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INFLUENCE OF ELEVATION DATASET ON WATERSHED DELINEATION OF THREE CATCHMENTS IN MISSISSIPPI

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ABSTRACT: This paper investigates the effect of DEM resolution on the delineation of three catchments in Mississippi: Jourdan and Wolf river catchments (sub-basins of the Saint Louis Bay watershed in the Gulf coast) and Luxapalilla watershed. The paper also discusses the implications of different watershed segmentations on parameter values exported to HSPF. Two elevation datasets were used to delineate the Saint Louis Bay and Luxapalilla watersheds. EPA-USGS DEM 300 meter Resolution and EPA-NED 30 meter Resolution. Results showed that for flat areas (e.g., Jourdan river catchment in Saint Louis Bay) overland flow plane slope values estimated using the NED dataset are at least 190% and up to 1322 % smaller than those sub-basin slope values estimated using the USGS-EPA elevation data. Stream channel slope values using NED are up to 9 times smaller than those estimated using the USGS-EPA database. Results for Luxapallila and Wolf showed that slope values resulting of using the NED dataset are also different (50% in average) than those values calculated using the USGS-EPA dataset. For these two catchments, that are located in higher terrain and are less flat than Jourdan River catchment, NED-generated sub-basin slope values are bigger than the USGS-EPA generated slopes (for Jourdan this was reversed). This seems to suggest that coarser datasets overestimate sub-basin slopes in flat watersheds and underestimate slopes in rougher terrain. Overall, the lengths of streams generated using the NED dataset are bigger than the USGS-EPA generated stream length values. This is also a reverse trend to the trend found in the stream length values for Jourdan River catchment.[1]
KEY TERMS: Digital Elevation Model; watershed delineation; Saint Louis Bay; Luxapallila; Mississippi

1. INTRODUCTION

Digital Elevation Model (DEM) is the terminology adopted by the United States Geological Service (USGS) to describe terrain elevation data sets in a digital raster form (EPA, 2004a). The USGS produces five types of elevation data: 7.5-minute, 7.5-minute-Alaska, 15-minute-Alaska, 30-minute, and 1-degree DEMs. 1-Degree DEMs correspond to the 3 arc-second (or 1:250,000-scale) USGS topographic map series, and are available for all of the contiguous U.S. and most of Alaska (USGS, 2005a). The standard DEM consists of a regular array of elevations cast on a designated coordinate projection system and covers the contiguous United States and most of Alaska (EPA, 2004a).

Digital elevations models (DEMs) are intensively used in water resources modeling. Watershed delineation and stream definition depend heavily on those DEMs. One software tool used in current modeling of watershed hydrology is the GIS system BASINS (Better Assessment Science Integrating Point and Non-Point Sources). BASINS is a multi-purpose environmental analysis system that integrates GIS, national watershed data, assessment and modeling tools (EPA, 2004b). Through the ArcView interface of the BASINS system, DEM data are easily downloaded and integrated in a project. However, the data sets downloaded through the BASINS interface do not consist of the original DEM values distributed by USGS. Figure 1 shows the implementation of the USGS-original data into the EPA-provided DEMs.

The BASINS interface also provides tools for downloading National Elevation Data (NED). The NED is a seamless mosaic of best-available elevation data having as primary initial data source the 7.5-minute elevation data for the conterminous United States (EPA, 2004c). NED has a consistent projection (geographic), resolution (1 arc second, approximately 30 m), and elevation units (meters) (USGS, 2005b). The horizontal and vertical reference data are NAD83 and NAVD88, respectively. The USEPA used a "clipgrid" program to clip the GRID from each 8 digit HUC code boundary with a one mile buffer for the United States and its territories (EPA, 2004c).

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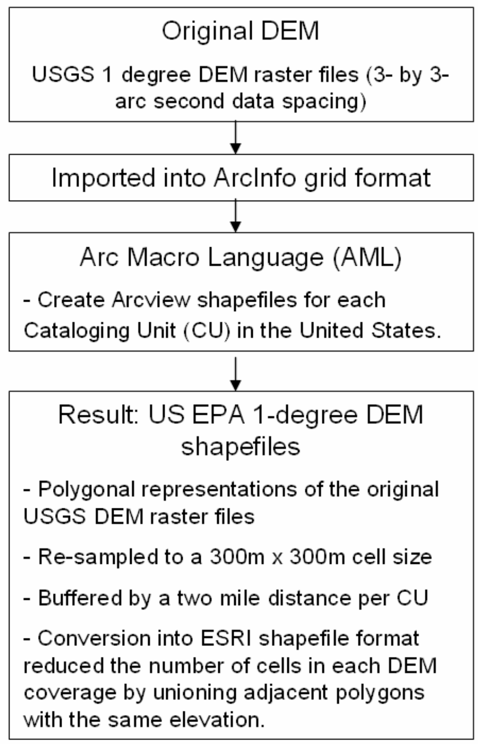

Figure 1. Implementation of EPA-provided DEM data. ArcInfo and the associated ArcMacro language are used to create ArcView shape files from the original USGS raster data files. (Flowchart was built from information found in EPA, 2004a)

Along with the tools to download, visualize and explore point source and non-point source data, BASINS allows the user to launch a suite of complementary models that are automatically fed with the information downloaded for a particular watershed. One of the hydrological models that can be launched from within BASINS is HSPF. Data describing watershed characteristics, such as elevation, sub-basin boundaries and land uses are read from the BASINS project and imported into the input files required by HSPF.

