Developing Dynamic River Boundary Conditions for Historic and Design Storms Combined Sewer Modeling

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GLWA
Great Lakes Water Authority

WADE TRIM

Introductions

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- 30 years of modeling experience

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- 6 years of modeling experience

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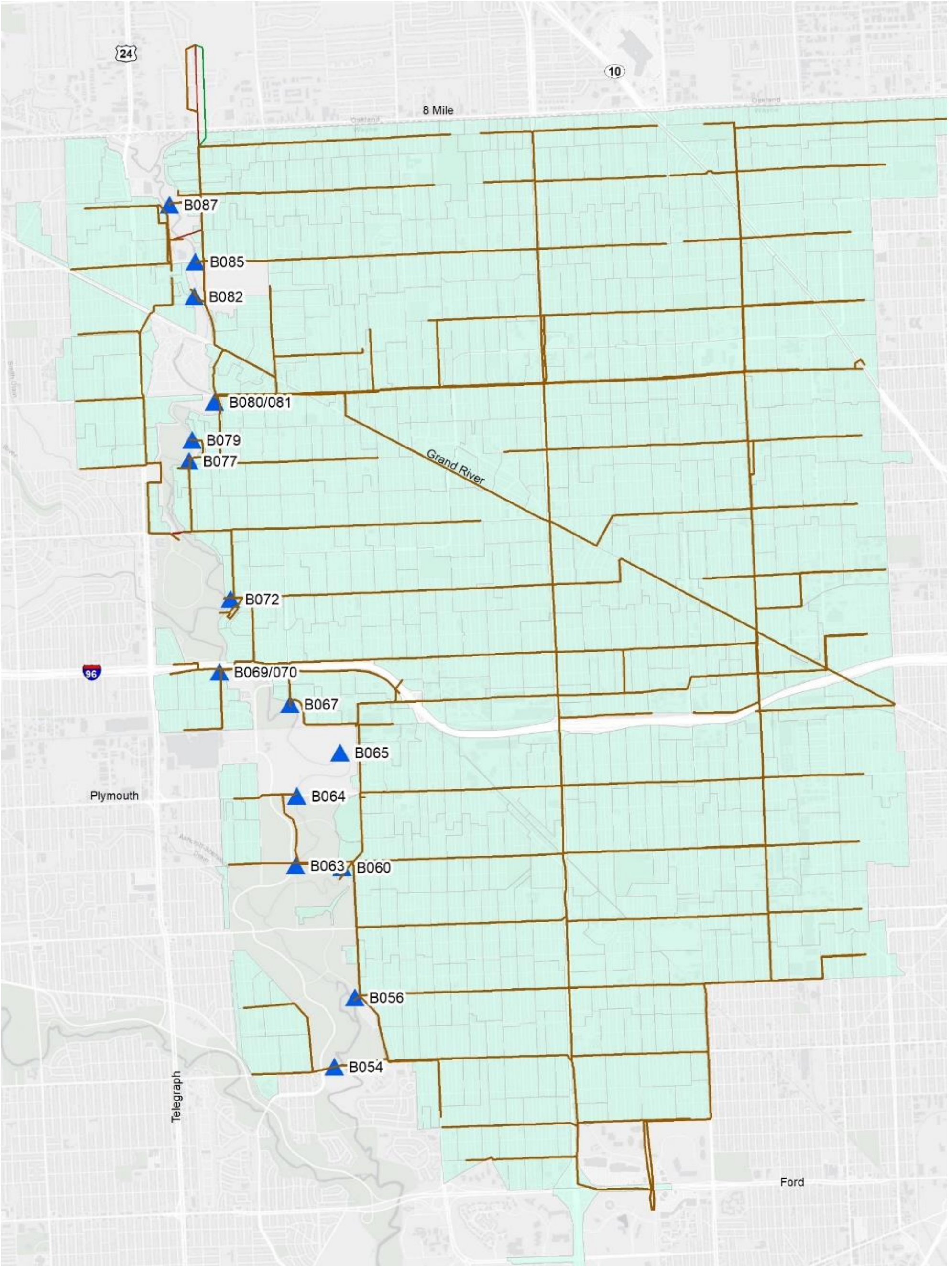
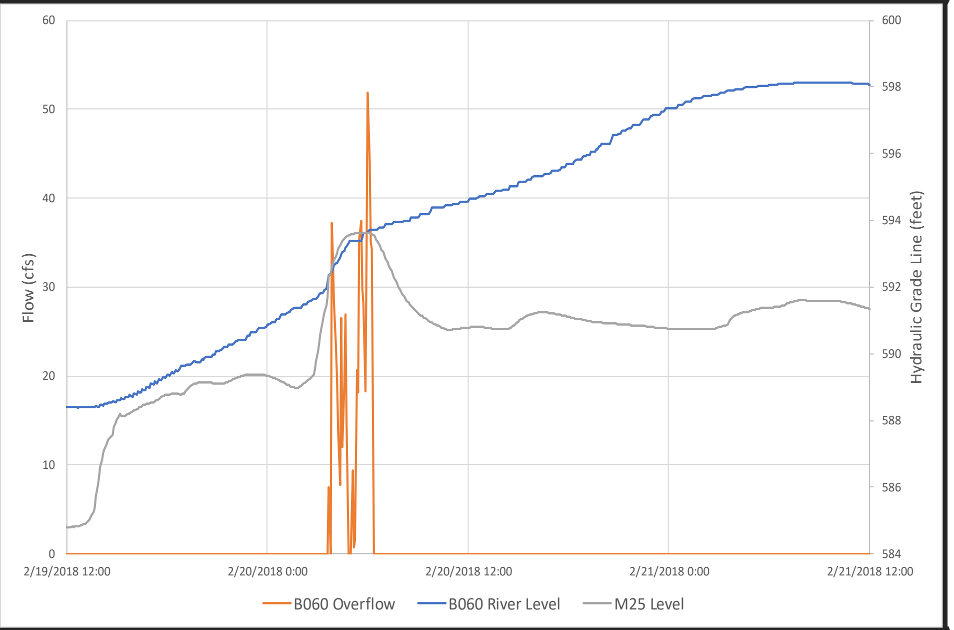
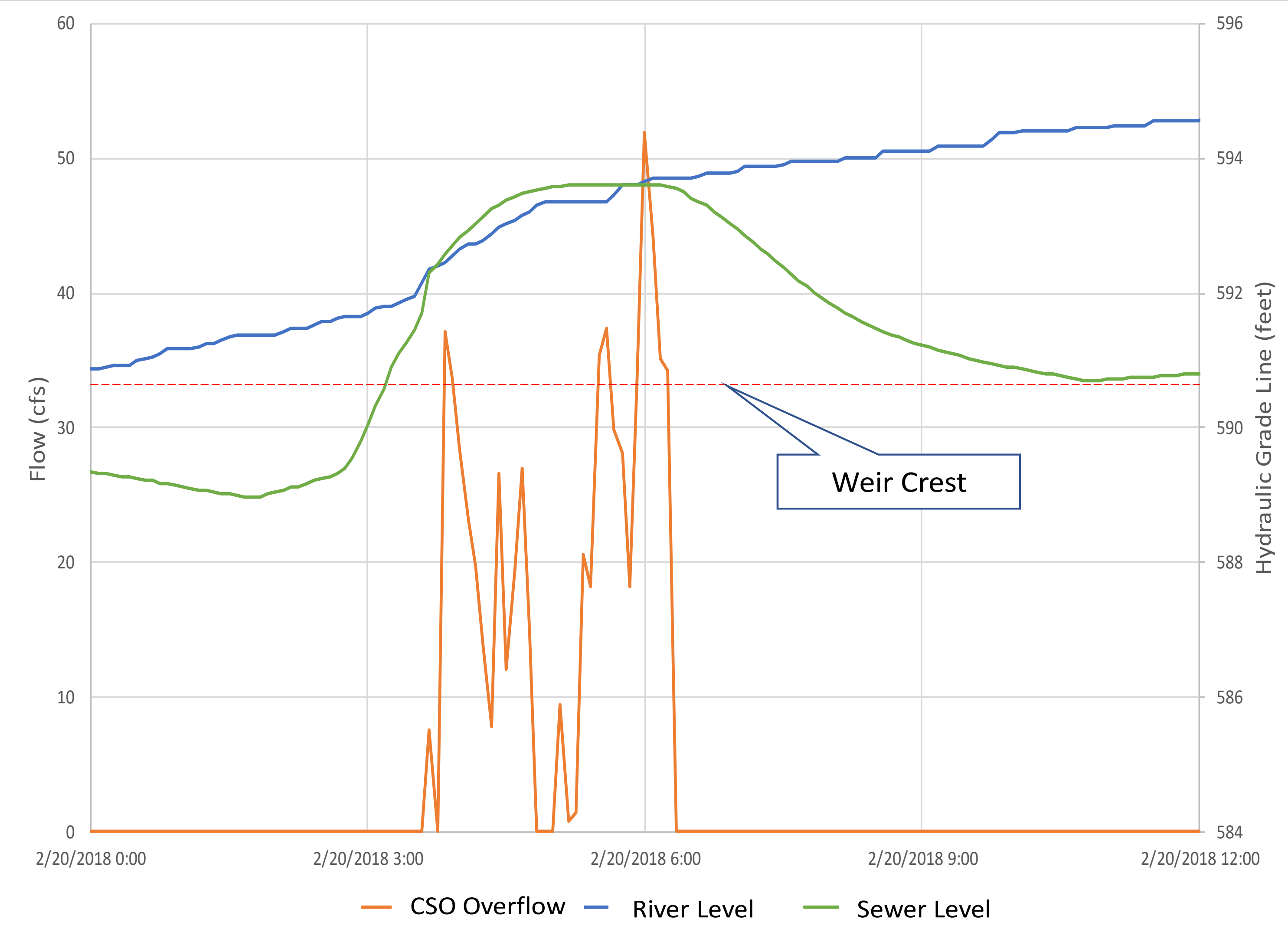
Detroit West Side System

