Phase 7 WSM Development – Updates on Dynamic Hydrology Model

Modeling Workgroup Quarterly Meeting – July 2021

Gopal Bhatt[1], Gary Shenk[2], Isabella Bertani[3], Lewis Linker[4], Peter Claggett[2] , Robert Burgholzer[5]

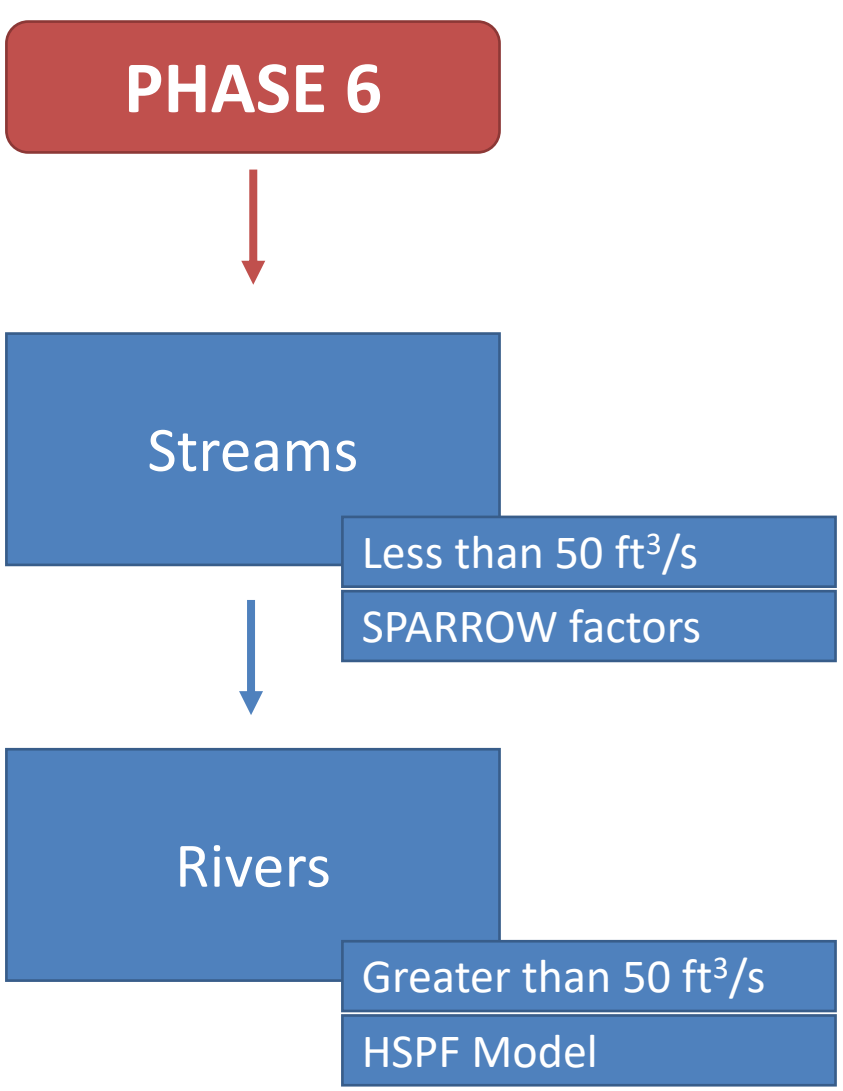
[1] Penn State, [2] USGS, [3] UMCES, [4] US EPA, [5] VA DEQ – Chesapeake Bay Program Office

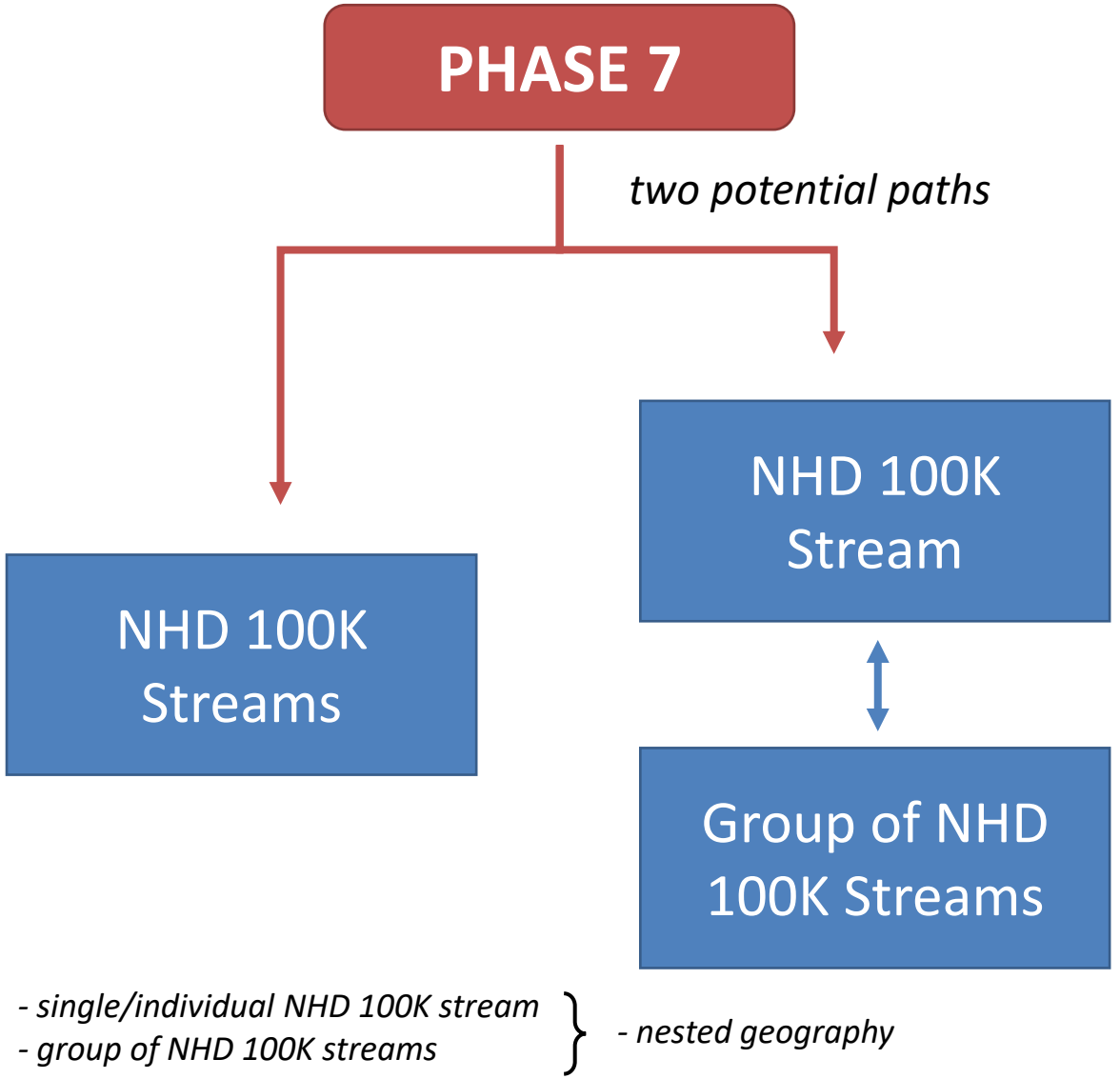
Presentation Outline

1. Building Blocks of the Dynamic Model
2. Simulation Framework and Operational Details
3. Results – Model Prototype Verification

1. Building Blocks of the Dynamic Model

River Segmentation



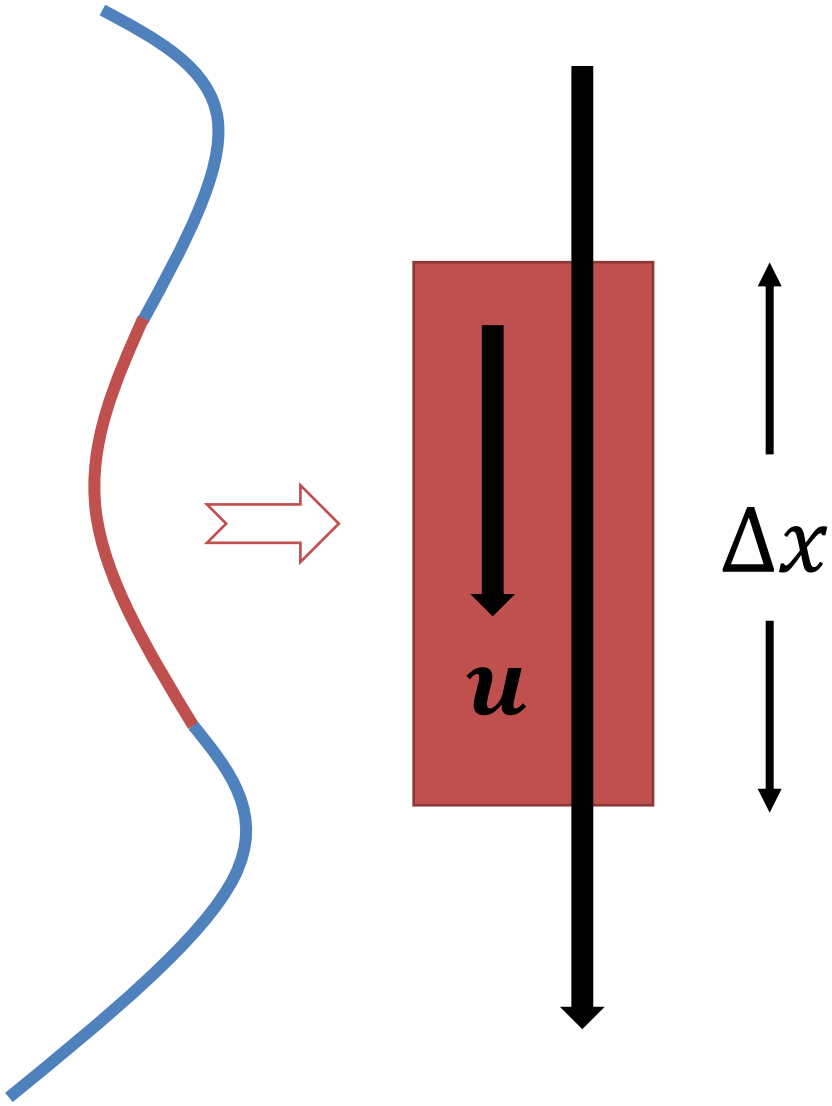


Why Group?