Several papers have reviewed the effect of DEM resolution and format in hydrological models. Chaubey et al. (2005) studied the effect of DEM spatial resolution by running seven scenarios at increasing horizontal scales ranging from 30 x 30 m up to 1000 x 1000 m. Their results showed that DEM data resolution affected: total area of delineated watershed, predicted stream network, sub-basin classification. Consequently, predicted stream flow values, NO3-N and Total Phosphorus concentrations were also affected. Hancock (2005) explored the effect of different grid scales (ranging from 10 x 10 m to 40 x 40 m) in the identification and characterization of catchments. Hancock found that the area-slope relationship, cumulative area distribution, width function and Strahler statistics were sensitive to digital model grid scale. Furthermore, hill slope detail was lost at grid scales greater than 10 m.

Thompson et al. (2001) examined how quantitative soil-landscape models are affected by DEM's horizontal resolution, vertical precision and information source. They used grid-based DEMs with 10 x 10 m and 30 x 30 m horizontal resolution and vertical precisions of 0.1 and 1 m. Thompson et al. found that decreasing horizontal resolution from 10 to 30 m create a less defined landscape, while decreasing the vertical precision produced a less continuous landscape with abrupt changes in slope gradient and slope curvature.

Wolock and McCabe (2000) compared DEMs for 50 locations in the contiguous USA (ranging from 100- to 1000-m resolution) for slope, specific catchment area and wetness index values. This paper reports that using a coarse DEM causes a decrease in mean slope and increases in mean specific catchment area and wetness index, being terrain discretization (not terrain smoothing) the primary mechanism by which DEM resolution affects those catchment indicators. Wolock and McCabe (2000) also found that the terrain-discretization effect of DEM resolution is more pronounced on relatively flat terrain with long length-scale terrain features. Similar results are reported in Wolock and Price (1994). In this paper, the authors compared the effects of DEM map scale and data resolution on the calculation of the topographic index (natural logarithm of the ratio of the specific catchment area to slope gradient) for 71 locations in Pennsylvania. This index is used by the hydrological model TOPMODEL to calculate the relation of the depth to the water table at any location. Consequently, Wolock and Price (1994) also assessed the effects of scale and resolution on the hydrological estimations provided by TOPMODEL (mean depth to water table, ratio of overland flow to total flow, daily flow statistics). Results reported in this paper show that DEM map scale and data resolution affect the statistics of the topographic index and TOPMODEL predictions.

Kenward et al. (2000) studied the effect of vertical accuracy of DEMs on hydrologic predictions of stream flow made by a soil-hydrology-vegetation model (Distributed Hydrology Soil Vegetation Model, DHSVM). DHSMV is a spatially distributed hydrological model that uses DEM data to simulate saturated areas and redistribute moisture in the unsaturated zone. Three DEM's were compared for a watershed located in Pennsylvania. Results showed that inaccuracies in coarser datasets were reflected in different drainage networks, elevation, slope and contributing area. The hydrological model also predicted higher mean annual run-off volumes for those coarser grids.

Cho and Lee (2001) investigated the sensitivity of SWAT simulated total run-off to two different USGS DEM datasets (1:24000 and 1:250000) in a 250 km^2 watershed. SWAT simulated results showed that runoff volumes were higher for the 1:24000 DEM than runoffs estimations corresponding to the 1:250000 DEM. Runoff peaks for the smaller scale DEM were also higher than those of the large scale DEM.

Zhang and Montgomery (1994) assessed how the grid size affects topographic representation, derived topographic attributes and hydrological simulations. Spot elevation data for two catchments were gridded at scales of 2, 4, 10, 30 and 90 m. The hydrological model TOPMODEL was used to estimate hydrographs for each of the grids. Topographic attributes (slope, drainage area, topographic index, etc.) were calculated and compared. Results reported Zhang and Montgomery (1994) showed that grid size significantly affects topographic parameters and hydrographs by decreasing slope estimations and increasing contributing areas for larger grids, and, increasing peak discharges (in the estimated hydrograph) with increasing grid size.

The review above shows that DEM grid size, scale and resolution affects substantially the calculation of topographic descriptors of catchments (slope, catchment area, topographic index, etc.). Since these topographic parameters are used by hydrological models to estimate runoff, stream flow, base flow and other hydrological indicators, the effects of DEM data in hydrological simulations is substantial. Most of the studies on the effects of varied-quality DEM input to hydrological models used the models SWAT or TOPMODEL for the hydrological estimations. A search in the EICOMPENDEX database shows that no studies have been done on the effects of DEM grid size, resolution or scale for hydrological simulations using HSPF. This paper investigates the effect of those DEM characteristics on the delineation of three catchments in Mississippi (Jourdan, Wolf and Luxapalilla) and the implications on parameter values exported to HSPF.

2. MATERIALS AND METHODS

2.1 Study sites

Two watersheds in Mississippi were selected for this study (see Figure 2.1). Luxapalilla watershed (USGS HUC 3160105) is located in northeastern Mississippi and northwestern Alabama (from 88° 40' W, 33° 17'; to 87° 41', 34° 5' N). The catchment's area is approximately 201227 ha; mostly barren lands according to the USGS GIRAS land use classification. Saint Louis Bay watershed (USGS HUC 03170009) drains approximately 202278 ha in the Mississippi gulf coast (from: 89° 44' W, 31° 7' N; to 87° 56' W, 30° 2' N). The region is mostly covered with forests with some agricultural lands in the western portions of the watershed. Urban development is concentrated along the Mississippi coast.

Two elevation datasets were used to delineate the Saint Louis Bay and Luxapalilla watersheds.

- EPA-USGS DEM: 300 Meter Resolution, 1-Degree Digital Elevation Models (DEM) that corresponds to 3 arc-second (or 1:250,000-scale) USGS topographic map series.
- EPA-NED: USGS 30 Meter Resolution, One-Sixtieth Degree National Elevation Dataset.

