

WATERSHED MODELING FOR THE UPPER FOX-WOLF BASINS TMDL

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The Cadmus Group

UFWB TMDL Stakeholder Meeting

September 17, 2014

Overview

- Watershed modeling background and process
- Input data and sources

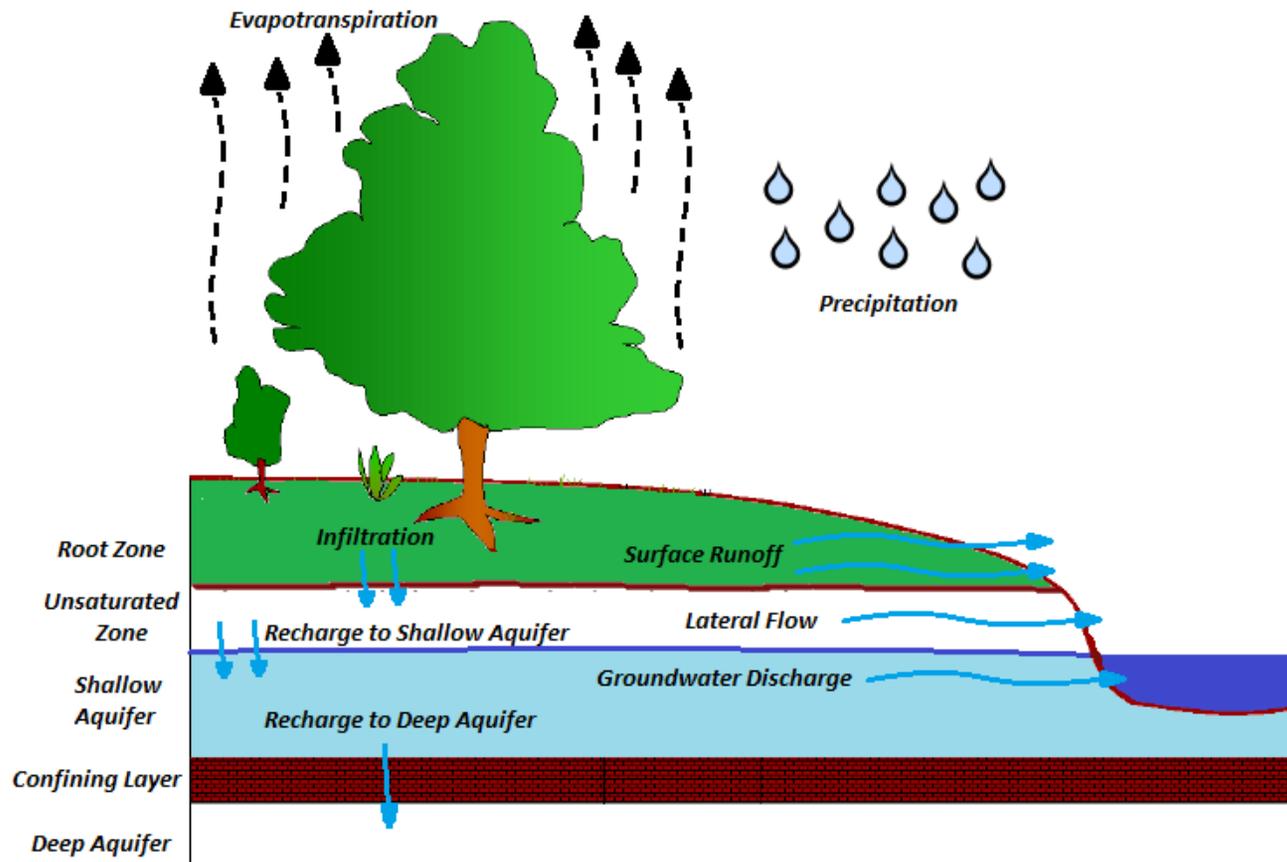
Watershed Modeling Purpose & Objectives

- Estimate water volumes, phosphorus loads, and sediment loads throughout the UFWB stream network.
- Evaluate phosphorus and sediment loading from nonpoint sources.
- Output used to determine phosphorus/sediment loading capacity of streams and to guide allocations.

Soil and Water Assessment Tool (SWAT)

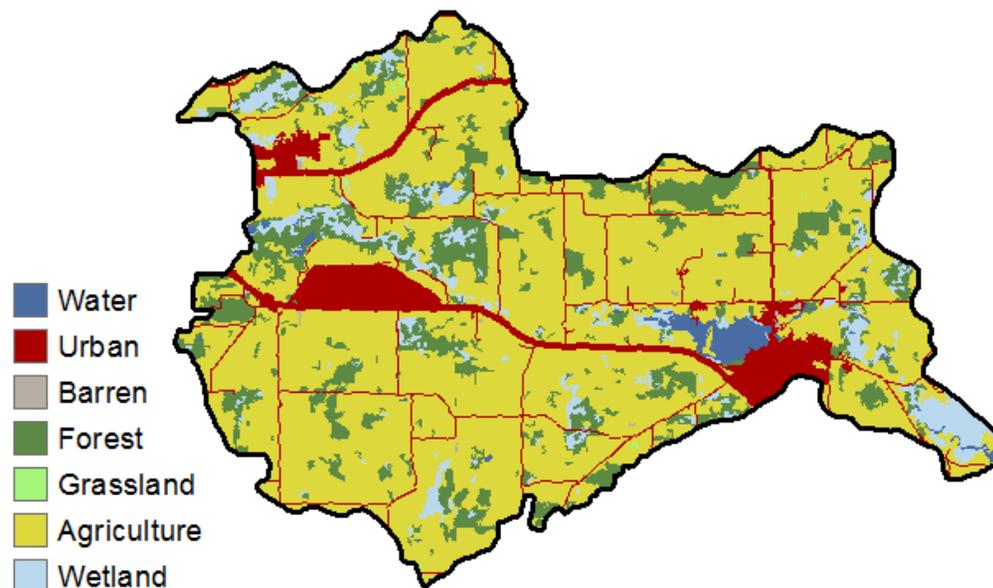
- Process-Based

- Simulates key hydrologic and water quality processes: surface runoff, evapotranspiration, erosion, groundwater discharge, etc.



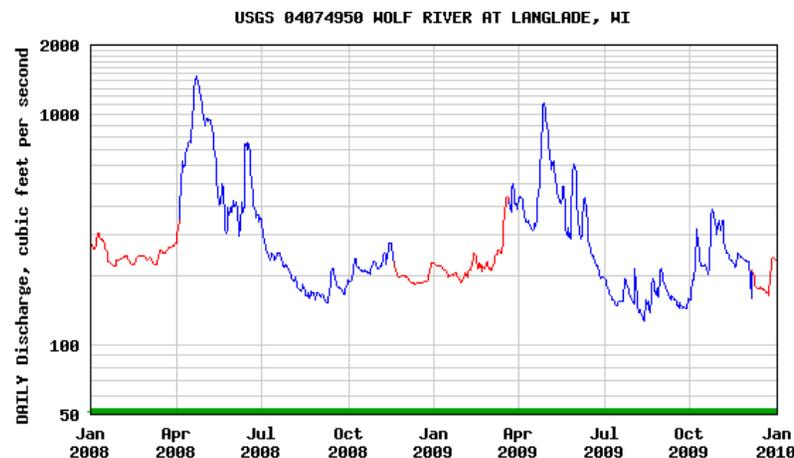
Soil and Water Assessment Tool (SWAT)

- Process-Based
 - Simulates key hydrologic and water quality processes: surface runoff, evapotranspiration, erosion, groundwater discharge, etc.
- Spatially-distributed
 - Parameters affecting runoff and water quality can vary throughout the modeled watershed.



Soil and Water Assessment Tool (SWAT)

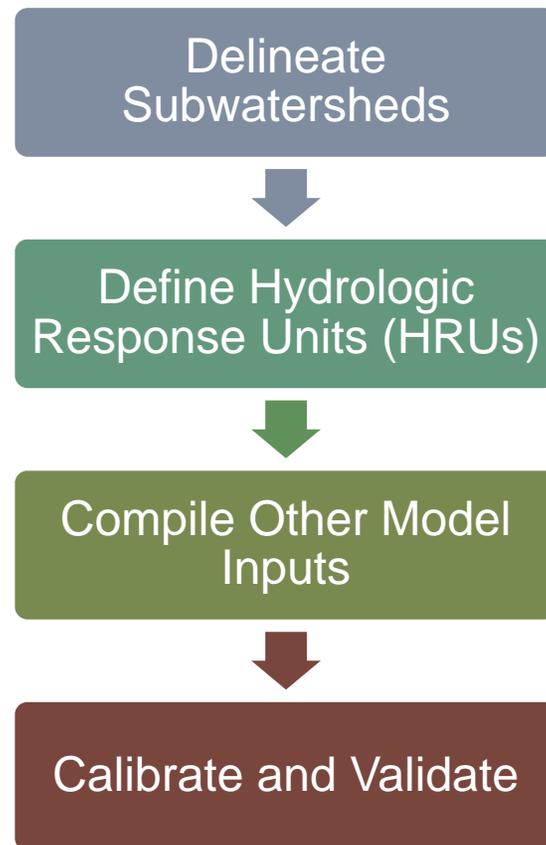
- Process-Based
 - Simulates key hydrologic and water quality processes: surface runoff, evapotranspiration, erosion, groundwater discharge, etc.
- Spatially-distributed
 - Parameters affecting runoff and water can vary throughout the modeled watershed.
- Continuous
 - Users enter daily weather data, SWAT tracks system response over time.