- Simple answer is efficiency; but …

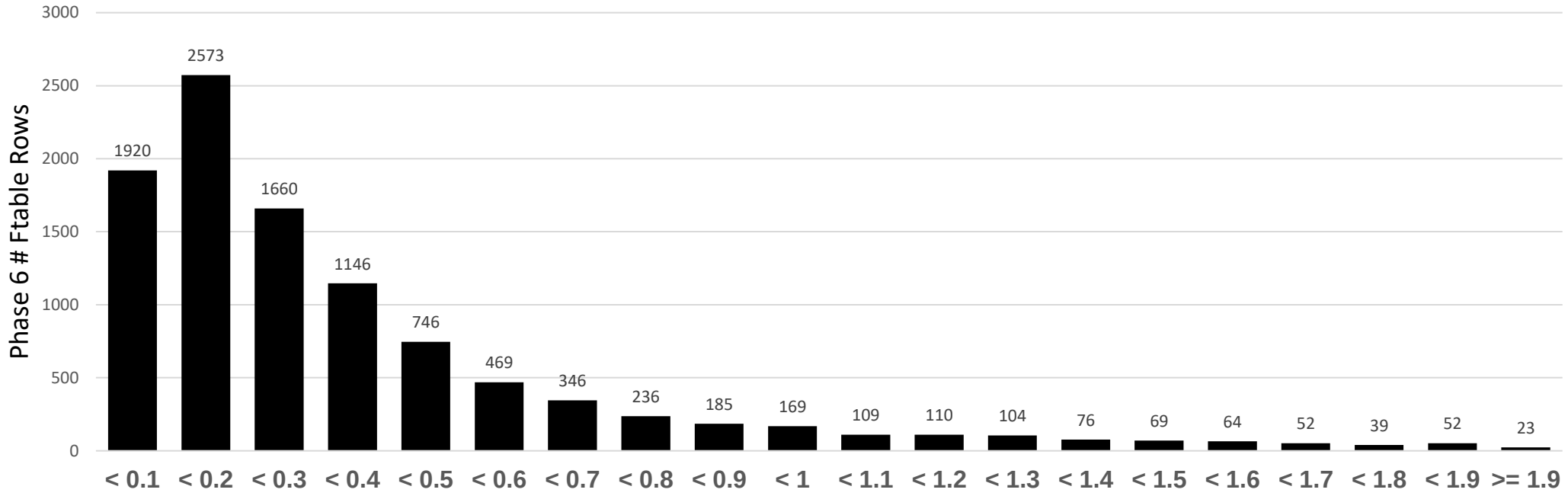
$$\boldsymbol{Cuhrant\ Number}, CN = u\frac{\Delta t}{\Delta x}$$

$u\ is\ velocity$;
$\Delta t\ is\ time\ step\ size$;
$x\ is\ the\ length\ of\ the\ model\ element$

