

Development of a National Agroecosystems Model to Support the Conservation Effects Assessment Project



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U.S. DEPARTMENT OF AGRICULTURE



TEXAS A&M
UNIVERSITY



Baylor University

Colorado
State
University



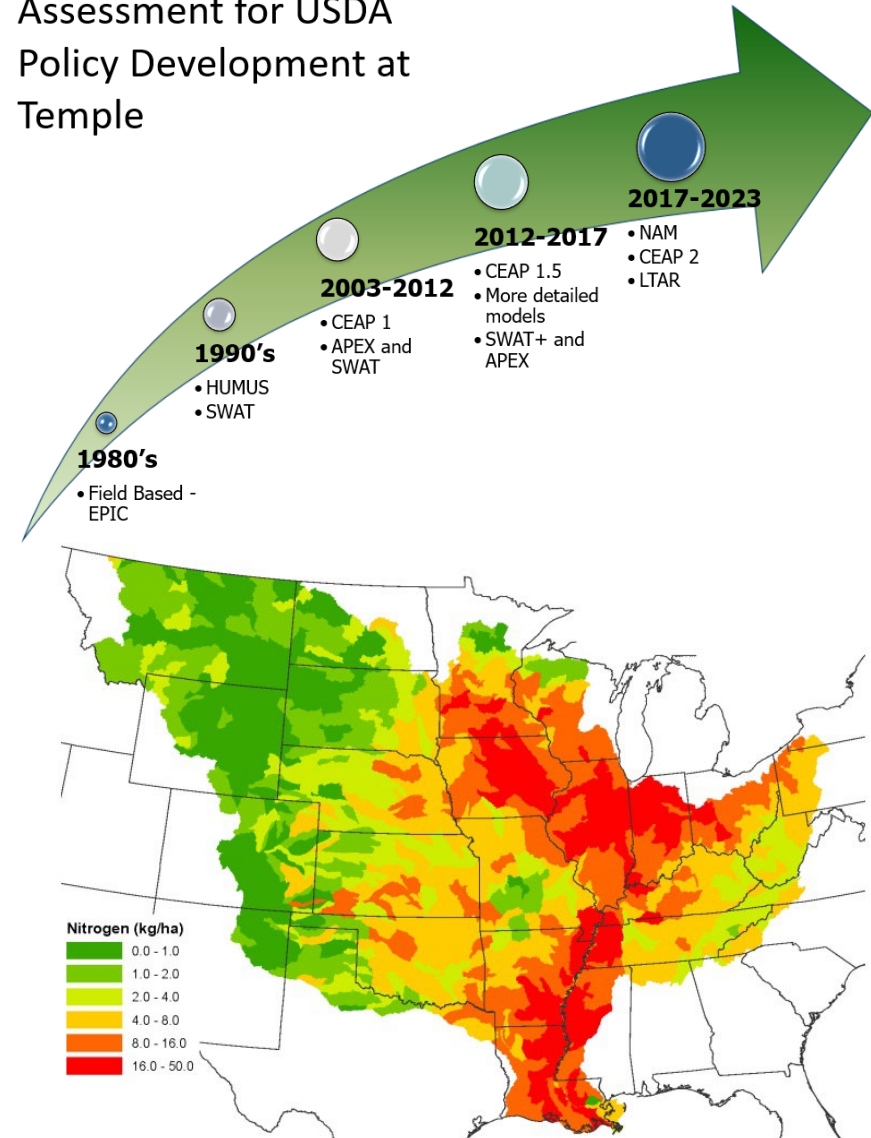
United States
Department of
Agriculture

Natural Resources Conservation Service

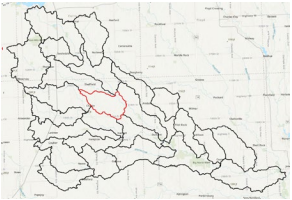
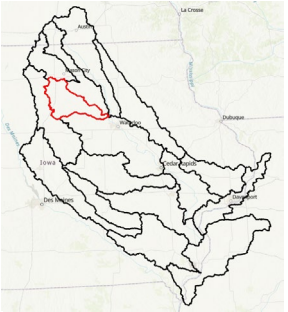
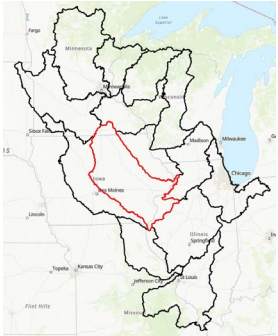
National Agroecosystems Model (NAM)

- A highly detailed national modeling framework developed to predict the effects of agriculture on the environment.
- Developed to support CEAP and other modeling efforts
- Conservation Effects Assessment Project (CEAP)
 - 2002 Farm Bill -significant increase in conservation funding
 - U.S. conservation investments average \$14.8 Billion annually
 - CEAP developed to guide and evaluate conservation programs
 - Estimate the benefits on water quality using models
 - **CEAP accounts for 0.1% of conservation program spending**

History of Conservation Assessment for USDA Policy Development at Temple



Scope and Scale



- Based on USGS Hydrologic Unit Code System
- Hierarchical watershed classification system
- More digits = smaller watershed
- Individual models for each HUC8 in the US
- Subbasins are HUC12

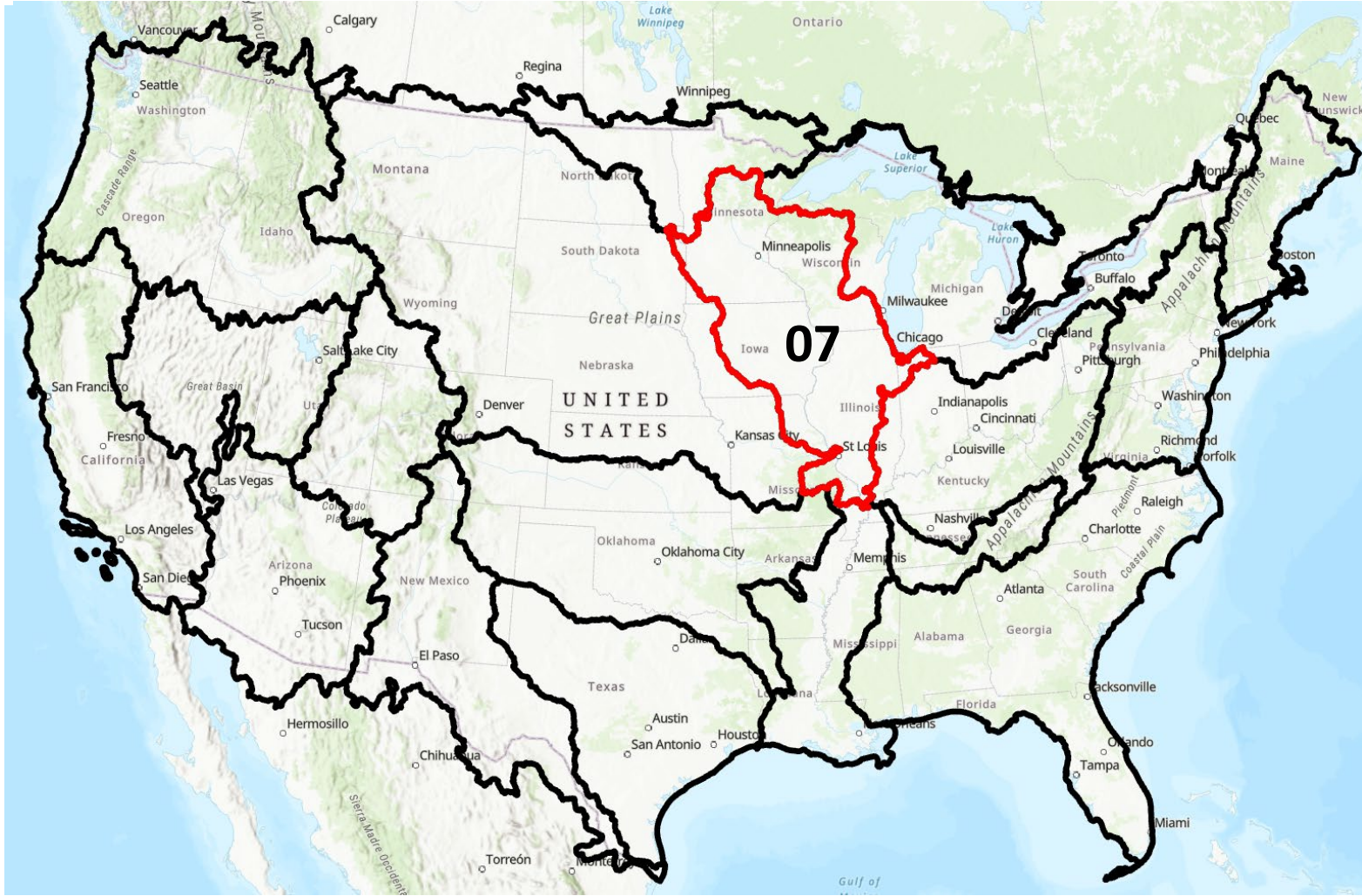
Scope and Scale

HUC2 – 18 Units



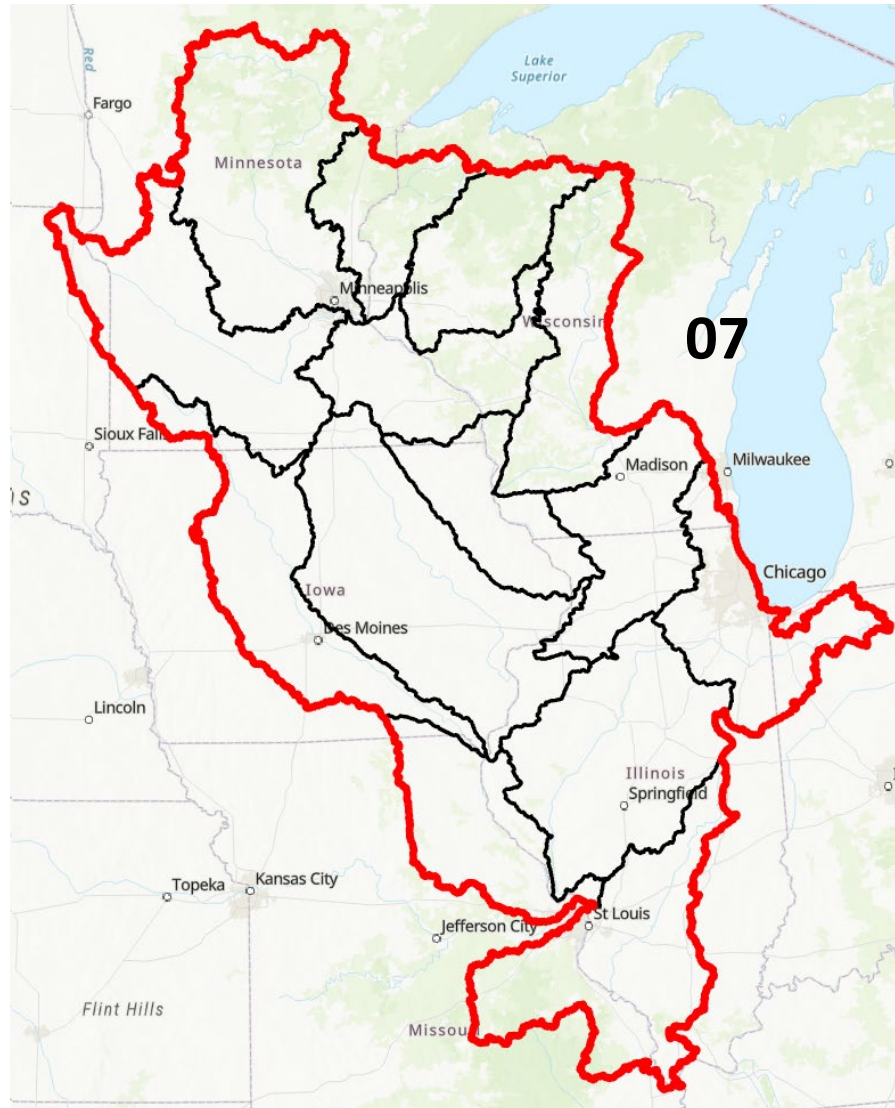
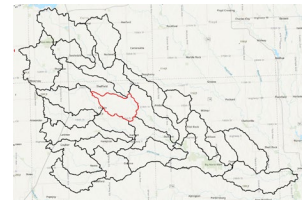
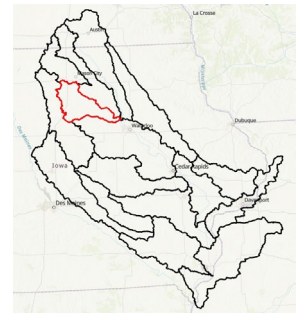
Scope and Scale

HUC2 – 18 Units



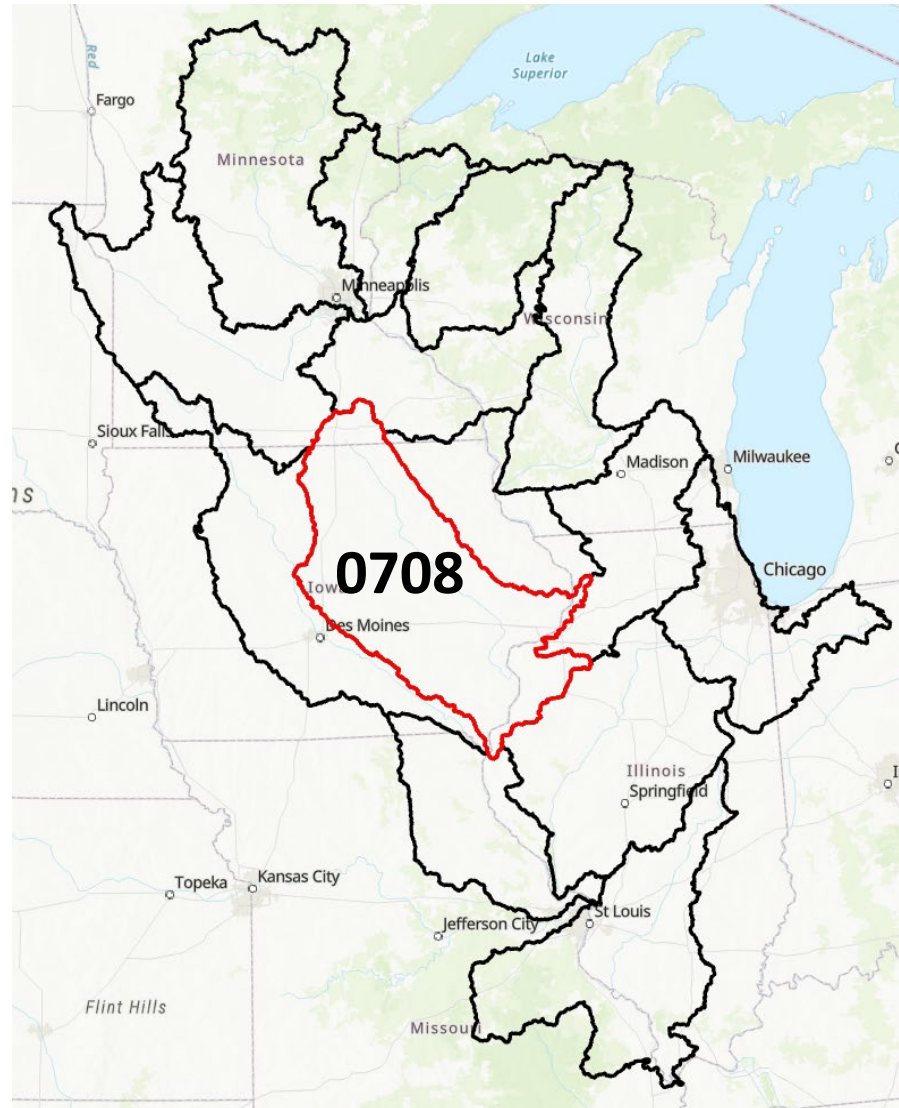
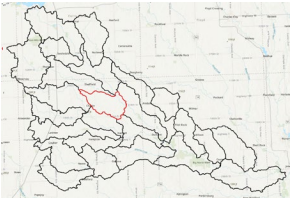
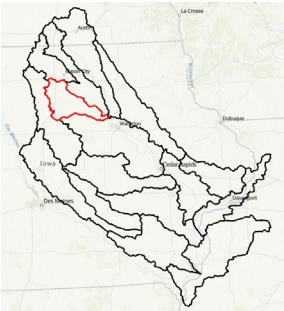
Scope and Scale

