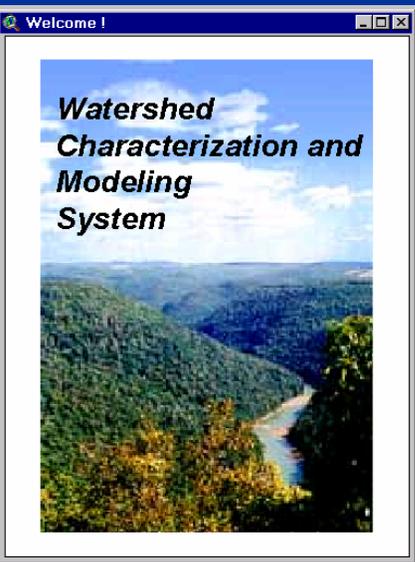


The Watershed Characterization and Modeling System (WCMS): An Overview



A product of the
Natural Resource Analysis Center
West Virginia University
Jerald J. Fletcher, Director



Natural Resource Analysis Center (NRAC) WCMS Development Team



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WCMS Development Support

- **WV Dept of Environmental Protection (WVDEP)**
 - Division of Mining and Reclamation (including PECA)
 - Division of Water and Waste Management
- **West Virginia University (WVU)**
 - WV Ag & Forestry Experiment Station
 - Davis College & Division of Resource Management
 - National Mine Land Reclamation Center
 - WV Water Research Institute
- **Other Grants and Support**

Primary Acknowledgments

- Larry Evans, WVDEP/TAGIS helped develop the initial concepts included in WCMS and provided financial support. Larry continues to support development and integration of advanced spatial technologies which complement and enable advanced applications such as WCMS in WVDEP.
- Tom Galya, OSM helped design the hydrologic capabilities now in WCMS
- Mike Strager, WVU/NRAC, has been the primary architect of the GIS capabilities within WCMS since 1995. Mike's insights and views that combine GIS with decision support are reflected in all aspects of the current version of WCMS.

Overview of the Presentation

- Background, development goals, and implications
- Summary of capabilities – What is WCMS?
- History of development – How did WCMS get where it is today? What resources have been used?
- Future plans – Where are current development activities headed?

Background

- **Regulatory agencies need:**
 - **Consistent and reliable sources of information to support analysis and document decisions**
 - **Time-saving analysis tools**
 - **Watershed-based analysis for statewide applications**

Overall Development Goals

- **Bring state-of-the-art GIS capabilities to watershed related assessment and management problems – with emphasis on West Virginia**
- **Make state-of-the-art GIS capabilities available to a variety of users without requiring GIS specialization**

Goals of the WCMS System

- Access and view data by bringing it to the desktop with ArcMAP
- Support activities of WVDEP personnel
- Customized interface for ease of use
- Determine NPDES stream pollutant loadings based on existing mining extents and discharge rates by land cover
- Answer common questions related to water quality modeling and stream flow for use in CHIA evaluation
- *Note: Usefulness of GIS tools are limited by data availability – data development to support appropriate analyses must be a complementary goal to software development*

WCMS-GIS Modeling System for Watershed Analysis

- Advanced GIS tools for calculation and visualization
- Spatially explicit landscape model
- Decision support tools – multiple criteria and economic analysis

WCMS-GIS Modeling System for Watershed Analysis

- Hydrological capabilities
 - Stream flow estimation – 30 year average
 - Low flow (7Q10) estimates
 - Delineation of watershed drainage area
 - Water quality prediction tools