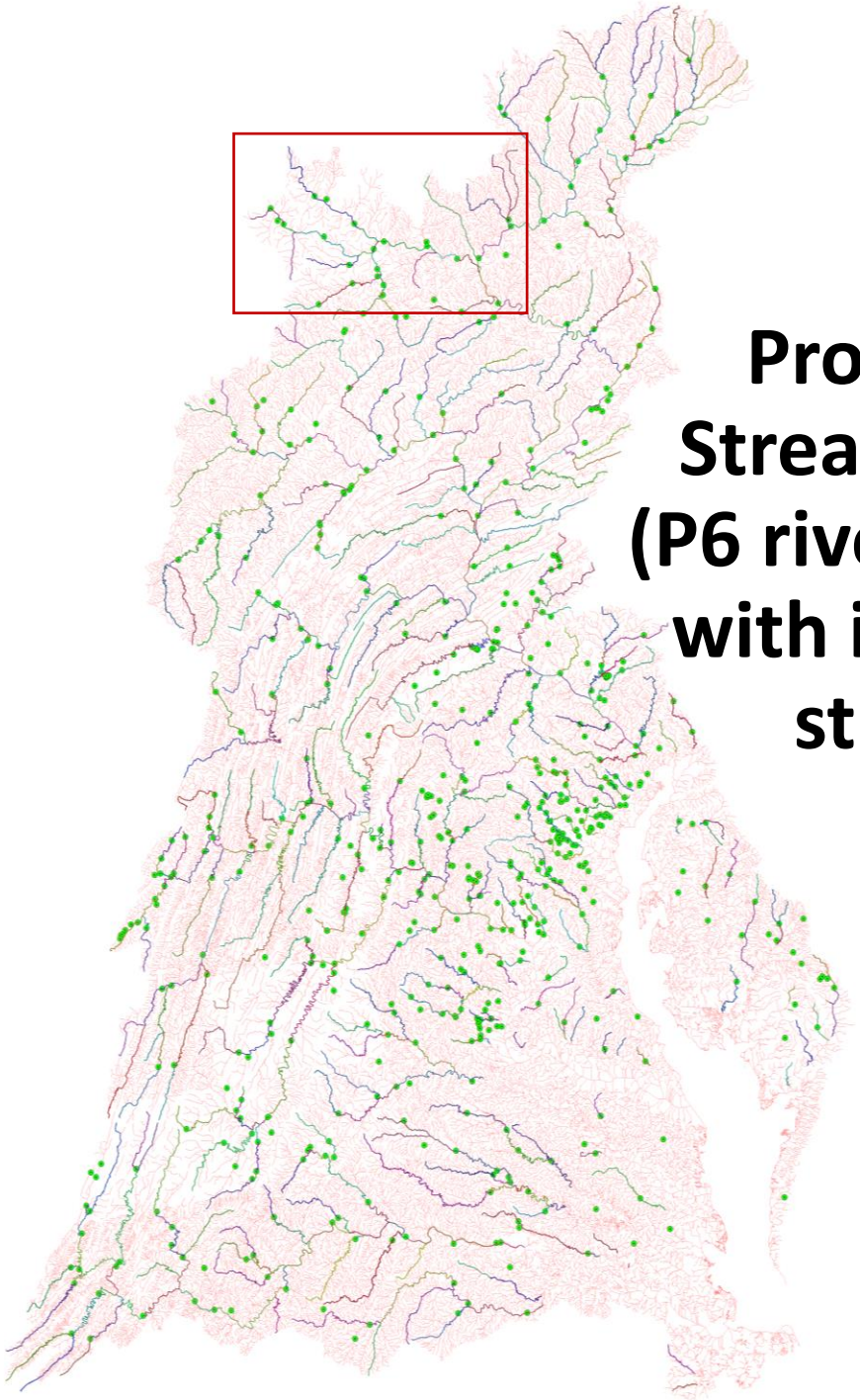


$CN\ less\ than\ 1\ is\ desired$

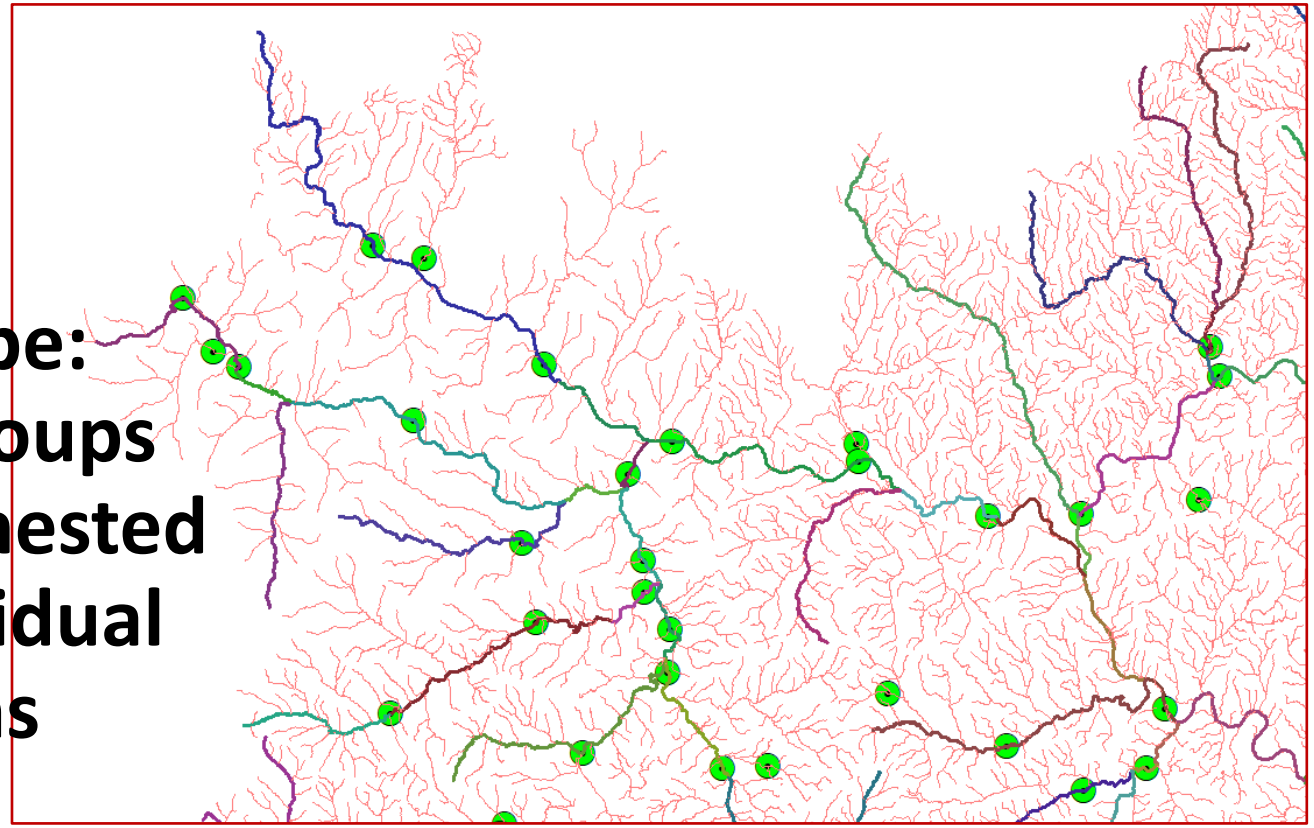
Distribution of P6 Cuhrant Numbers



- **Most of the entries satisfied CN < 1 condition**
- We had to run HSPF for PS3_6161_6280 (North River) at 15-minute time step in stead of 1 hour used for all others.

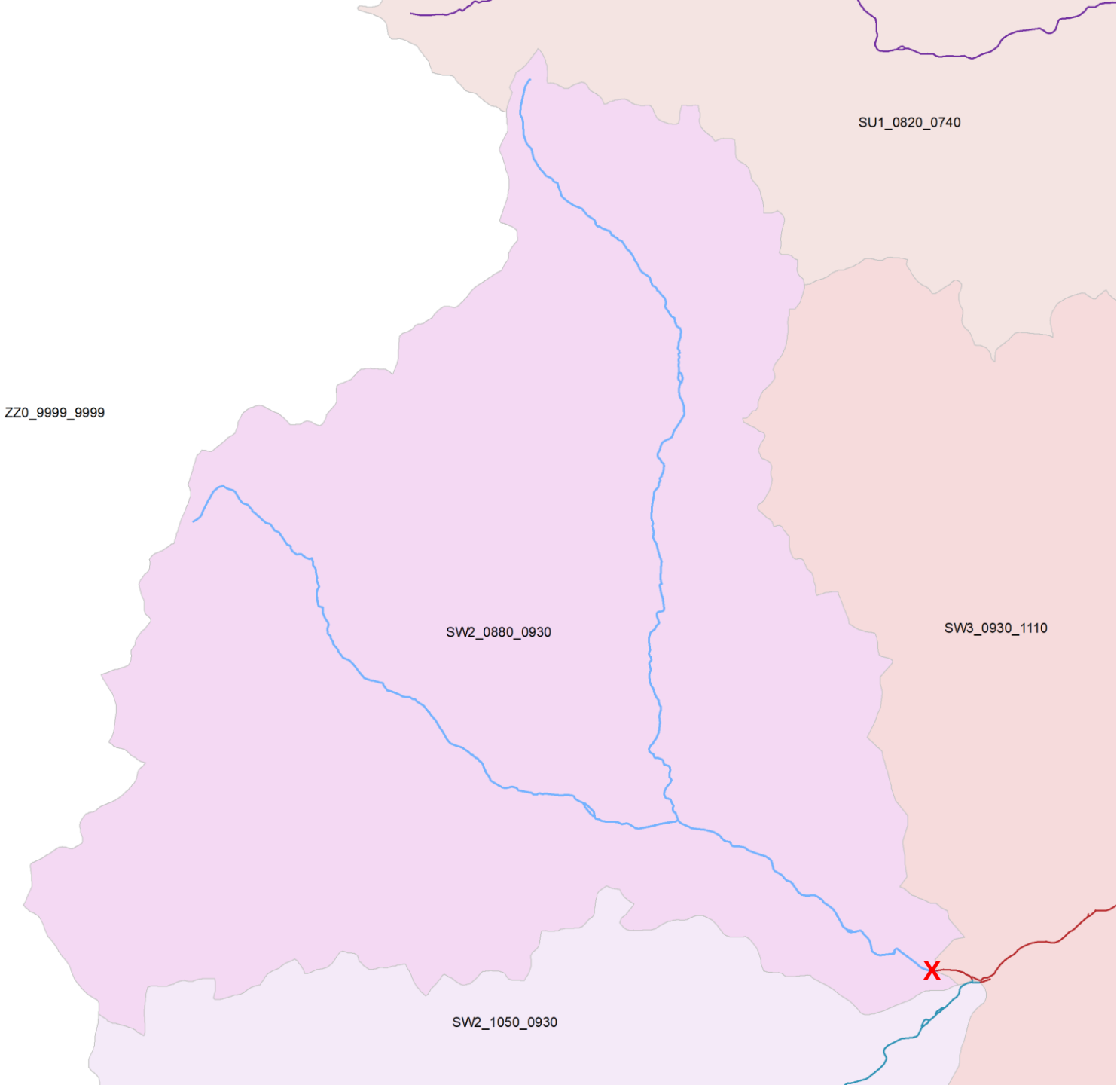


Prototype: Stream groups (P6 rivers) nested with individual streams



P6 rivers consistent with the NHD 100K streams (edited, deleted, added)

12,198 NHD 100K streams were grouped into 602 rivers (2 more than simulated P6 rivers in the watershed)

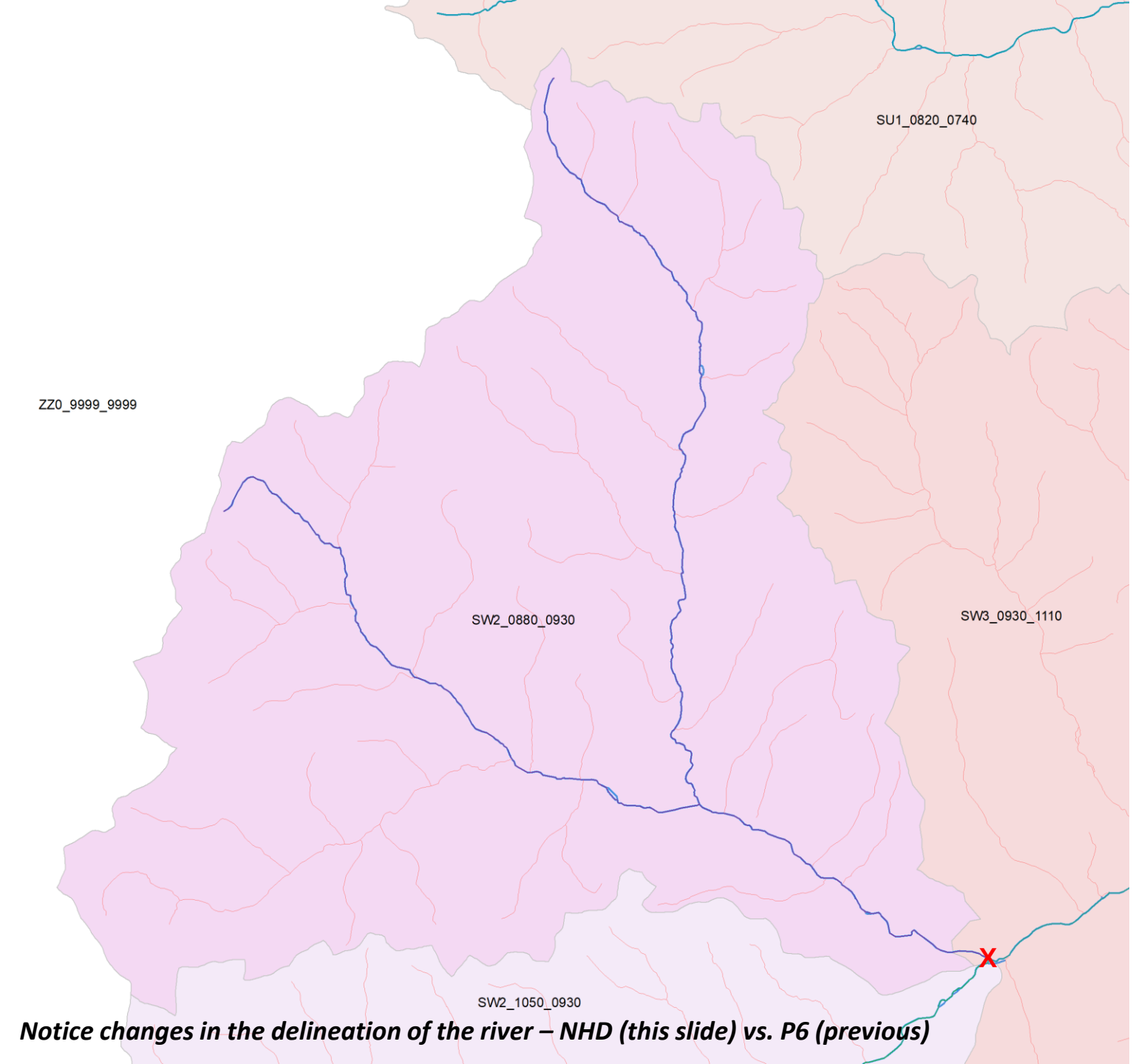


Edits for aligning with the NHD 100K; confluences; etc.

Deletions when P6 river segments were smaller than NHD 100K; error in P6 segmentation;

Additions for achieving better alignment of terminal rivers with the monitoring station; correction to P6 rivers; etc.

Also, corrections were made for alignment with monitoring stations.



