



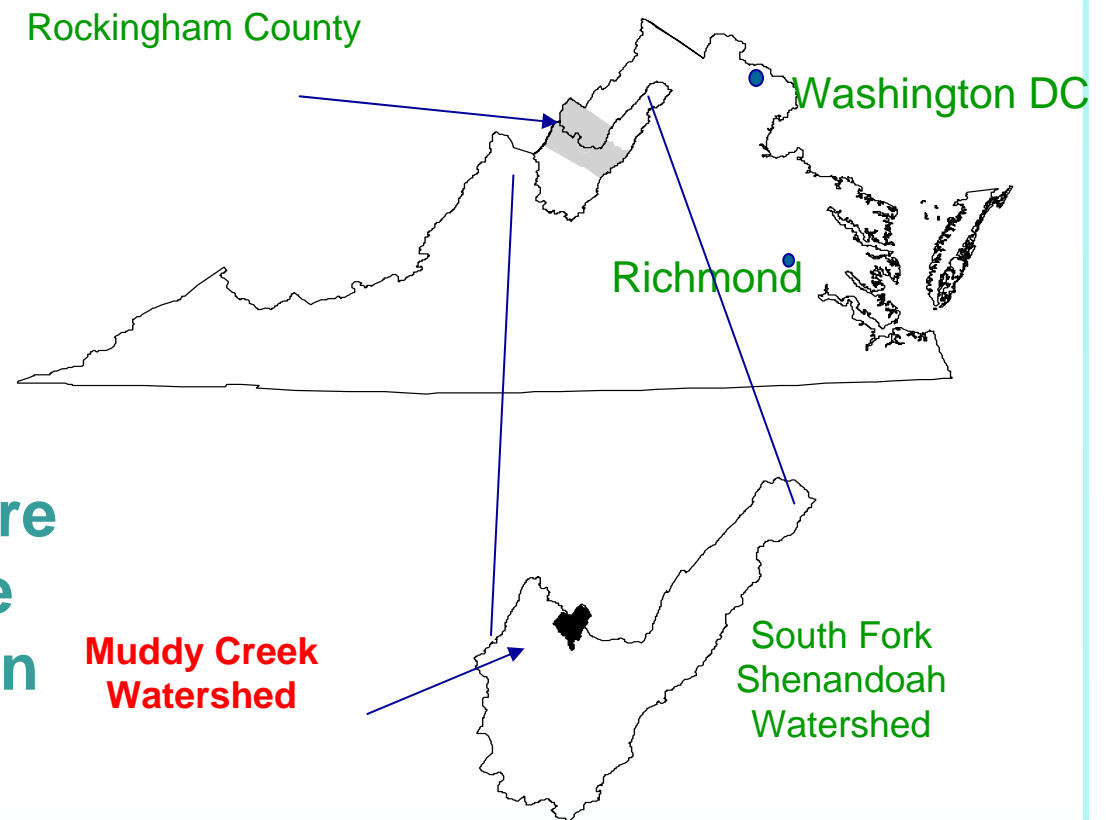
TMDL Case Study

Virginia - EPA Region 3

**Fecal Coliform Bacteria TMDL
Development for the Muddy Creek
Watershed**

Muddy Creek Watershed

- Located in northwestern Virginia
- Covers approximately 20,025 acres
- Primarily pasture land, with some forest and urban areas



Muddy Creek Watershed



Muddy Creek – Problem Statement

- Included on VA's 1998 303(d) list
- Impaired due to fecal coliform bacteria exceeding state water quality criteria
- Exceedances occur during both wet and dry weather conditions
- Most probable sources include wildlife, poultry waste, livestock, and septic systems

Background: Fecal Coliform Bacteria

- **Unicellular organisms**
- **Found in warm-blooded animal waste (humans, livestock, domestic pets, and wildlife)**
- **Monitored to indicate presence of pathogenic contamination**
- **Human health effects from pathogenic contamination can range from nausea and vomiting to acute respiratory illness, meningitis, and even death**

Muddy Creek - Water Quality Criteria

- **Fecal coliform bacteria criteria in the state of Virginia are:**
 - **1,000 fecal coliform per 100 ml**
 - not to exceed at any time
 - **200 fecal coliform per 100 ml as a geometric mean**
 - not to exceed, based on 2 or more samples over 30 days