HUC4 – 202 Units in US



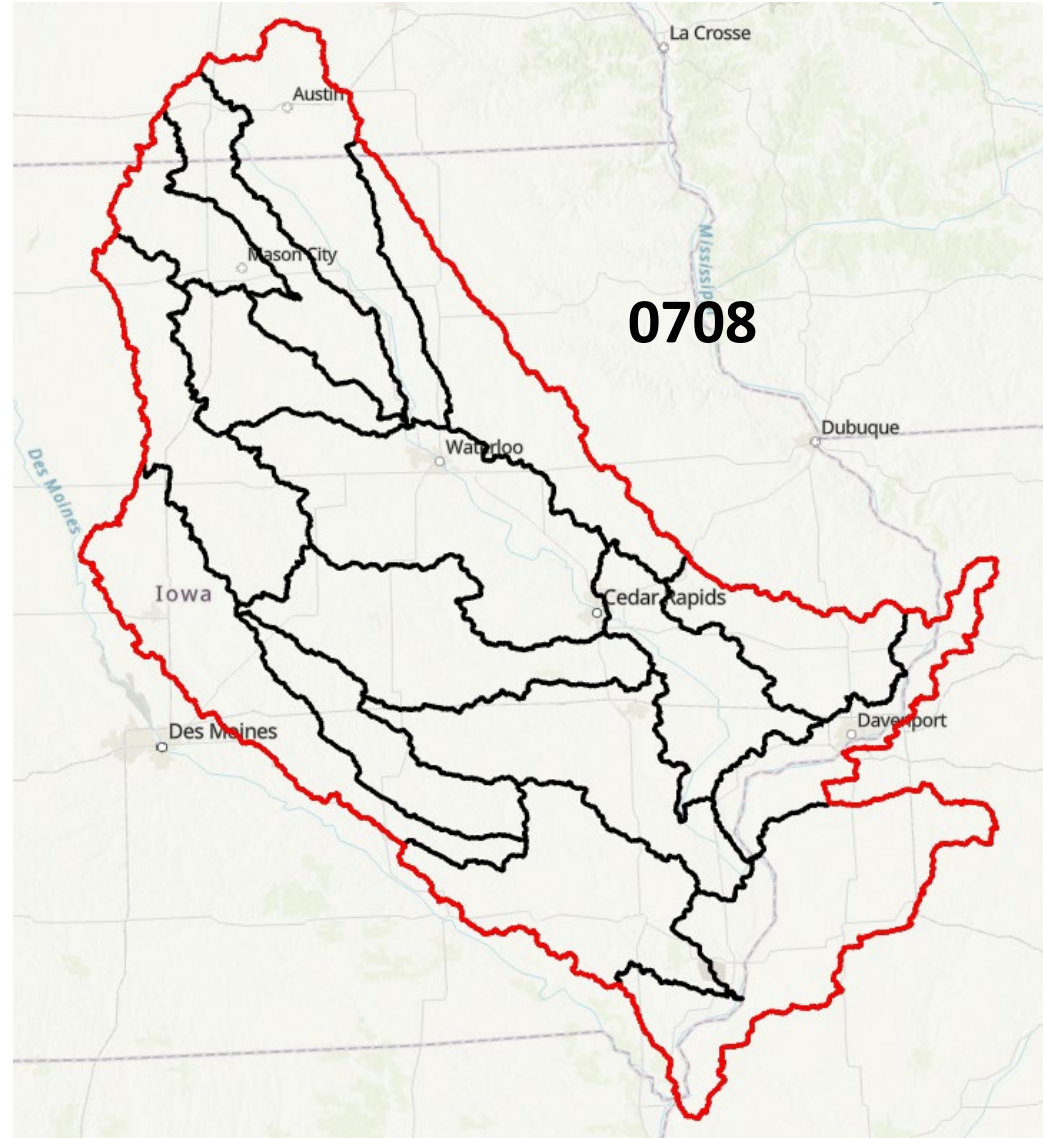
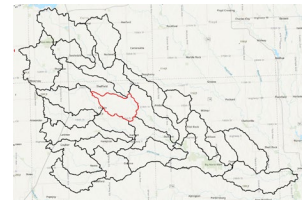
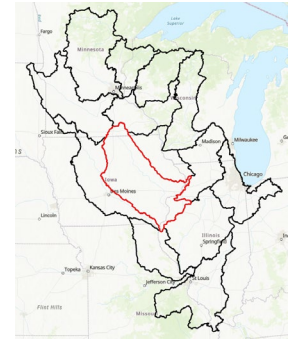
Scope and Scale

HUC4 – 202 Units in US



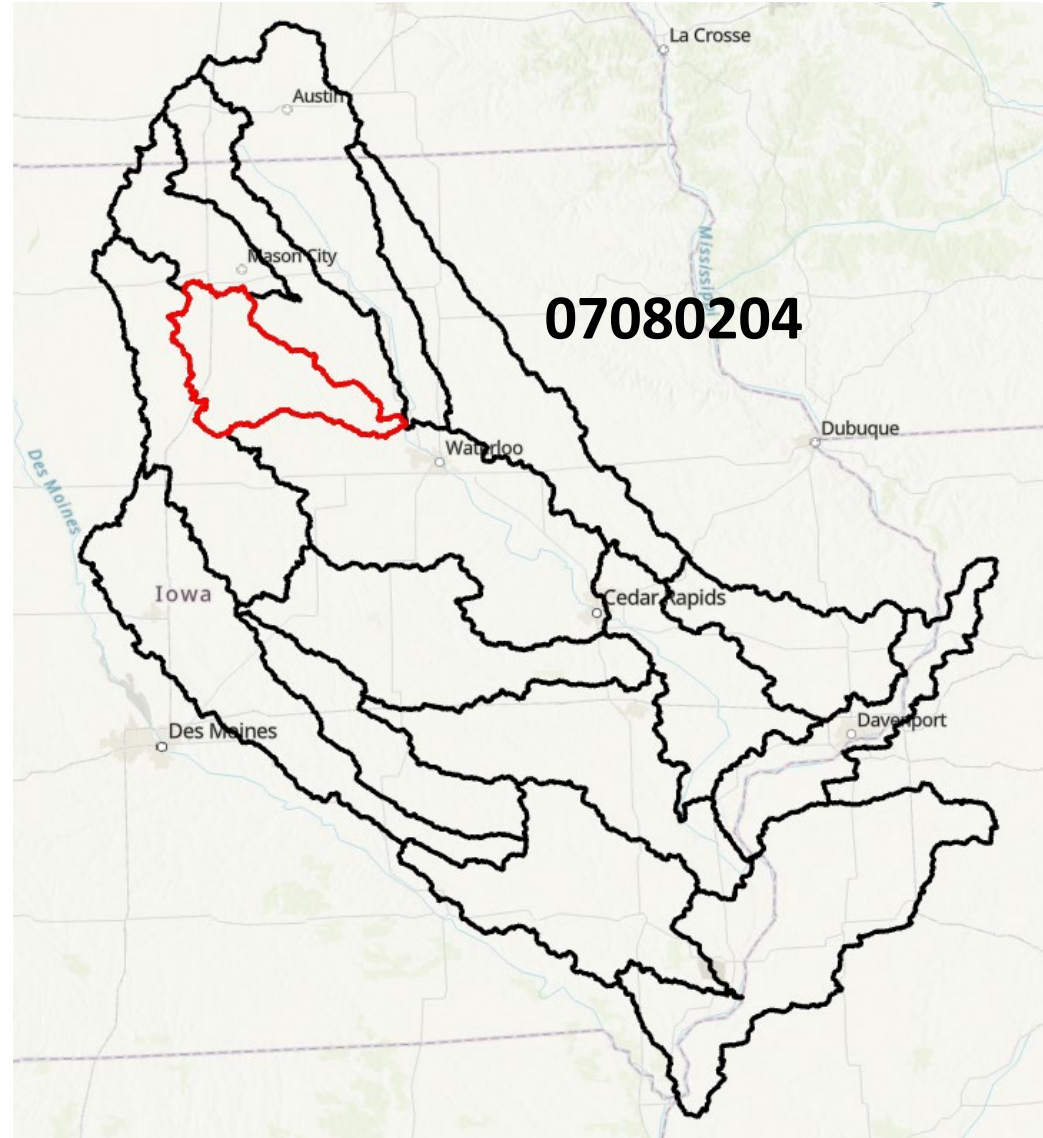
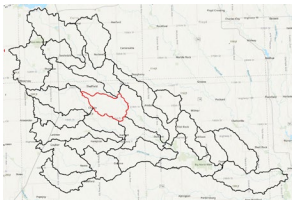
Scope and Scale

HUC8 – 2,121 Units in US



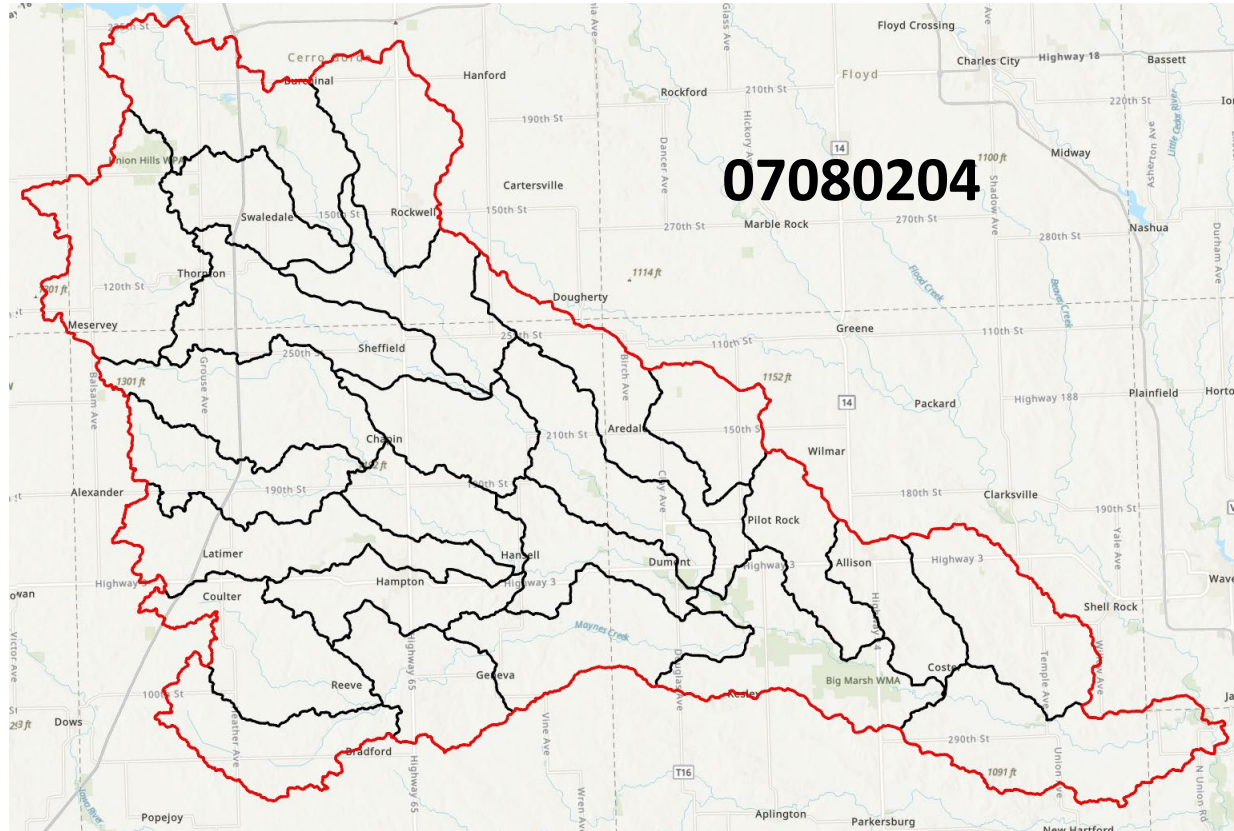
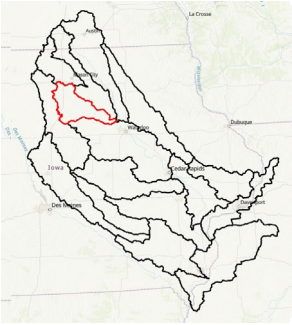
Scope and Scale

HUC8 – 2,121 Units in US



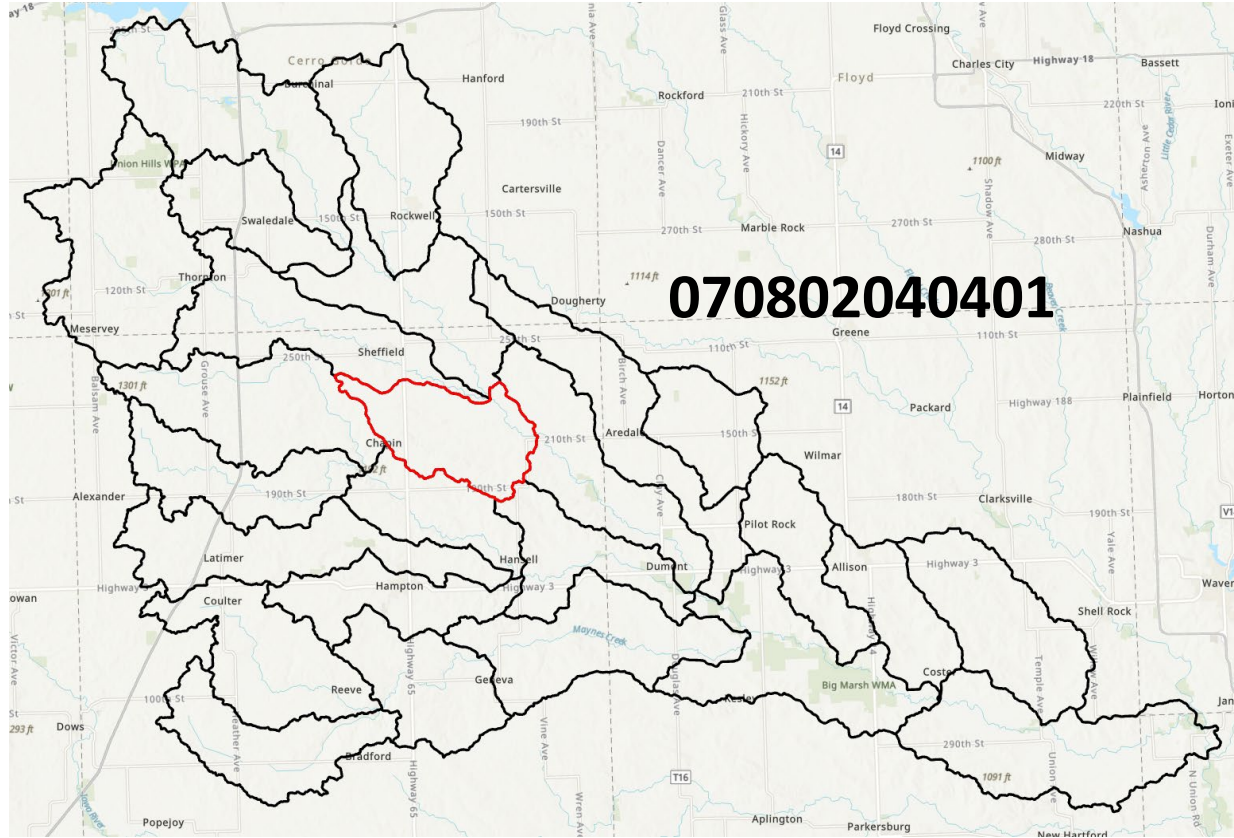
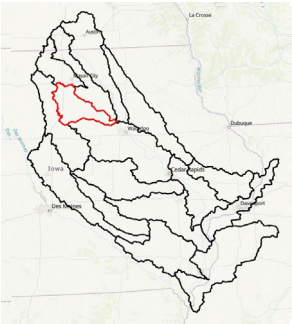
Scope and Scale

