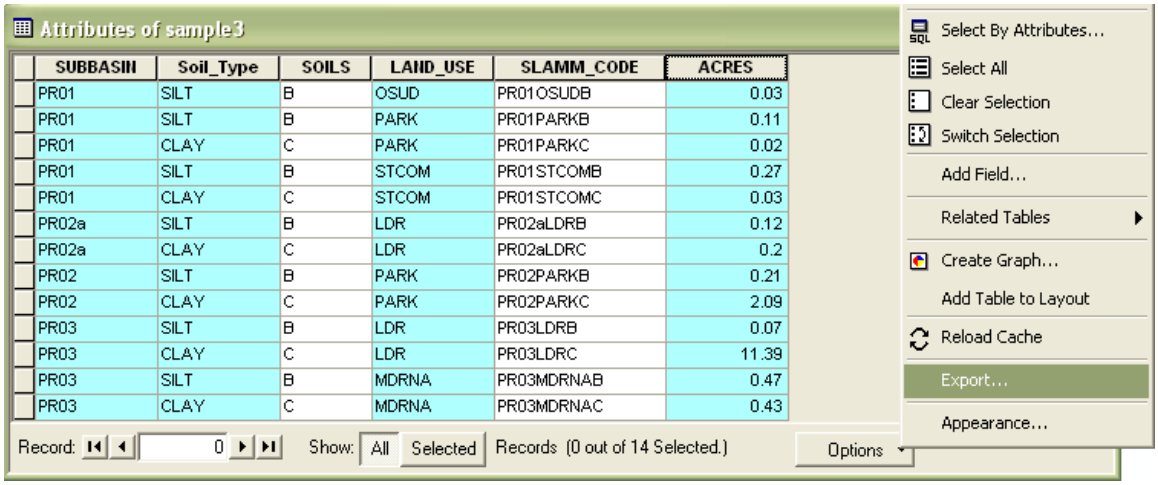
Basin ID	Land Use	Hydrologic Soil Value	Soil Type	Roadside Drainage	BMP Type	Area (acres)
PR01	PARK	B	SILT	g	C1	0.7
PR01	PARK	C	CLAY	g	C1	0.8

Note: In some instances a Bio-filter may be associated with a particular Basin. If this is the case, perform a query on the shapefile for the associated Basin (i.e. Basin ID = 001). All records within this basin would receive a lower case “b” after the land use type (i.e. “PARK” would become “PARKb”). The database will need a final format change for use in the SLAMM model

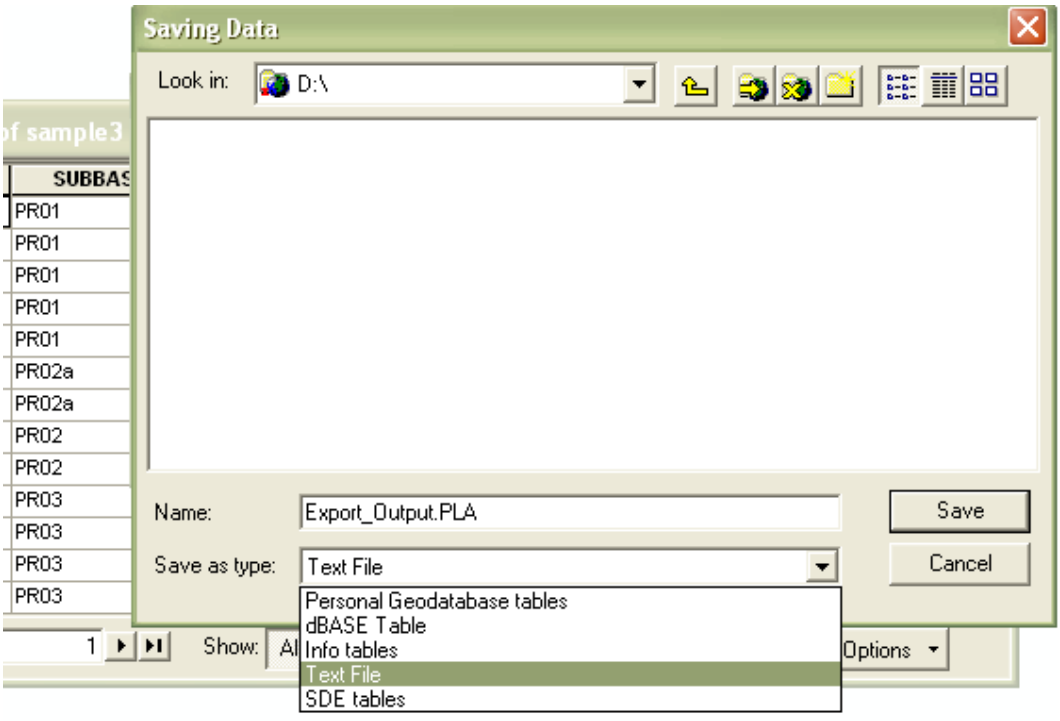
The sample below shows how the re-format would look in order to produce a SLAMM table with the minimal base conditions. Note: the drainage and bmp fields are not necessary for base conditions, however, these fields will be used when modeling for those conditions is necessary.