Impairment Analysis

- **In-stream water quality data inventory**
- **Impairment confirmation**
 - **Magnitude of impairment**
 - **Frequency**
- **Seasonal patterns**
- **Background conditions**
- **Identification of data sets to support modeling**

Long-term Water Quality Monitoring – VA DEQ

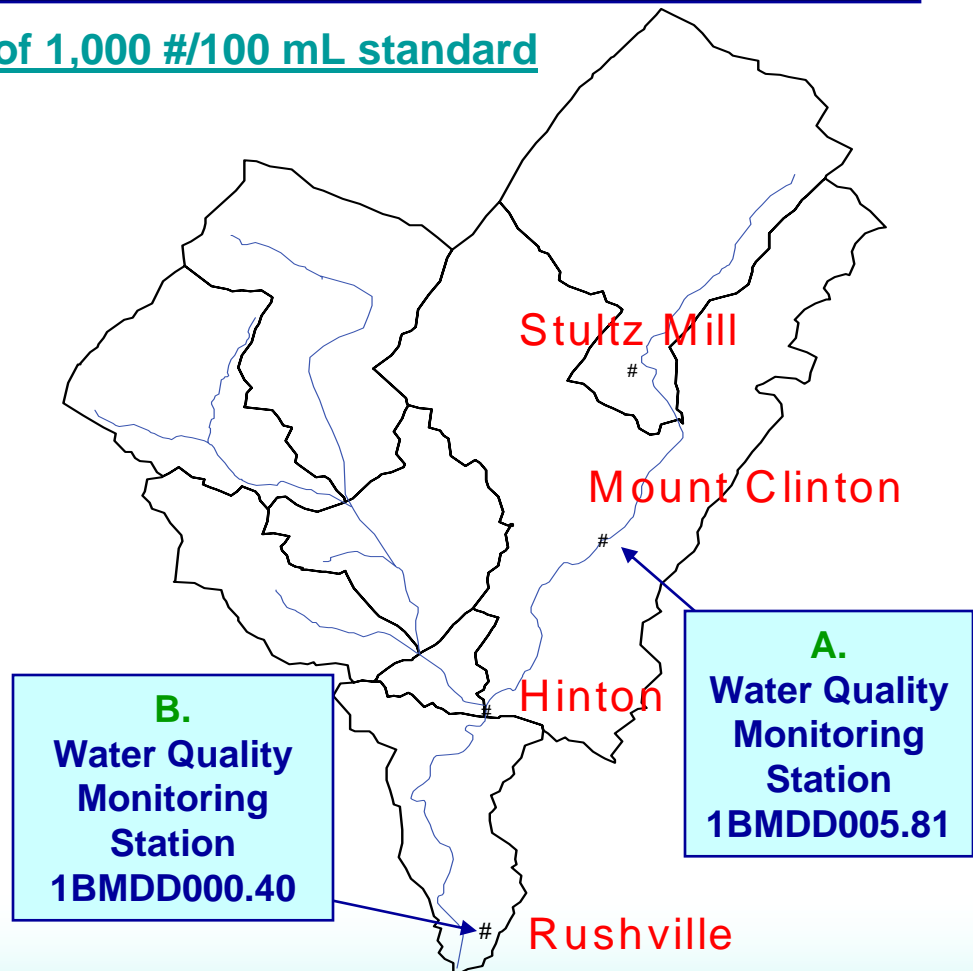
Violations of 1,000 #/100 mL standard

A.

