

# Integrated Multi-disciplinary Modeling Capabilities

**FRAMES, MRA-IT, D4EM,  
MapWindow, SuperMUSE**

**Ecosystems Research Division**  
National Exposure Research Laboratory  
Office of Research and Development  
U.S. Environmental Protection Agency

October 16, 2009



RESEARCH & DEVELOPMENT

*Building a scientific foundation for sound environmental decisions*

# Acknowledgements

- John Ravenscroft (OW-HECD)
- Mitch Pelton (Battelle, Pacific Northwest Division)
- Jeff Soller (Soller Environmental)
- Lourdes Prieto (ORD-ERD)
- Multimedia Ecosystem Exposure Research Team (ORD-ERD)

# Discussion Topics

- Demonstrate FRAMES (using a pathogen example)
- Demonstrate the linkage of MRA-IT to FRAMES through an example QMRA
- Explain how this relates to the APES Integrated Modeling Regional Assessment



# Definitions

- **FRAMES: Framework for Risk Analysis in Multimedia Environmental Systems**
  - facilitates the seamless linking and execution of individual models
  - automates what one already does by hand
- **D4EM: Data for Environmental Modeling**
  - accesses, retrieves, and processes (including Geo-processing) data for integrated modeling systems
- **SuperMUSE: Supercomputer for Model Uncertainty and Sensitivity Evaluation**
  - facilitates the execution of modeling systems across a clustered network of PCs



# Definitions

(cont'd)

- **MapWindow**

- provides geospatial mapping tools
- is a free, extensible, geographic information system (GIS) that provides open source GIS (mapping) applications and a set of programmable mapping components

- **MRA-IT: Microbial Risk Assessment - Interface Tool**

- takes pathogen concentration data at receptor locations, dose-response relationships, and various pre-defined exposure scenarios and performs static (individual-based) or dynamic (population-based) risk characterization from exposures to **reclaimed waters** containing pathogens and/or interactions with people infected by pathogens (Soller et al. (2008))

- **QMRA: Quantitative Microbial Risk Assessment**

- estimates human health risks due to exposures to microbial pathogens



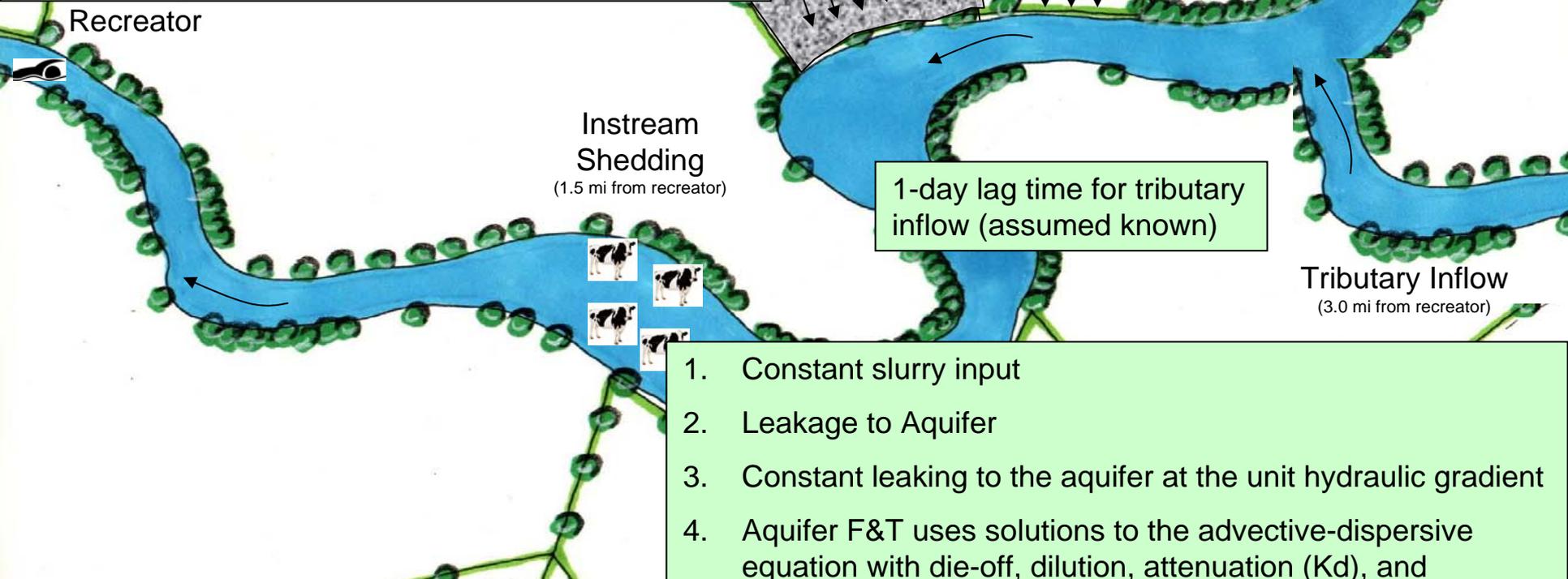
# Example Problem



1. Ten 1-yr, 24-hr rainfall events per year
2. Instream F&T uses solutions to the advective-dispersive equation with die-off, dilution, and dispersion
3. Recreators exposed 1.5 to 3.0 miles downstream of various sources

- 1 Land application of pond contents 4 times a year
- 2 Overland routing using Kinematic Wave Equations

1. 360 grazing cows (2 cows/ac on 180 ac)
2. Shedding 24 kg/d/cow
3. Overland routing using Kinematic Wave Equations

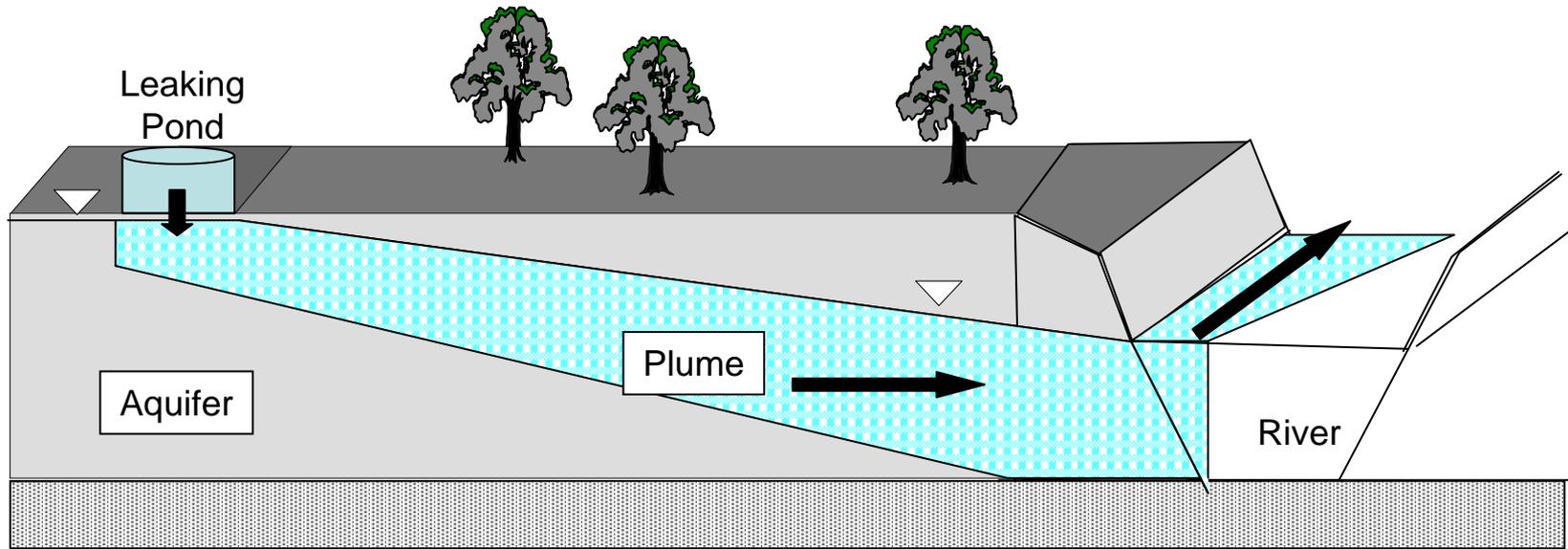


1. Constant slurry input
2. Leakage to Aquifer
3. Constant leaking to the aquifer at the unit hydraulic gradient
4. Aquifer F&T uses solutions to the advective-dispersive equation with die-off, dilution, attenuation ( $K_d$ ), and