HUC12 – 65,000 Units in US



Scope and Scale

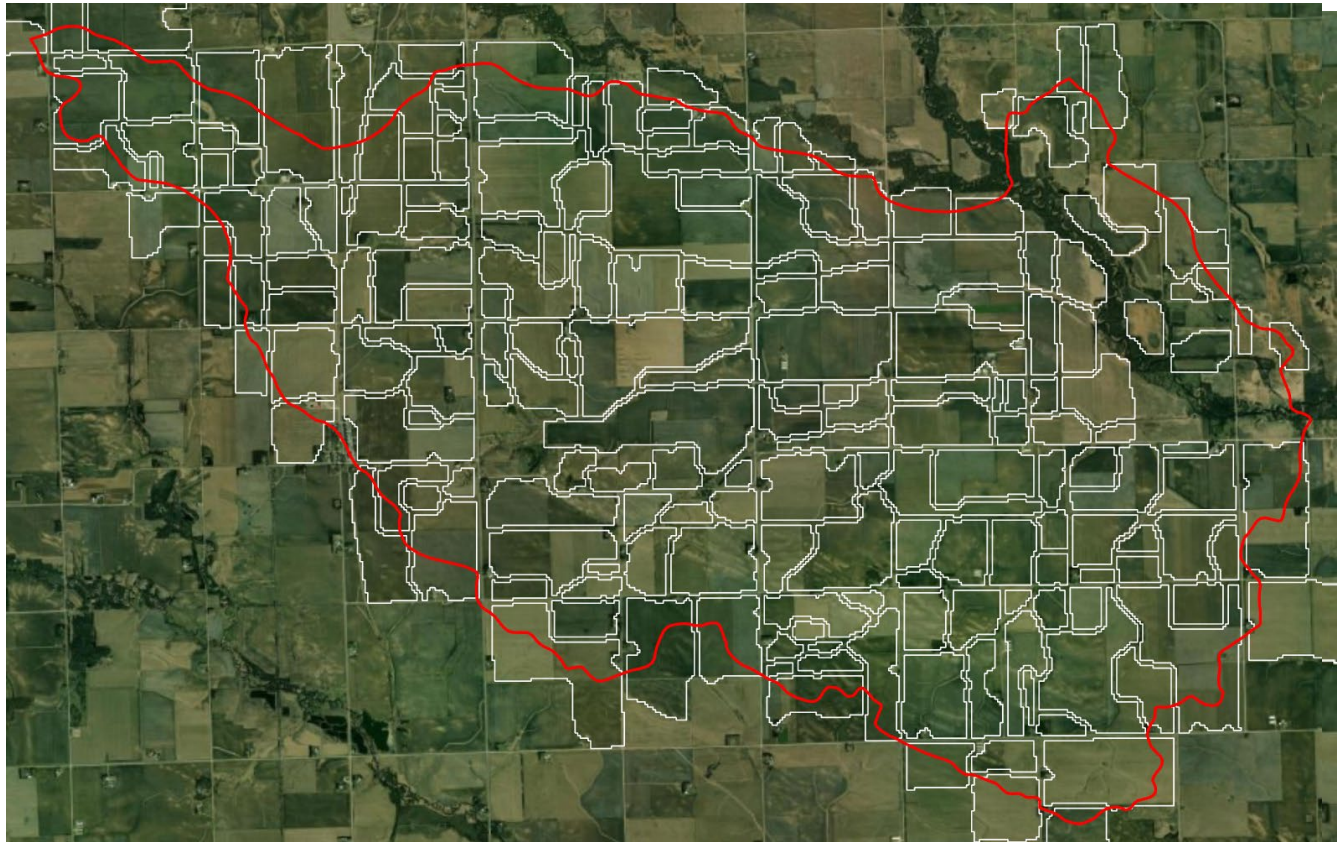
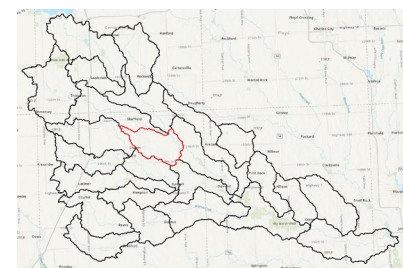
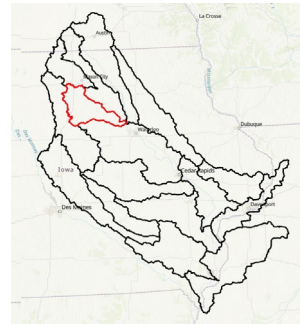
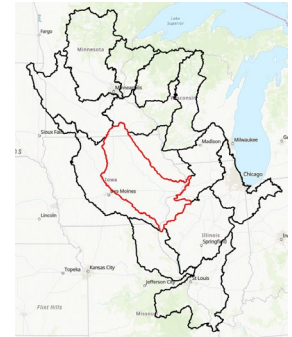
HUC12 – 65,000 Units in US



Scope and Scale

HUC12 – 65,000 Units in US

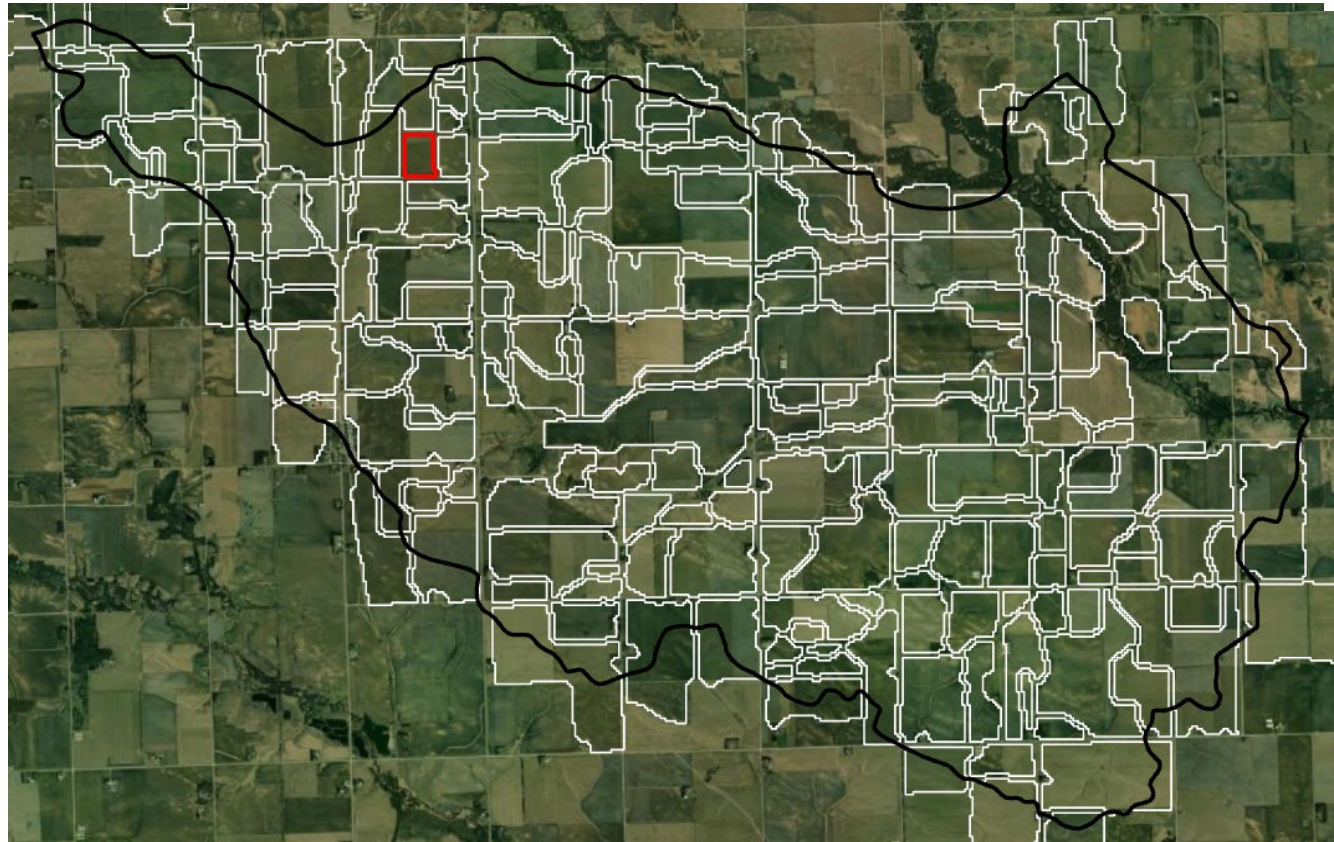
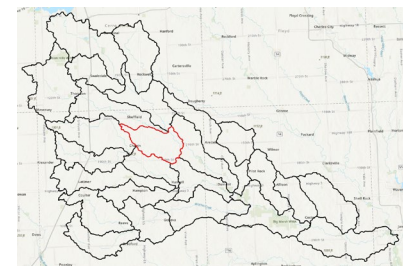
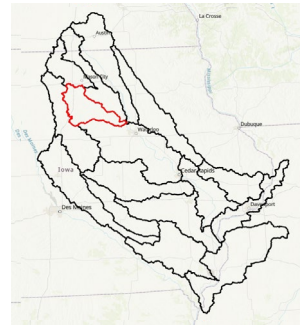
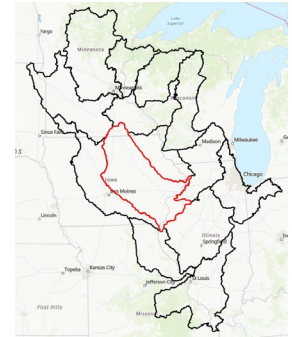
070802040401



Scope and Scale

HUC12 – 65,000 Units in US

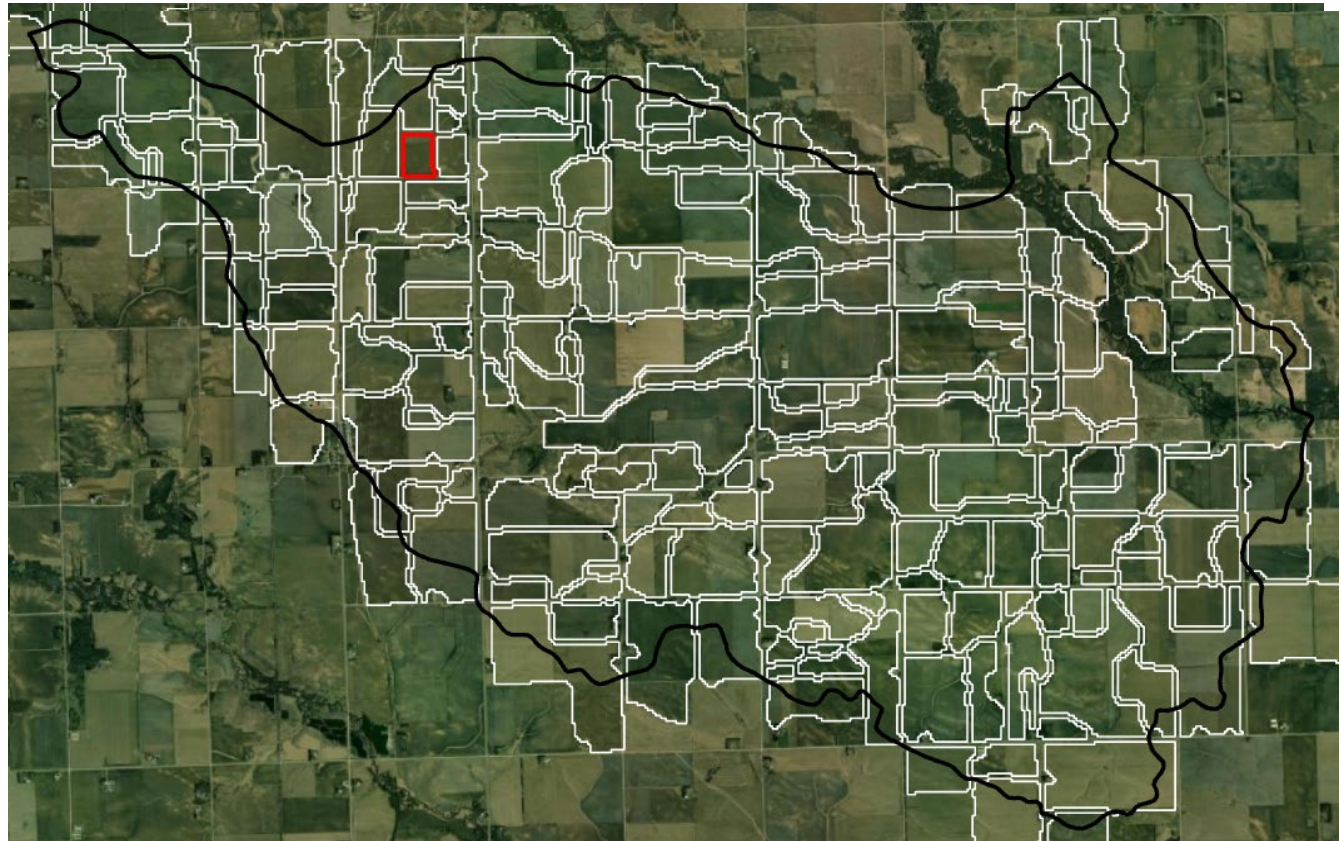
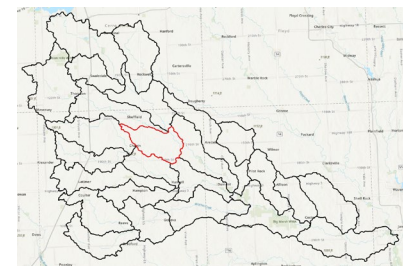
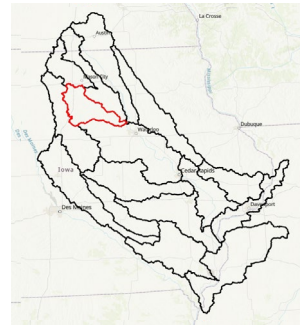
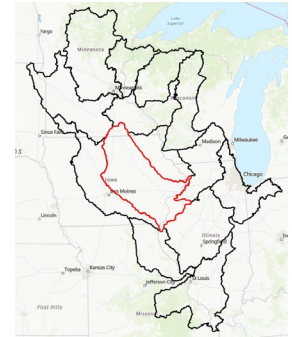
070802040401



