SSO 700 Integrated Watershed Action Plan: Development of an Integrated Water Quality Modeling Framework

OWEA
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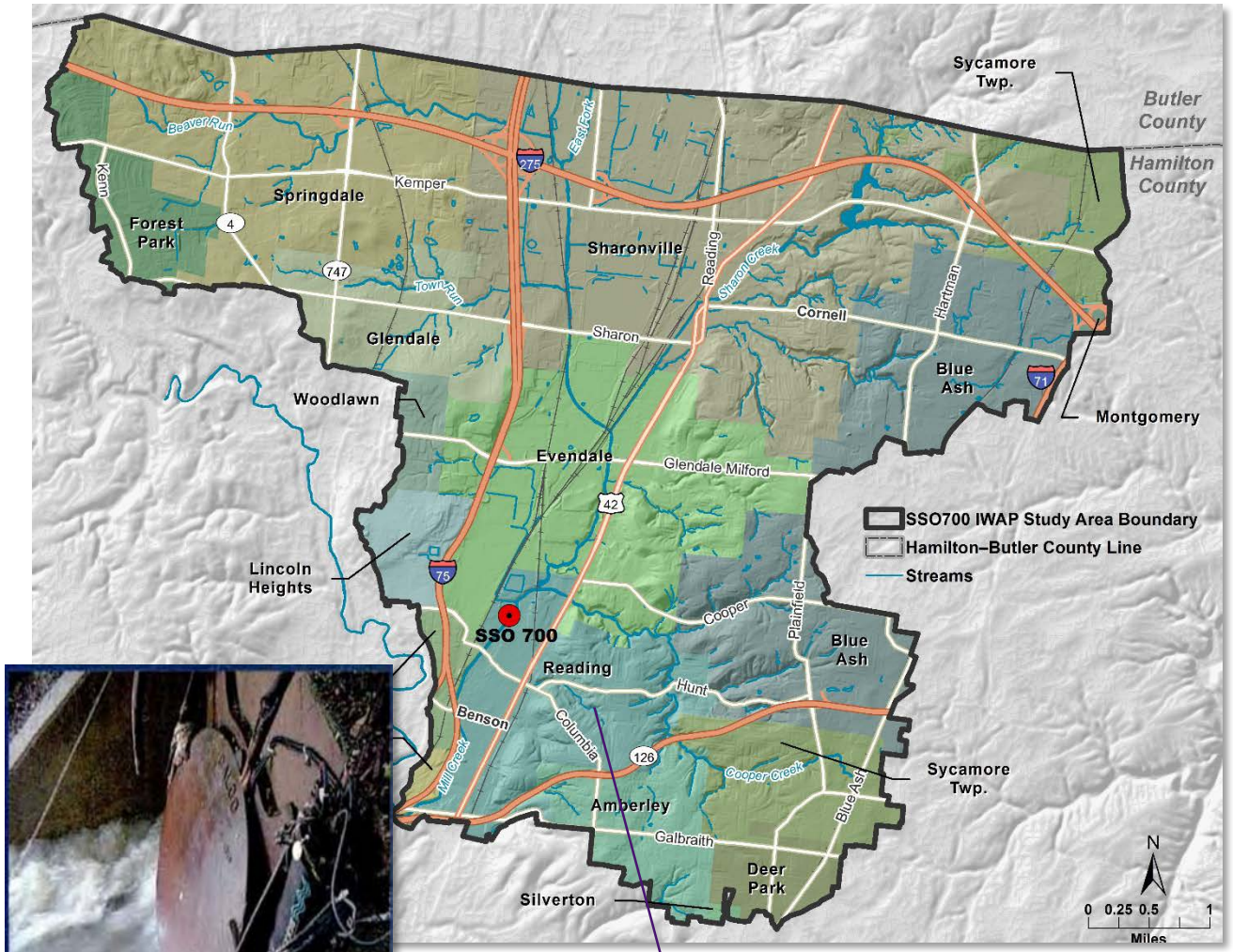
Agenda

- Project Overview
- Approach to Model Framework Development
- Water Quality Background
- Components of Integrated Model Framework
- Data to Support Model Calibration and Validation
- Project Status

Project Overview

Problem

- SSO 700 is the largest SSO in MSDGC's service area (approx. 38 MG of overflow annually to Mill Creek)
- MSDGC's Consent Decree requires elimination of overflow.
- 2012 SSO 700 FRP identified Gray Solution – costly to ratepayers with no upstream benefits



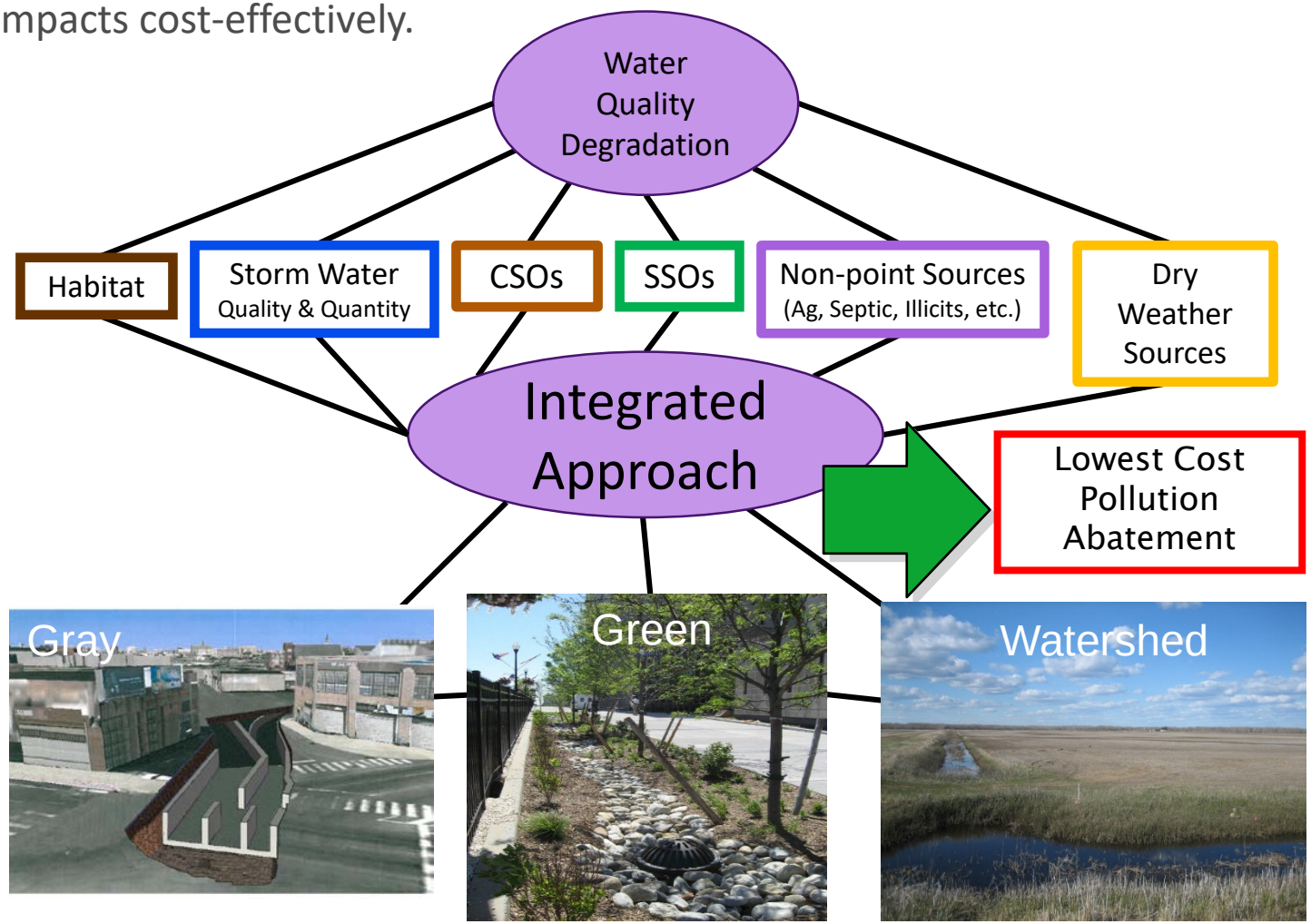
SSO 700 Sewershed = 35 Sq Miles; 16 Political Jurisdictions

Goal

- Develop solution that will cost less and do more.

