Evaluating the Aggregate Effects of Geographically Isolated Wetlands (GIWs) on Downstream Hydrology

Grey Evenson, US EPA, Oak Ridge Institute of Science & Education Fellow, Cincinnati, OH, USA
Heather Golden, US EPA, Ecological Exposure Research Division, Cincinnati, OH, USA
Chuck Lane, US EPA, Ecological Exposure Research Division, Cincinnati, OH, USA
Ellen D'Amico, CSS-Dynamac Corporation, Cincinnati, Ohio, USA

Background:

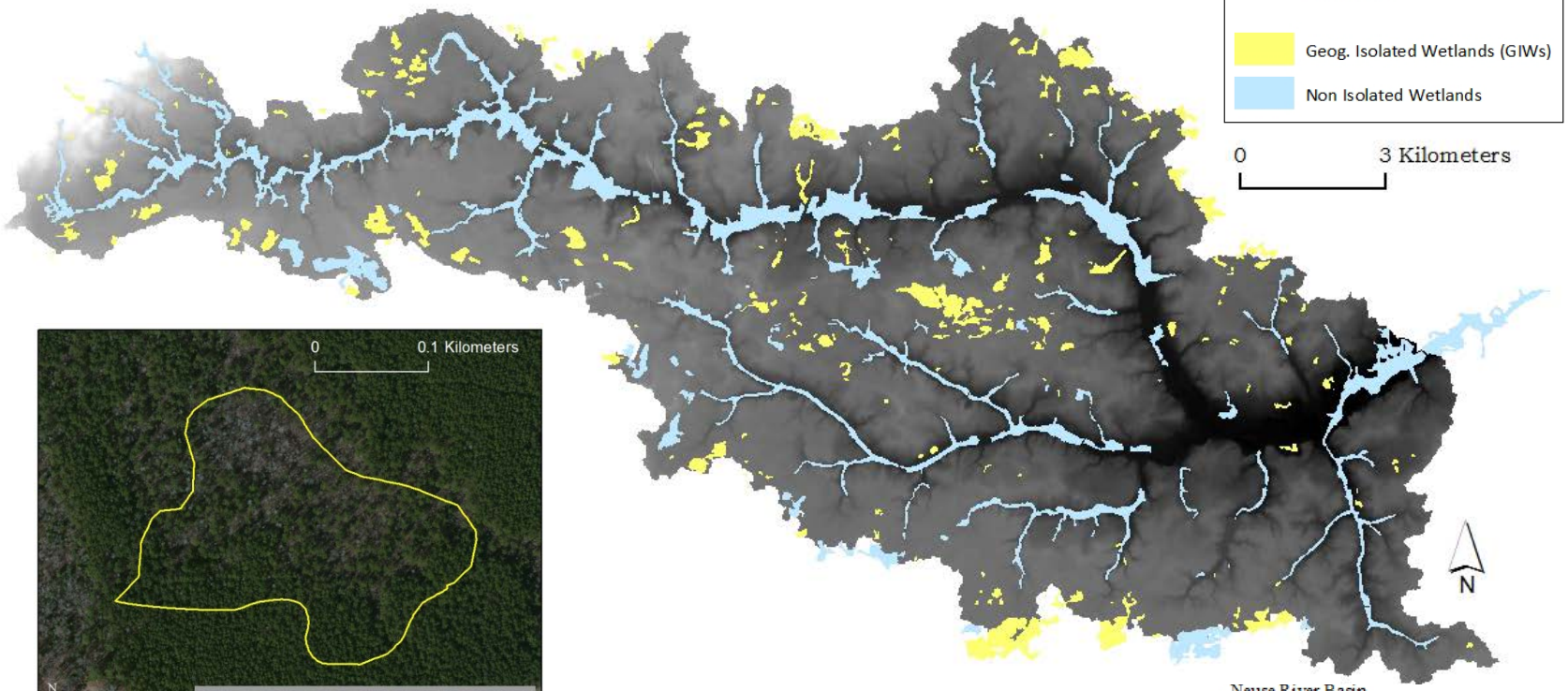
- GIW defined: depressional wetlands surrounded by uplands (Tiner 2003)
- GIWs are hydrologically and ecologically important (Leibowitz 2003)
- 2001 SWANCC v. US ACOE SCOTUS ruling removed CWA protections
- 2006 Rapanos v. U.S. SCOTUS ruling and the “significant nexus”
- Research need: Methods capable of simulating GIWs at watershed scale
- **Research question:**

What is the aggregate effect of GIWs on downstream hydrology?

Method Overview:

1. Setup watershed scale model to represent GIW hydrologic relationships
2. Calibrate the hydrologic model with GIWs
3. Remove the GIWs from the model and observe impact on simulations

The Nahunta Study Area



- North Carolina Coastal Plain in the Neuse River Basin
- Nahunta watershed is ≈ 202 km^2
- High percentage of GIWs (7.5 km^2 of 25.4 km^2; ≈29%)
- NC-CREWS (Sutter et al. 1999)
- Wetland storage estimation procedure (Lane and D'Amico 2012)

SWAT basics:

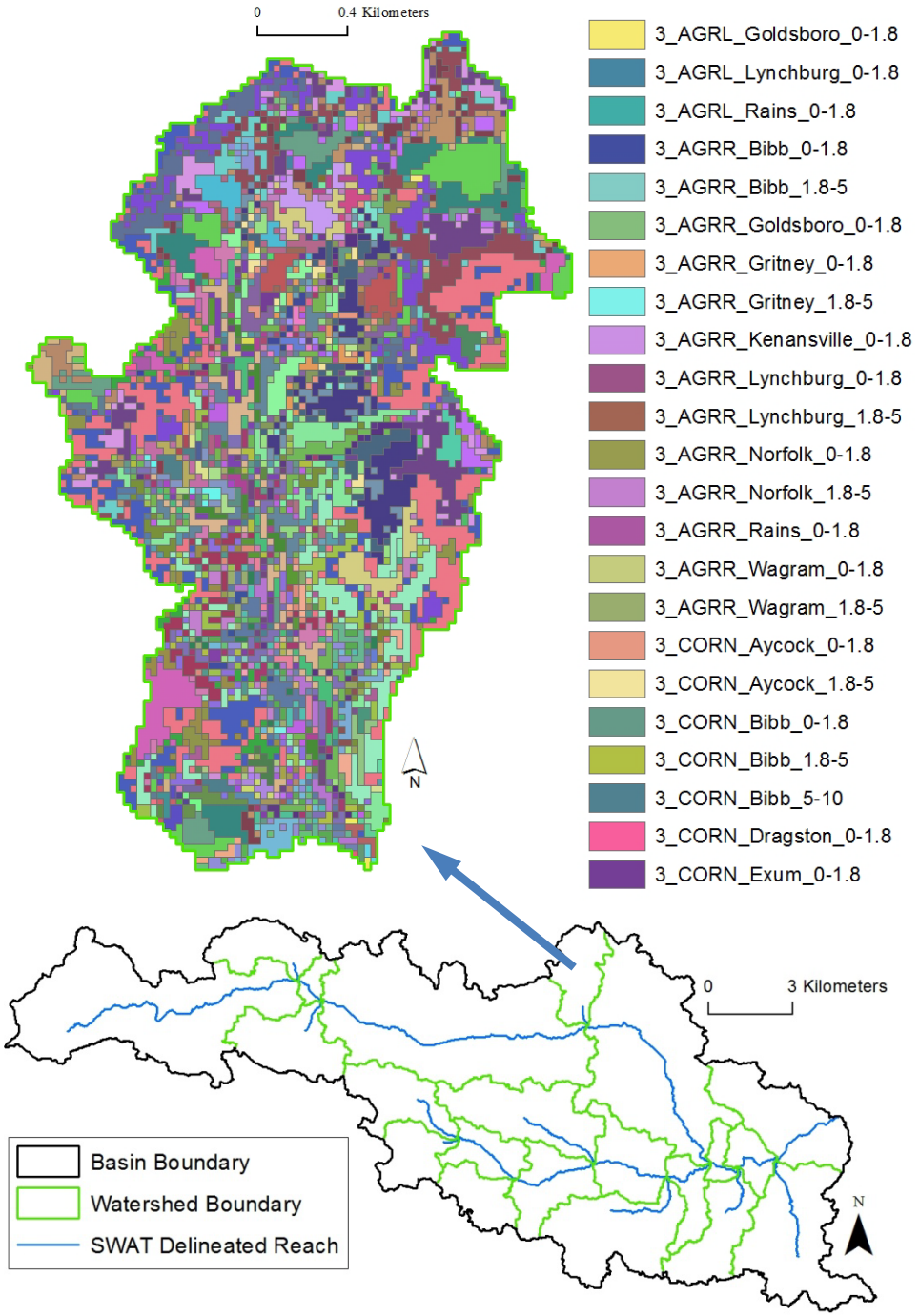
- The Soil and Water Assessment Tool (SWAT) is a semi-distributed, semi-physically based, watershed hydro model
- SWAT spatial hierarchy