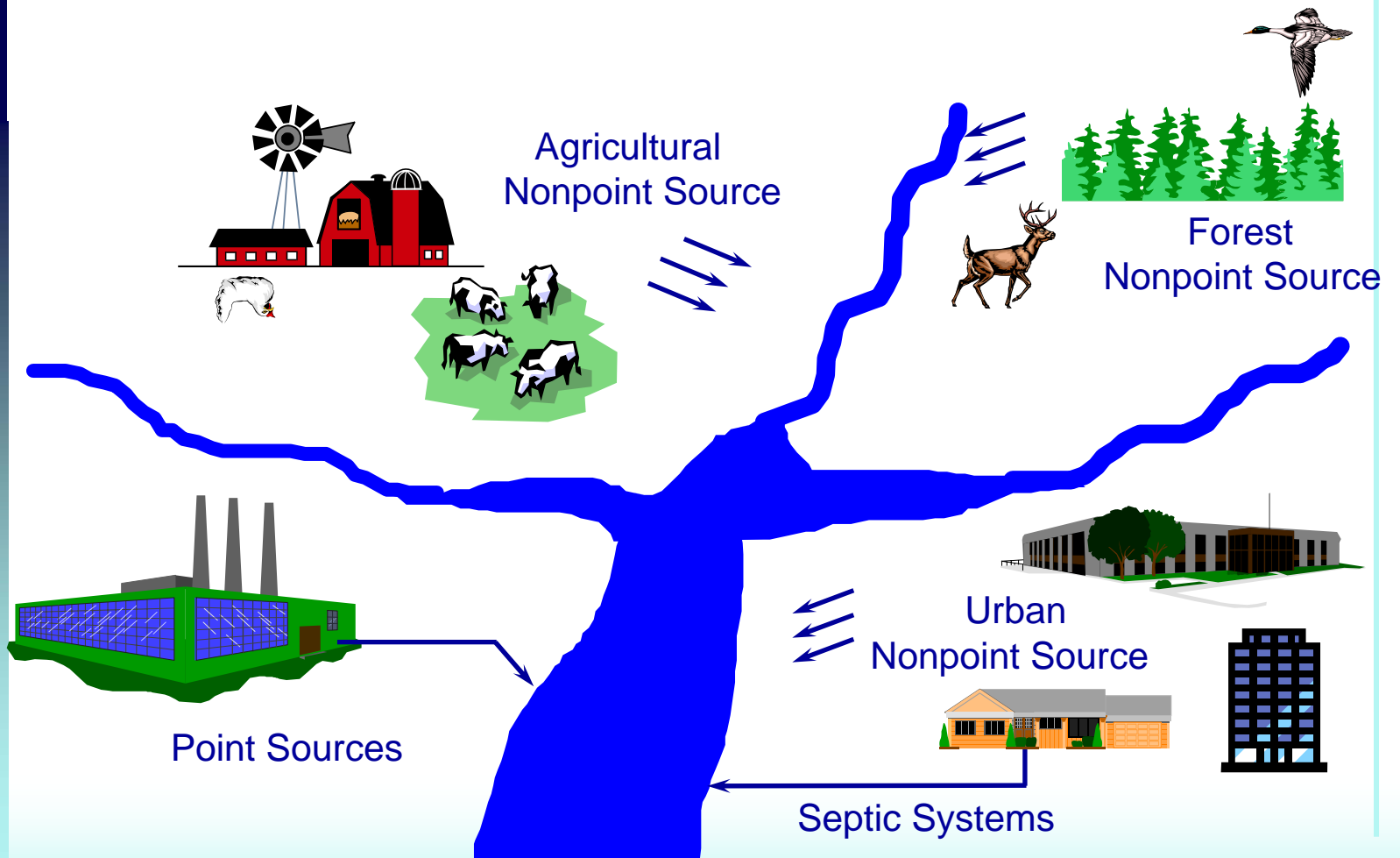
	% Violating	# Samples
1993	75%	4
1994	69%	13
1995	77%	13
1996	58%	12
1997	75%	12
1998	83%	6
Total	72%	60
Maximum	>16,000	
Minimum	20	
Median	3,300	

B.

	% Violating	# Samples
1992	60%	5
1992	75%	12
1993	67%	12
1994	62%	13
1995	69%	13
1996	67%	12
1997	83%	12
1998	83%	6
Total	71%	85
Maximum	>16,000	
Minimum	45	
Median	3,500	