Notice changes in the delineation of the river – NHD (this slide) vs. P6 (previous)

Edits for aligning with the NHD 100K; confluences; etc.

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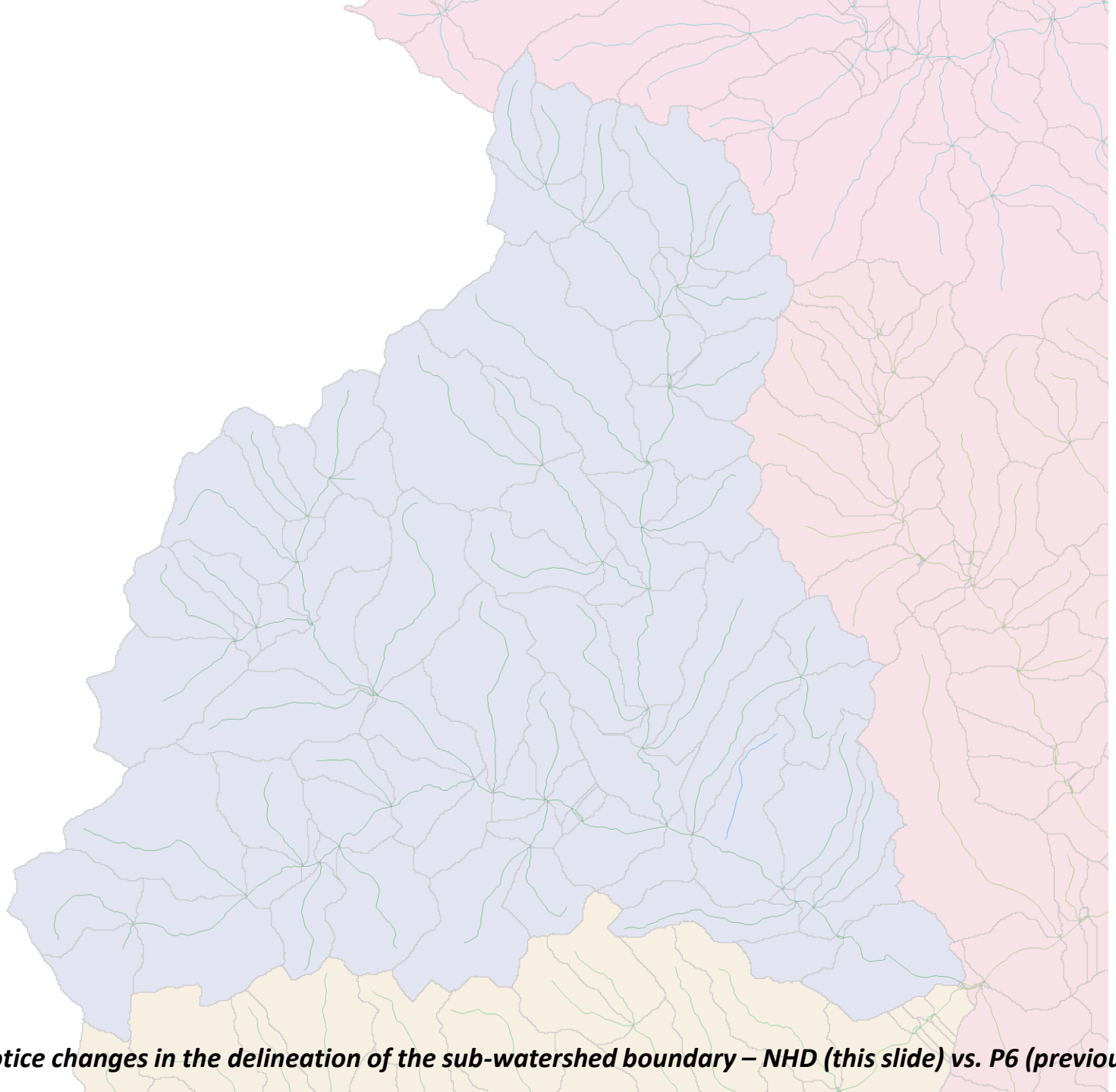


Notice changes in the delineation of the sub-watershed boundary – NHD (this slide) vs. P6 (previous)

Edits for aligning with the NHD 100K; confluences; etc.

Deletions when P6 river segments were smaller than NHD 100K; error in P6 segmentation;

Additions for achieving better alignment of terminal rivers with the monitoring station; correction to P6 rivers; etc.

Also, corrections were made for alignment with monitoring stations.

River Simulation

HSPF

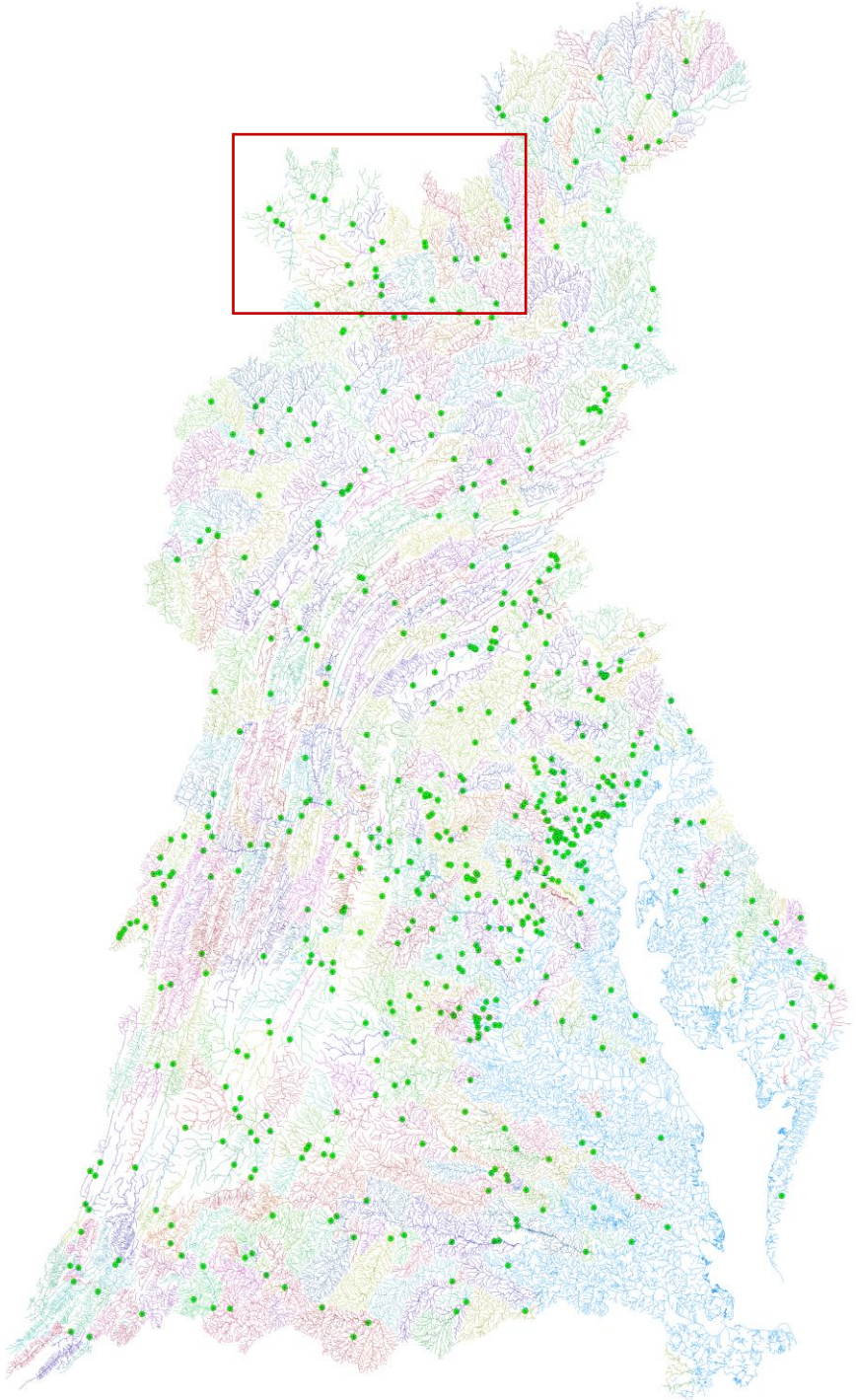
Complex model and requires estimation of several model parameters.