Large ↑ Basin

Subbasin

Small ↓ HRU

- Hydrologic response unit (HRU) are unique combo of slope, land use and soil characteristics
- HRU hydro processes simulated and then flow routed to reach



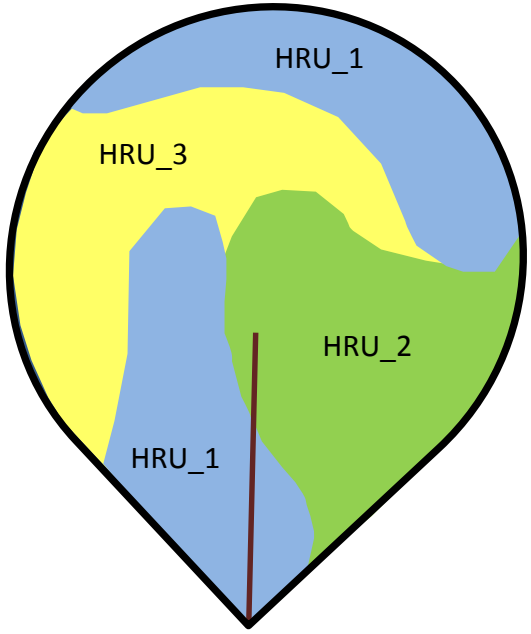
Wetland representations in SWAT

1. Conventional wetland
   - $V_w = V_{w,stored} + V_{w,flowin} - V_{w,flowout} + V_{w,pcp} - V_{w,evap} - V_{w,seep}$
   - Influence governed by WET_FR parameter

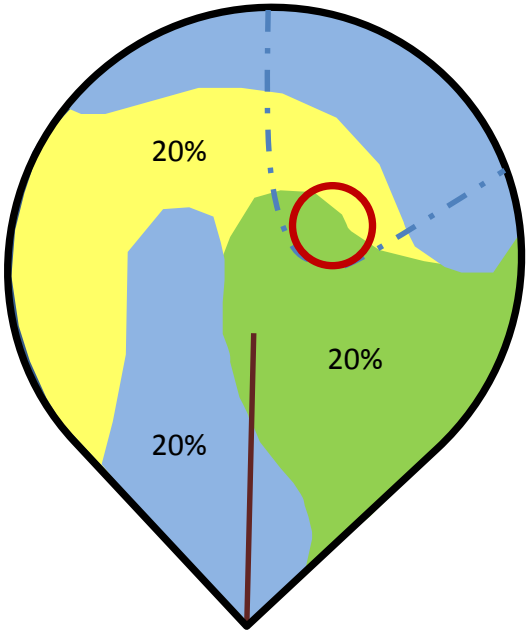
2. Pond
   - Nearly identical to conventional wetland
   - Additional management functions

3. Pothole
   - $V_{pot} = V_{pot,stored} + V_{pot,flowin} - V_{pot,flowout} + V_{pot,pcp} - V_{pot,evap} - V_{pot,sep}$
   - Influence governed by routing flow from subset of HRUs to a pothole HRU

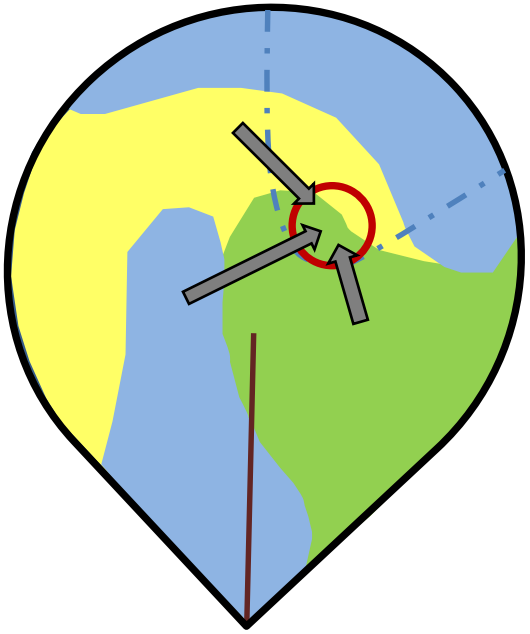
Problems with representations as applied to GIWs:



- Simplified subbasin
- w/o GIW



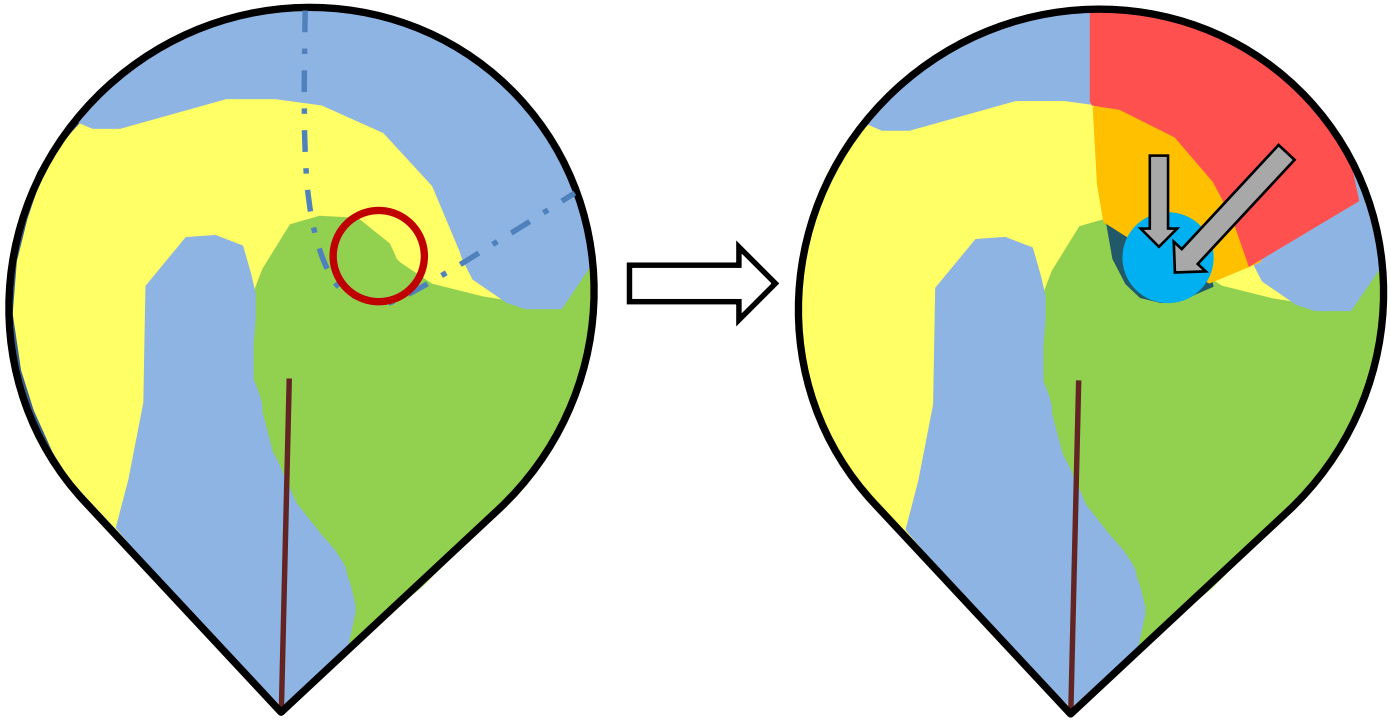
- Simplified subbasin
- w/ GIW represented using conventional wetland rep.