Fecal Coliform Sources



Source Assessment

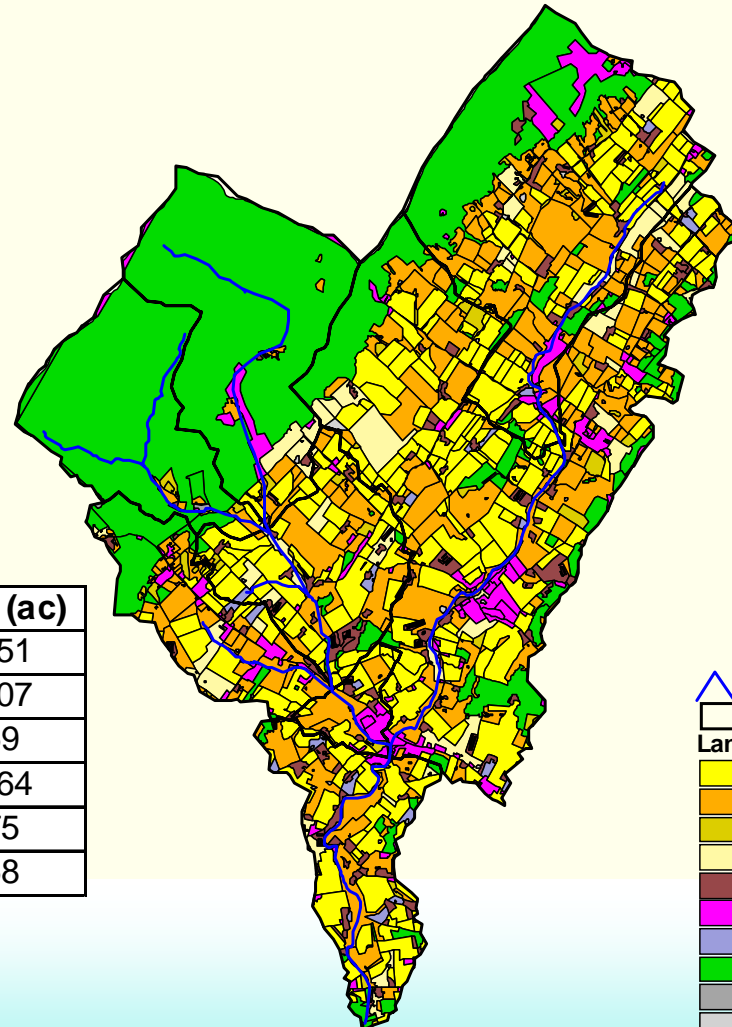
- **Nonpoint Sources**

- **Agriculture**
 - Cropland/hayland (application of cow manure and poultry litter)
 - Pasture and loafing lots (animal grazing and feeding)
 - Beef cattle, dairy cows, hogs, sheep, turkeys
- **Wildlife**
 - Key wildlife contributions
 - Deer
 - Other small animals (beaver, muskrat, raccoon, etc.)
- **Urban**
 - Built-up land areas (pets, waste products)
 - Septic systems













