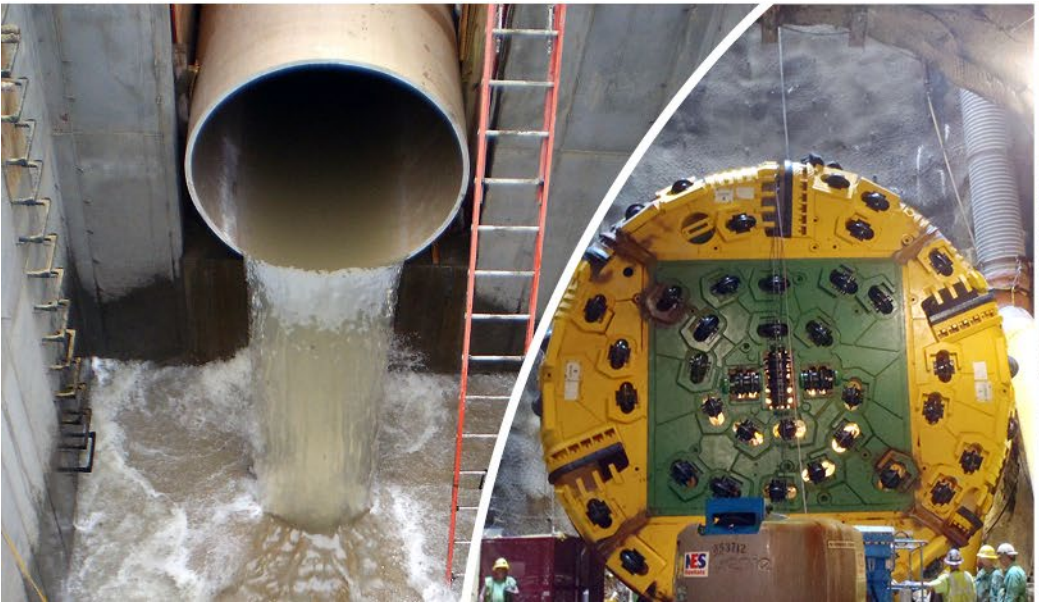


CSO CD and NPDES Permit Performance Compliance Project (PCP)

WBS No. 1407

Buckeye GI & E140CRS GI PCMP Site-Specific Performance Summary

February 15, 2021

WADE TRIM

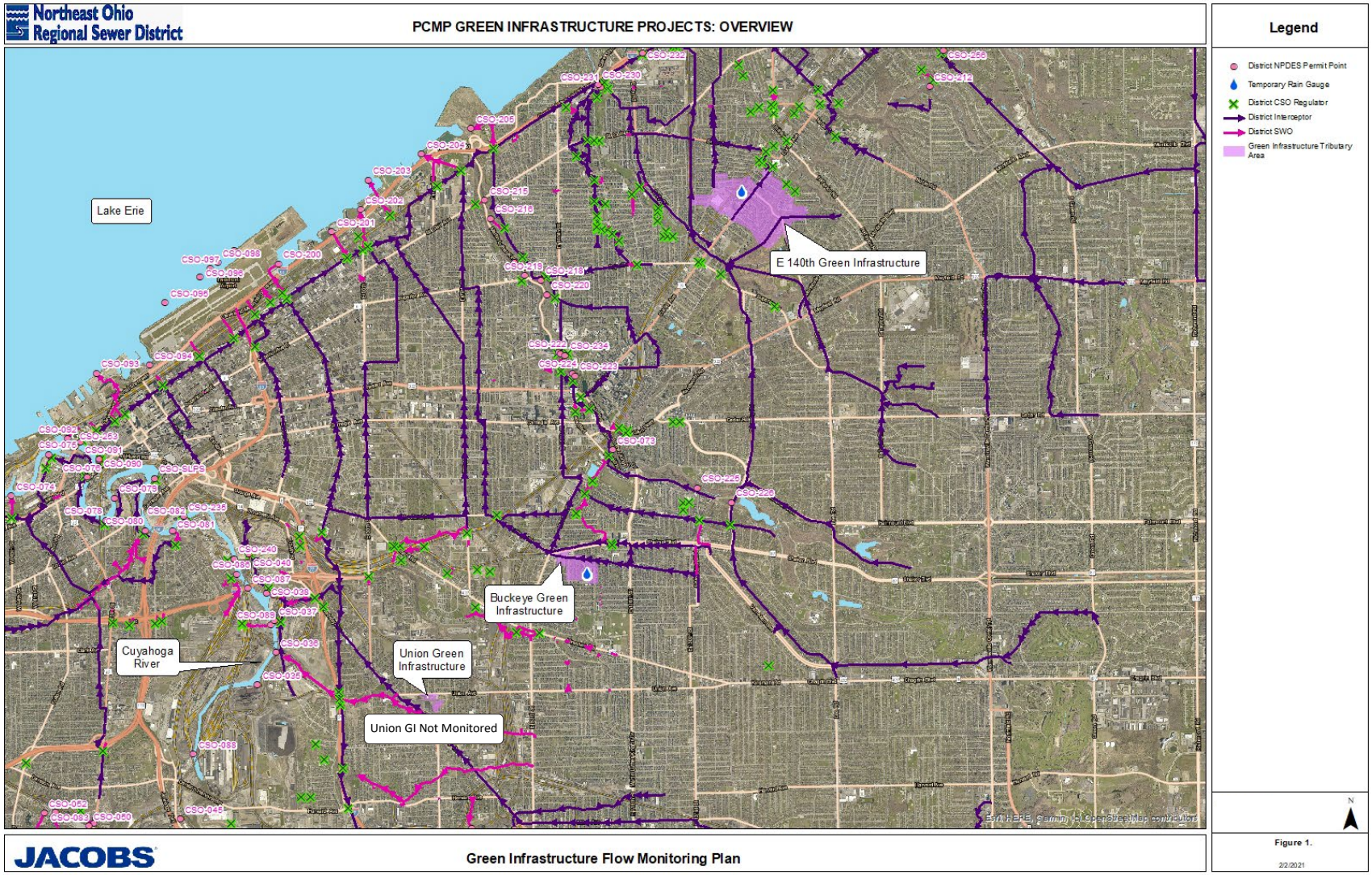
PROJECT CLEAN LAKE

Northeast Ohio Regional Sewer District

Buckeye GI & E140CRS GI PCMP Site-Specific Performance Purpose & Approach

- Flow Monitoring & Data Analysis
  - Monitor GI performance & submit data to EPA per Appendix 3 of CD
- Assess GI model representations using FM data
  - Calibrate and update representations as necessary
- Identify updates from adjusted model representations as appropriate to unmonitored GI projects