1. Constant and direct shedding to stream for 10% of cows
2. Shedding of 24 kg/d/cow

directly to stream during each rainfall event

# Leaking Pond to an Aquifer



# FRAMES Demo



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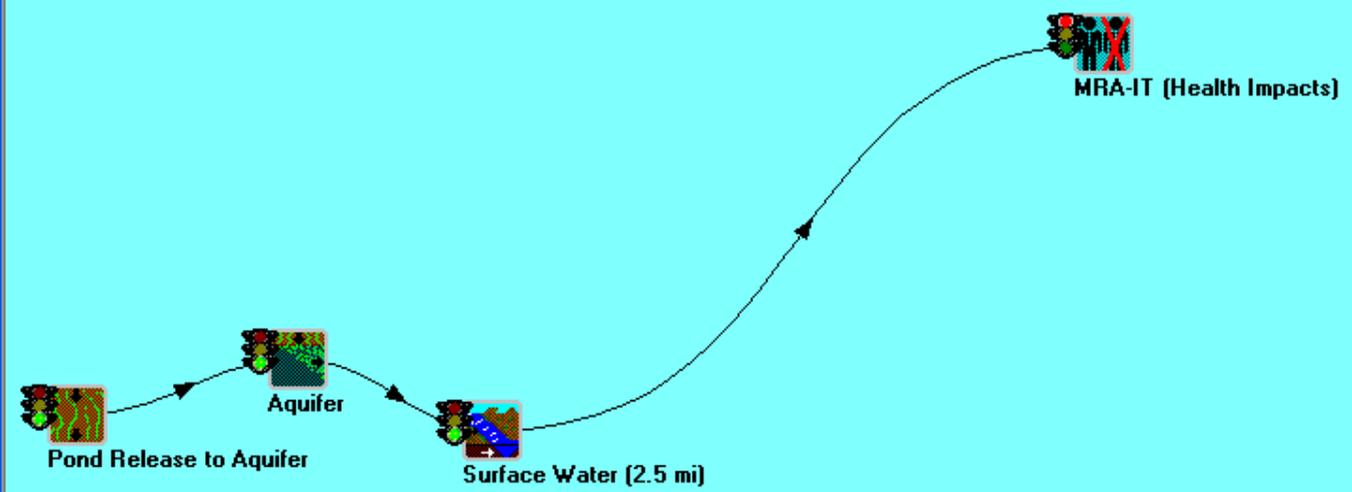
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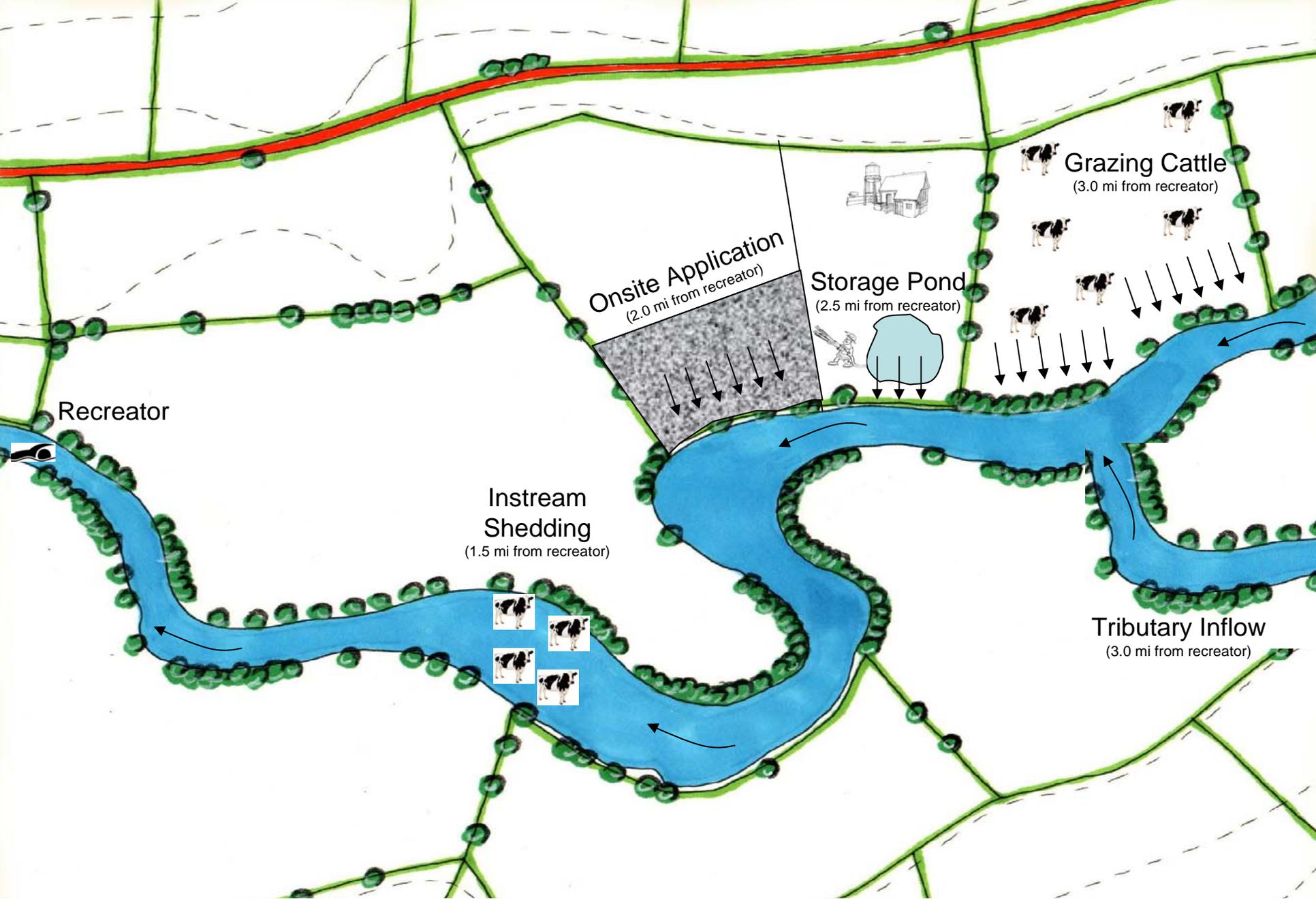


Pathogen Database GIS

- Database
  - Distribution
  - GIS
  - Constituent
  - Aquatic Benchmarks
  - Aquatic Organism Selector
- Model
  - Example
  - Fate & Transport
    - Air
    - Surface Water
    - Aquifer
    - Source
    - Vadose Zone
    - Overland Flow

Pond Leaking to an Aquifer, migrating to a Stream, then being transported to a downstream Receptor





Recreator

Onsite Application  
(2.0 mi from recreator)

Storage Pond  
(2.5 mi from recreator)

Grazing Cattle  
(3.0 mi from recreator)

Instream  
Shedding  
(1.5 mi from recreator)

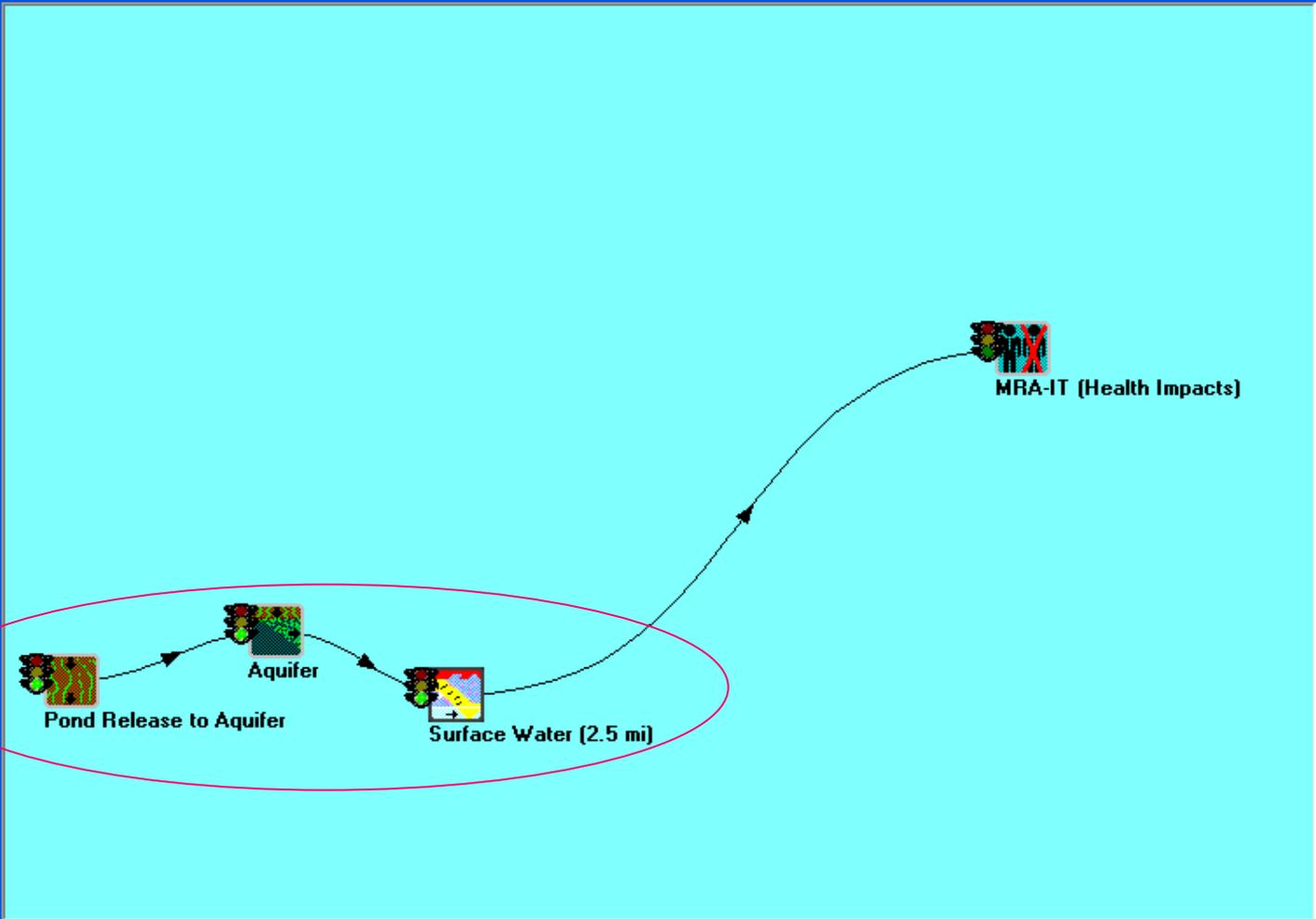
Tributary Inflow  
(3.0 mi from recreator)