Basin ID	Land Use	Hydrologic Soil Value	Area (acres)	SLAMM Code
PR01	PARK	B	0.7	PR01PARKB

Once the database has been updated to the SLAMM Standard Land Use codes, **Export** the Subbasin, Soil_type, Land use, and acres fields, as highlighted in illustration, to a comma delimited format.



Select the text file format from the “Save as type” options.

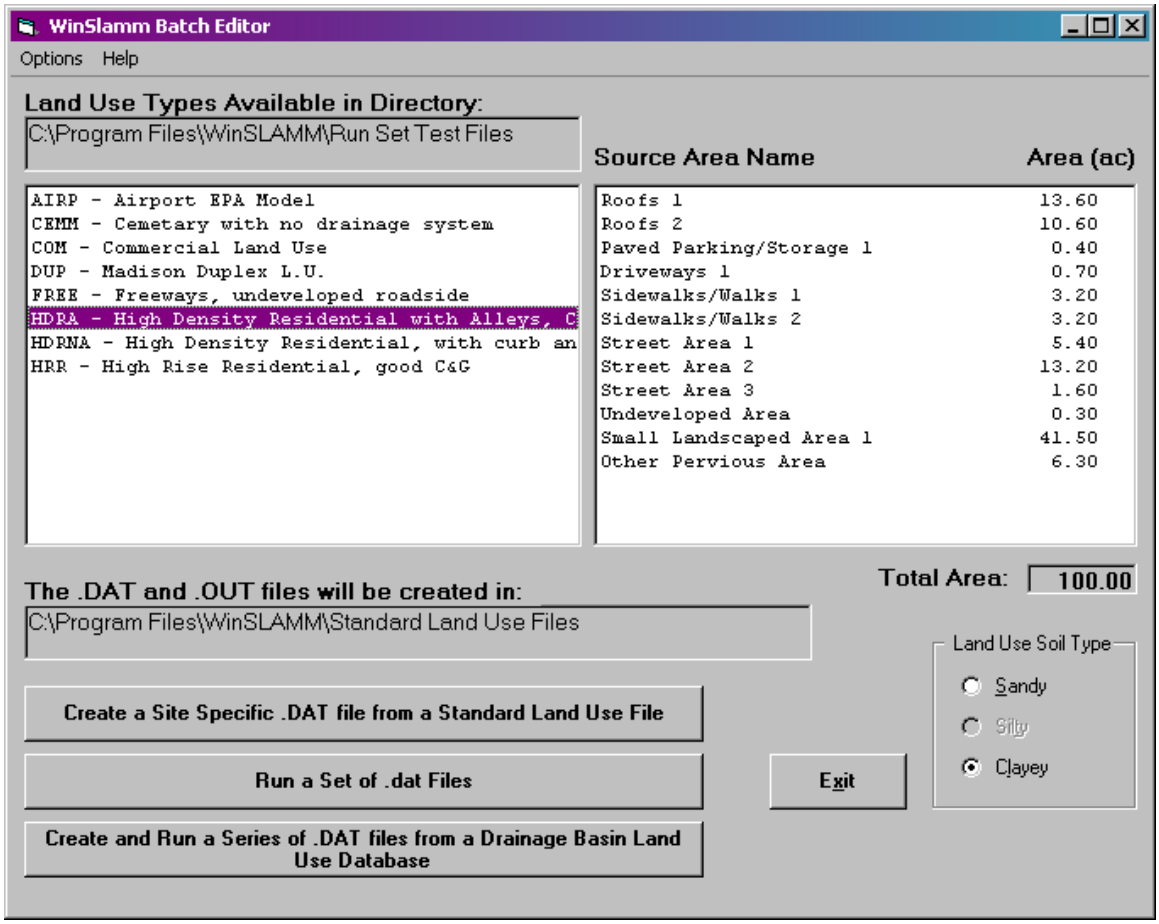


The file should be saved with a **.pla** extension rather than the standard .txt extension. The **.pla** file is then used in the SLAMM batch processor to evaluate all drainage basins from the database.

VI. USING THE WinSLAMM BATCH EDITOR TO CALCULATE BASIN LOADINGS

The batch processing subroutine for WinSLAMM serves two functions: 1) To allow a user to create a land-use specific WinSLAMM .DAT format files based upon Standard Land Use files, and 2) To allow the user to divide a large drainage basin into standard land use areas and then calculate the runoff volume, sediment load, and pollutant loads for each of the areas.

To run the batch processor in WinSLAMM, select “Run/Run Batch Editor” from the main menu list. Respond “Yes” to the query unless you need to save the currently loaded file. This places you in the WinSLAMM Batch Editor, shown below. Select the “Options” menu item from the batch editor, and select the directory paths for both the standard land use files and for where to save the output files.