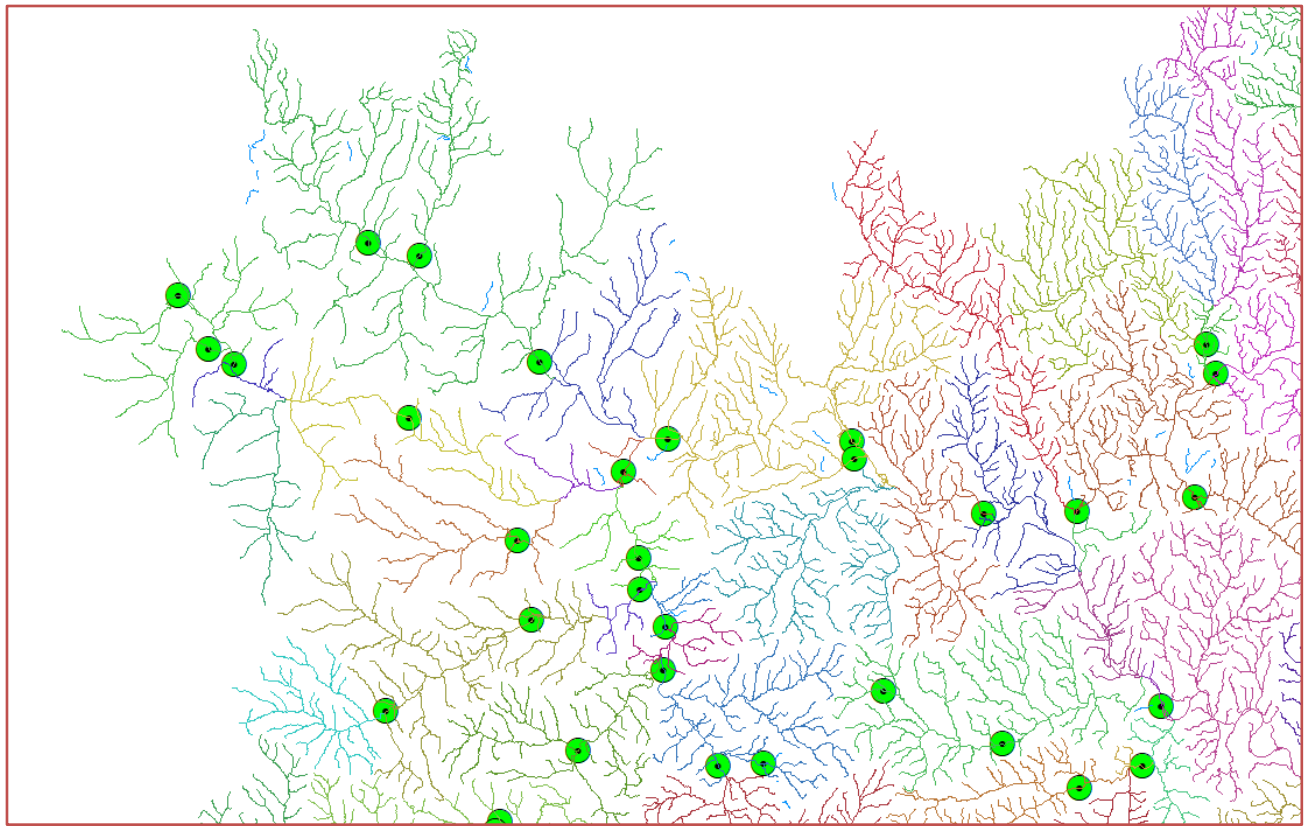
Simple Routing

Potential for providing better agreement with the time-averaged model, CalCAST.

Hybrid

A combination of Simple Routing and HSPF (and better understand trade-offs).



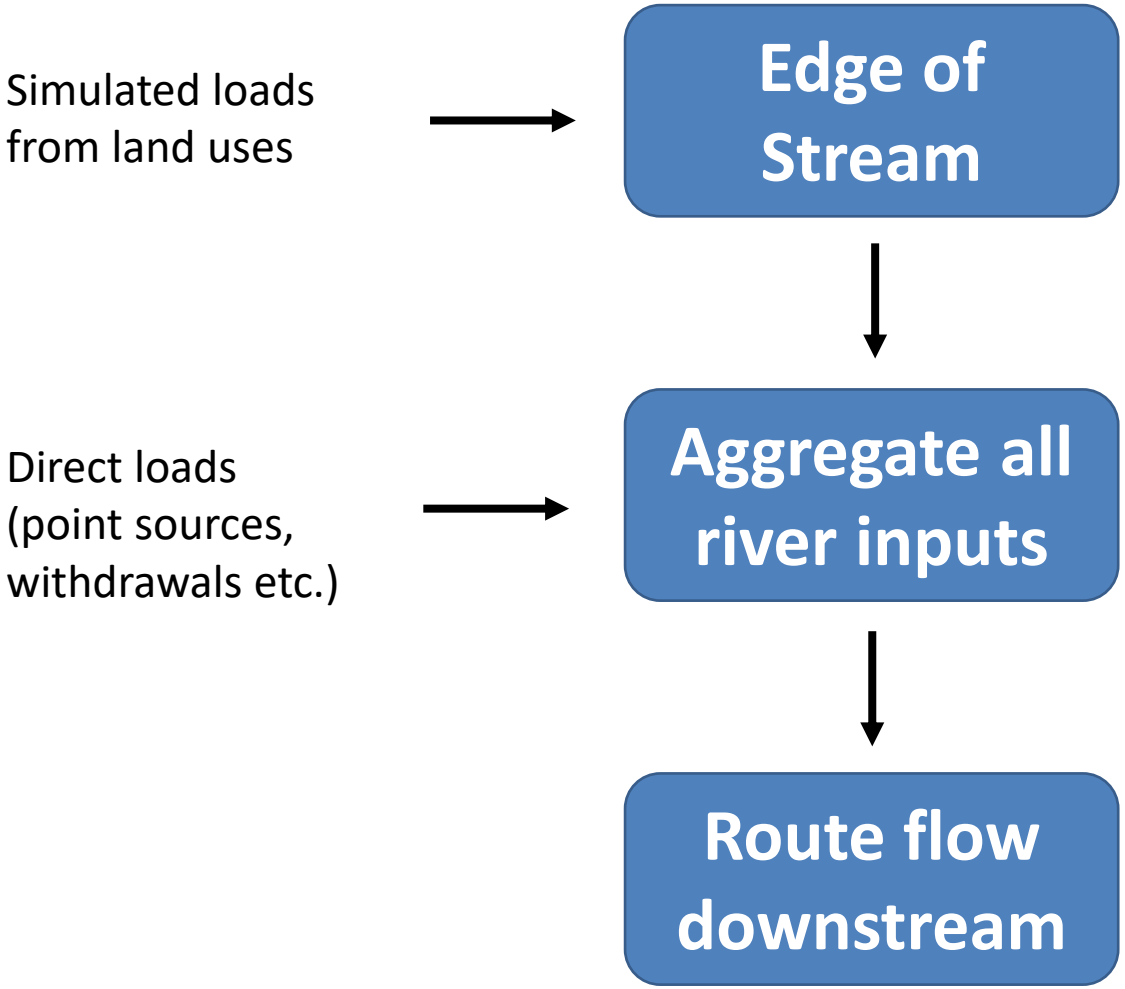


Nomenclature

e.g.,
COMID 9423425 is tracked as SU4_009423425
SW2_0880_0930 is tracked as SW2_0880_0930

2. Simulation Framework and Operational Details

Dynamic Model Model Structure



Our first NHD 100K scale time-varying, dynamic spatially distributed hydrology model prototype

Model Runs

- We ran the hydrology model prototype as
  - **Simple Geography, Simple Model**: Each NHD 100K streams as an individual model segment using the Simple Routing Model
  - **Nested Geography, Simple Model**: Combination of individual and group NHD streams using Simple Routing Model
  - **Nested Geography, Hybrid Model**: Individual NHD streams using Simple Routing Model and Group of stream segments using HSPF

Compute Time (CBP AWS Cloud HPC)

	Simple Geography, Simple Model	Nested Geography, Simple Model	Nested Geography, Hybrid Model
Run Time	**3 HR 50 MIN***	**3 HR 20 MIN**	**3 HR 20 MIN**
Storage	**580 GB**	**529 GB**	**529 GB**

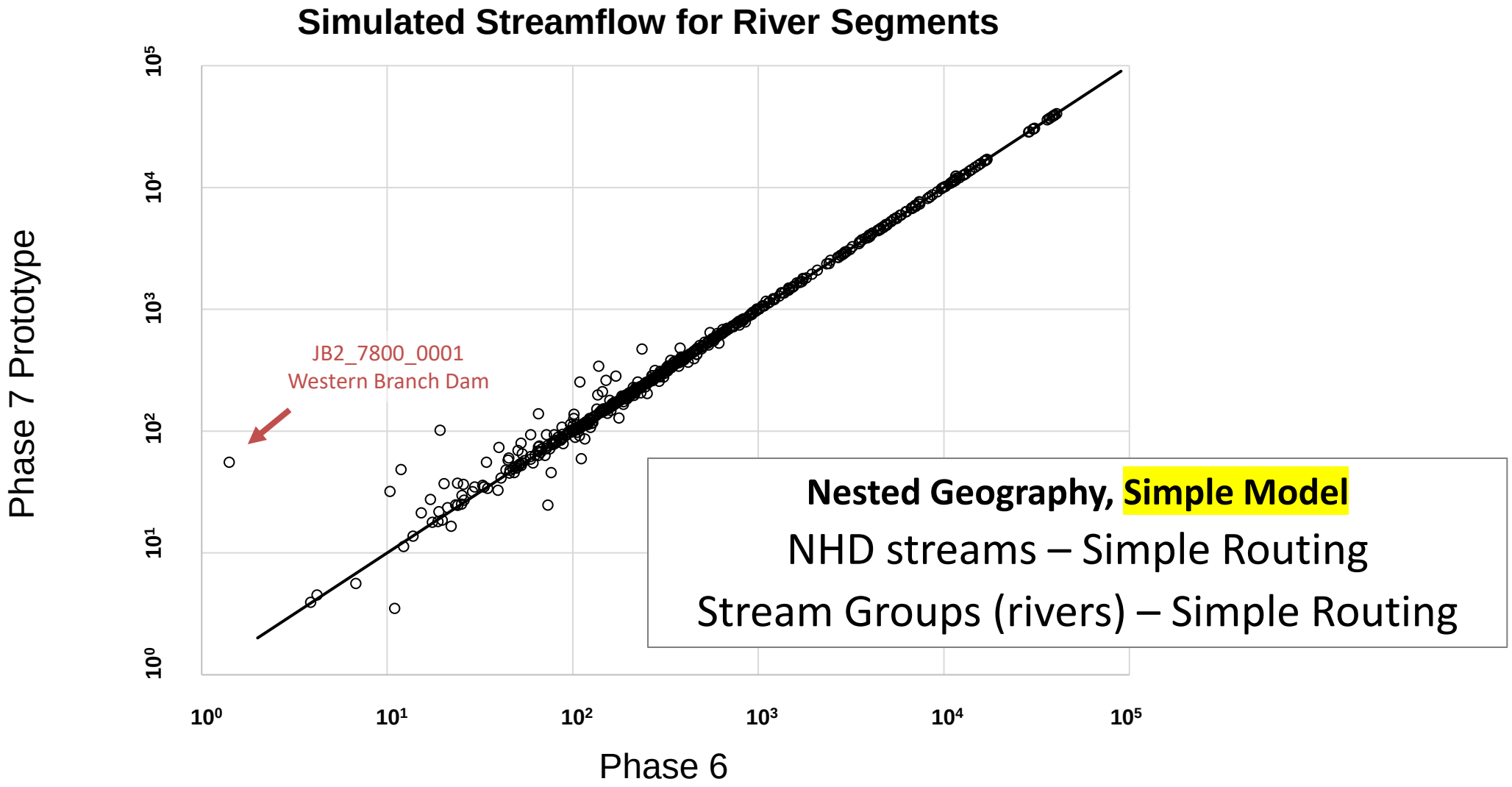
** based on just a single model run*

- 4 Nodes with 36 Cores each, i.e., processing of a max of 144 streams at a time
- Hydrology and water temperature only