Pathogen Database      GIS

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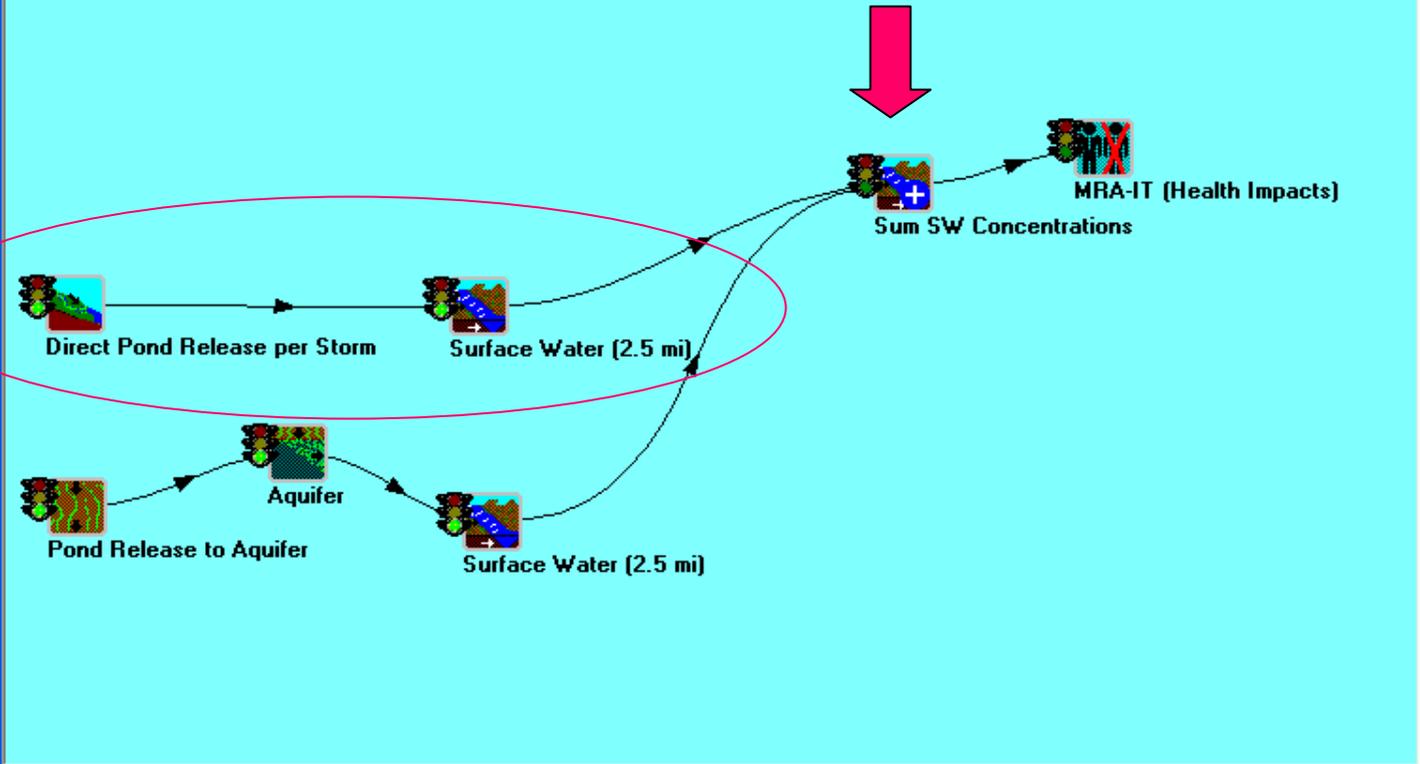


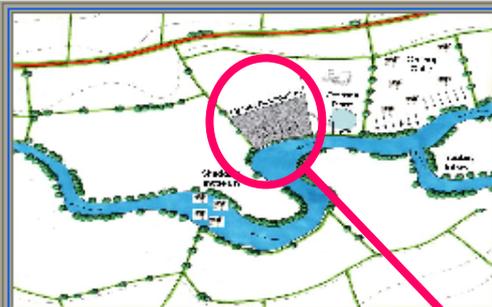


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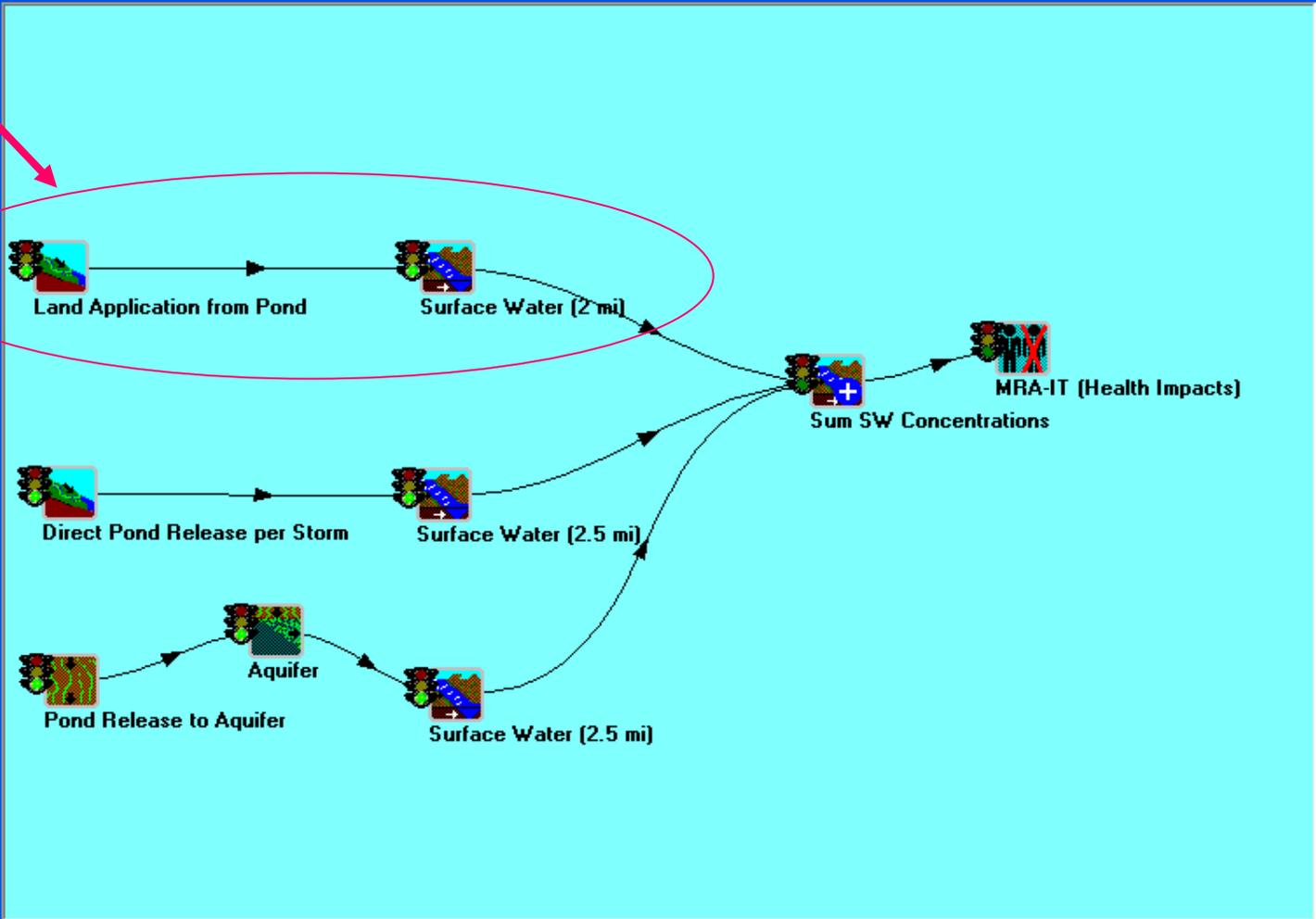
Linear superposition of multiple inputs at receptor location