2.3 Watershed delineation

The watersheds under study were delineated using the automatic delineation option available in BASINS. To compare results, all delineations were performed with no-flow towards inner cells, 3800 ha threshold area, 31 outlets (1 outlet was manually placed at the location of the USGS 02481510 Station at Landon). The National Hydrographic Dataset (NHD) for streams was used in all delineation procedures.

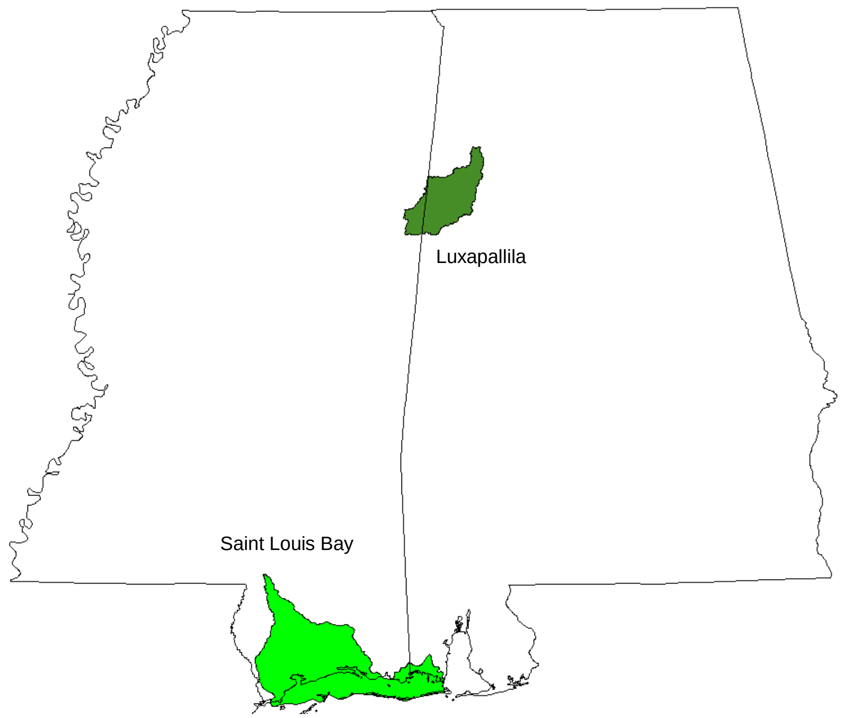

Figure 2.1 Study sites.

During delineation, BASINS summarizes the topographic information per sub-basin and per stream in two tables: Attributes of Sub-Basins and Attributes of Streams. The information contained by these tables is summarized below:

- Attributes of Sub-Basins: area, stream reach length (longest path within the sub-basin), sub-basin slope, field slope length (slope length is the distance from the origin of overland flow along its flow path to the location of either concentrated flow or deposition), stream reach slope, stream reach width, stream reach depth, latitude of the sub-basin centroid, elevation of the sub-basin centroid.
- Attributes of Streams: cumulative drainage area, stream reach length, stream reach slope, stream reach width, stream reach depth, minimum elevation of the stream reach, maximum elevation of the stream reach.

BASINS documentation on the algorithms used to generate the information contained in the tables described above is inexistent. Some parameters, however, are calculated from values also reported in the table. For example, the stream reach slopes are calculated using the maximum and minimum elevations, and the stream reach length. Some parameters are repeated in both tables with different names, e.g., widths and depths of streams. In this study, these tables are used to do a first comparison (per sub-basin) between the resulting delineations from the different elevation datasets for each of the watersheds under study.

2.4 Topographic information used by HSPF for hydrologic simulations

When a new HSPF project is launched from BASINS, four files are generated by the BASINS interface from which the new HSPF project loads topographical, channel geometry and land use information into the HSPF's User Control Input (*.uci) file. Those files are:

- Watershed file (*.wsd): contains sub-basin area and slope (Area Factor and SLSUR in HSPF, respectively)
- Reach file (*.rch): contains information for each stream reach such as elevation difference between start and end of the reach, flags identifying and connecting reaches, etc.
- Channel geometry file (*.ptf): contains information on the stream channel reach geometry (cross sections, length and depth, channel slope, side-slopes) and Manning's roughness coefficient for impervious zones. Used by HSPF to build F-tables for each sub-basin.

- Point sources file (*.psr): point sources discharges in the watershed.

HSPF loads selected information from the files described above into specific tables of the *.uci file. The table PWAT-PARM2 uses the slope values from the *.wsd file (per sub-basin) and assigns them to the variable SLSUR. Table RCHRES_HYDR_PARM2 loads the reach length values assigning them to the variable LEN. This table also uses the values of elevation difference between start and end of the reach (variable assigned: DELTH).

The hydrologic routing algorithm in HSPF calculates storages and outflows using rating curves. These function-tables (F-tables) are set-up automatically by HSPF with trapezoidal cross-sections (by default) when a new project is generated from BASINS. The user can modify the cross-sections with other data if available. If the F-tables are not modified by the user, F-tables in the *.uci file are built using the information contained by the *.ptf file. However, although the *.ptf file provides several columns with geometrical attributes of the stream reach, only three columns come directly from the BASINS' summary tables: length of stream, mean width and mean depth.

Figure 2.2 shows a summary of the HSPF use of topographic information extracted from BASINS.

