



# ALCOSAN's Water Quality Modeling Approach

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# GIS Fundamentals for Efficient Infrastructure Management

Introduction to Geographic  
Information Systems (GIS)

Sam Shamsi, PhD, PE, GISP

# Presenter

- B.Sc. Civil Engineering, AMU, India, 1982
- M.Sc. Water Resources Engineering, AIT, Thailand, 1984
- Ph.D. Civil Engineering, University of Pittsburgh, USA, 1988
- Private sector to government sector (2018)
- Over 100 papers + 4 books
  - 👉 **2023 book: Search GIS Shamsi on Amazon**
- Licensed Professional Engineer: OH, PA, WV, GA
- Interests: golf, fishing, kites, cricket, GIS, modeling
- **26th** paper in this conference

# Outline

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Introduction

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Water quality problem

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Water quality solution

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Water quality modeling

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Results

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Conclusions

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# Allegheny County Sanitary Authority (ALCOSAN)

- Operating since 1959
- Provides wastewater treatment to 83 municipalities in Allegheny County, including the City of Pittsburgh.
- 90 mi interceptor
- 318 overflows (270 CSO)
- 310 SM service area, 20% combined
- 800K customers
- Funded completely by ratepayers.

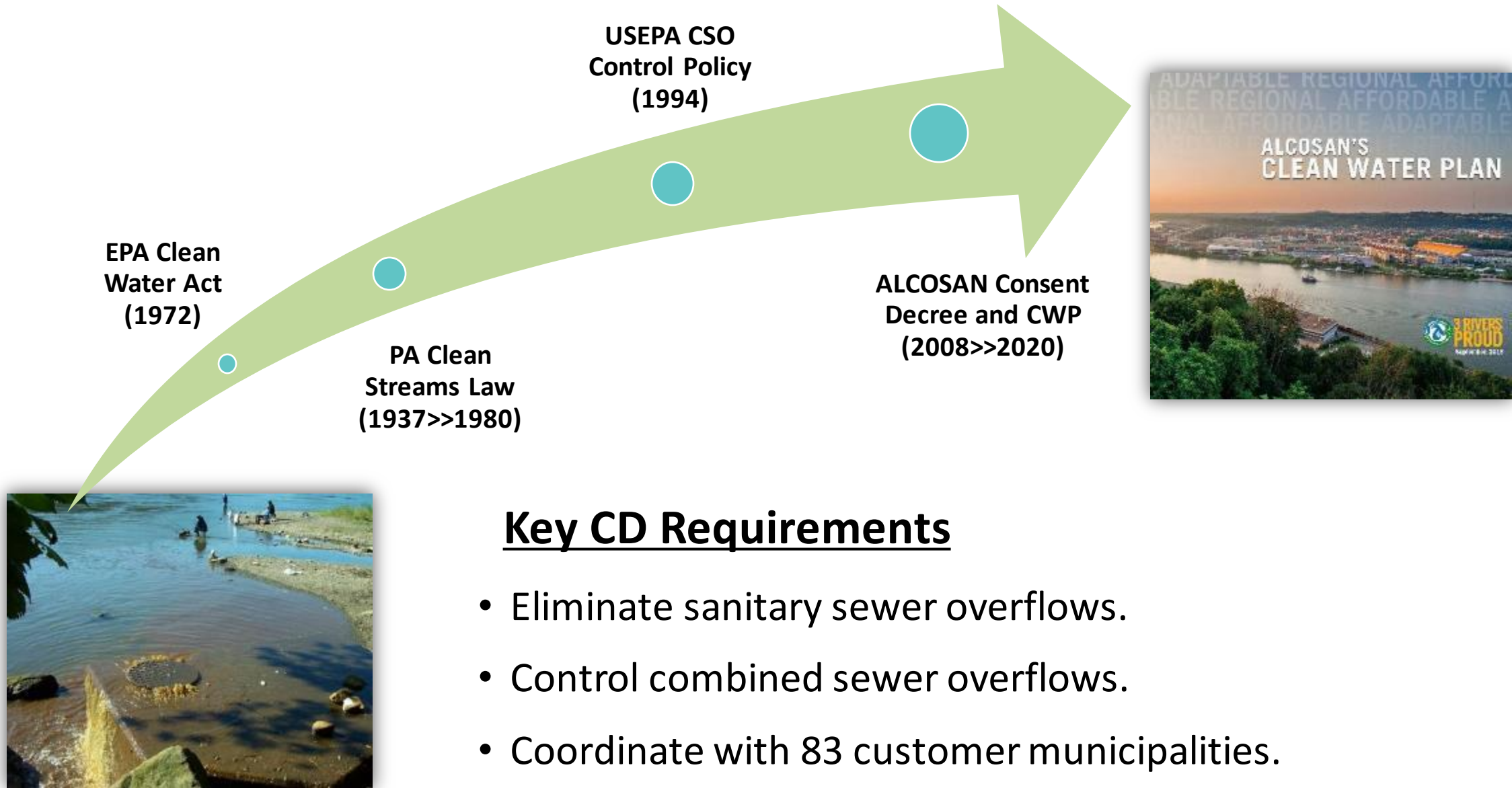


# The Water Quality Problem...

- Pittsburgh's 3 Rivers and tributary streams do not always meet water quality standards for recreational use.
- During rainstorms or snow melts, stormwater overwhelms the system and diluted, untreated wastewater spills into rivers and streams.
- ALCOSAN and its 83 customer municipalities have regulatory mandates to address wet weather overflows.



# What Are ALCOSAN's Regulatory Obligations?



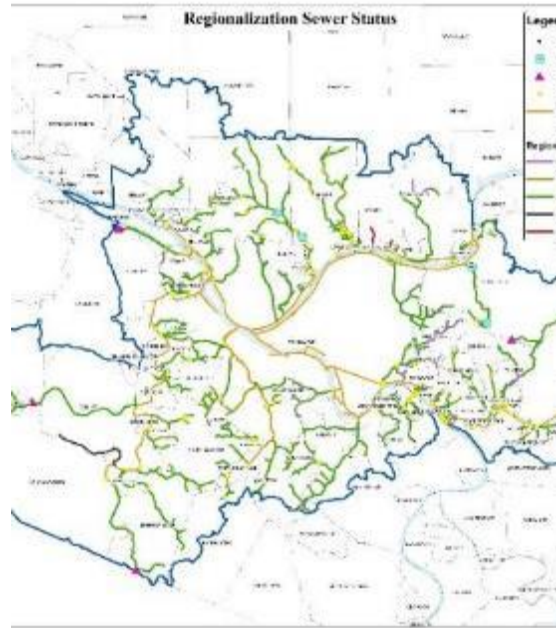
# *A model-based solution to a model-based Consent Decree!*