1. 17 CSO outfall locations
2. Boundary condition Main Rouge River
3. River is very flashy
4. River level sensors installed on the river at each CSO location on the river
5. 18-month monitoring period



Influence of River on Overflow Timing is Everything





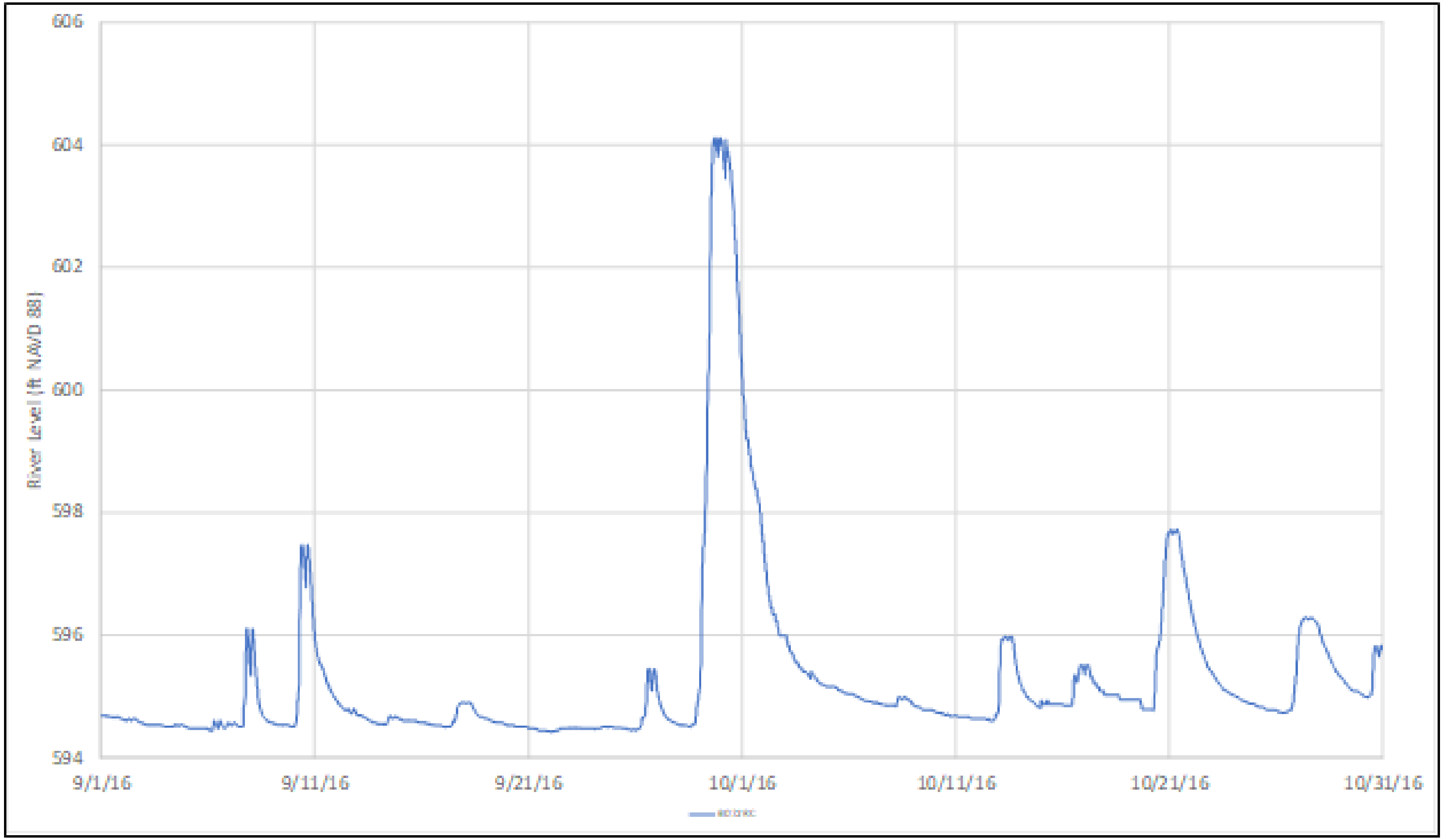
Rouge River Boundary Condition

Three Separate Boundary Condition Methods Developed

1. Historic Storm Calibration period (2016 forward)
2. Historic Storm Pre-calibration period (Prior to 2016)
3. Design Storms

Rouge River Boundary Condition
Historic Storm - Calibration period (2016 forward)

Measured data used as a direct model input (Example B072)