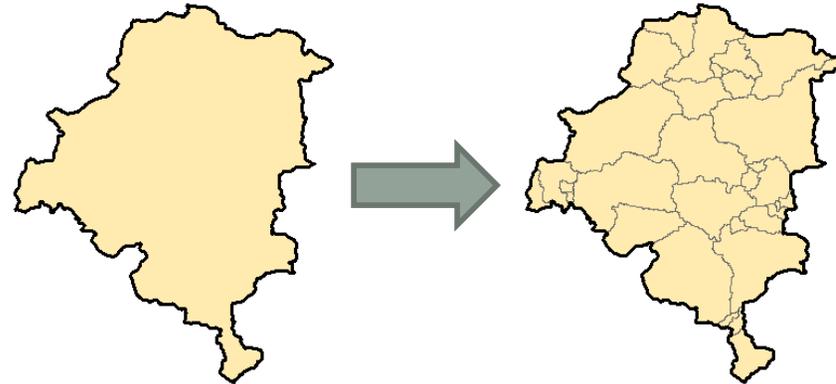
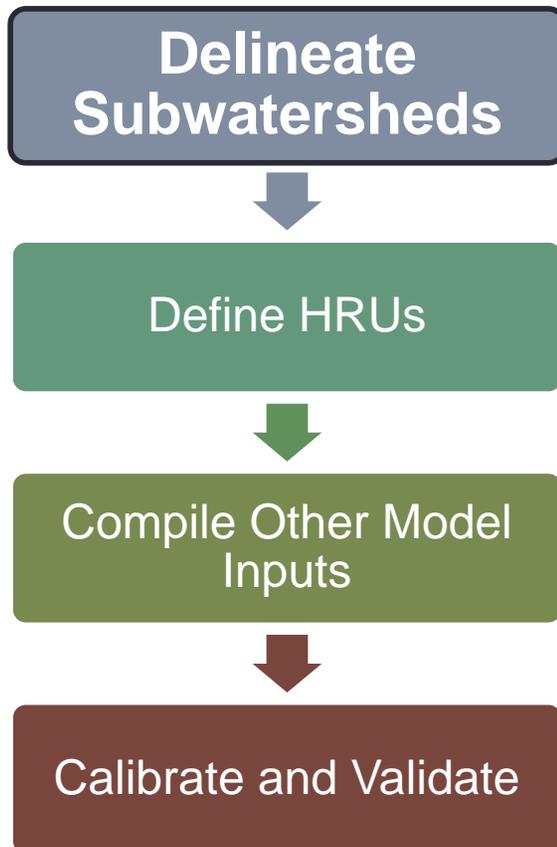
Why SWAT?

- Accessibility
 - Public domain code and software supported by USDA Agricultural Research Service: <http://swat.tamu.edu/>
- Familiarity
 - Build on previous applications of SWAT for Wisconsin TMDLs.
- Suitability
 - Able to simulate variables of interest (phosphorus, sediment, streamflow) with appropriate level of spatial and temporal resolution.
 - Tailor-made for watersheds with variable agricultural practices.

SWAT Modeling Process

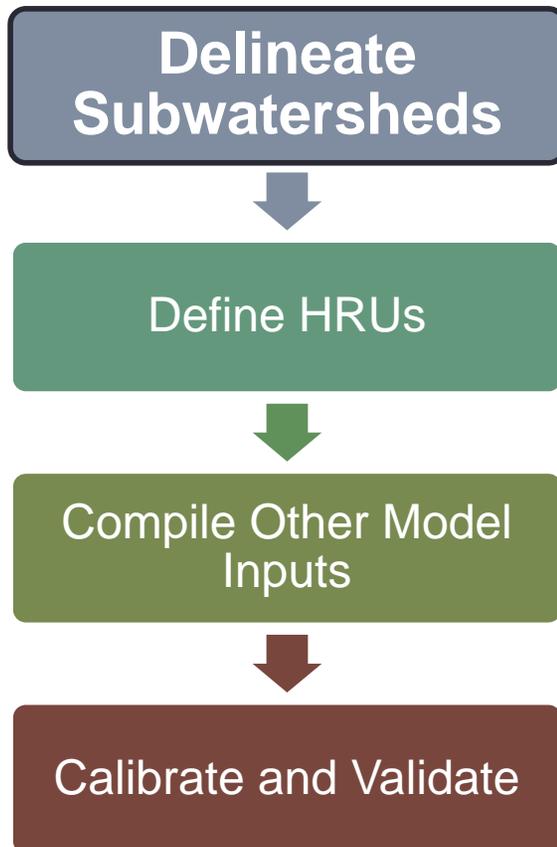


Subwatershed Delineation

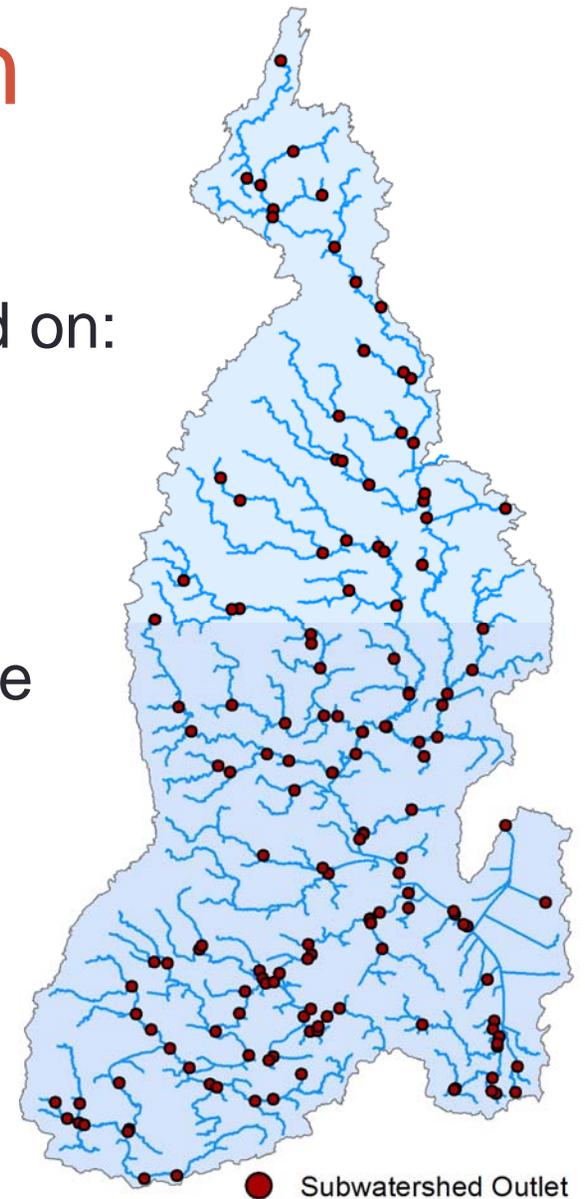


- Partition entire UFWB into smaller drainage units.
- First level of watershed division.
 - Reflect actual drainage patterns.
 - Obtain model predictions for specific outlet locations.
 - Capture variability in subwatershed level parameters (climate, instream routing, etc.).