Buckeye GI & E140CRS GI PCMP Site-Specific Performance Overview



Buckeye GI & E140CRS GI PCMP Site-Specific Performance Flow Monitoring & Data Analysis

FMP timeline: August 2019 – August 2020

Project Site	Flow Monitors	Precipitation Gauges	Monitoring period
Buckeye GI (Part of District's Union Buckeye Green Infrastructure (UBGI) project)	3	1	8/1/2019 through 7/31/2020
E 140th Consolidation Relief Sewer (E140CRS) - Green Infrastructure	2	1	8/15/2019 through 8/14/2020

Buckeye GI (*see Slides 5-12*)

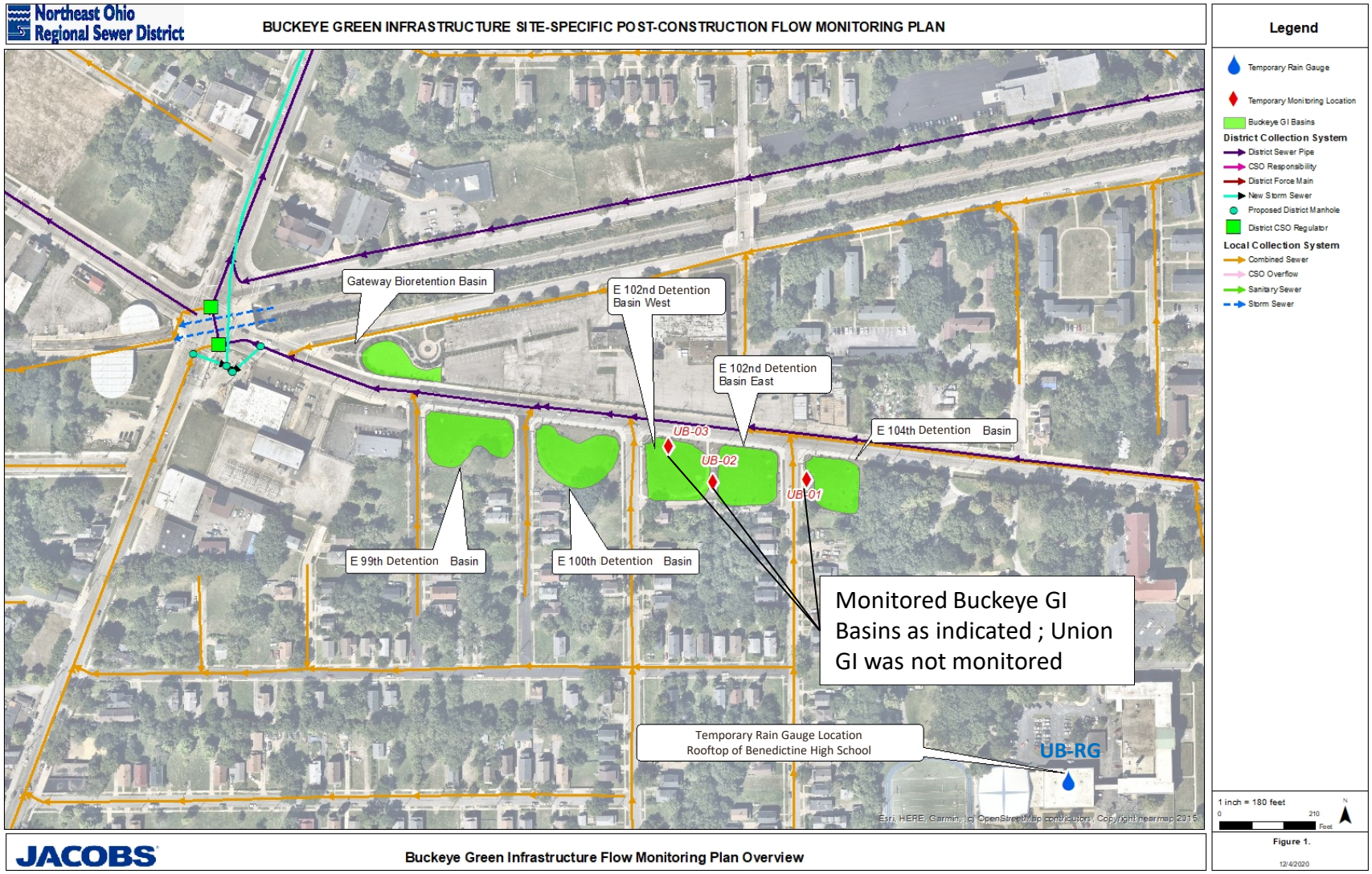
- Low depth and low velocity observed during wet weather flow (WWF) due to small tributary area (<5 acres)
- Dry pipes during dry weather

E140CRS GI (*see Slides 13-20*)

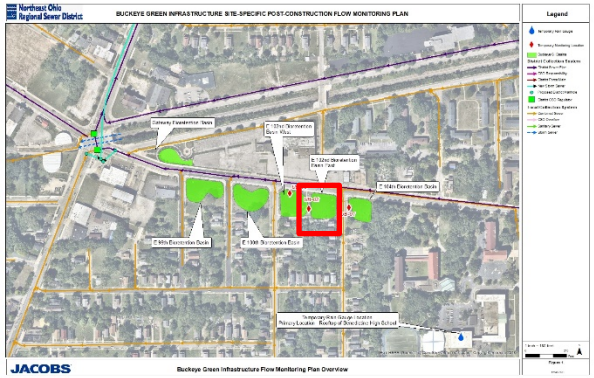
- Flow balance discrepancies observed
  - Majority of calibration events with flow discrepancies started prior to full dewatering of basin
- Small baseflow observed at E140CRS but field observations indicated standing water
  - Baseflow believed to be due to standing water and lower limit of velocity reading when submerged

- In general, data with equal time intervals (i.e., no gaps) was used for analysis unless otherwise noted.
- Not all inflows were monitored, therefore observed outlet flow could exceed observed inflows.