Taking an integrated approach

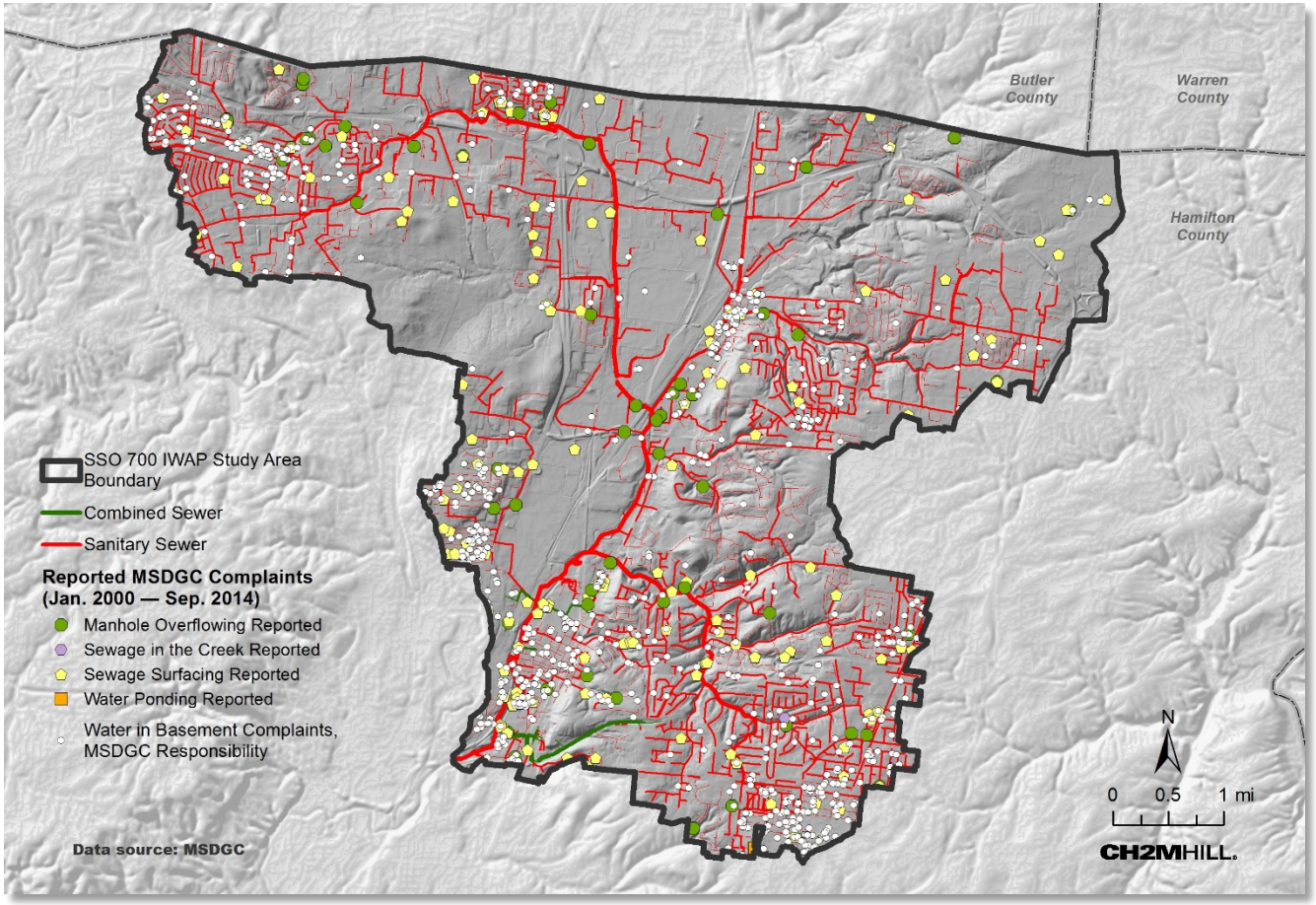
Address both volumetric control and water quality impacts cost-effectively.



Taking an integrated approach

Address other upstream wet weather issues and achieve other benefits.

- 9 CSOs and 11 SSOs, including SSO 700
- Sewer backup complaints
- Sewage surfacing or manholes overflowing
- Water ponding in streets
- Flooding along Mill Creek
- Opportunities for aesthetic improvements and economic development



Project Goal

An Integrated Watershed Action Plan to meet MSDGC's Consent Decree obligations through an optimized and affordable suite of gray, green, and watershed controls. The plan will also:

- Maximize improvement to in-stream water quality,
- Obtain regulatory approval,
- Advance the economic development and quality of life for local watershed jurisdictions.

Approach to Framework Development

Purpose of Modeling Framework

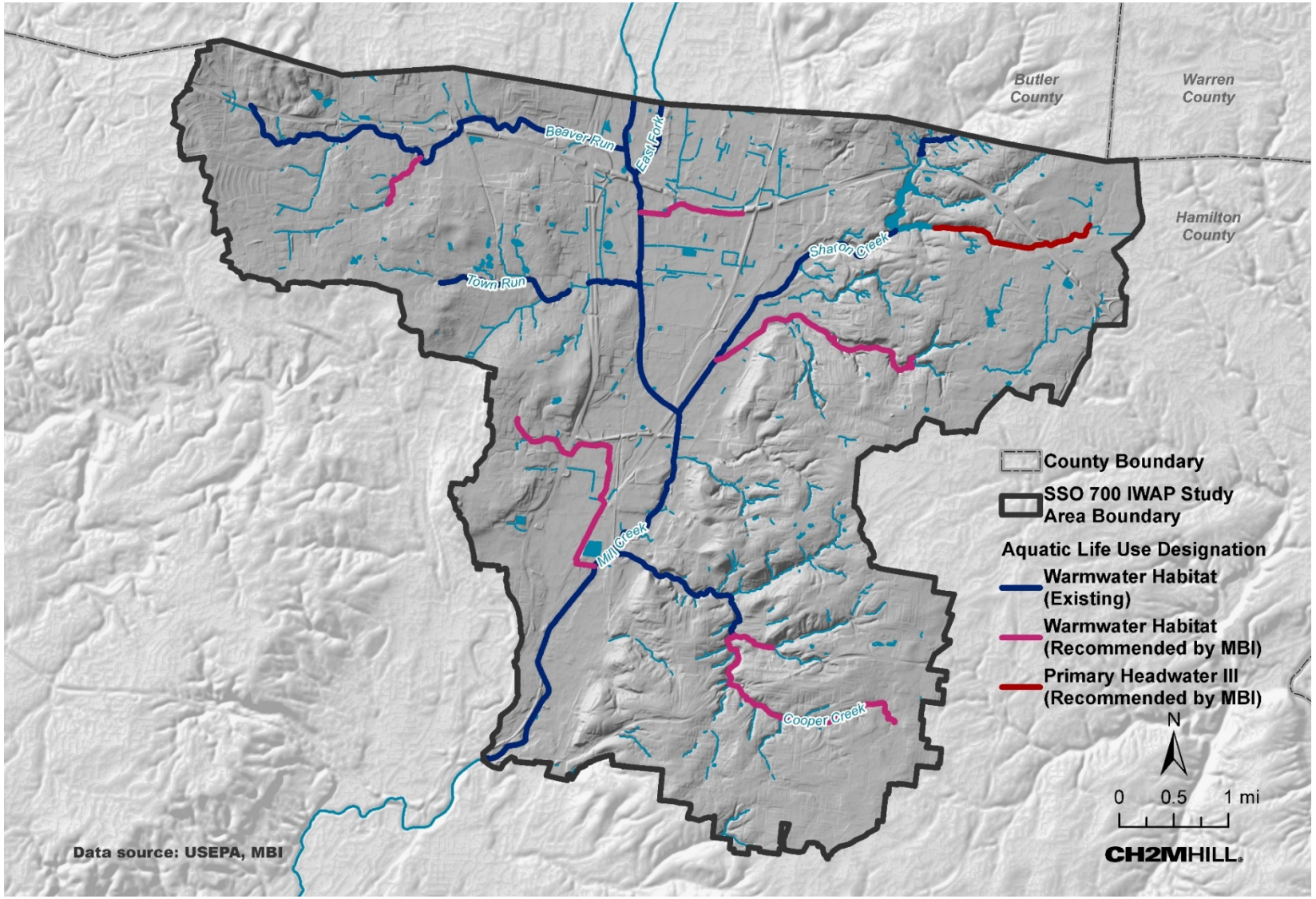
Project Goal	Mathematical Modeling System Needed to Achieve Project Goal	Modeling System Components
<u>Develop plan to:</u> Manage/control causes and sources of impairment. Improve instream water quality. Reduce or even eliminate impairments. Achieve regulatory buy-in.	<u>Models must be suitable to:</u> Characterize existing causes and sources of impairment Evaluate different control alternatives Quantify the improvements associated with the implementation of various infrastructure types.	<u>Modeling system must quantify on a temporal scale the following:</u> Flow volume and velocity generated from variety of sources Temperature WQ parameters representing causes of impairment