- Simplified subbasin
- w/ GIW represented using pothole rep.

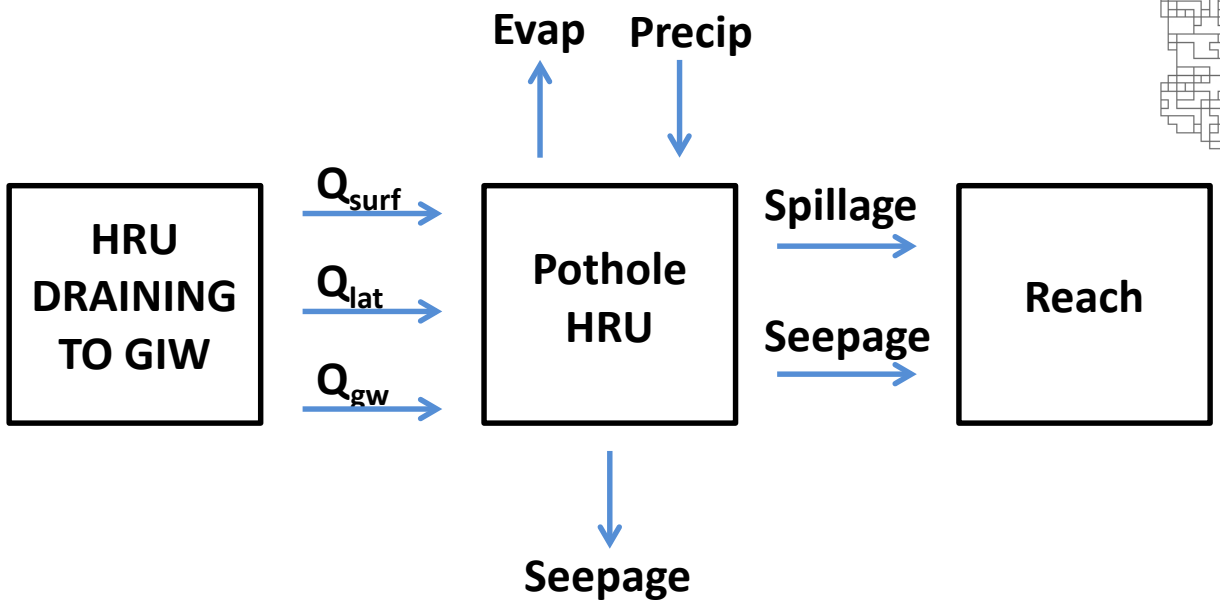
Our solution: redefine HRUs

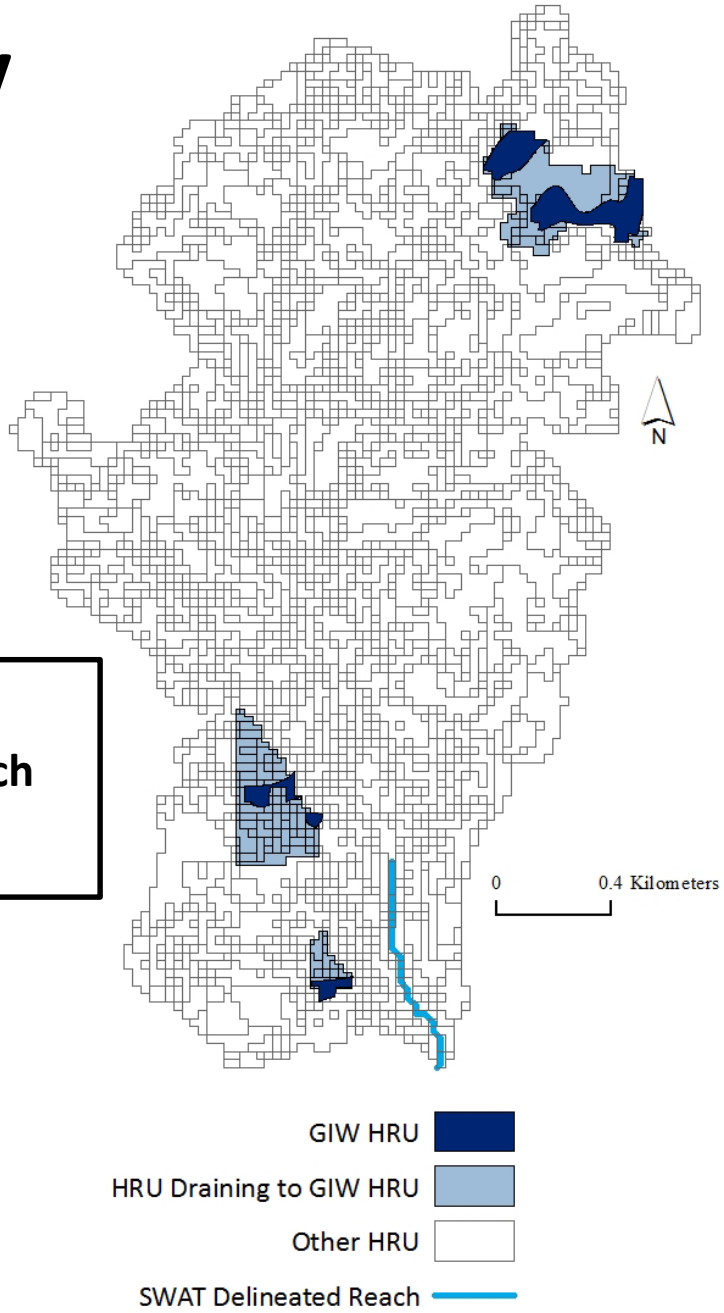
- 3 HRUs become 7 HRUs
- HRU boundaries conform to GIW drainage area borders
- GIW represented as singular HRU
- HRUs in GIW drainage area route flow to GIW HRU