- **Point Sources**

- Wampler Facility discharge
- Mt. Clinton Elementary School

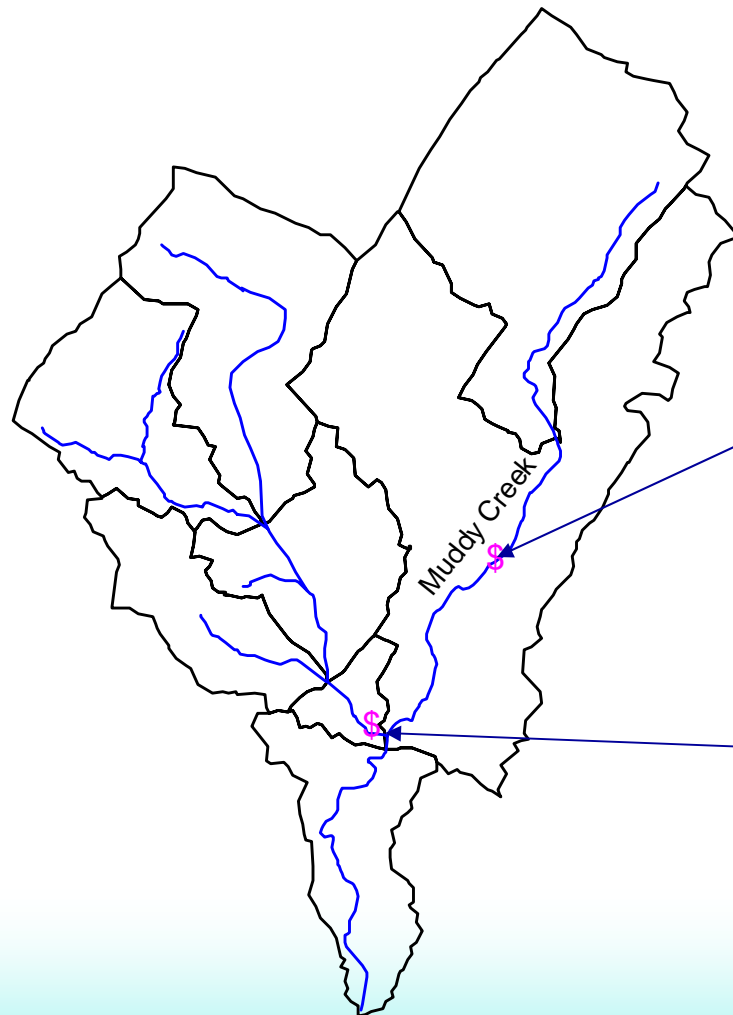
Landuse Distribution



Landuse	Area (ac)
Cropland and Hay	5,151
Pasture Land	6,007
Feedlots (Loafing)	159
Forestland	6,864
Farmstead	875
Urbanized/Housing	958

-  Reach File Version 3 (U.S. EPA)
-  Muddy Creek Subwatersheds
- Land Use**
-  Cropland
-  Pasture 1
-  Pasture 2
-  Pasture 3
-  Farmstead
-  Build-up
-  Loafing Lots
-  Forest
-  Barren
-  Unclassified

Point Source Locations



**Mount Clinton
Elementary School**

Negligible Flow

Wampler Foods

1990 - 1998 DMR Data
Flow (mean) = 0.47 cfs
Fecal Coliform (mean) = 3.5
Fecal Coliform (max) = 54.8

Source-response Linkage

- **Selected HSPF model to address following requirements:**
 - **Examine effects of both point and nonpoint sources**
 - **Quantify source loading under existing and hypothetical/management conditions**
 - **Examine in-stream conditions under various loading scenarios**
 - **Compare estimated in-stream concentrations to geometric mean-based water quality criteria**
 - **Identify critical periods when exceedances occur**
 - **Define a load reduction plan that best meets the water quality standard**