Requirements for Use

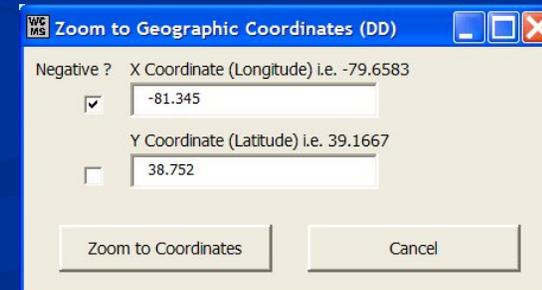
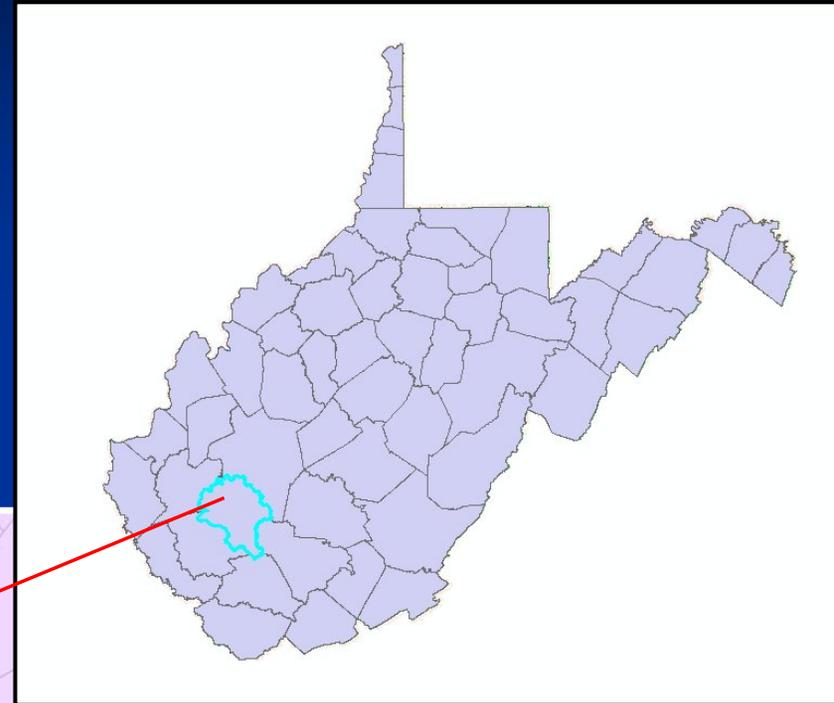
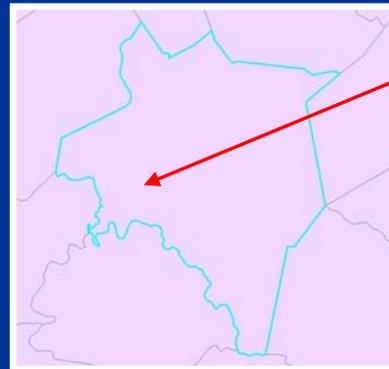
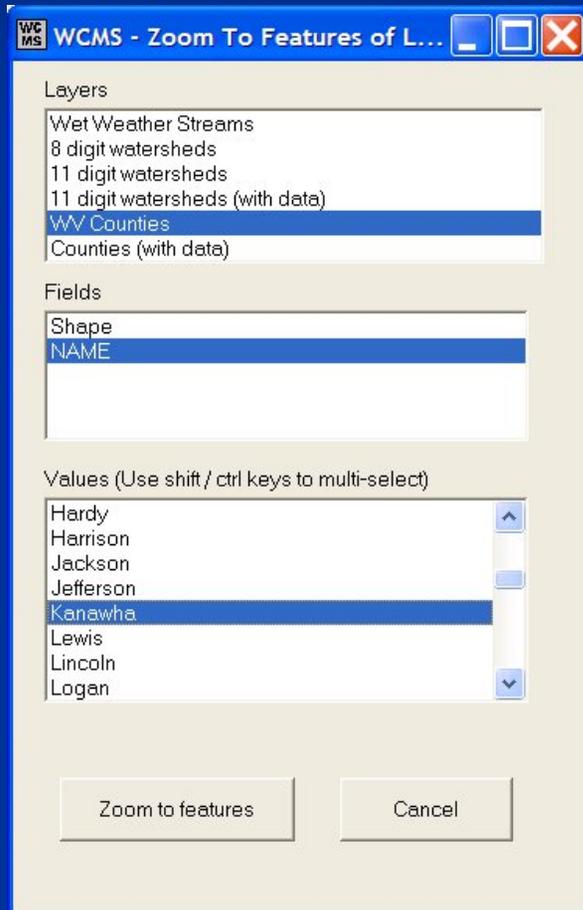
- ArcGIS and Spatial Analyst
- PC platform - Windows 2000/XP or Server 2000/2003
 - Runs in a Citrix environment at WVDEP
- Basic ArcMAP skills
- Appropriate GIS data available to WCMS

GIS Data Developed for WCMS (Provided for West Virginia)

- Raster stream network
- Flow direction grid
- Flow accumulation grid
- Runoff grid
- Cumulative runoff grid
- Hydro-corrected DEM with burned in streams
- 30m DEM (the standard DEM that is not hydro-corrected)
- Landcover from the WV GAP analysis project
- Landcover made from MRLC data
- Table of expected mean concentration values
- Layer of critical low flow values
- Layer of USGS gauged watersheds
- Regional stream flow variability curve
- Stream flow variability index
- 1:24K NHD

Using WCMS - Defining a Study Area

From list, graphic, or point



WCMS Basic Query Tools

- Elevation tool: Find the elevation of a point
- Elevation profile tool: Creates an elevation profile along a user drawn line
- Slope information tool: Derive the slope along a drawn line
- Polygon area tool: Find the area of a user drawn polygon
- Coordinate tool: Find the coordinates of a point clicked in the display

WCMS Watershed Tools

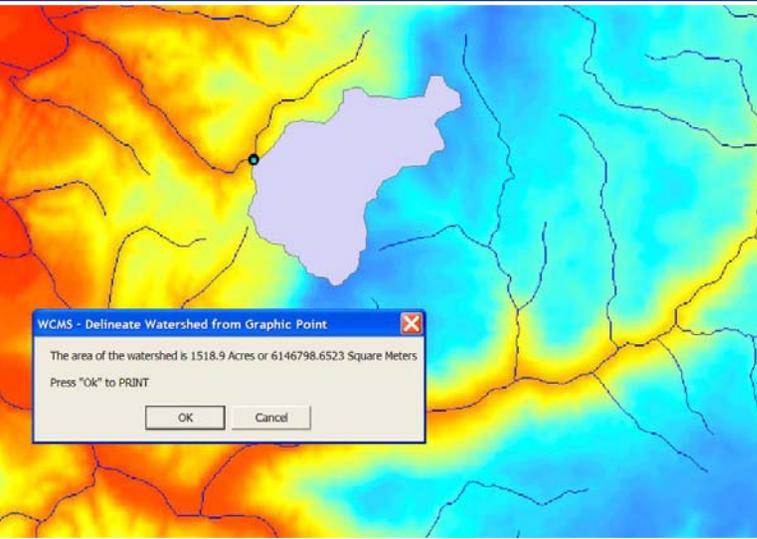
- Trace the path of a raindrop across the landscape (flow direction)
- Find the 30 yr-average annual and monthly streamflow
- Report the drainage area for a stream reach
- Find estimated 7Q10 flow for any stream location