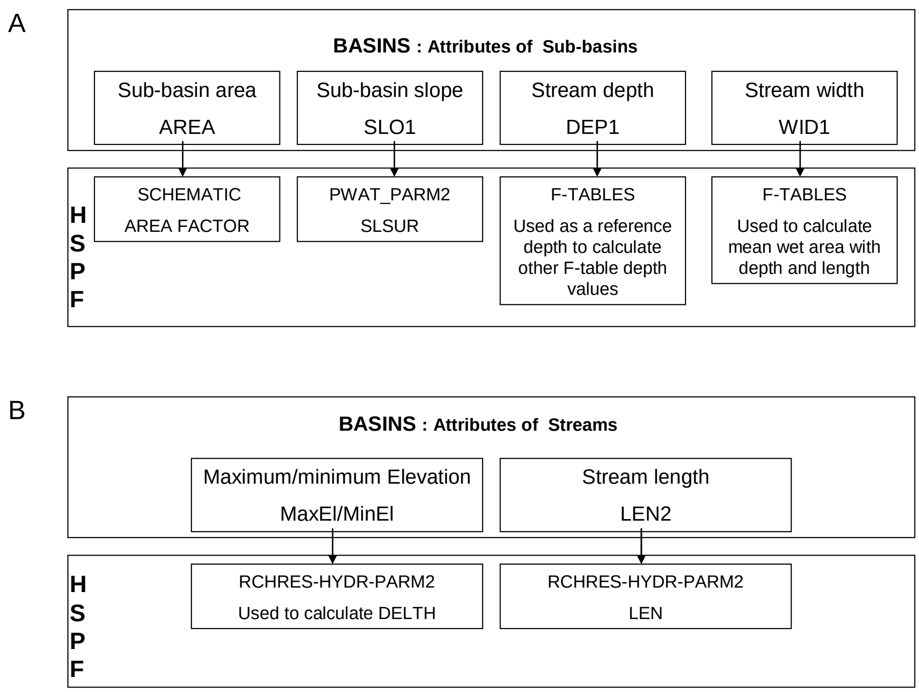

Figure 2.2. Data transfer from BASINS tables to HSPF tables. Topographical information is transferred from BASINS to HSPF in 6 variables: A) sub-basin area, sub-basin slope, stream depth, stream width, max/min elevation, and, B) stream length (all the information transferred is per sub-basin).

Topographical data are used to calculate runoff and hydraulic behavior in streams. HSPF calculates runoff based on the Chezy-Manning equation (Bicknell et al. 2001). The overland flow algorithm uses the sub-basin slope SLSUR variable. The AREA FACTOR values are used to specify areas of a land segments that are tributary to a stream reach. The F-TABLEs specify the geometric and hydraulic properties of a stream reach.Every stream reach is associated with one FTABLE. DELTH is the drop in water elevation from the upstream to the downstream extremities of the stream reach. It is used if section OXRX (dissolved oxygen) is active and reaeration is being computed using the Tsivoglou-Wallace equation; or if section SEDTRN (sediment transport) is active and sand-load transport capacity is being computed using either the Toffaleti or Colby method).

3. RESULTS

3.1 Saint Louis Bay delineation

Figure 3.1 shows the watershed delineation in Saint Louis Bay watershed using the EPA-USGS DEM and NED data sets downloaded through BASINS. The region corresponding to Jourdan and Wolf rivers (main tributaries in the Saint Louis Bay Watershed) is shown in the figure. Notice that the delineation using the NED database (Figure 2 B) covers more surface area surrounding the rivers. This is particularly noticeable in the Jourdan River region (southwestern stream in both delineations). While the delineation that uses the NED database dedicates 15 sub-basins to Jourdan River and tributaries, the delineation using the EPA-USGS database (Figure 2 A) generates only 8 sub-basins leaving the southeastern portions of Jourdan River un-delineated. For Wolf River (northeastern stream), the delineation using EPA-USGS DEM generates 9 sub-basins while the NED-delineated sub-basins are 7.

