SSO 700 Integrated Watershed Action Plan: Continuous Calibration of a Model

5 Cities Plus
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Presented by

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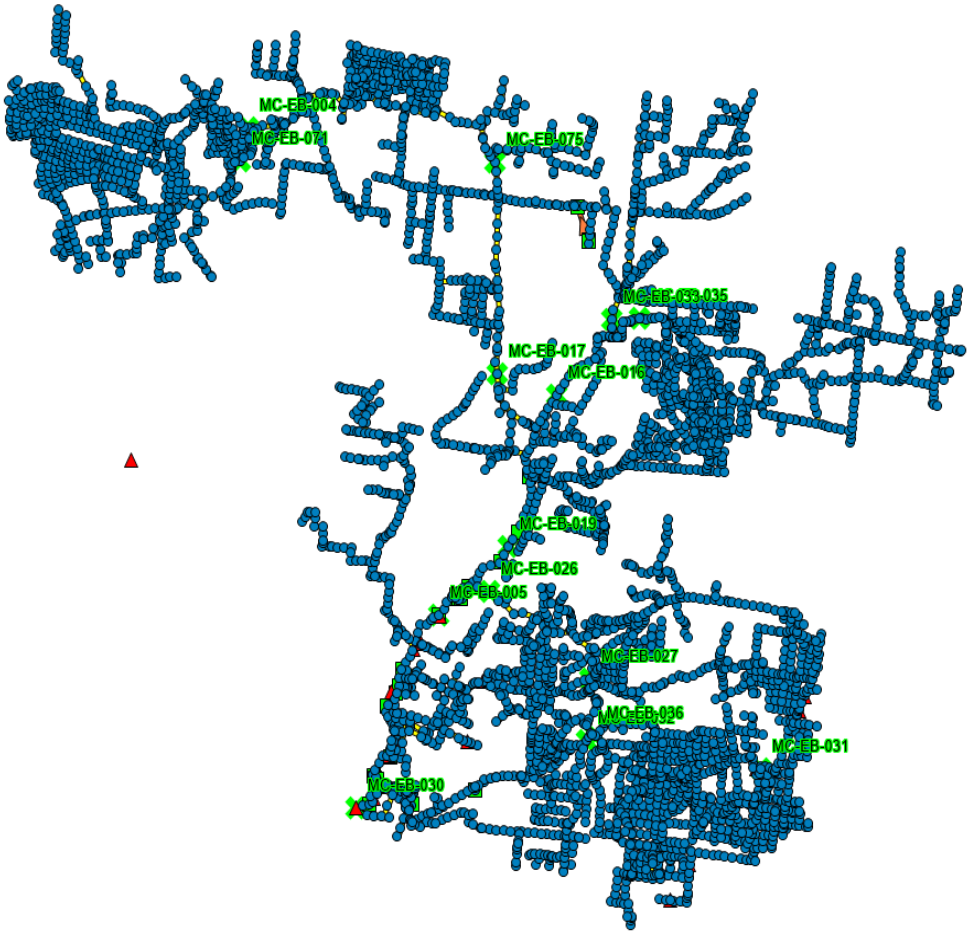
Overview of Presentation

- Project Background
- Calibration and Validation Approach
- Calibration and Validation Results
- Interceptor Depth Investigation
- Summary & Conclusions



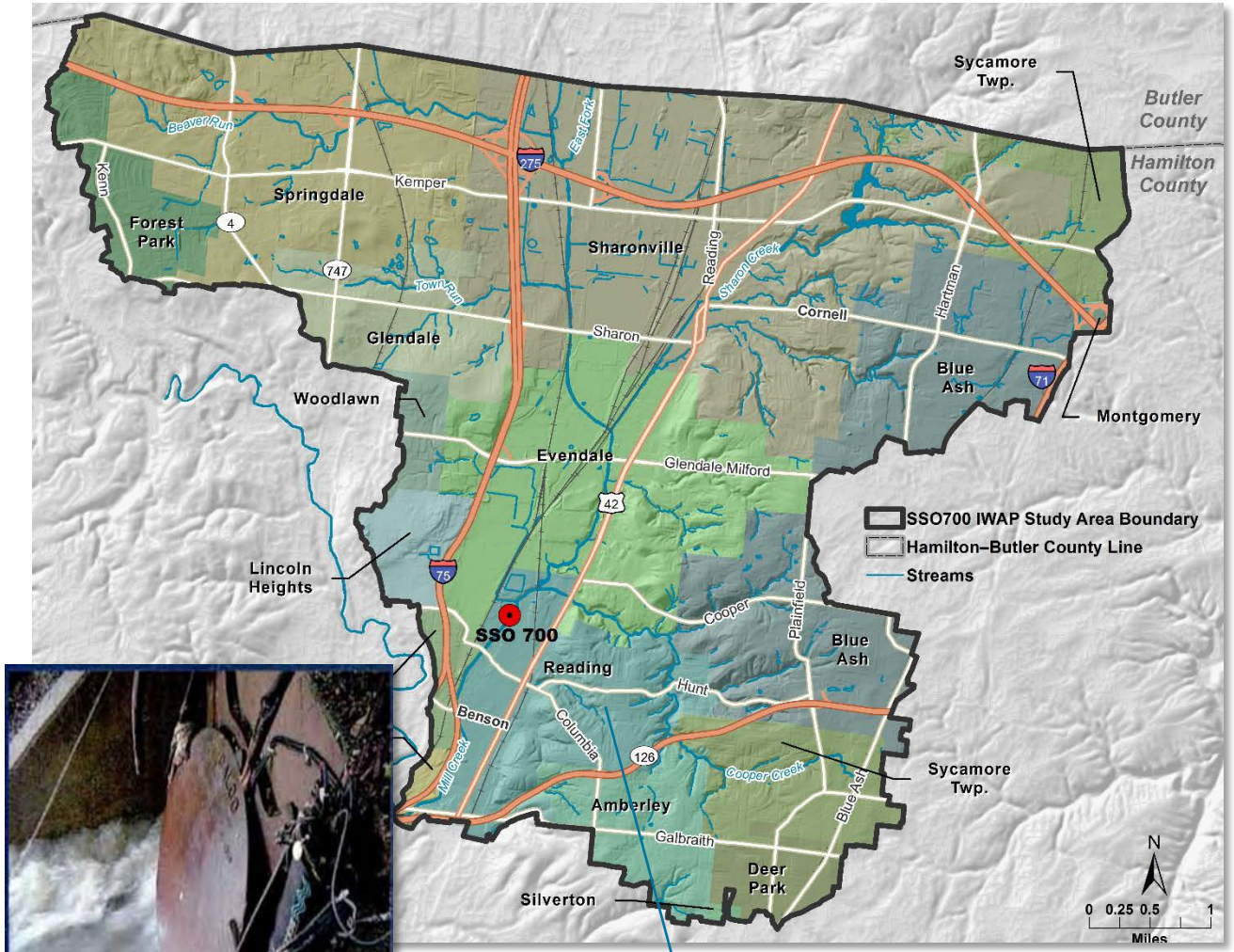
Project Background

Description

- SSO 700 is the largest SSO in MSDGC's service area
- MSDGC's Consent Decree requires elimination of overflow.
- 2012 SSO 700 FRP identified Gray Solution

Goal

- Develop solution that will cost less and do more.