- **It shows no constraints on operational feasibility for the NHD 100K scale Dynamic Model.**

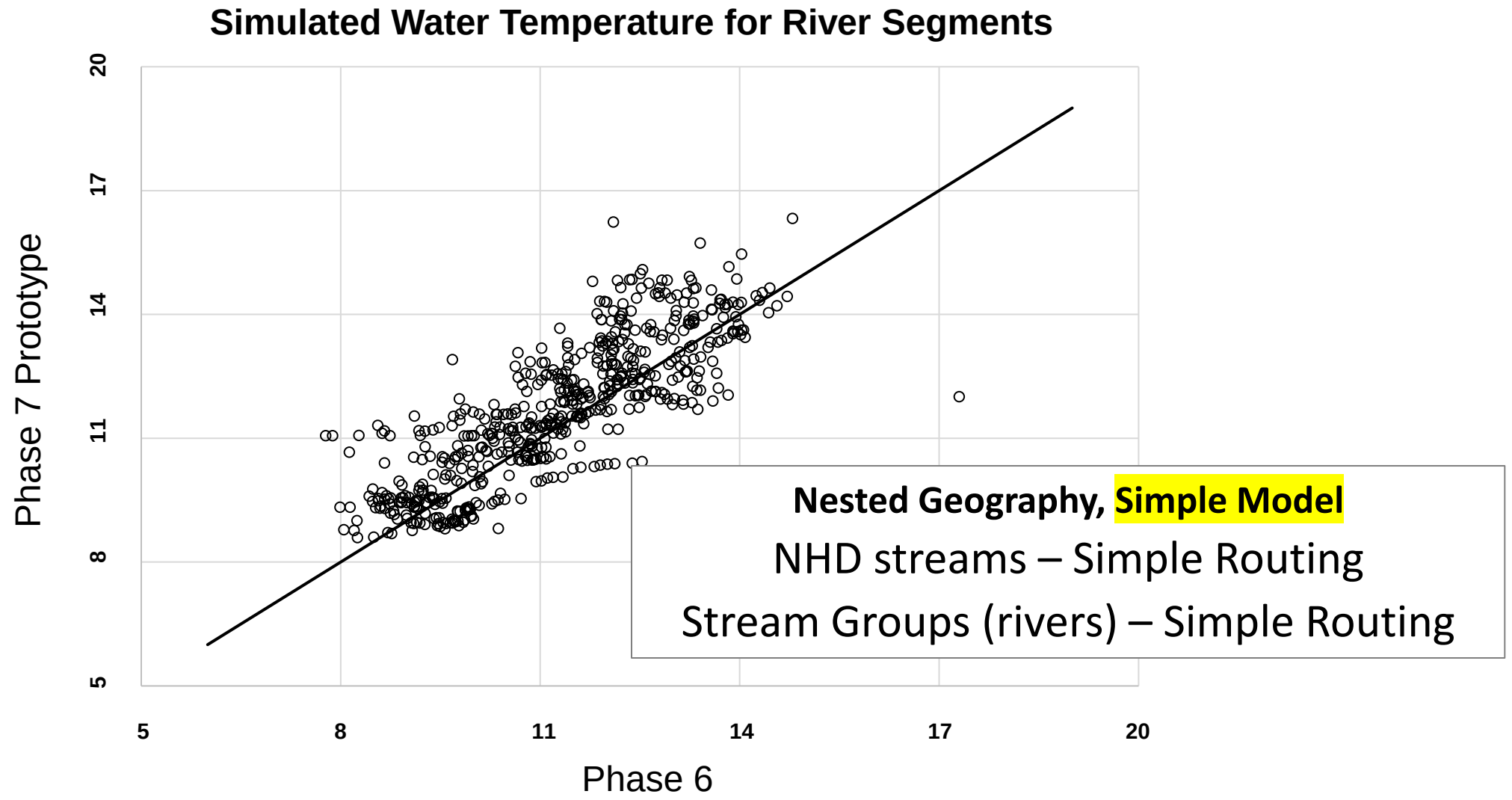
3. Results – Model Prototype Verification

Results (DM Hydrology – an initial, operational prototype)



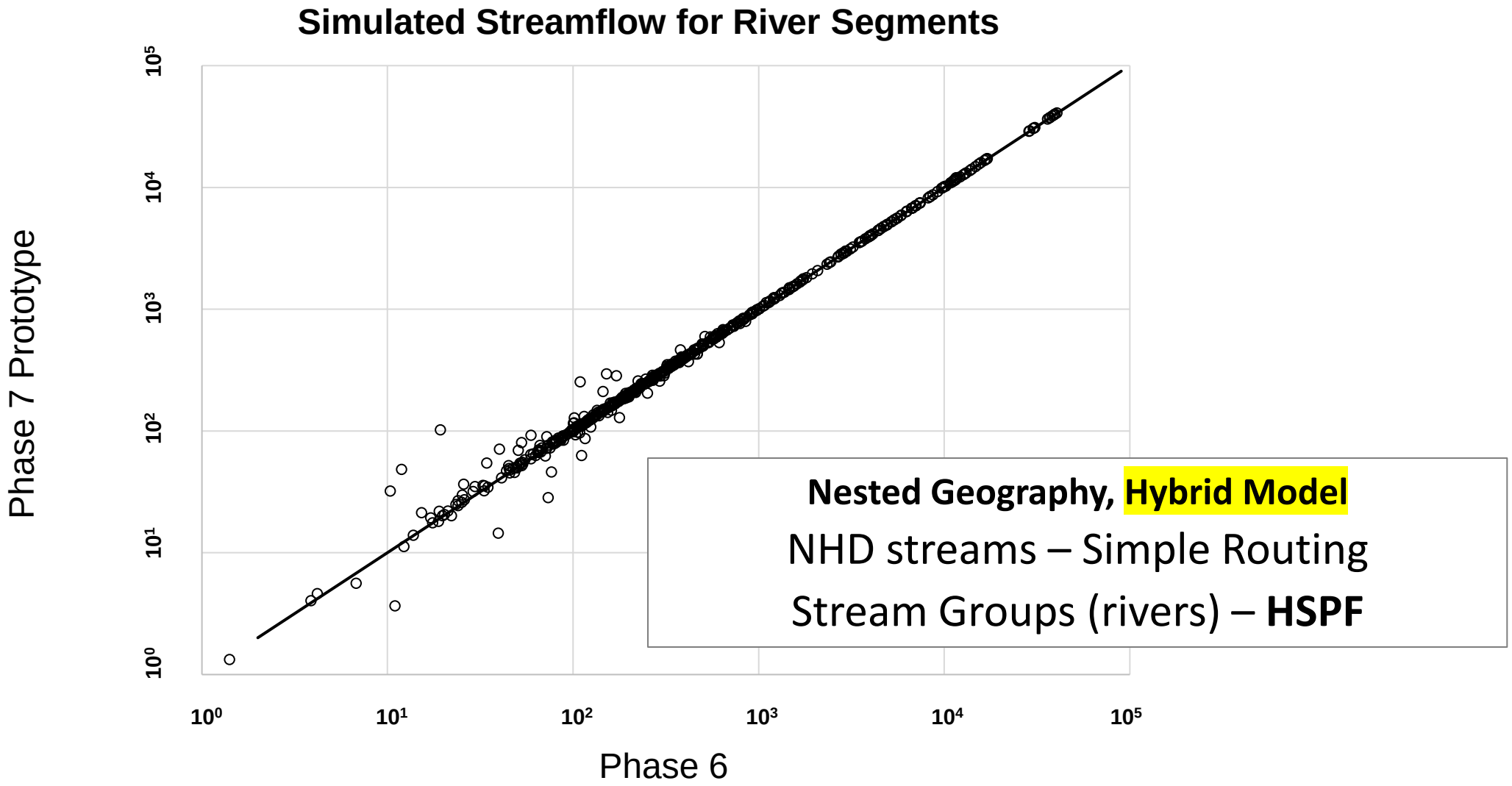
It shows the model is well set up, and Simple Routing as currently implemented is performing well except for a few cases

Results (DM Hydrology – an initial, operational prototype)