Scope and Scale

Fields – 4.5 Million Units in US

FUID = 1277645001



Scope and Scale

Fields – 4.5 Million Units in US

FUID = 1277645001



HRU_ID = 1484863

FUID = 1277645001

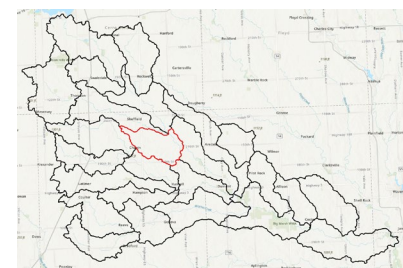
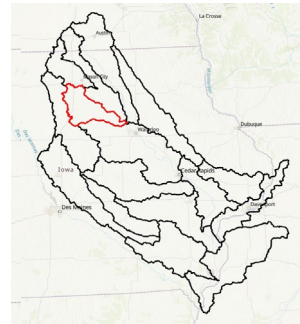
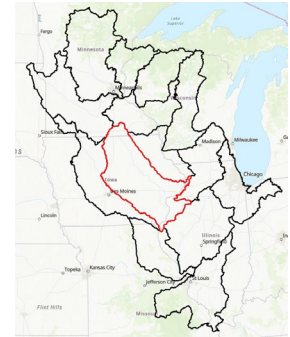
1% Slope

Soil = Dinsdale

Corn-Soybean rotation

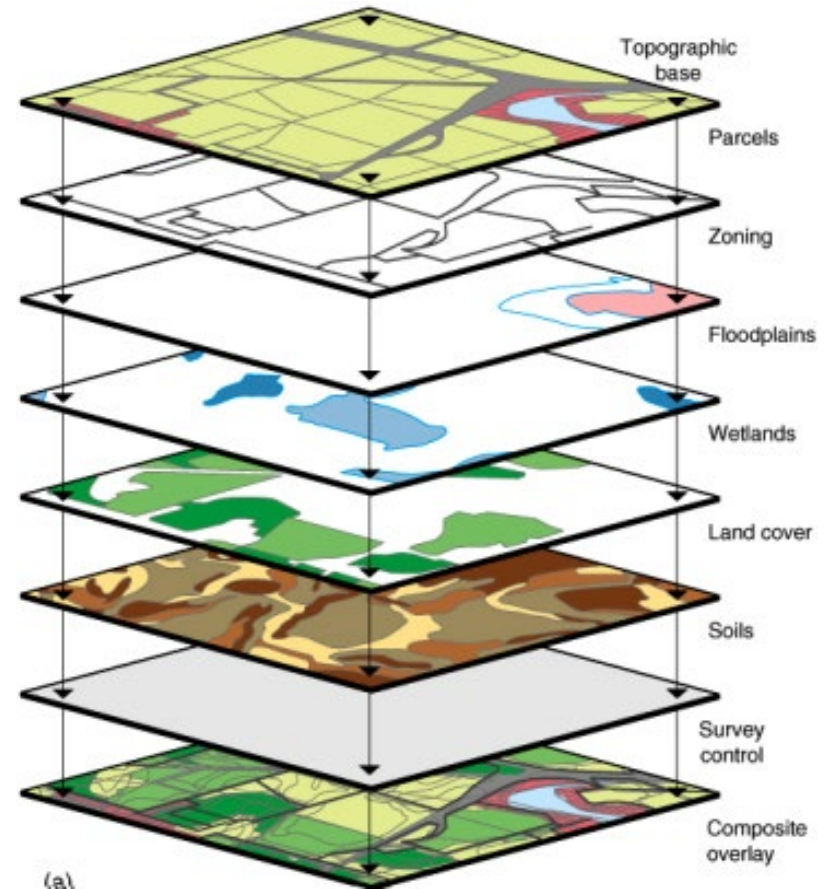
Tiled

Not Irrigated



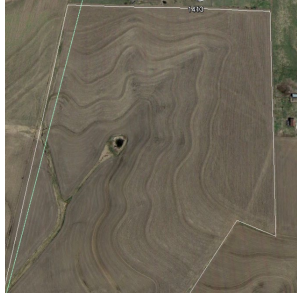



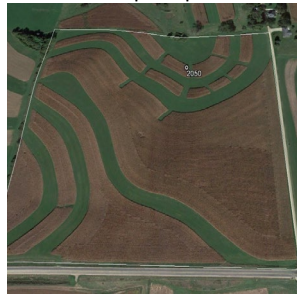
Upland Model Input Data

- Landcover - NLCD (30m)
- Crop rotation – CDL (30m)
- Soils – SSURGO – Pedon (vector)
- Topography – NED (10m)
- Irrigation (30m)
- Tiles (30m)
- Atmospheric Deposition
- Weather
 - Station
 - NEXRAD (4km)
- Management
 - NRCS RUSLE2 - 20,000 templates
 - Fertilization – County Ag Census
 - **Conservation Practices**



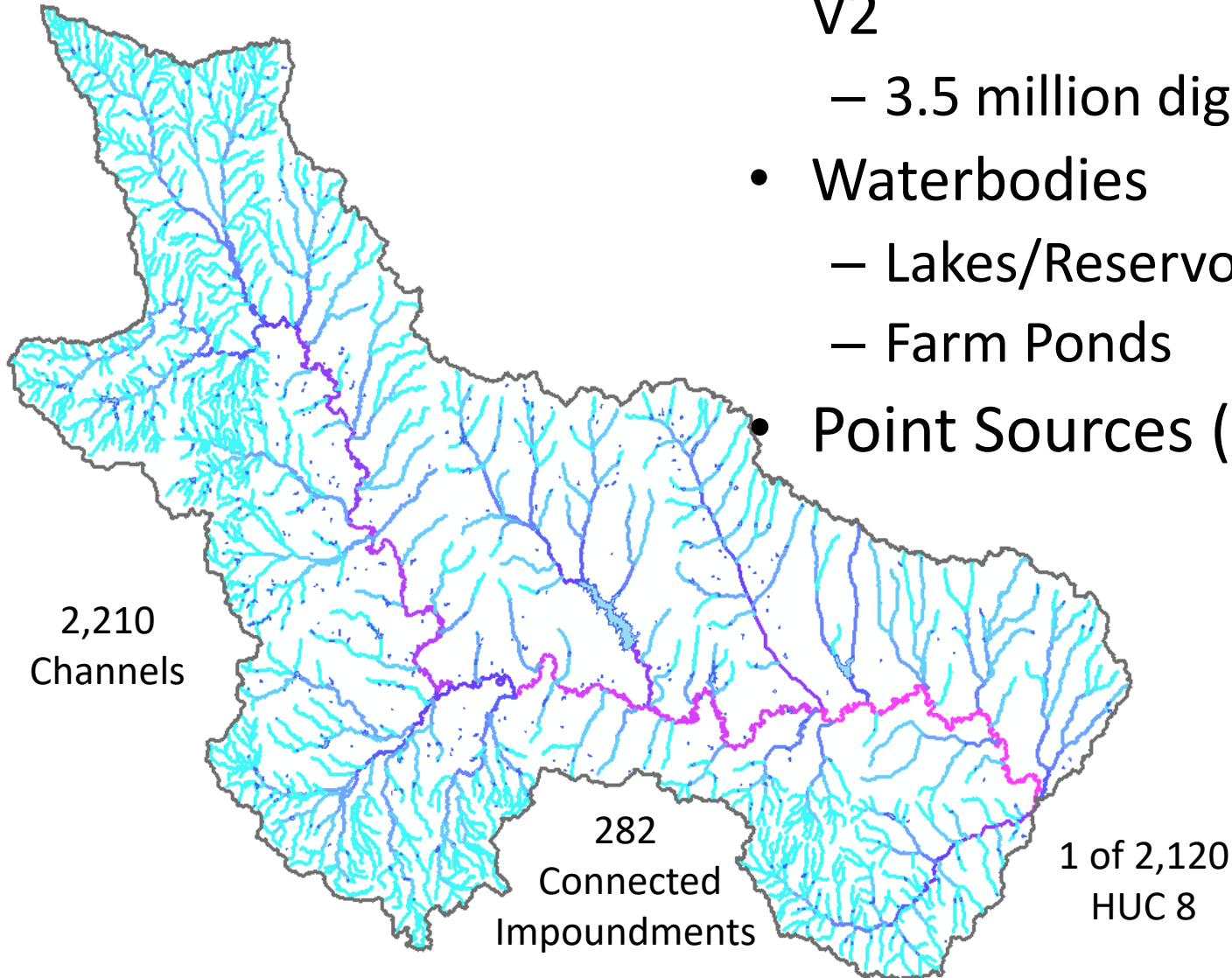
Agricultural Conservation Practices

- US Agricultural Census
 - Cover Crops
- Survey
 - Tillage Intensity (CTIC)
 - Structural Practices
- CEAP Survey
- Google Earth
 - 40,000 fields surveyed
 - Multi-year imagery
 - Details Published in JAWRA

<p style="text-align: center;">Terraces</p>  <p>Roughly parallel lines, running cross slope, sometimes accompanied by shadows. Terraces follow contour lines and are usually accompanied by contour planting. The distance between terraces is related to field slope. Terraces are permanent and are generally visible in multiple past images.</p>	<p style="text-align: center;">Waterways</p>  <ul style="list-style-type: none"> • Strips of grass following field drainage. usually they have a strong color contrast as compared to the crop area. Waterways generally appear green, but may vary depending on season. Waterways are generally visible in past images. 	<p style="text-align: center;">Filter Strip/Field Borders</p>  <p>A strip of grass that borders one or more sides of a field, a stream. The strip or border is generally uniform in thickness and much wider than a waterway. The filter strips are almost always a shade of green in one or more past images.</p>
<p style="text-align: center;">Contour Planting</p>  <p>The implement marks follow contour lines and share the same patterns as seen on topographical maps. Practice is most often associated with terraces, but may be found singularly.</p>	<p style="text-align: center;">Center Pivot Irrigation</p>  <p>Very clear and distinct lines that form a circular pattern. Most fields with a center pivot are fully circular, but half and quarter coverages are common. The center pivot itself is often visible.</p>	<p style="text-align: center;">Strip Crops</p>  <p>Crops grown in alternating strips, which can be easily distinguished from aerial photography due to the contrast may not be present in past images, so the most recent image is used to make the final determination.</p>

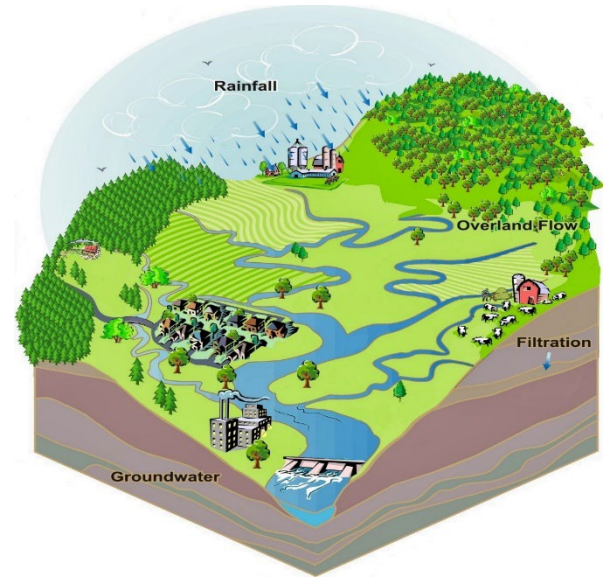
Stream Reaches and Water Bodies

- National Hydrography Dataset V2
 - 3.5 million digitized reaches
- Waterbodies
 - Lakes/Reservoirs
 - Farm Ponds
- Point Sources (EPA DMR)

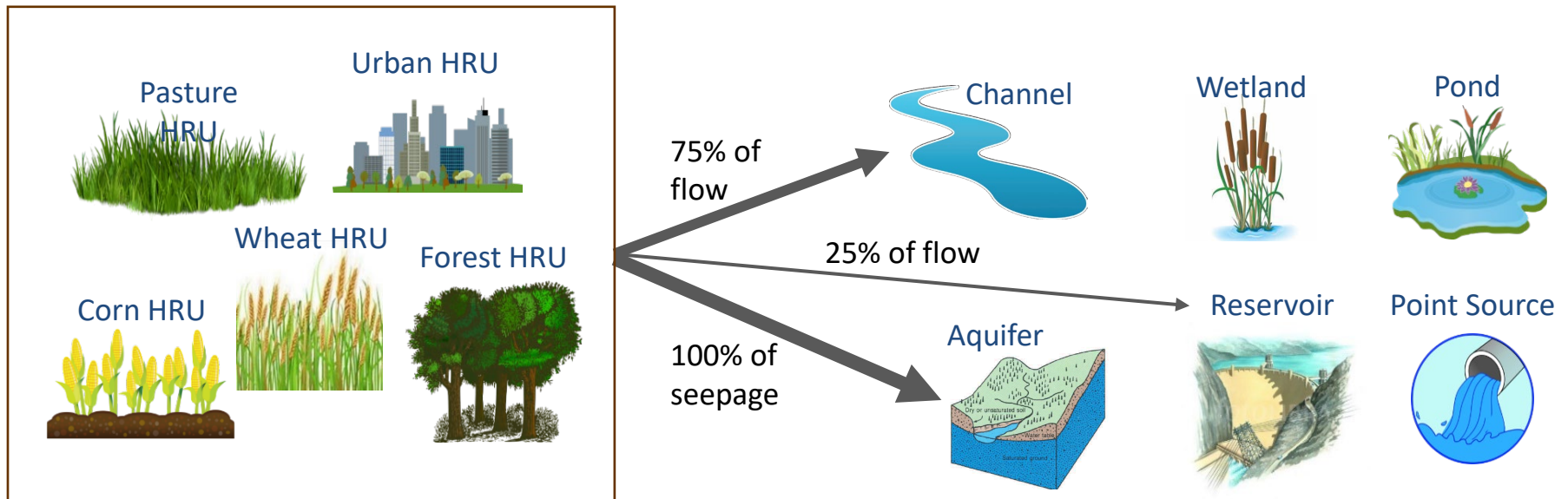


SWAT+ Object Connections

- Flexible spatial representation of connectivity within a watershed using “connect” files
- The interface **Does NOT** connect objects this way