The output from the batch editor process is a comma separated ASCII file that has the name [Planning Level Sub-Basin Description file name].CSV. The format of this file includes a header that lists total runoff (c.f.), particulate solids (lbs), and the loadings for the selected pollutants. The total runoff, total particulate solids, and total pollutant loadings for each sub-basin listed in the .pla file are then listed. This file can be imported

into an Excel spreadsheet where you can total the runoff values, particulates, and pollutant loadings using the spreadsheet.

The program calculates the ratio of the new area for each sub-basin divided by the Standard Land Use file area, and multiplies the following variables by this area ratio:

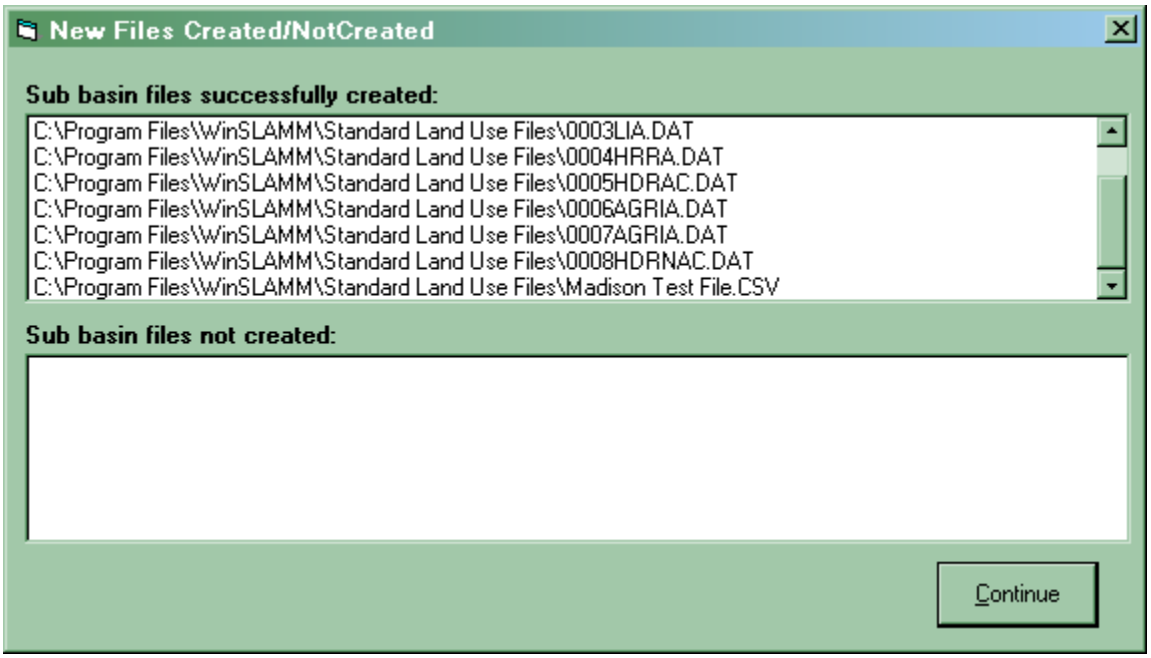
All Source Areas	
Area Served by the Infiltration Device	Infiltration Device Area
Porous Pavement Area	
Area Served by Detention Pond	Each Area corresponding Pond Stage
Area Served by the 'Other' Device	
Area Served by Catchbasins	Catchbasin Sump Volume
Biofilter Area (top and bottom areas)	