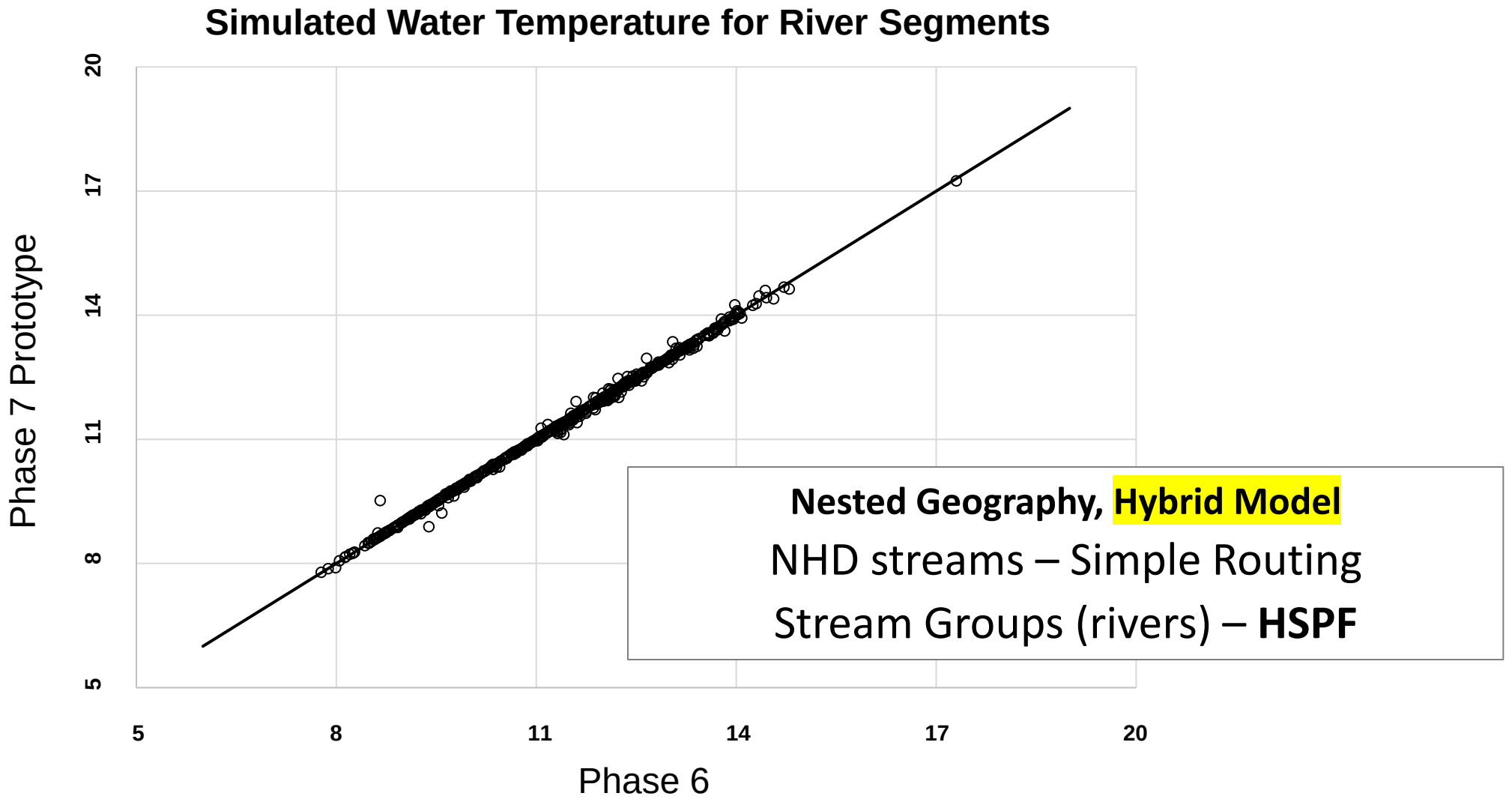
It shows the model is well set up, and Simple Routing as currently implemented is not sufficiently reproducing P6 results

Results (DM Hydrology – an initial, operational prototype)



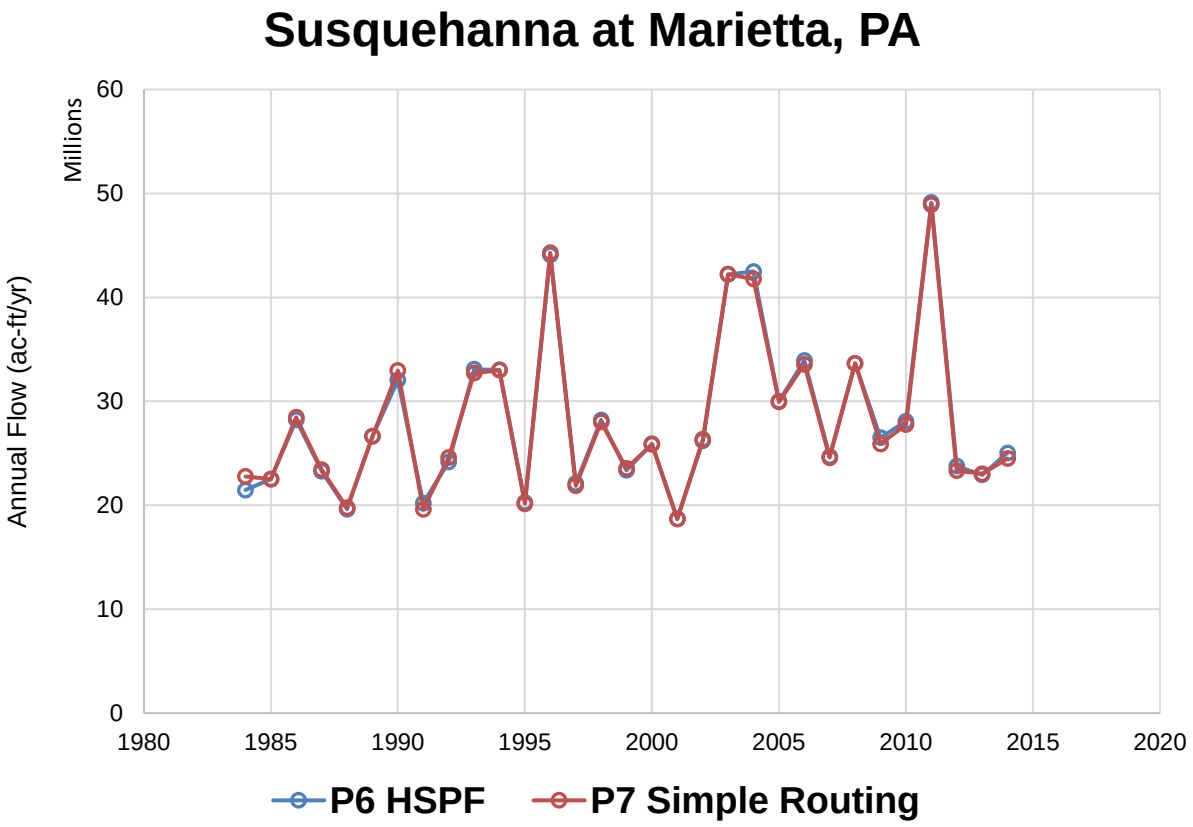
It shows the model is well set up, and HSPF did well for resolving some of the reservoir

Results (DM Hydrology – an initial, operational prototype)



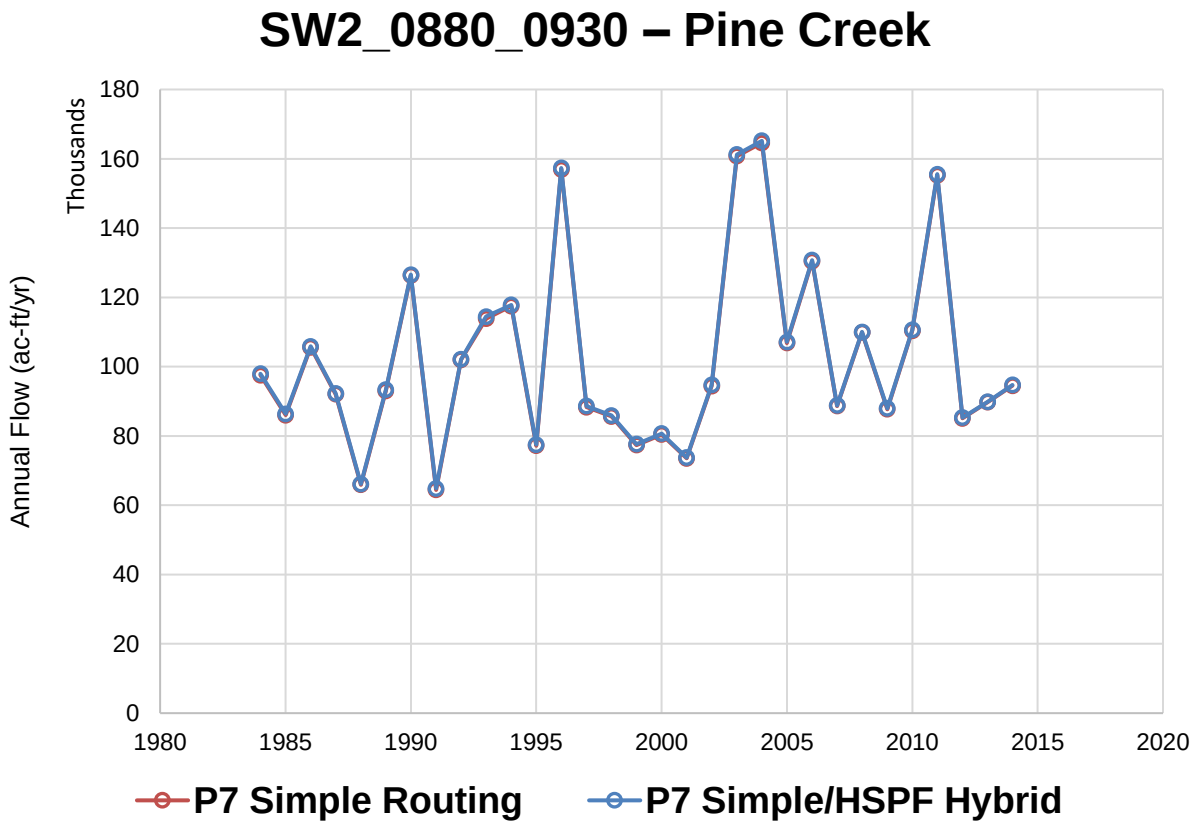
It shows the model is well set up, and HSPF did well for reproducing P6 water temperature results