Clean Water Plan (CWP)  
Includes 4 components

Plant Expansion



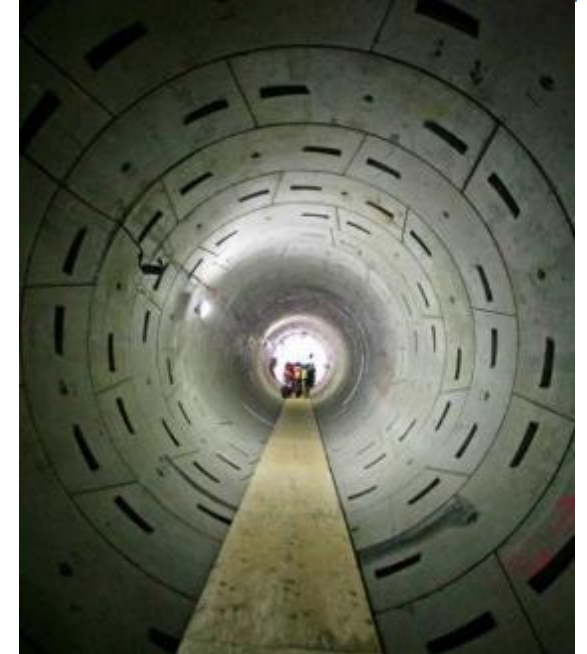
Regionalization



GROW/Source Control

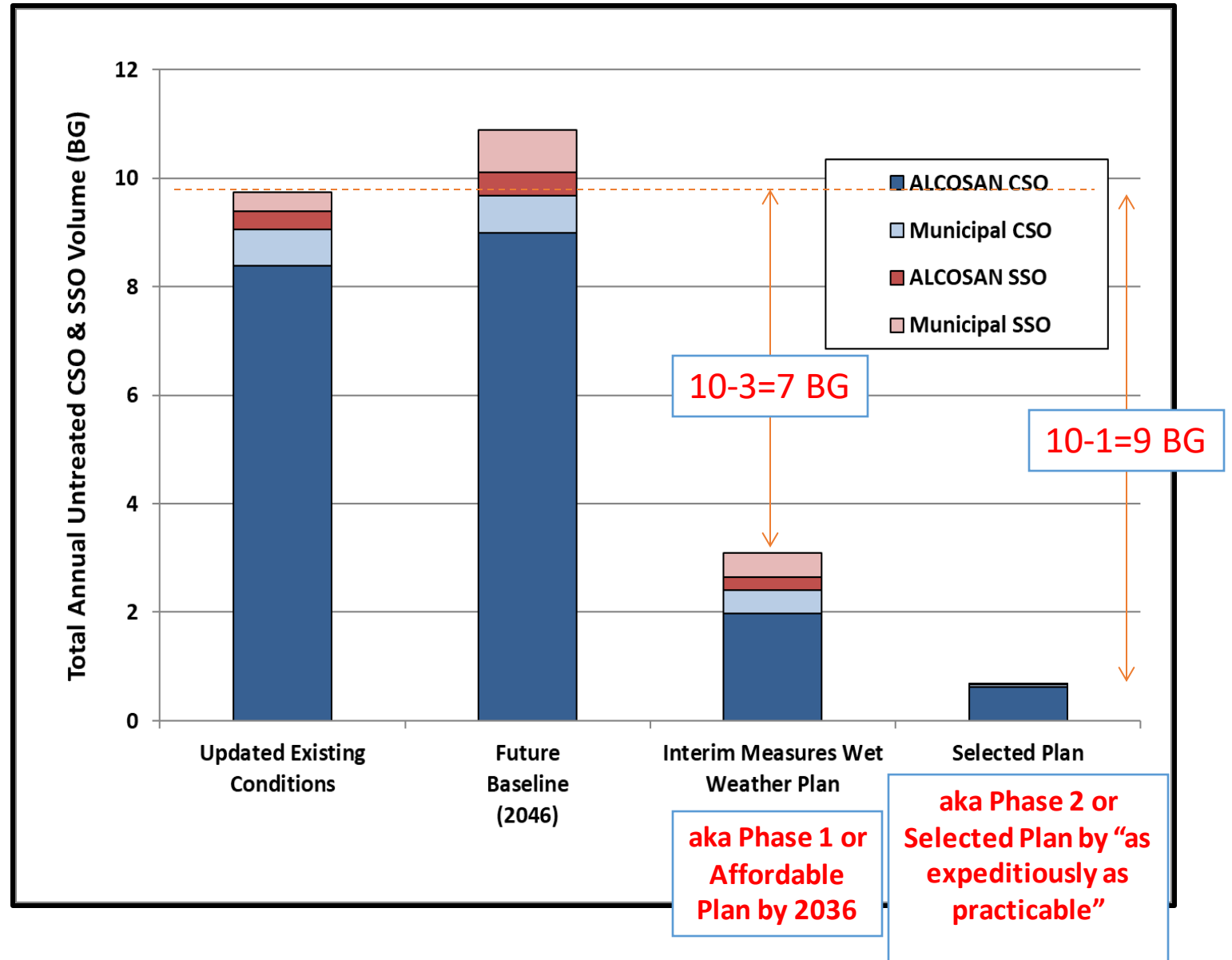


Regional Tunnel System

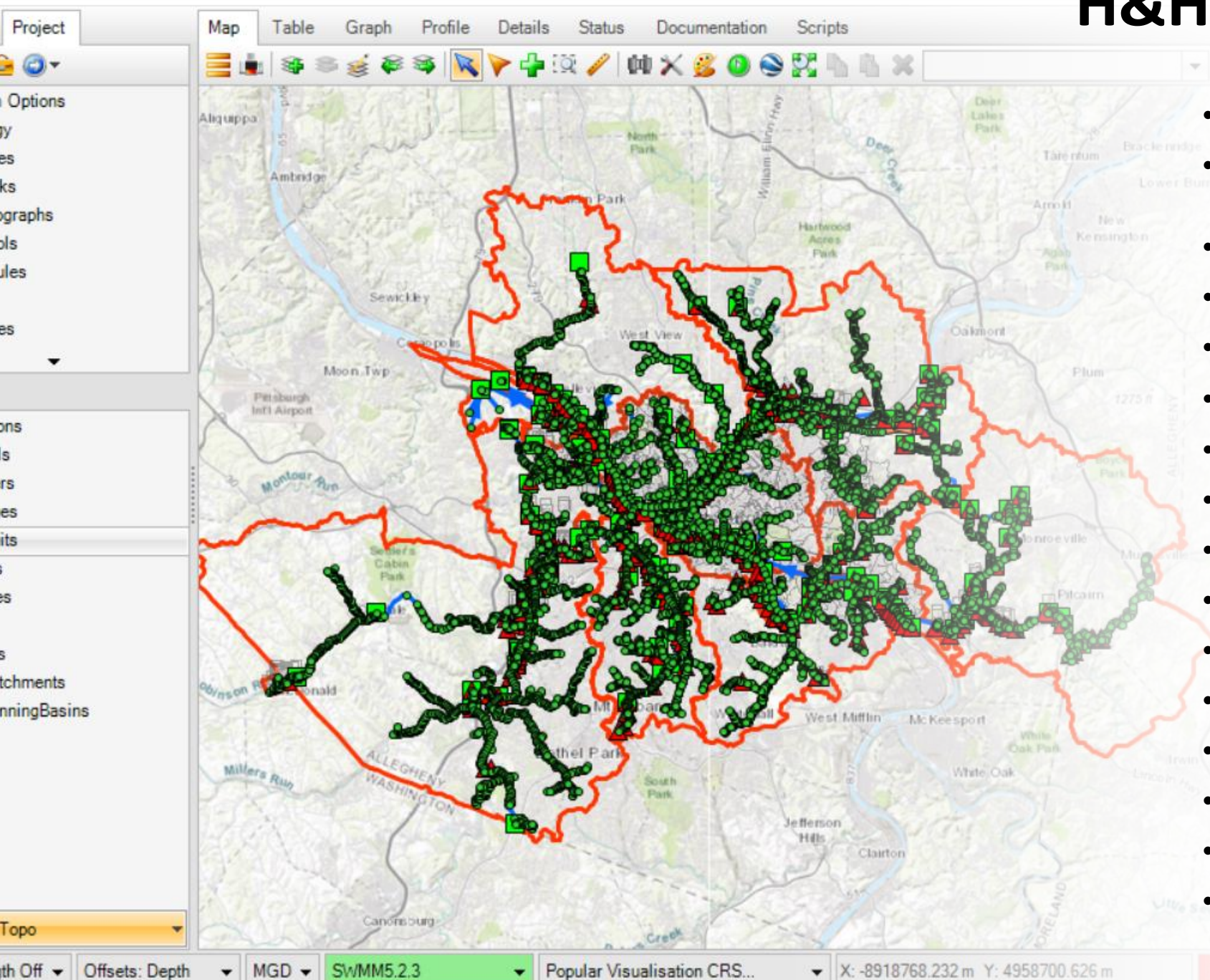


# Clean Water Plan Water Quality Benefits

- Overflows will be reduced by ~7 billion gallons per year by 2036.
- Additional projects will be scheduled as expeditious as practicable until compliant with regulatory requirements to not preclude attainment with water quality standards.
- Water quality monitoring and modeling are used to measure improvement and **demonstrate compliance.**



# H&H Modeling (PSWMM)



- 2023 SP Model
- One systemwide model for 7 planning basins
- **Nodes: 11,084**
- Conduits: 11,631
- Subcatchments: 3,842
- Storage nodes: 631
- Outfall nodes: 434
- Raingages: 106
- RDII inflows: 1,426
- Pump curves: 107
- Pump links: 66
- Orifice links: 675
- Weir links: 632
- Control rules: 252
- Time series: 173
- Run time: 35 hr (2019) >> **15 hr (2023)**



## Water Quality Modeling (EFDC)

- USEPA's Environmental Fluid Dynamics Code (EFDC)
- 280 miles of streams and rivers
  - 3 main rivers
  - 13 tributaries
- Simulate:
  - High and low flow hydraulics
  - Sources of bacteria load
  - Transport
  - Decay (1<sup>st</sup> order with temperature)
- Fecal coliform and *E. coli*
- Assess water quality improvements from removal of SSO/CSO bacteria load