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
Buckeye GI Overview



Buckeye GI & E140CRS GI PCMP Site-Specific Performance
Buckeye E 102nd GI Basin East Monitor Locations



UB-02 located at outlet of E 102nd GI Basin East is largest single point discharge to E 102nd GI Basin West (next slide)

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
Buckeye E 102nd GI Basin West Monitor Location

E 102nd GI Basin West discharge to Combined sewer; monitored at outlet structure (UB-03)

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
Buckeye GI: Design Criteria

Detention Basins in series designed to intercept runoff prior to inlet to Doan Valley Interceptor on Buckeye Rd

Buckeye GI Basin ID	BODR Max Available Storage Volume (MG)	BODR Max Basin Ponding Depth (ft)	BODR Design Storm Peak Detention Volume (MG)	BODR Design Storm Peak Release Rate (MGD)	BODR Design Storm Peak Release Rate (MGD)	BODR Drainage Area (acres)	Calculated Drainage Area based on As-built Conditions[1] (acres)	Monitored
Gateway	0.25	8.0	0.19	6.3	0.10	5.2	3.7	No
E 99	0.16	2.5	0.08	1.3	0.03	2.1	2.1	No
E 100	0.18	2.0	0.07	1.1	0.03	1.6	1.6	No
E 102 West	0.24	3.0	0.14	1.9	0.11	3.2	2.4	Yes
E 102 East	0.20	2.5	0.12	1.7				
E 104	0.17	3.5	0.08	1.8		7.4	2.6	Yes

[1] *Delineated per as-built conditions based off GIS DCIA and overland flow routes*

- Design Storm: Typical Year Storm 86

Storm Event	Rainfall Volume (in)	Peak 1-Hour Intensity (in/hr)	Design Criteria
Design			
Storm 86	2.38	0.40	Basin
10-yr, 6-hr	2.70	3.88	Storm Sewer

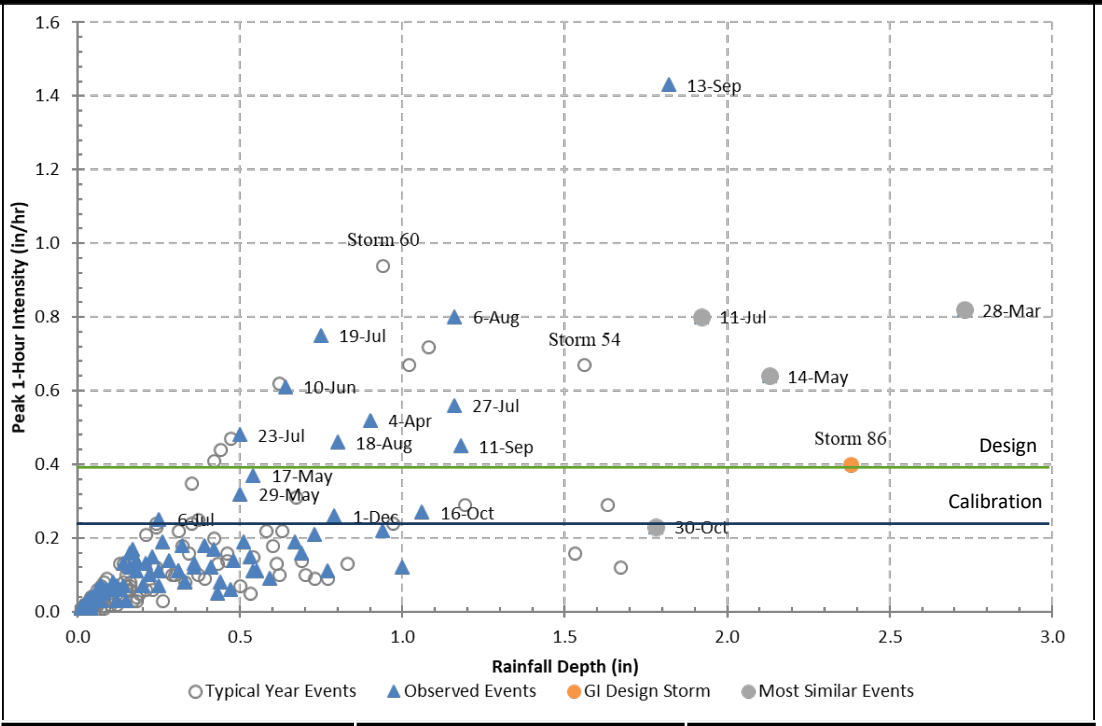
Buckeye GI & E140CRS GI PCMP Site-Specific Performance
Buckeye GI Monitoring Data Summary

- Precipitation, flow depth and velocity data collected
  - 8/1/2019 – 7/31/2020
- Total Precipitation: 39.75 inches
- Individual Precipitation Events (12-hour inter-event): 119 events
  - No. of Events with intensity > 0.25 in/hr: 17
- Gaps in data:
  - Missing precipitation data for July 14th and 15th due to a low battery (UB-RG)

GI Structure (Meter Name)	Total Flow Duration (Days)[1]	Total Flow Volume (MG)	Total Drainage Area (Acre)
E 102 West [2] Outfall (UB-03)	18.8	2.04	5.00
E 102 East Outfall (UB-02)	17.2	0.40	3.51
E 104 Outfall (UB-01)	30.7	0.33	2.60

[1] *Defined as total time flows at meter are greater than 0 MGD*
[2] *Backflow preventer directly downstream of monitor noted to cause backwater like conditions for some events*

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
Buckeye GI Comparison of Observed to TY Storm Events