WCMS Watershed Delineation

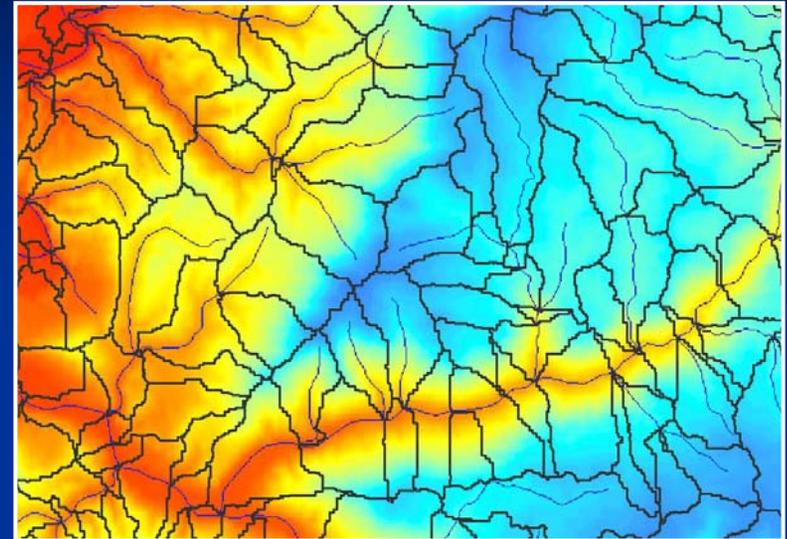
- Delineate watersheds from graphic point(s)
 - Choose a spot on the raster stream
 - Choose any point in the watershed
 - Area of a polygon may be delineated
 - Watershed, mine site polygons
- Delineate drainage paths
- Delineate many watersheds
- Calculate the distance between two points in a stream

Watershed Delineation

Point



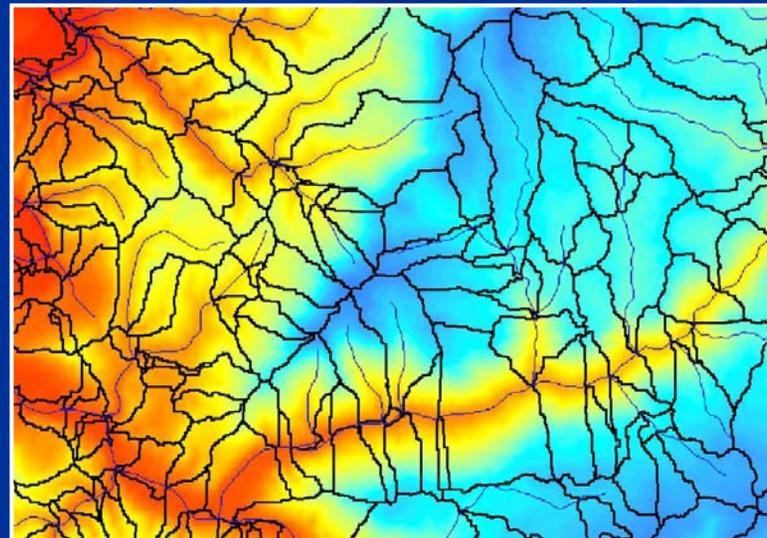
Area Threshold



Segment

Level

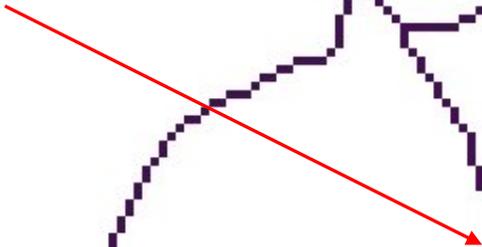
Watersheds



Watershed Tools

Drainage area and flow

Click Point on Stream



3 - Drainage Area of Point Clicked

7555.64 Acres
(11.81 Square Miles)

OK

WCMS - Modeled Stream Flow (cfs)

Annual Average: 426.02

Jan:	643.38
Feb:	697.56
Mar:	832.27
Apr:	621.26
May:	457.82
Jun:	276.93
Jul:	200.53
Aug:	183.21
Sep:	129.46
Oct:	221.28
Nov:	323.02
Dec:	571.39

OK

WCMS - Modeled Stream Flow (cfs)