# WQ Modeling Software Comparison

Modeling Platform	Model Platform Developer/ Maintainer	No. of Dimensions	Hydrodynamics	Watershed Runoff	First order decay	Mixing downstream of CSO	Sediment diagenesis	Eutrophication Model	Bacteria resuspension from sediment	Application examples
RMA2/RMA4	Army Corp (public domain)	2D	Yes	No	Yes	Yes	No	No	No	ALCOSAN Main Rivers Massachusetts Estuaries Project (nitrogen)
EFDC (Environmental Fluid Dynamics Code)	USEPA (public domain, open source)	3D	Yes	No	Yes	Yes	Yes	Yes	Yes*	Philadelphia Water *CDM Smith customization
RMA10/RMA11	Resource Modeling Associates/Ian King	3D	Yes	No	Yes	Yes	Yes	Yes	No	San Francisco Bay, Galveston Bay, Sydney Australia
DELFT3D	Deltares (commercial and open source versions)	3D	Yes	No	Yes	Yes	Yes	Yes	No	Kensico Reservoir (NYCDEP)
MIKE 3	DHI	3D	Yes	No	Yes	Yes	No	Yes	No	
AEM3D	Hydronumerics	3D	Yes	No	Yes	Yes	No	Yes	No	
HSPF	USGS (public domain)	1D	Yes	Yes	Yes	No	No	Yes	No	Code used by PWSA for SMR integrated planning
SWMM	USEPA (public domain)	1D	Yes	Yes	Yes	No	No	No	No	ALCOSAN Tributaries

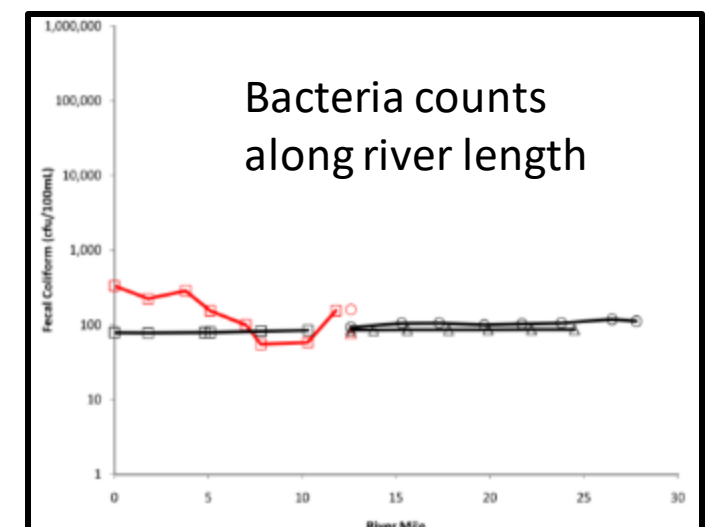
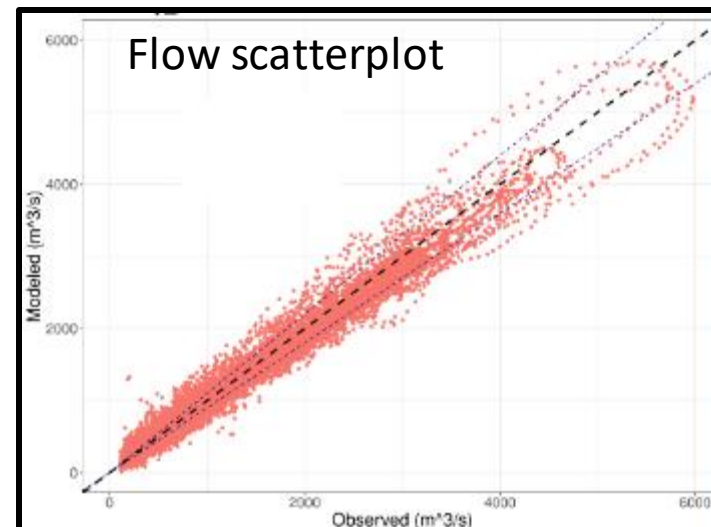
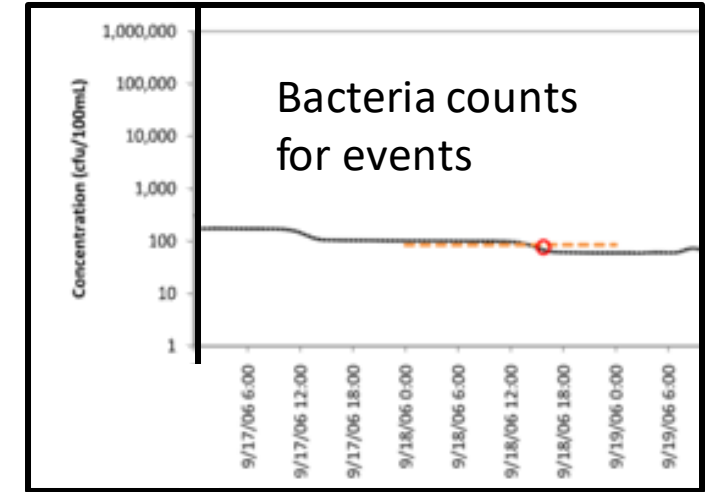
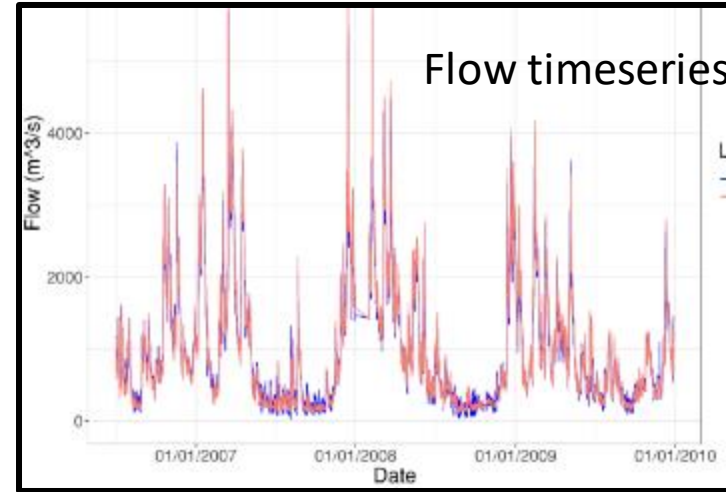
# History of Water Quality Modeling