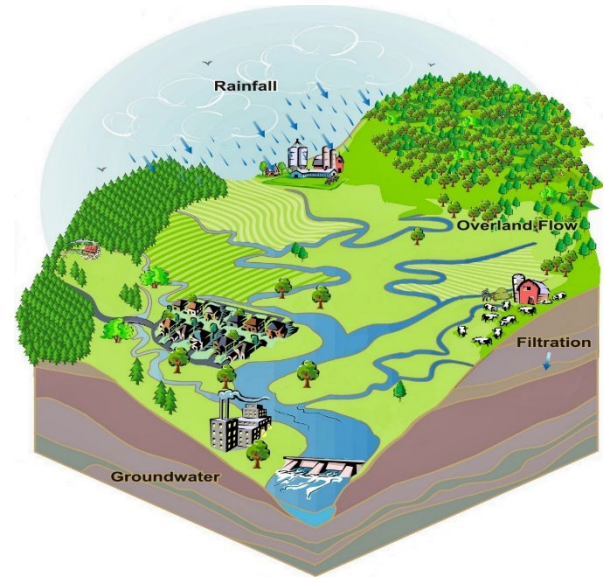
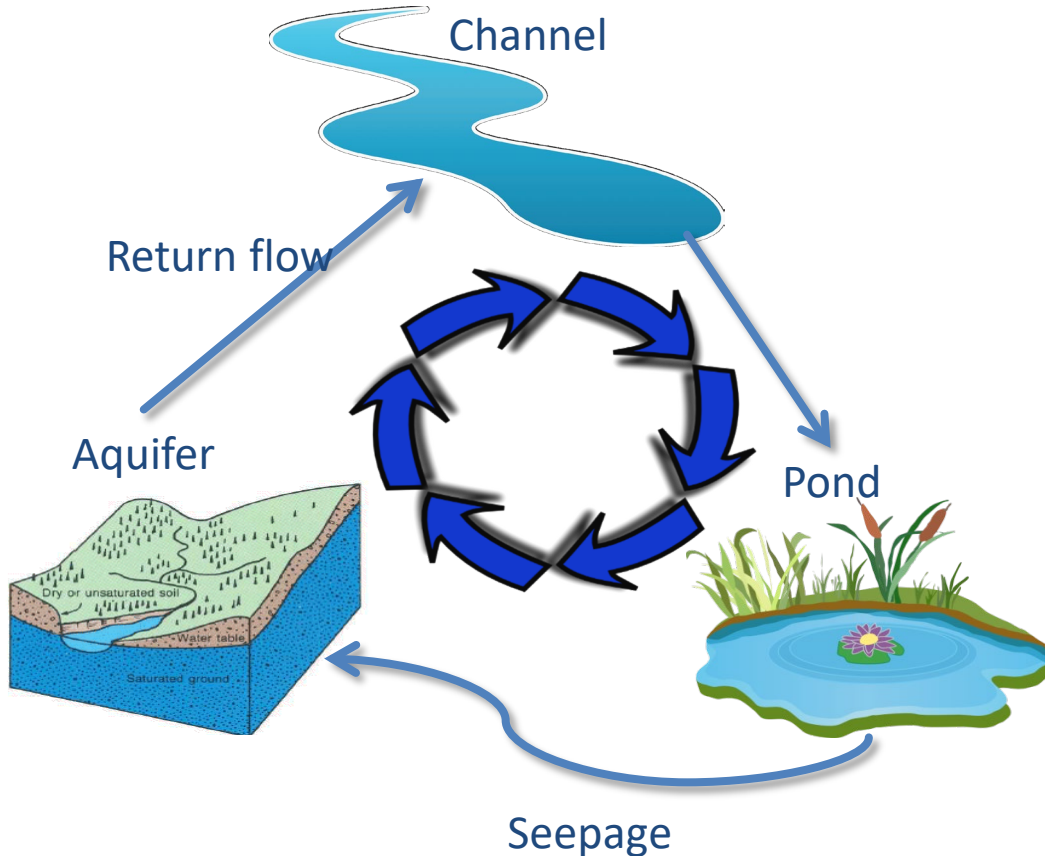


Landscape Unit





SWAT+ Object Connections

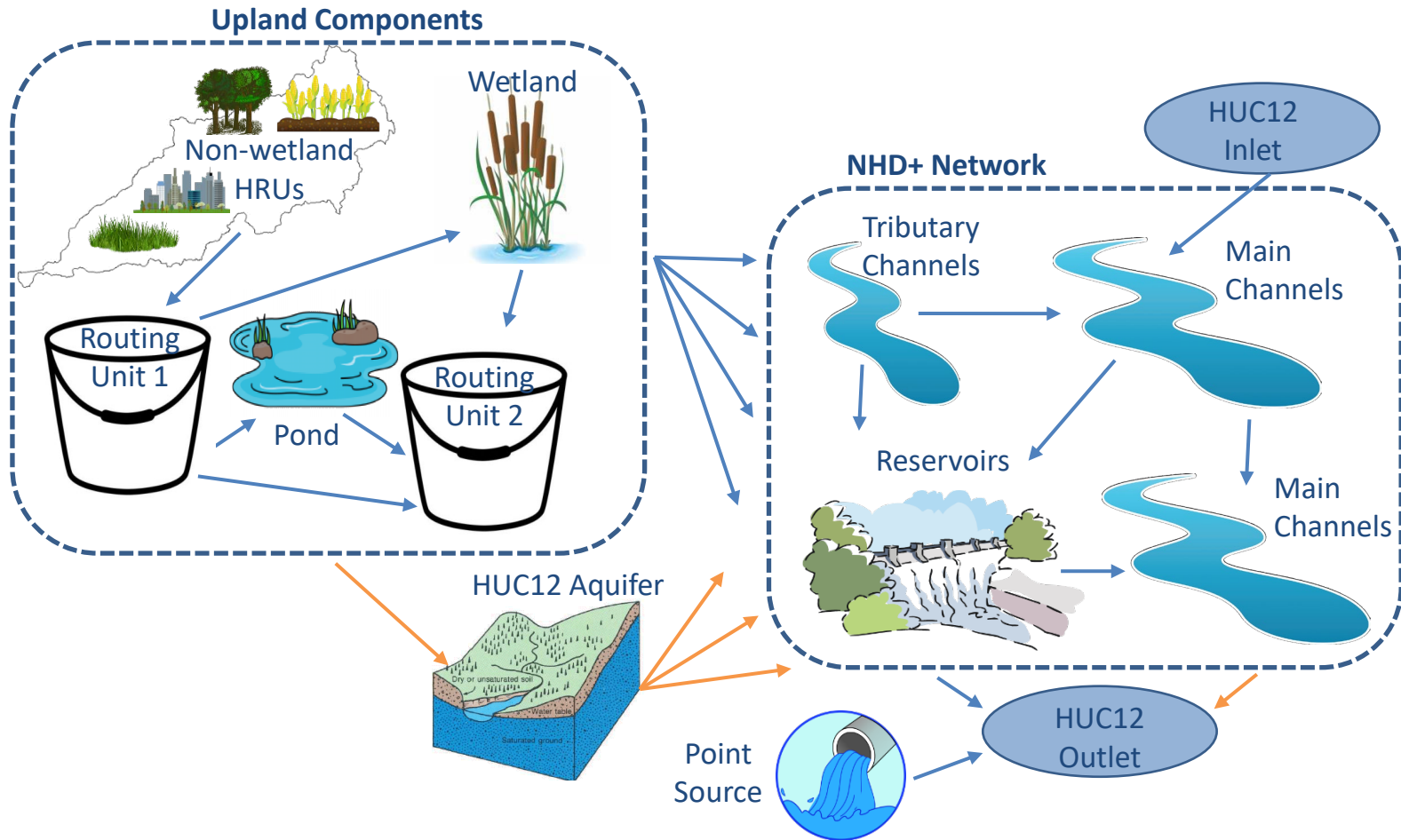
- Flexible spatial representation of connectivity within a watershed using “connect” files
- The interface **Does NOT** connect objects this way