Overide 7Q10 Value (cfs) = 1980
Due To = Lower Kanawha

Graph 7Q10 Values = 94.03
Area of Watershed (Sq mi) = 11365.63

Gauged 7Q10 Values

Annual:	86.27
Jan:	2022.29
Feb:	2339.73
Mar:	2689.9
Apr:	1844.64
May:	522.59
Jun:	190.72
Jul:	122.75
Aug:	203.79
Sep:	180.26
Oct:	335.74
Nov:	695.01
Dec:	2595.8

Gauge Used for Calculations: 3201410

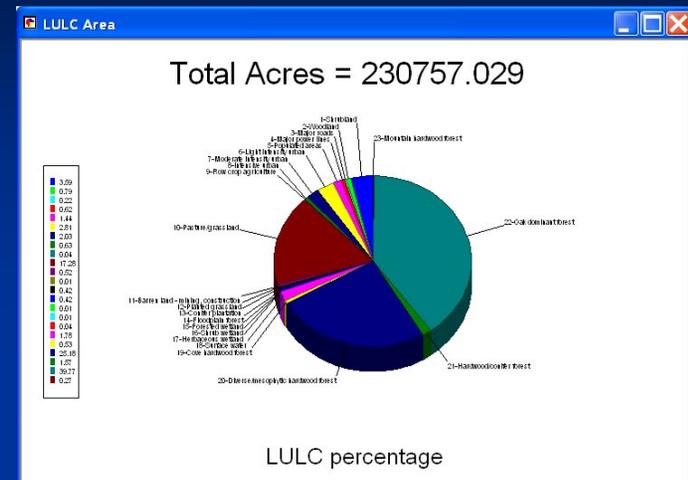
OK

Tabulate Landuse Statistics

Attributes of wcmsTmpLCTable

OID	Value-LULC	Hancock	Hancock%	Brooke	Brook
0	1-Shrubland	16843450.53	7.82	17753785.63	
1	2-Woodland	38167442.58	17.72	41408991.92	
2	3-Major roads	0	0	0	
3	4-Major power lines	180086.07	0.08	75636.15	
4	5-Populated areas	5317941.77	2.47	4953267.47	
5	6-Light intensity urban	18922544.26	8.79	29590843.3	
6	7-Moderate intensity urban	22813303.89	10.59	41263122.2	
7	8-Intensive urban	3693565.38	1.72	4273442.54	
8	9-Row crop agriculture	122458.53	0.06	441210.88	
9	10-Pasture/grassland	33861584.55	15.72	35104178.46	
10	11-Barren land - mining, construction	1071512.14	0.5	670820.63	
11	12-Planted grassland	212501.57	0.1	38718.51	
12	13-Conifer plantation	1846782.69	0.86	2713897.14	
13	14-Floodplain forest	384483.77	0.18	171081.77	
14	15-Forested wetland	29714.2	0.01	177384.78	
15	16-Shrub wetland	8103.87	0	9004.3	
16	17-Herbaceous wetland	49523.67	0.02	61229.26	
17	18-Surface water	13960272.48	6.48	7326801.93	
18	19-Cove hardwood forest	0	0	0	
19	20-Diverse/mesophytic hardwood forest	28277115.39	13.13	24775341.67	