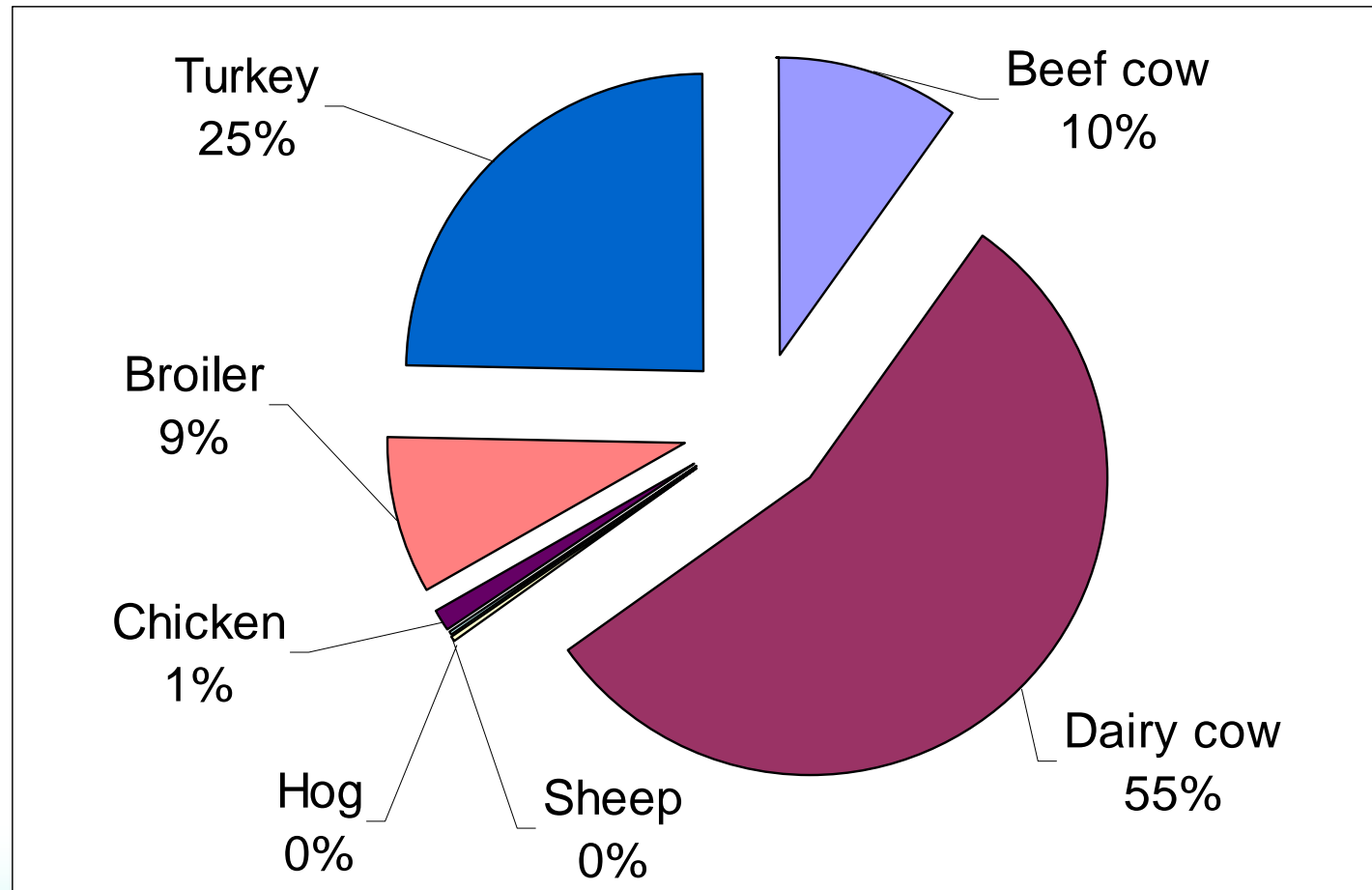
Modeling Approach

- **Configure model to represent all sources**
- **Calibrate hydrology (flow) and water quality (fecal coliform) for historical conditions**
- **Evaluate loading scenarios that meet the fecal coliform criteria**
 - **assess how changes in source loads impact in-stream conditions**
 - **provide information for exploring opportunities in improved management practices**
- **Complete the TMDL Equation for a successful scenario, i.e. allocate source loads**

Source Loading Analysis

- **Represent fecal coliform sources and loading pathways (contribution mechanisms)**
 - **direct inputs**
 - **runoff/wet weather inputs**
 - **dry weather inputs**
- **Source loading estimation**
 - **estimate nonpoint source loading, e.g. fecal coliform content in waste produced by animals**
 - **estimate point source loadings, based on discharge monitoring data**

Waste Production by Animal



Waste Usage on Agricultural Lands

- **Poultry Litter**
 - Cropland: 5 tons/acre/year
 - Pasture: 4 tons/acre/year
- **Liquid manure (confined dairy cows)**
 - Cropland: 6,600 gal/acre/year
 - Pasture: 3,900 gal/acre/year
- **Direct waste contributions**
 - Pasture
 - Grazing cattle (beef and dairy)
 - Unhoused turkeys
 - Sheep

Critical Influence: Grazing Cattle in Waterbodies

- **Monitoring sweep identified high fecal concentrations during low-flow conditions**
- **Field survey verified presence of cattle within waterbodies**



Hydrology Calibration

- Adjusted model parameters to match model output with flow observations
- **Methods:**
 - **Temporal Plots/Comparisons**
 - Annual
 - Monthly
 - Weekly
 - Daily
 - Hourly
 - **Flow-frequency Curves**
 - **Linear regression**
 - **Statistical Comparisons**
 - 50% Lowest Flows
 - 10% Highest Flows

Fecal Coliform Calibration

- **Analytical Considerations:**
 - **Annual loading (overall amount)**
 - **Seasonal variability**
 - **Concentrations during storms**
 - loading as it relates to antecedent conditions
 - rising and falling limb of hydrograph
 - peak concentration
 - **Interflow and groundwater components**
 - **Source contributions**
- **Used similar comparison methods to hydrology calibration**

Source-Response Analysis

- **Adjusted individual sources and evaluated response**
- **Considered dry and wet weather sources separately**
- **Major source categories evaluated:**
 - **cropland**
 - **pasture**
 - **direct discharges from livestock to streams**
 - **point source discharges**