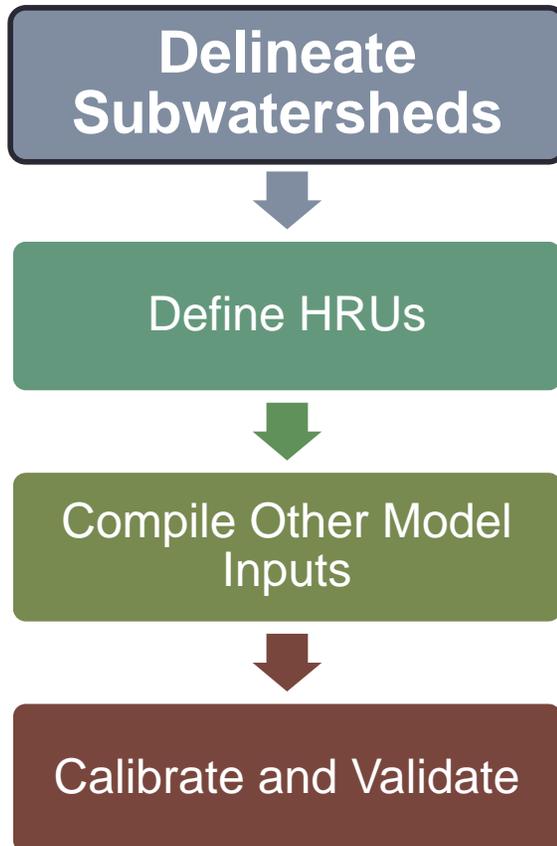
Subwatershed Delineation



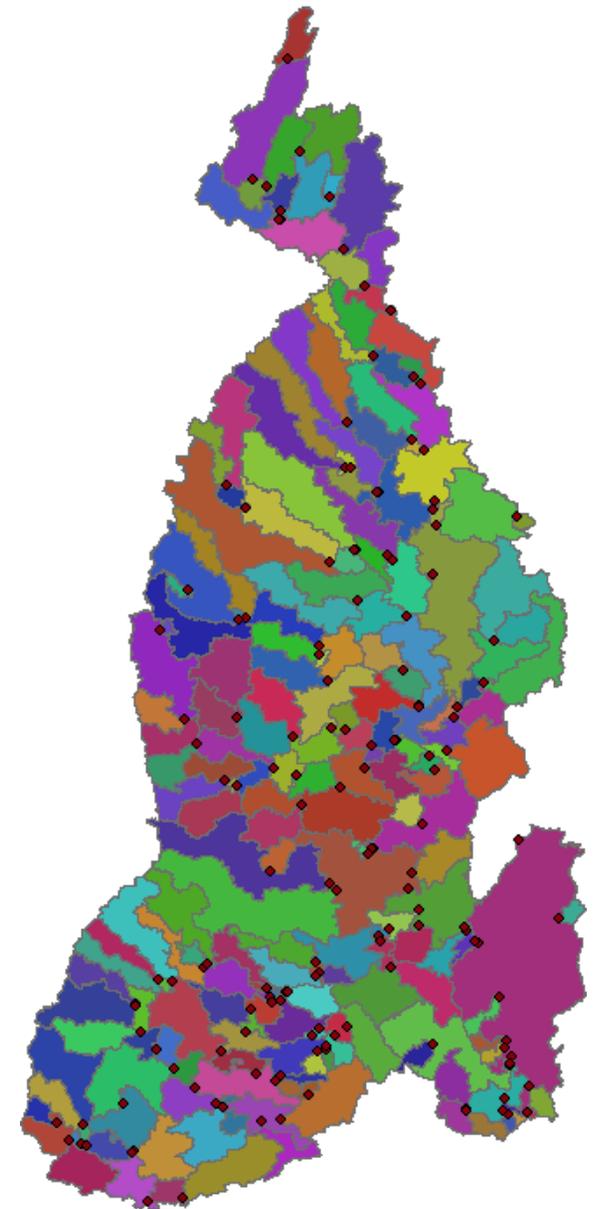
- Outlets of model subwatersheds based on:
 1. Impaired waters
 2. Monitoring sites
 3. Contributing area threshold (20 square miles; approximate HUC12s)



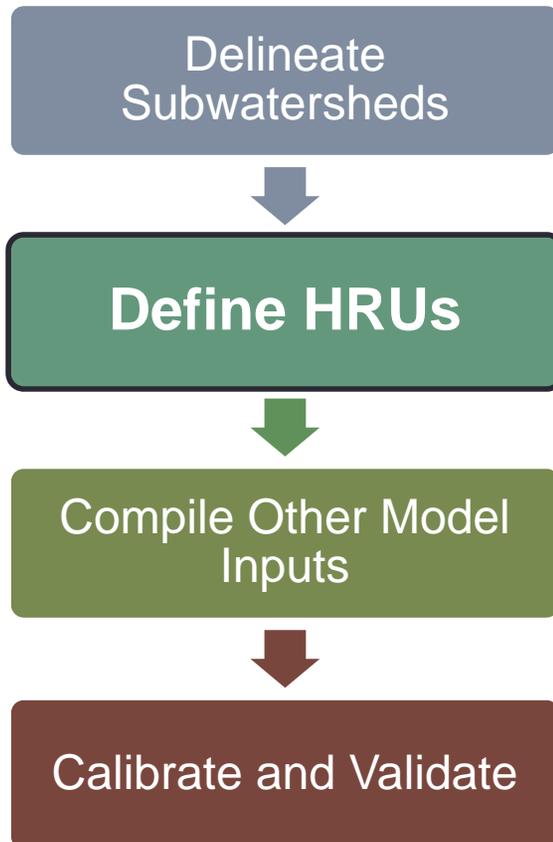
Subwatershed Delineation



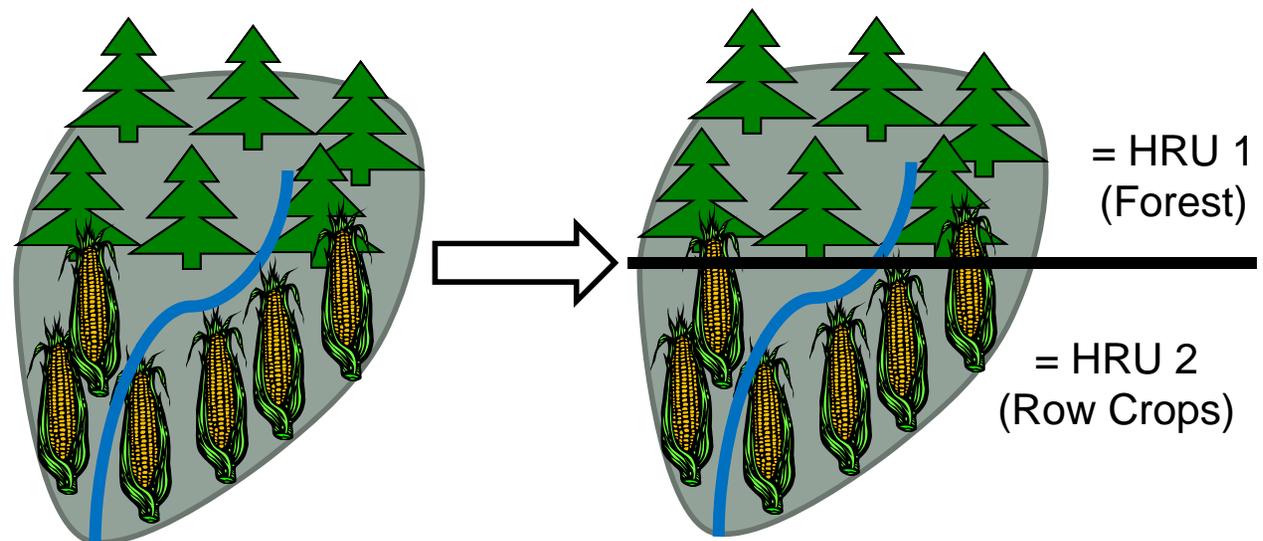
- 218 subwatersheds delineated for UFWB



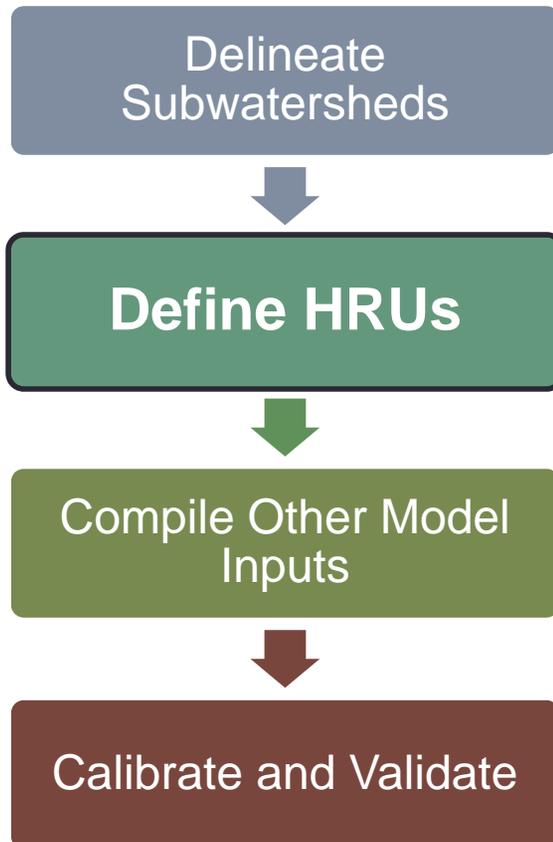
HRU Definition



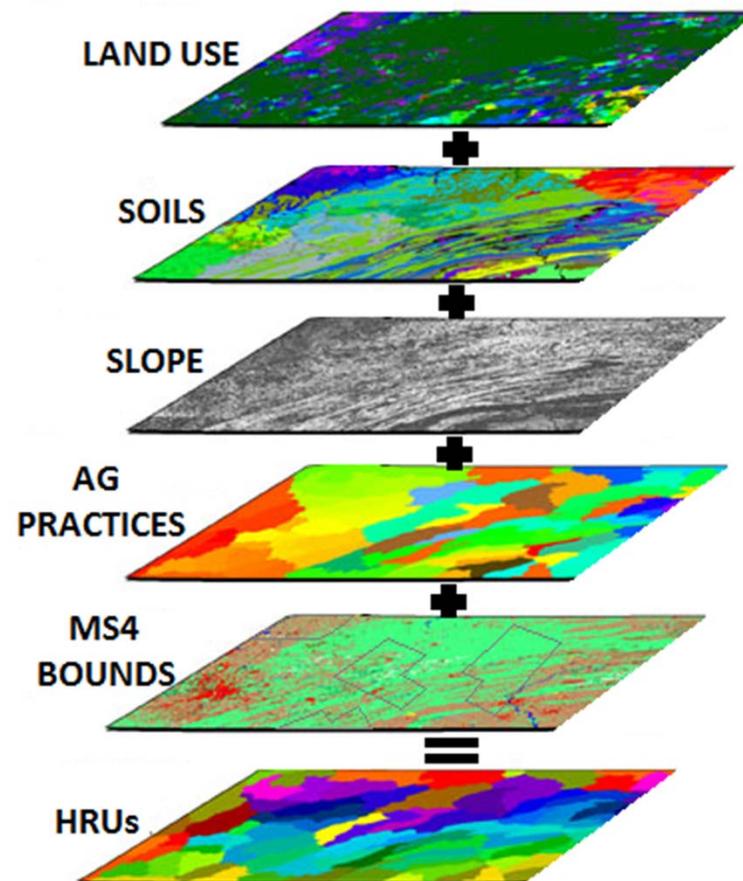
- Hydrologic Response Unit = “portions of a subwatershed that possess unique landuse, management, or soil attributes”
- Second level of watershed division.
 - Represent finer-scale variation in hydrologic and water quality parameters.