Approach to Development of Integrated Water Quality Model Framework

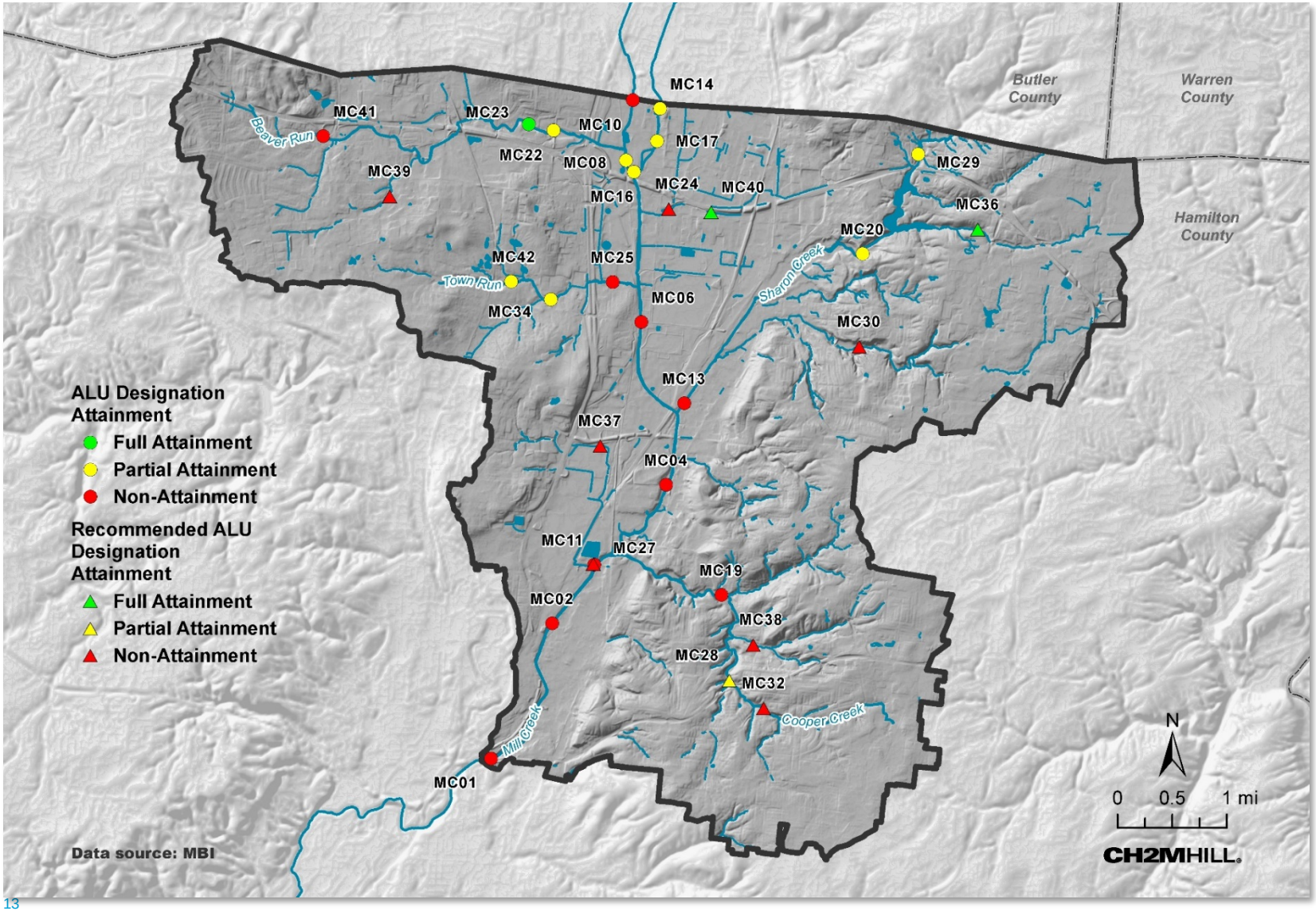
1. What do we know about water quality in the study area?
    - Review available water quality data and studies to identify known causes and sources of impairment.
2. What existing models are available to represent these causes and sources of impairment?
3. How well do these existing models fit the project needs?
    - Evaluate for their representation of the SSO 700 watershed
    - Evaluate for their applicability in supporting the development of IWAP
    - Evaluate for calibration and validation deficiencies
    - Identify data gaps and gaps in existing models.
4. Develop detailed water quality framework from combination of existing and new models to meet needs of IWAP.

Water Quality Background

Receiving Waters – Aquatic Life Designated Uses



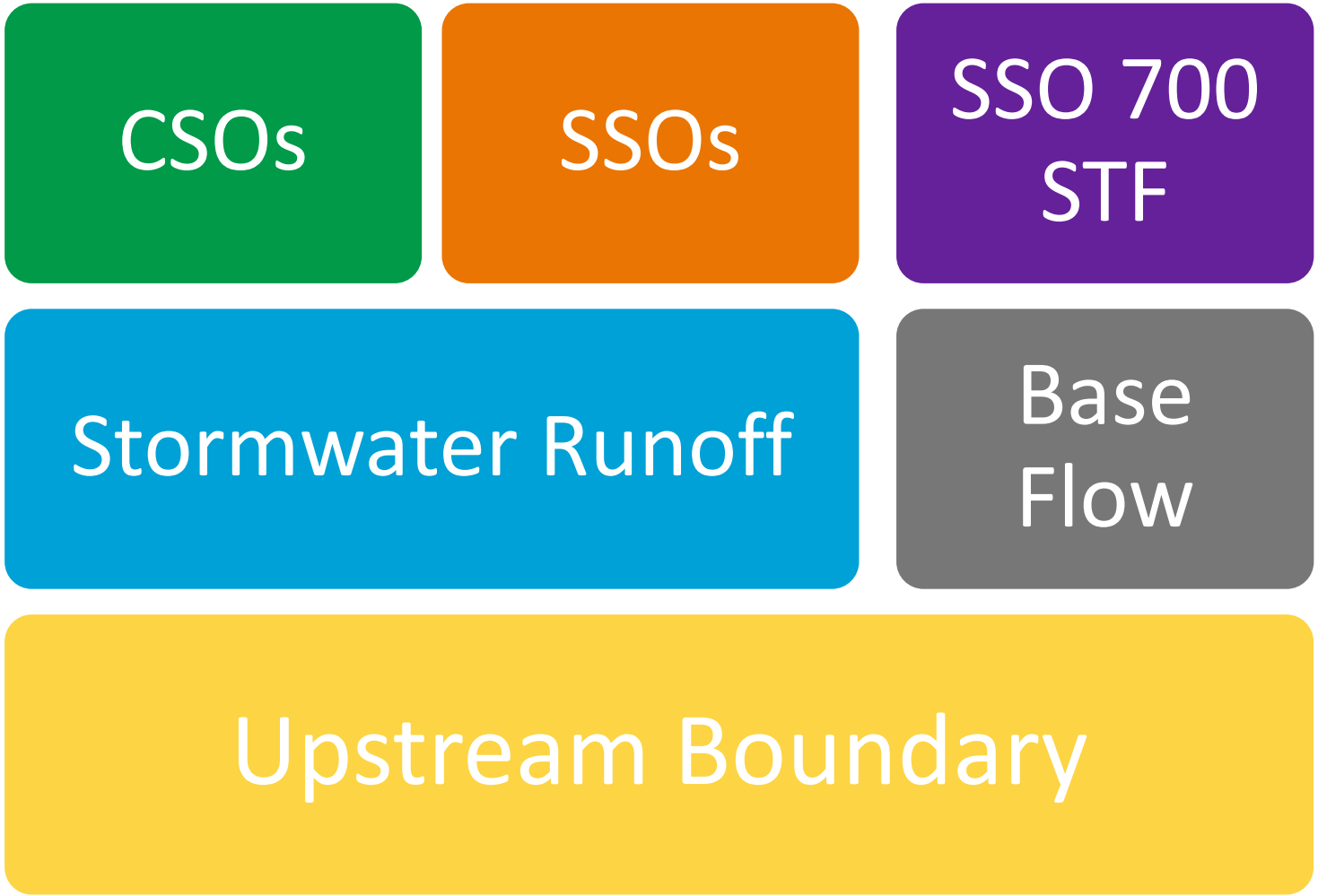
Receiving Water – Use Attainment



Causes of Impairment

Waterbody	Bacteria	Sedimentation	Chlorides	Flow	Habitat Alteration	Nutrients	Dissolved Oxygen
Mill Creek	x	x	x		x	x	
East Fork Mill Creek	x	x	x			x	x
Beaver Creek	x	x	x	x			
Sharon Creek	x	x				x	x
Town Run	x	x	x				
Cooper Creek	x	x				x	
Small tributaries	x	x	x		x	x	