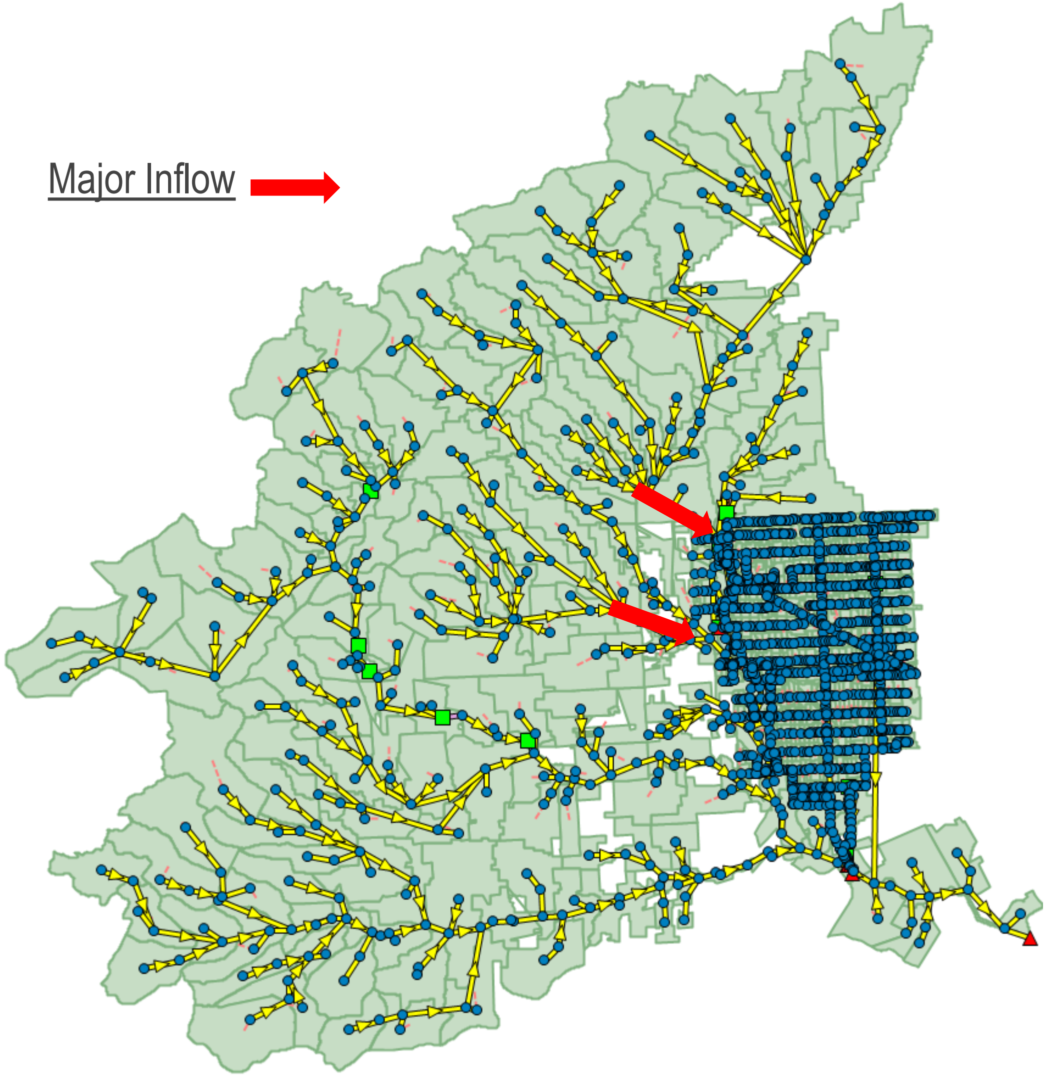


Rouge River Boundary Condition
Historic Storm Prior to 2016 – No Monitoring Data

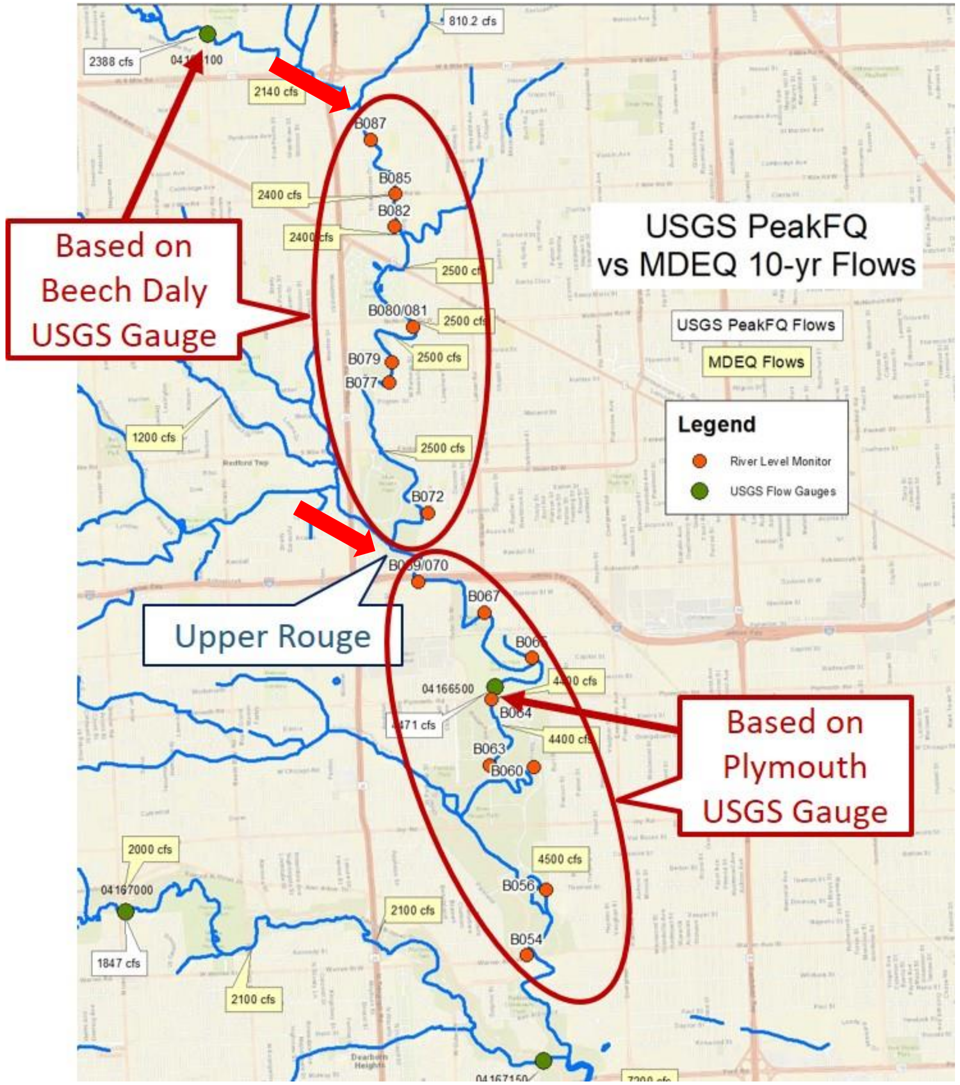
1. Available information
   - Long term USGS stream gauge data
   - 18 months of river level data

2. Rating curve developed at each outfall location to the river
   - Rating curves based on relationship of local USGS stream gauge and measured level data
   - Rating curves are only representative for the analysis period
   - Rating curves should be updated/verified periodically