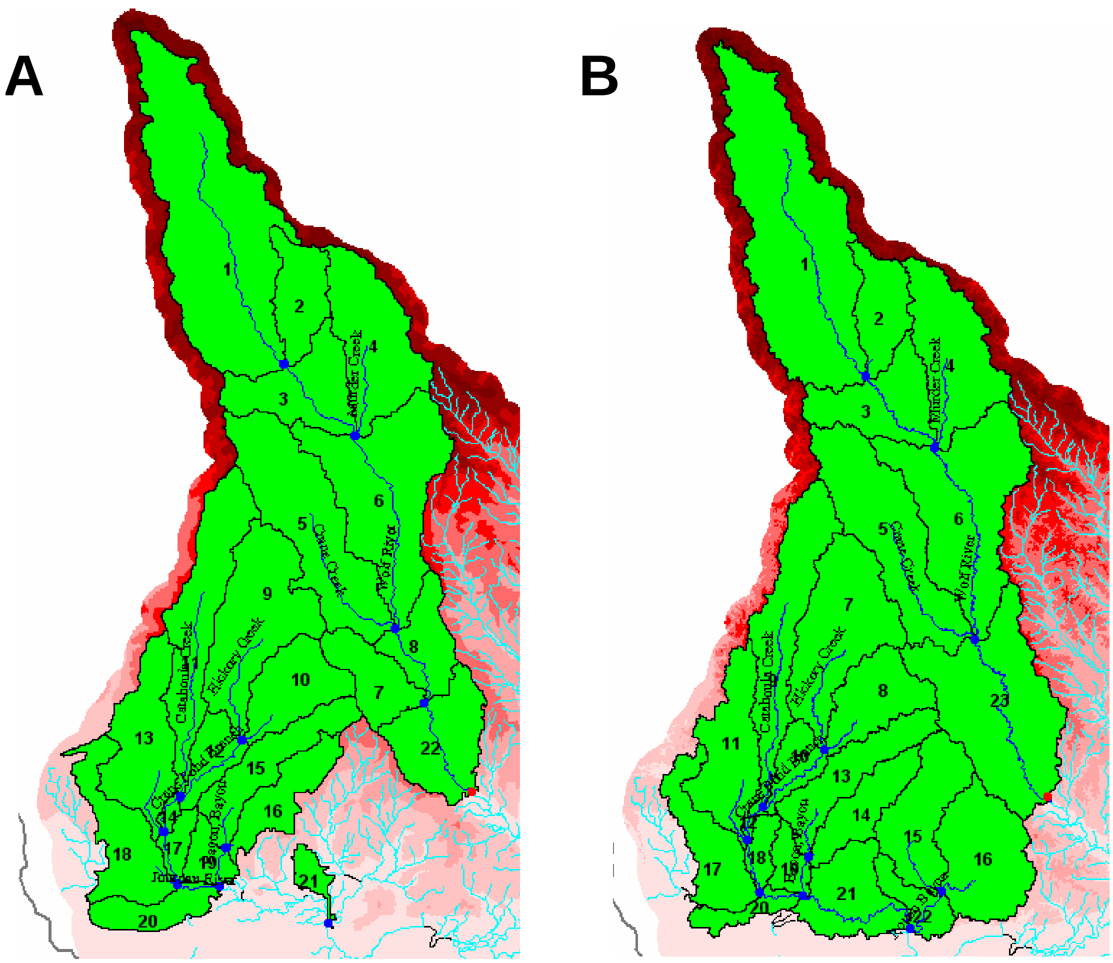

Figure 3.1. Delineation of Jourdan and Wolf rivers catchments using A) EPA-USGS DEM, and B) NED dataset.

3.1.1 Jourdan River in Saint Louis Bay

Figure 3.2 shows selected sub-basins from the Jourdan River catchment for comparison of topographic indicators. Care was taken to choose similar sub-watersheds for easier comparison. Table 3.1 shows results of percent differences in the topographical indicators that are exported to HSPF. The BASINS names for topographical indicators are used in the table. Percent differences are calculated with respect to the NED database. Major differences are found in the overland flow plane slope values (SLO1), the stream channel slope values (SLO2) and the length of the stream channel (LEN2).

Percent differences for SLO1 range from 190 to 1322, meaning that SLO1 values estimated using the USGS-EPA data base are at least 2.9 times bigger (and up to 14 times bigger in the worst case) than those SLO1 estimated values using the NED elevation data. SLO2-estimated values using USGS-EPA are up to 9 times bigger than those SLO2 estimations using the NED database. LEN2 percent differences show that USGS-EPA-estimated values are up to 1.27 times bigger than NED-estimated stream lengths. Minimum and maximum elevations (MinEl and MaxEl respectively) values also present substantial percent differences. In most cases estimated MinEl and MaxEl values are smaller when the source is the USGS data set.