Sources of Impairment



Components of Integrated Model Framework

Integrated Modeling Framework for SSO 700 IWAP

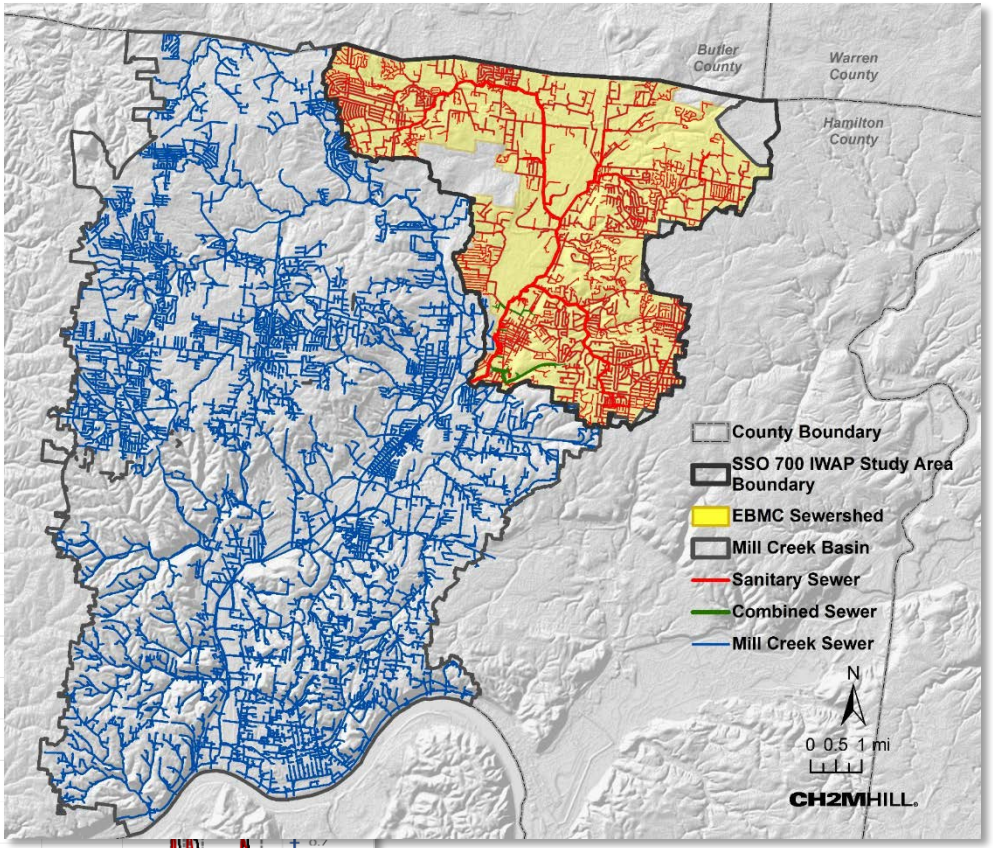
Watershed Models:
Calculate flows and loads from sources

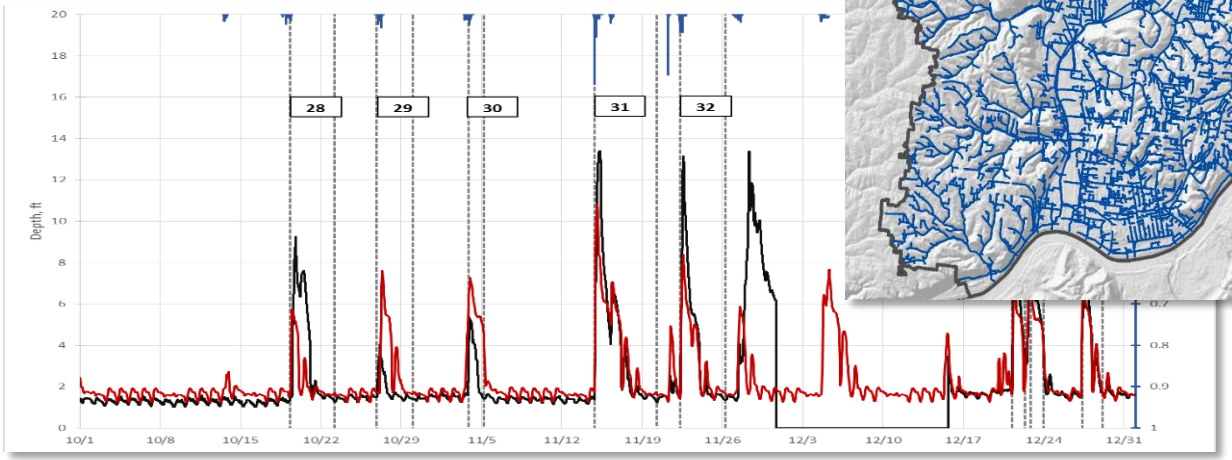
Surface Water Models:
Calculate hydrodynamics and water quality dynamics of receiving waters

Collection System Hydraulic Model

Collection System Hydraulic Model

- MSDGC maintains system wide model using EPA SWMM.
- Calculates CSO, SSO, and other wet weather discharges from the collection system.
- Model must be calibrated and validated to MSDGC's current modeling standards.
- Calculates flow only. Event mean concentrations applied to flows to estimate pollutant loads.





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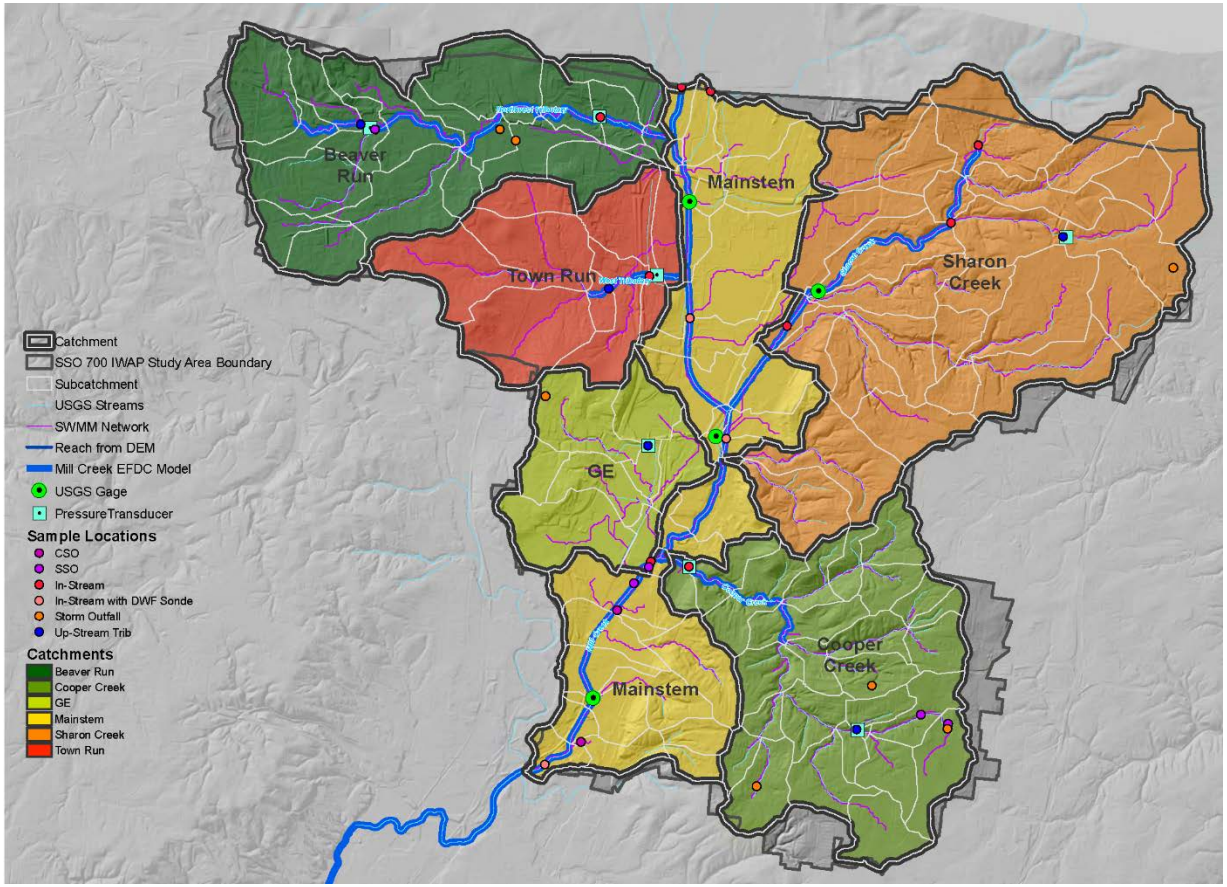
Collection System Hydraulic Model