Major River Inflow (flow change) & USGS Stream Gauge Locations



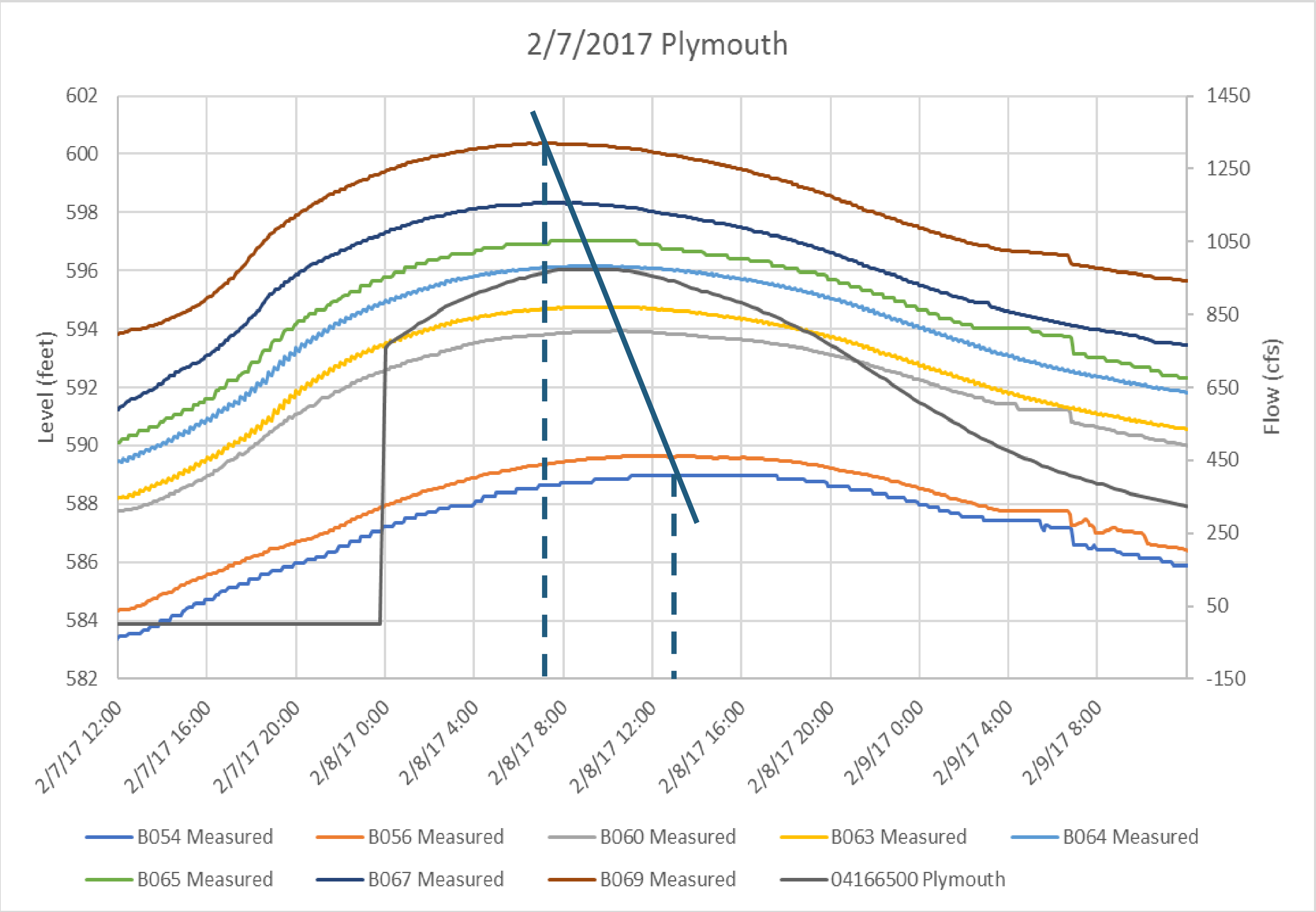
Outfall Locations Grouped to USGS Gauge



Relationship of peak river flow a peak river level timing

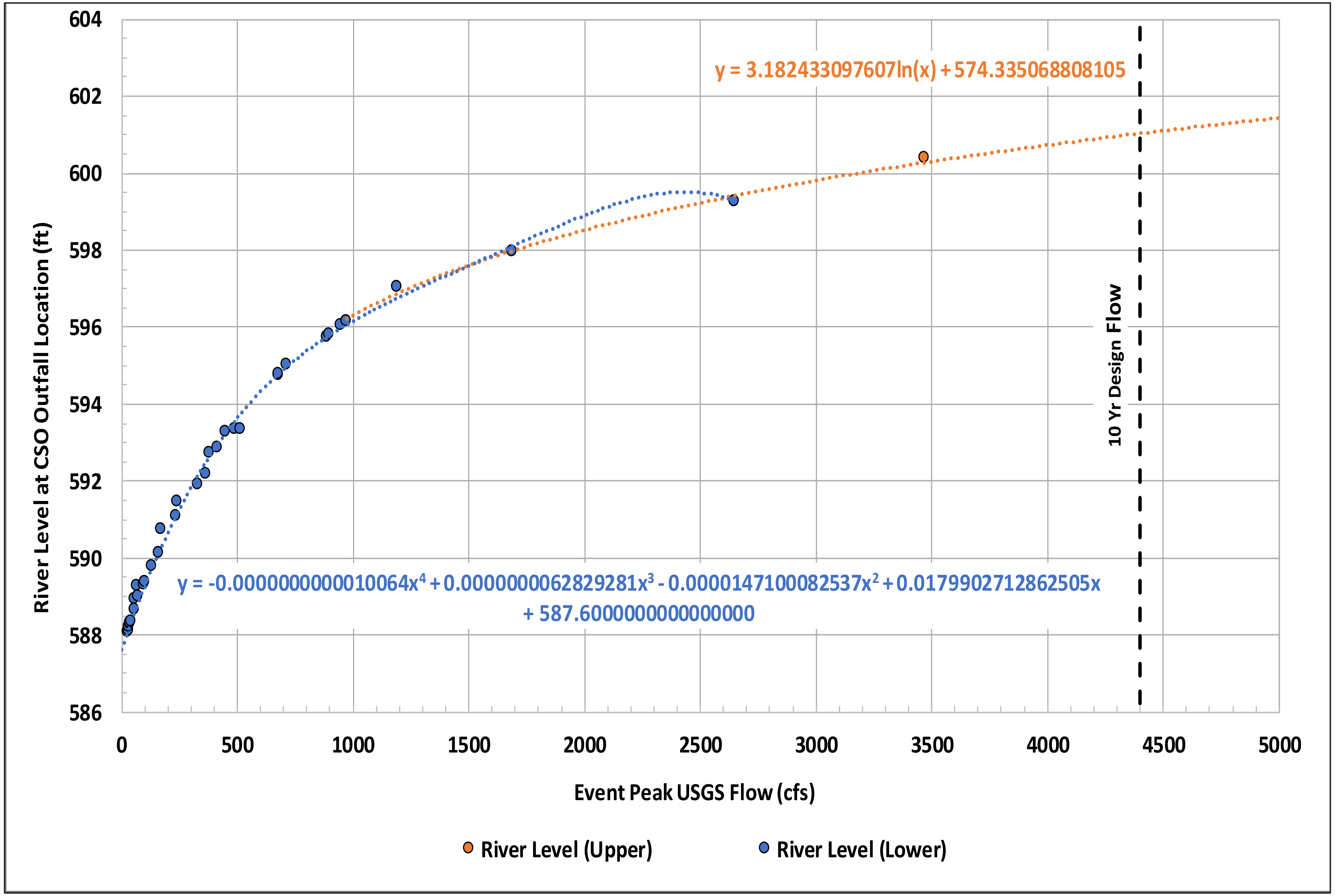
Stream flow timing estimated at each USGS gauge for:

- 10 events
- Both groups of USGS gauges and outfall locations



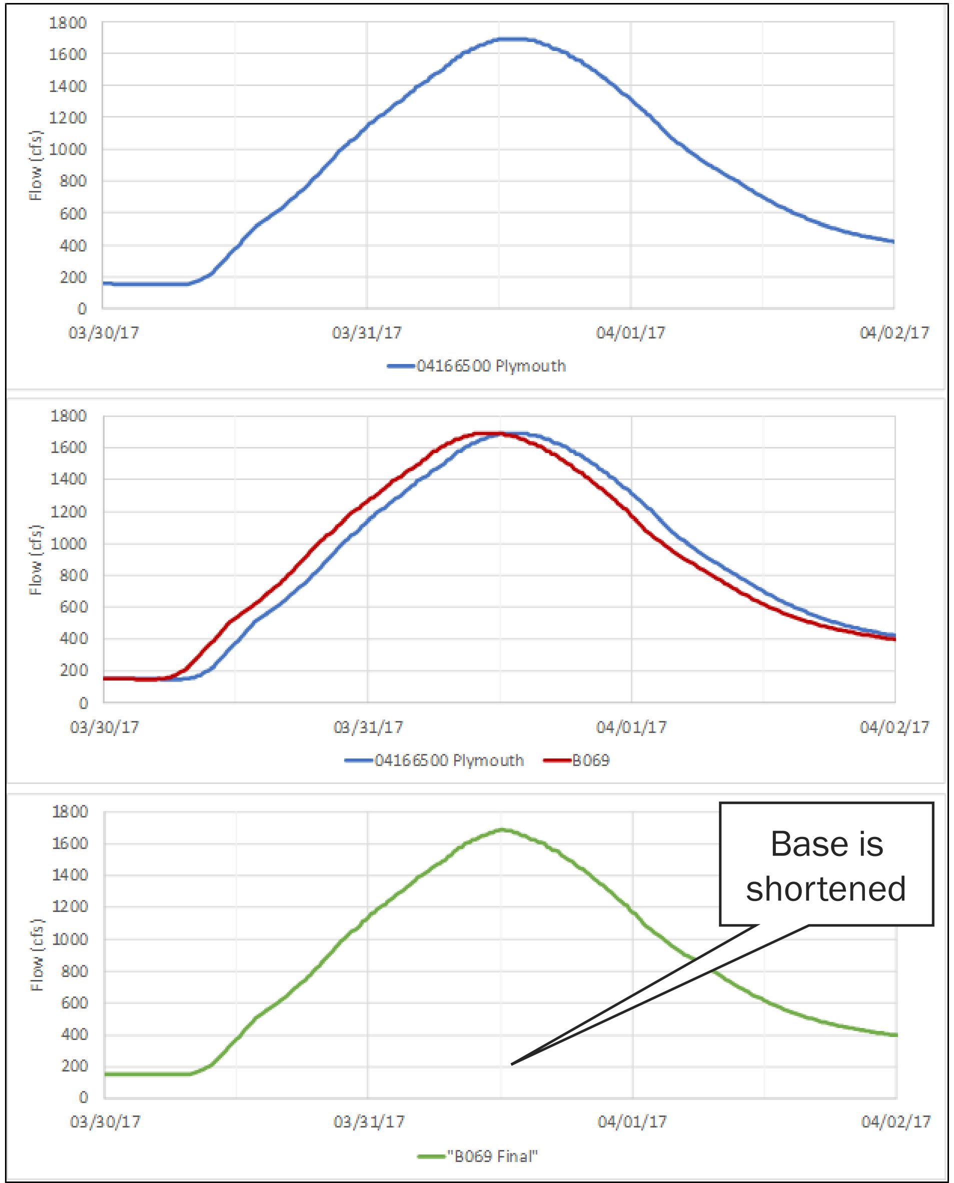
Measured Flow and Level River Rating Curve

1. Peak flow and level analyzed for a range of flow rates
2. Largest measured flow within 80% of 10-year design flow
3. Rating curve separated into upper and lower

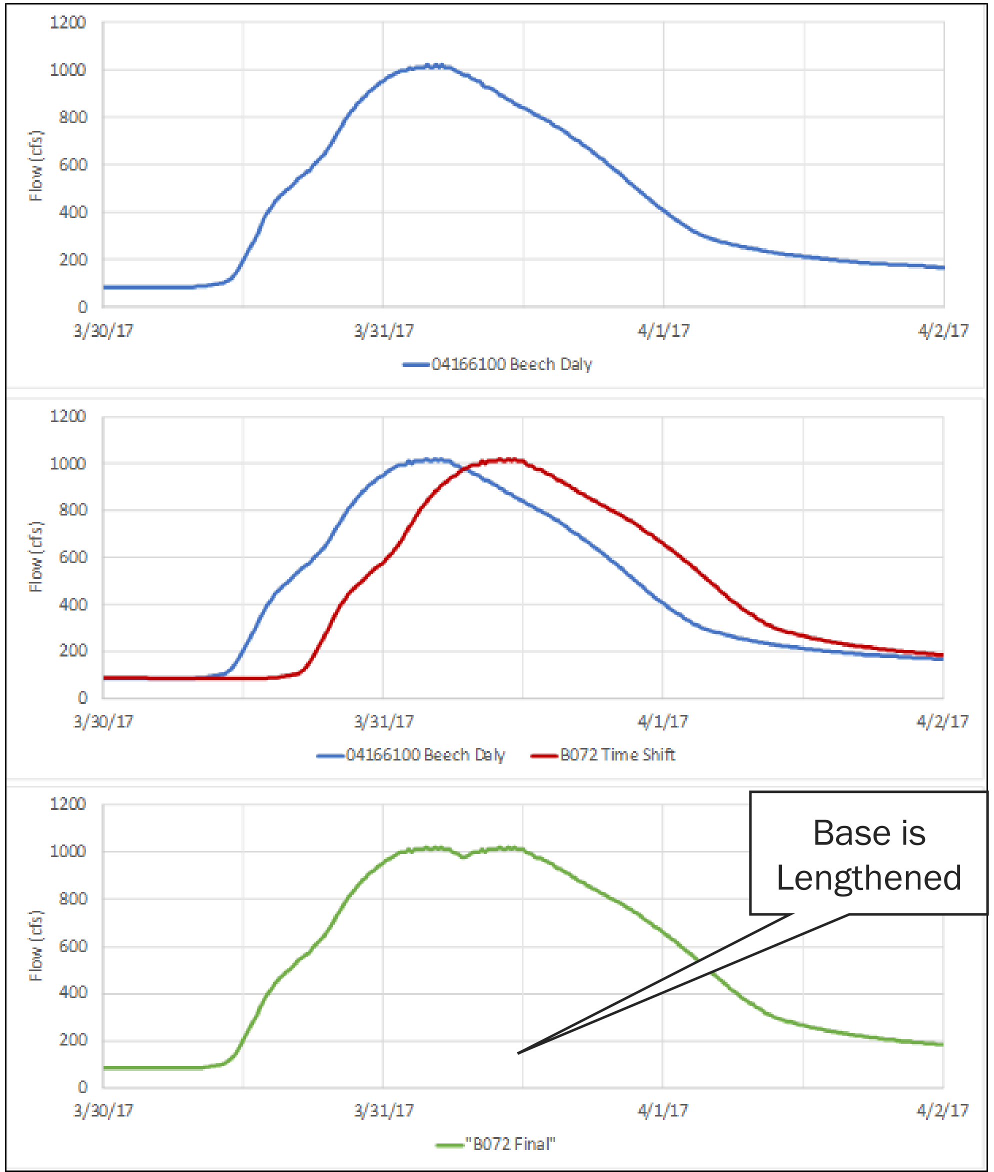


Stream Hydrograph for each River location
USGS Flow Shifted to Account for flow Attenuation