Storm Event	Total Volume (in)	Peak 1-Hour Intensity (in/hr)
Design		
TY Storm 86	2.38	0.40
4 Most Similar Observed Storm Events		
October 30, 2019	1.78	0.23
March 28, 2020	2.73	0.82
May 14, 2020	2.13	0.64
July 11, 2020	1.92	0.80

Observed Storm Summary (1 Year Period):

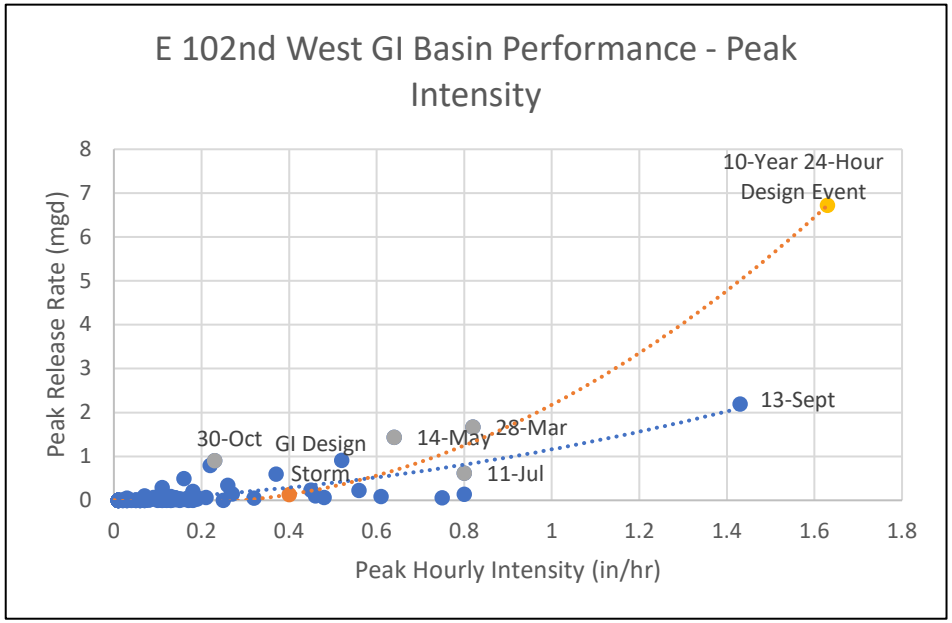
- 17 calibration events (above blue line)
  - Accounted for 18.83 inches of the 39.75 inches of rainfall.
- 12 events exceeded peak 1-hr intensity of Storm 86; shown above green line
- 1 event exceeded the total volume of Storm 86
- May 14, 2020 event was the most similar to Storm 86 in both peak 1-hr intensity & volume
- September 13, 2020 event has the greatest peak 1-hr intensity (1.4 in/hr); 2-year design intensity

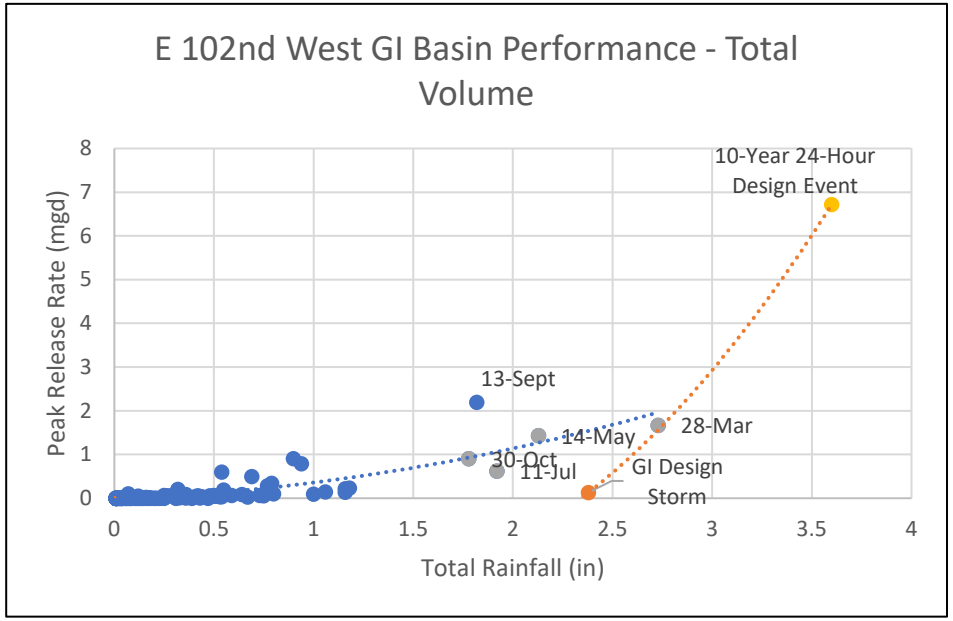
Performance Considerations:

- Basin response to events most similar to design storm; (see table - 10/30/19, 3/28, 5/14, 7/11/20)
- Peak Release Rate of similar observed storms compared to the Design Release Rate
  - Design release rate for Storm 86,
  - Release rate for 10-yr, 6-hr provided in BODR
- Flow returning to the combined sewer system
  - E 102nd West GI Basin outlet (UB-03)

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
Buckeye E 102nd West GI Basin Performance

- E 102nd GI Basin performed as expected within the range of the observed data set, supporting that the Buckeye GI will perform greater than expected during larger more intense storms
  - Events with similar volume of precipitation perform similarly well to design criteria
  - Trend lines indicate basin release rates are higher than expected for lower volume/intense storms, but lower than expected for larger volume/intense events (such as March 28th storm)
    - Note additional storm intensities greater than 1 in/hr would need to be observed to confirm this trend holds





Trendline based on typical year 86 and 10-year 24-hr design flow rates

Trendline based on observed data

Observed Storm Peak Release Rate

Design Storm Approximation

Most Similar Events

10-Year 24-Hour Design Event

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
Buckeye E 102nd West GI Basin Model Representation

Model representation:

- Validated tributary area and updated hydraulics per as-built drawings
- Assessed basin operation using FMP data