Pathogen Database GIS

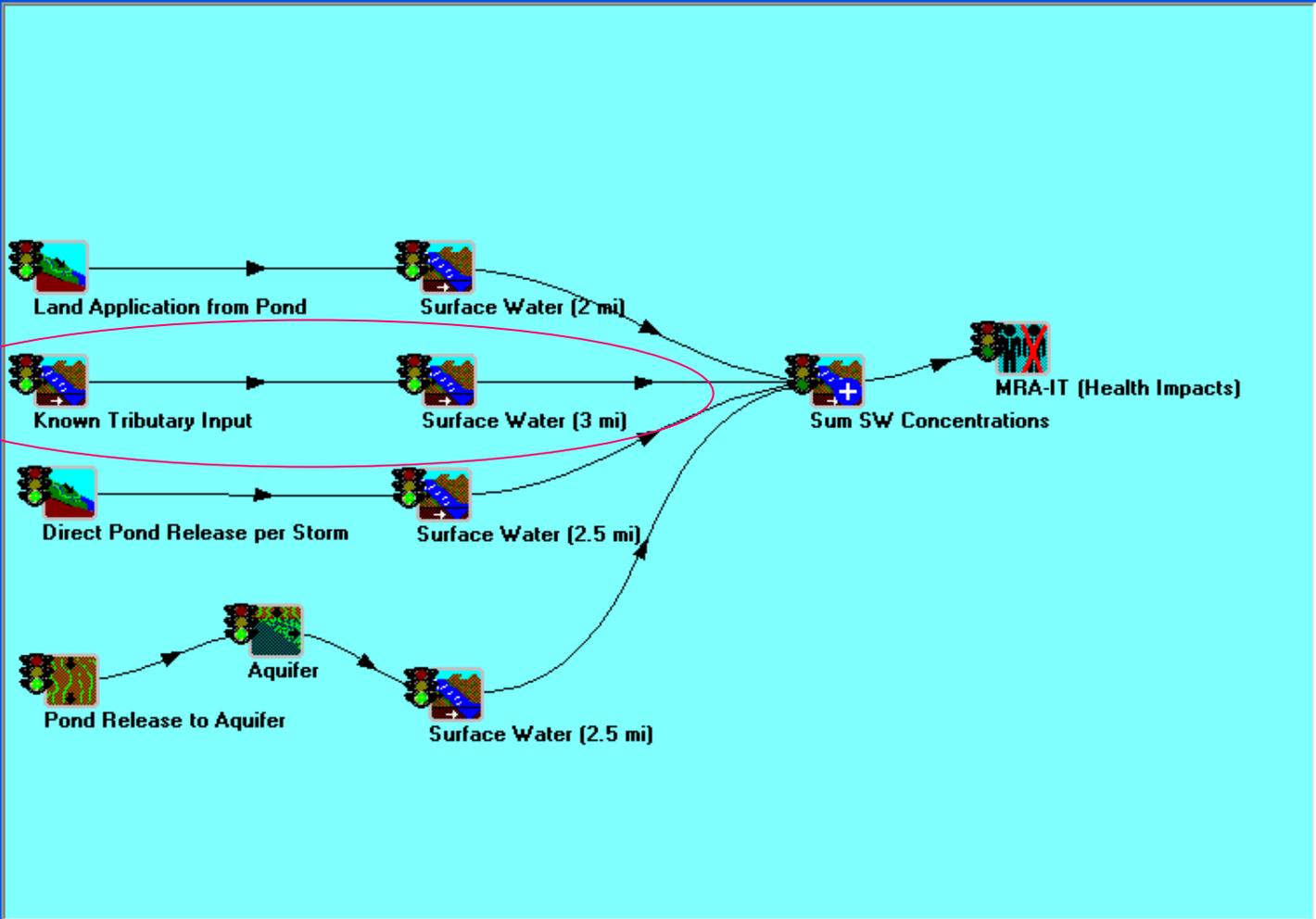
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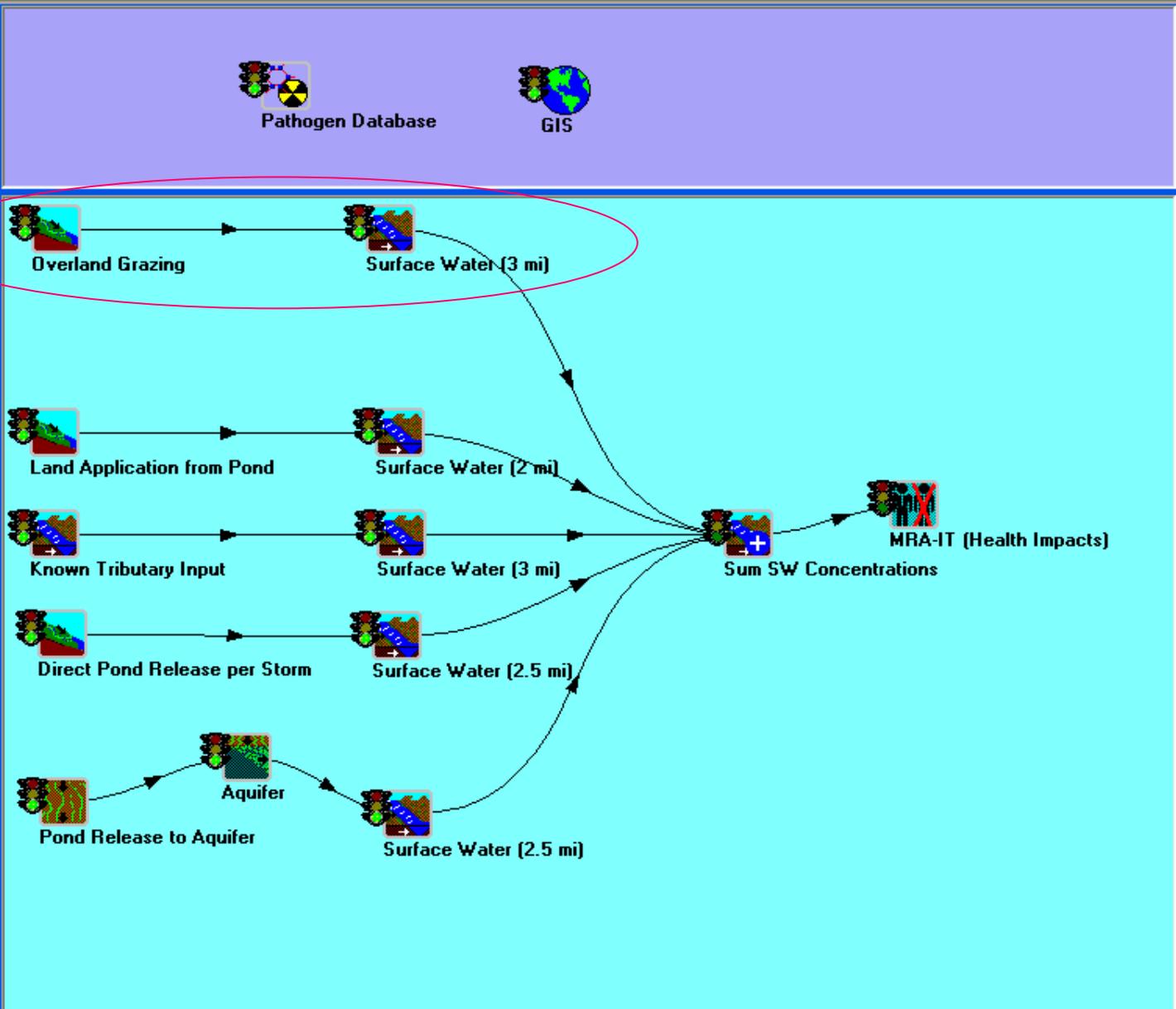
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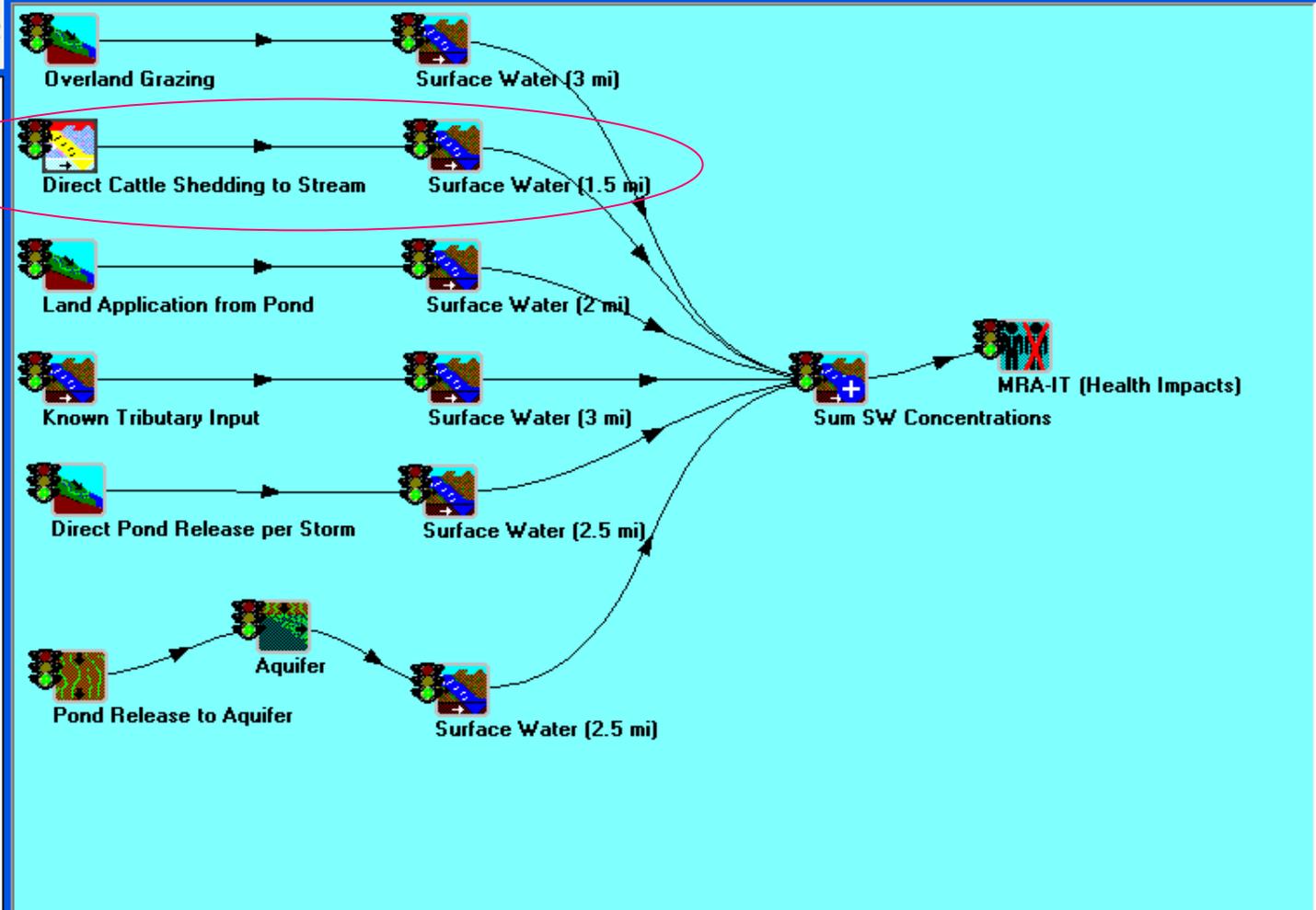
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Pathogen Database GIS