Beware the
Infinite Loop

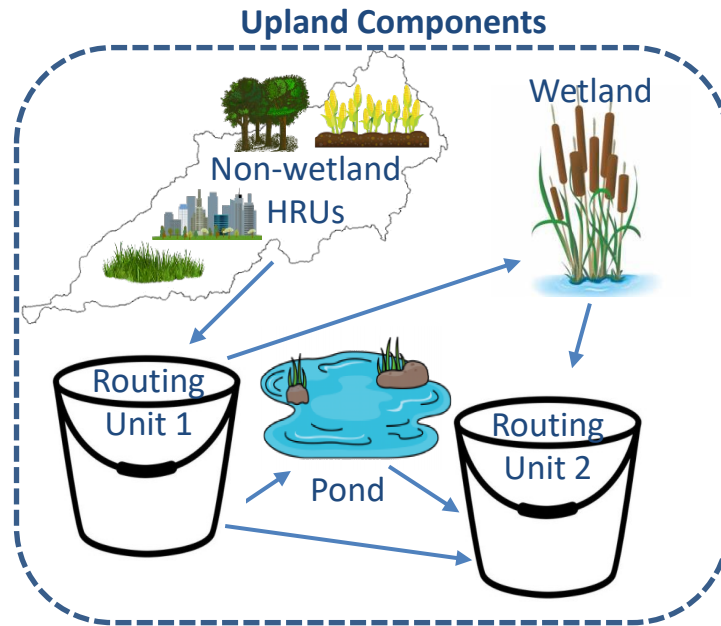
Object Connections

Surface Water 
Ground Water 





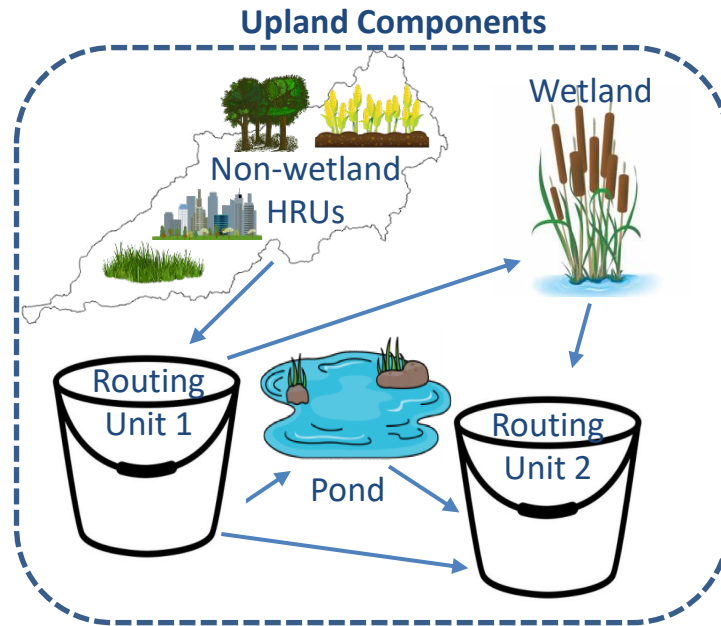
Object Connections

Surface Water 
Ground Water 



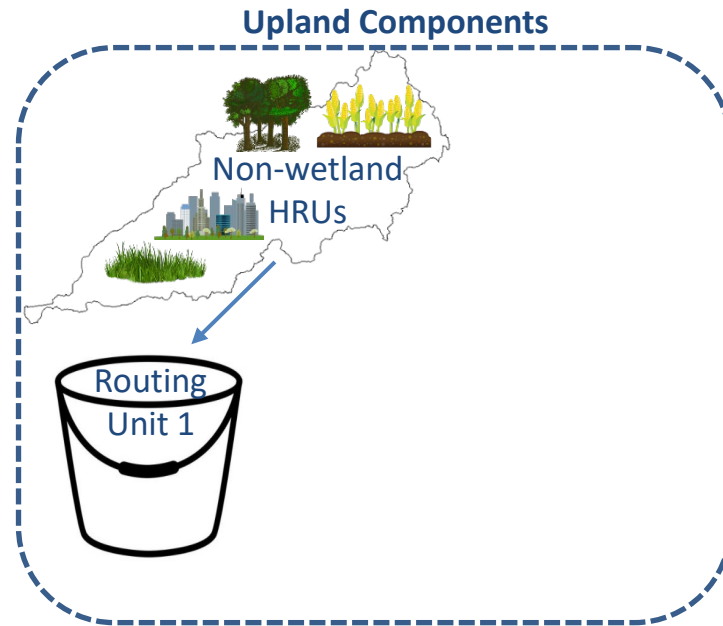
Object Connections

Surface Water 
Ground Water 





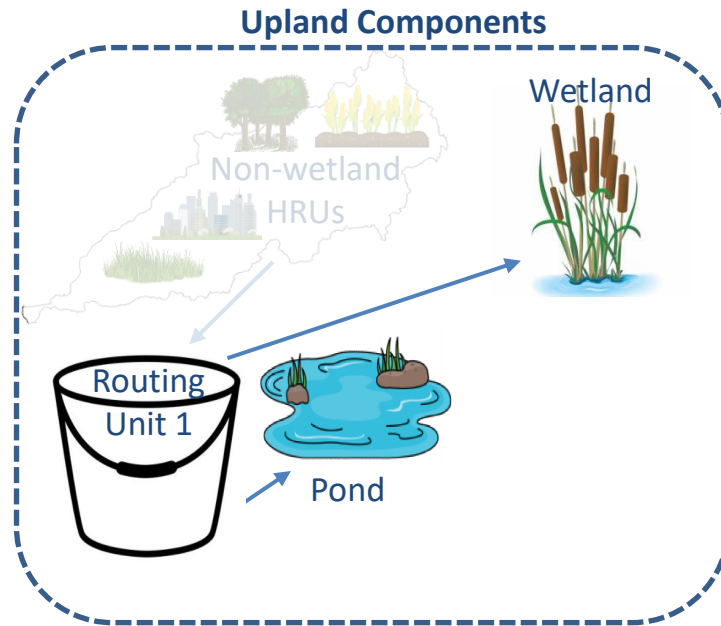
Object Connections

Surface Water →
Ground Water →





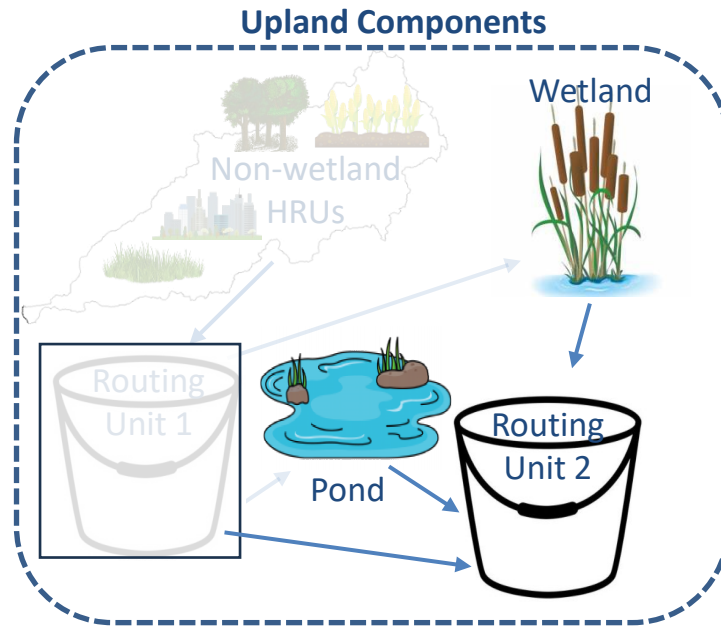
Object Connections

Surface Water 
Ground Water 



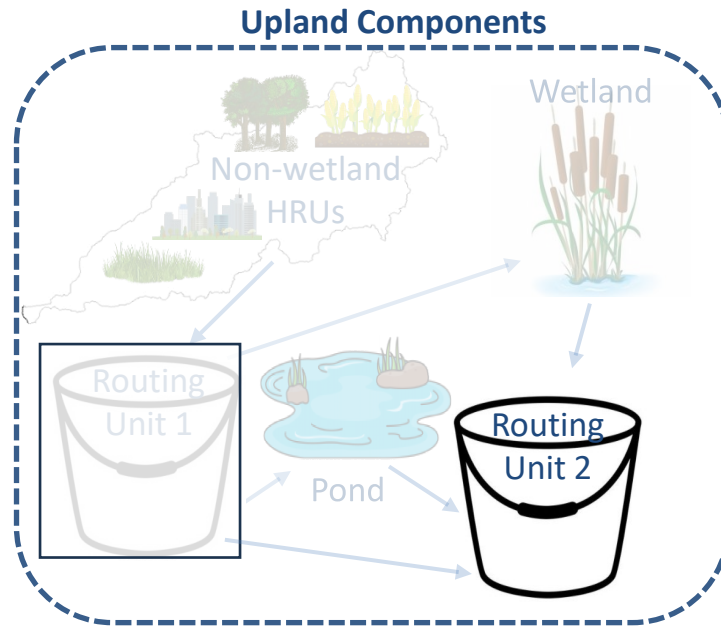
Object Connections

Surface Water 
Ground Water 



Object Connections

Surface Water →
Ground Water →



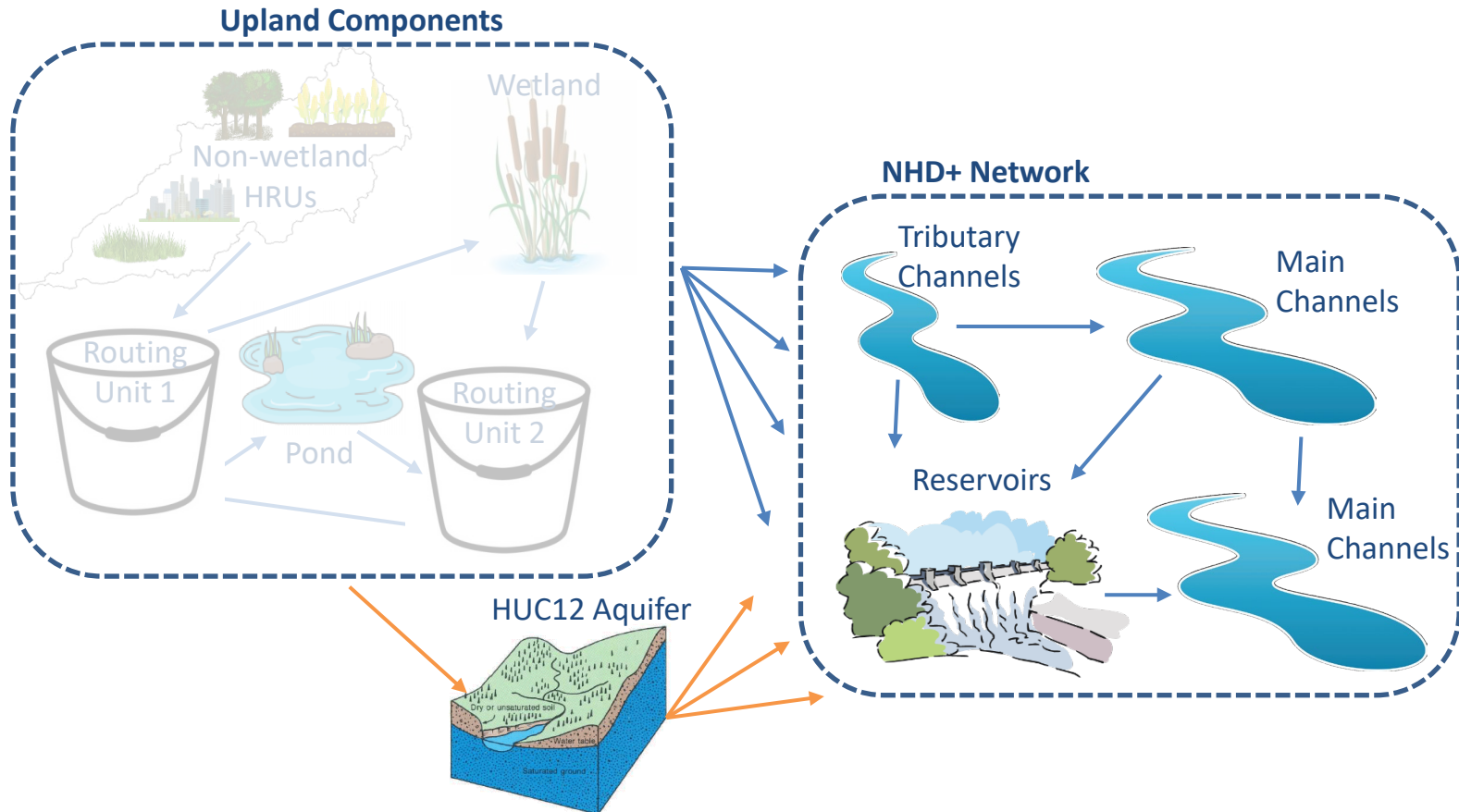
Routing Unit 2

Contains:



- Surface
- Lateral
- Tile Components
- Within a HUC 12

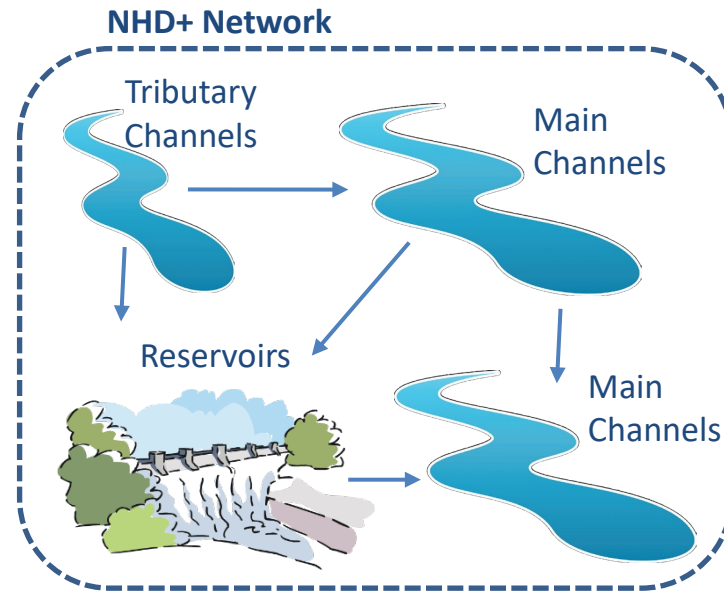
Object Connections

Surface Water →
Ground Water →



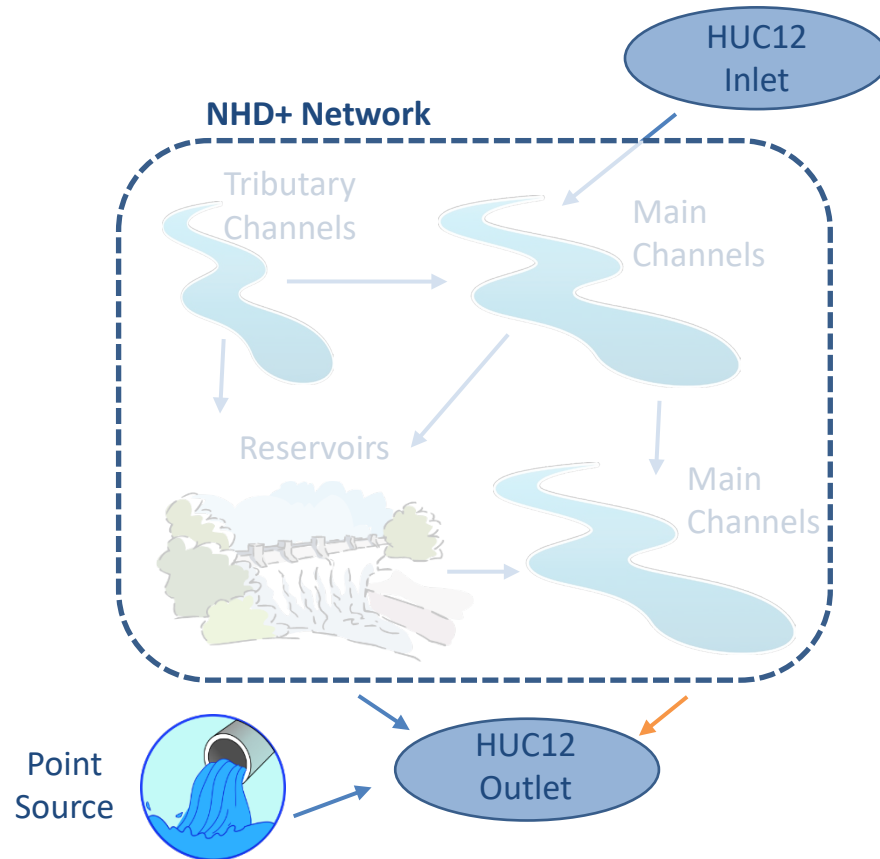
Object Connections

Surface Water 
Ground Water 





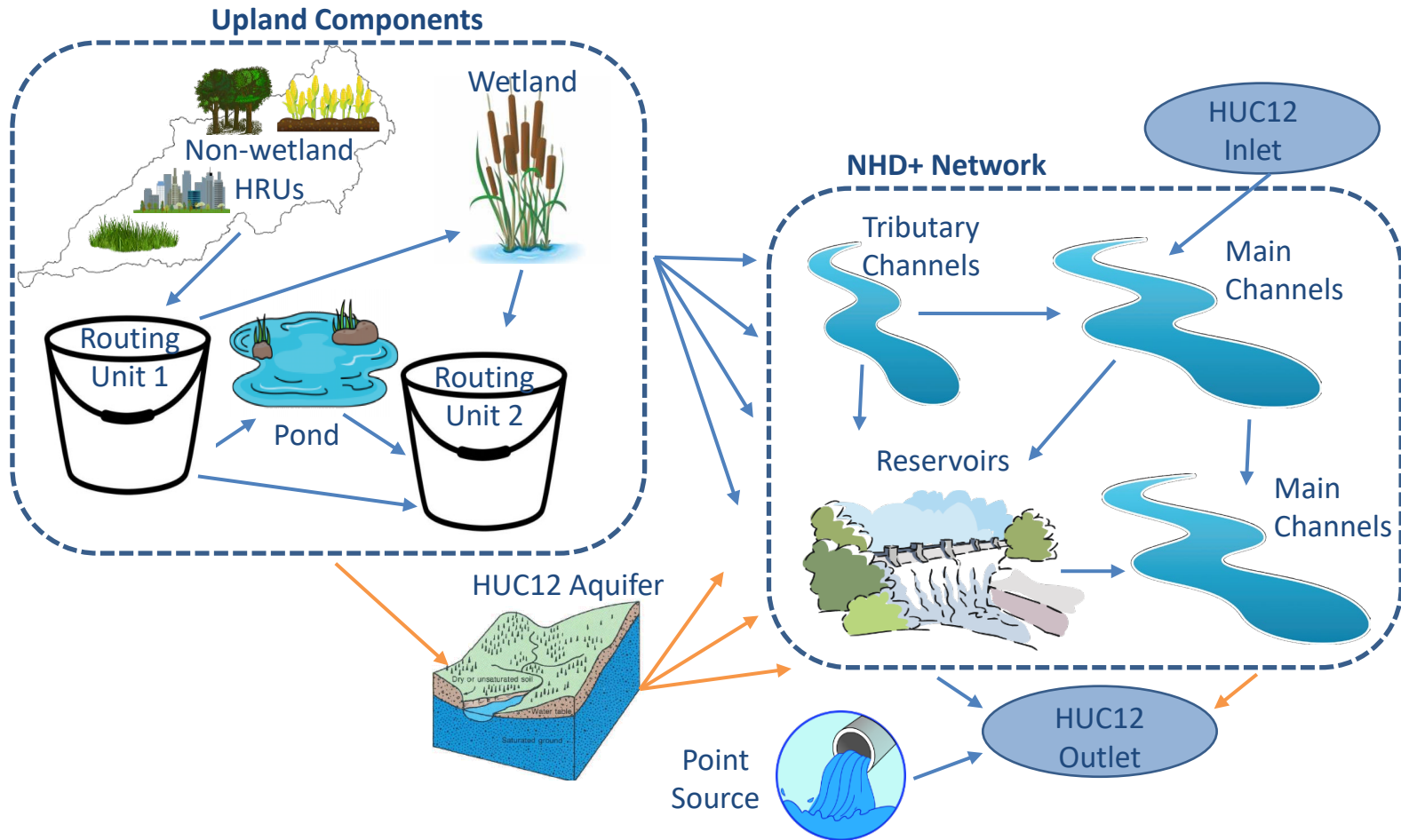
Object Connections

Surface Water →
Ground Water →



Object Connections

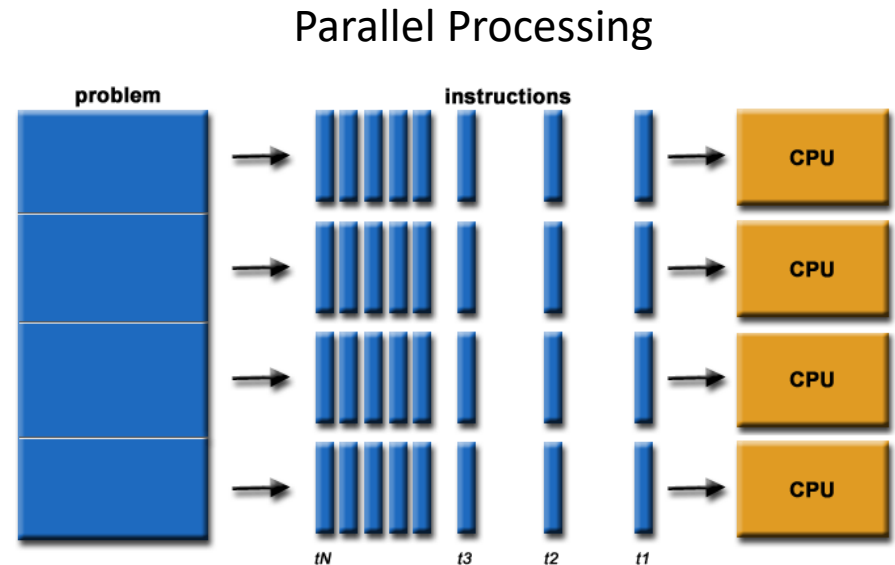
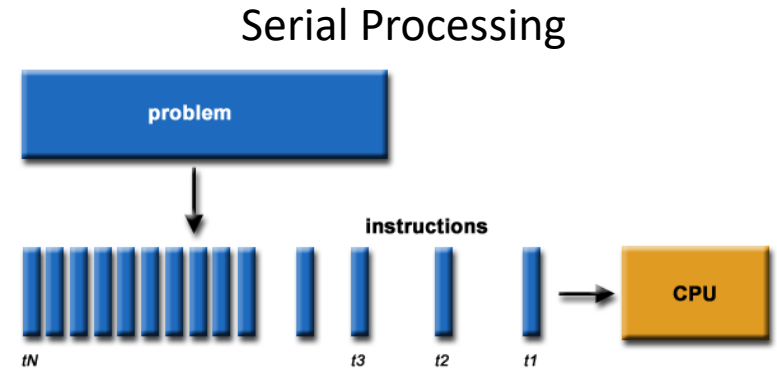
Surface Water 
Ground Water 