Watershed Runoff Model

Watershed Runoff Model

- No existing model
- New model built using EPA SWMM
- Calculates stormwater runoff
- Event mean concentrations are applied to land uses to calculate pollutant loadings from stormwater
- EMCs are defined as the total constituent mass discharge divided by the total runoff volume



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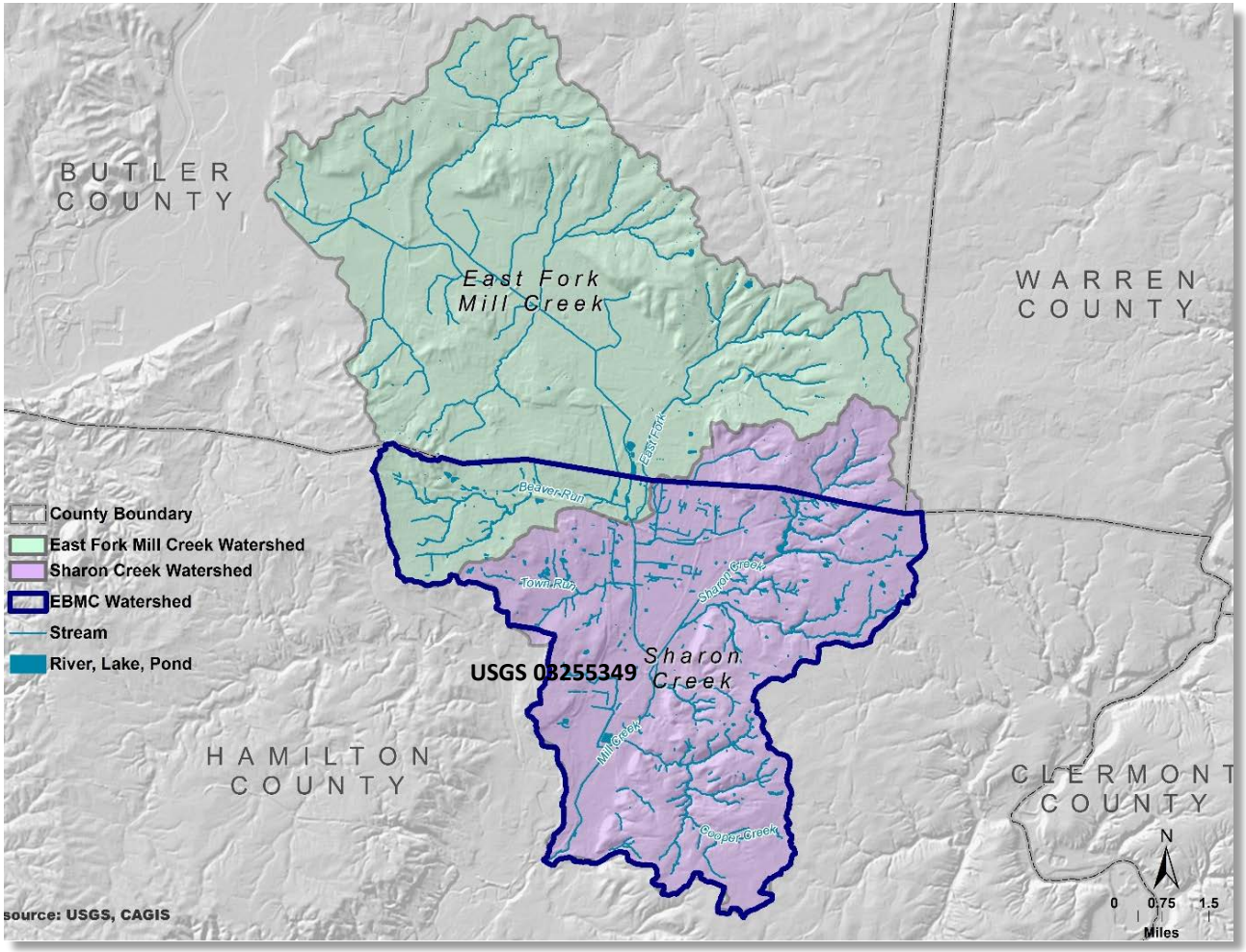
Watershed Runoff Model

Upstream Boundary Calculations

Upstream Boundary Calculations

- Flow enters SSO 700 IWAP project area from Butler County at Mill Creek and East Fork Mill Creek, and through three smaller tributaries.
- Upstream flow not included in the watershed runoff model.
- Quantified boundary flows based on flow scaled from the USGS gage at East Sharon Road (USGS 03255349)
- Event mean concentrations are applied to estimate water quality loads



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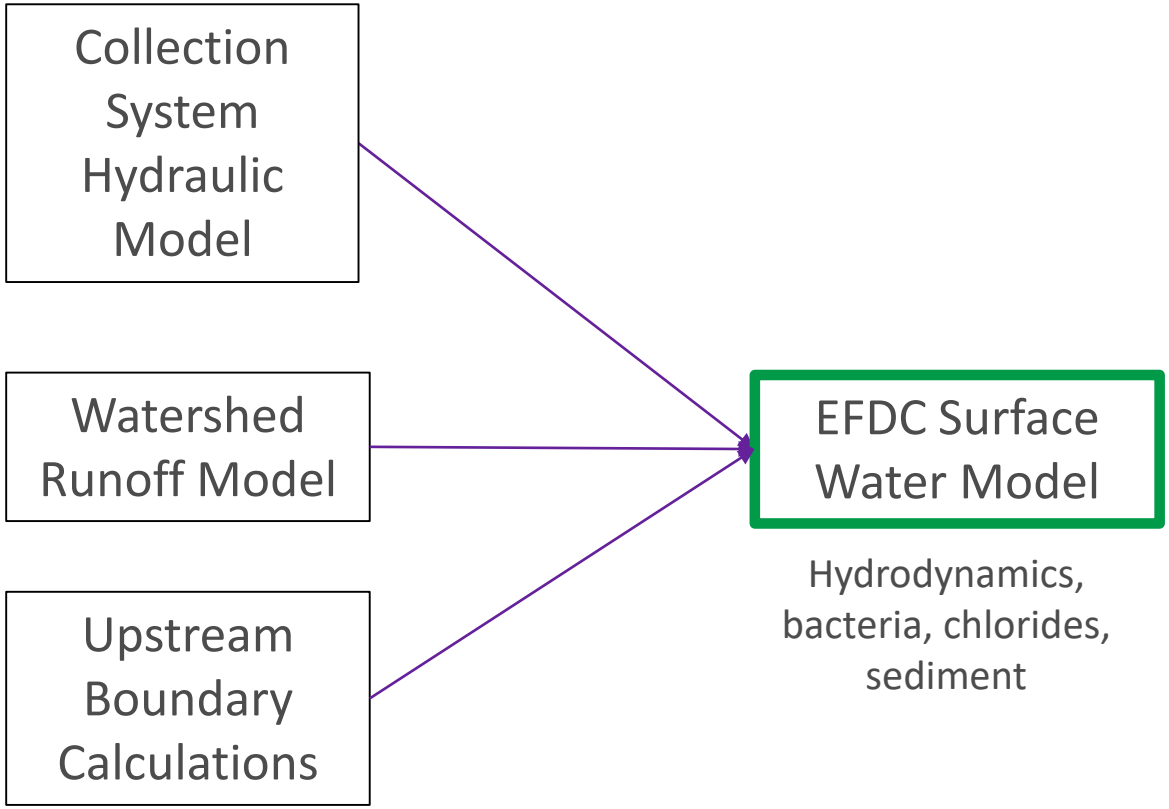
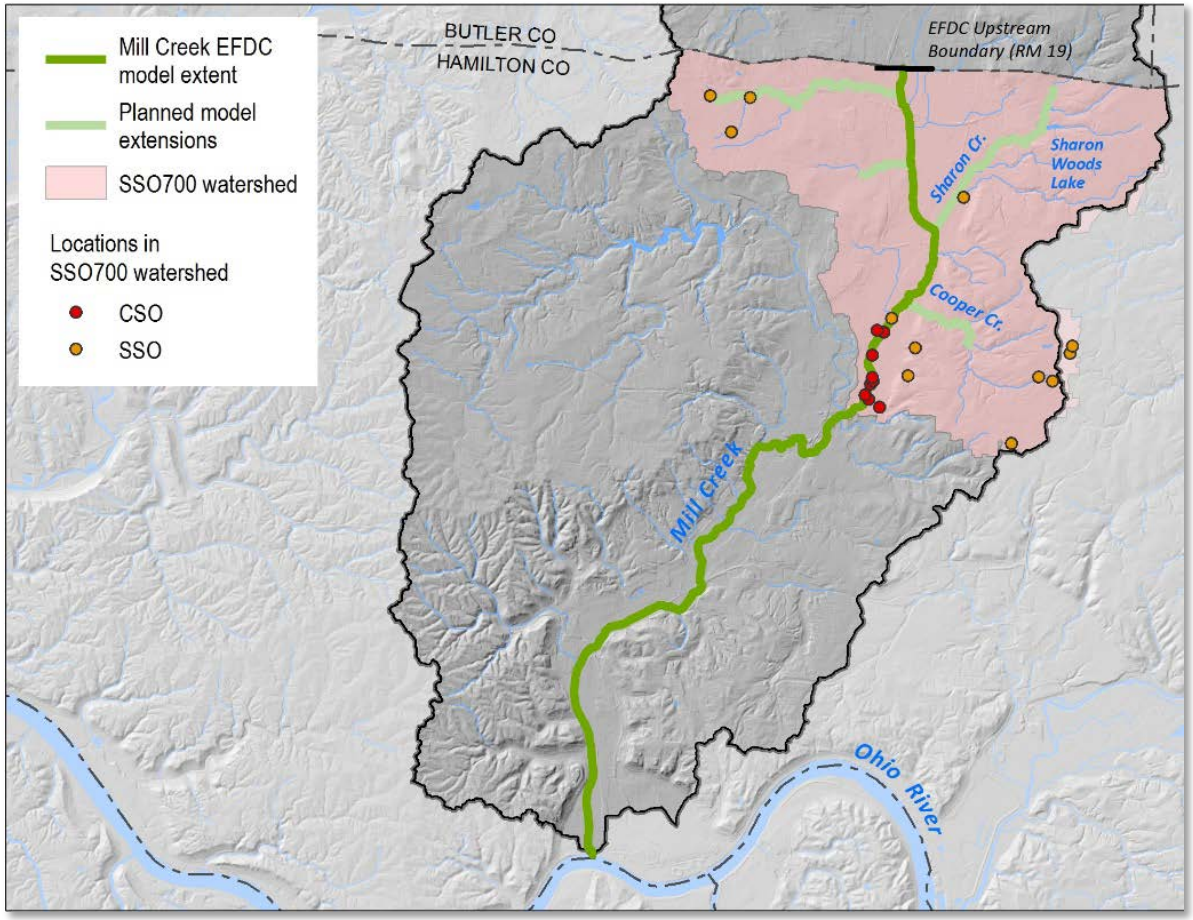