Allocation Analysis

Allocation Steps:

- **Applied the model to existing conditions**
- **Applied to existing conditions with point sources at permit limits**
- **Applied model to future conditions**
- **Developed and tested allocation scenarios**
- **Selected final TMDL scenario**

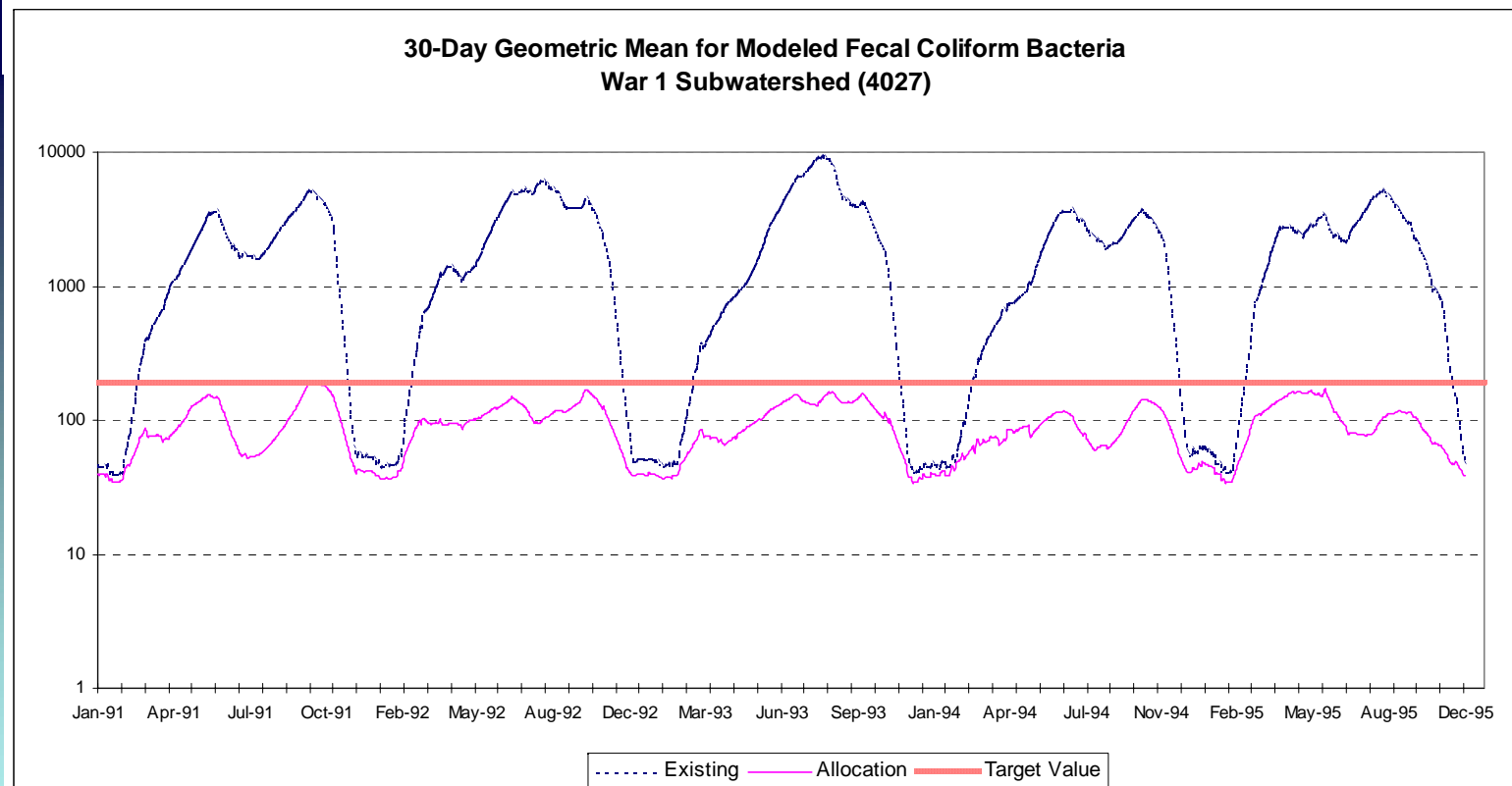
Developing Scenarios

- Define magnitude of sources
- Examine sensitivity of waterbody response to changes in individual sources
- Develop roadmap for control opportunities
- Show results to stakeholders/public