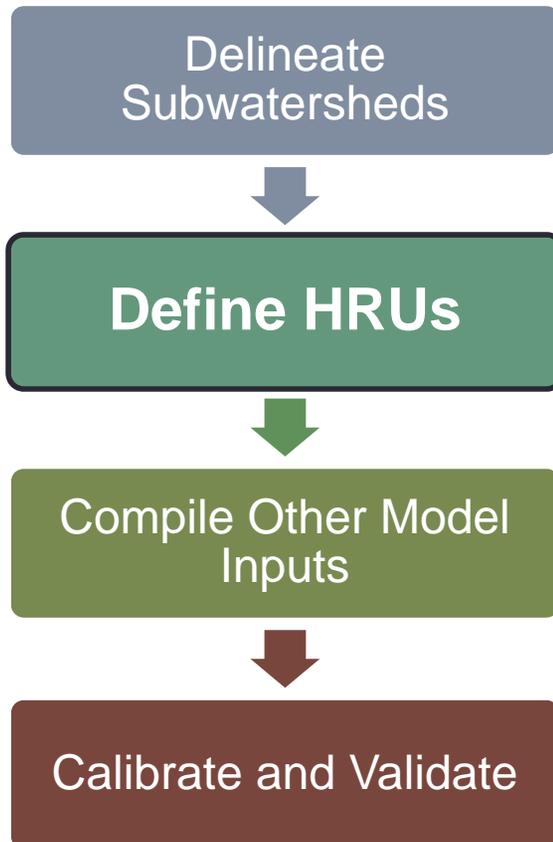
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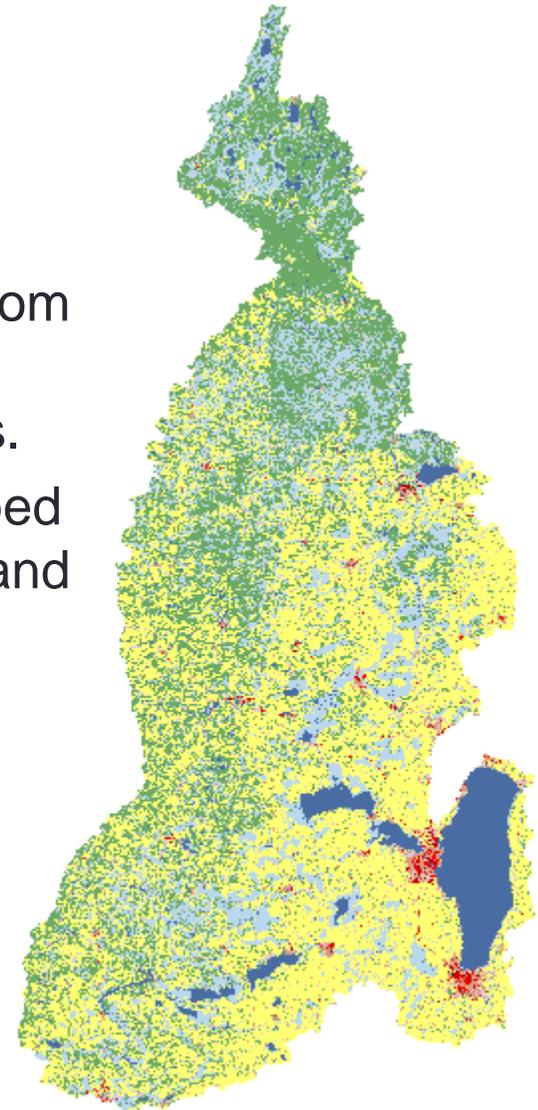
- For UFWB model, HRUs based on overlay of:



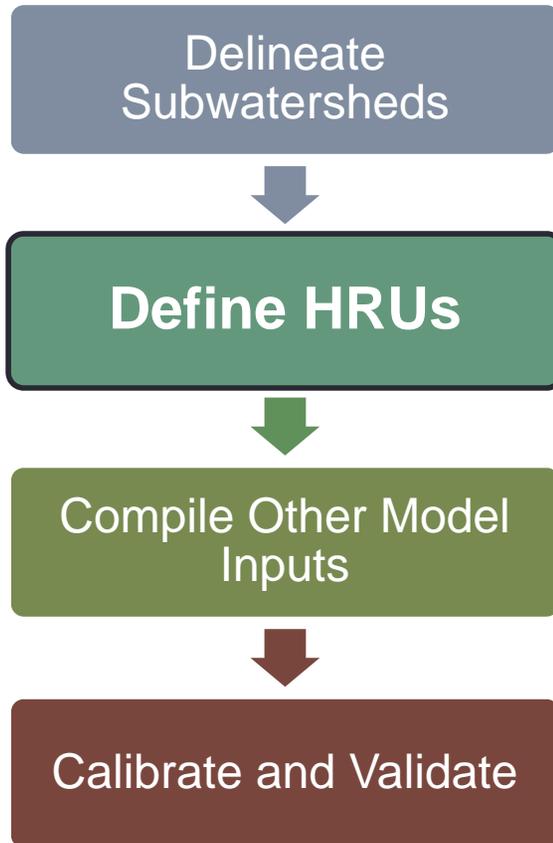
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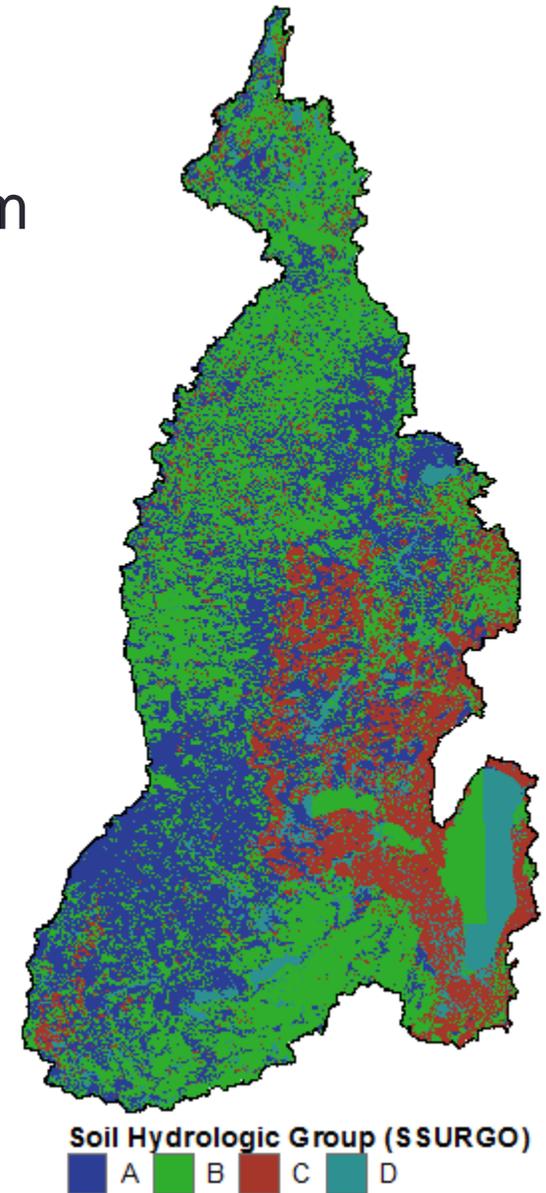
- Land use:
 - Agriculture mapped from 2008-2012 USDA Cropland Data Layers.
 - Non-ag classes mapped from 2006 National Land Cover Database.