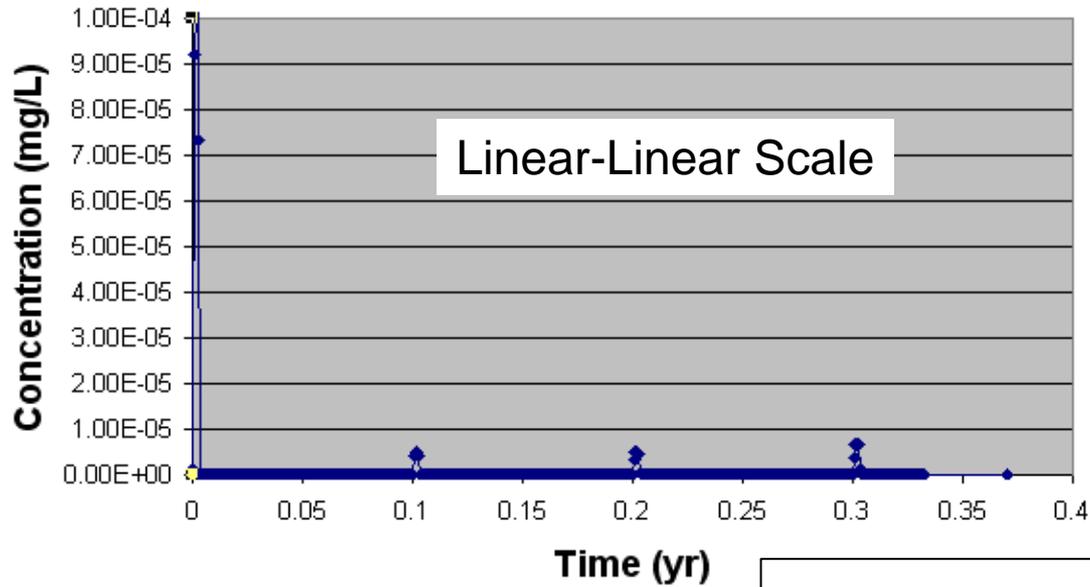
# FRAMES Demo



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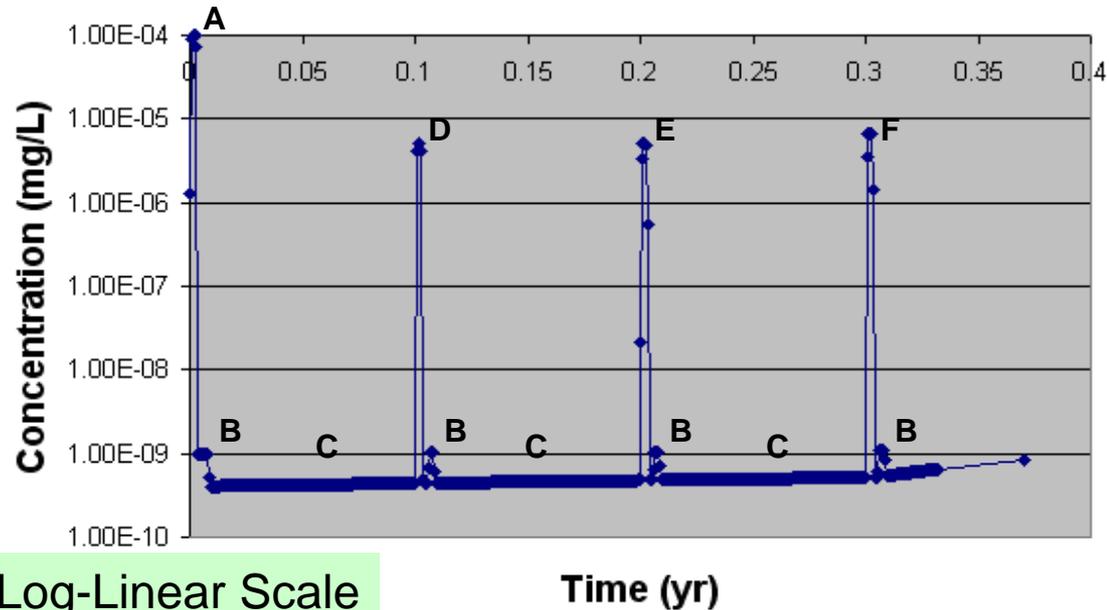
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Combined Results at the Receptor  
Surface water Constituent Concentration for Cryptosporidium (Crypto)



# Combined Results at Receptor for Cryptosporidium

Combined Results at the Receptor  
Surface water Constituent Concentration for Cryptosporidium (Crypto)



## Sources of Contamination

- A 95% Land Application, 5% Pond Overflow
- B 60% Tributary, 40% Shedding
- C 90% Shedding, 10% Leaking Pond
- D 99% Pond Overflow, 1% Land Application
- E ~100% Pond Overflow, 0.06% Grazing
- F 78% Pond Overflow, 22% Land Application

# Microbial Risk Assessment Interface Tool (MRA-IT)

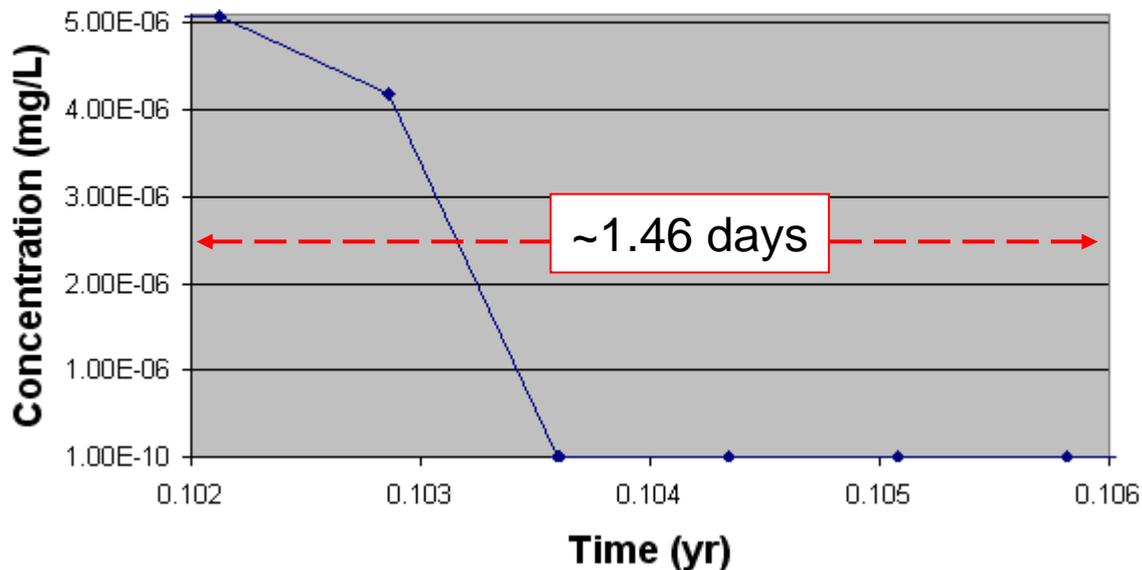
- Designed for **Reclaimed Water** analysis
- Performs both static (individual-based) or dynamic (population-based) risk characterization
- Accepts pathogen data in the form of #/L
- Assumes that input data of raw or treated wastewater can reasonably fit a lognormal or Weibull distribution
- Not specifically designed to explicitly handle temporal or spatial variability



### Event Window for MRA-IT Input

Combined Results at the Receptor

Surface water Constituent Concentration for Cryptosporidium (Crypto)