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- 2006 to 2009 – Water quality data collected for model calibration
- 2010 – Receiving water quality model developed in SWMM and RMA2/RMA4
  - Separate models for each river and stream
- 2023 – Upgrades including migrating main rivers model to **EFDC**, and calibration to E. coli
  - Systemwide model
- 2024-28 – Interim WQ sampling
- 20337-38: Post-construction WQ sampling

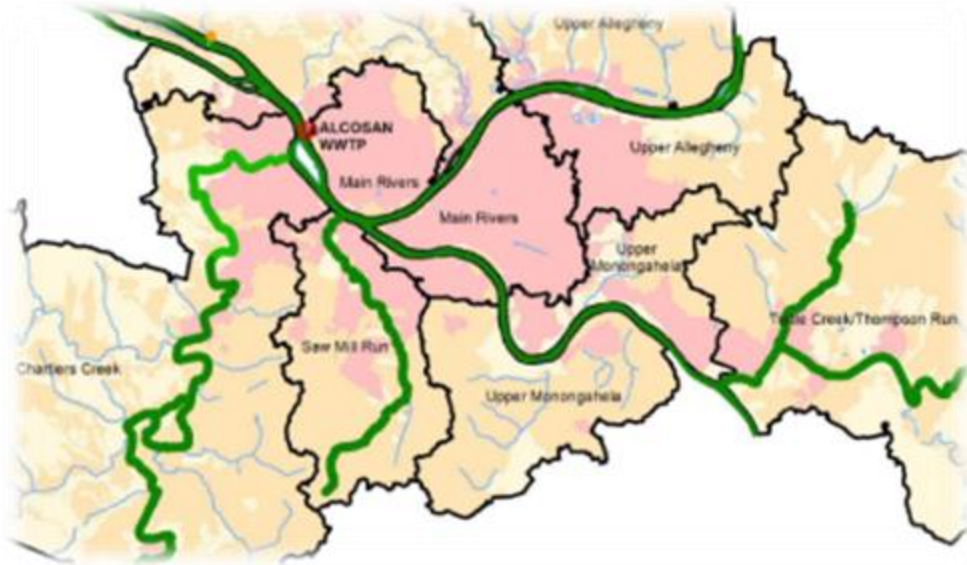
# Model Validation Approach

- Validate for:
  - Hydrodynamics (flow, velocity, depth)
  - Temperature and water quality
- Validate using:
  - Timeseries - continuous and event based
  - Scatterplots
  - Comparison to target criteria by water body