To create a batch output file, follow these steps:

1. Select the 'Create and Run a Series of .DAT Files from a Drainage Basin Land Use Data Base' button on the WinSLAMM Batch Editor.

2. Select the Planning Agency file that you want to use from the 'Select a Planning Agency Database File' dialog box. The file will have the extension '.PLA'. You can create planning agency files by selecting 'Planning File Editor' from the Options menu or as described above using a GIS program.

3. After selecting a .PLA file, the batch processor will run. After all files are created and have run, the 'New Files Created/Not Created' form will appear. If any file names appear in the 'Sub Basin Files not created' list box (shown below), review the listed files. Files will appear on the list if the .PLA file incorrectly lists a land use code or if a parameter file is not found in the path listed in the file.

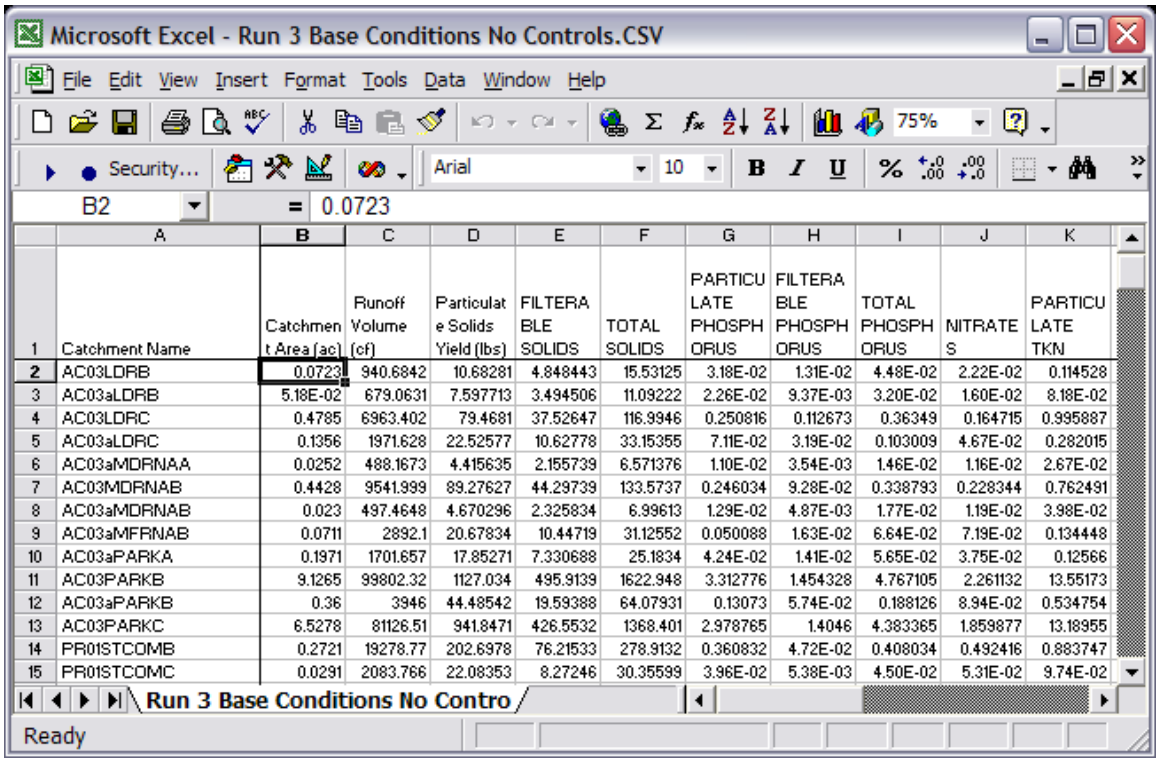


An example comma-separated-value output file for a batch processor model run is listed below. The first line of the output file is the header, which lists labels for each of the columns in the output file. The header will always include the catchment name, runoff volume (cu.ft.), and particulate solids yield (lbs) labels, and will also include any pollutants that were included in the analysis. The catchment name is a combination of the sub-basin number, the sub-basin land use descriptor, and the soil type (A - Sand, B - Silt, and C - Clay). For example, the Catchment Name 0001DUPC describes the output for sub-basin 0001, duplex land use, soil type C.

Example batch processor output:

Catchment Name,Catchment Area (ac),Runoff Volume, Particulate Solids Yield
0001DUPC,13.89, 431704.2 , 4269.431
0002AIRPC,45.45, 1210407 , 15575.52
0003HDRC,55.80, 1000304 , 8979.444
0004FREEC,71.50, 3414805 , 521680.7
0005HDRAC,91.45, 7129931 , 59899.82
0006AGRIA,2.10, 17229.63 , 72.24279