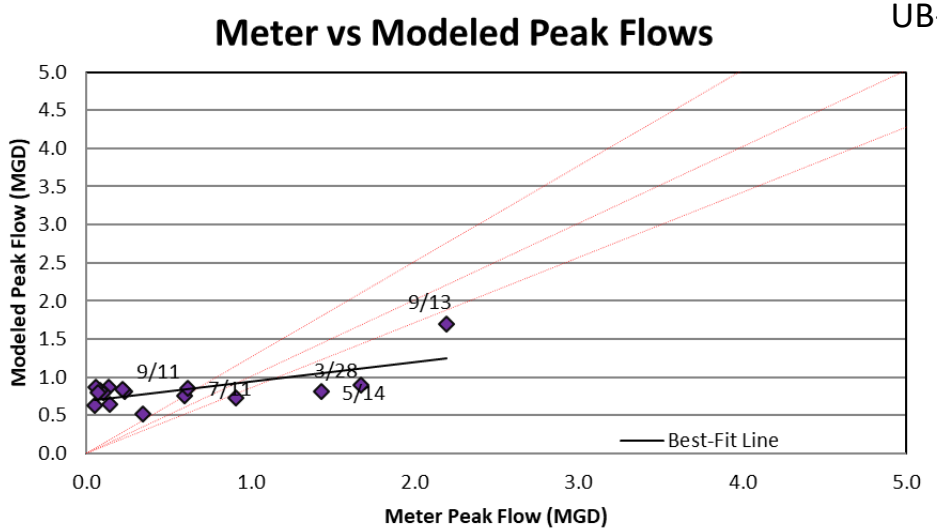
Calibration updates:

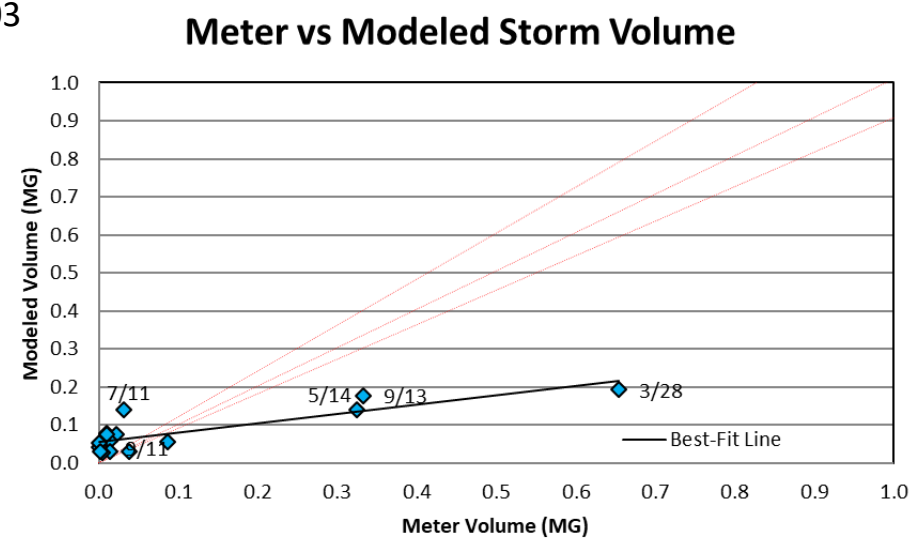
- Head discharge curve applied to outlet structure based on meter data
  - Head discharge from West 102nd applied to East 99th basin
- Contributing area varied from GIS Total area
  - Most likely caused by catch basin being proportionally less effective during larger runoff events

Summary findings post model updates:

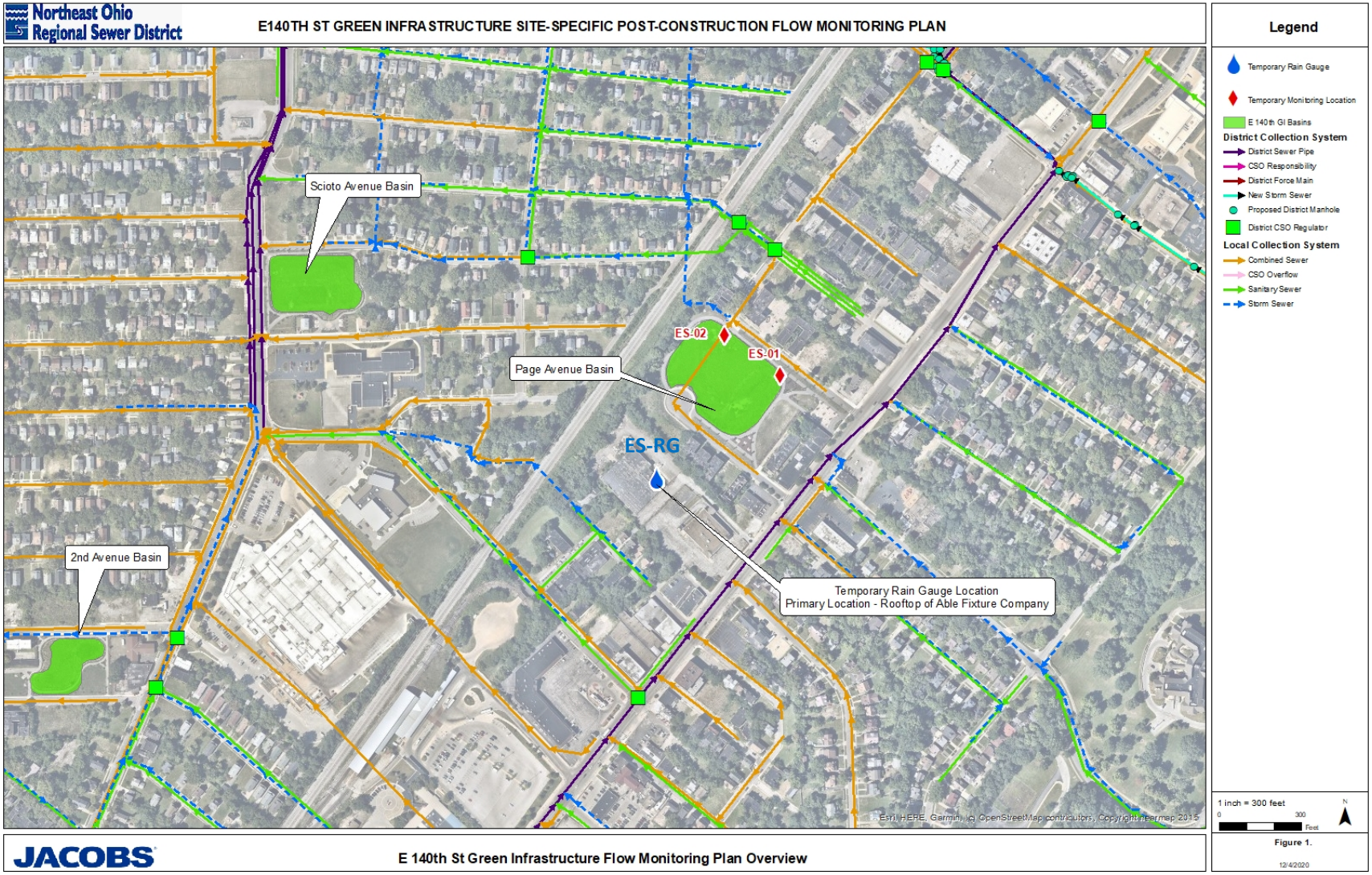
- Model updates improve GI representation from original model
- At the point of discharge to the combined system (UB-03), peak discharge of the calibrated model matches the observed peak discharge while total volume for larger events slightly underpredicted by the model
- Peak discharge and volume slightly larger than observed during smaller events due to contributing area varied from GIS area; for reasons described previously
- Limited lessons learned during calibration were transferable to other GI facilities as described in calibration updates