EFDC Model

Environmental Fluid Dynamics Code (EFDC) surface water model was developed in 2012 as part of a regional Ohio River Water Quality Model project.

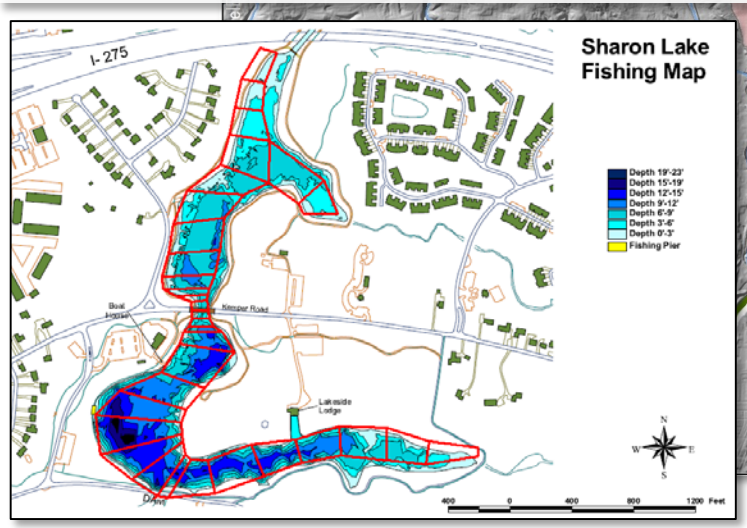
Current model simulates creek flows and E. coli levels in the main stem of the Mill Creek from the Butler County Line to the Ohio River.



EFDC Model Grid Extension and Update

EFDC Improvements for IWAP study area:

- Extend EFDC into the main stems of primary tributaries
- Re-calibrate EFDC to calculate:
  - Bacteria
  - Sediment transport
  - Chlorides and metals



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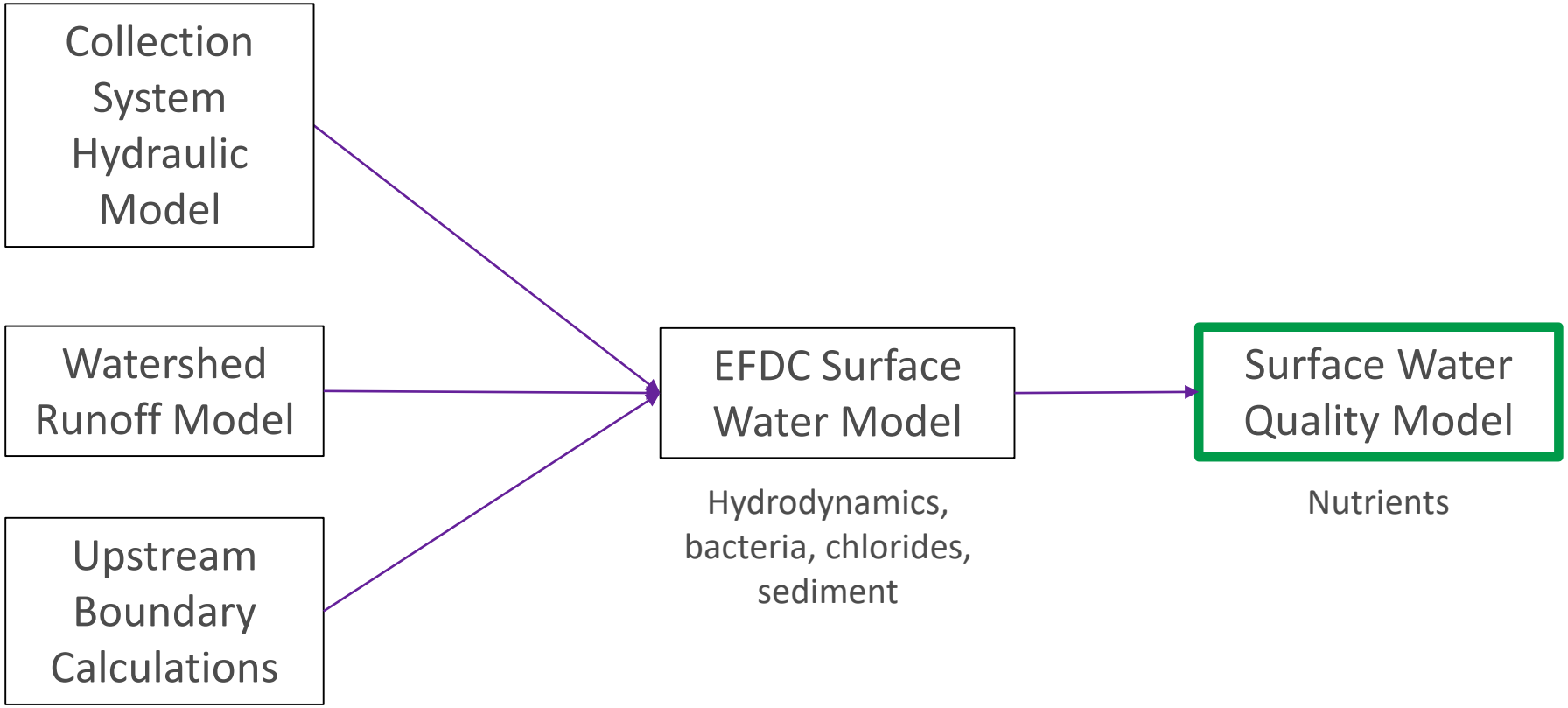
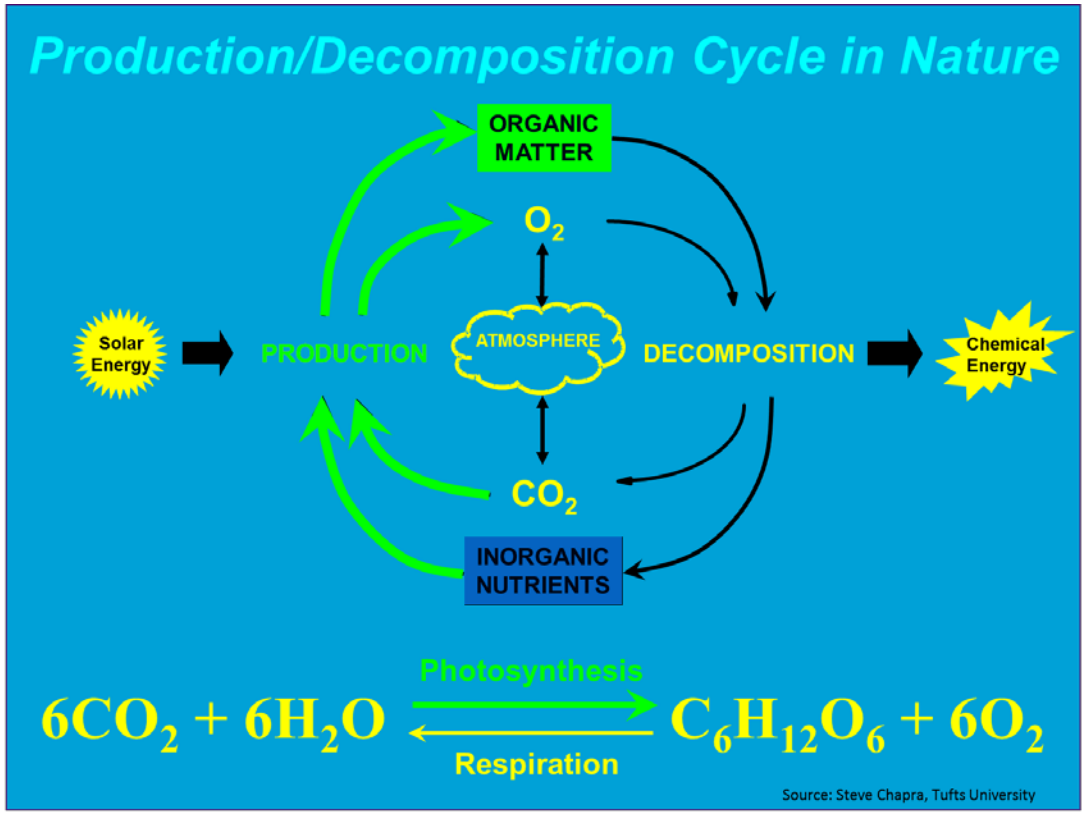