0007AGRIA,21.90, 172296.3 , 699.1801
0008HDRC,46.74, 7997329 , 71696.17

This file can be imported into Excel (as shown below using an example from another model run) for further analysis or imported into the GIS database for mapping purposes, as described in the next section.



	A	B	C	D	E	F	G	H	I	J	K
1	Catchment Name	Catchment Area (ac)	Runoff Volume (cf)	Particulate Solids Yield (lbs)	FILTERABLE SOLIDS	TOTAL SOLIDS	PARTICULATE PHOSPHORUS	FILTERABLE PHOSPHORUS	TOTAL PHOSPHORUS	NITRATES	PARTICULATE TKN
2	AC03LDRB	0.0723	940.6842	10.68281	4.848443	15.53125	3.18E-02	1.31E-02	4.48E-02	2.22E-02	0.114528
3	AC03aLDRB	5.18E-02	679.0631	7.597713	3.494506	11.09222	2.26E-02	9.37E-03	3.20E-02	1.60E-02	8.18E-02
4	AC03LDRC	0.4785	6963.402	79.4681	37.52647	116.9946	0.250816	0.112673	0.36349	0.164715	0.995887
5	AC03aLDRC	0.1356	1971.628	22.52577	10.62778	33.15355	7.11E-02	3.19E-02	0.103009	4.67E-02	0.282015
6	AC03aMDRNAA	0.0252	488.1673	4.415635	2.155739	6.571376	1.10E-02	3.54E-03	1.46E-02	1.16E-02	2.67E-02
7	AC03MDRNAB	0.4428	9541.999	89.27627	44.29739	133.5737	0.246034	9.28E-02	0.338793	0.228344	0.762491
8	AC03aMDRNAB	0.023	497.4648	4.670296	2.325834	6.99613	1.29E-02	4.87E-03	1.77E-02	1.19E-02	3.98E-02
9	AC03aMFRNAB	0.0711	2892.1	20.67834	10.44719	31.12552	0.050088	1.63E-02	6.64E-02	7.19E-02	0.134448
10	AC03aPARKA	0.1971	1701.657	17.85271	7.330688	25.1834	4.24E-02	1.41E-02	5.65E-02	3.75E-02	0.12566
11	AC03PARKB	9.1265	99802.32	1127.034	495.9139	1622.948	3.312776	1.454328	4.767105	2.261132	13.55173
12	AC03aPARKB	0.36	3946	44.48542	19.59388	64.07931	0.13073	5.74E-02	0.188126	8.94E-02	0.534754
13	AC03PARKC	6.5278	81126.51	941.8471	426.5532	1368.401	2.978765	1.4046	4.383365	1.859877	13.18955
14	PR01STCOMB	0.2721	19278.77	202.6978	76.21533	278.9132	0.360832	4.72E-02	0.408034	0.492416	0.883747
15	PR01STCOMC	0.0291	2083.766	22.08353	8.27246	30.35599	3.96E-02	5.38E-03	4.50E-02	5.31E-02	9.74E-02