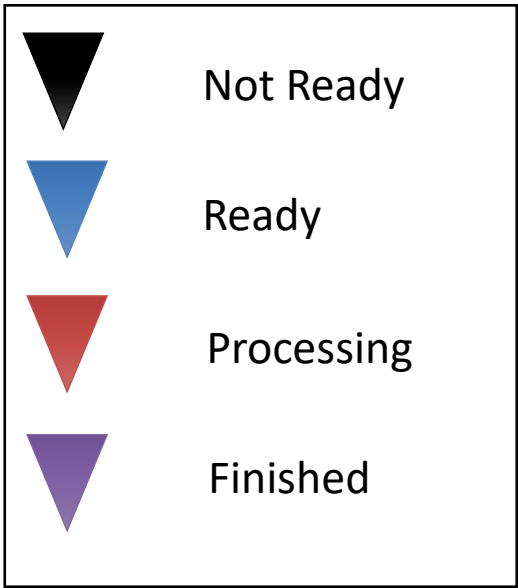


This is Getting Complicated

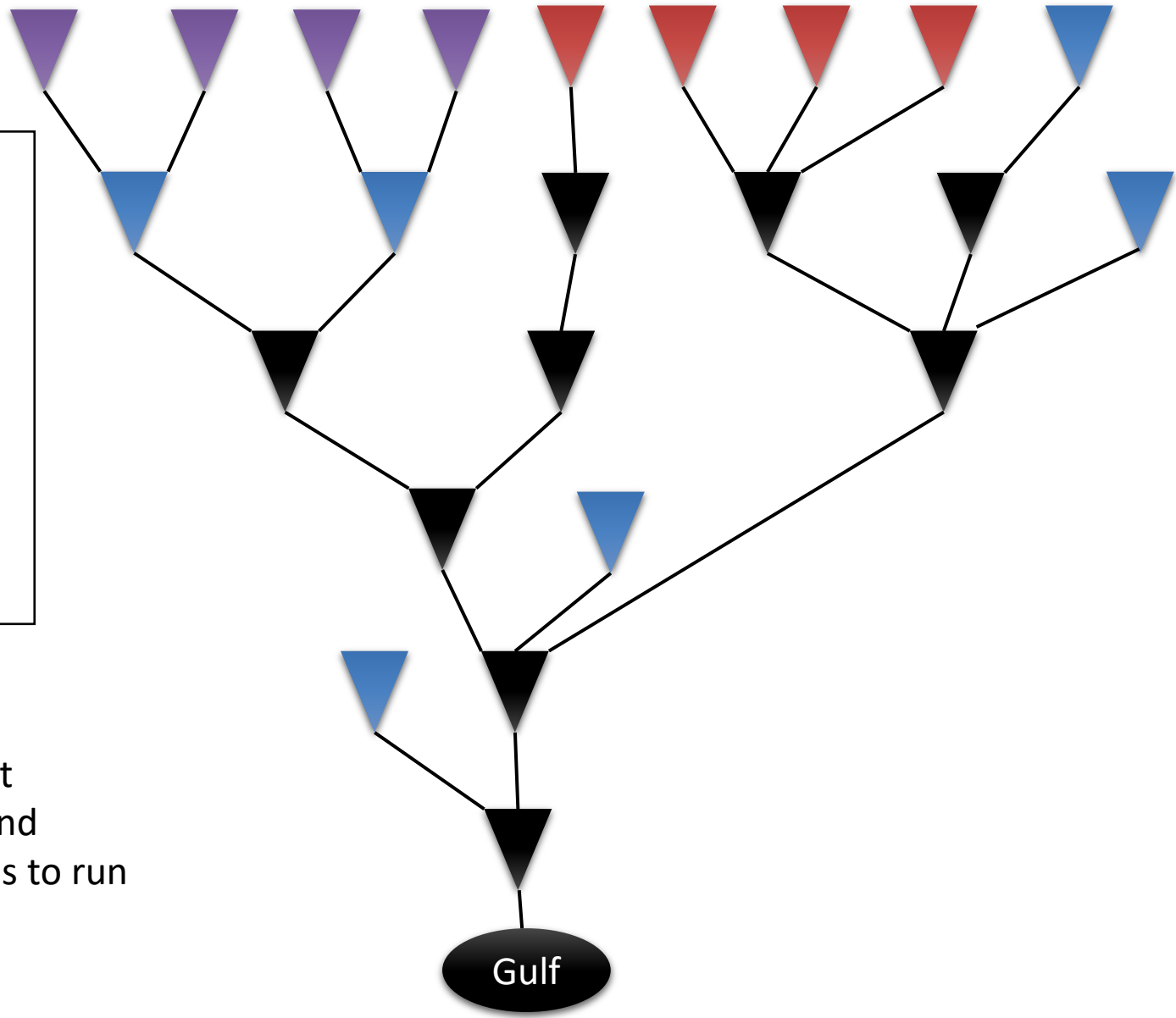
- National Agroecosystems Model
 - 7.5 million HRUs
 - 3.5 million streams
 - 150,000 impoundments

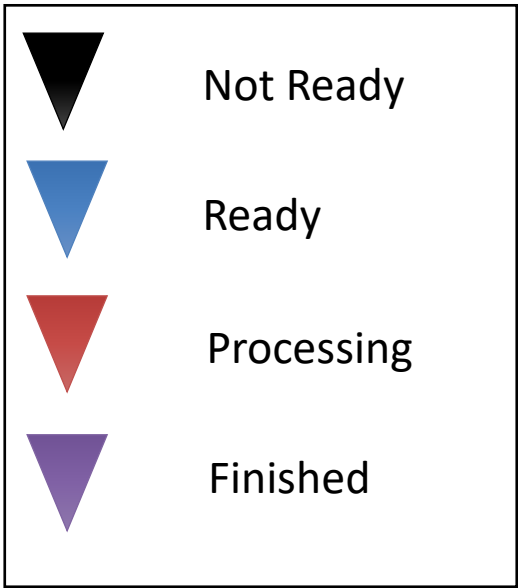
- Options
 - Parallelize SWAT+ Code
 - Parallelize NAM Model



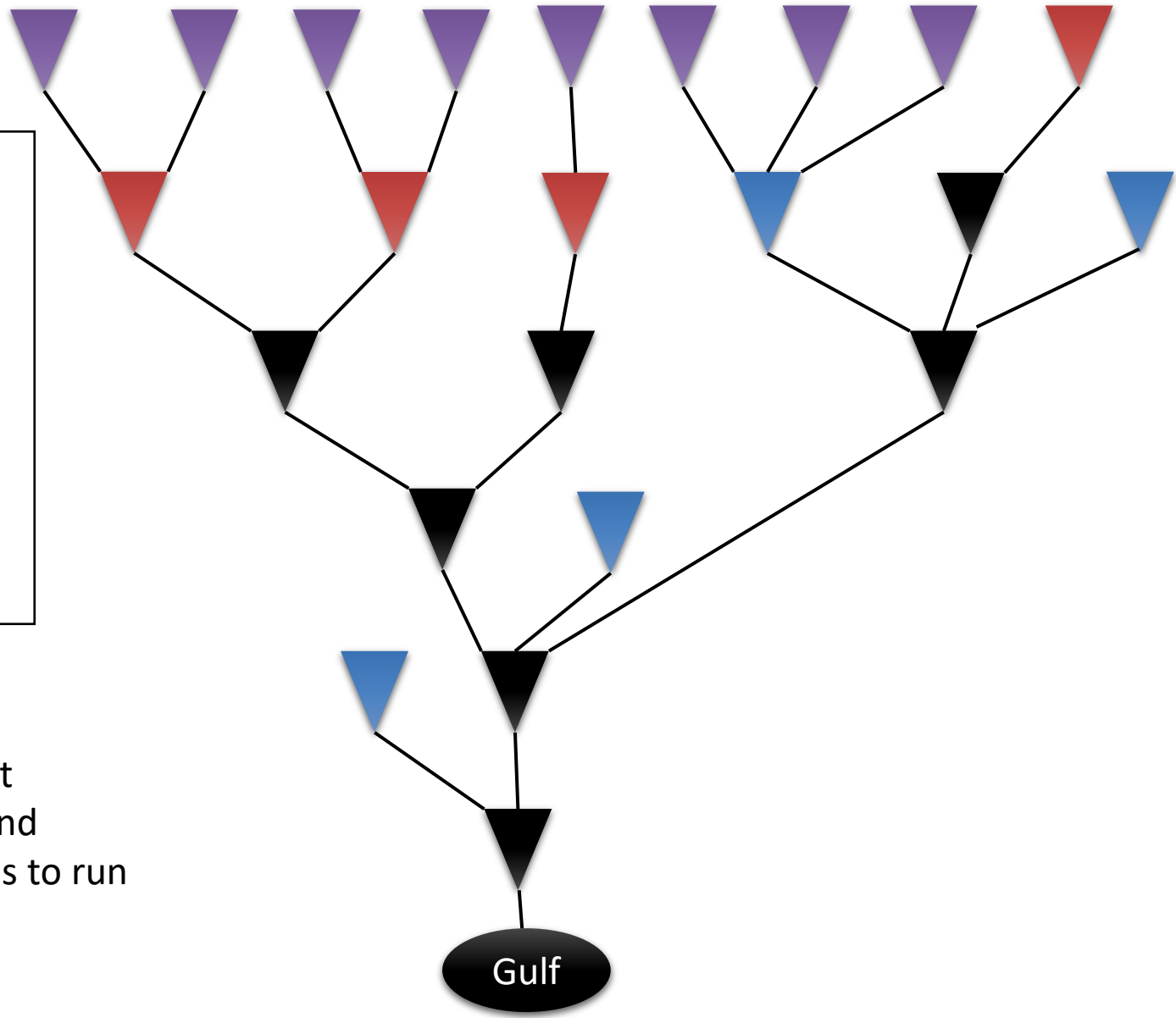


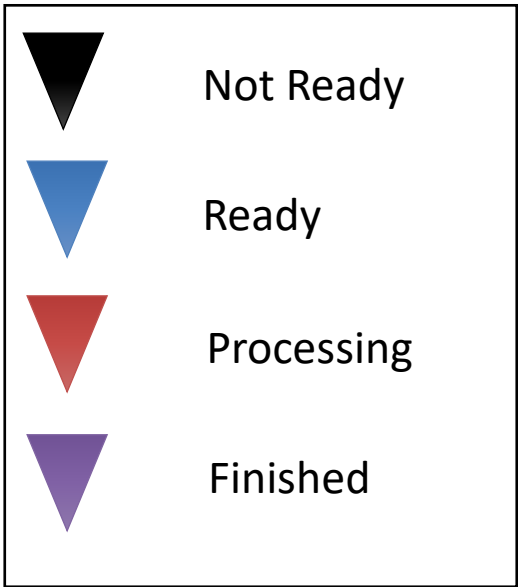
Cycle #2
 Identify models without unmet dependencies and
 Select another 4 models to run





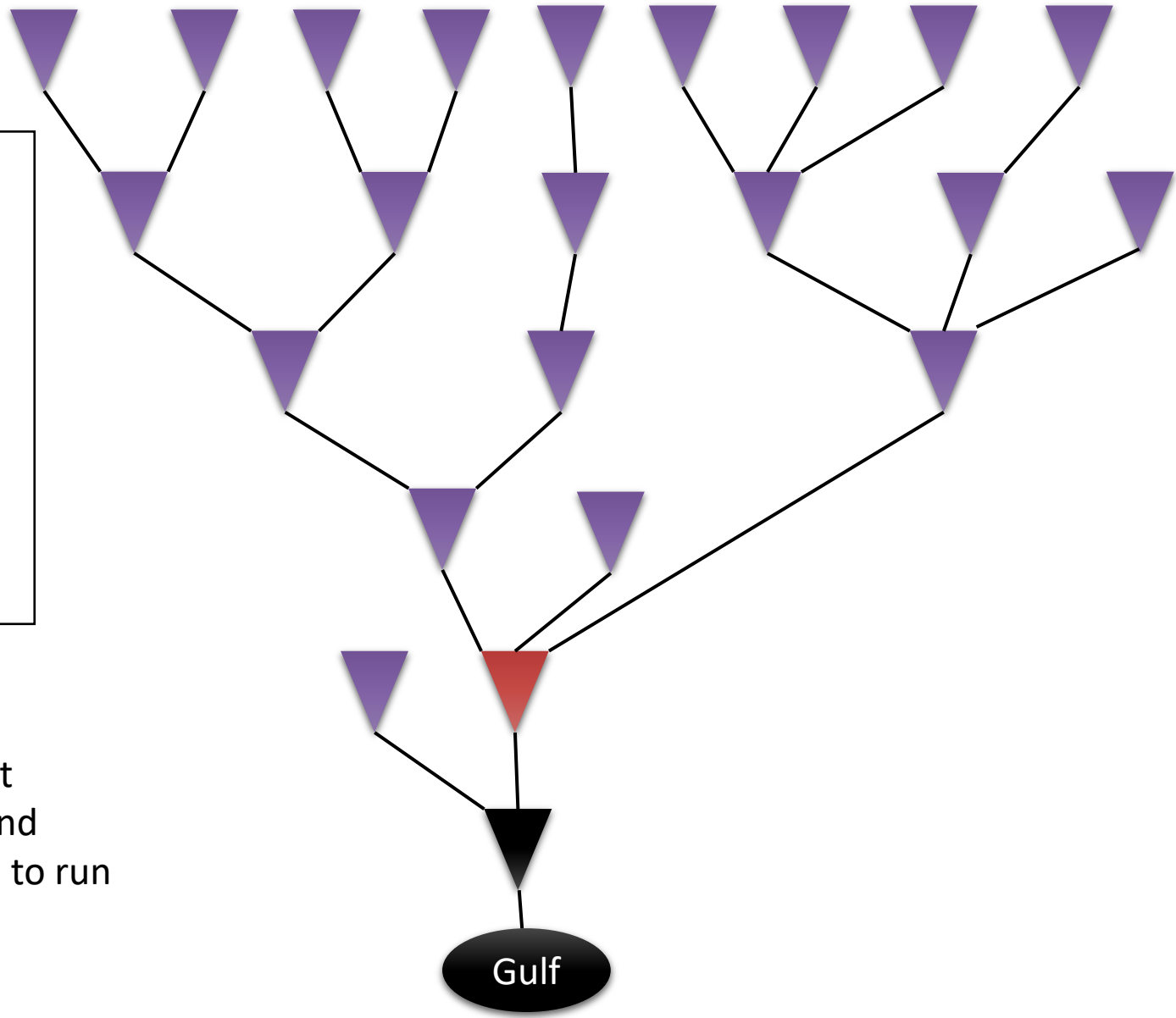
Cycle #3
Identify models without unmet dependencies and
Select another 4 models to run