Shifted to Upstream Location

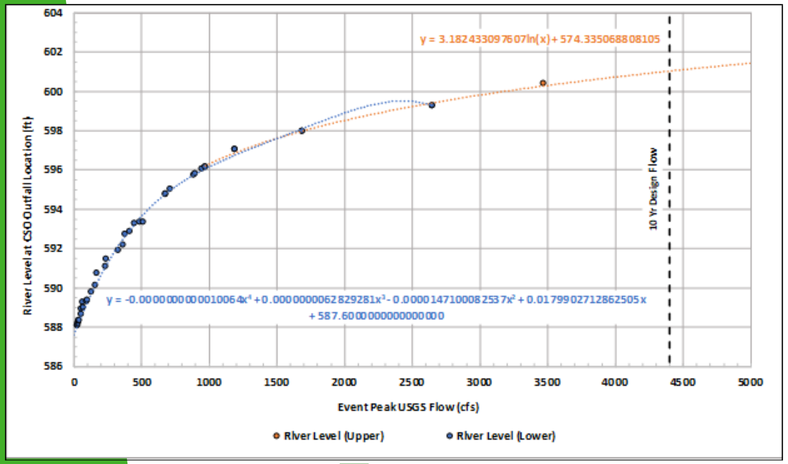


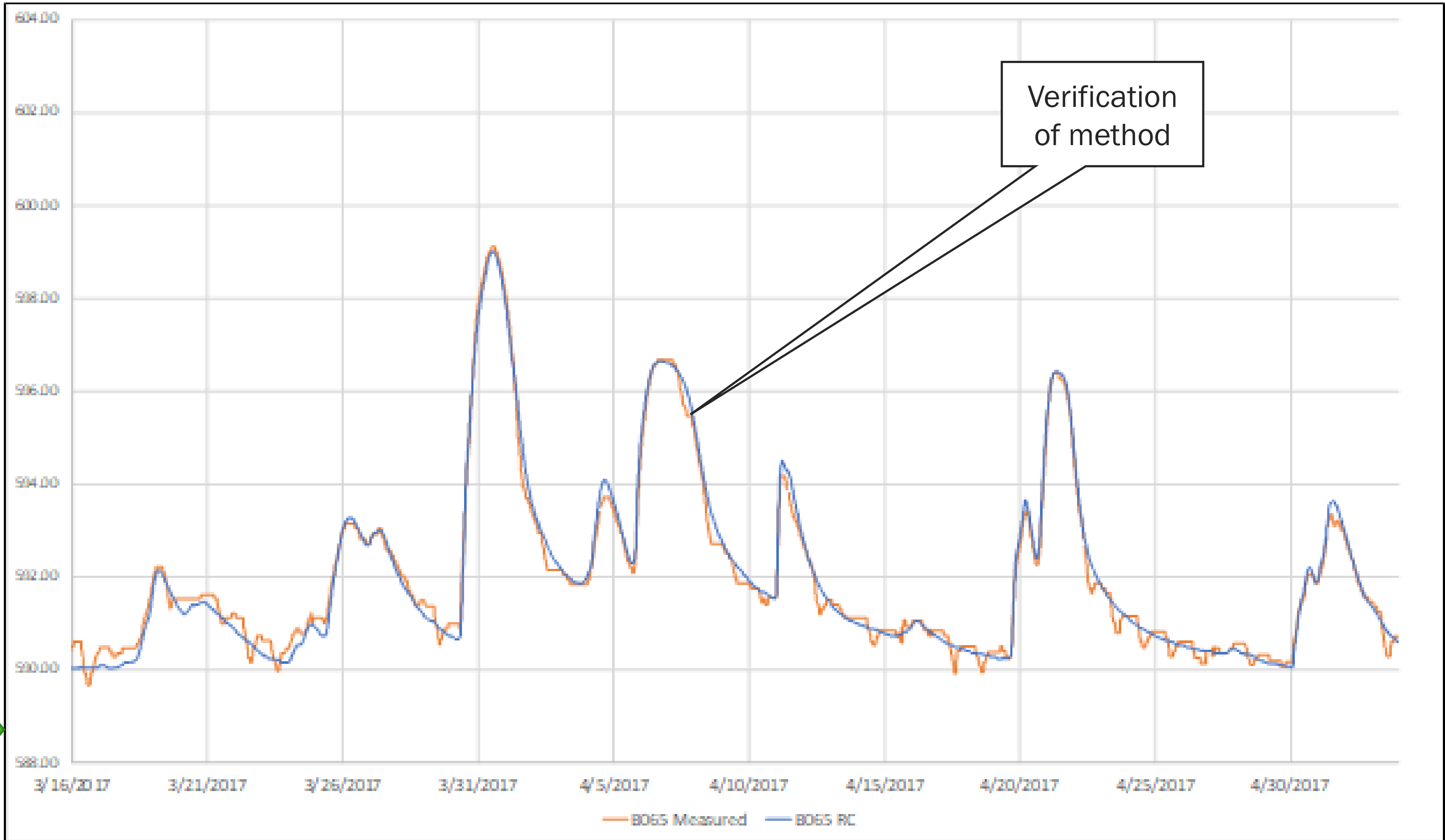
Shifted to Downstream Location



Rouge River Boundary Condition
Historic Storm - Pre-calibration period (Prior to 2016)

Measured USGS flow data used with individual river rating curves to calculate river level at individual outfalls





Rouge River Boundary Condition
Historic Storm - Pre-calibration period (Prior to 2016)

1. River rating curves developed for CSO outfall location
2. 10 years of historic USGS flow data downloaded
2. USGS flow data shifted and converted to time series level data
3. Time series level data used as direct input boundary condition in the model
4. Model run continuously for 10 years to generate performance statistics

Main Rouge River Boundary Condition Design Storm

1. River flow generated using existing SWMM4 watershed model
2. Watershed model converted to SWMM5 and calibrated to 10-year design flow rates
3. CSO flows can be a significant component of river flow during the initial part of a large event

Main Rouge River – Connection to West Side Model

1. Goal – Interconnect Main Rouge Model to West Side model.
2. Purpose – Develop a dynamic boundary condition for Main Rouge at CSO points of connection.
3. Problem – Mixed Hydrology

- RPO = Green Ampt
- WSM = Horton
- Model cannot run mixed hydrology methods

Main Rouge River – Connection to West Side Model
Model Methodology Solution

1. Main Rouge Hydraulic representation removed from RPO model and added to WSM
2. Points of inflow from Rouge Watershed (RPO model) are now connected to the Main Rouge model (in WSM) using model interface file.