VII. CREATING MAPS WITH LOADING CALCULATIONS

After loading calculations have been performed in the SLAMM model, the results can be linked back to the GIS database and mapped showing loading distribution.

Calculating loads per acre

One example of how the data can be presented on a map would be to show loadings in YIELDS/ACRE. Prior to joining the .CSV file (loadings table) with the GIS data, you may want to bring the .CSV file into Excel, or some other spreadsheet program, to calculate loadings per acre *(as shown in column E of the illustration).*

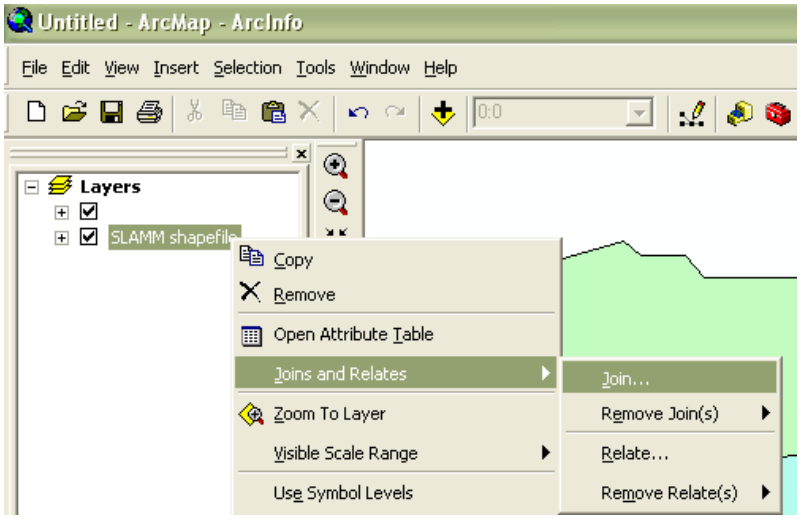
	A	B	C	D	E	F	G
1	Subbasin	Catchment Area (ac)	Runoff Volume (cf)	Particulate Solids Yield (lbs)	Yield per acre	FILTERABLE SOLIDS	TOTAL SOLIDS
2	PR01OSUDB	0.0251	175.7654	1.209843	48.2	1.470574	2.680416
3	PR01PARKB	0.1053	1149.915	13.13413	124.7	5.720133	18.85426
4	PR01PARKC	0.0207	261.3366	3.005724	145.2	1.374246	4.379971
5	PR01STCOMB	0.2721	19278.77	202.6978	744.9	76.21533	278.9132
6	PR01STCOMC	0.0291	2083.766	22.08353	758.9	8.27246	30.35599
7	PR02aLDRB	0.1244	1606.91	18.21367	146.4	8.300193	26.51387
8	PR02aLDRC	0.1988	2895.801	33.15463	166.8	15.60112	48.75575
9	PR02PARKB	0.212	2312.625	26.12287	123.2	11.4998	37.62267
10	PR02PARKC	2.086	25929.66	300.9043	144.2	136.3272	437.2316
11	PR03LDRB	6.90E-02	890.9761	10.25012	148.6	4.601761	14.85188
12	PR03LDRC	11.3893	165673.1	1892.278	166.1	893.0616	2785.34
13	PR03MDRNAB	0.4684	10095.11	94.33146	201.4	46.86229	141.1937
14	PR03MDRNAC	0.4289	10572.02	96.0756	224.0	48.97432	145.0499
15	PR03PARKB	4.946501	54094.77	611.0455	123.5	268.7978	879.8434

The resulting column will be used in ArcMap to symbolize the results.