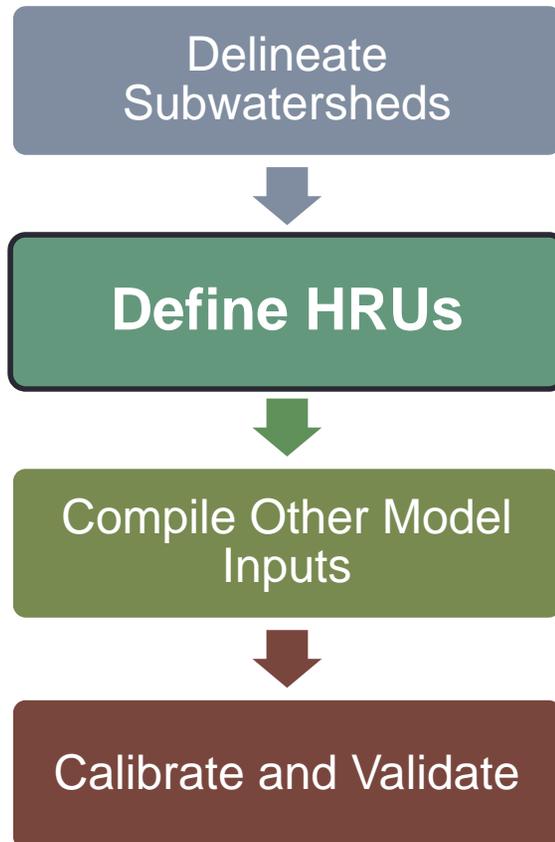
HRU Definition



- Soil classes defined from USDA soils data
 - STATSGO2 = Coarse resolution
 - SSURGO = Detailed resolution
 - Combine STATSGO2 and SSURGO into “hybrid” soil map
 - Detailed resolution for:
 - Runoff potential
 - Erosion potential



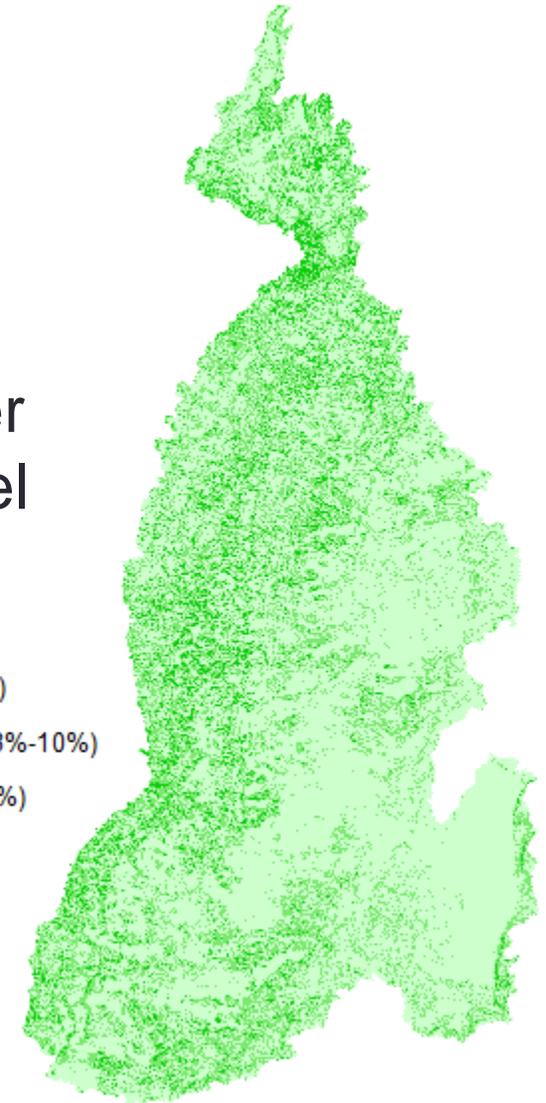
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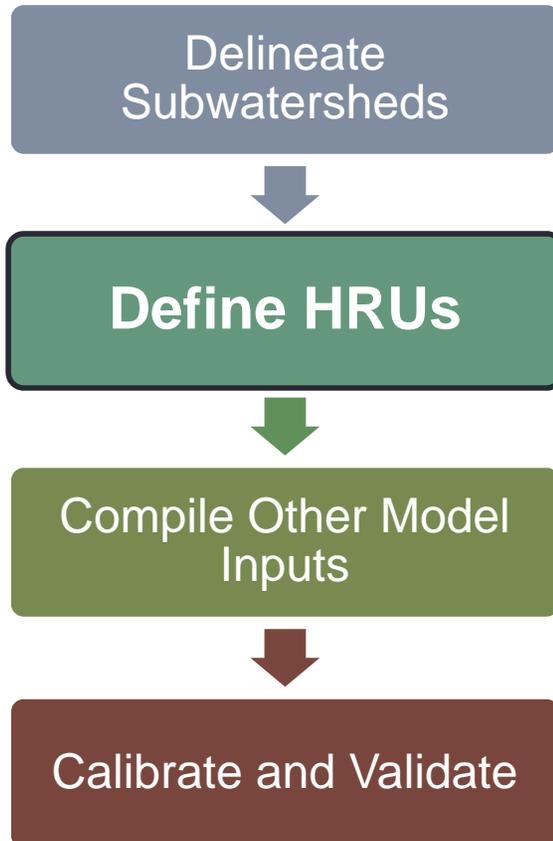
- Slope classes:
 - Low (<3%)
 - Medium (3% - 10%)
 - High (10%)
- Mapped from 10 meter Digital Elevation Model (DEM)

Slope

- Low (<3%)
- Medium (3%-10%)
- High (>10%)

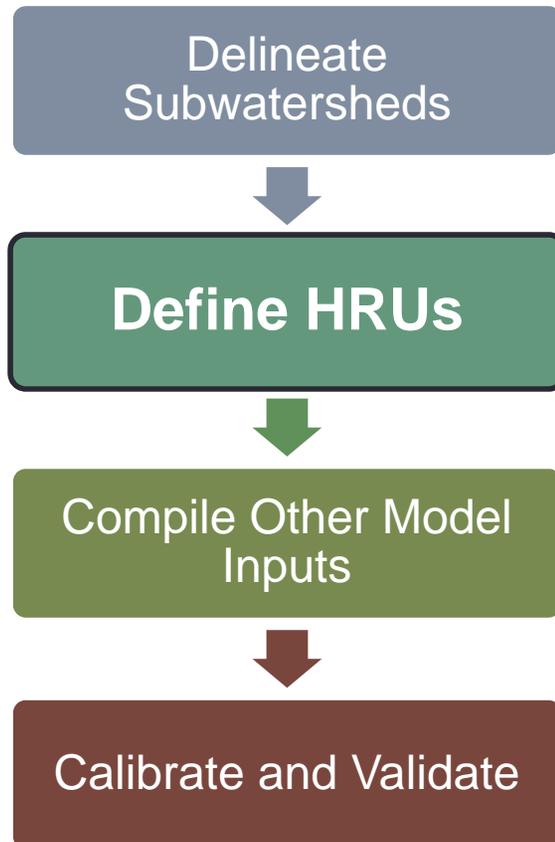


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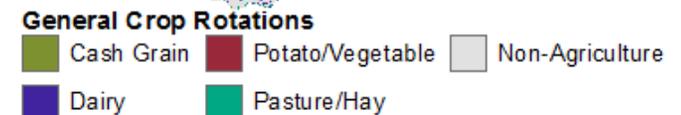
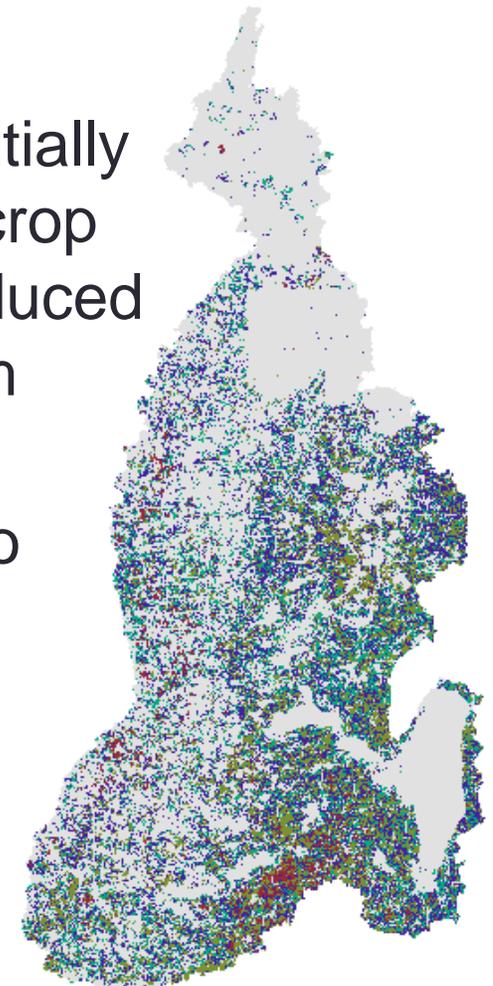


- Agricultural practice classes. Each class has unique:
 - Crop rotation
 - Tillage
 - Fertilizer & manure application
- Example:
 - Cash Grain Rotation
 - 1 Year Corn, 1 Year Soybean
 - Conventional Tillage
 - Chemical fertilizer @ 200 pounds/acre

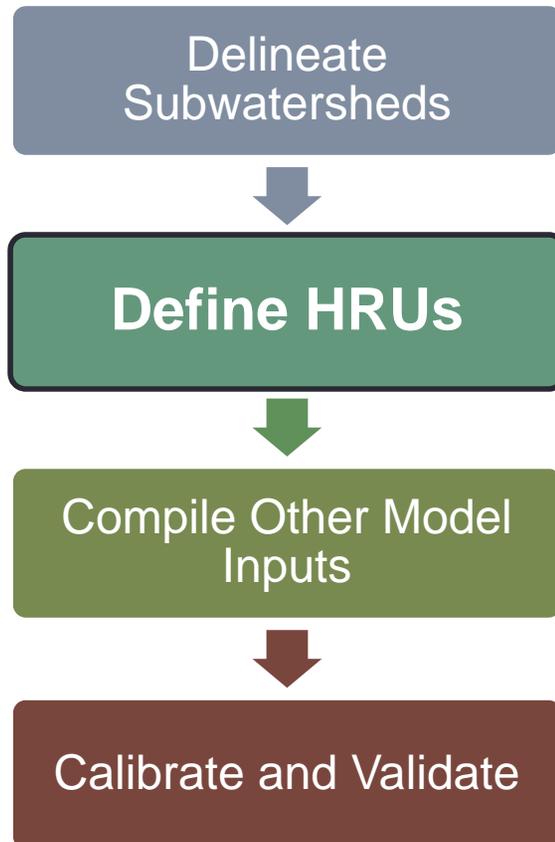
HRU Definition



- Agricultural practices initially mapped from “general crop rotation” map layer produced by WI River TMDL Team
- Used 2008-2012 USDA Cropland Data Layers to map 4 rotations:
 - Cash Grain
 - Dairy
 - Potato/Vegetable
 - Pasture/Hay