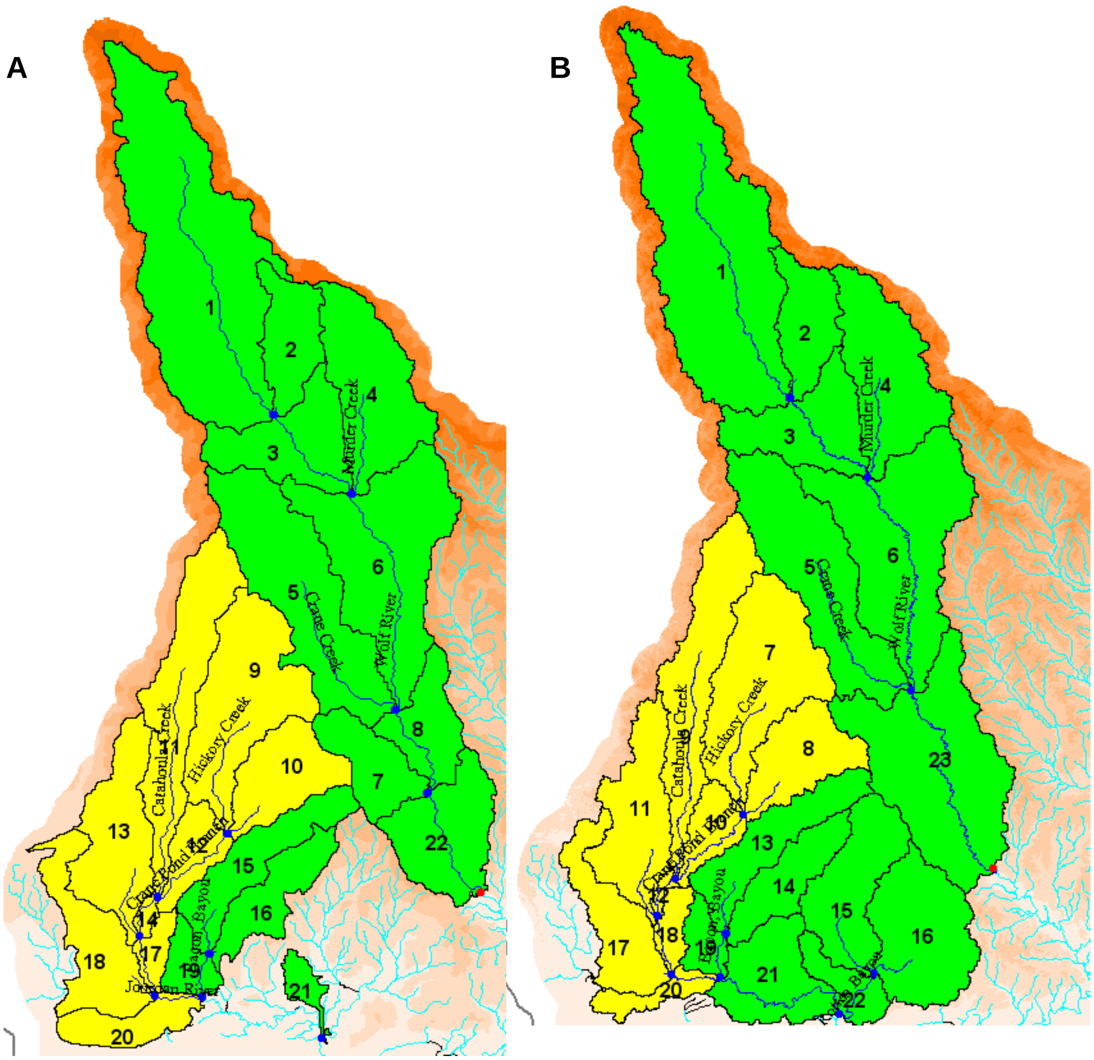

Figure 3.2. Jourdan River sub-catchment

Notice that the maximum and minimum elevations for the whole catchment are 33.10 m and 0.74 m, respectively, according to the USGS database (30 and 3, respectively, according to the NED database). These ranges show that the total elevation difference is around 27 to 32 m and the mean elevation ranges from 16 m to 17m.

Table 3.1. Percent differences in topographical indicators for Jourdan River sub-catchment

		PERCENT DIFFERENCES							
Basin	**Sub-basin name**	**Area**	**Slo1**	**Wid1**	**Dep1**	**Len2**	**Slo2**	**MinEl**	**MaxEl**
9	**Hickory Creek**	0.51	209.69	0.30	0.20	10.02	77.31	-46.17	10.33
10	**White Cypress Creek**	0.35	295.51	0.21	0.14	27.20	17.86	-46.28	-14.22
11	**Catahoula Creek**	-1.25	190.76	-0.75	-0.50	4.08	10.18	-63.29	-9.04
12	**Crane Pond Branch**	-9.36	209.95	-5.72	-3.84	11.76	8.90	-68.00	-30.63
14	**Jourdan River**	-16.81	1322.55	-10.46	-7.12	7.26	245.15	-55.00	-8.50
13	**Crabgrass Creek**	-3.50	238.11	-2.11	-1.42	5.17	218.06	-57.17	1.20
17		7.39	344.73	4.37	2.91	3.32	39.84	-70.63	-32.25
18	**Dead Tiger Creek**	-11.94	295.71	-7.35	-4.95	-70.46	806.53	-70.88	-44.33
20	**Jourdan River**	-42.66	508.70	-28.38	-19.96	16.65	-16.31	-75.33	-29.75

3.1.2 Wolf River at Saint Louis Bay

Figure 3.3 shows the Wolf River sub-catchment used for comparison of topographical indicators. Table 3.2 summarizes the comparison per sub-basin. The ranges of elevations for the whole catchment for the USGS-EPA and NED databases are: 9 m to 87 m, and, 8.98 m to 84.62 m, respectively. Therefore, Wolf River is located, overall, in higher terrain than Jourdan River (mean elevation ranges from 46 to 48 meters) having a total elevation difference that ranges from 75 m to 78 m.

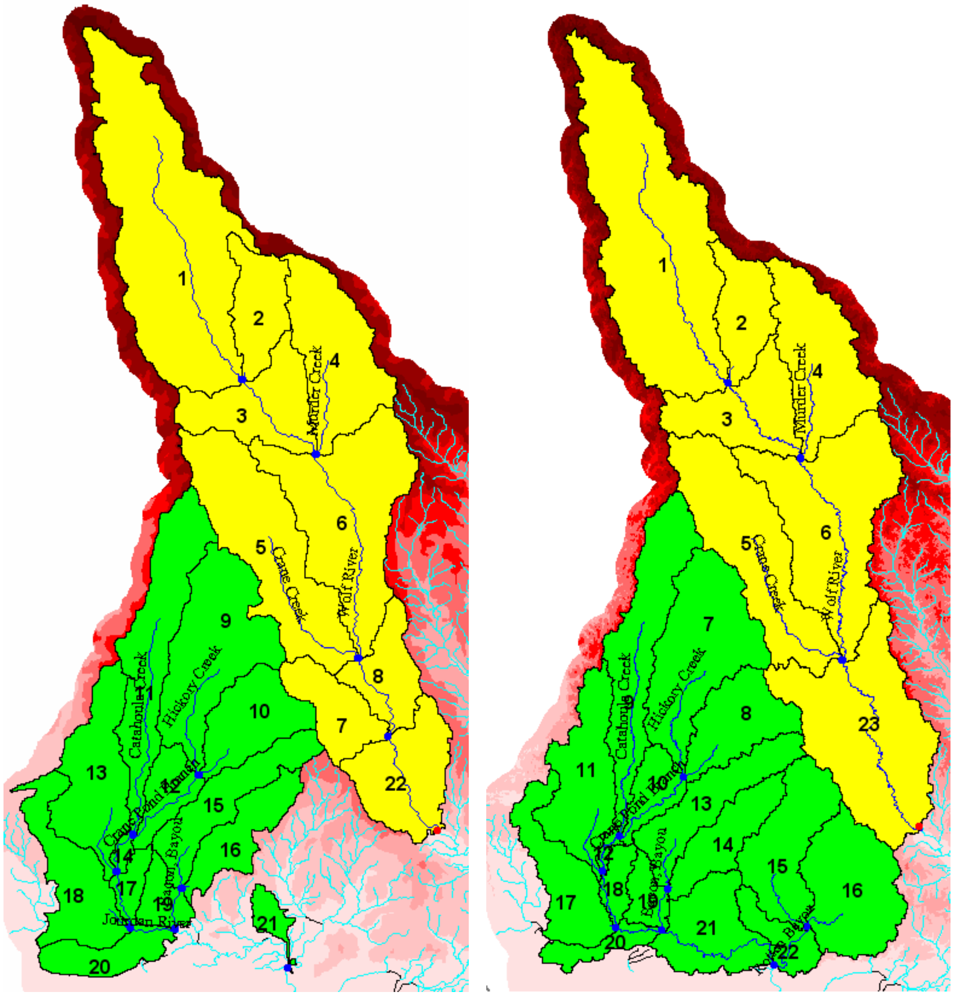

Figure 3.3. Wolf River sub-catchment.