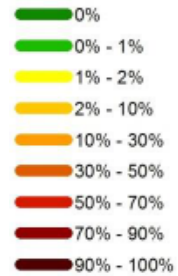


# Modeled Fecal Coliform Before and After Interim Plan

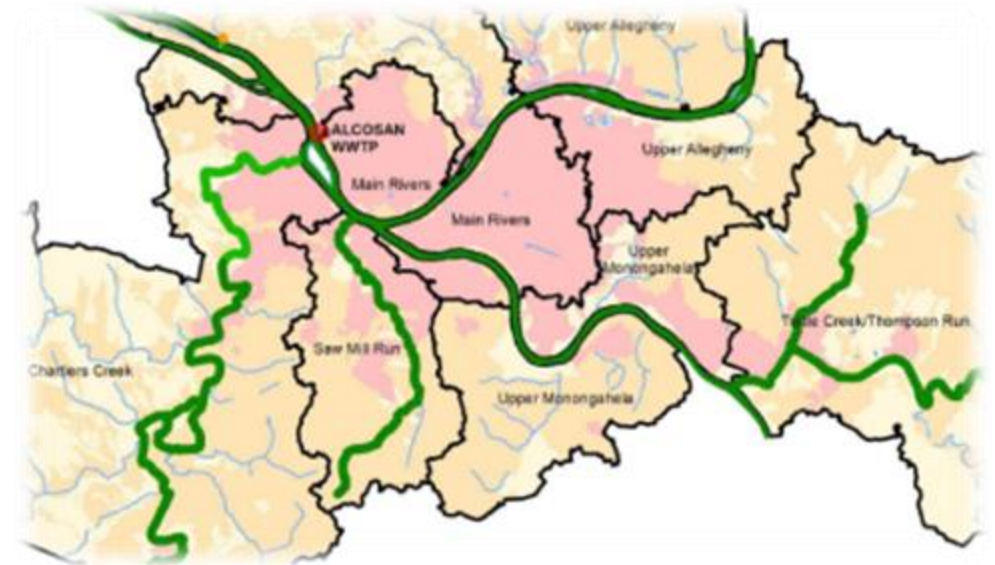
Non-Recreation Season (Oct 1 – April 30)



BEFORE



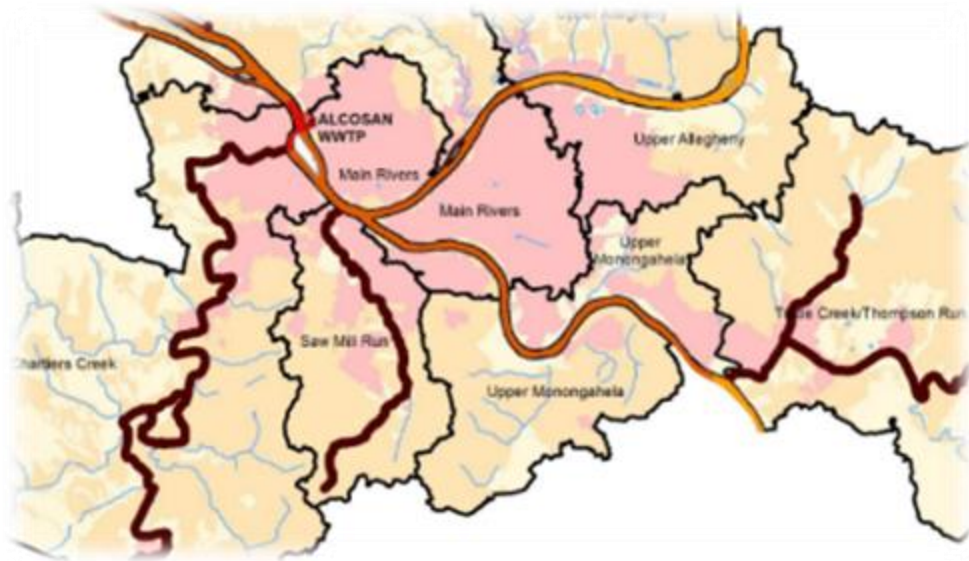
% probability  
of not  
meeting WQS



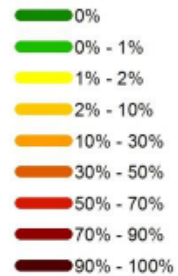
AFTER  
(2036, Interim Plan)

# Modeled Fecal Coliform Before and After Interim Plan

Recreation Season (May 1 – Sep 30)