Surface Water Quality Model: Eutrophication/Dissolved Oxygen

- Eutrophication: Excess production of algae and aquatic plants
- Results in large swings in dissolved oxygen (DO)
  - Some DO conditions could have a negative effect on the fish community
- High levels of nutrients often fuel excessive algal growth
- Dissolved oxygen also affected by other processes
- Complex interrelationship between nutrients, algae and dissolved oxygen



Data to Support Model Calibration and Validation

Water Quality Data Gaps

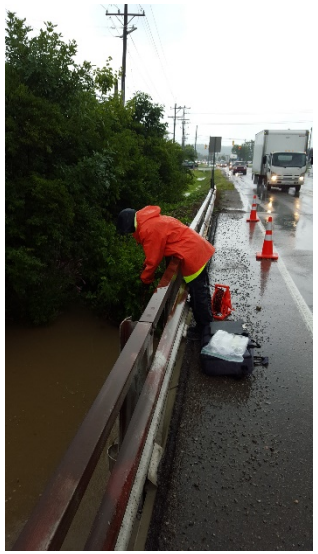
Data Inventory and Gap Analyses identified **three primary data gaps**:

- **Dry and wet weather measurements** of parameters of interest to characterize and calibrate watershed and surface water quality models
- **Observations from different land use types** for parameters of interest to characterize and calibrate watershed models
- **Flow data for tributaries** with which to calibrate watershed runoff model

SSO 700 IWAP Water Quality Data Collection Program developed to fill these requirements.

Sampling Components Based on Data Gaps

- **Dry Weather Sampling:** water quality sampling in the Mill Creek and its tributaries
- **Wet Weather Sampling:** water quality sampling in the Mill Creek, its tributaries, and CSO, SSO and stormwater outfall locations
- **Instream Flow Measurement:** in tributary and upstream reaches to provide datasets for enhancing the hydrologic and hydraulic calibrations of the watershed and water quality models