USGS-estimated sub-basin slopes (SLO1) for the Wolf River sub-catchment are more than twice smaller than the NED-estimated SLO1 values (opposite to what happens for the Jourdan River sub-catchment). Similarly, SLO2 values (slope of the stream channel) estimated using USGS-EPA data are up to 1.4 times smaller than the values estimated using the NED database (opposite to the Jourdan River case). LEN2 values (length of the stream channel) are also smaller (up to 1.6 times) for USGS-EPA estimations as opposed to being up to 1.27 times bigger in the Jourdan River case. Minimum and maximum elevation values (MinEl and MaxEl) are also (mostly) bigger for the NED database.

Table 3.2. Percent differences in topographical indicators for Wolf River sub-catchment

		PERCENT DIFFERENCES							
Basin	**Sub-basin name**	**Area**	**Slo1**	**Wid1**	**Dep1**	**Len2**	**Slo2**	**MinEl**	**MaxEl**
1	Wolf River	1.73	-59.57	1.03	0.69	-5.00	-5.06	13.51	2.81
2	Alligator Creek	-0.34	-66.70	-0.20	-0.14	-60.96	-42.87	6.98	-11.10
3	Wolf River	1.09	-67.56	0.65	0.43	-18.87	-22.76	30.04	0.55
4	Murder Creek	0.62	-61.92	0.37	0.25	-3.88	-31.08	28.33	-0.58
5	Crane Creek	6.45	-67.52	3.82	2.53	-9.56	-2.87	-3.45	-8.29
6	Wolf River	-3.99	-65.56	-2.42	-1.61	-18.69	29.84	-0.99	2.12
7	Wolf River (*)		-56.88	-54.67			32.63		
8	Wolf River (*)		-59.60	-54.38			58.62		
23	Wolf River (*)	-1.38	-64.20	-38.21	-27.46	-12.46	-28.25	0.22	-43.65

3.1.3 Luxapalilla watershed

The resulting delineations of the Luxapallila watershed using the USGS-EPA and NED datasets are shown in Figure 3.4. Table 3.3 shows a summary of the estimated topographical indicators for both databases. Maximum and minimum elevation values range from 46 m to 148 m (average= 97 meters) for the USGS-EPA data source, and from 47 m to 152 m (average= 99.5 m) for the NED dataset. The total elevation difference in the watershed is around 102 to 105 m. Sub-basin slopes (SLO1) for values estimated using the USGS-EPA data source are at least 1.4 times smaller than the SLO1 values calculated using the NED dataset. There is not a uniform pattern in the percent differences of LEN2, SLO2, minimum elevation and maximum elevation estimated values (percent differences do not show a uniform sign). In general, percent differences for this watershed are of smaller value than those percent differences seen in the Jourdan and Wolf rivers