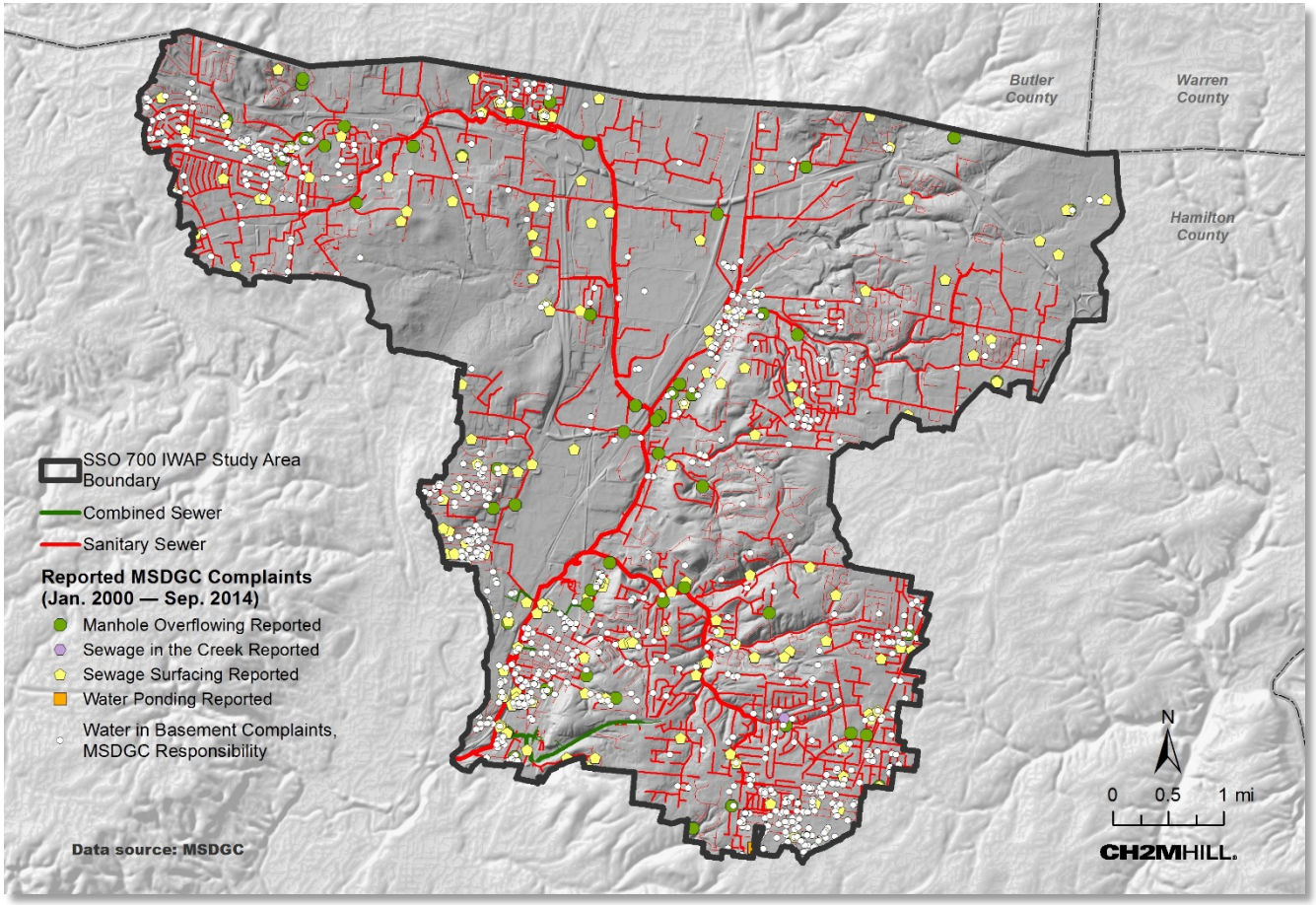


SSO 700 Sewershed = 35 Sq Miles; 16 Political Jurisdictions

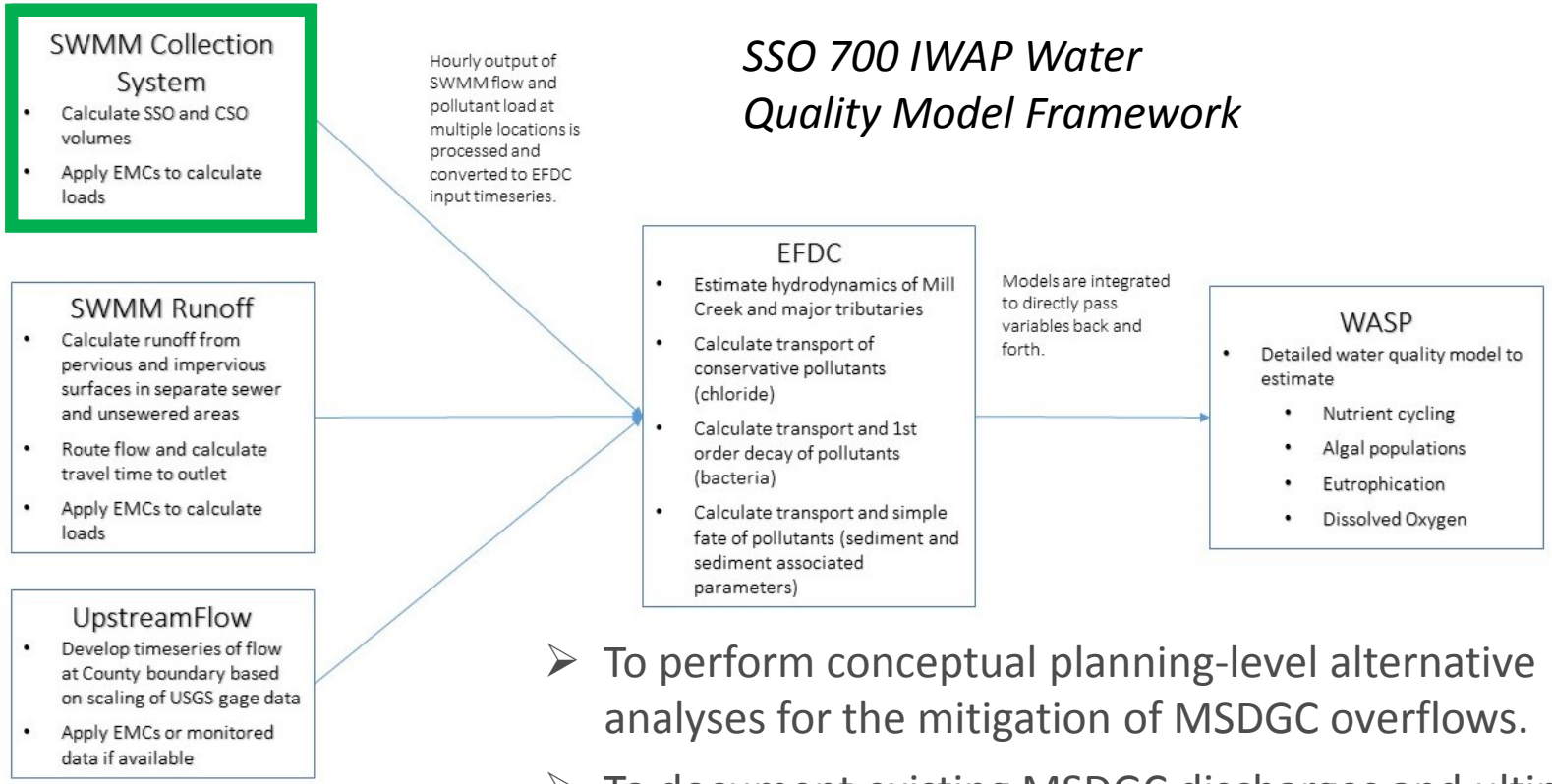
Taking an integrated approach

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



Purpose of Collection System Hydraulic Model for SSO 700 IWAP



SSO 700 IWAP Water Quality Model Framework

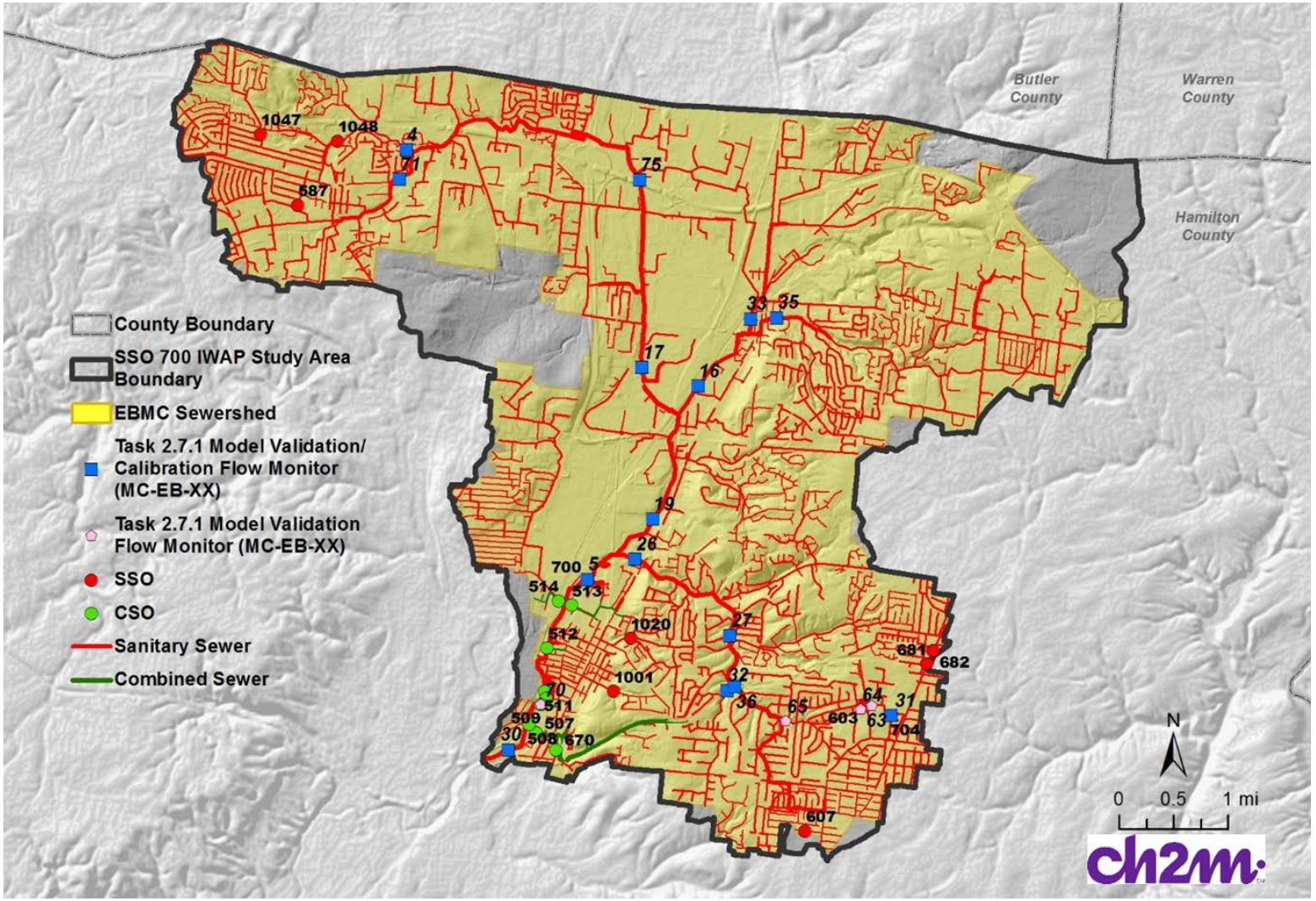
- To perform conceptual planning-level alternative analyses for the mitigation of MSDGC overflows.
- To document existing MSDGC discharges and ultimate achievement of consent decree compliance.
- To provide input to water quality model framework for characterization of instream water quality conditions.

Calibration and Validation Approach

Calibration Approach

Calibration Approach- Continuous Calibration Using 2012 Data

- 11 SSOs
- 9 CSOs
- SSO 700 Storage & Treatment Facility
- 3 potential SSOs
- 14 Flow Monitors/ Metersheds for calibration to 2012 data



Why did we select 2012 for recalibration?

Flow monitoring data

- 2006: 11 flow monitors
- 2007 & 2008: 13 flow monitors
- 2009: 16 flow monitors
- 2010: 14 flow monitors
- 2011: 13 flow monitors
- 2012: 14 flow monitors
- 2013 – present: 5 flow monitors

SSO data

- Estimated activation data prior to 2011
- Level data for 3 SSOs beginning in late-2011
- Level data for 6 additional SSOs & 2 potential SSOs beginning in early to mid-2012
- Level for remaining 2 SSOs in EBMC beginning early-2013 and late-2013

CSO data

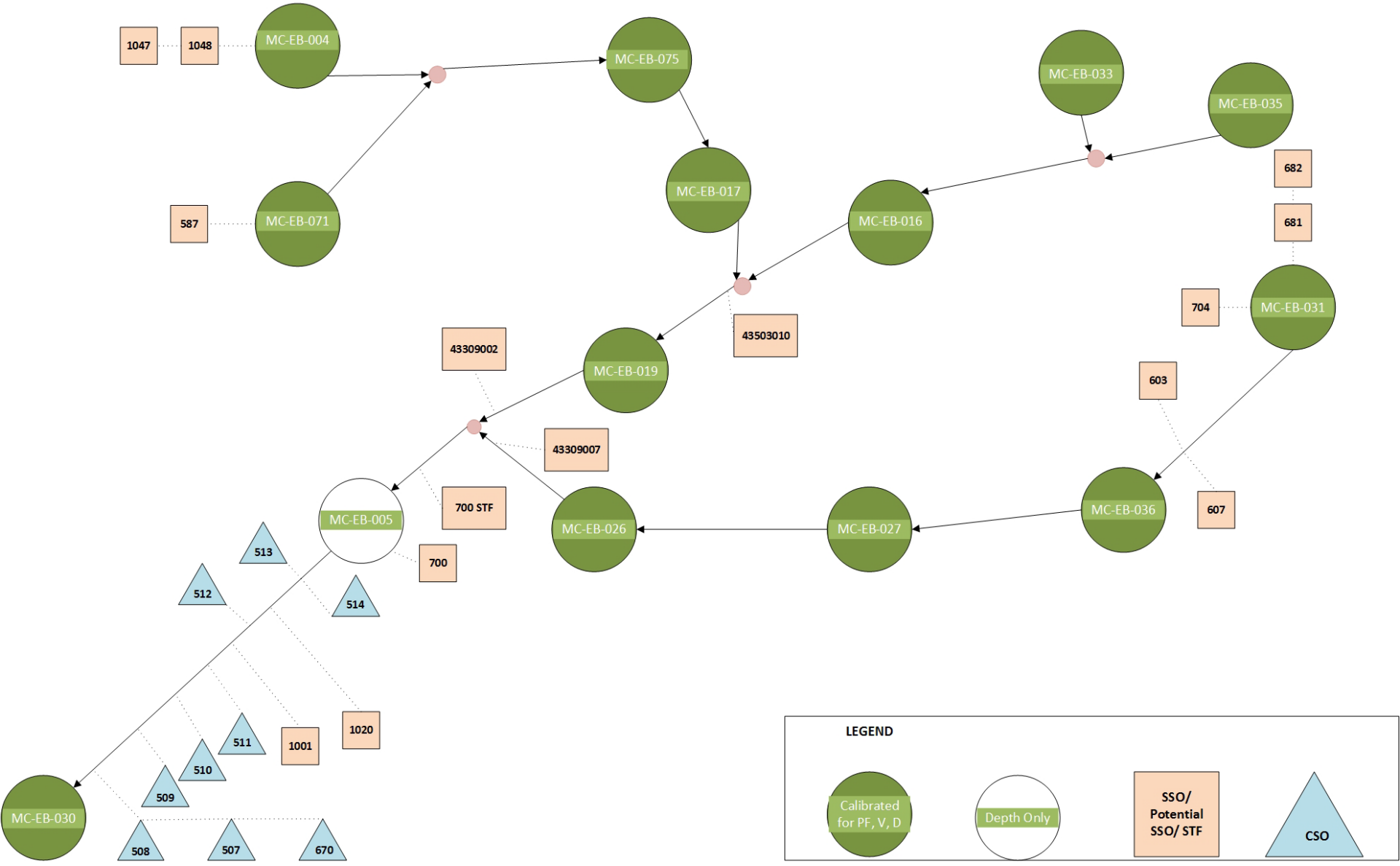
- Activation data for 3 CSOs prior to 2009
- Level data for 2 additional CSOs beginning in early-2009
- Level data for 6 remaining CSOs in EBMC beginning mid to late-2009