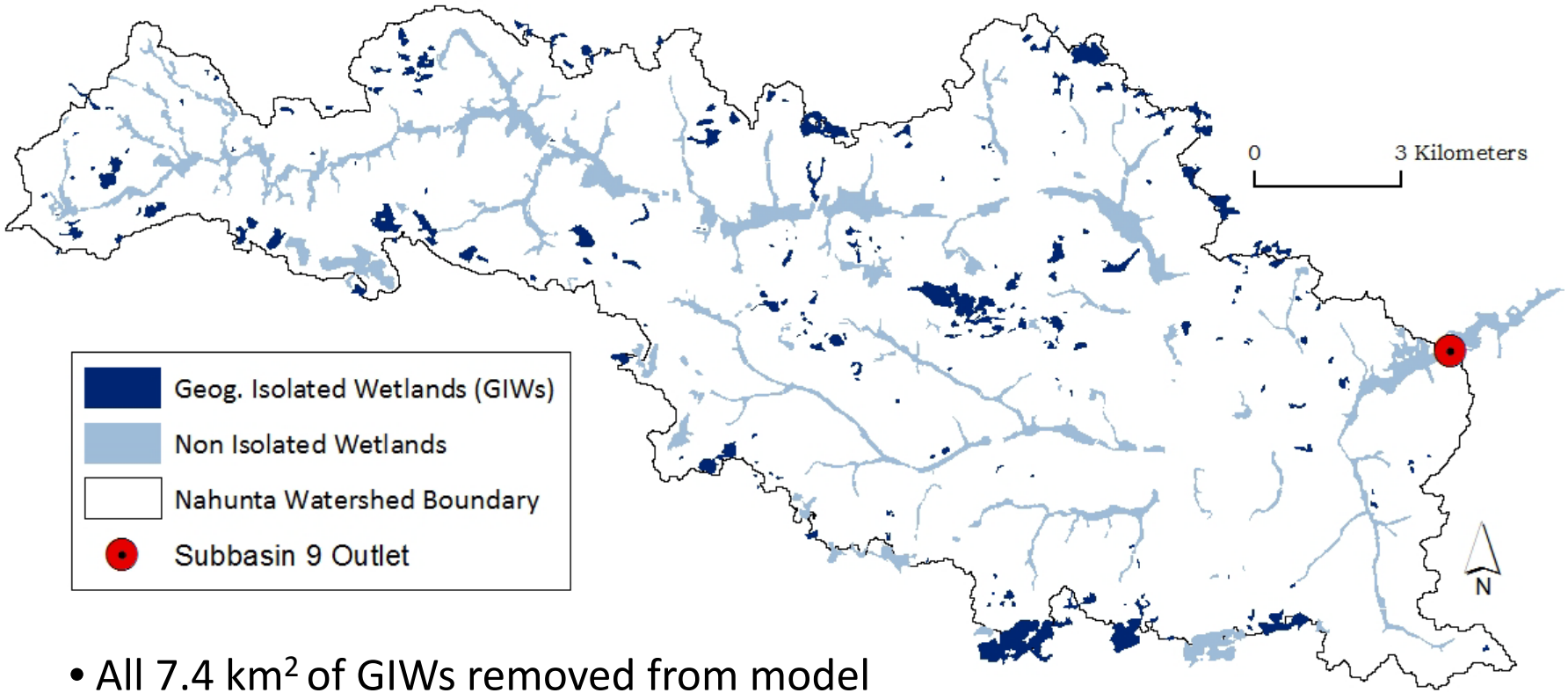
Representation in Summary

- GIWs as potholes
- Conceptual model of GIW/landscape interaction:



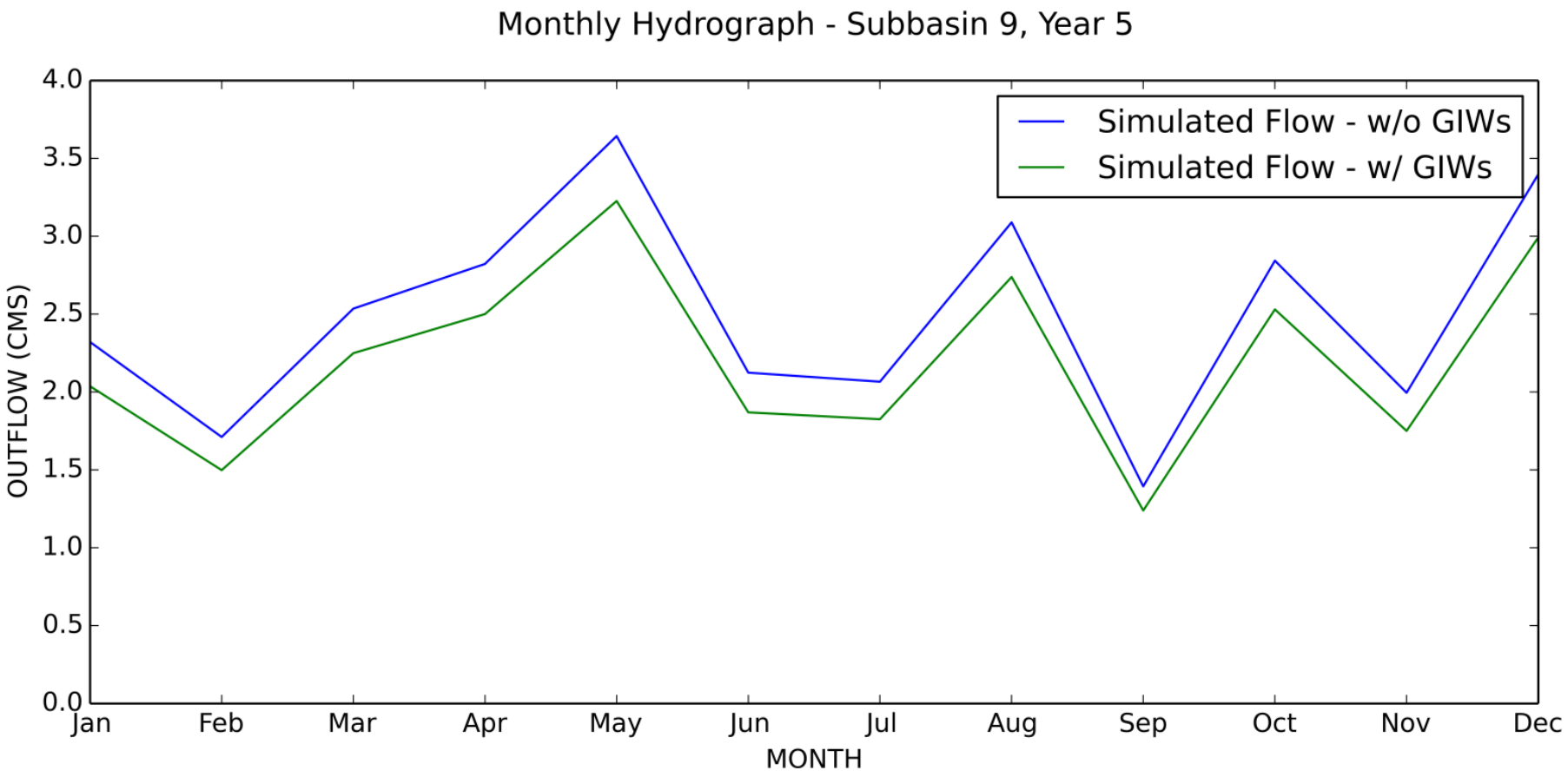


Scenario 1: GIWs removed

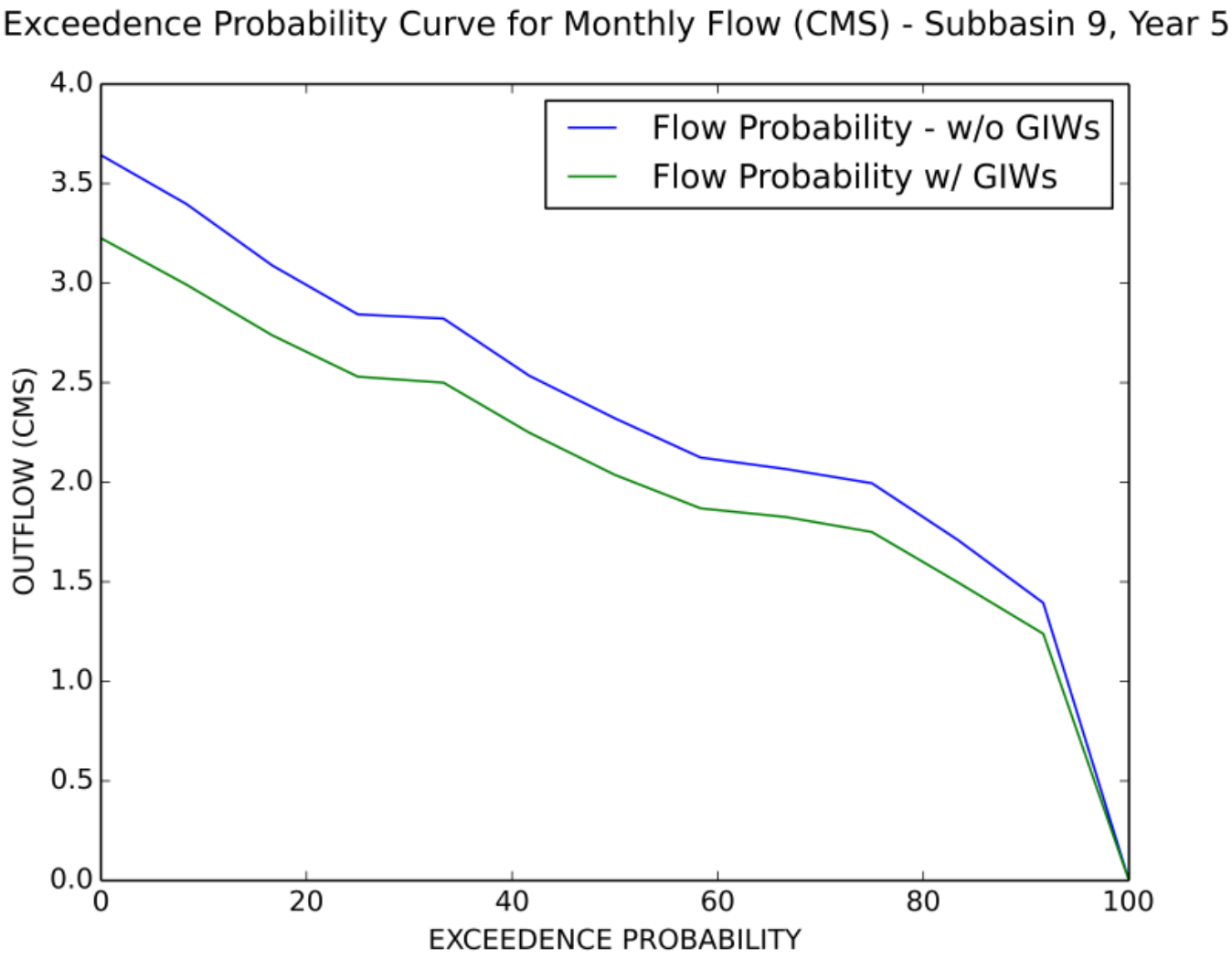


- All 7.4 km^2 of GIWs removed from model

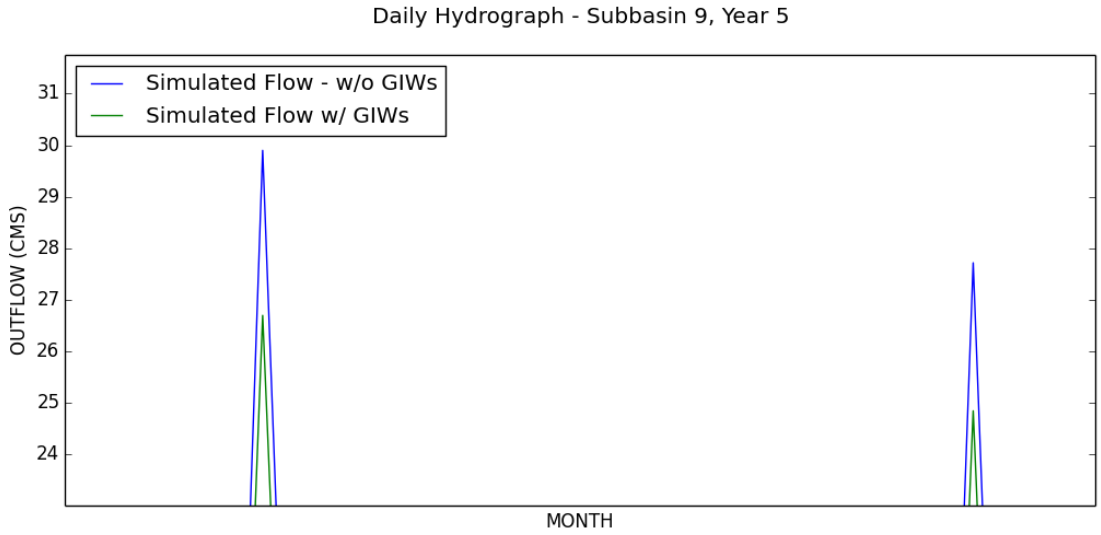
Scenario 1: GIWs removed

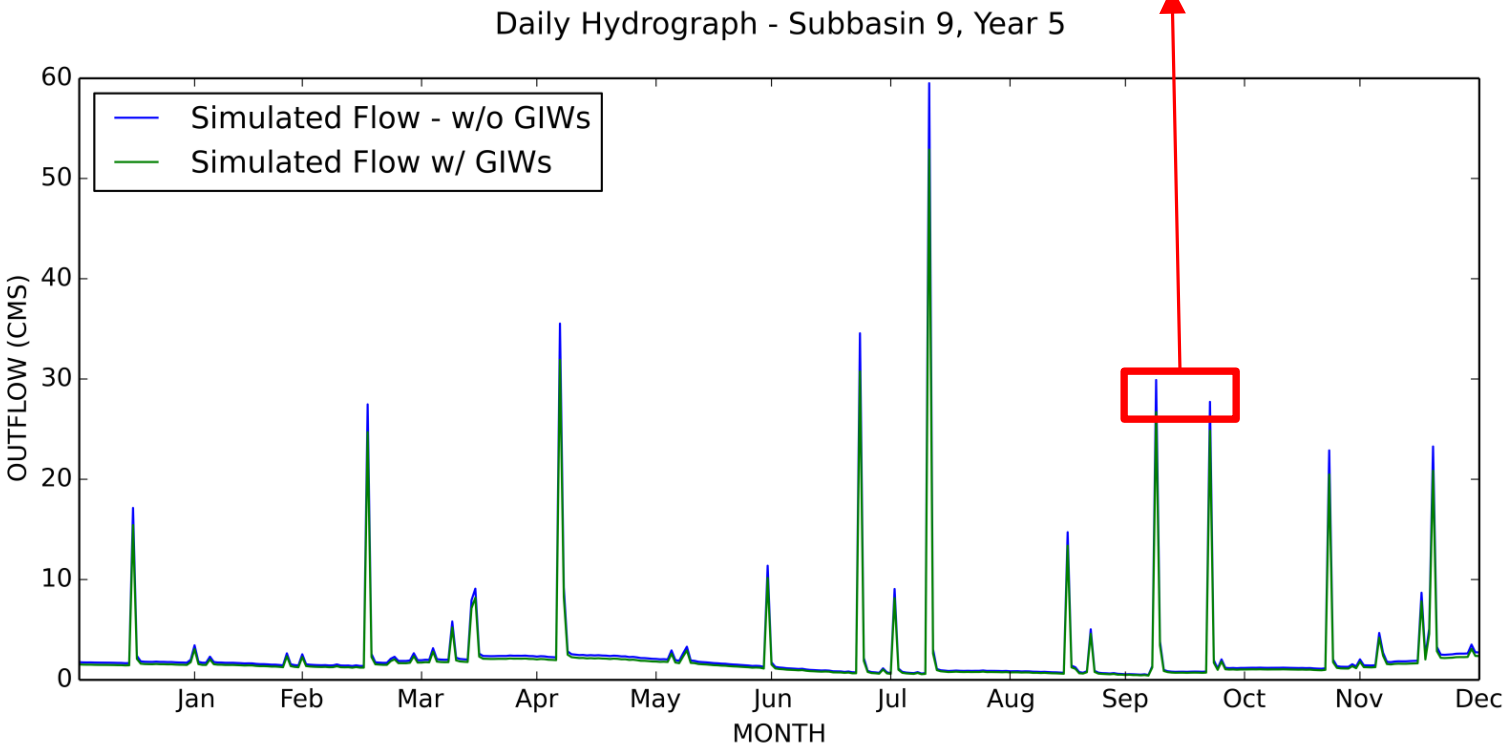