Record: 1 Show: All Selected Records (of 25) Options



Update/Change Landuse



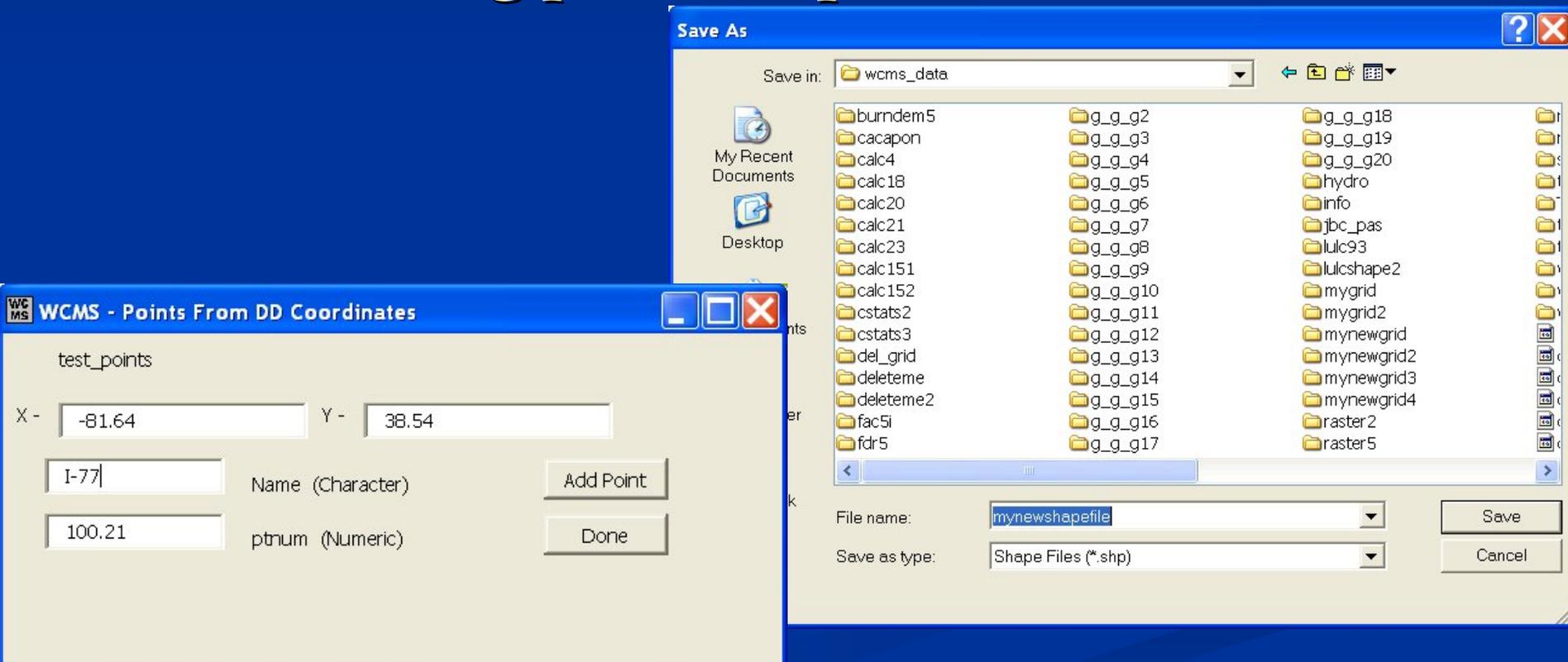
Original

Digitize new

Update grid

Adding Points

- To create new point shapefile
- Add to existing point shapefile



Ranking Model (Multiple Criteria)

WCMS - Ranking Model

Select up to 10 fields for ranking and then adjust the sliders to rank each field (use Ctrl key to multi-select).

Selected Layer is "wshedrank4"

Run Model Help

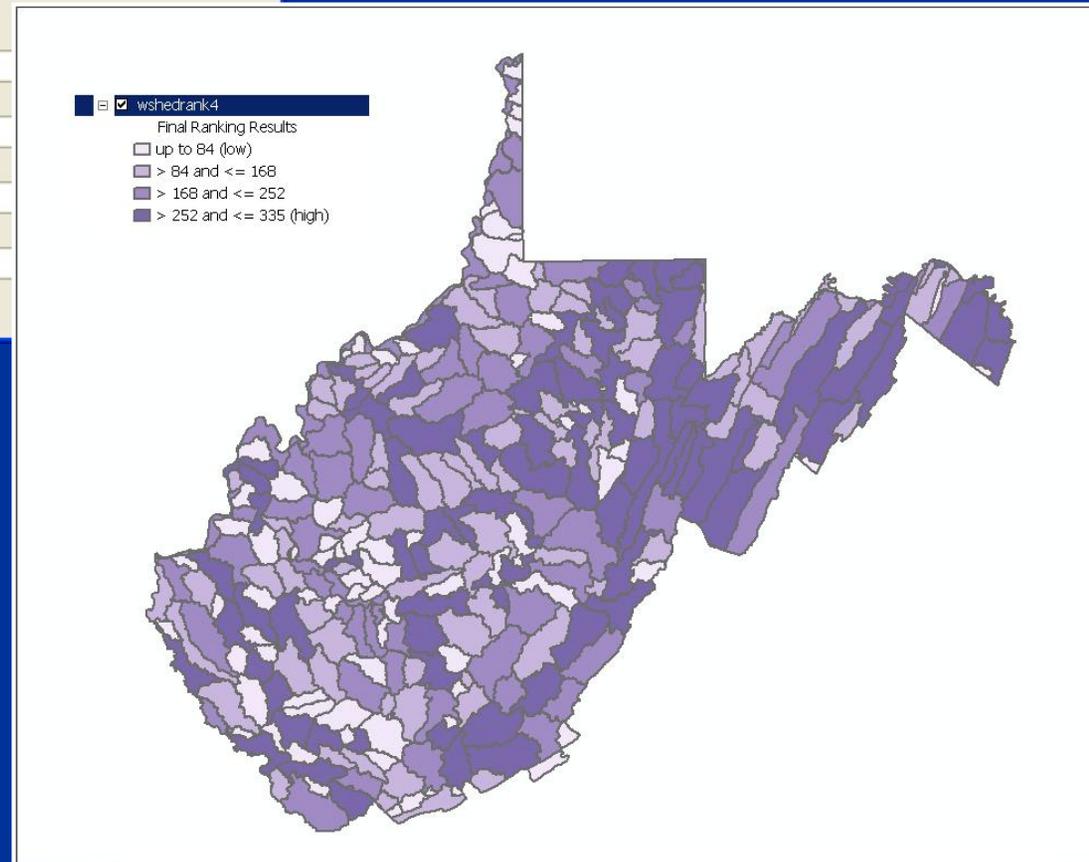
Output Log = "D:\development\vb\WCMS\wcms-Rlog.txt"

ROAD_LEN (Value = 30)

ROAD_DEN (Value = 10)