SSO 700 STF data

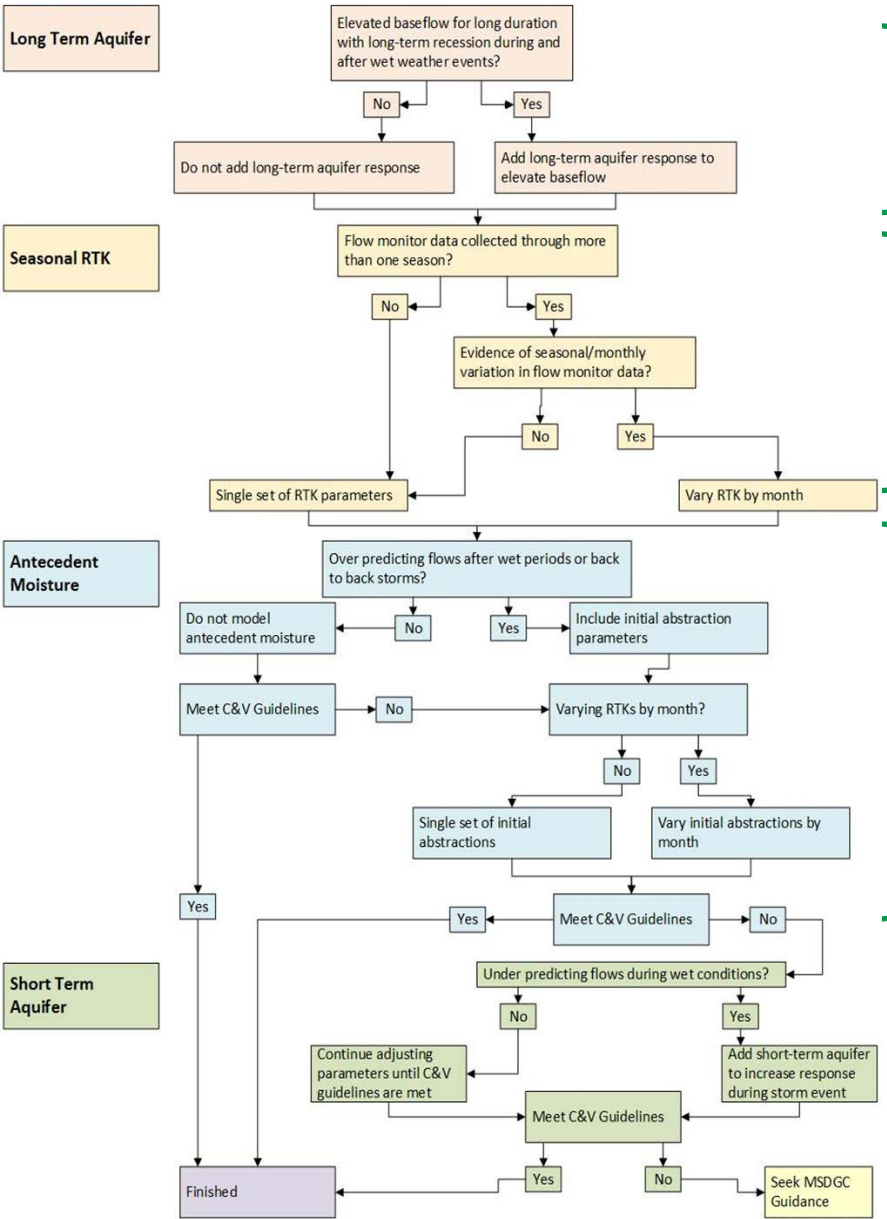
- Operating summary data beginning April 2009

Year	Total Rainfall (in)
2007	32.05
2008	32.50
2009	29.71
2010	27.99
2011	50.24
2012	41.72
2013	47.53
2014	40.57
Typical Year	**40.81**

SSO 700 Study Area



Recalibration Approach



Input base sanitary flow from SSOAP

Calibrate ground water infiltration using Long-term Aquifer Module

Calibrate RDII using monthly RTKs

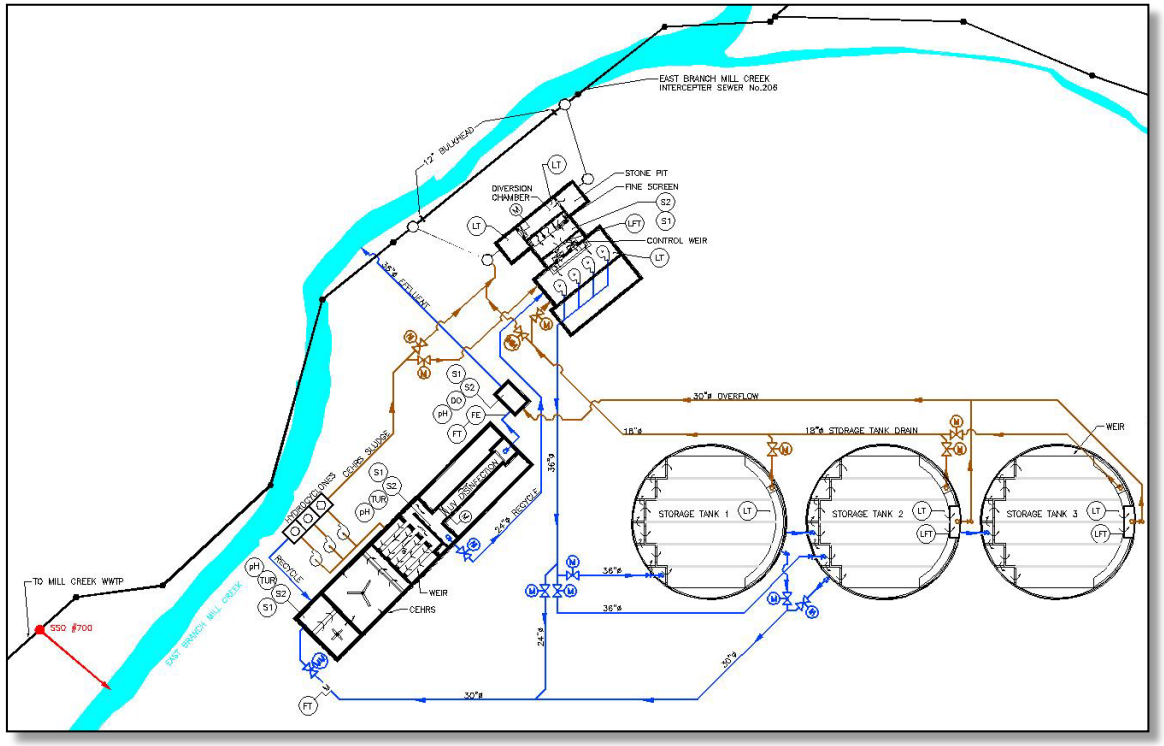
Calibrate antecedent moisture conditions using monthly IAs

Flowchart Source: *SSO 700 IWAP Task 2.7.2 Hydraulic Model Development Detailed Scope of Work and Estimated Level of Effort TM, Revision 2*, dated 5/11/2016.

Additional Calibration Steps

SSO 700 STF:

- Review SSO 700 STF data from 2012 to determine how facility was operated in 2012
- Develop and implement ONE SET of model controls that best represent how STF was operated in 2012 for model calibration.



Field Verification:

- Field check model-calculated flooding manholes to verify model accuracy.
- Use Water in Basement Prevention Program (WIBPP) and sewer back up (SBU) complaints to compare against model-calculated surcharging sewers and flooding manholes.

Calibration Criteria

Item	Criteria
DWF Calibration	60% of the dry weather flow events meet peak flow, volume, and depth guidelines
WWF Calibration	60% of the qualified wet weather flow events meet peak flow, volume, and depth guidelines
DWF Calibration Events	One period of dry weather flow per month
WWF Calibration Events	All qualifying wet weather events will be used for calibration
Peak Flow	-15 to +25% of observed flow
Total Flow Volume	-10 to +20% of observed flow volume
Depth of Water	-15 to +15% of observed depth or ±0.33 ft in non-surcharge conditions and -0.33 to 1.64 ft in surcharge conditions
Shape	The shape of predicted hydrographs should closely follow the observed one.
SSO 700 Overflow Data	Model output for peak flow, peak depth, and total volume compares reasonably well to observed flow data of sufficient quality. Where flow data are of insufficient quality to represent peak flows and total volumes, flow data will be used as an indication of overflow activation.
Overflow Telog Data	Modeled activations of overflows correspond reasonably well with observed overflow activations during calibration period.

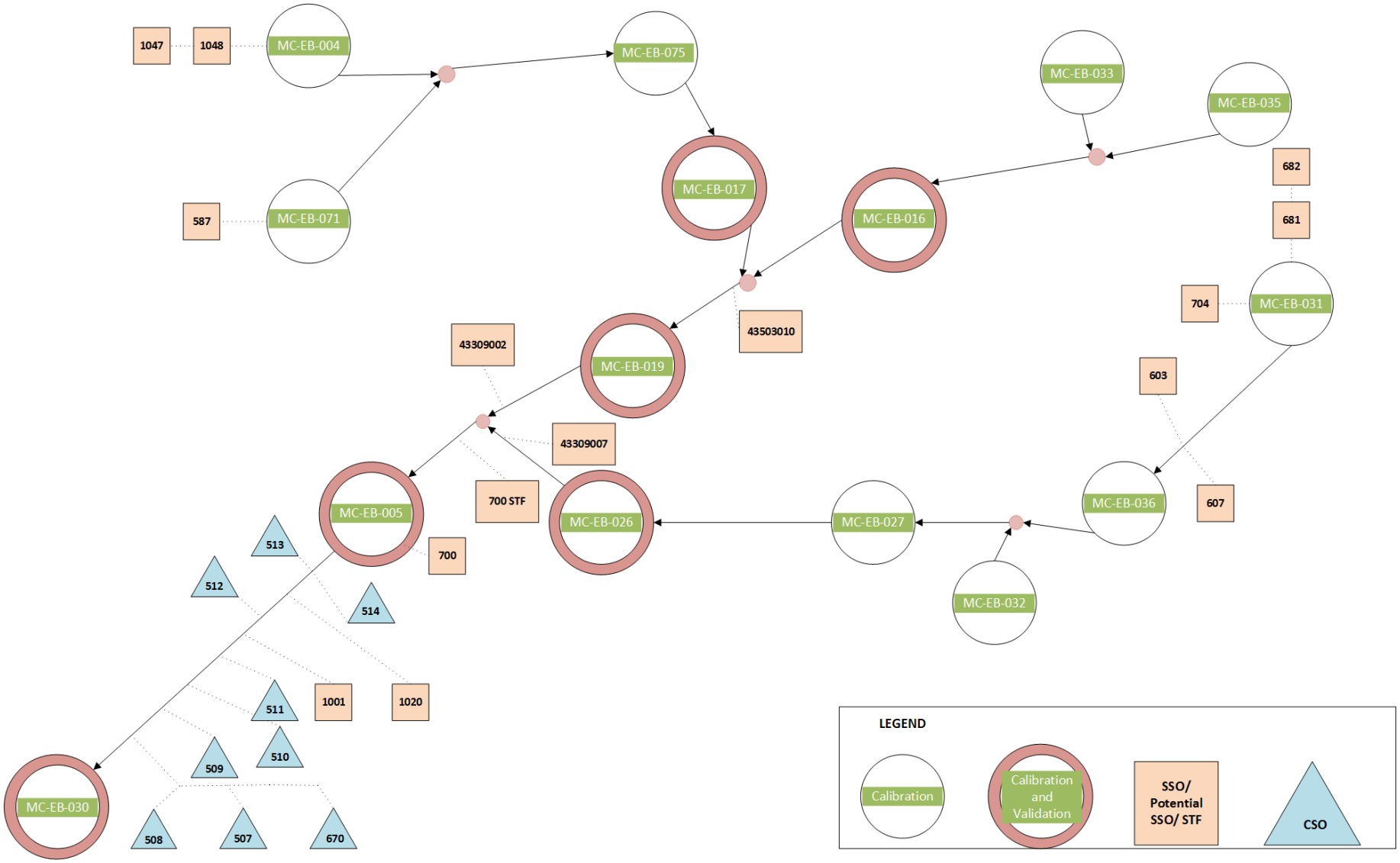
Source: *SSO 700 IWAP Task 2.7.2 Hydraulic Model Development Detailed Scope of Work and Estimated Level of Effort Technical Memorandum, Revision 2*, dated 5/11/2016.