Scenario 1: GIWs removed

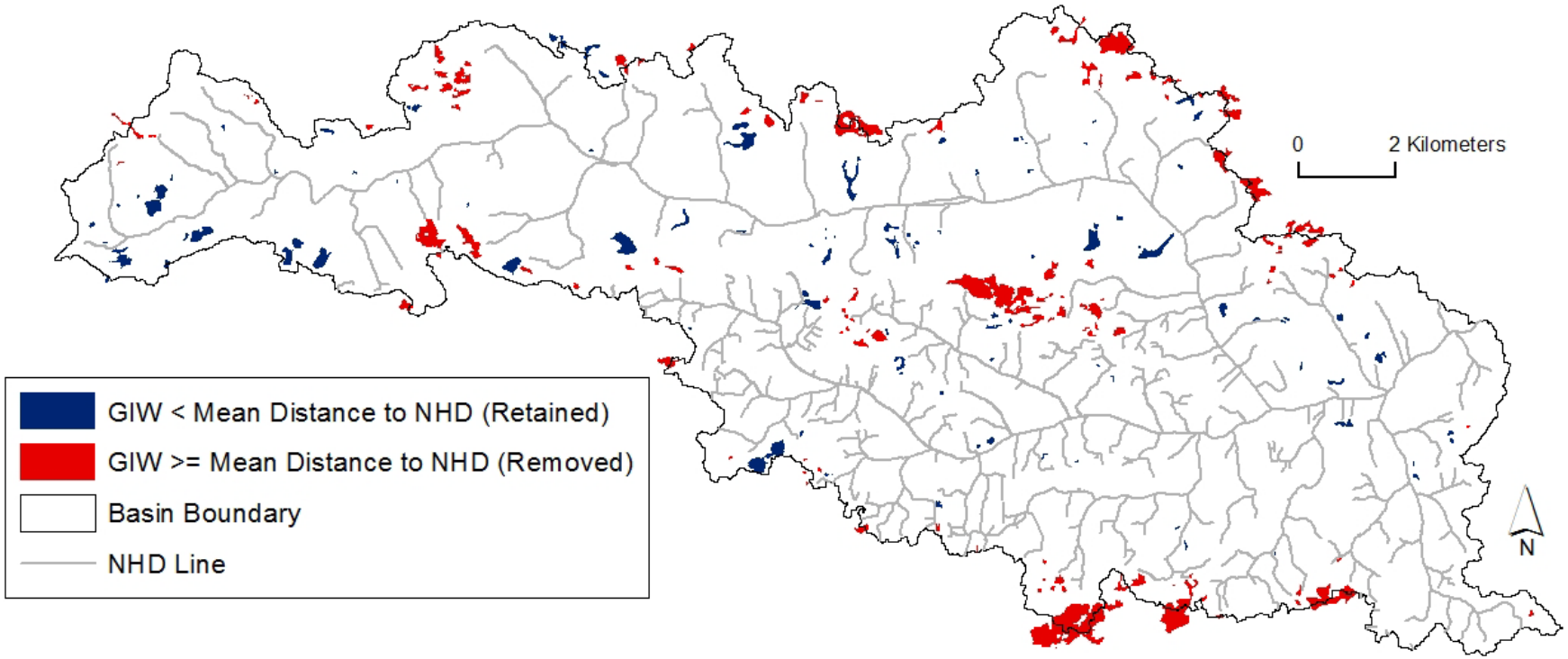


Scenario 1: Daily uncalibrated results



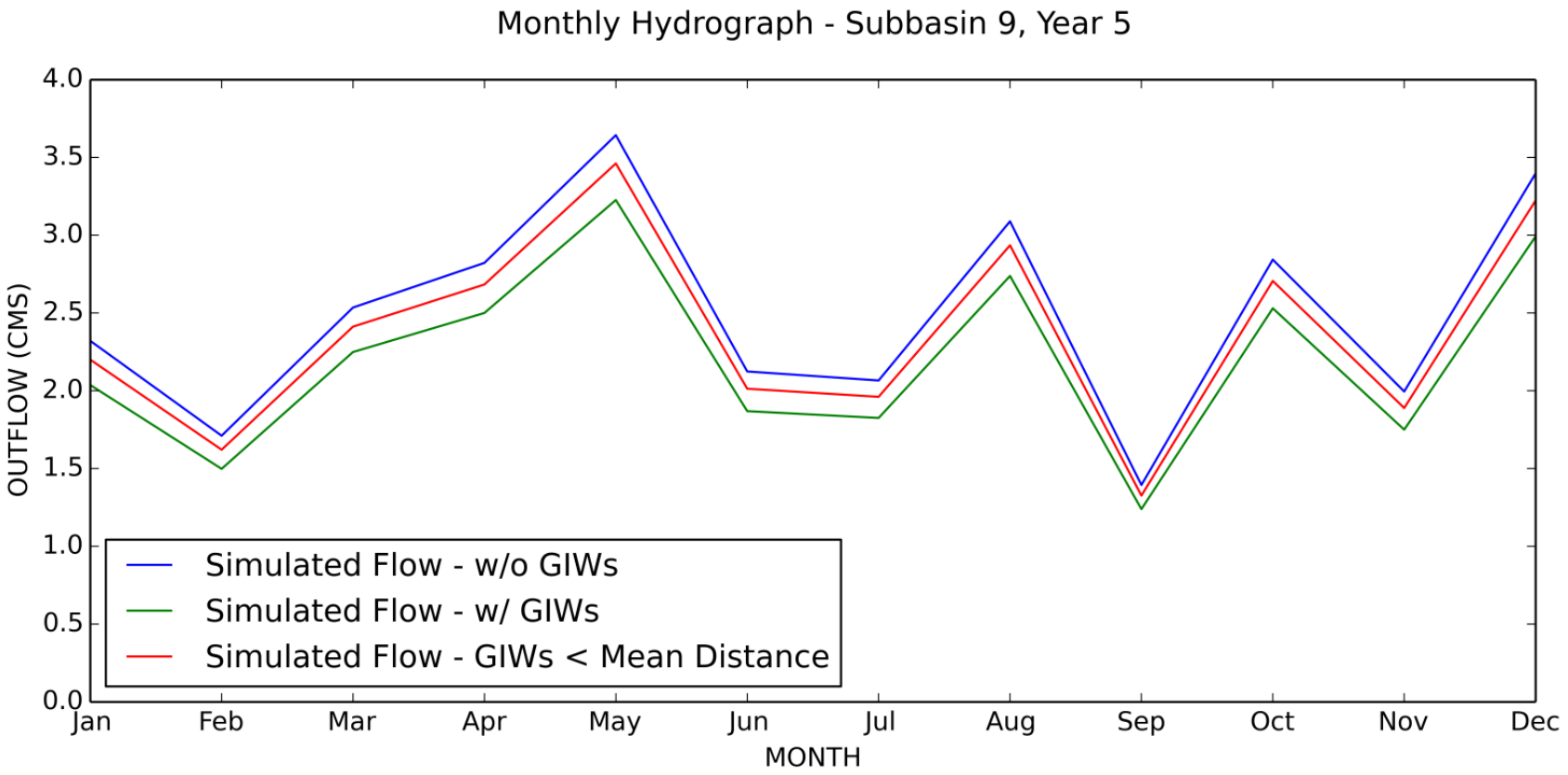


Scenario 2: GIWs beyond mean distance removed

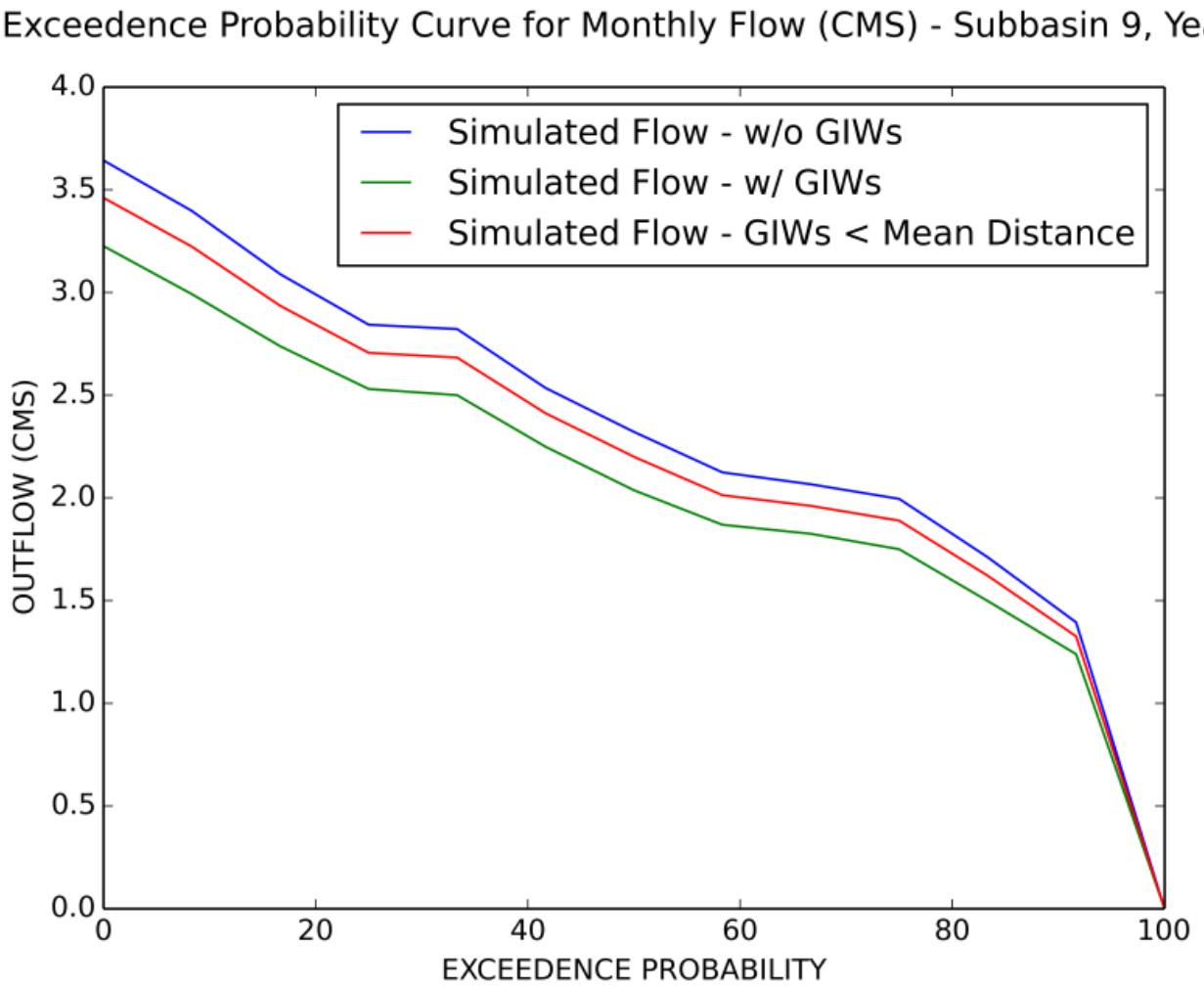