Key Considerations in the Allocation Analysis

- Selection of where the TMDL is calculated and the location of individual allocations
- Grouping of sources for allocation
- Identification of background condition
- Determination of the season or time period for the allocation
- Expression of the TMDL

Successful Loading Scenario



Allocations

Point Sources

Wampler Foods:

Existing Load: 8.34×10^8 counts/day
 Allocated Load: 8.34×10^8 counts/day
 Percent Reduction: 0%

Mount Clinton Elementary School:
 assumed negligible
 (no allocation)

Nonpoint Sources

Source	Total Annual Loading for Existing Run (counts/year)	Total Annual Loading for Allocation Run (counts/year)	Percent Reduction
<i>Diffuse nonpoint sources</i>			
Built-up	1.88E+10	1.88E+10	0%
Farmstead	1.78E+10	1.78E+10	0%
Forest	7.33E+10	7.33E+10	0%
Barren	1.32E+08	1.32E+08	0%
Cropland	2.48E+11	2.16E+11	13.10%
Loafing lots	4.11E+12	8.08E+11	80.30%
Pasture 1	1.72E+12	1.01E+12	41.30%
Pasture 2	2.19E+11	1.28E+11	41.80%
Pasture 3	3.34E+12	1.94E+12	42.00%
<i>Subtotal</i>	<i>9.75E+12</i>	<i>4.21E+12</i>	<i>56.80%</i>
<i>Direct nonpoint sources</i>			
In-stream cattle	5.82E+14	4.14E+12	99.30%
Failing septic systems	7.72E+11	0	100%
Uncontrolled discharges	8.12E+13	0	100%
<i>Subtotal</i>	<i>6.64E+14</i>	<i>4.14E+12</i>	<i>99.40%</i>
TOTAL	6.73E+14	8.35E+12	98.80%

Implementation

- VA will install a phased implementation process
- This allows for evaluation of management practice effectiveness and refinement of the model, as necessary
- Target for first phase: 10% or less violation of the 1,000 #/100 ml criteria
- First phase assumes reduction of most critical and manageable contribution (in-stream cattle)
- Cornerstone of plan is to cultivate shared sense of responsibility for reducing pollution, build partnerships, foster voluntary implementation

Creating the Implementation Plan -- Public Participation

- **Public Meetings**
 - TMDL development – three meetings held
 - Implementation Plan development -- additional meetings held
- **Focus Groups**
 - Agricultural (livestock producers)
 - Residential/Commercial (homeowners, septic contractors)
 - Environmental
 - Governmental (local and state govt. representatives, industry organizations)
- **Steering committee**
 - Consisted of members from each focus group

Public Participation – Public Meetings

- **High degree of public involvement and proactive management response**
- **Three public meetings for TMDL**
 - **Pre-modeling - to introduce TMDL process and data available**
 - **Modeling - to present model set-up and watershed representation**
 - **Allocation phase – to present TMDL allocation scenarios**
- **>1,100 man-hours devoted to public participation in developing Implementation Plan**

Public Participation – Focus Groups

- **Agricultural, Residential, Commercial, Environmental**
 - Identify obstacles to implementation in respective community
 - Identify workable solutions to overcome obstacles
- **Governmental**
 - Identify regulatory authority in specific areas related to implementation
 - Identify existing programs/funding sources to aid implementation

Public Participation – Steering Committee

- **Responsible for formulation of TMDL implementation plan**
 - **Identify practical control measures**
 - **Establish time line**
 - **Set measurable goals and milestones**



Focus Group Emphasis

Highlighted:

- **BMP Specifications**
- **Locations of Control Measures**
- **Funding**
- **Education and Technical Assistance**
- **Timeline**

Example Focus Group Recommendations

- **Recommended education and technical assistance strategies**
- **Agriculture**
 - program of small workshops
 - farm visits
- **Residential**
 - small workshops on importance of septic system maintenance,
 - educational packets for new homeowners,
 - Stream walks to identify failing septic systems followed by targeted outreach to homeowners on options for corrections