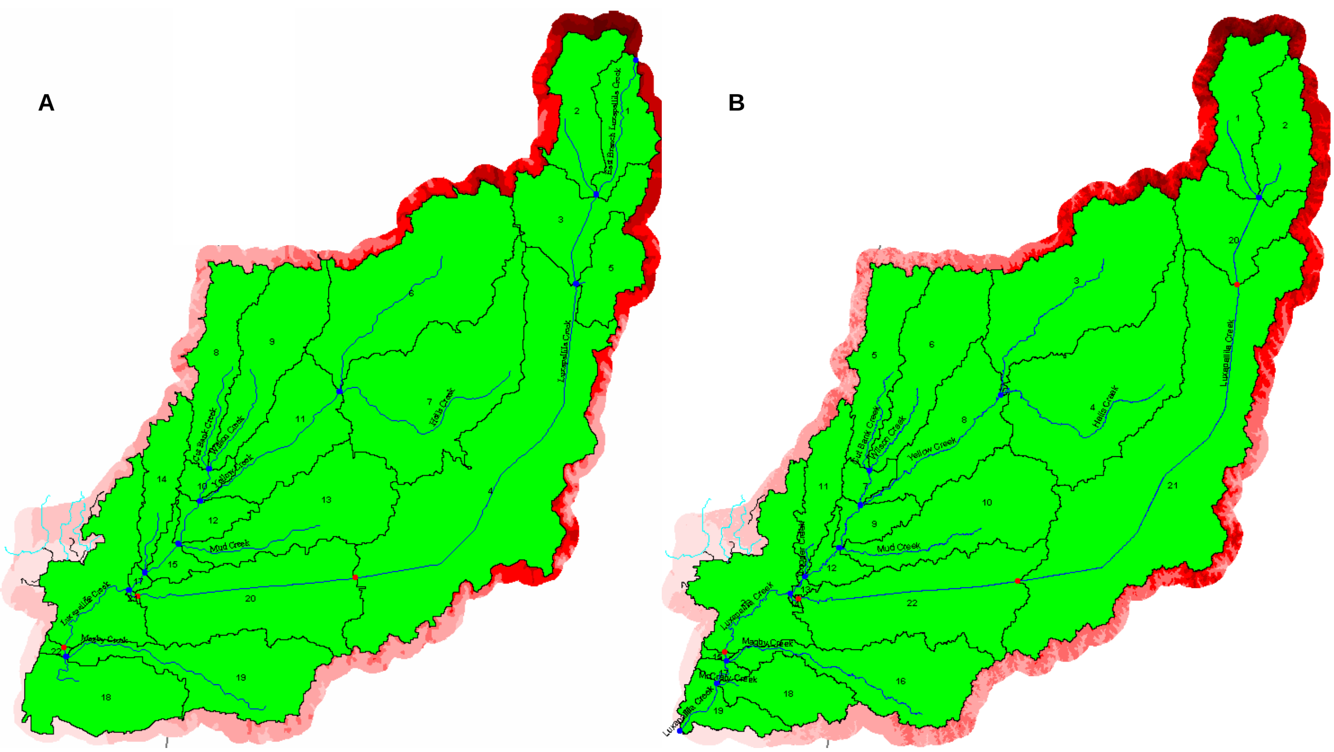

Figure 3.4. Delineation of the Luxapallila watershed. A) Using elevation data from USGS-EPA dataset, and, B) using the NED dataset

Table 3.3. Percent differences in topographical indicators for Luxapallila watershed

		PERCENT DIFFERENCES							
Basin	**Sname**	**Area**	**Slo1**	**Wid1**	**Dep1**	**Len2**	**Slo2**	**MinEl**	**MaxEl**
2	**Luxapallila Creek**	-0.52	-65.63	-0.31	-0.21	-2.42	-61.33	6.84	-2.78
1	**East Branch Luxapallila Creek**	-10.16	-66.20	-6.23	-4.19	248.39	123.93	6.84	54.57
3	**Luxapallila Creek**	2.16	-58.57	1.29	0.87	2.99	37.80	3.69	7.59
5	**Stewart Creek**		-69.29	-58.79			-39.50		
6	**Yellow Creek**	4.91	-50.18	2.92	1.93	-5.27	11.63	-2.47	-0.10
8	**Cut Bank Creek**	0.73	-60.27	0.44	0.29	-5.71	26.16	-2.78	1.97
9	**Wilson Creek**	0.06	-55.01	0.04	0.02	10.05	24.01	-2.57	4.03
7	**Hells Creek**	1.04	-48.65	0.62	0.41	-4.32	50.36	-1.23	11.78
10	**Cut Bank Creek**	-4.44	-54.26	-2.69	-1.79	-17.37	61.17	3.30	10.73
11	**Yellow Creek**	-4.33	-53.14	-2.62	-1.75	-13.71	-25.52	-4.42	-15.37
12	**Yellow Creek**	-2.97	-51.20	-1.79	-1.21	-14.23	-6.72	18.32	8.78
13	**Mud Creek**	-1.93	-44.25	-1.16	-0.78	-8.78	71.46	-1.70	13.09
14		6.50	-67.96	3.85	2.56	63.48	36.04	-21.88	2.79
15	**Yellow Creek**	-3.62	-24.03	-2.19	-1.45	-31.63	111.32	-14.85	-6.38
17	**Yellow Creek**	29.22	-37.24	16.63	10.81	-0.11	-61.07	-14.66	-24.13
21	**Luxapallila Creek**	6.90	-48.08	4.09	2.71	-15.70	-66.28	-14.85	-22.06
16	**Luxapallila Creek**	-4.40	-61.89	-2.67	-1.79	-12.26	-79.17	2.79	-13.87
4	**Luxapallila Creek**	-4.71	-53.21	-2.85	-1.91	-1.24	-15.48	12.11	0.78
22	**Luxapallila Creek**	20.95	-44.31	12.09	7.87	2.90	-77.07	-2.17	-10.30
20		-2.52	-47.47	-1.52	-1.02	-4.58	72.21	-14.75	8.98
19	**Magby Creek**	6.10	-55.62	3.62	2.40	-3.08	19.52	-2.17	6.56

4. CONCLUSIONS

The exploration showed that the resolution of elevation data affects watershed delineation by providing more sub-basins (for the same area) when using coarser datasets, i.e., lower resolution produces further segmentation of a watershed. Higher-resolution datasets allow better delineation of flat areas. This is particularly evident in the coastal areas examined for this report (Saint Louis Bay).

For flat areas (e.g., Jourdan river catchment in Saint Louis Bay) overland flow plane slope values estimated using the USGS-EPA dataset are at least 190% and up to 1322 % bigger than those sub-basin slope values estimated using the NED elevation data. Stream channel slope values using USGS-EPA are up to 9 times bigger than those estimated using the NED database. Minimum and maximum elevations values (per sub-basin) also present substantial percent differences. In most cases estimated elevation values are smaller when the source is the USGS data set.

Results for Luxapallila and Wolf show major percent differences in the sub-basin slope values. Although not as noticeable as in the Jourdan River case, slope values resulting of using the NED dataset are also different (50% in average) than those values calculated using the USGS-EPA dataset. Interestingly, for these two catchments (Wolf and Luxapalllila) that are located in higher terrain and are less flat than Jourdan River catchment, NED-generated sub-basin slope values are bigger than the USGS-EPA generated slopes (for Jourdan this was reversed). This seems to suggest that coarser datasets overestimate sub-basin slopes in flat watersheds and underestimate slopes in roughed terrain. Overall, the lengths of streams generated using the NED dataset are bigger than the USGS-EPA generated stream length values. This is also a reverse trend to the trend found in the stream length values for Jourdan River catchment.

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