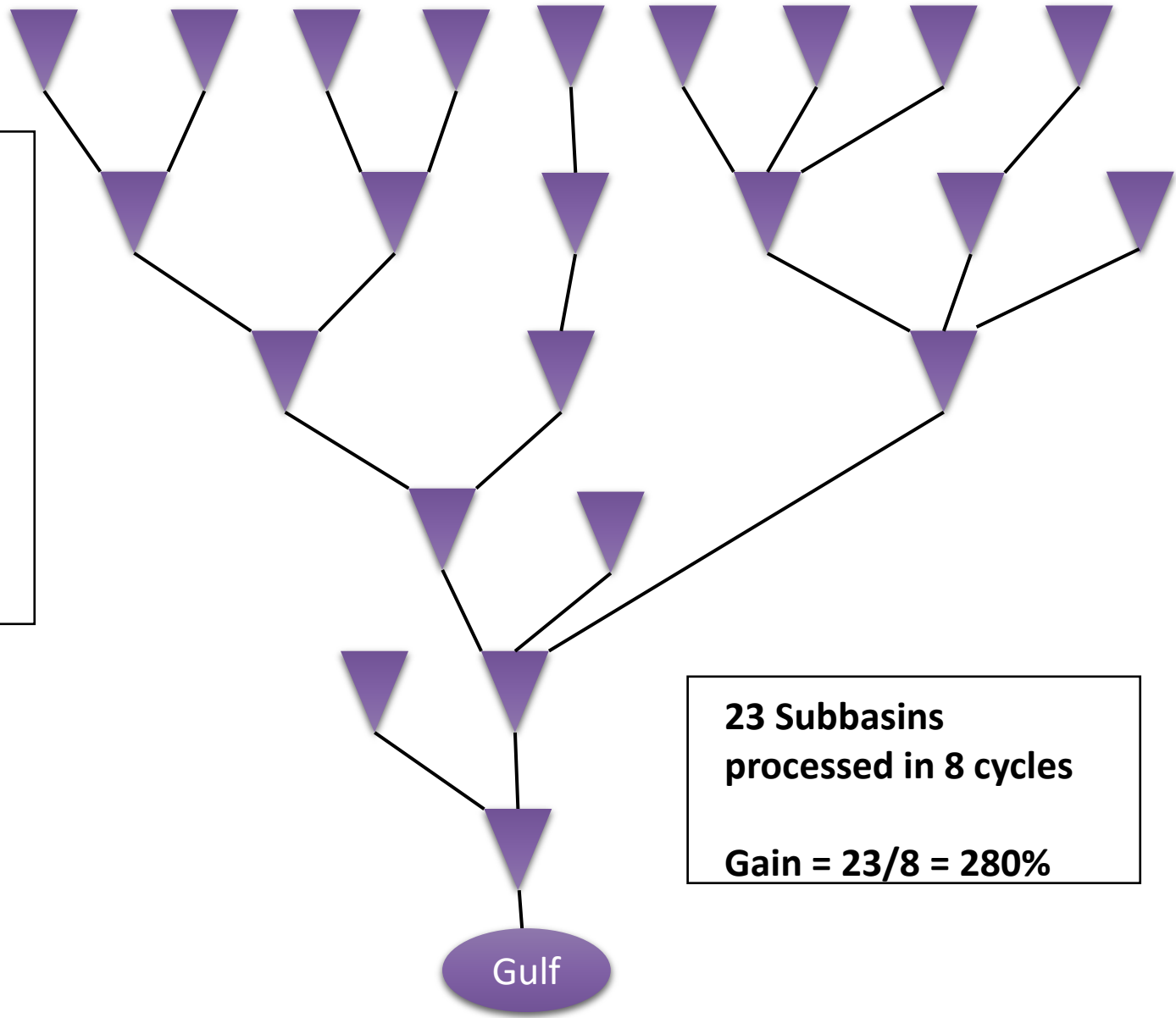
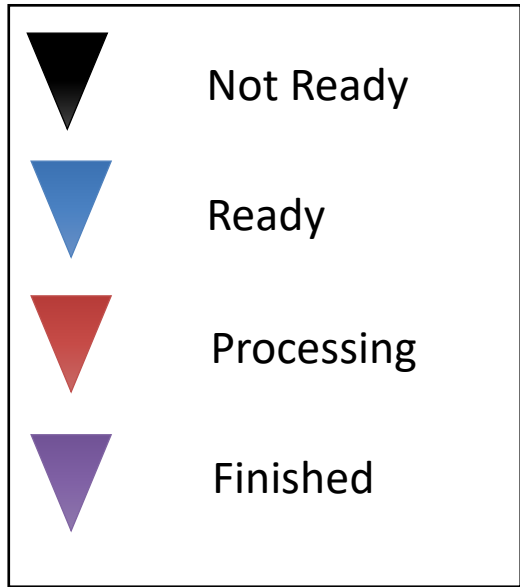




Cycle #7

Identify models without unmet dependencies and
Select available models to run

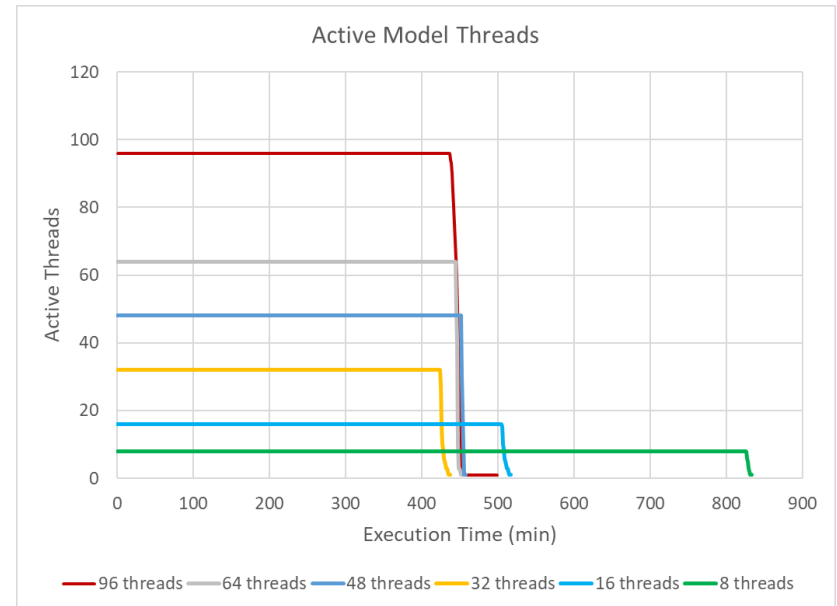




Finished

Automated Execution

- Standalone EXE runs SWAT model in order
- Full NAM Model
 - 7.5 hours
 - AMD Threadripper/EPYC
 - Not much benefit after 32 cores.



Automated Execution Software

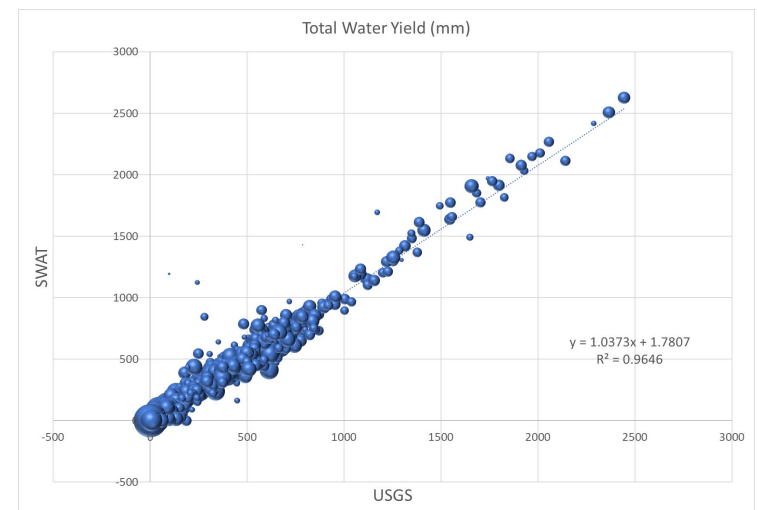
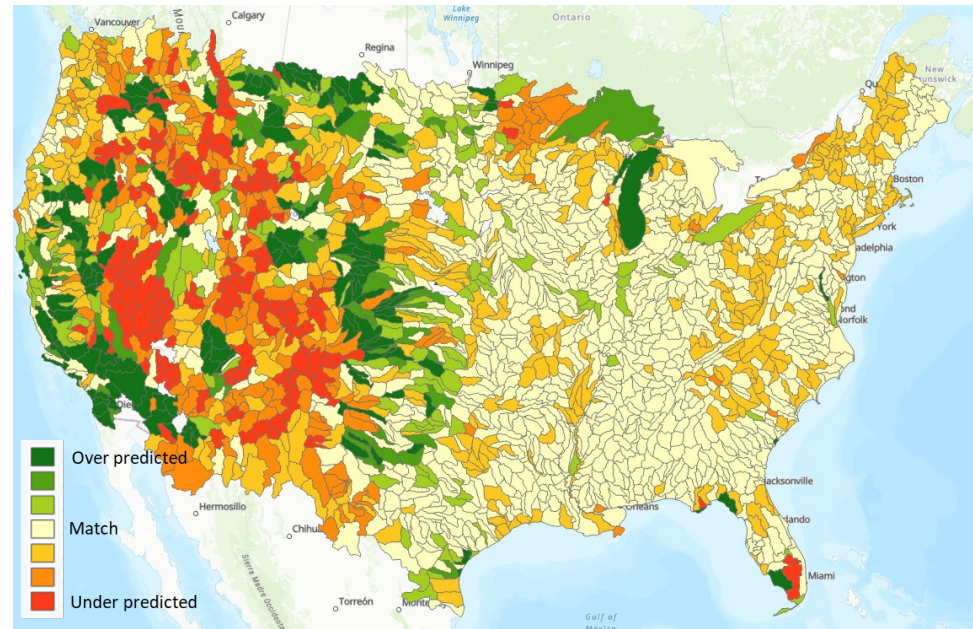
```
N:\Software\Model_Commanders\US_Model_Run\Bat_US_model_run\bin\Debug\Bat_US_model_run.exe
Preparing to run 10190006
Spawning 10190006 (107/748) (depth = 24) (Level = 1)
Preparing to run 10190007
Spawning 10190007 (108/748) (depth = 24) (Level = 1)
Preparing to run 10190008
Spawning 10190008 (109/748) (depth = 24) (Level = 1)
Preparing to run 10120103
Gather dependents for 10120103
Gather dependents for 10120103
Spawning 10120103 (110/748) (depth = 25) (Level = 2)
Preparing to run 10190009
Spawning 10190009 (111/748) (depth = 24) (Level = 1)
Preparing to run 10090207
Gather dependents for 10090207
100902060507_con.out
Gather dependents for 10090207
100902060507_con.out
Spawning 10090207 (112/748) (depth = 27) (Level = 3)
Preparing to run 10080005
Gather dependents for 10080005
10080001006_con.out
Gather dependents for 10080005
100800011006_con.out
Gather dependents for 10080005
10080001006_con.out
Spawning 10080005 (113/748) (depth = 30) (Level = 4)
Preparing to run 10020005
Gather dependents for 10020005
```

Threadripper 64 Core 3990X

Soft Calibration

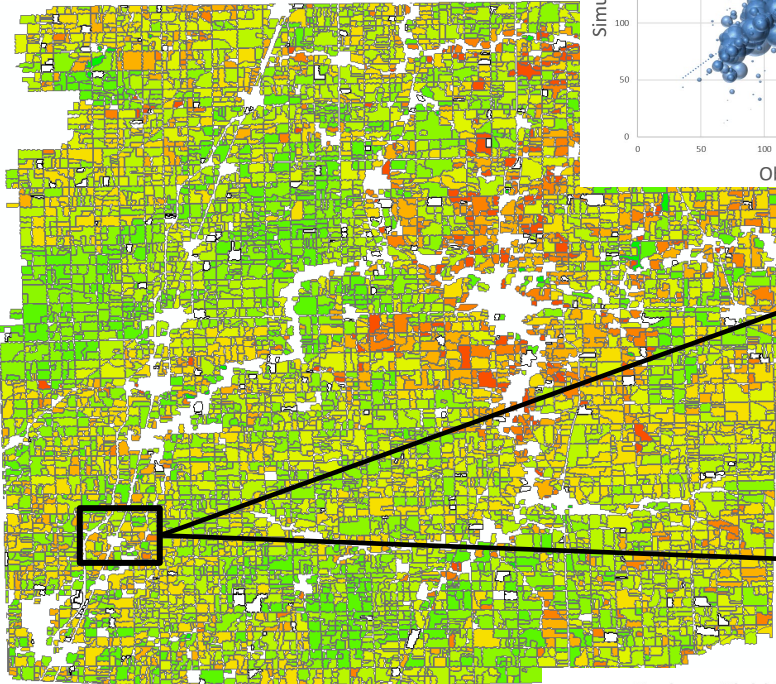
- SWAT+ Internal code for calibration
- Upland water balance
- Crop yields
- Takes about 10-12 cycles

- No routing is needed
- Each model is independent
- Executed on Servers
- > 800 EPYC Cores
 - 4x 128 physical core EPYC
 - 2x 192 physical core EPYC

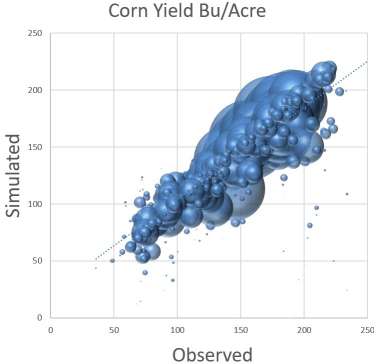


Crop Yield – After Calibration

Corn Yield



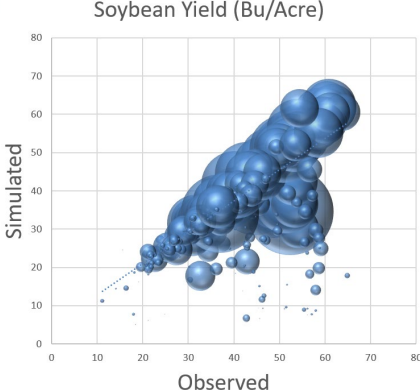
Iroquois County, Illinois
7,918 Fields



Corn Yield

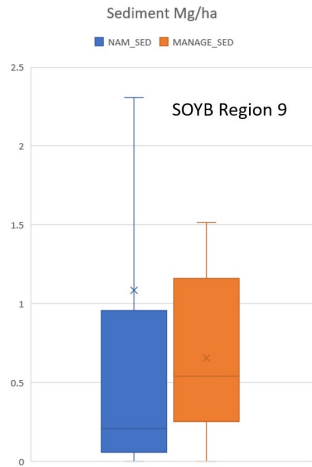


Soybean Yield



Topics For Another Day.....

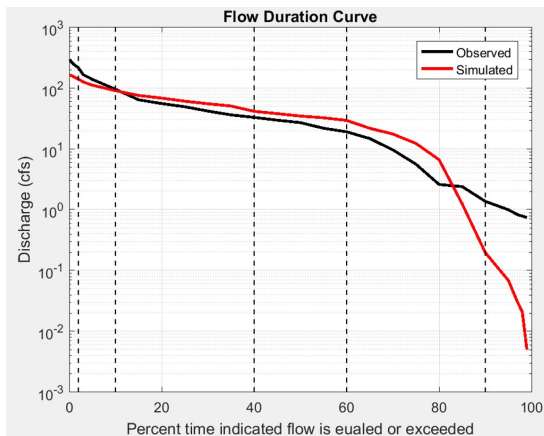
Calibration to
Field Monitoring
Data



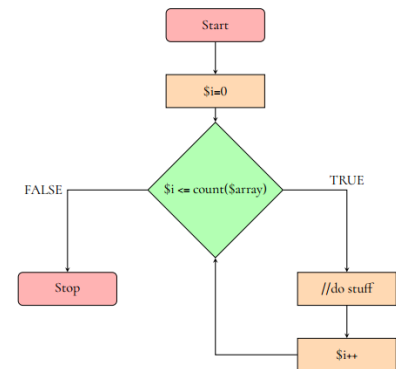
Load
Estimation at
>1,000 USGS
Gages



Flow Duration Curve Calibration



Heuristic
Calibration
Strategies



NAM Current Applications



- **Cropland CEAP**
 - Link NAM and APEX to evaluate current and future conservation policy (NRCS/Texas A&M/Iowa State)
- **CEAP Wildlife**
 - Link NAM with fish habitat model in UMRB (NRCS/TNC/U. Kansas/U. Missouri/Texas A&M)
- **Legacy P Project**
 - Goal of improving SWAT+ P routines and develop regional P models (NRCS/Many ARS/Univ partners)
- **Natural Infrastructure Project**
 - Mitigate Flood and Nitrate Risks in the Mississippi-Atchafalaya River Basin using NAM (Iowa State/Environmental Defense Fund)
- **Integrated Assessment Model**
 - Link NAM with socioeconomic model identify disproportionately pollutant impacted communities and possible solutions (Univ Mass/Cornell)

Questions?