Results (DM Hydrology – an initial, operational prototype)



- Phase 6 rivers simulated using HSPF RCHRES model
- Phase 7 NHD 100K streams simulated using a Simple hydraulic Routing Model (currently as Hourly Input = Output)
- Shows annual flow is working well at one of the downstream lower Susquehanna river reach

Results (DM Hydrology – an initial, operational prototype)

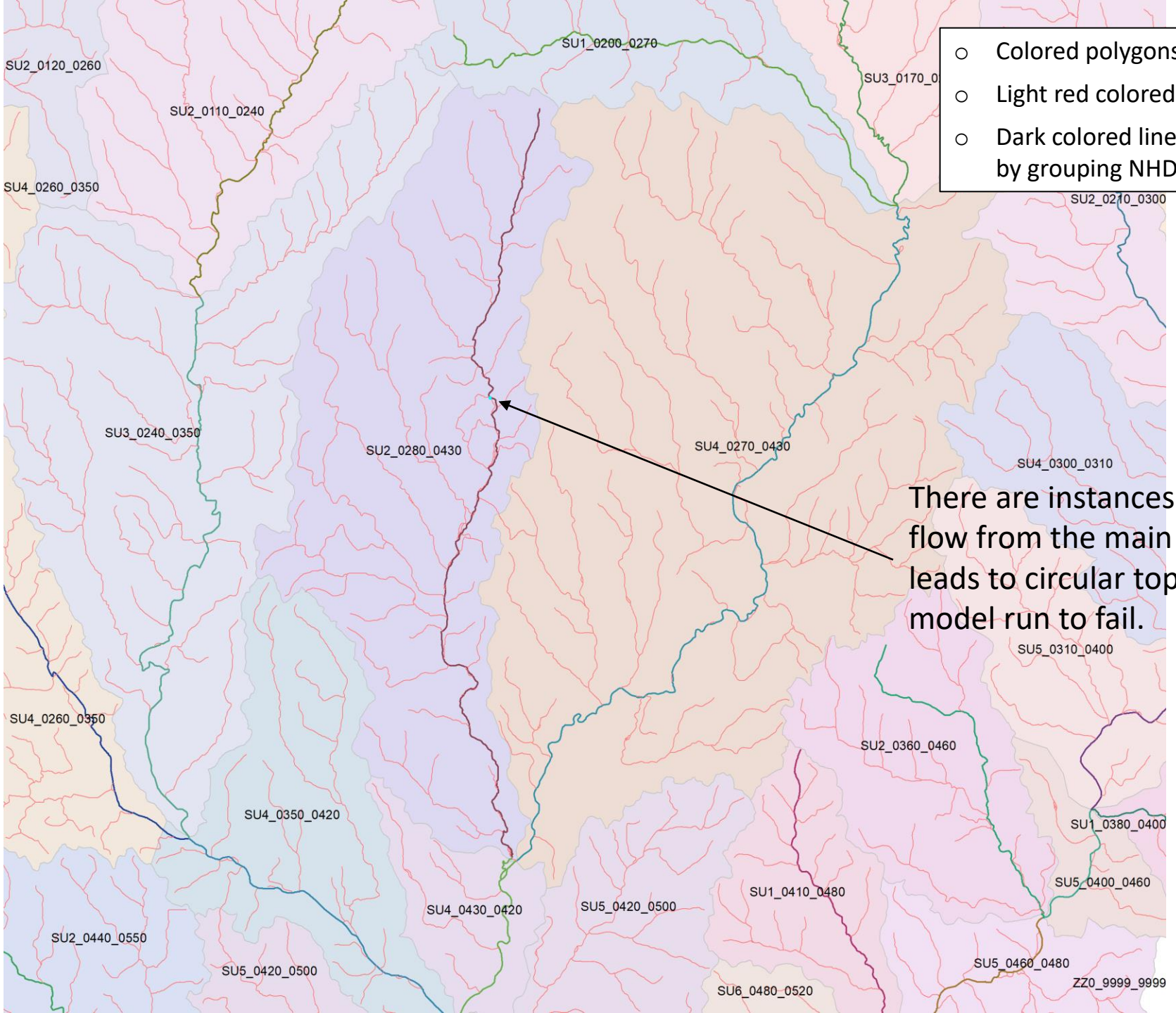


- Phase 6 rivers simulated using HSPF RCHRES model
- Phase 7 NHD 100K streams with nested geography of individual and grouped streams
- Shows annual flow is working well with ability to switch between HSPF and a different routing model

Next Steps / Issues

- Steps needed for putting together NHD **sediment model** prototype.
- This isn't the last time we are looking at the hydrology and water temperature. We will bring this back with new information, as appropriate.
  - **New Issues**: (a) calibration framework for NHD 100K; (b) linkage with the time-averaged hydrology model, CalCAST.
  - **Old Issues**: (a) expansion of the calibration period to 2020 (+6 years).
- Need to restructure the code and data (looking backwards).
- NHD stream topology issues that emerge with grouping into P6 rivers.

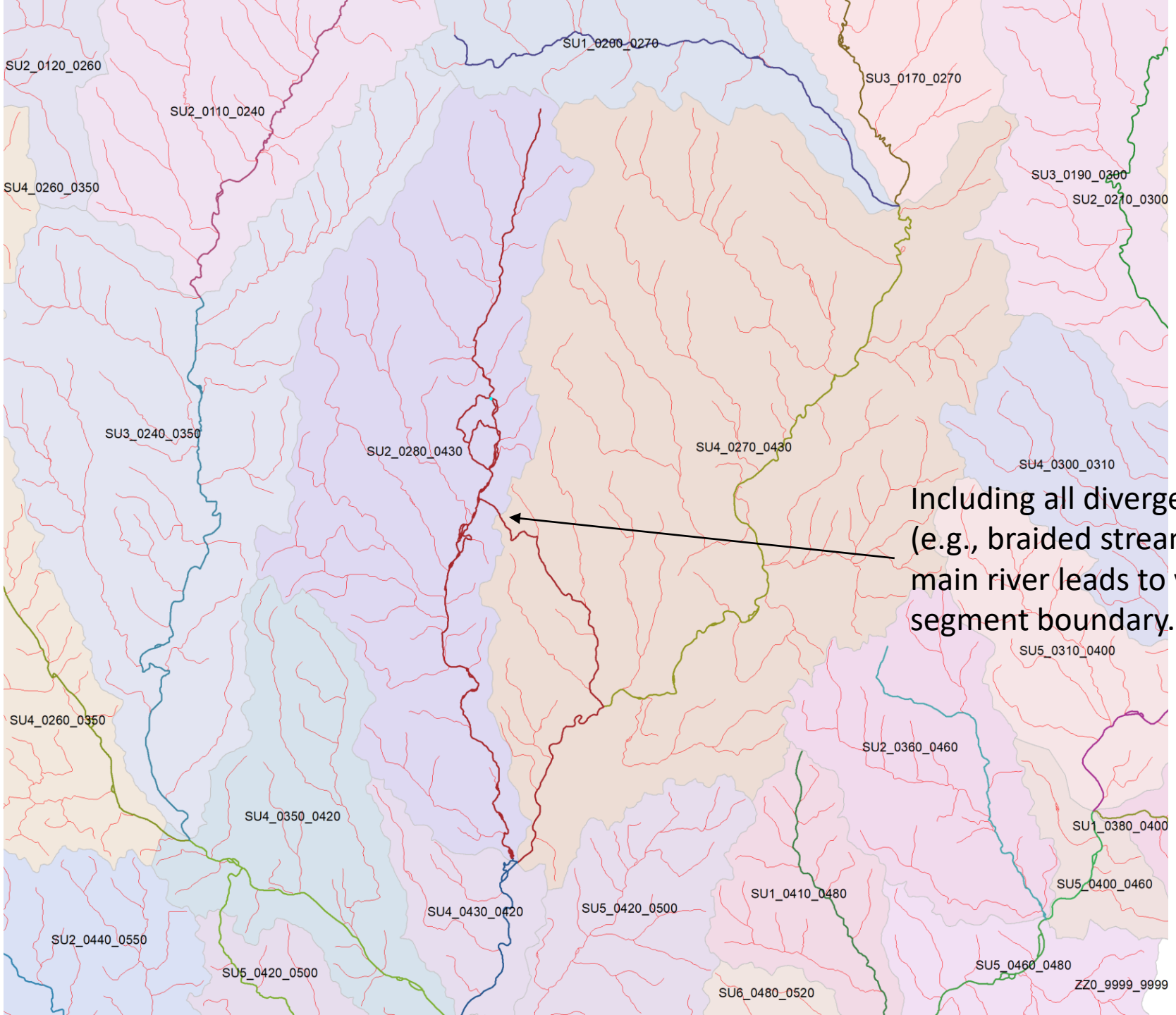
Circular Topology Issue



- Colored polygons show P6 river segments
- Light red colored lines are NHD streams
- Dark colored lines are P6 rivers developed by grouping NHD streams

There are instances of divergence of flow from the main P6 rivers, which leads to circular topology that causes model run to fail.

Circular Topology Issue



Including all divergence streams (e.g., braided streams) as part of the main river leads to violations of river segment boundary.