Joining loading results

Add the final SLAMM shapefile into ArcMap and use the “Join” database tools as illustrated in the following steps:

1) Right-click the final SLAMM shapefile in the table of contents and select the Joins and Relates function – Join…

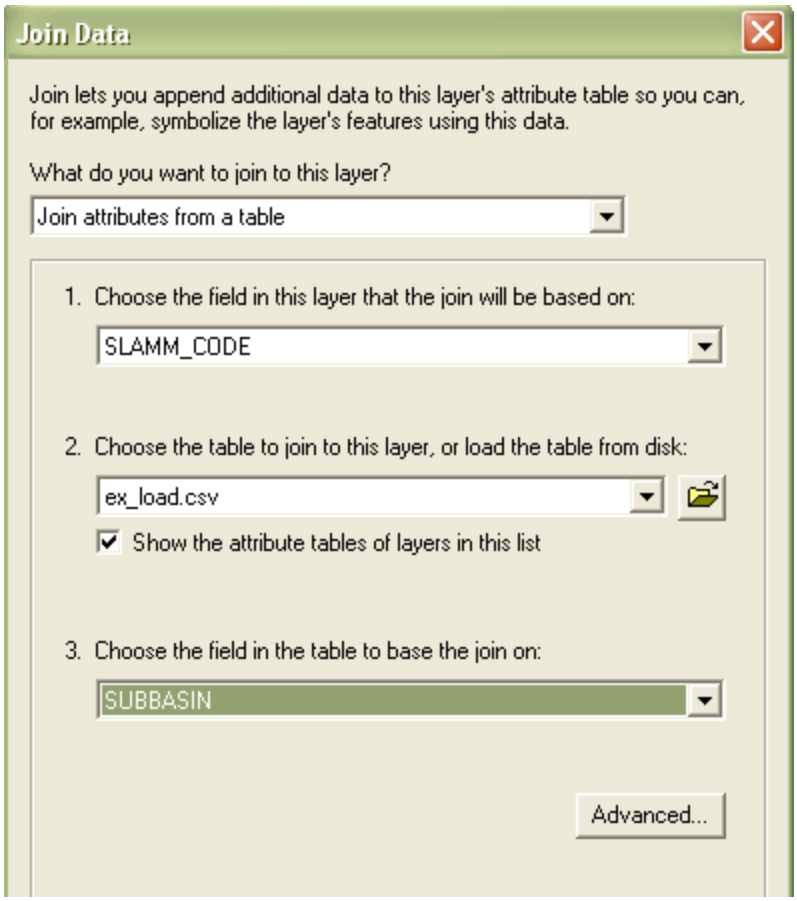


2) Follow the Join Data wizard steps:

--Step 1, select the SLAMM code field from the SLAMM shapefile database as the common link between the map and the loadings database. *(In the example shown, the combined basin, land use and soils field is called SLAMM_CODE)*

--Step 2, select the browse button to locate the .CSV loadings table that will be joined to the SLAMM shapefile. *(example, ex_load.csv)*

--Step 3, select the field from the loadings database that contains the common values that will join the two table together. *(example, SUBBASIN)*



Displaying loading results

Once the Join is complete, the SLAMM shapefile can be symbolized to show the YIELD/ACRE as a graduated symbol or unique value.

Symbolize the results by opening the properties for the SLAMM shapefile and modify the symbology based on the appropriate loadings fields. *(The illustration shows the subbasins color coded by graduated colors – represented as range values.)*