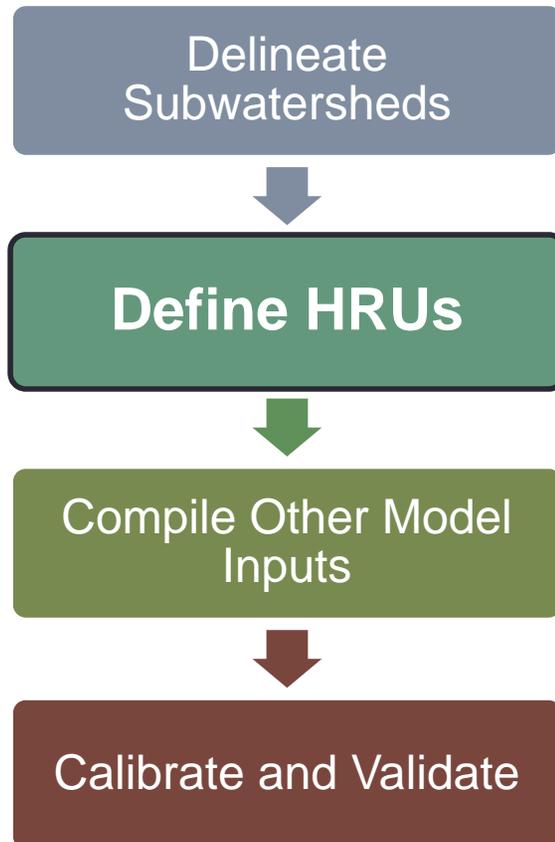


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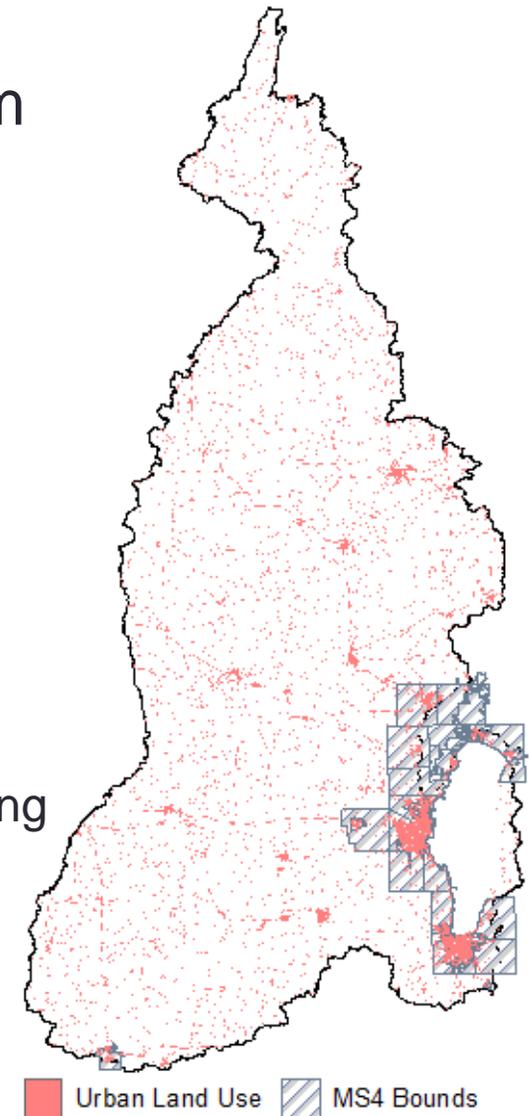


- Agricultural practices further refined using input from County Conservationists.
- Questionnaire delivered in August 2014 requesting feedback on:
 - Crop rotation types and extent;
 - Tillage timing and type;
 - Fertilizer and manure application rates;
 - Planting/harvest timing;
 - Grazing extent/animal density; and
 - Soil phosphorus levels.
- Average practices per HUC12 subwatershed.
- Responses delivered September 2014.

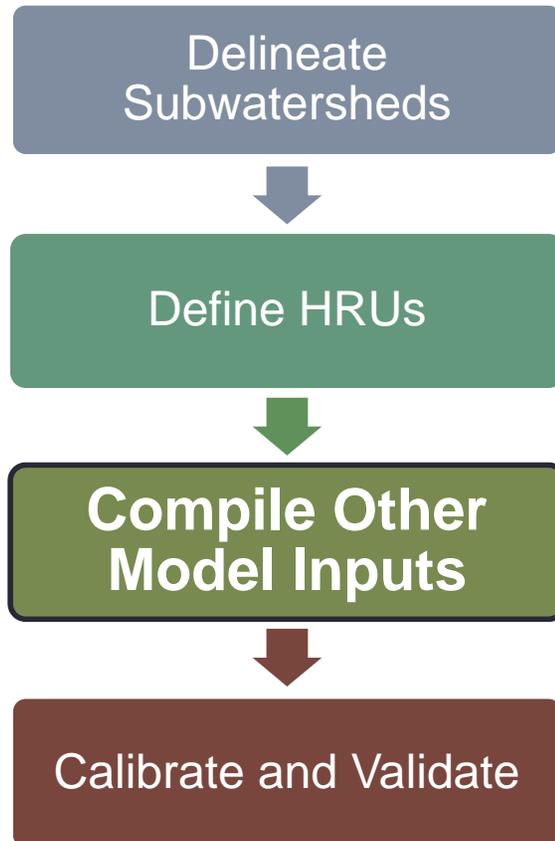
HRU Definition



- Municipal Separate Storm Sewer Systems (MS4s)
 - 30 MS4s.
 - Boundaries used to differentiate between MS4 and non-MS4 urban lands.
 - SWAT predictions for MS4 areas will be replaced with WinSLAMM predictions for allocation planning.
 - WinSLAMM = Source Loading and Management Model for Windows