UB-03

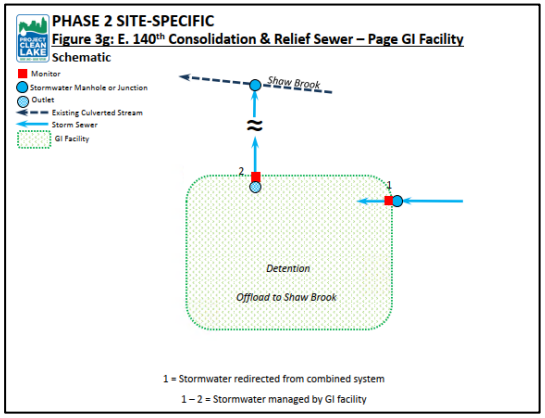




Buckeye GI & E140CRS GI PCMP Site-Specific Performance
E140CRS GI Overview



Buckeye GI & E140CRS GI PCMP Site-Specific Performance
E140CRS GI Page Basin

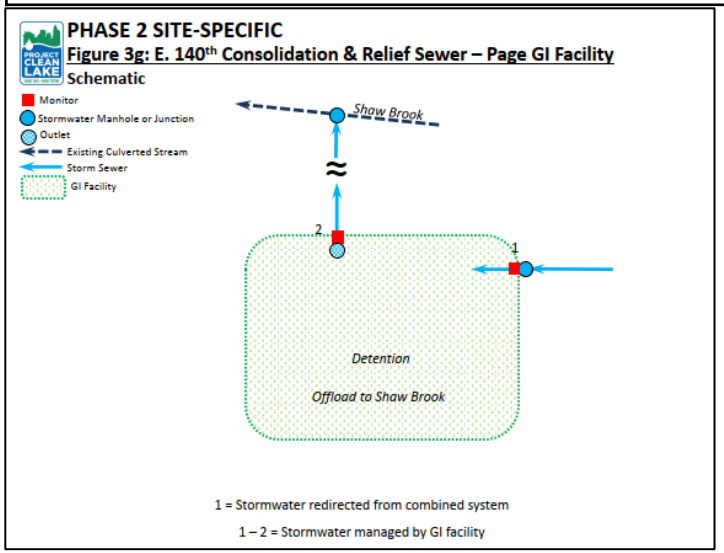


Buckeye GI & E140CRS GI PCMP Site-Specific Performance E140CRS GI Design Criteria

3 Dry bioretention basins designed to intercept runoff that previously entered the combined sewer. Excess wet weather runoff is diverted back into the combined system

GI Facility	BODR WQv (MG)	BODR WQv Basin Ponding Depth (ft)	BODR WQv Peak Release Rate (MGD)	BODR Design Storm Volume (MG)	BODR Design Storm Depth (ft)	BODR Design Storm Peak Release Rate (MGD)	BODR Drainage Area (acres)	Calculated Drainage Area based on As-built Conditions[1] (acres)	**Monitored**
Page Basin	0.36	1.10	0.83	2.16	4.4	4.87	86	89.9	Yes
Scioto Basin	0.55	1.68	4.82	2.12	5.6	15.80	102	95.7	No
Second Ave Basin	0.13	1.26	0.93	0.33	3.8	6.16	35	42.0	No

[1] Delineated per as-built conditions based off GIS DCIA and overland flow routes



- Design Storm: 5-yr, 6-hr

Storm Event	Rainfall Volume (in)	Peak 1-Hour Intensity (in/hr)
Design		
5-yr, 6-hr	2.14	1.43

Buckeye GI & E140CRS GI PCMP Site-Specific Performance E140CRS GI Monitoring Data Summary

- Precipitation, flow depth, and velocity data collected
  - 8/15/2019-8/14/2020
- Total Precipitation: 40.00 inches
- Individual Precipitation Events (12-hour inter-event): 119 events
  - Events w/ intensity>0.25 in/hr: 18 events; 18.21 inches
- Gaps in data:
  - January 18-21, 2020: ES-01 Flow monitor battery outage
  - July 29-30, 2020: ES-RG Missing precipitation data due low battery
- Constant baseflow detected at both monitors
  - Flow and depth are both small, appears to be caused by velocity sensor readings at the lower limit of the velocity sensor when sensor is submerged; based on:
    - Field observation of standing water
    - No diurnal pattern in baseflow
- Flow balance discrepancy of 0.66 MG during calibration events:

GI Structure (Meter Name)	Total Flow Volume (MG)	Total Drainage Area (Acre)
Page Basin Inflow (ES-01)	10.74	89.2
Page Basin Outfall (ES-02)	11.40	100.6

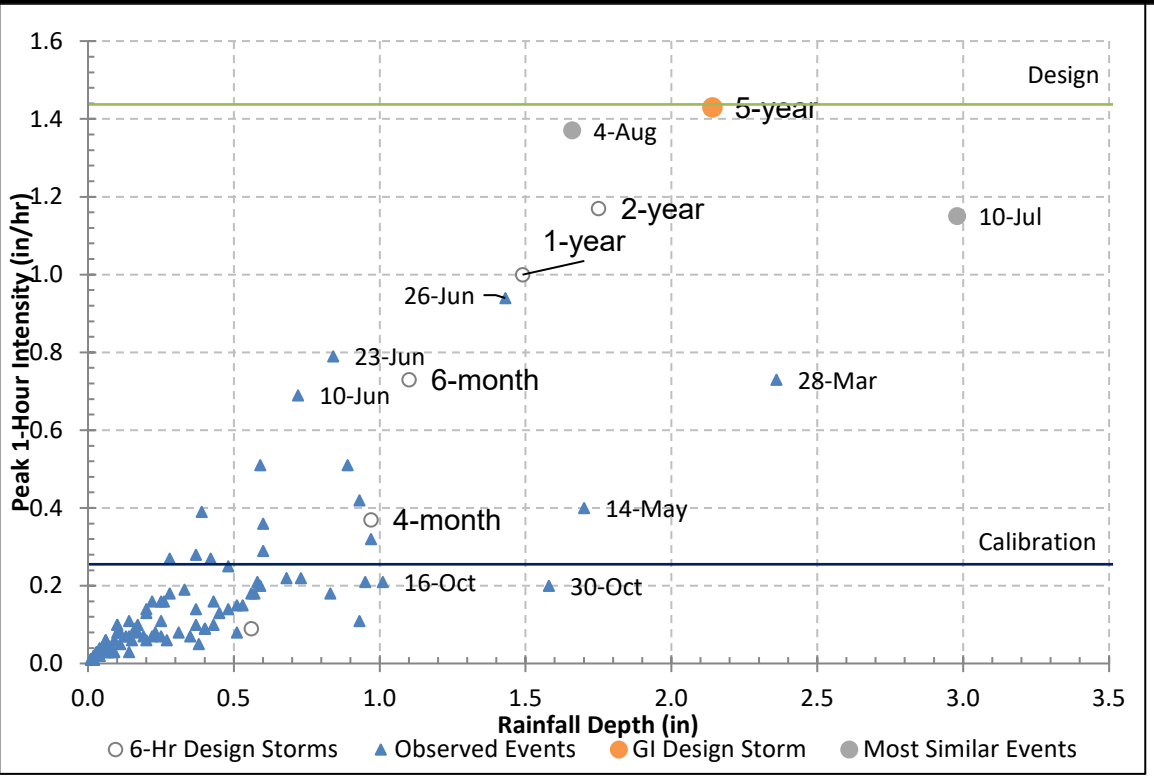
Buckeye GI & E140CRS GI PCMP Site-Specific Performance E140CRS GI Data Analysis Flow Discrepancy

- 8 of 18 had flow discrepancy after 24-hr draw down
- 5 of 8 events with flow discrepancies had an additional wet weather event occur within a 24-hour period following the end of the original wet weather event
- 24-hr drawdown period based on quality event (0.75-in precipitation).
- Discrepancy may be caused by
  - Difference in drainage area
  - Varying drawdown times
  - Baseflow; as described in previous slide

Storm Event	Volume per Monitor (MG)					
	During Storm Event			24-hour Drawdown		
	ES-01	ES-02	ES-02 – ES-01 Difference[3]	ES-01	ES-02	ES-02 – ES-01 Difference[3]
Aug 17, 2019[2]	0.05	0.01	-0.04	0.08	0.06	-0.02
Aug 18-19, 2019[1]	0.27	0.20	-0.07	0.35	0.34	-0.01
Aug 22, 2019	0.25	0.20	-0.05	0.30	0.33	0.03
Sep 11-12, 2019	0.31	0.24	-0.07	0.35	0.35	0.00
Sep 13. 2019	0.20	0.03	-0.17	0.27	0.29	0.02
Mar 28-29, 2020[1,2]	2.29	2.40	0.11	2.62	3.05	0.43
Apr 7-8, 2020[2]	0.23	0.05	-0.18	0.36	0.29	-0.07
May 14-15, 2020	1.08	0.64	-0.44	1.31	1.46	0.15
May 17. 2020[2]	0.13	0.02	-0.11	0.22	0.16	-0.06
May 22, 2020[1]	0.16	0.03	-0.13	0.26	0.22	-0.04
May 29, 2020[1]	0.10	0.02	-0.08	0.16	0.12	-0.04
June 10-11, 2020	0.18	0.10	-0.08	0.22	0.23	0.01
June 23, 2020[1]	0.24	0.01	-0.23	0.35	0.37	0.02
June 26-27[2]	0.50	0.28	-0.22	1.58	1.34	-0.24
June 27, 2020[1]	0.14	0.03	-0.11	1.48	1.67	0.19
July 10-11, 2020	0.81	0.42	-0.39	1.31	1.63	0.32
Aug 3, 2020[1,2]	0.02	0.00	-0.02	0.26	0.13	-0.13
Aug 3-5, 2020[1,2]	1.14	1.35	0.21	1.27	1.41	0.14

1. Precipitation within 24hr prior to storm event
2. Precipitation during 24hr draw down; reported flow volume does not include second event
3. Flow discrepancies in red text

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
E140CRS GI Comparison of Observed to Design Storm