Validation Approach

Model Validation Approach

- **2015 selected as validation period because it corresponds to IWAP Water Quality Sampling Program**
- Used all available data sets to measure model validation
- Selected 5 flow monitors which were common for 2012 and 2015
- Selected 9 wet weather events which represent a range of storms (rainfall intensity, duration, back-to-back storms, seasonal variation, and wet weather sampling events)
- Did not adjust calibration parameters in the calibrated model
- Adjustments for validation
  - SSO 700 STF controls for 2015

2015 Validation Period



Calibration and Validation Results

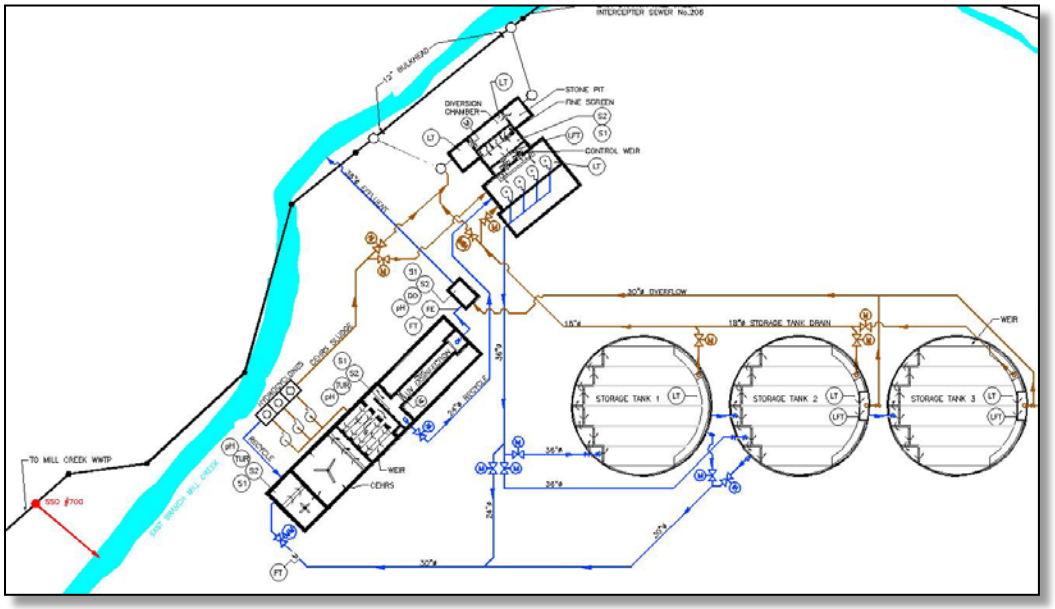
Calibration Results

Final Flow Calibration Results (Target: ≥60% of all qualifying events)

Metershed	Number of Qualifying Events	Percent of All Qualifying Storms within 2012 Meeting Calibration Tolerances			
		Peak Flow Only	Volume Only	Peak Depth Only	Peak Flow, Volume, & Depth
MC-EB-030	24	96	100	100	96
MC-EB-019	19	100	100	63	63
MC-EB-026	23	74	83	65	61
MC-EB-027	25	76	60	100	60
MC-EB-036	24	71	71	100	63
MC-EB-031	22	91	73	100	68
MC-EB-016	25	84	92	72	64
MC-EB-033	20	95	75	90	70
MC-EB-035	21	90	76	100	71
MC-EB-017	23	96	91	61	61
MC-EB-075	21	90	86	76	62
MC-EB-071	21	81	67	100	67
MC-EB-004	21	86	76	100	67

SSO 700 STF Results Summary

Flow Measure Location	2012 Observed Volume (MG)	2012 Modeled Volume (MG)	Difference (MG)	Difference (%)
Facility Influent	254.7	262.1	7.4	6
CEHRS	138.5	149.8	11.3	18
Tank Overflow	51.5	53.1	1.6	3



CSO Overflow Activation Comparison

CSO	Telog/ Observed Overflows for Comparison	Modeled Overflows	Modeled Overflow Volume (MG)	Modeled Overflows Corresponding with Observed Overflows	
				Number	Percent of Observed
507	59		27.6	39	66%
508	9		0.8	1	11%
509	4	9	2.3	4	100%
510	10	5	1.2	5	50%
511	32	0	0.0	0	0%
512	45		2.0	8	18%
513	48	48	24.2	37	77%
514	4	3	2.1	3	75%
670	2	1	0.0	1	50%

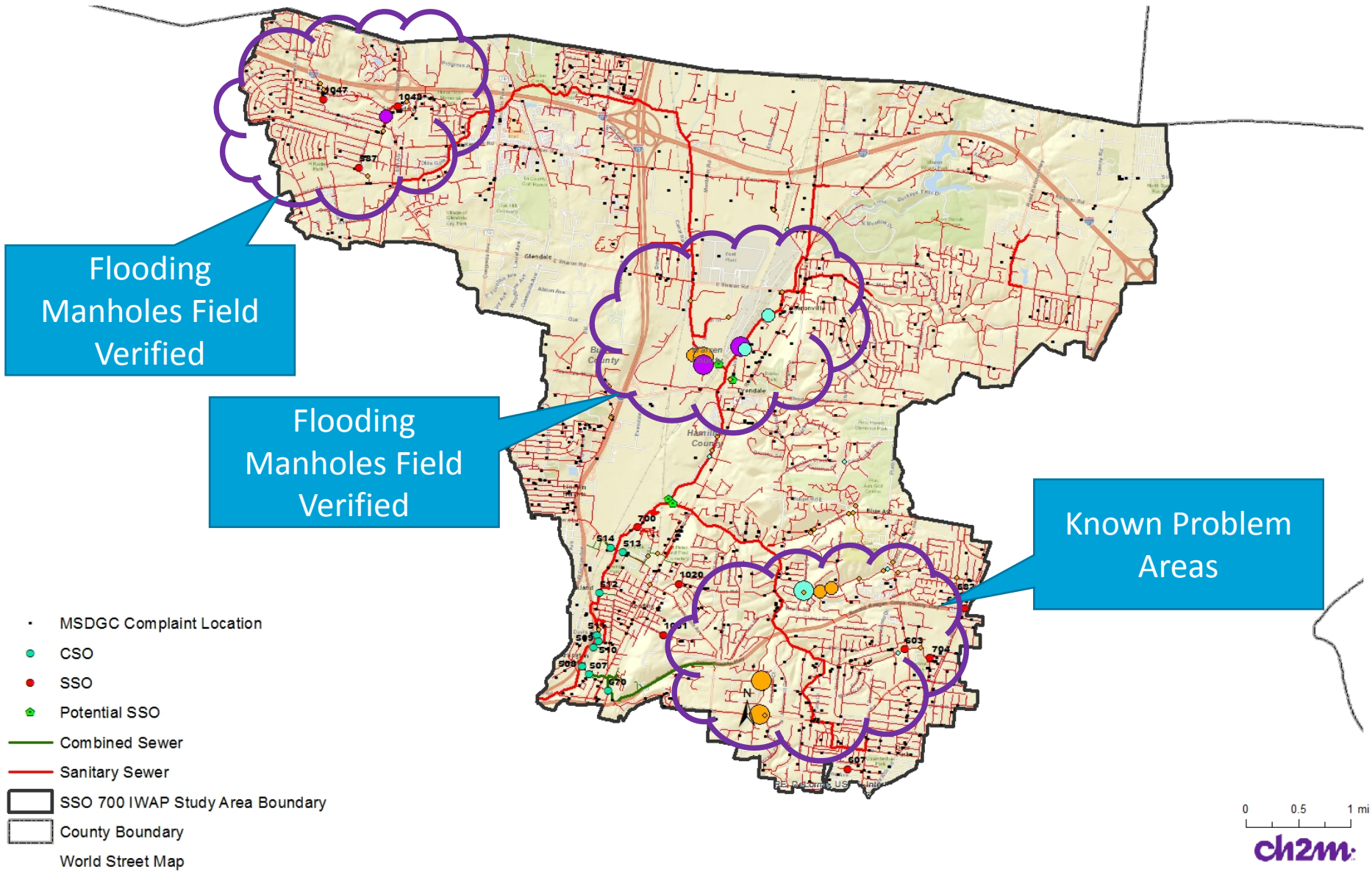
Telog: 0.008 MG

Telog: 0.19 MG

SSO Overflow Activation Comparison

SSO	Telog/ Observed Overflows for Comparison	Modeled Overflows	Modeled Overflow Volume (MG)	Modeled Overflows Corresponding with Observed Overflows	
				Number	Percent
587	2	2	0.2	2	100%
603	8	10	1.0	6	75%
607	2	0	0.0	0	0%
681	2	2	1.0	1	50%
682	1	2	0.6	0	0%
700	8	3	1.2	1	13%
704	8	4	0.3	4	50%
1001	5	0	0.0	0	0%
1020	4	1	0.0	1	25%
1047	1	2	0.8	1	100%
1048	4	5	5.5	4	100%
43309002	0	3	2.4	0	0%
43309007	1	0	0.0	0	0%
43503010	1	3	2.8	1	100%

Model- Predicted Flooding Manholes Summary



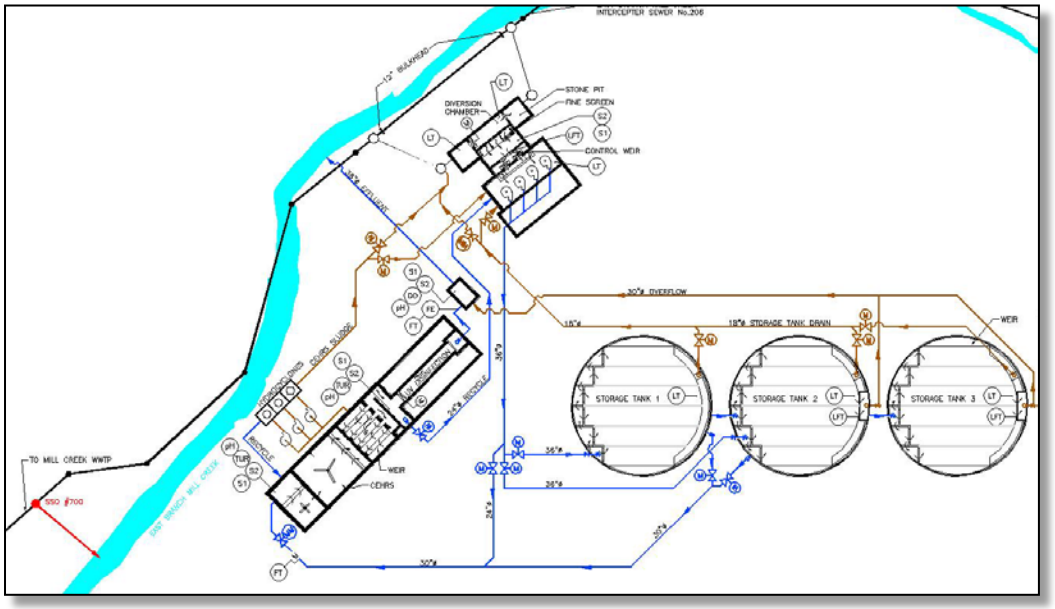
Validation Results

Overall Flow Validation Results (Target: ≥60% of all validation events)