BEFORE



% probability  
of not  
meeting WQS



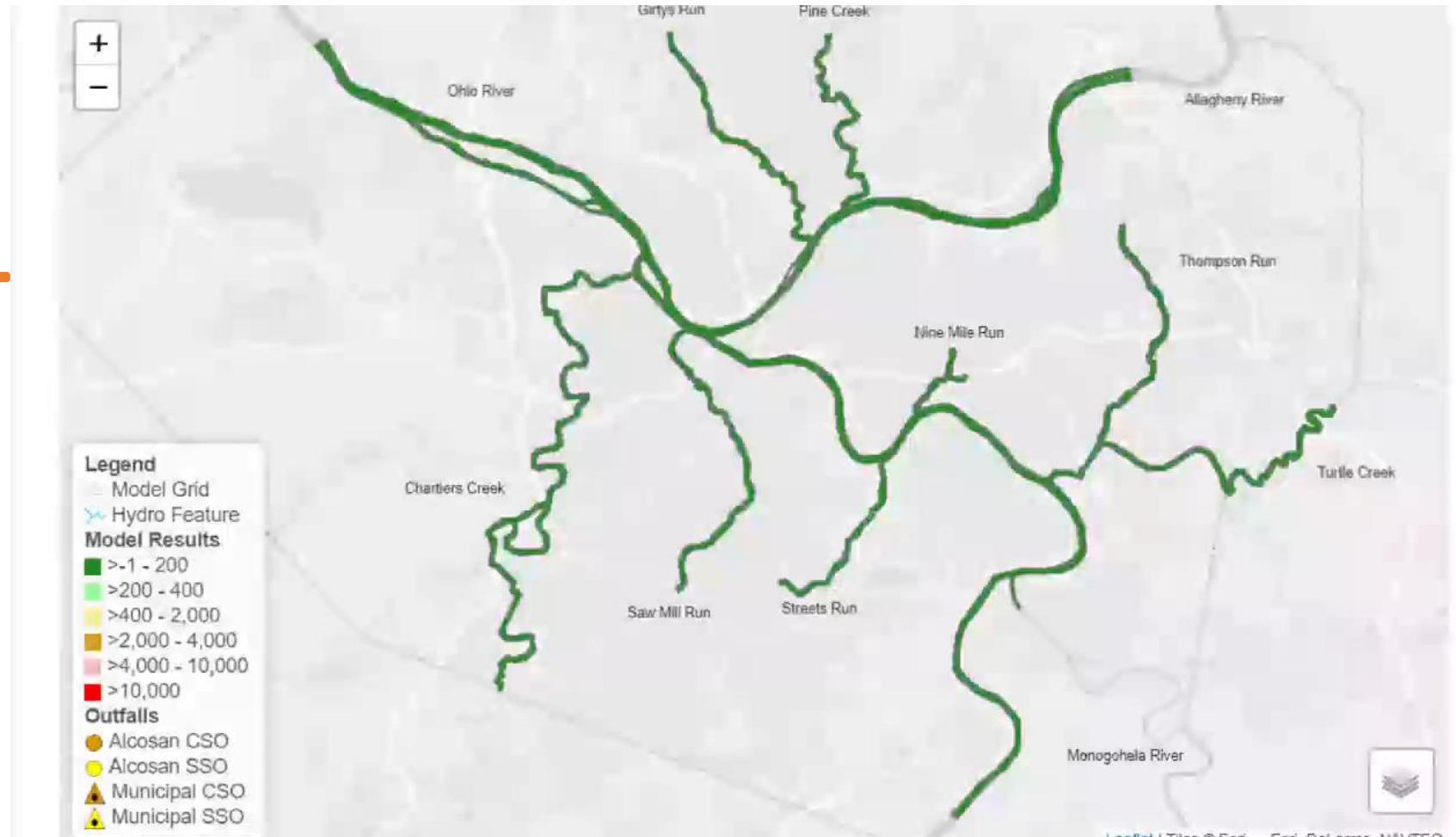
AFTER

- In rec season, WQ models forecast substantial improvement in main rivers after Interim Plan.
- In rec season, ALCOSAN does not meet the fecal WQ standards in 3 tributaries (CC, GR, TC).
- Additional CSO and SSO controls will still be needed after 2036 >> Phase 2 (Selected Plan)
- Demonstration approach / adaptive management

# Sample WQ Modeling Results (DRAFT)

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- Fecal bacteria during a typical year storm (IWWP)
- 4-day January simulation
- 1.25" in 19 hours followed by 0.26" in 38 hours.
- 1 wet day (1.25"/19-hr)  
>> 1.5 drizzly days (0.26"/38-hr)  
>> 1.5 dry days.





**3 RIVERS  
PROUD**



# Conclusions

- CWP projects will improve WQ and provide enhanced recreational use experiences for Pittsburgh residents and visitors.
- WQ monitoring and modeling are the primary tools for demonstrating attainment with WQ standards and compliance with ALCOSAN's Consent Decree.
- ALCOSAN continues to advance its WQ monitoring and modeling in coordination with its customer municipalities.

Thank You!

Cannot wait to answer your questions after the session!

Thanks

Gracias

Merci



धन्यवाद



شكراً

ขอบคุณ

Dikey



Teşekkürler



תודה

Vielen Dank

Bedankt