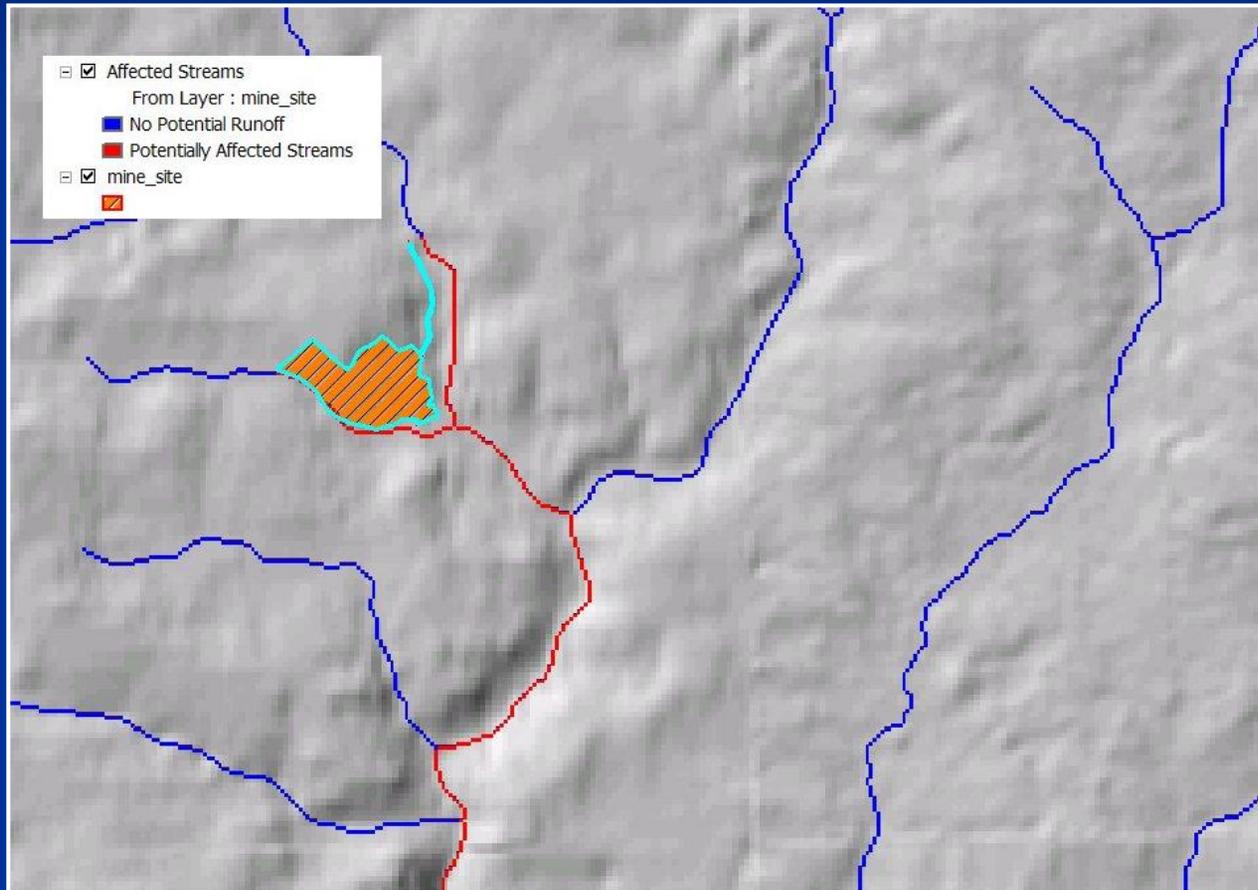
POP_DENSIT (Value = 50)

LOW_INT_DE (Value = 60)