Metershed	Number of Qualifying Events	Percent of Validation Events Meeting Calibration Criteria			
		Peak Flow Only	Volume Only	Peak Depth Only	Peak Flow, Volume, & Depth
MC-EB-030	9	100	67	100	67
MC-EB-019	9	78	33	67	22
MC-EB-026	8	38	13	50	0
MC-EB-017	5	100	40	40	0
MC-EB-016	6	83	100	67	67

SSO 700 STF Validation Results

Flow Measure Location	2015 Observed Volume for Validation Events (MG)	2015 Modeled Volume for Validation Events (MG)	Difference (MG)	Difference (%)
Facility Influent	166.7	124.5	-42.3	-25%
CEHRS	103.3	79.5	-23.8	-23%
Tank Overflow	43.5	26.8	-16.7	-38%



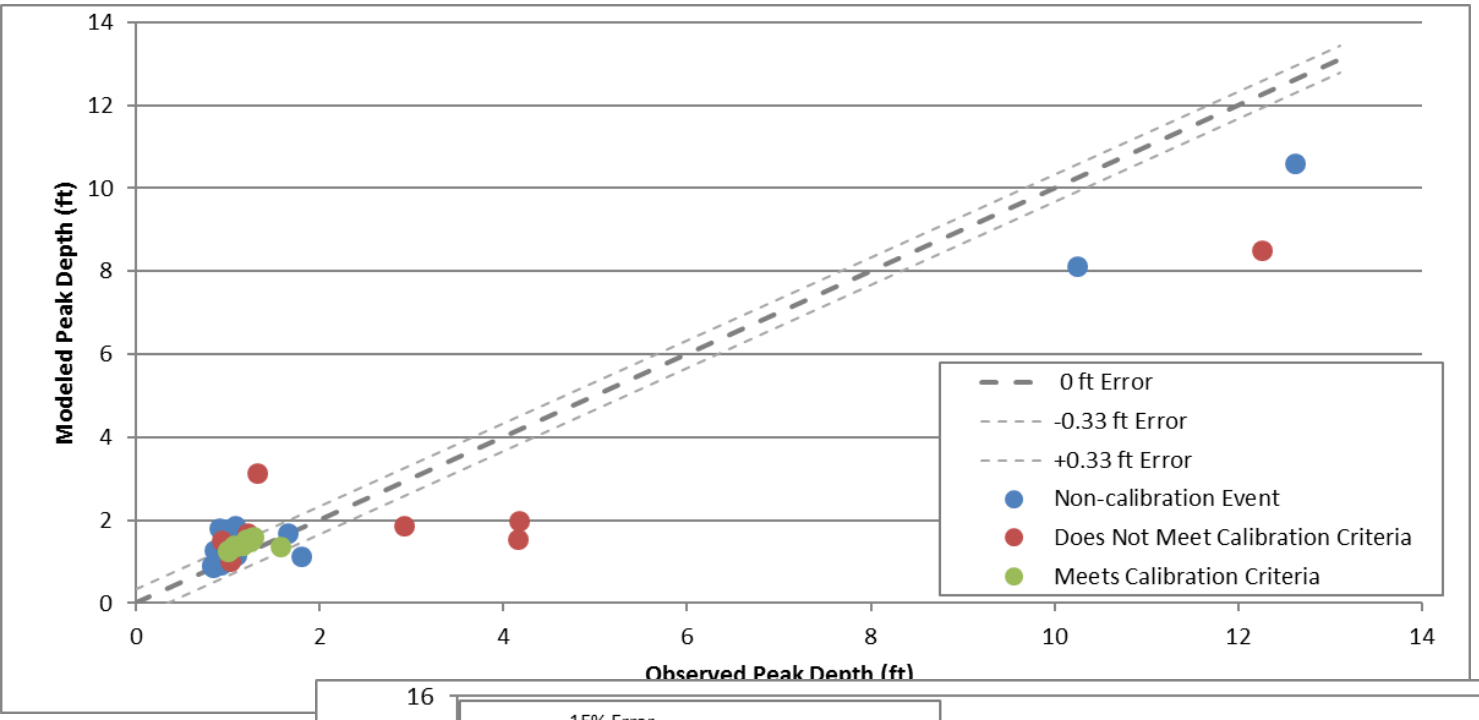
CSO Overflow Activation Comparison

CSO	Telog/ Observed Overflows for Comparison	Modeled Overflows	Modeled Overflows Corresponding with Observed Overflows	
			Number	Percent
507	9	8	8	88%
508	7	3	3	43%
509	3	3	3	100%
510	4	3	3	75%
511	5	0	0	0%
512	7	5	5	71%
513	8	9	8	100%
514	7	3	3	43%
670	0	0	0	100%

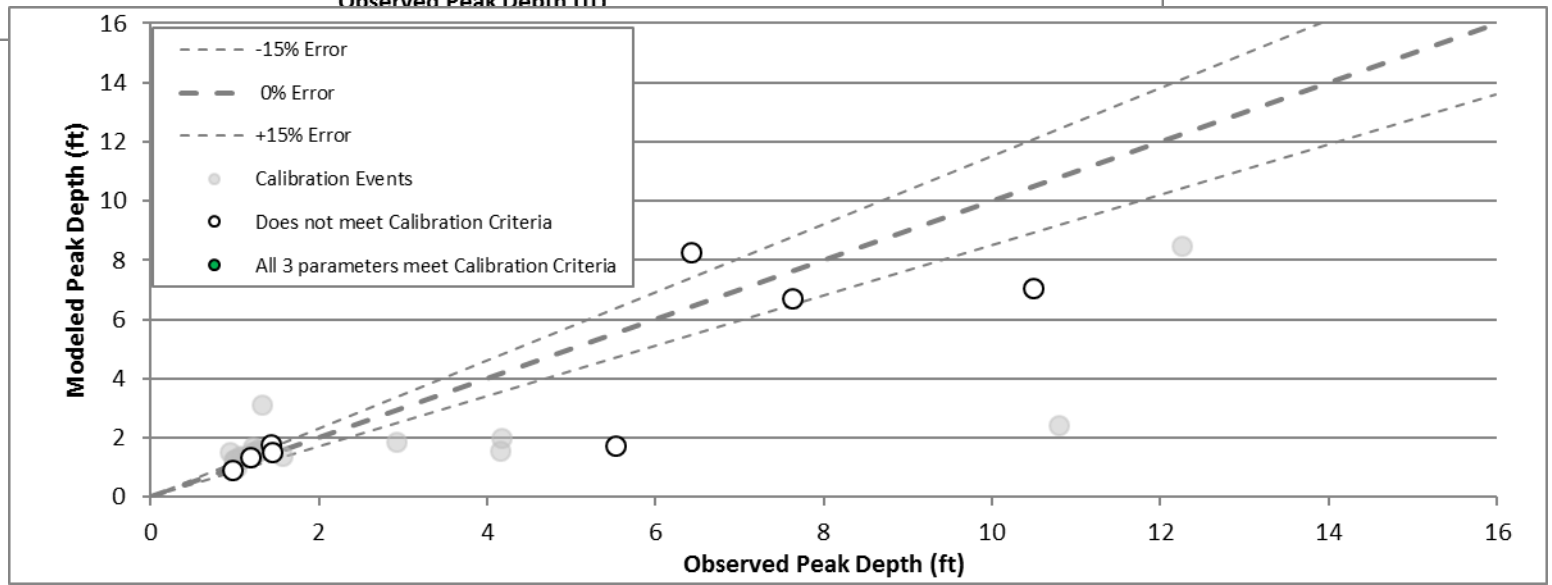
SSO Overflow Activation Comparison

SSO	Telog/ Observed Overflows for Comparison	Modeled Overflows	Modeled Overflows Corresponding with Observed Overflows	
			Number	Percent
587	1	0	0	0%
603	2	1	0	0%
607	2	0	0	0%
681	1	0	0	0%
682	0	0	0	100%
700	3	3	3	100%
704	2	0	0	0%
1001	0	0	0	100%
1020	0	0	0	0%
1047	1	0	0	0%
1048	2	0	0	0%
43309002	0	1	0	0%
43309007	0	0	0	0%
43503005	1	2	0	0%
43503010	2	2	0	0%

Depth Results for Meter 26



For events that didn't calibrate and validate, modeled depths trend low



Interceptor Depth Investigation

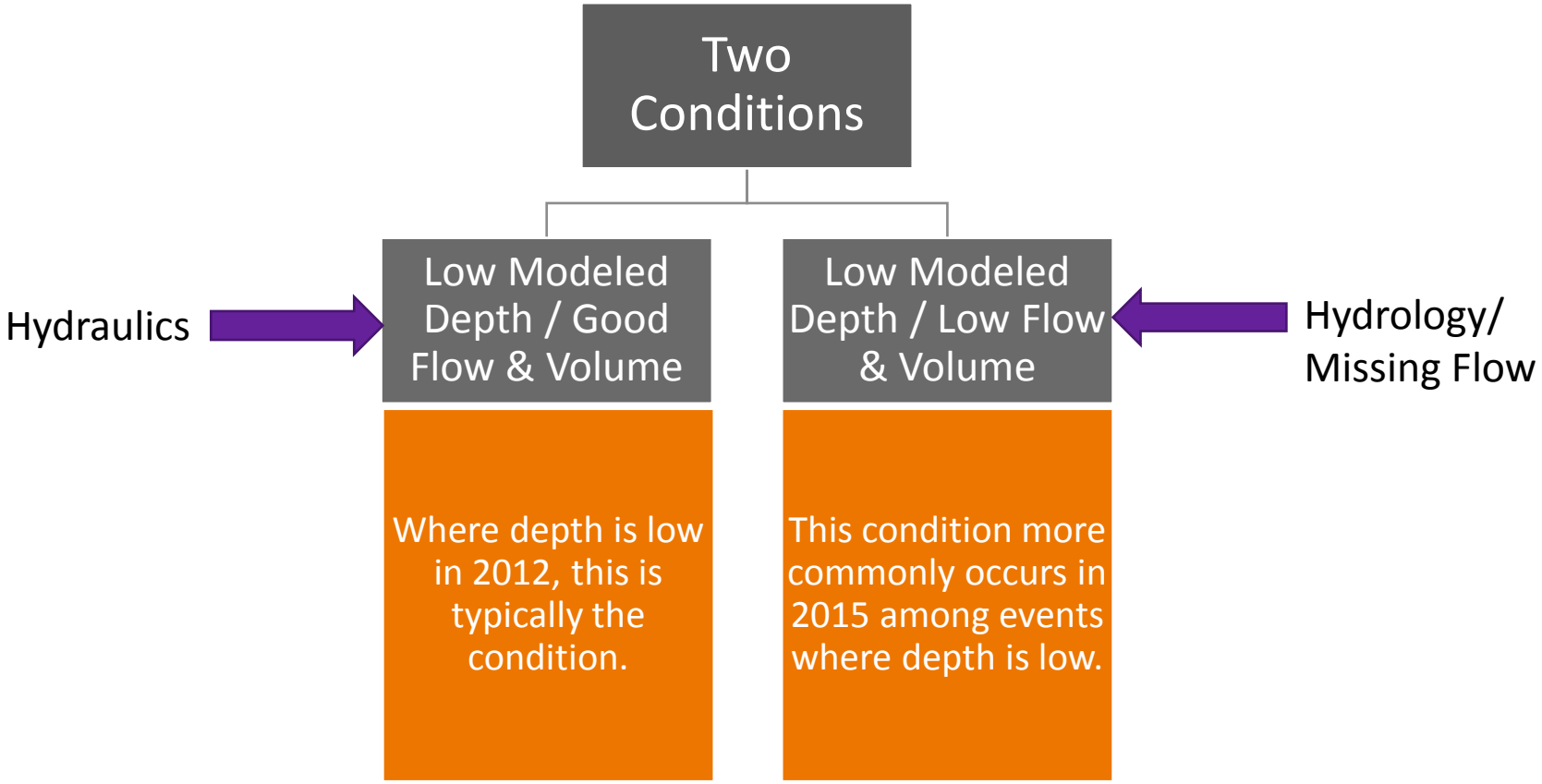
Events Selected for Depth Investigation

- 5 representative events were selected with which to perform depth investigation.
- Events selected for which most meters exhibited lower modeled depths than observed data.