Main Rouge River – Connection to West Side Model
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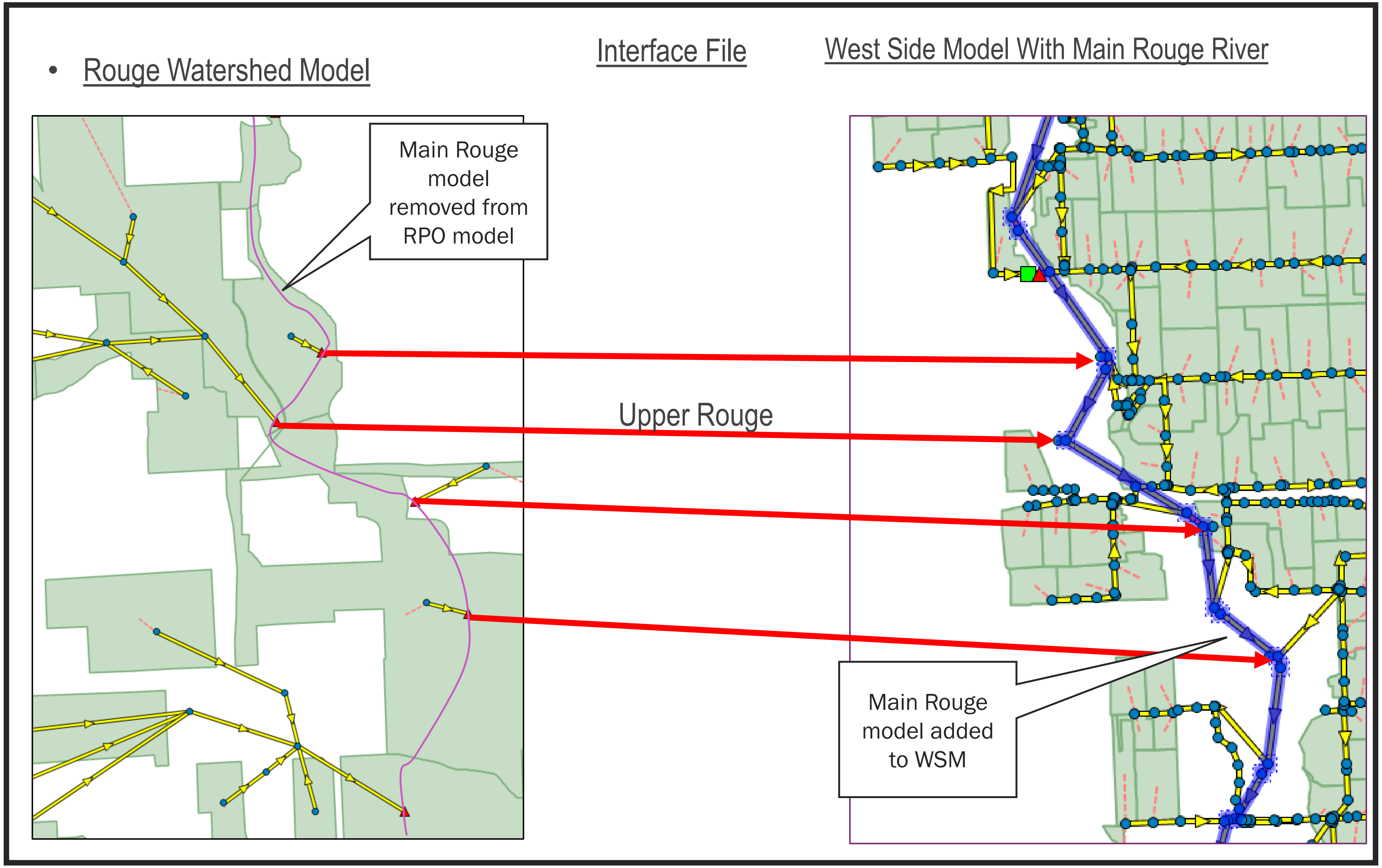
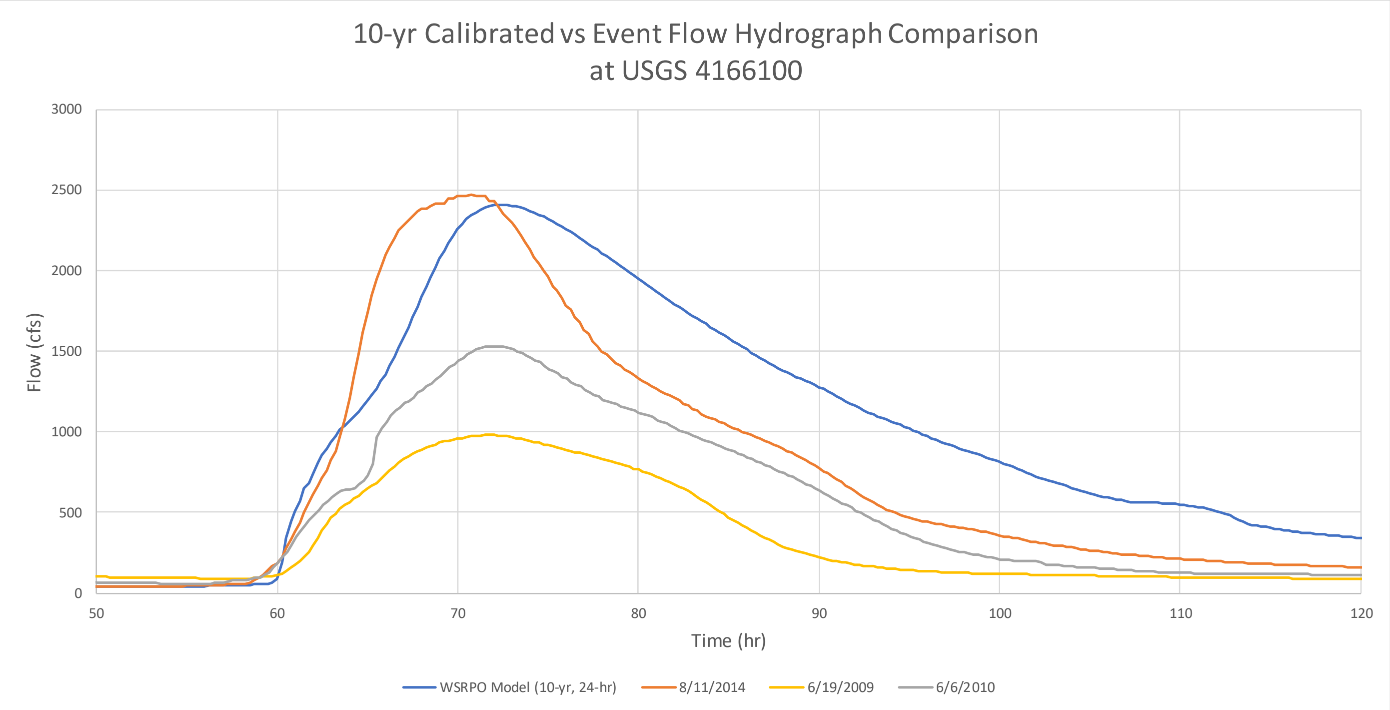
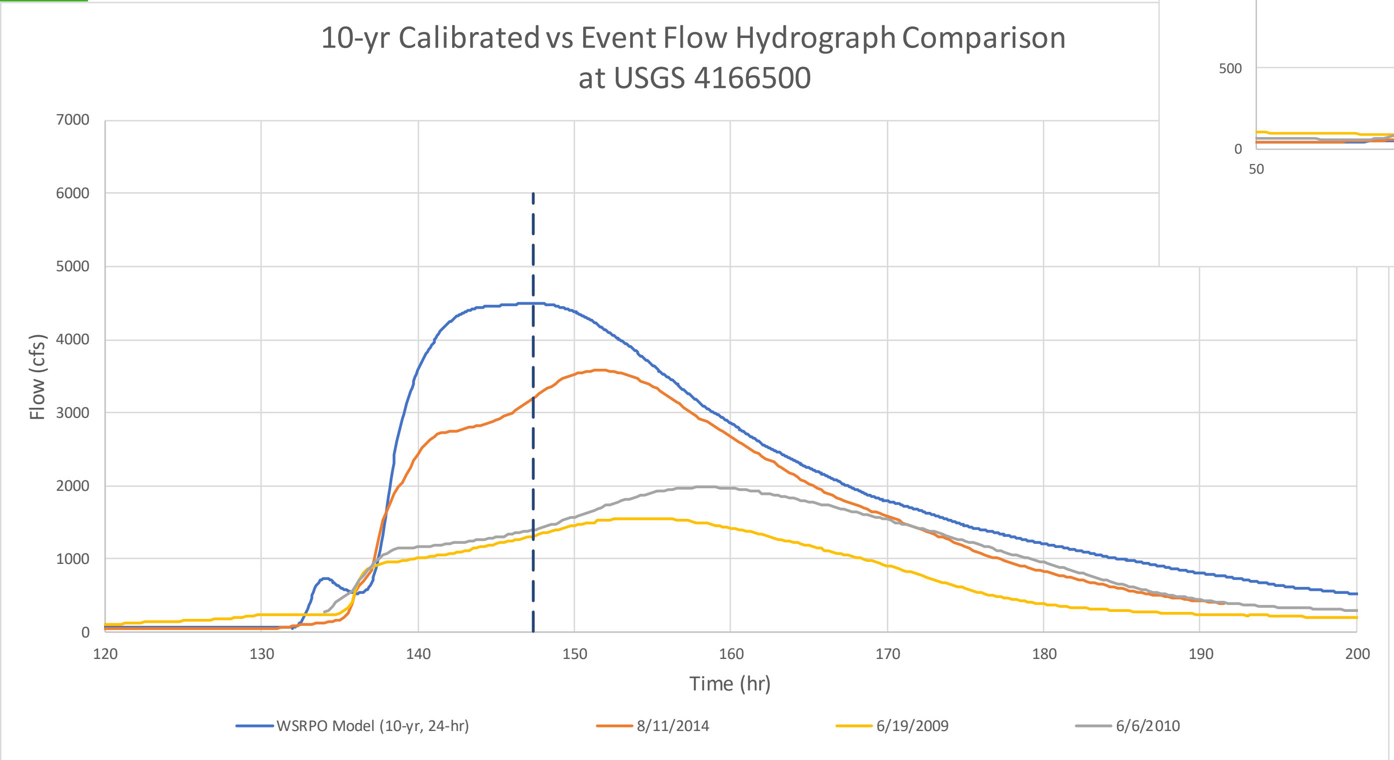