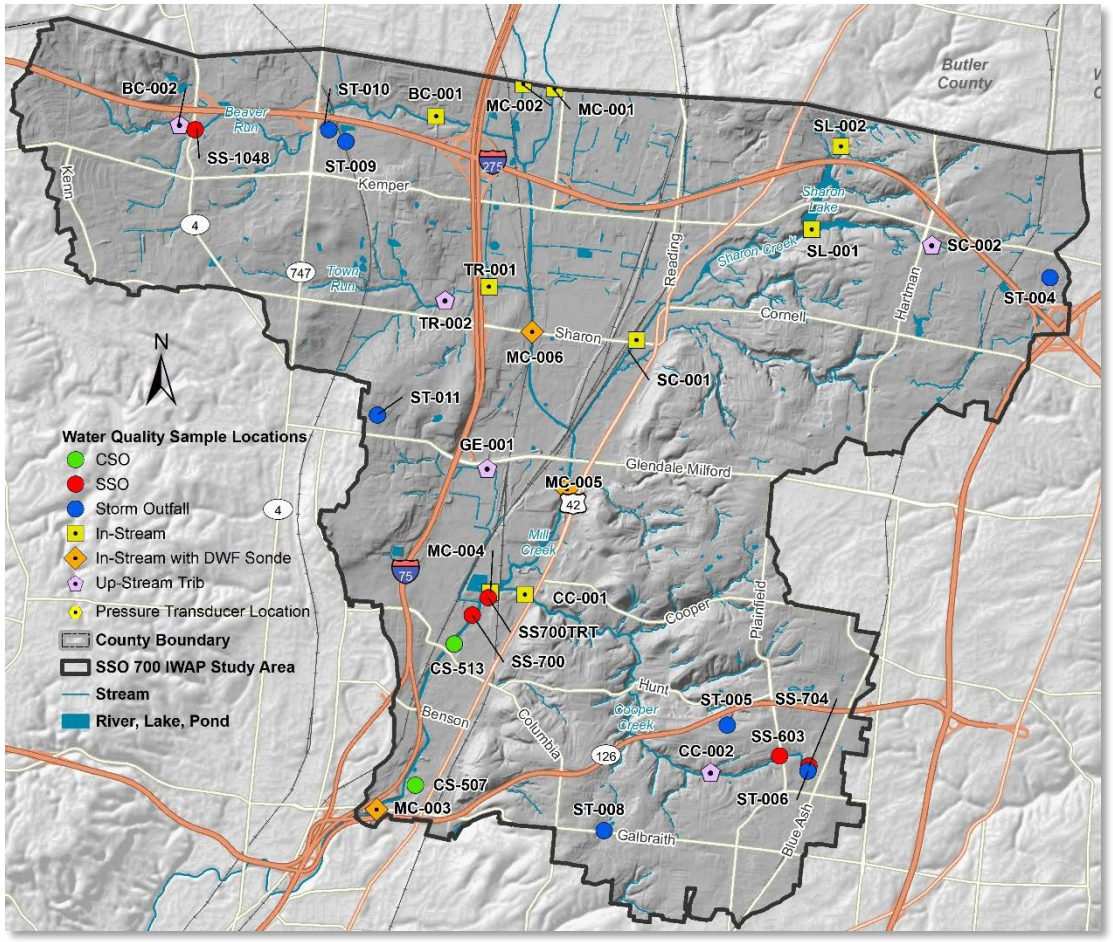
Wet weather sampling at MC-001

Autosampler deployed at CSO-507 sampling manhole

Pressure transducer installation at TR-001

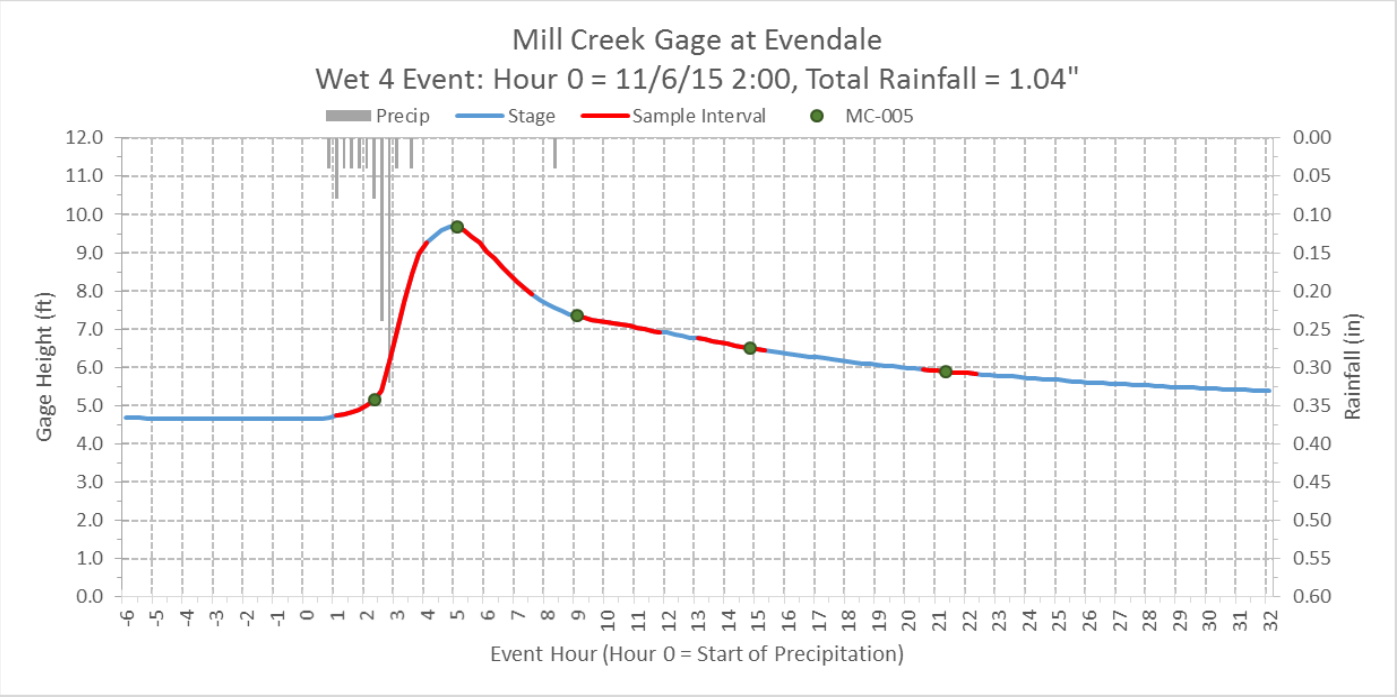
Sampling Locations

- In-Stream Sampling Locations: Same as Dry Weather Event Locations
- Upstream Tributary Locations: Same as Dry Weather Event Locations
- SSO and CSO Outfall Locations: Choose CSO and SSO Outfalls most likely to overflow during sampling period
- Stormwater Outfall Locations:
  - Purpose is to validate literature-based EMCs
  - Seek to quantify pollutant concentrations for 3-5 residential, commercial, and industrial areas
  - Seek outfalls with well-defined and uniform land use



Wet Weather Event Sampling Intervals

- Upstream Tributary Locations:
  - Four sets of samples: Pre-first flush, 1st flush, 30 minutes, and 60 minutes
- Outfall Locations:
  - Three sets of samples: 1st flush, 30 minutes, and 60 minutes
- In-Stream Sampling Locations:
  - Five sets of samples: approximately Hour 0.5-2.5, Hour 4.5-6.5, Hour 8.5-10.5, Hour 14.5-16.5, and Hour 22-24 from the start of rainfall



Analytical and Field Parameters

Parameter	Description	Sampling Program	Type of Measurement
E. coli	Escherichia coliform	Dry, Wet	Grab
TSS	Total suspended solids	Dry, Wet	Grab
Cl-	Chloride	Dry, Wet	Grab
Copper	Total recoverable copper	Dry, Wet	Grab
Lead	Total recoverable lead	Dry, Wet	Grab
Zinc	Total recoverable zinc	Dry, Wet	Grab
Hardness	Hardness	Dry, Wet	Grab
CBOD5	5-day Carbonaceous Oxygen Demand	Dry, Wet	Grab(s)[1]
NH3	Total ammonia (NH3)	Dry, Wet	Grab(s)[1]
NO3+NO2	Nitrate plus nitrite (NO3+NO2)	Dry, Wet	Grab(s)[1]
TKN	Total Kjeldahl nitrogen	Dry, Wet	Grab(s)[1]
TP	Total Phosphorus	Dry, Wet	Grab(s)[1]
oPO4	ortho-Phosphate	Dry, Wet	Grab(s)[1]
Chl a	Chlorophyll a	Dry	Grab(s)[1]
TOC	Total organic carbon	Dry, Wet	Grab(s)[1]
DO	Dissolved oxygen	Dry, Wet	In-situ
		Dry	Continuous 3-5 days[1]
wTemp	Water temperature	Dry, Wet	In-situ
		Dry	Continuous 3-5 days[1]
pH	pH	Dry, Wet	In-situ
		Dry	Continuous 3-5 days[1]
Cond	Conductivity	Dry, Wet	In-situ

[1] The continuous DO monitoring were conducted at three locations in Mill Creek (see Table 1-1). Additional grabs for nutrient and BOD parameters were collected once per day during the continuous DO monitoring period at these three Mill Creek locations and at the Sharon Creek at Reading Road location where the USGS gauge is located.

Project Status

Project Status

- Calibration and validation of the collection system hydraulic model has been completed.
- Water quality data successfully collected under sampling program.
- Water quality models have been developed and calibration is currently in progress.
- Next step is to use the integrated model to perform a component analysis to quantify the causes and sources of impairment.

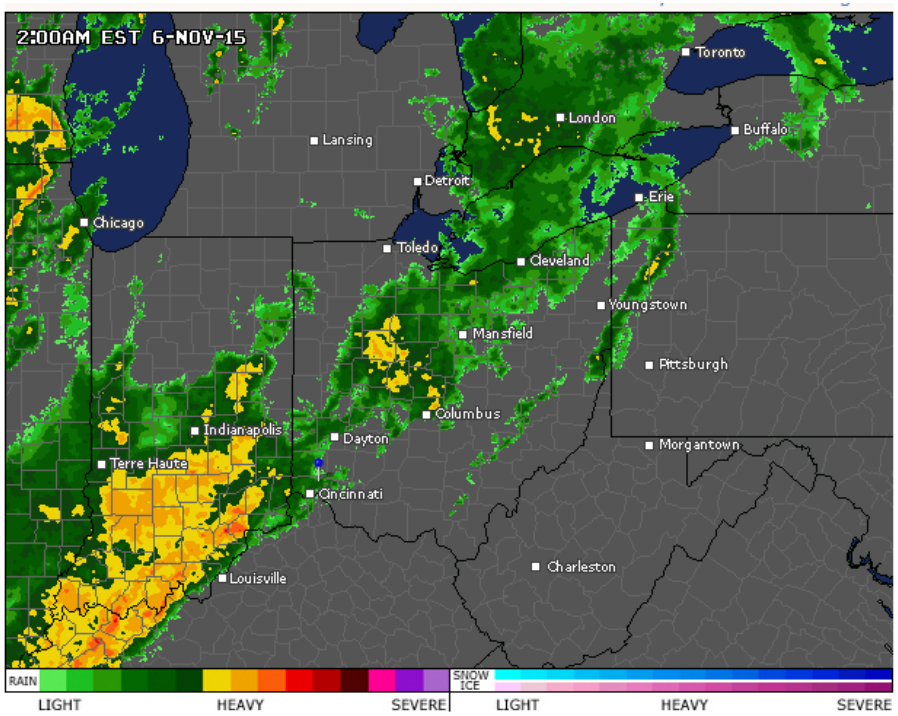
Program Consultant Team Roles

CH2M – Project Management, Collection System Modeling, Water Quality Modeling, Sampling Coordination, Technical Oversight

LimnoTech – Water Quality Modeling, Technical Oversight, Field Sampling Support

Browne E & C Services – Collection System Modeling, Field Sampling

Alloway Laboratories – Sample Analysis



Radar at Hour 0 of Wet Weather Event 4

Questions?

Thank You