Event	MC-EB-030 Difference in Depth (ft)	MC-EB-026 Difference in Depth (ft)	MC-EB-019 Difference in Depth (ft)	MC-EB-016 Difference in Depth (ft)	MC-EB-017 Difference in Depth (ft)	MC-EB-005 Difference in Depth (ft)*
Calibration Events						
4/14/2012	0.30	-2.61	-2.78	-3.57	-3.96	-0.32
5/31/2012	0.12	-8.34	-4.91	-5.71	-3.50	-3.07
7/18/2012	0.00	-0.68	-	-2.37	-4.54	-2.31
Validation Events						
3/3/2015	-0.03	-3.42	0.48	-	-	-0.61
11/5/2015	0.00	-3.79	-2.16	-0.03	-2.29	-1.08

*MC-EB-005 is not a calibration meter.

Two conditions are evident from review of wet weather events in which modeled depth is significantly lower than observed.



Depth Analysis

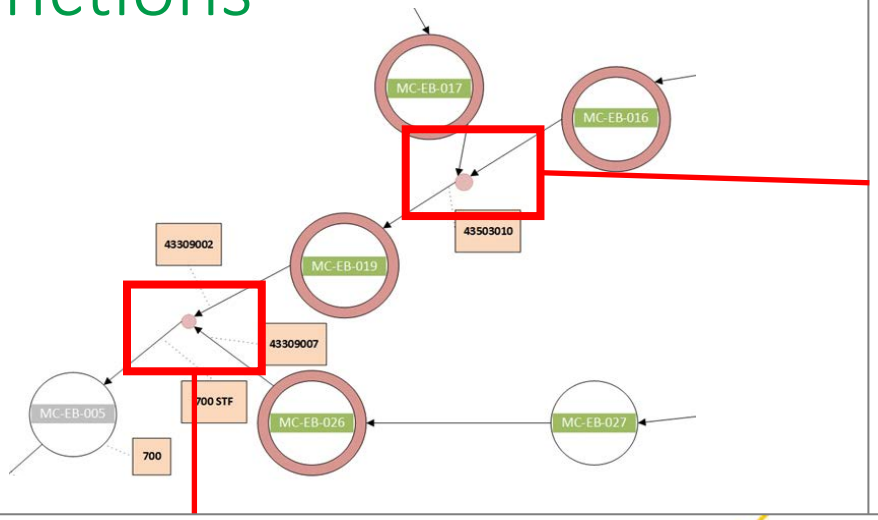
- Hydraulics Evaluation
  - Zone of Interceptor Surcharging: compared the zone of surcharge in the model with the zone of surcharge in the collection system as indicated by flow monitoring data
  - Debris in sewer: evaluated the impact of adding static debris to the sewer
  - SSO 700 STF controls: evaluated the impact of adjusting the facility controls to mimic the operations during the individual events
  - Losses at key junctions: evaluated the impact of adding hydraulic restrictions at 2 key junctions along the interceptor
- Missing Flow Evaluation
  - Stream Intrusion: evaluated the impact of stream intrusion on interceptor depth of flow
  - RDII: evaluated the impact of RDII on interceptor depth of flow

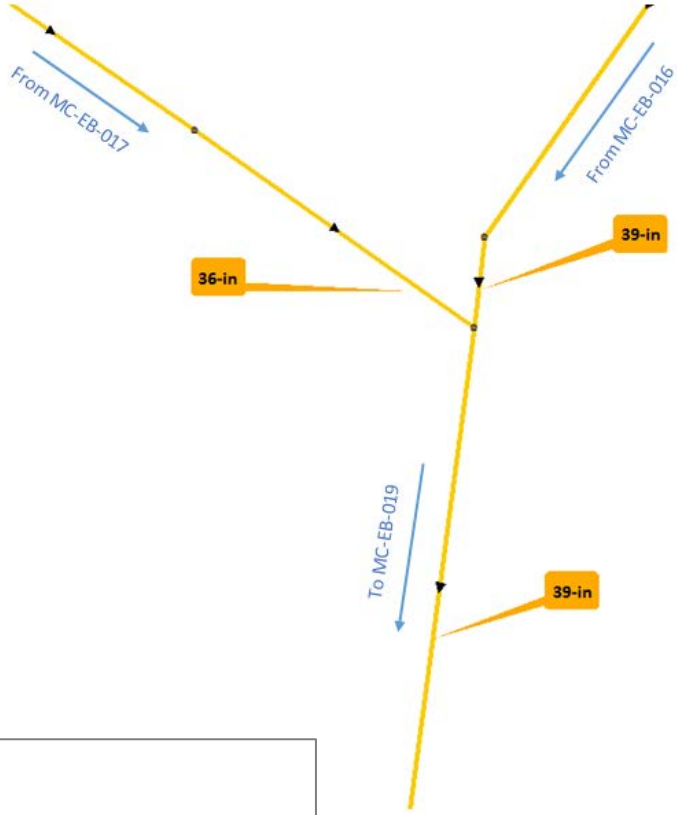
Analysis Findings

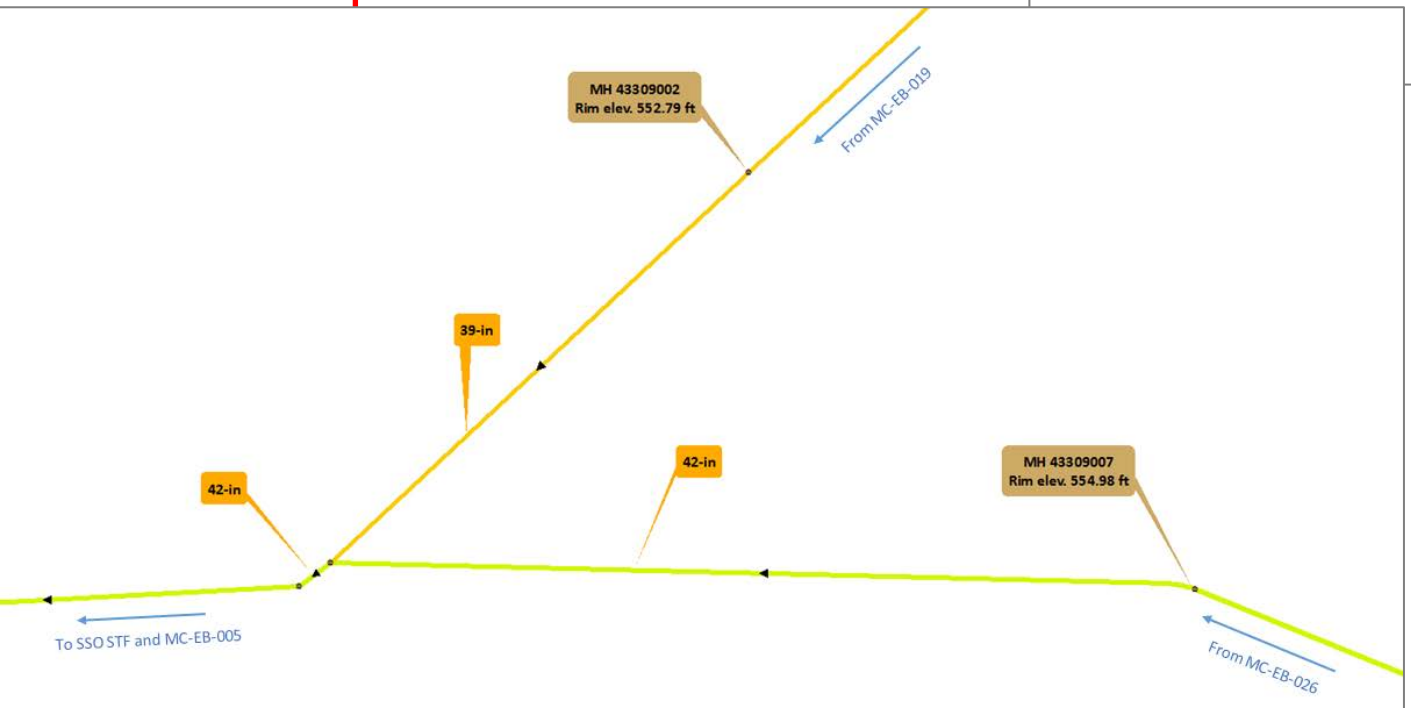
Evaluation	Description	Potential Cause?	Findings
Hydraulics Evaluation			
Zone of Interceptor Surcharging	Evaluate role of interceptor surcharging as potential cause of depth discrepancies at MC-EB-016 and MC-EB-017	No	While the zone of interceptor surcharging may impact the upstream meters for select events, it does not appear to be the prevalent issue.
Debris in Sewer	Seek evidence of debris in sewers. Evaluate impact of debris on flow depth.	No	Addition of debris would not significantly raise depths for wet weather events with low modeled depths, but may negatively affect the depth for calibrated WW events and DWF periods .
SSO 700 STF Controls	Evaluate impact of facility controls on modeled depth at key meters.	No	STF controls have event-specific impact on depth and flow, though not significantly enough to drive depth to within calibration tolerances.
Losses at Key Junctions	**Evaluate sensitivity of depth to losses at major junctions.**	**Yes**	**Flow-driven hydraulic restrictions appear to largely resolve depth differences, but restrictions vary by event.**
Missing Flow Evaluation			
Stream Intrusion	For key events, evaluate impact of stream flooding on unprotected CSOs as another potential source of flow.	No	Boundary conditions at CSOs for events where Mill Creek was high do not result in change in depth.
RDII	**Compare I/I volume versus depth at key meters for events for which depth is low to determine if low I/I volume could be issue. Perform sensitivity analysis.**	**Yes**	**Missing I/I not an issue for 2012. However, significantly different monthly R values potentially due to changes in rainfall pattern and/or changes in the sewer system between 2012 and 2015.**