- Mean GIW distance to NHD is 2223.4m
- GIWs further than mean are removed from model
- 98 of 209 GIWs retained
- 111 of 209 GIWs removed

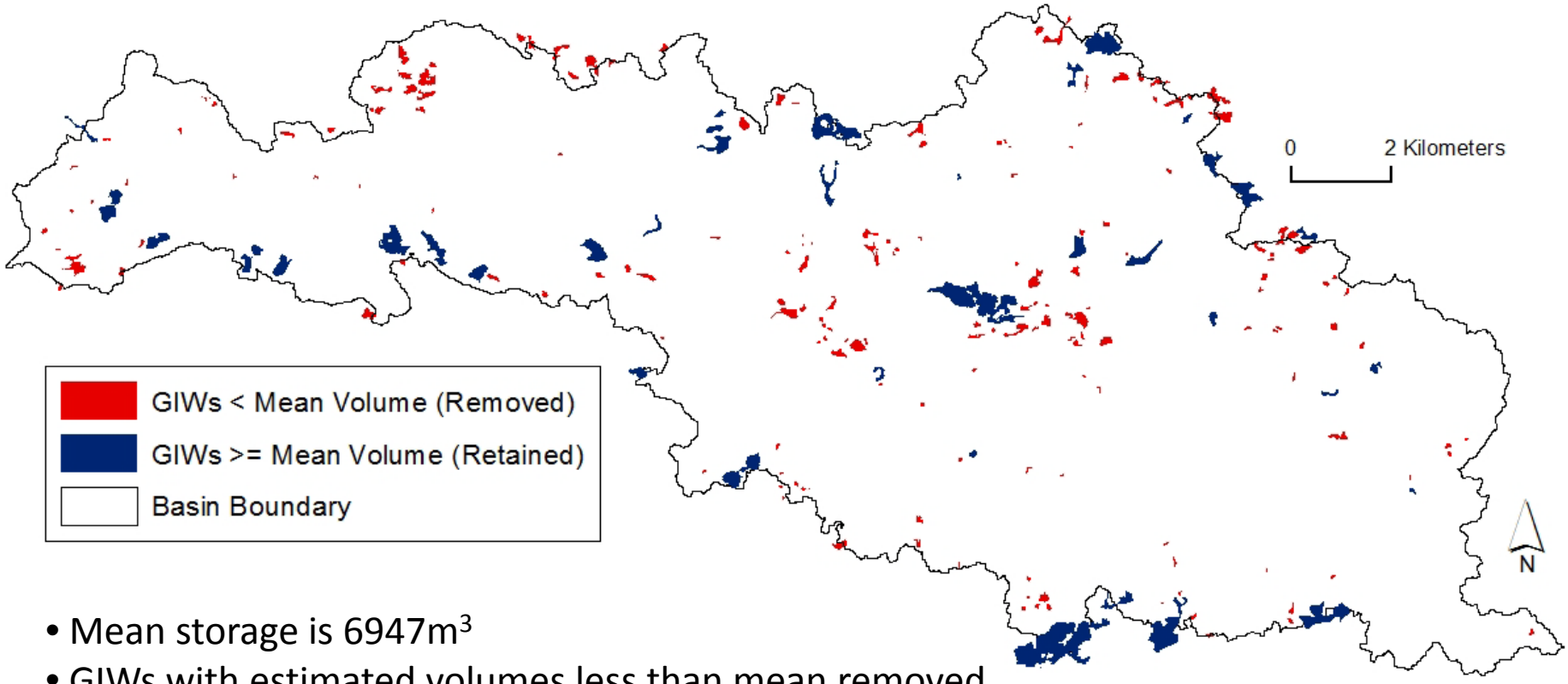
Scenario 2: GIWs beyond mean distance removed