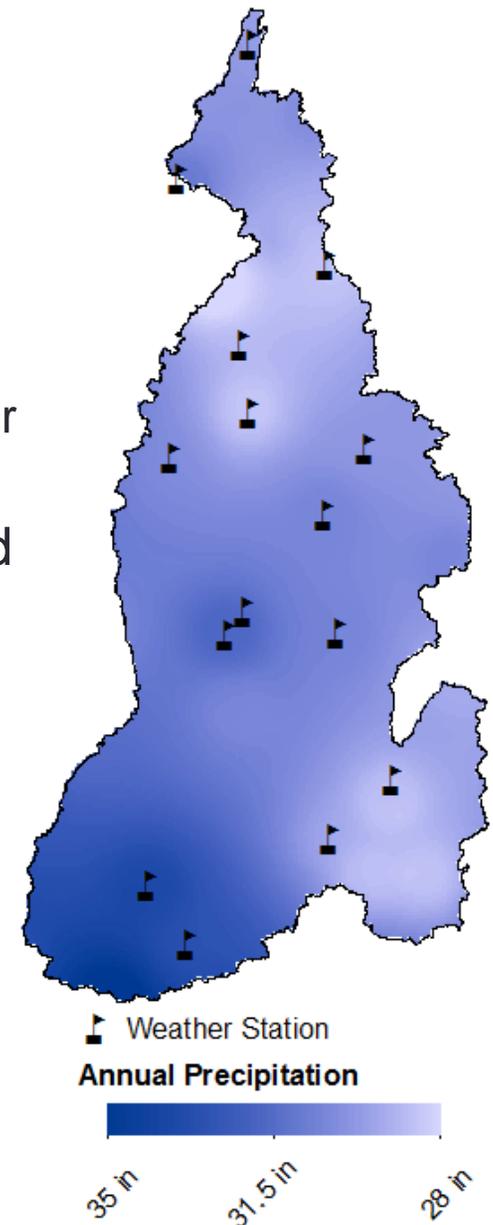


Other Model Inputs

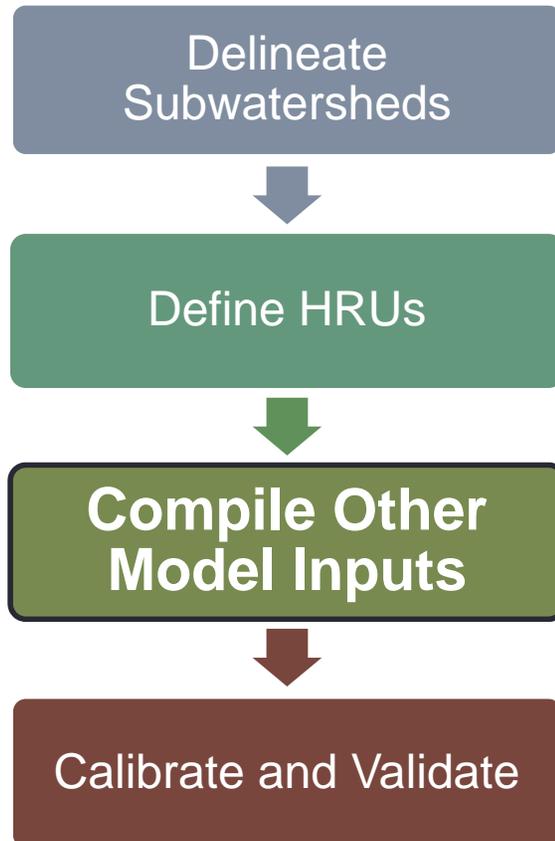


- Weather Data

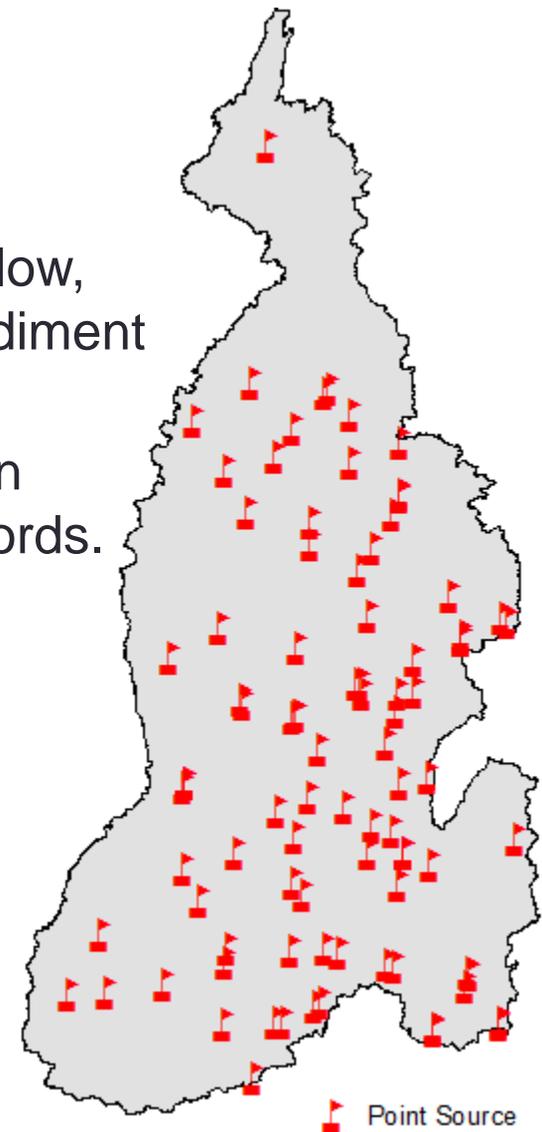
- Daily Precipitation & Air Temperature
 - Observations from 15 weather stations
- Daily Relative Humidity, Wind Speed, Solar Radiation
 - SWAT Internal Weather Generator



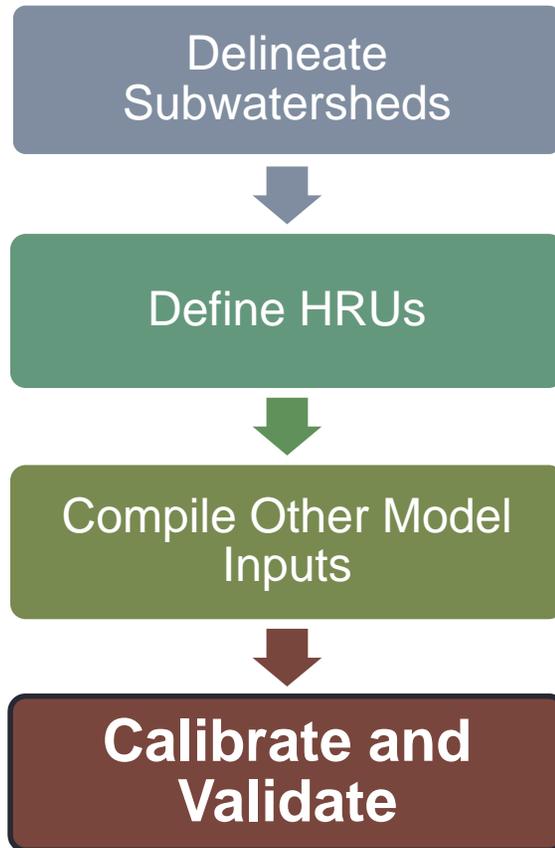
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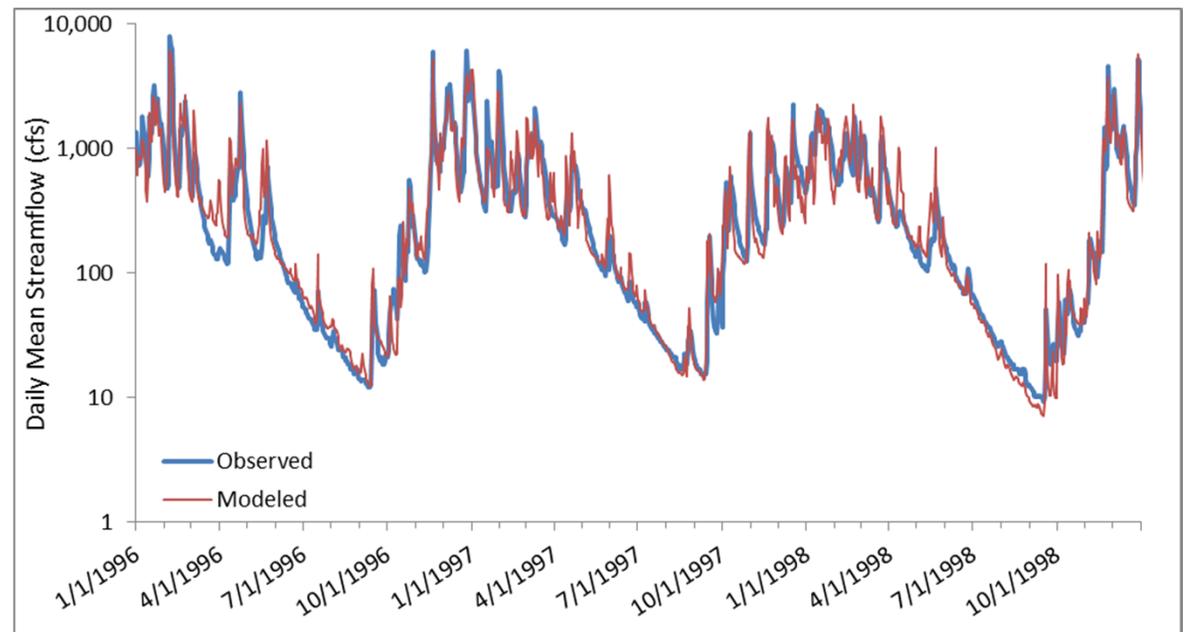
- Point Source Inputs
 - Annual average effluent flow, phosphorus load, and sediment load.
 - Flows and loads based on discharge monitoring records.