## Purpose

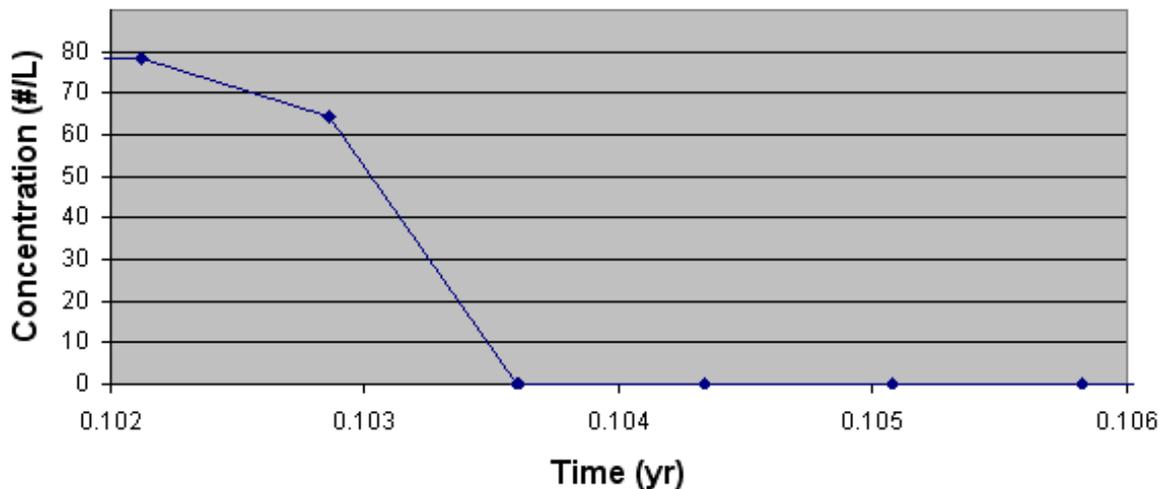
Demonstrate that MRA-IT can

1. be linked to FRAMES
2. communicate with FRAMES (e.g., UI)
3. consume upstream input data from fate and transport models

### Event Window for MRA-IT Input

Combined Results at the Receptor

Surface water Constituent Concentration for Cryptosporidium (Crypto)



Conversion used for Example

1 Cryptosporidium weighs 6.468E-11 g

# Execute MRA-IT from within FRAMES



# Regional Assessments

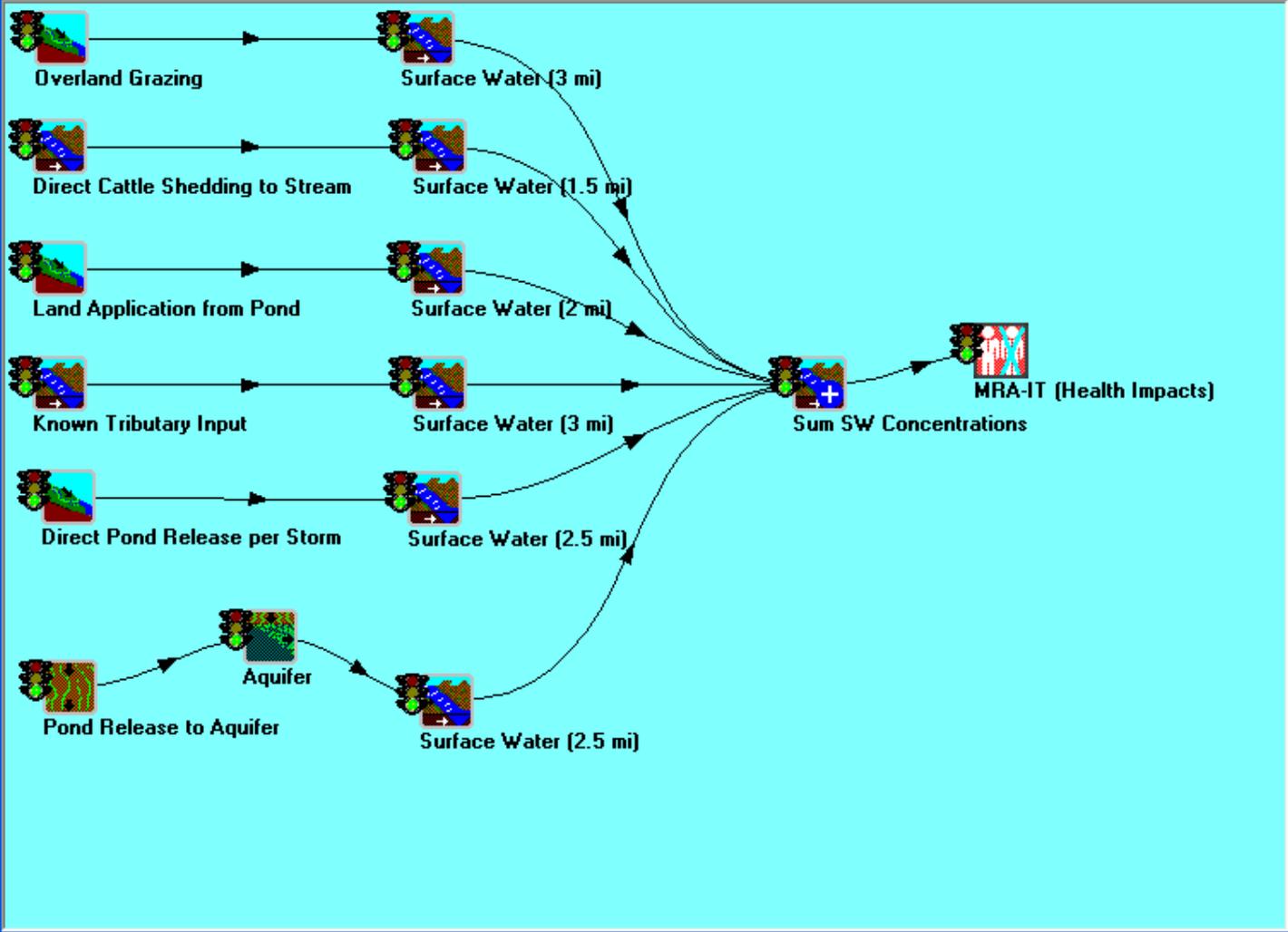
How does one take a site-specific assessment and up-scale the system to perform a regional assessment?

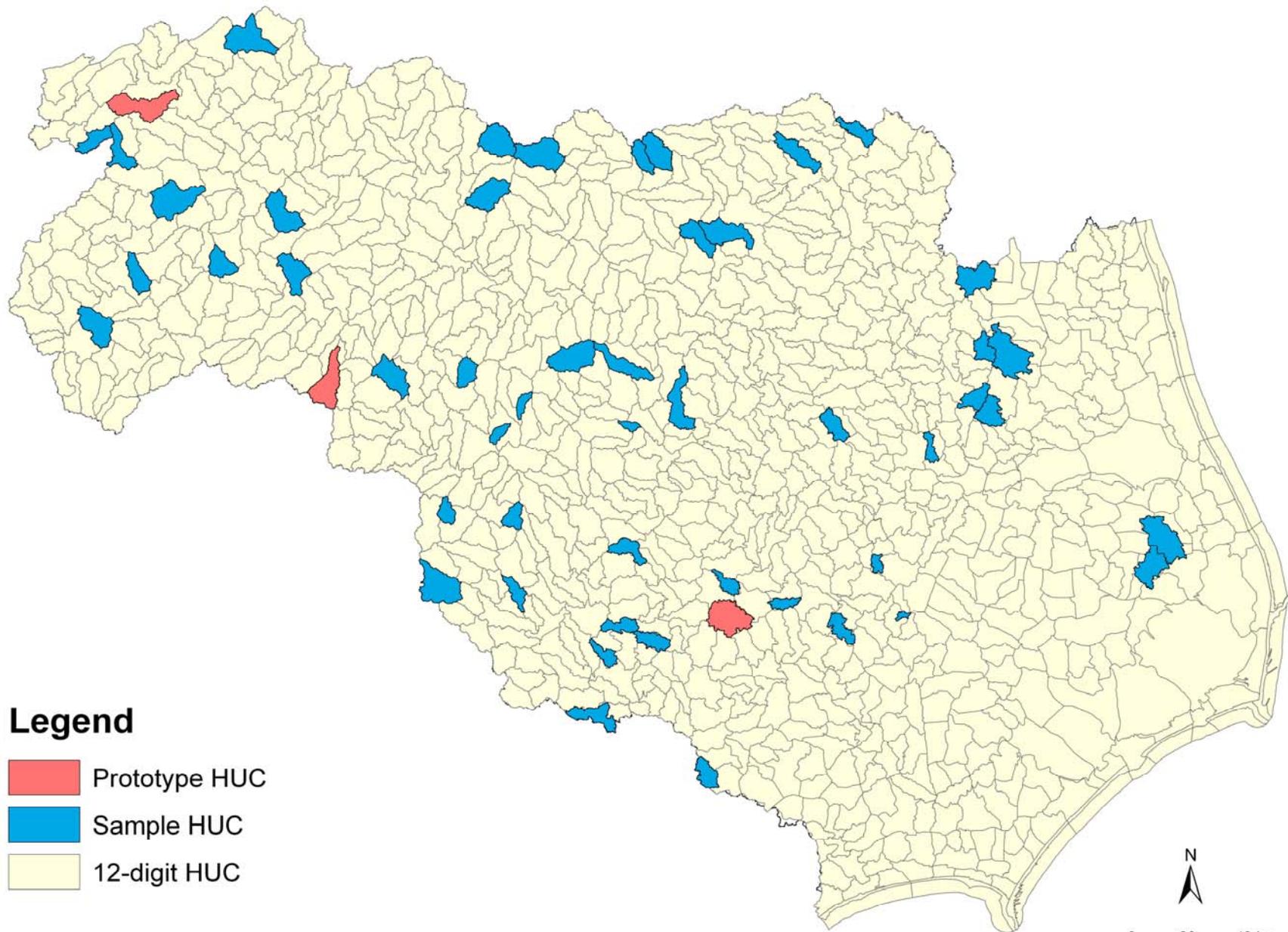




Pathogen Database  GIS 

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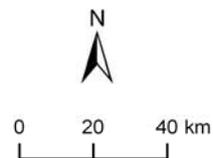