Scenario 2: GIWs beyond mean distance removed

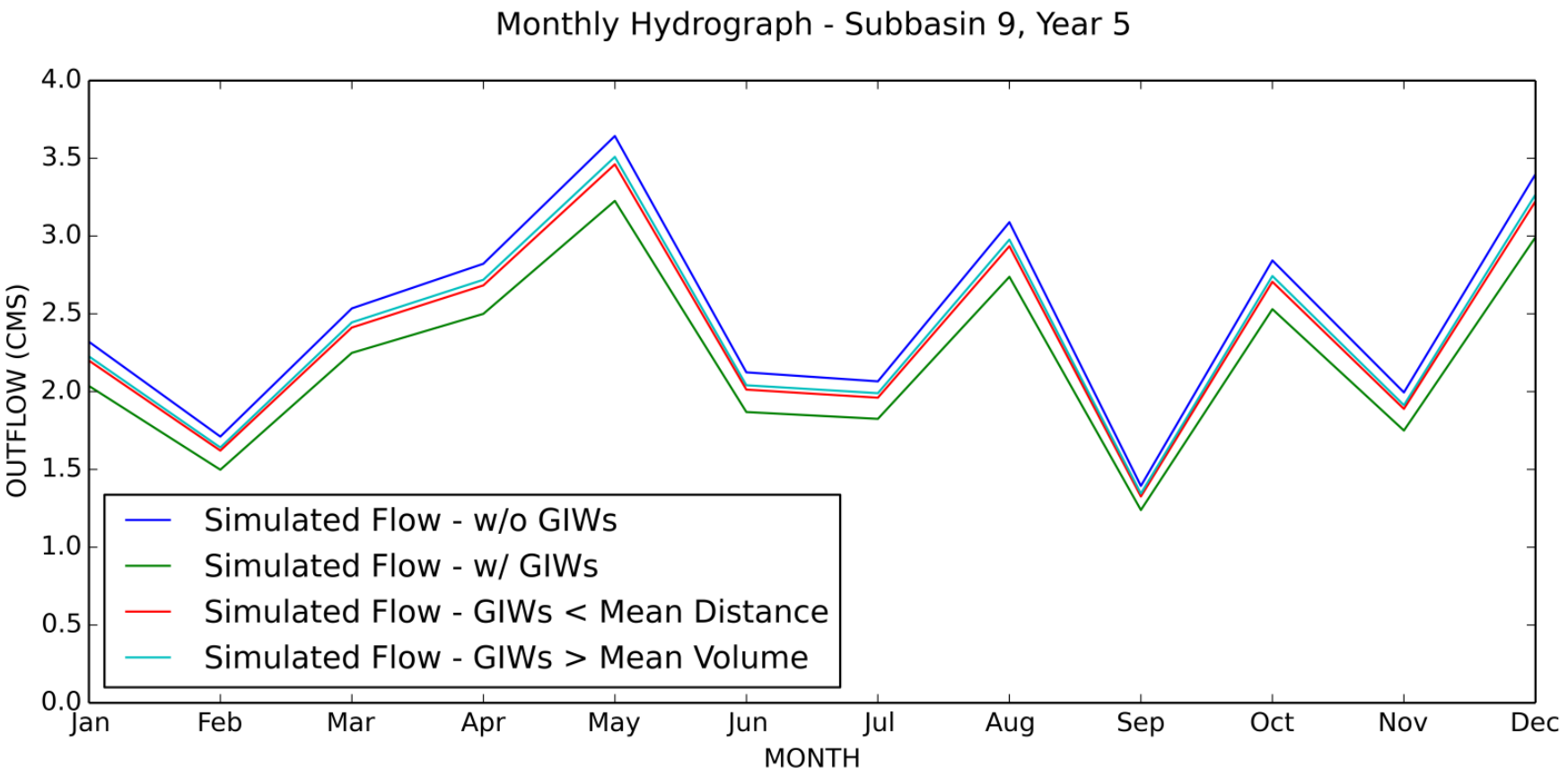


Scenario 3: GIWs with storage volume less than mean removed

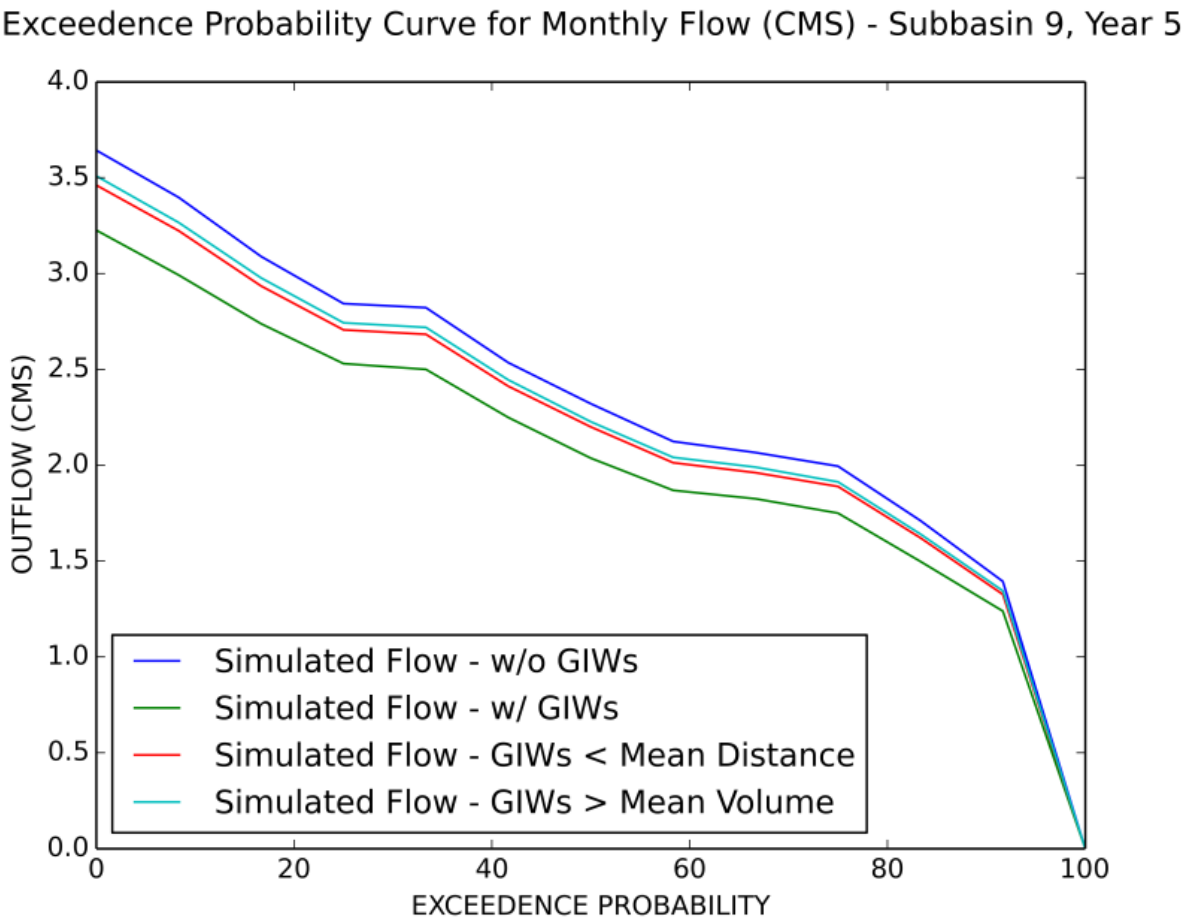


- Mean storage is 6947m^3
- GIWs with estimated volumes less than mean removed
- 171 GIWs removed
- 38 GIWS retained

Scenario 3: GIWs with storage volume less than mean removed



Scenario 3: GIWs with storage volume less than mean removed



In summary:

- Existing models may be modified to better represent GIW spatial and hydrologic relationships
- GIWs have an measureable aggregate effect upon downstream hydrology
- GIWs show a greater impact upon downstream hydrology during wetter months

Future work:

- Planned prairie pothole region (PPR, USA) applications
    - SWAT source code modifications to depict:
        - Fill-spill dynamics
        - Temporal lags
- Daily calibration!
- Additional scenario evaluations
- Choptank River Basin (Maryland, USA) applications
    - Wetland data, validation

Thanks for your time!

Questions/comments may be directed towards:

Grey Evenson (evenson.grey@epa.gov)
Heather Golden (golden.heather@epa.gov)
Chuck Lane (lane.charles@epa.gov)

www.npwrc.usgs.gov