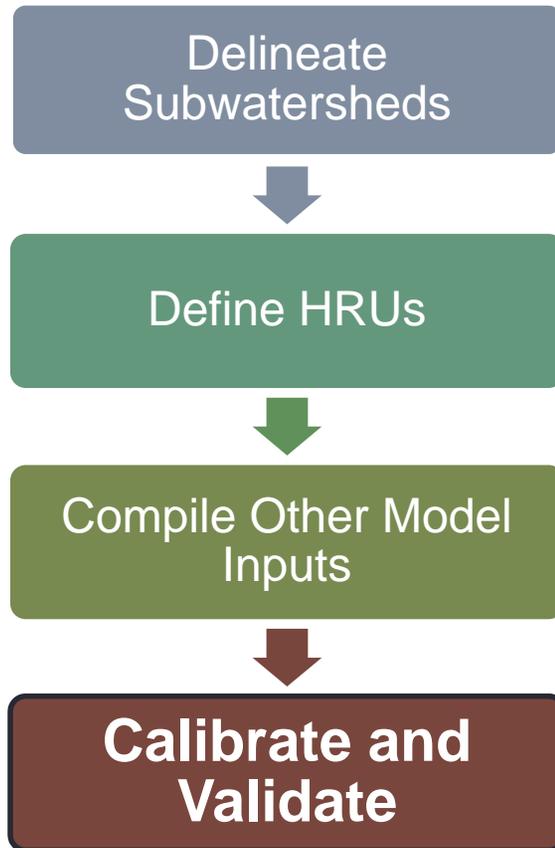
Calibration and Validation



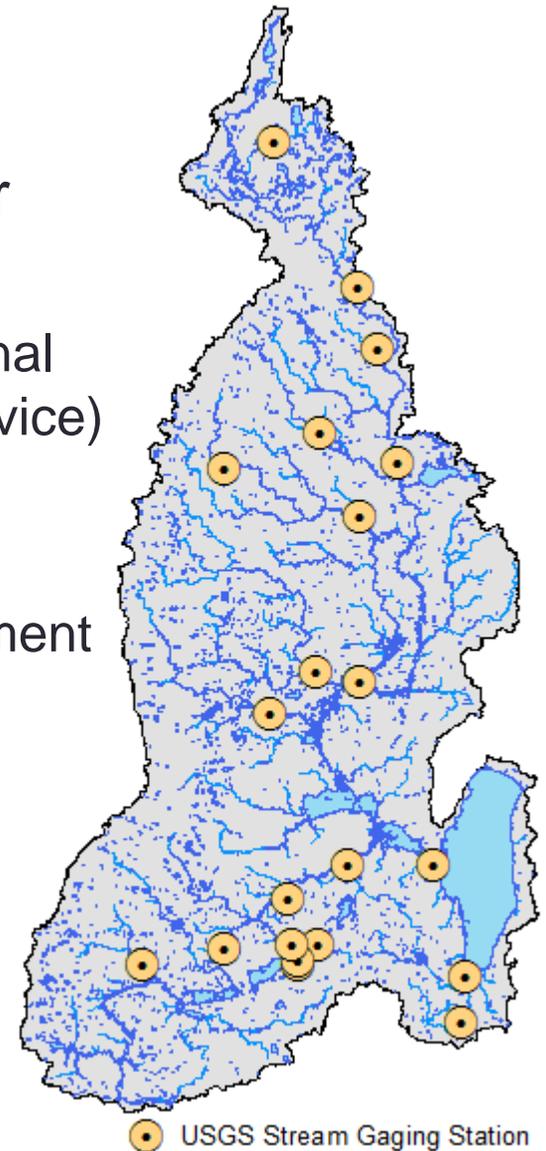
- Calibration = Adjust model parameters so that predictions match observations.
- Validation = Verify calibrated model predictions using additional observations.



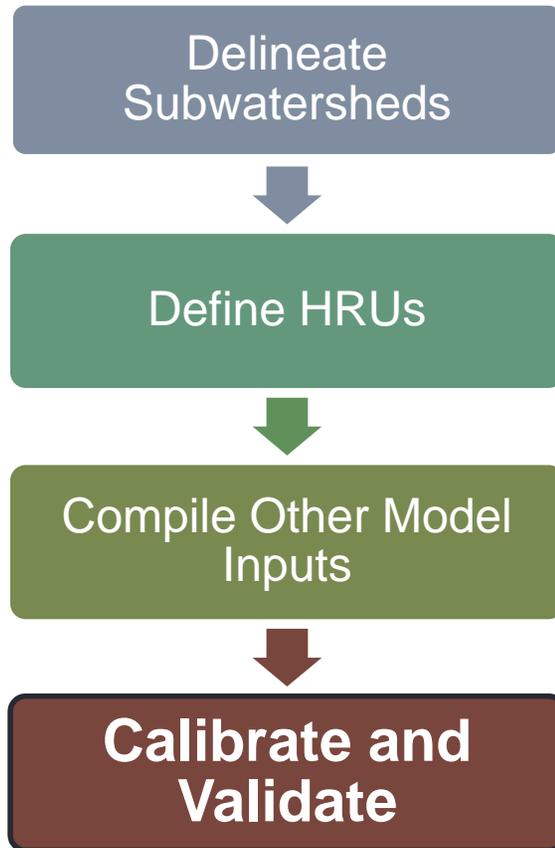
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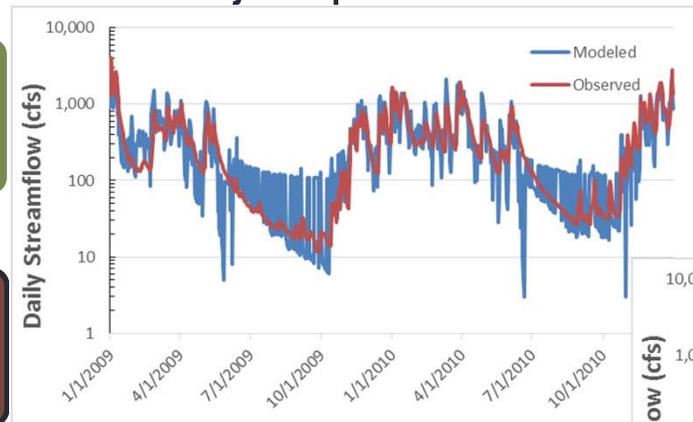
- Observed data used for calibration:
 - Crop yields (USDA National Agricultural Statistics Service)
 - Daily streamflow records (USGS)
 - Daily phosphorus & sediment loads (USGS)



Calibration and Validation

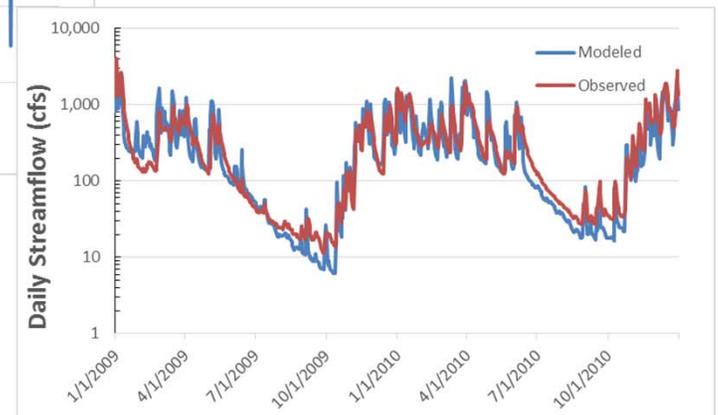


- Calibration process
 - Select goodness-of-fit measures
 - Annual flow volume, phosphorus load, etc.
 - Sensitivity analysis
 - Which parameters affect measures?
 - Adjust parameters to maximize goodness-of-fit

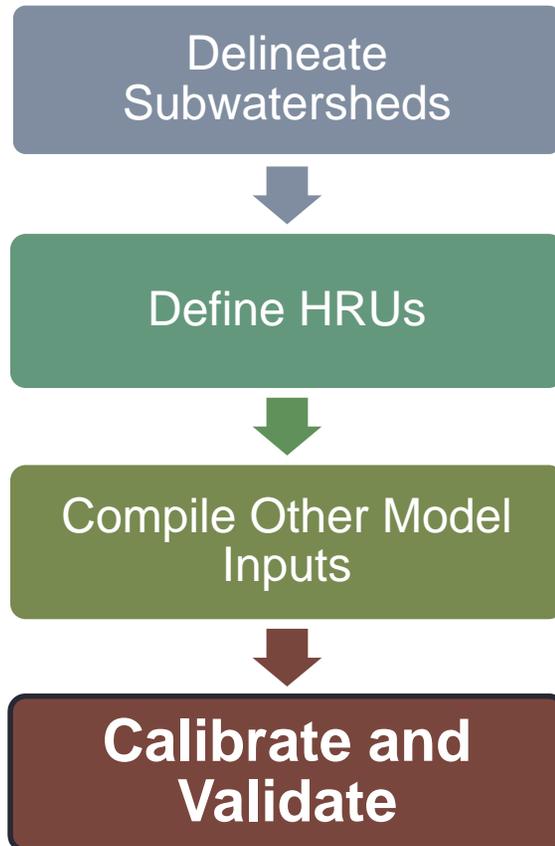


← Pre-Calibration

Post-Calibration →

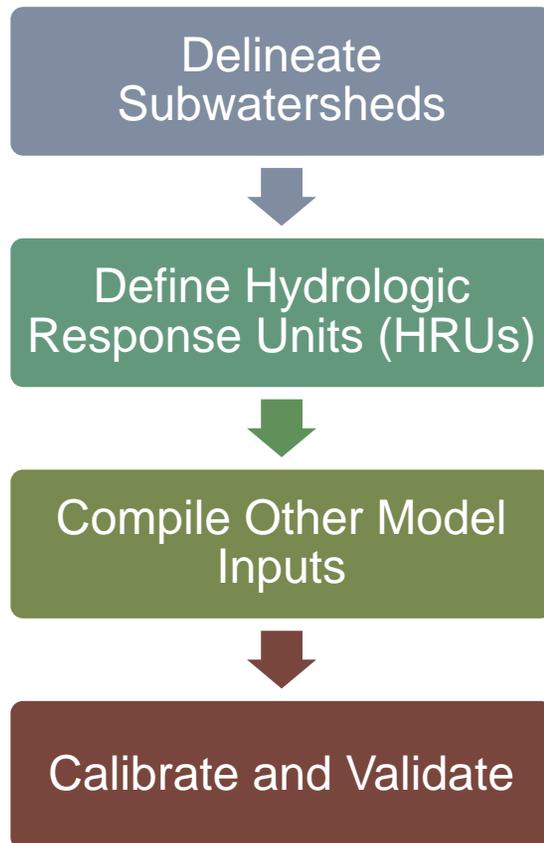


Calibration and Validation



- Validation process
 - Select measures of predictive error
 - Correspond to goodness-of-fit measures
 - Identify thresholds for acceptable error
 - e.g., average annual flow volume within X% of observed value
 - Is error within acceptable range?
 - If yes, model validated for further use
 - If no, re-visit model inputs

WATERSHED MODELING FOR THE UPPER FOX-WOLF BASINS TMDL



- Questions?