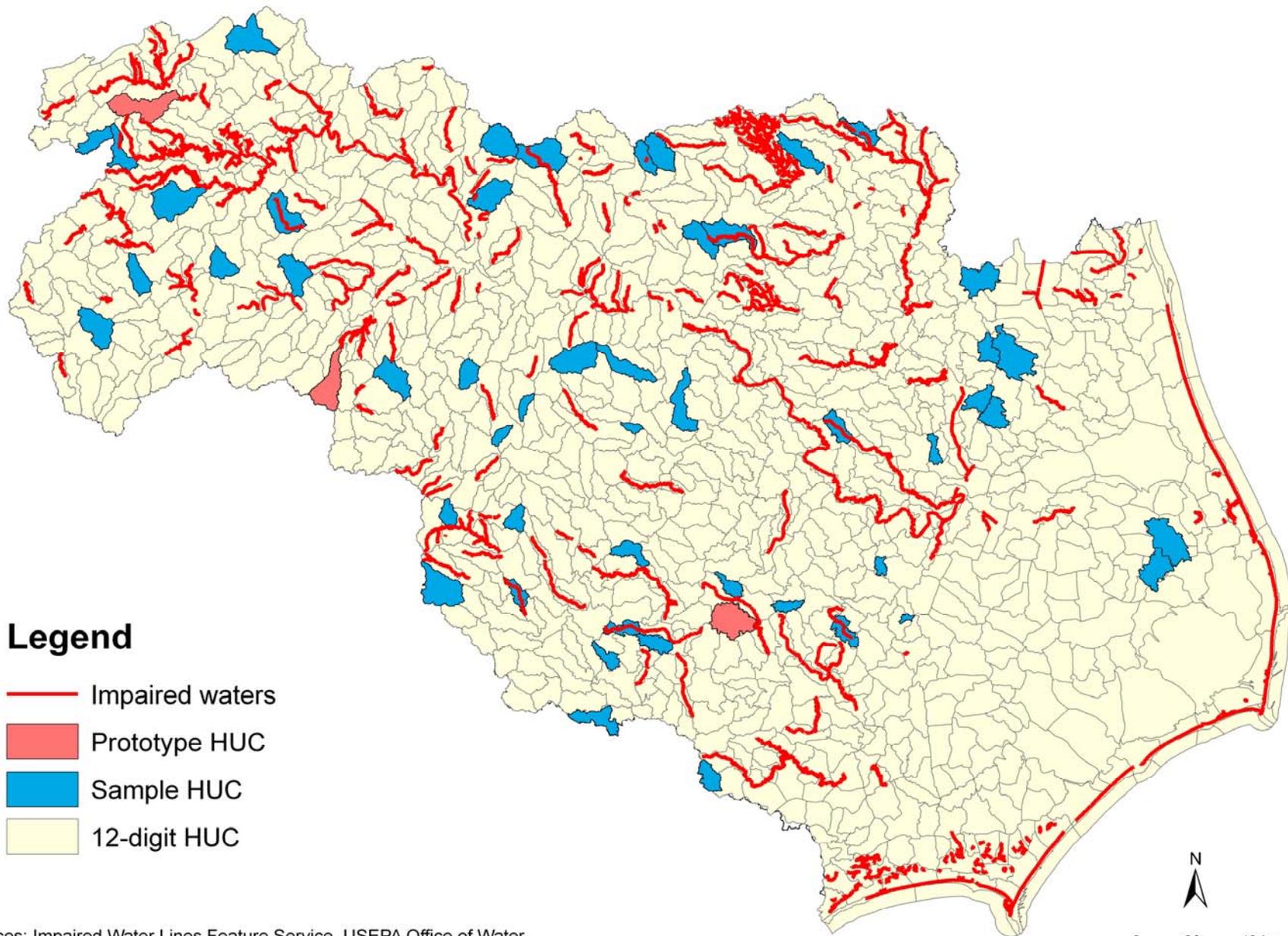


## Legend

- Prototype HUC
- Sample HUC
- 12-digit HUC

Source: 12-Digit Watershed Boundary Data 1:24,000, U.S. Department of Agriculture-Service Center Agencies

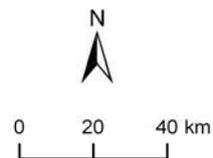




## Legend

- Impaired waters
- Prototype HUC
- Sample HUC
- 12-digit HUC

Sources: Impaired Water Lines Feature Service, USEPA Office of Water  
12-Digit Watershed Boundary Data 1:24,000, U.S. Department of Agriculture-Service Center Agencies



## Legend

### Poultry farms (Synthesized)

● Broilers

● Ducks, Geese, and Other

● Layers

● Pullets

● Turkeys

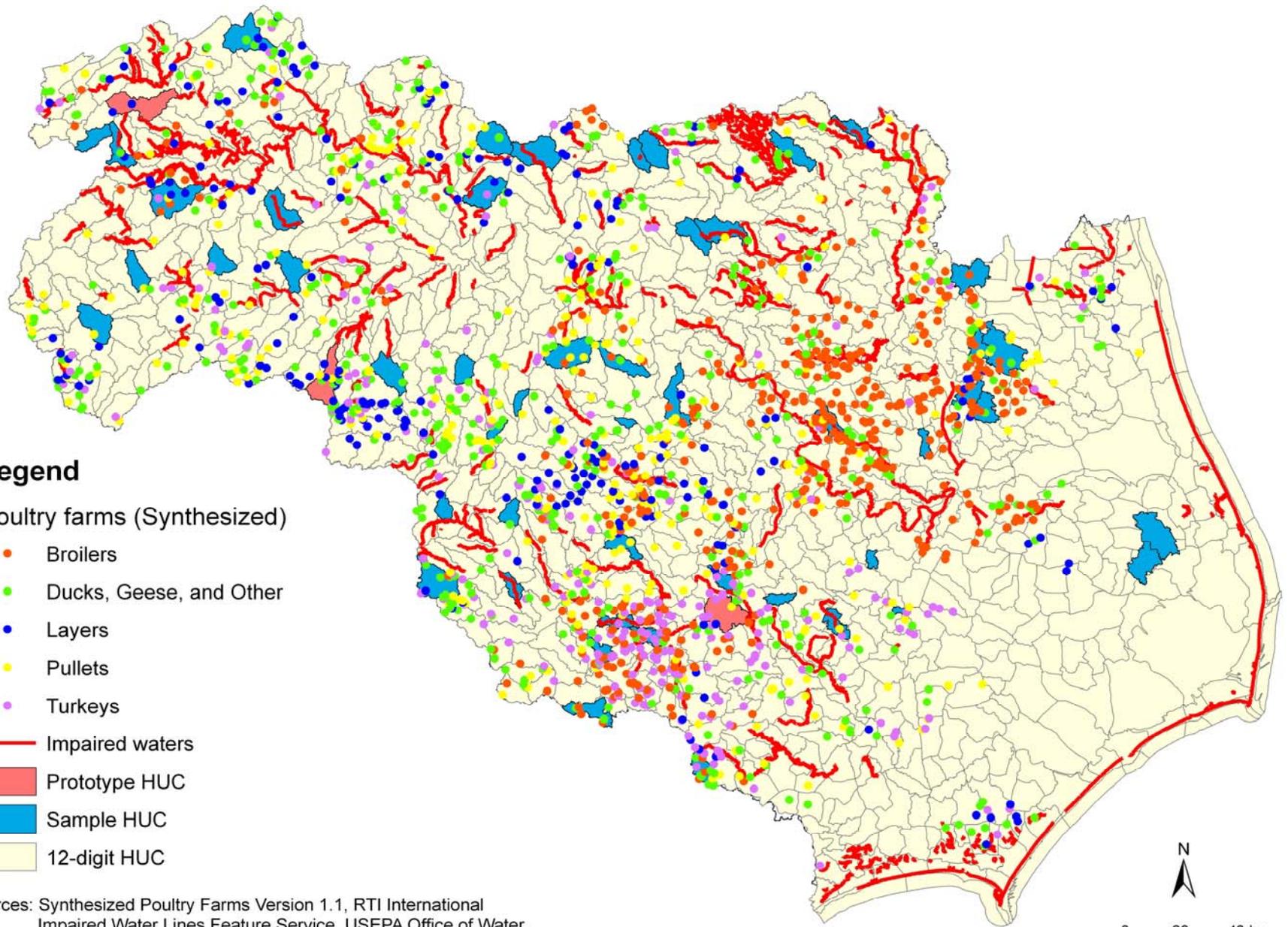
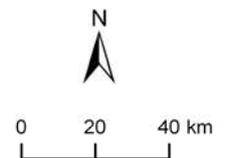
— Impaired waters

■ Prototype HUC

■ Sample HUC

■ 12-digit HUC

Sources: Synthesized Poultry Farms Version 1.1, RTI International  
Impaired Water Lines Feature Service, USEPA Office of Water  
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## Legend