Main Rouge Calibration

10-year, 24-hour model flow compared to other large measures events



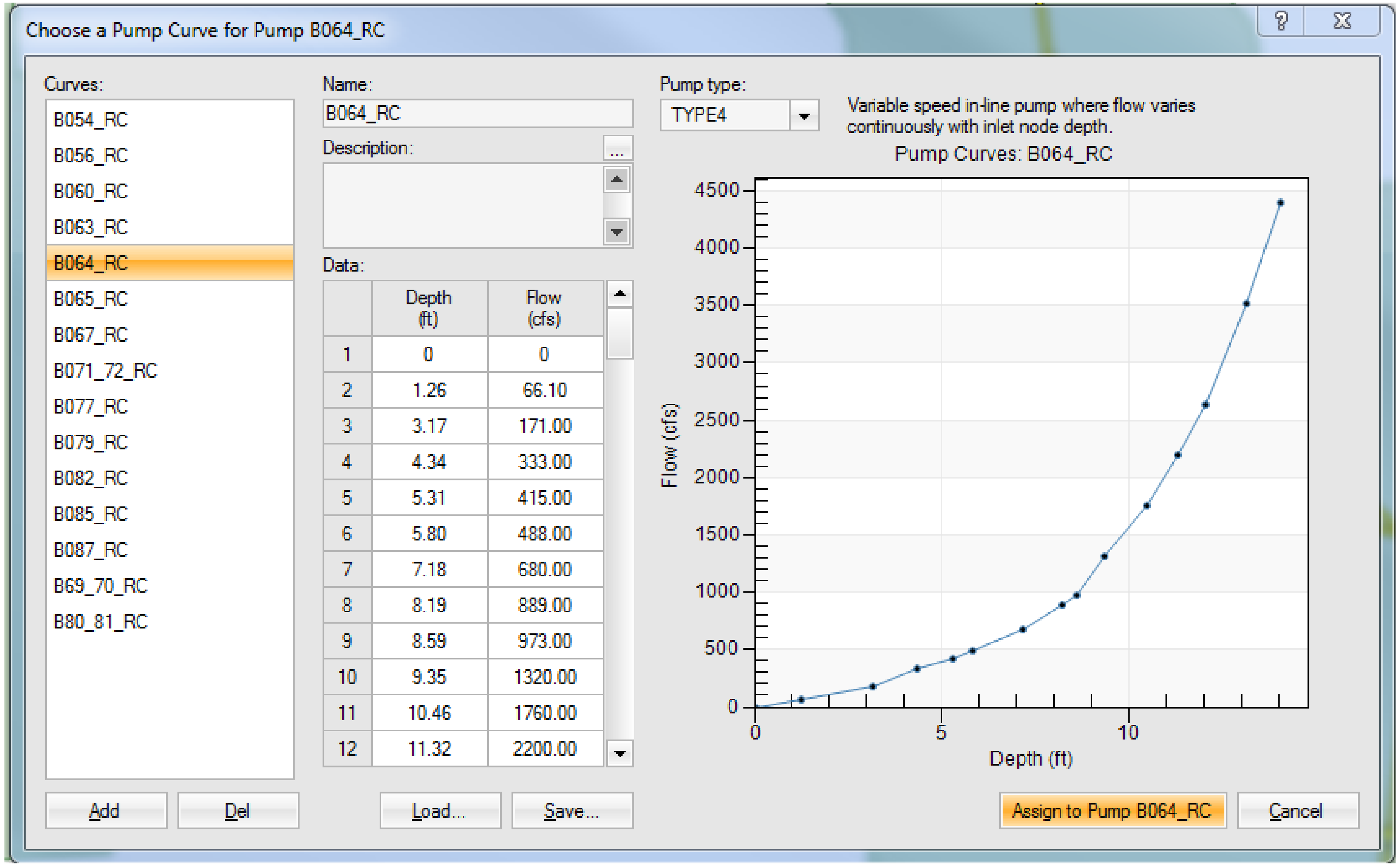


Main Rouge – Design Storm Boundary Condition Model Representation

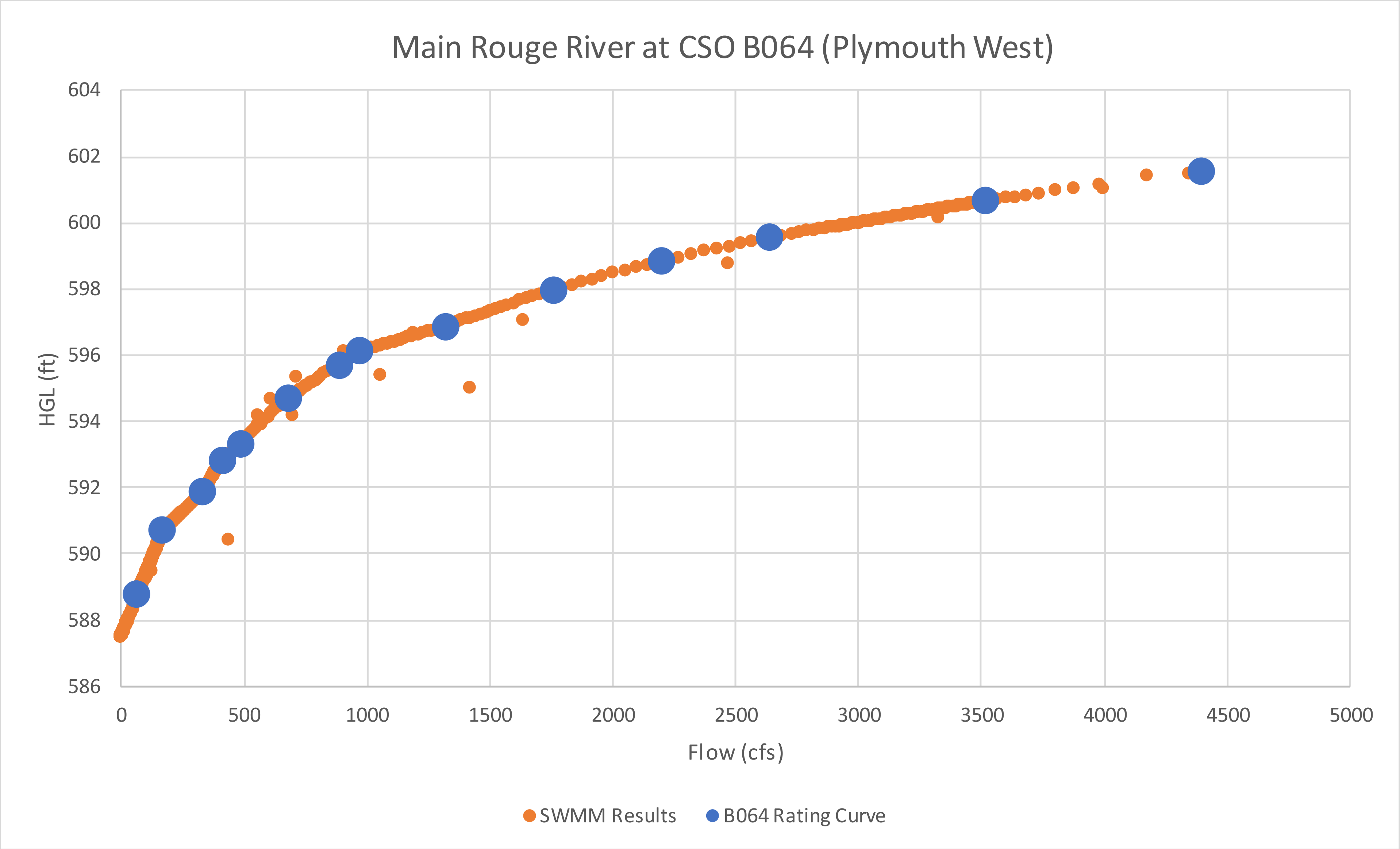
1. Goal – Under design storm conditions, precise Main Rouge River levels are required for any given flow rate at each CSO point of inflow to the river.
2. Options Considered:
    a. Calibrate Main Rouge River hydraulics
    b. Utilize Main Rouge River head discharge rating curves developed for this project.
3. Selected Option – Incorporate Main Rouge River rating curves into model.

Main Rouge – Design Storm Boundary Condition Model Representation

- River rating curves for the Main Rouge were represented in the WSM using Type 4 pumps
- Model outlet elements were considered and rejected due to dependence on US and DS HGL's



Comparison of Model and Rating Curve Head Discharge Results



Main Rouge River Model Profile

- Type 4 Pump locations show slight increase of HGL in the DS direction