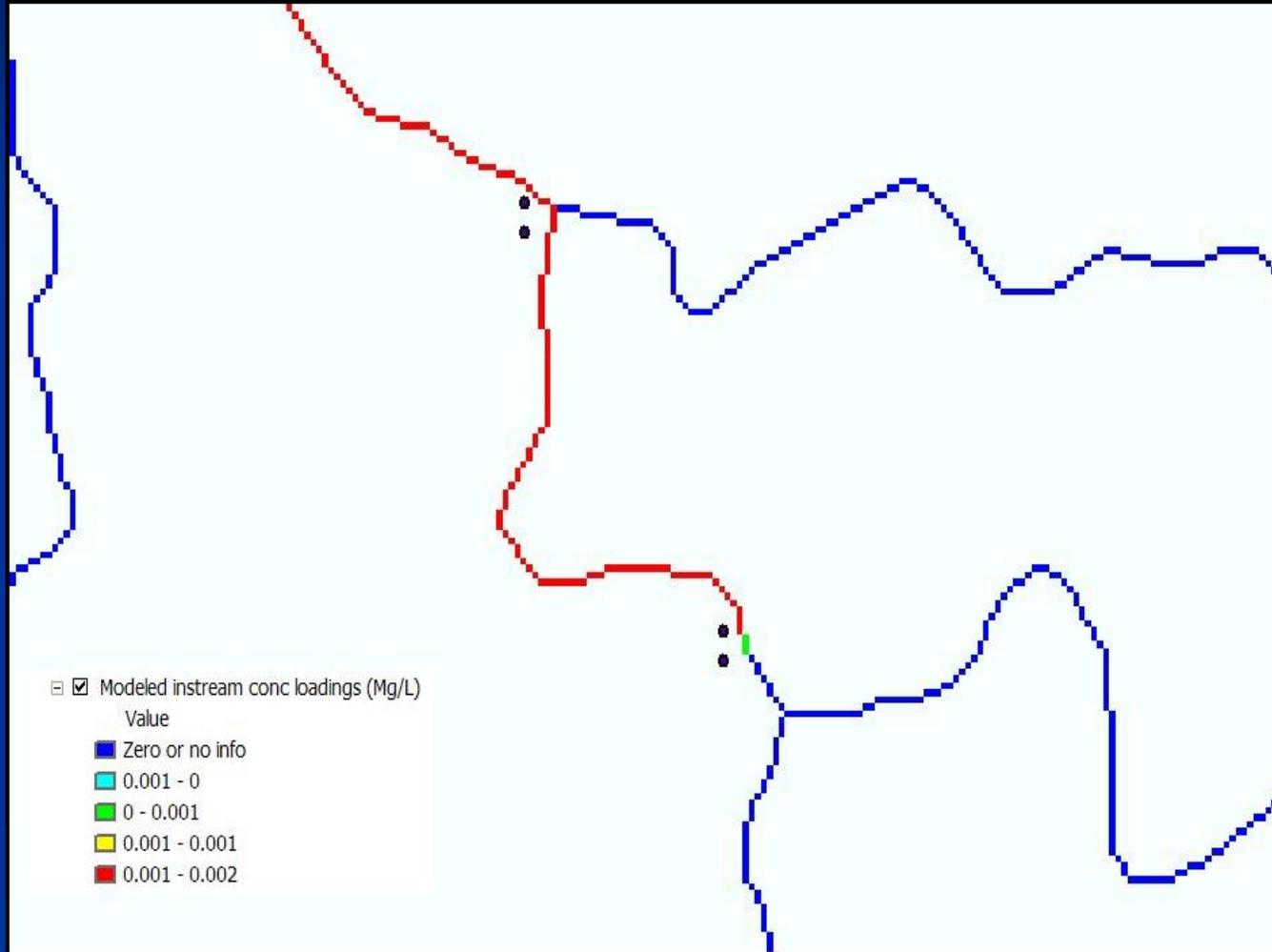


Water Quality Prediction

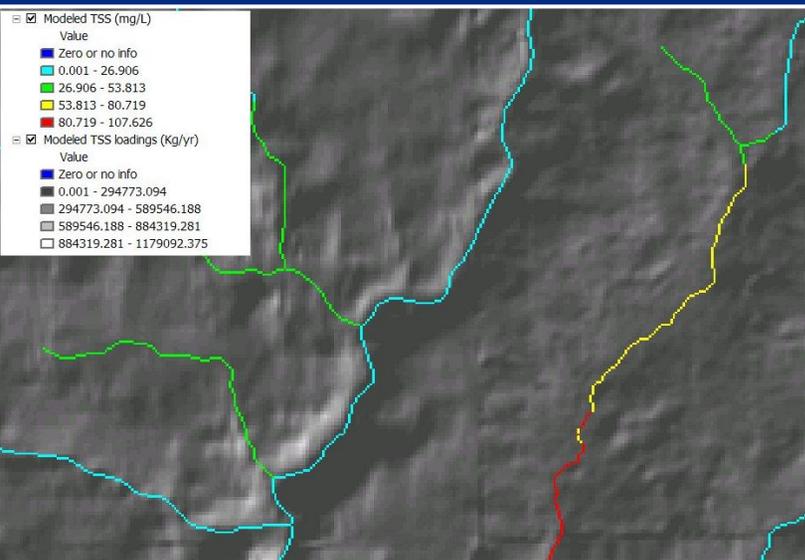
Potentially Affected Streams Results



Water Quality-Average Concentrations

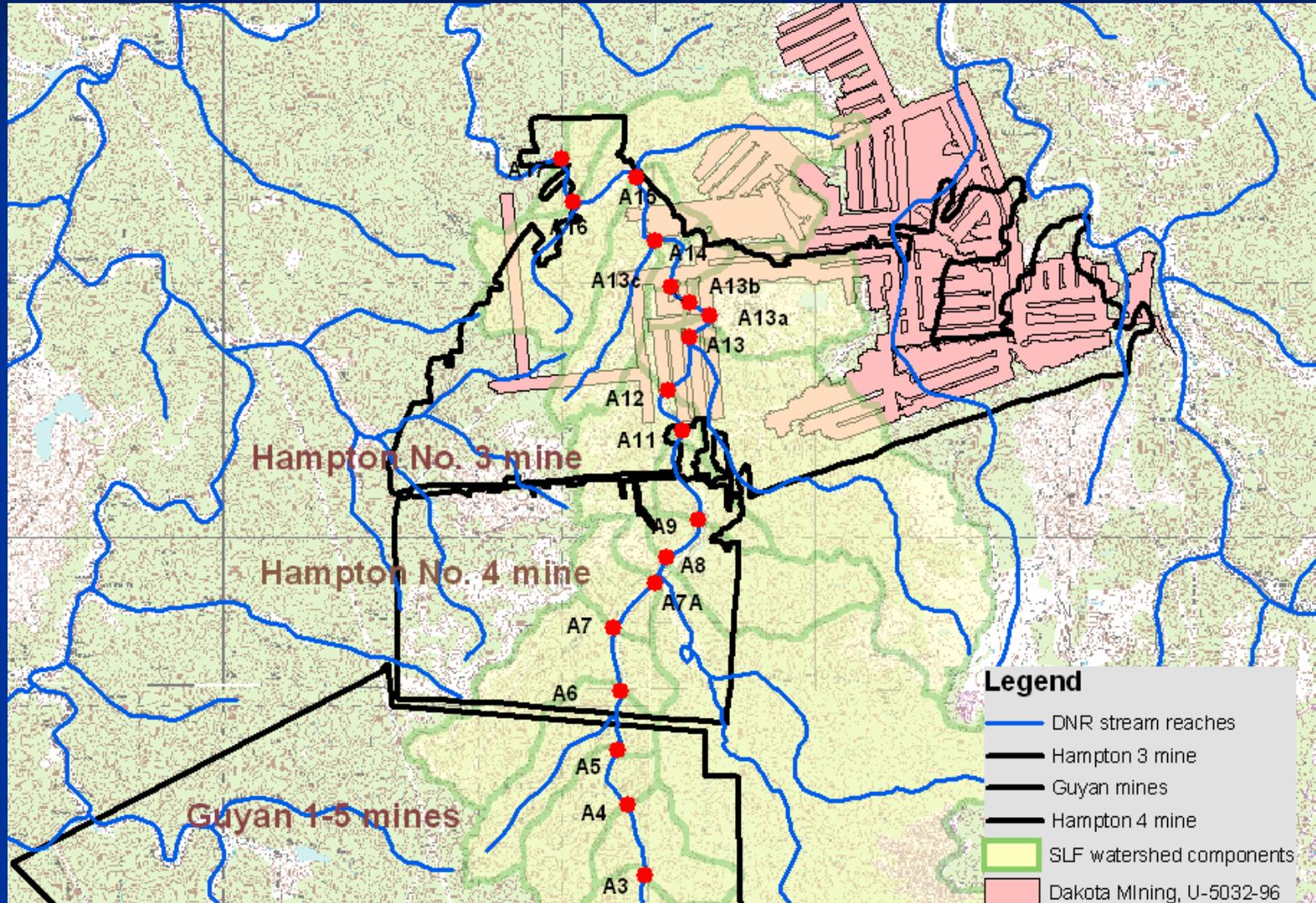


Water Quality - Expected Mean Concentrations from Landuse and Soils



NITROGEN	PHOSPHORUS	TSS	ZINC	BOD	COPPER	LEAD	CADMIUM	CHROMIUM	NICKEL
1890.00	9.00	166000.00	145.90	13300.00	17.30	12.00	0.70	4.90	5.40
2190.00	130.00	70000.00	26.80	4500.00	5.90	3.40	0.50	3.00	4.80
3410.00	240.00	201000.00	23.50	4200.00	5.40	3.10	0.50	2.90	4.70
790.00	6.00	39000.00	24.80	4300.00	5.60	3.20	0.50	2.90	4.70
3900.00	100.00	2200000.00	45.90	6400.00	8.30	5.00	0.50	3.50	5.00
790.00	6.00	39000.00	22.90	4100.00	5.30	3.00	0.50	2.80	4.70

WCMS Example: Analysis of Stream Dewatering/Underground Mining



WCMS - Historical Perspective

- Initial work toward what is now WCMS was initiated in 1990 and has continued to the present
- Primary Steps:
 - ArcInfo (AML) – estimated \$30-50,000/user
 - ArcView (Avenue) – estimated \$7-12,000/user
 - ArcGIS (Visual Basic) – lower cost
 - ArcGIS (.NET) – facilitate ease of integration with other models and systems

Data Development

- Scanned, georeferenced, and digitized mine permit maps for WV
- Completed development of 1:24K NHD
- Development of 1:4800 NHD in progress
- Developed improved land cover data for WV

WCMS - Current Development

- Major effort to improve the hydrologic modeling capabilities available to WVDEP/DMR
- Objective – develop appropriate models of flow for streams in the WV mining region
- Consider web based implementation through ArcGIS Server

Major Investment to Support the CHIA Process

- Since 2001, WVDEP support for WCMS related development focused on the CHIA process (partially supported by one time PECA funds from OSM)
- Supported the transition of WCMS from an ArcView to an ArcGIS application
- Current work concentrates on improved hydrologic and water quality models and integration with WVDEP Oracle databases

Summary

- WCMS remains a work in progress – capabilities continue to expand
- ArcGIS version now being used by WVDEP users
- Usefulness of advanced GIS modeling tools will continue to be data dependent
- Additional data tools developed by WVDEP/TAGIS significantly ease the integration of additional spatial datasets

Future Plans

- Continue to improve and expand capabilities of the ArcGIS WCMS extension
- Complete port of current Visual Basic version to Microsoft .Net environment
- Expand the capability to work with other models
 - supported in the .Net environment
- Incorporate additional tools
 - Mine planning tools are a priority