Losses at Key Junctions

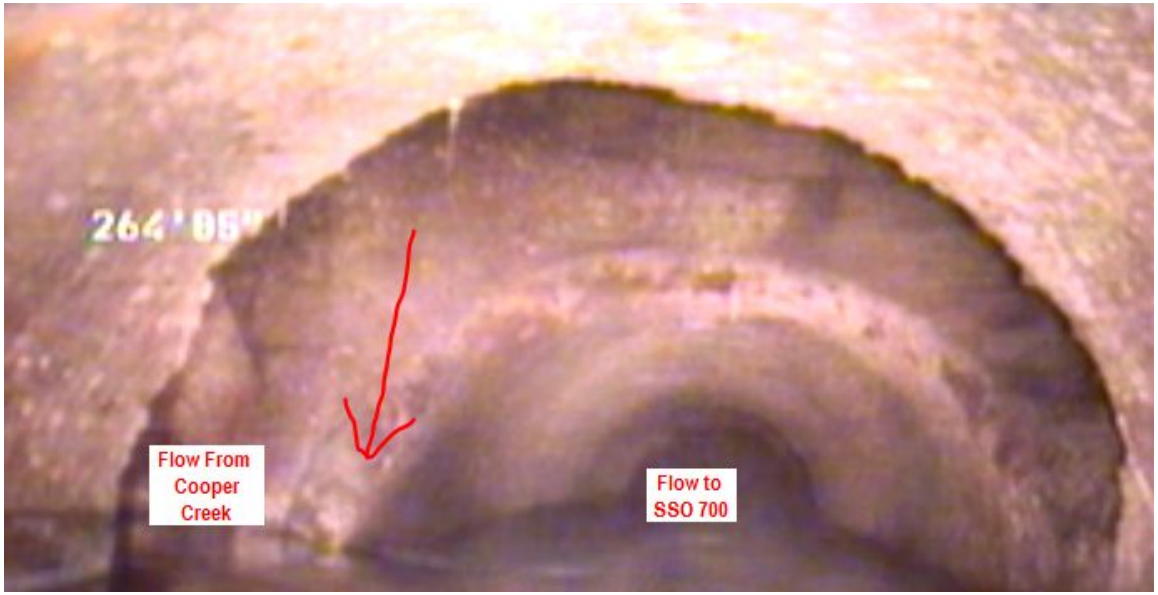
Losses at Key Hydraulic Junctions

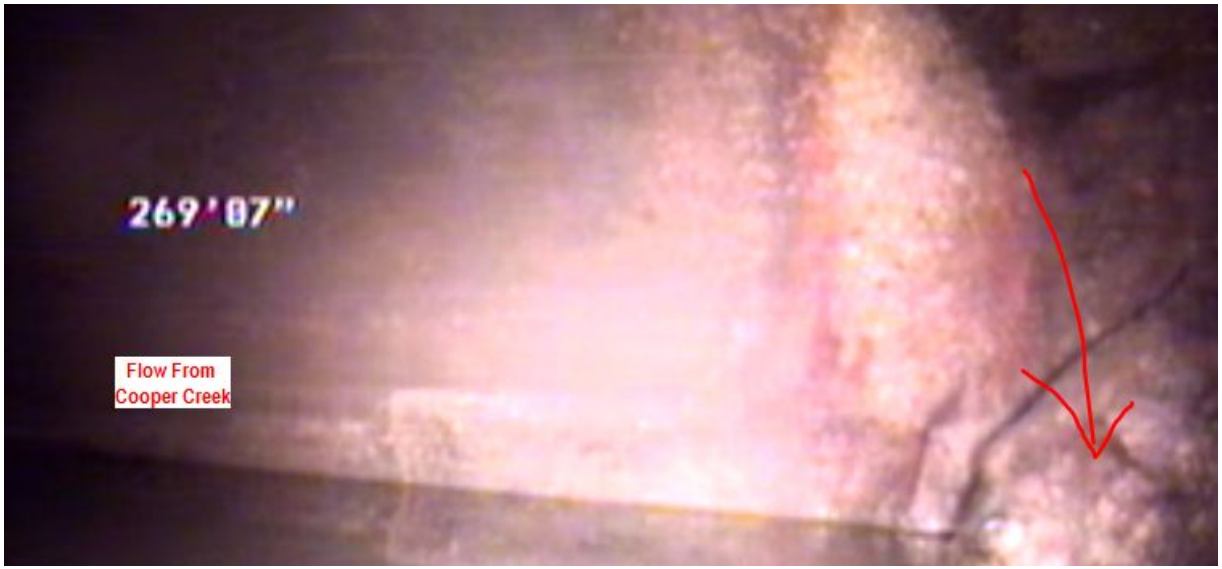






Losses at Key Hydraulic Junctions – Cooper Creek Sewer & Interceptor

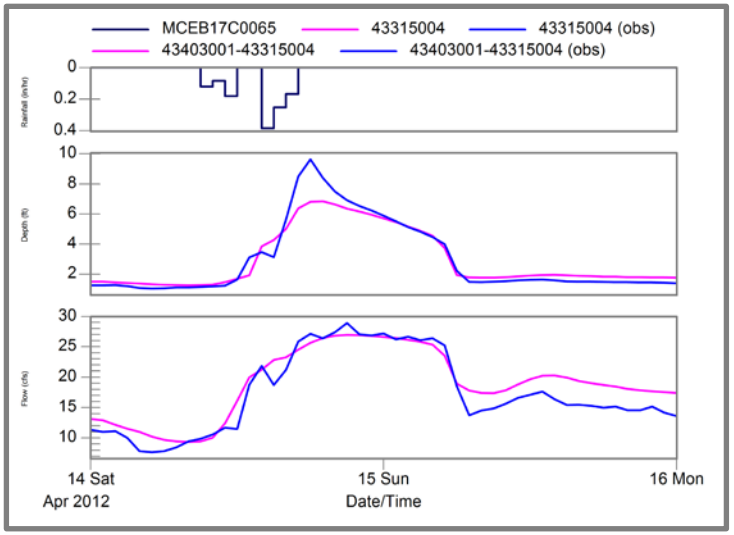




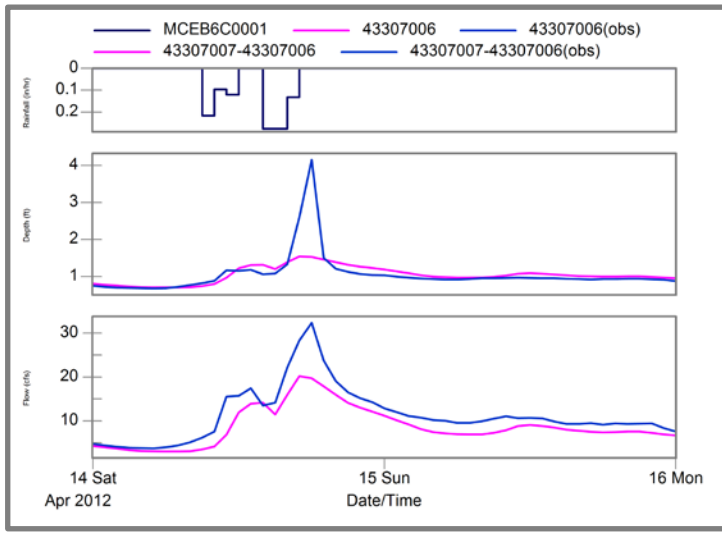
- CCTV data for the junction of the Cooper Creek sewer with the mainline interceptor shows the outlet pipe protrudes roughly 6” into the manhole and partially obstructs flow from Cooper Creek.
- When flows increase, this could result in a significant disturbance.

Modeling Losses at Key Hydraulic Junctions 4/14/12 Event

No hydraulic control at junction chamber

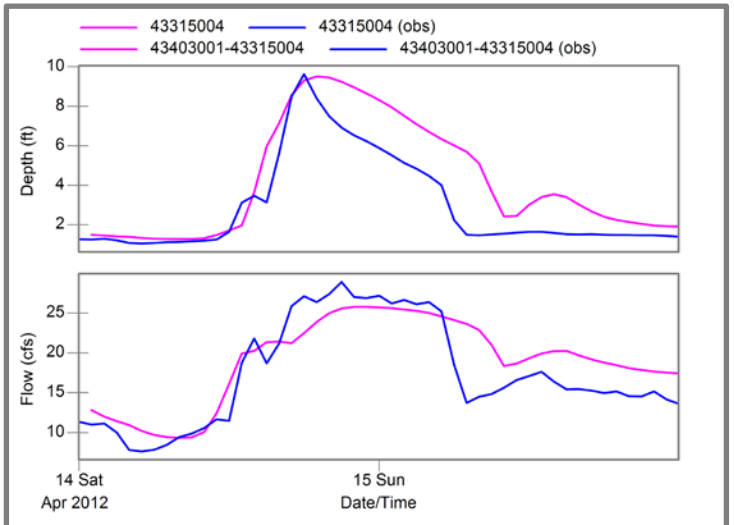


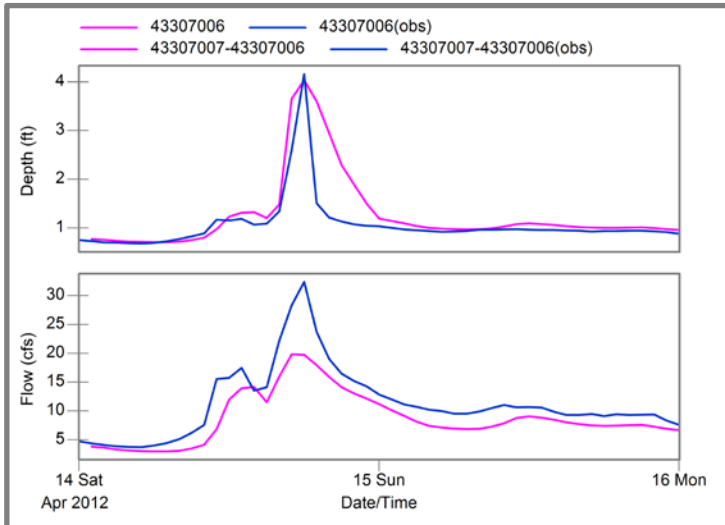
MC-EB-019



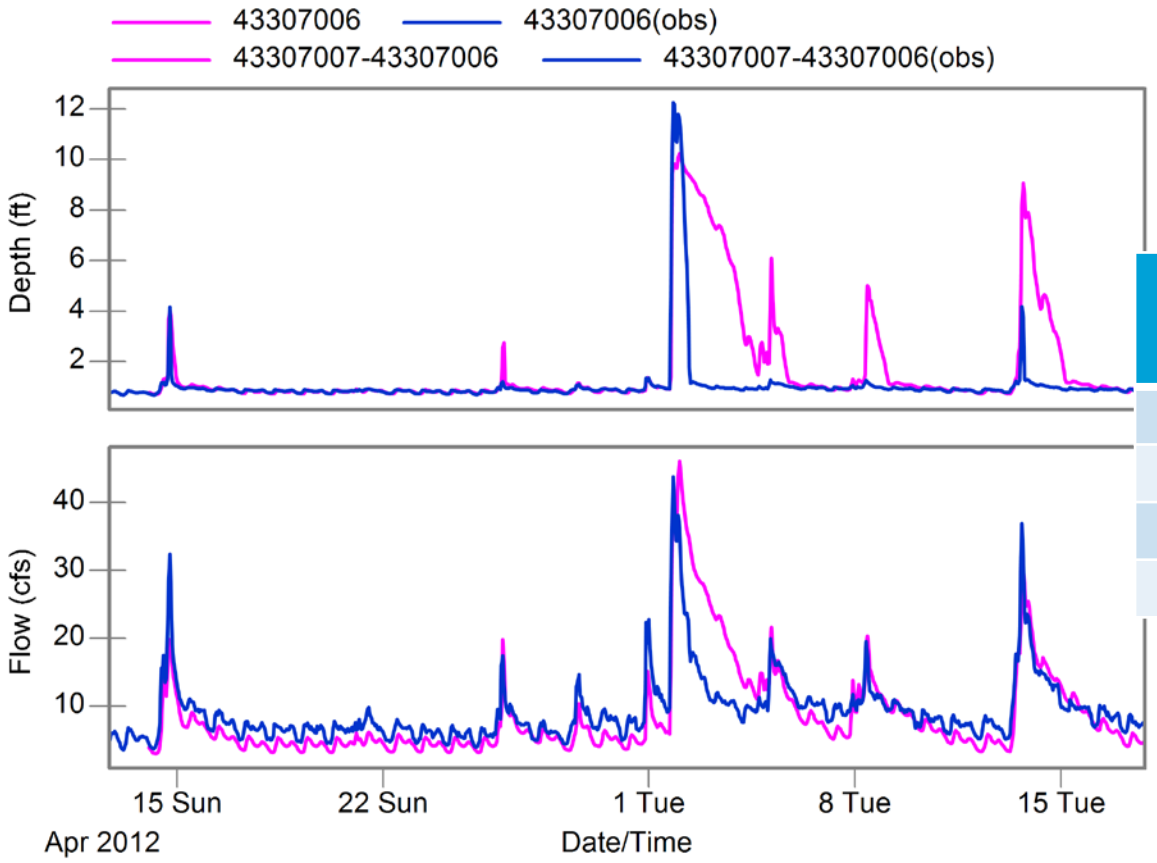
MC-EB-026

Event-specific hydraulic controls at junction chamber





Adding hydraulic controls at the junction chambers significantly raised the modeled depths, but the impact of the hydraulic controls are flow driven and vary by event