### Poultry farms (Synthesized)

- Broilers
- Ducks, Geese, and Other
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— Impaired waters

■ Prototype HUC

■ Sample HUC

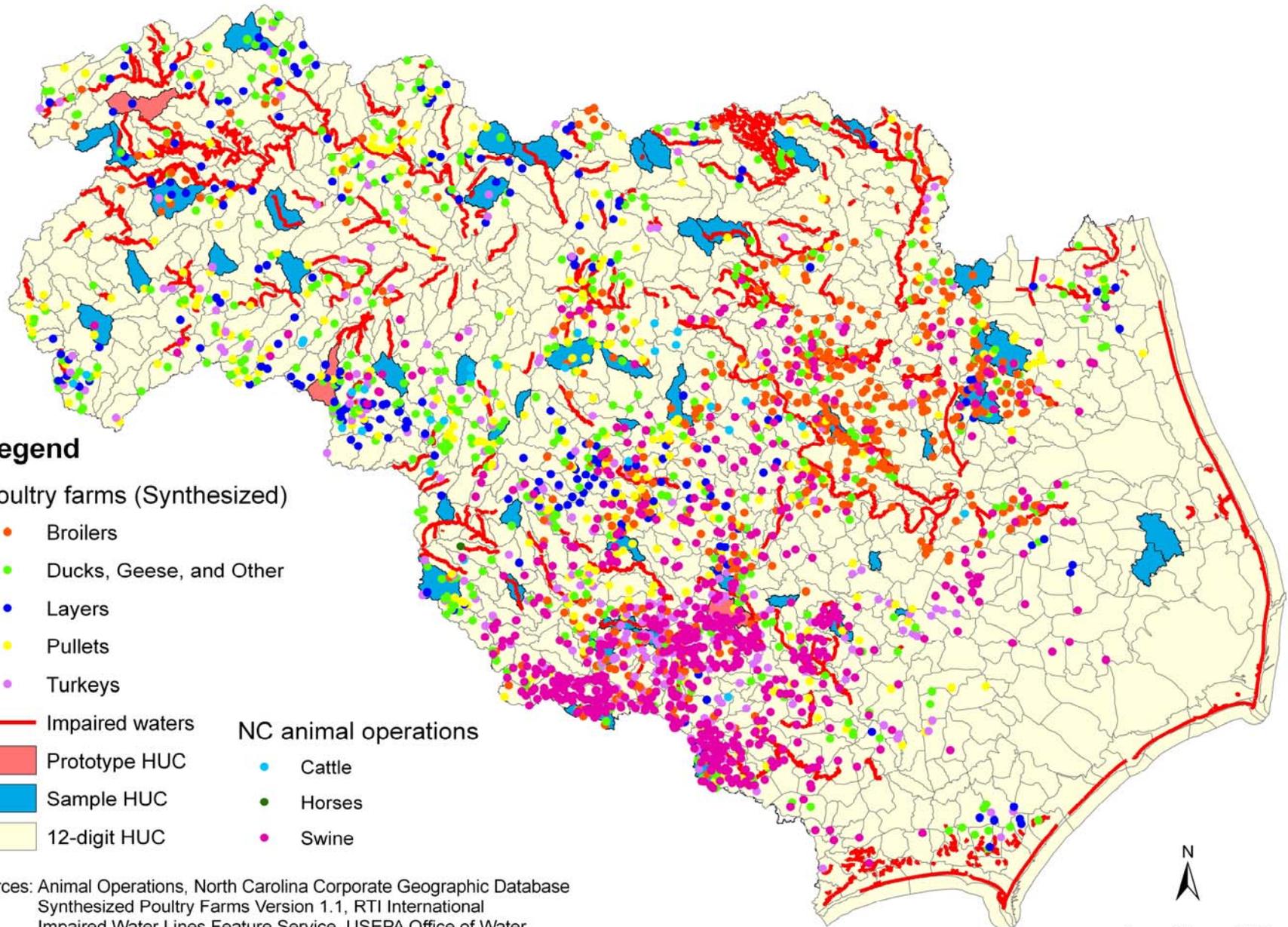
■ 12-digit HUC

### NC animal operations

● Cattle

● Horses

● Swine



Sources: Animal Operations, North Carolina Corporate Geographic Database  
Synthesized Poultry Farms Version 1.1, RTI International  
Impaired Water Lines Feature Service, USEPA Office of Water  
12-Digit Watershed Boundary Data 1:24,000, U.S. Department of Agriculture-Service Center Agencies

## Legend

### Poultry farms (Synthesized)

● Broilers

● Ducks, Geese, and Other

● Layers

● Pullets

● Turkeys

● Sewerage system

— Impaired waters

■ Prototype HUC

■ Sample HUC

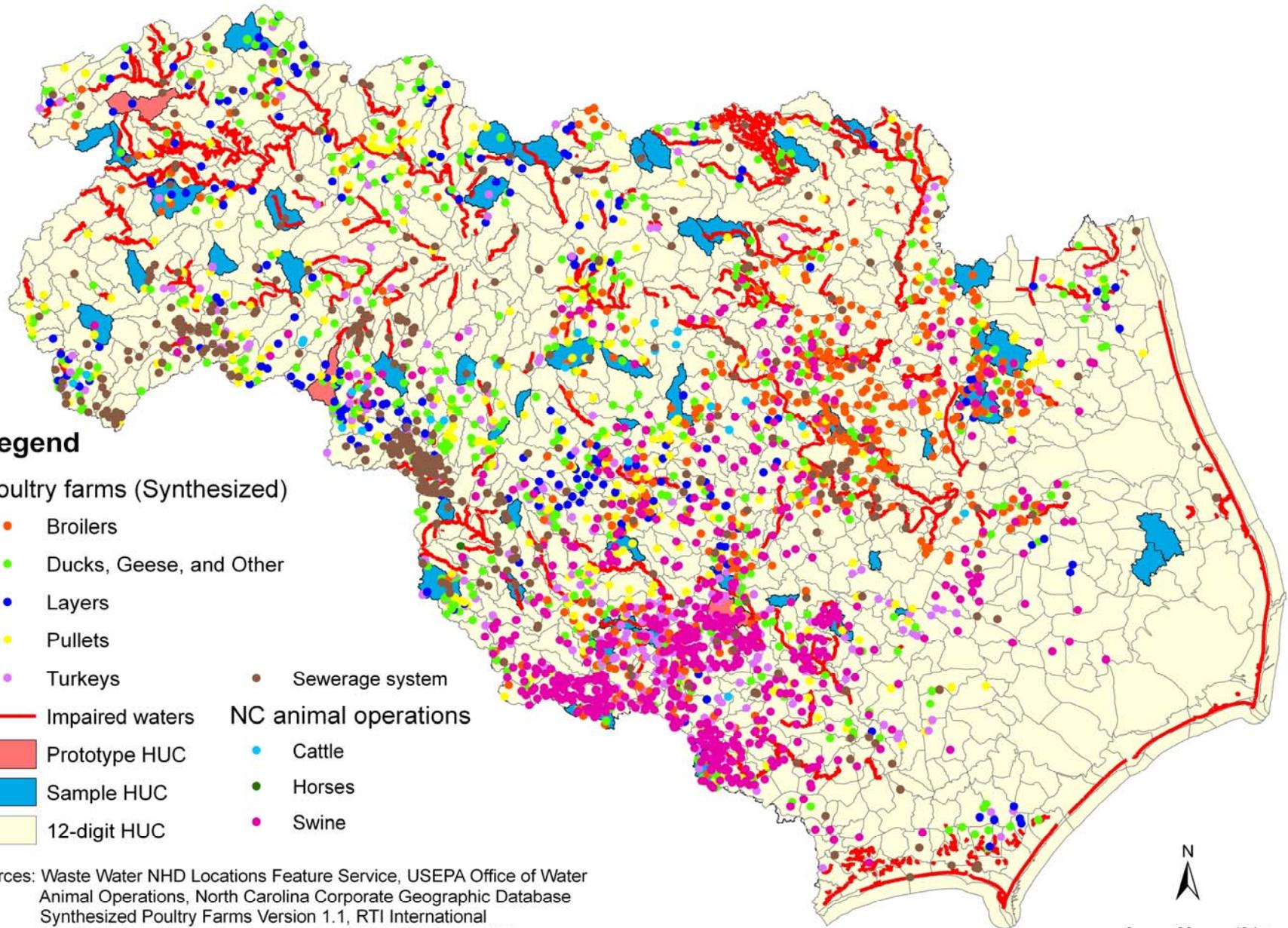
■ 12-digit HUC

### NC animal operations

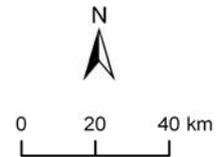
● Cattle

● Horses

● Swine



Sources: Waste Water NHD Locations Feature Service, USEPA Office of Water  
Animal Operations, North Carolina Corporate Geographic Database  
Synthesized Poultry Farms Version 1.1, RTI International  
Impaired Water Lines Feature Service, USEPA Office of Water  
12-Digit Watershed Boundary Data 1:24,000, U.S. Department of Agriculture-Service Center Agencies



# Vision

- Automate those portions of an assessment that are manually repeated
- Pick a location
- Pick models of choice
- Automatically download the data
- Automatically populate the models
- Run the models
- Reduce user intervention, until review



# Albermarle-Pamlico Estuary System Integrated Modeling Problem



# Gerry Laniak's Presentation