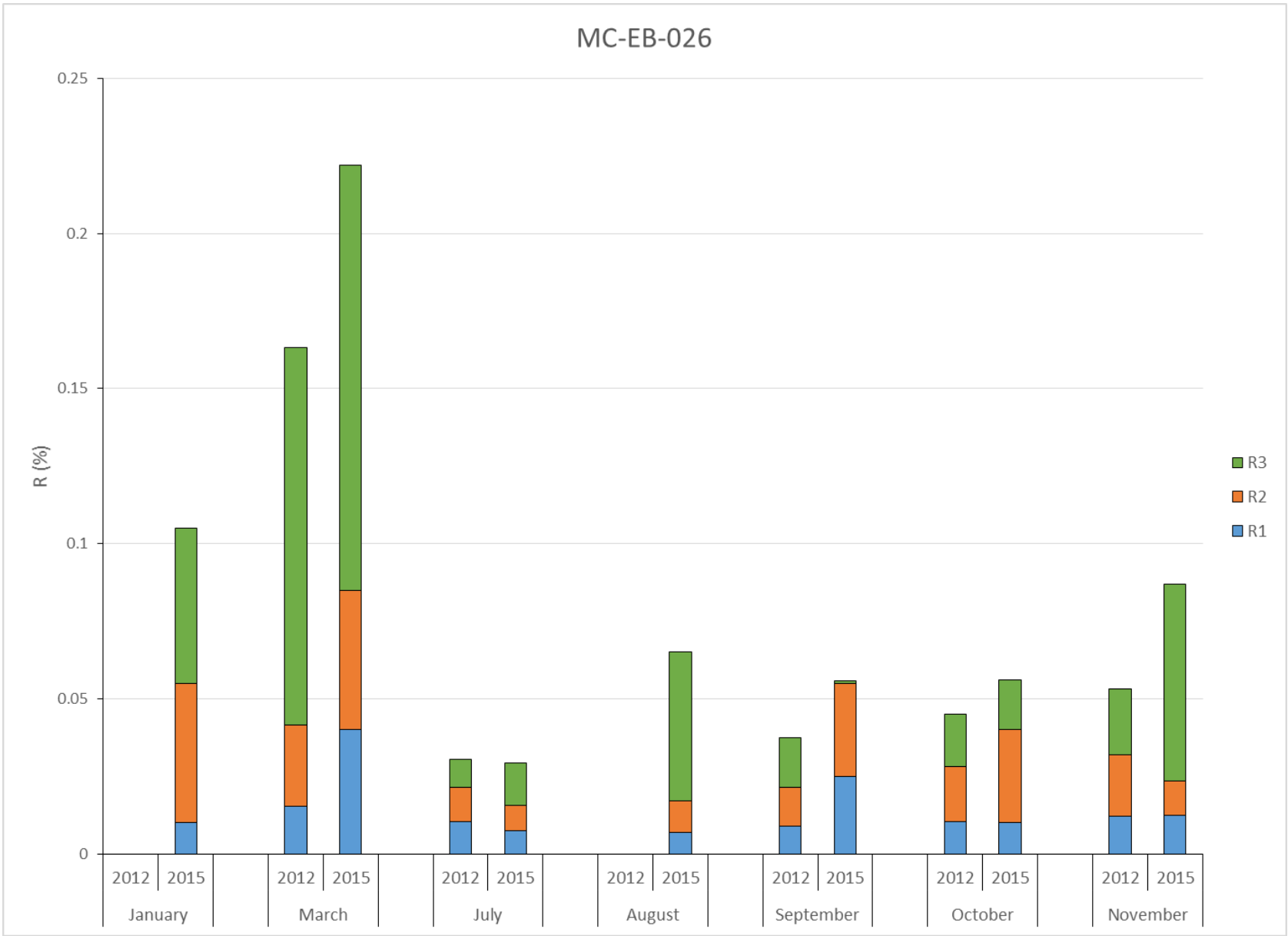
Event	Downstream Orifice Coefficient	Cooper Creek Orifice Coefficient
4/14/2012	0.28	0.25
5/31/2012	0.21	0.12
7/18/2012	0.17	1.00
11/5/2015	0.28	0.20

Missing Flow- RDII

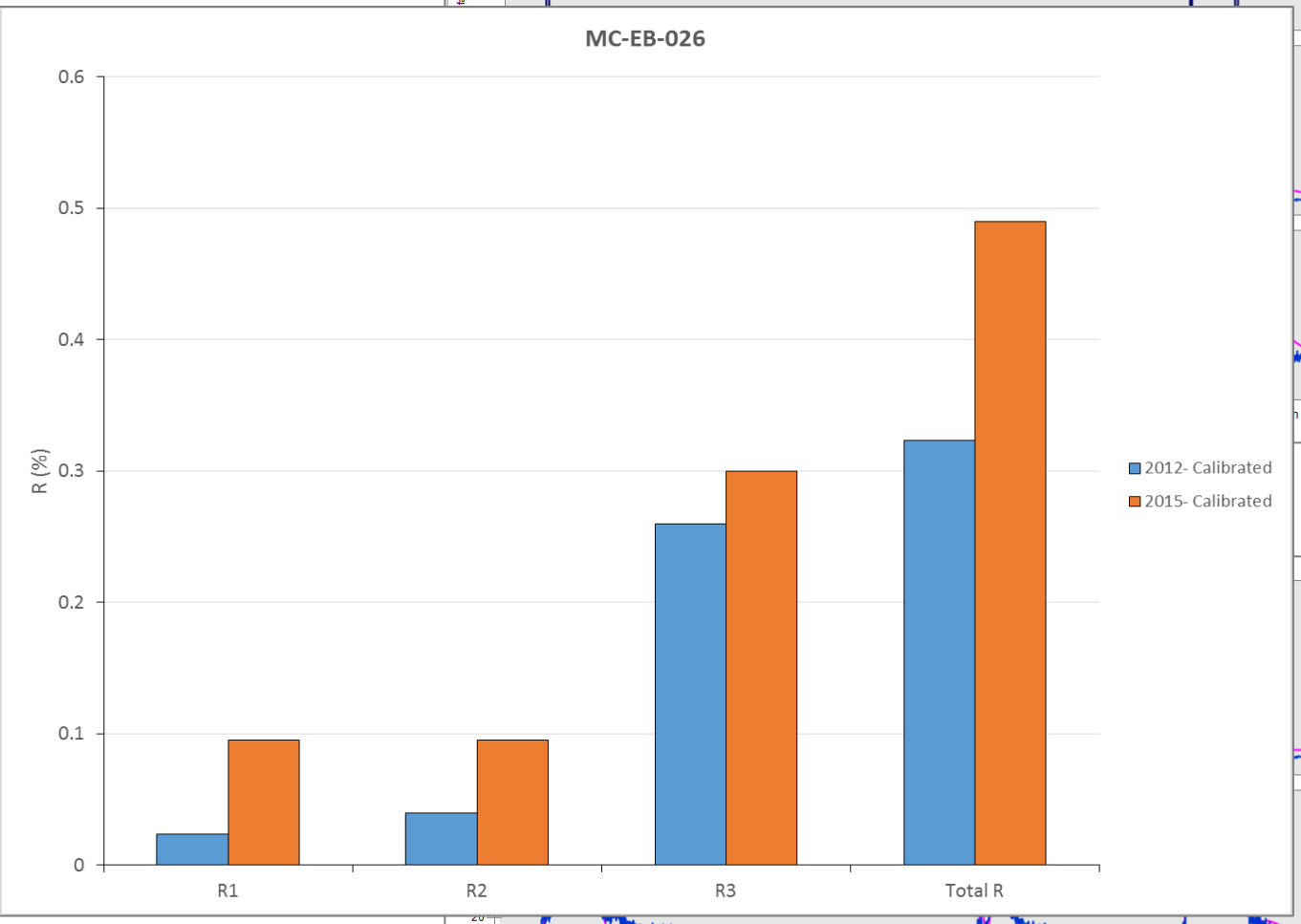
Missing Flow – RDII at MC-EB-026

Event	Peak Flow Difference (%)	Volume Difference (%)	Depth Difference (ft)	Observed Depth (ft)	Surcharged
1/2/2015	6%	-13%	-0.91	12.17	Y
3/3/2015	-34%	-30%	-3.42	10.49	Y
7/28/2015	-21%	-8%	0.149	1.187	N
8/3/2015	-5%	-9%	0.348	1.422	N
8/18/2015	No Data				
9/29/2015	-52%	-27%	-0.04	0.9651	N
10/27/2015	4%	18%	1.846	6.425	Y
11/5/2015	-48%	-29%	-3.79	5.519	Y
11/17/2015	-37%	-26%	0.066	1.45	N

2012 vs 2015 R-values from SSOAP



Calibration of March Validation Event for MC-EB-026



Calibration of March Validation Event for MC-EB-026

MC-EB-026 Results

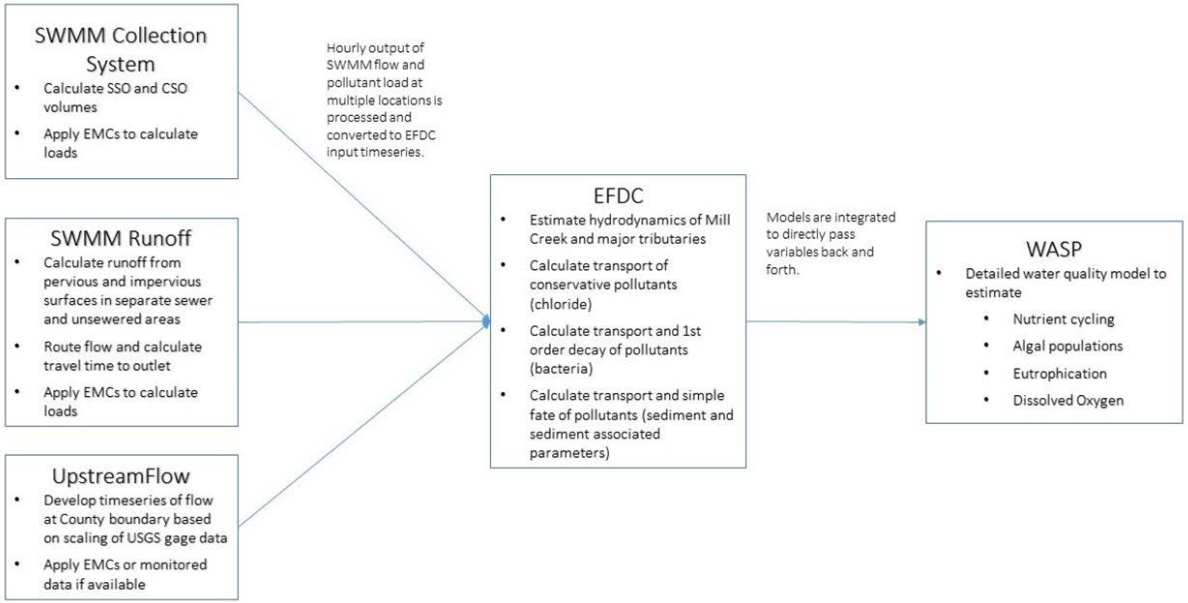
Conditions	Peak Flow Difference (%)	Volume Difference (%)	Depth Difference (ft)
2012 Calibrated RTKs	-34%	-30%	-3.42
2015 Calibrated RTKs	-1%	-2%	-0.19

Conditions	Observed Influent (MG)	Modeled Influent (MG)	Influent Difference (MG)	Observed Treated (MG)	Modeled Treated (MG)	Treated Difference (MG)	Observed Overflow from Tanks (MG)	Modeled Tank Overflow (MG)	Tank Overflow Difference (MG)
2012 Calibrated RTKs	111.9	72.3	-39.6	69.1	45.5	-23.6	39.1	20.8	-18.3
2015 Calibrated RTKs	111.9	112.9	1.0	69.1	55.3	-13.8	39.1	35.9	-3.2

Summary & Conclusions

Summary & Conclusions

- Successfully calibrated the SSO 700 Study Area model using a robust set of data
- Reasonably validated the SSO 700 Study Area model
- Next Steps:
  - Results from the hydraulic model provide input to water quality model framework for characterization of instream water quality conditions.



Thank You