Storm Event	Rainfall Volume (in)	Peak 1-Hour Intensity (in/hr)	Peak Release Rate (MGD)
Design			
5-year, 6-hour Design Storm	2.14	1.43	4.87
2 Most Similar Observed Events			
July 10, 2020	2.98	1.15	4.68
August 4, 2020	1.66	1.37	5.03

Observed Storm Summary:

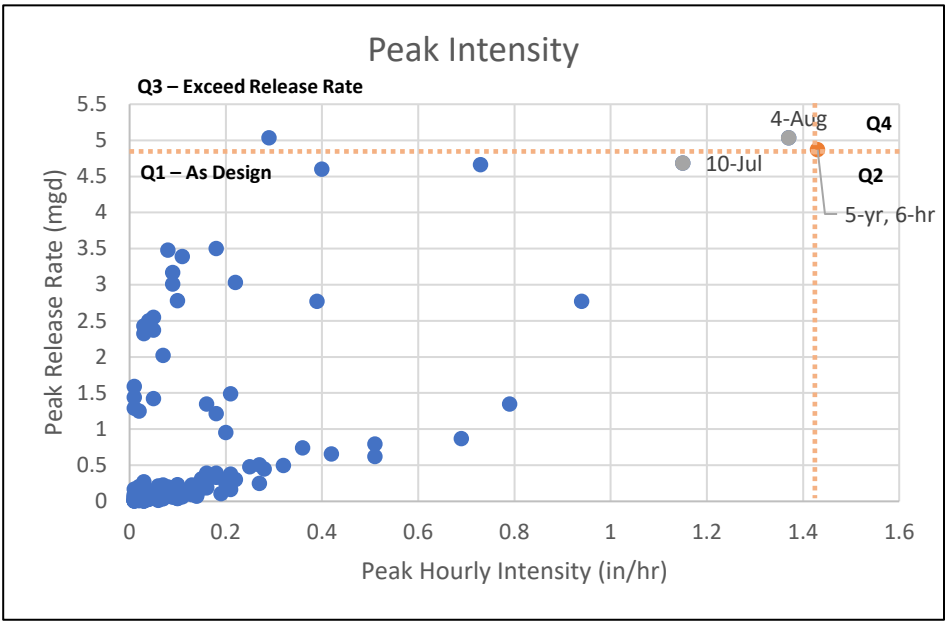
- 18 events accounted for 18.21 inches of total 40.00 inches
- No events exceeded the peak hourly intensity of the 5-yr event (1.43 in/hr)
- Aug 4, 2021 event has the greatest peak 1-hr intensity (1.37 in/hr)
- 2 events (7/10/21 and 3/28/21) exceeded the 5-yr total volume

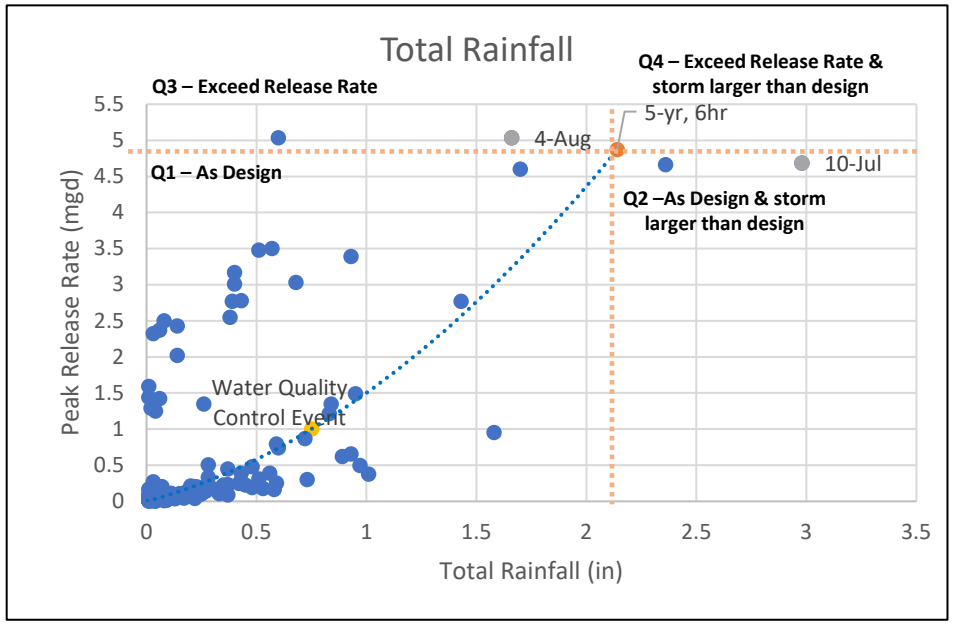
Performance Considerations:

- Basin response to events most similar to design storm; (see table - 8/4/21,7/10/21)
- Peak Release Rate of all observed storms compared to Design Release Rate
  - Design release rate for 5-yr, 6-hr & WQv provided in BODR
- Comparison based flows at outlet of Page GI Basin (ES-02)

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
E140CRS GI Page Basin Performance

- Basin performed as expected for 117 of 119 (>98%) of storm events as indicated by Peak Intensity and Total Precipitation Volume scatter plots
  - Regions Q1 and Q2 in scatter plots indicate outflow is below design max discharge
  - For the monitoring period, two events (8/3/2020,8/4/2020) had observed discharge rates greater than design discharge rates
    - August 4 – the most intense storm and most similar to design criteria (5-yr, 6-hr design storm) should in theory have a peak discharge less than the design discharge but did not; with precipitation events ending on 8/2 and 8/3 (totaling precipitation equaling 1.22") it assumed the page basin was still in drawdown for both August 4 and 3 events
  - When precipitation exceeds design criteria as with high intensity storm during a period of basin drawdown (i.e. 8/4/2020), the peak discharge is only slightly greater than design, supporting the basin is operating as intended





*No peak intensity for WQv event
(WQv is capture of first 0.75 in precipitation)

Water Quality Control Event
Design Storm Approximation
Observed Storm Peak Release Rate
Most Similar Events
Trendline based on Design Storm and WQv event

Buckeye GI & E140CRS GI PCMP Site-Specific Performance
E140CRS GI Page Basin Model Representation

Model representation

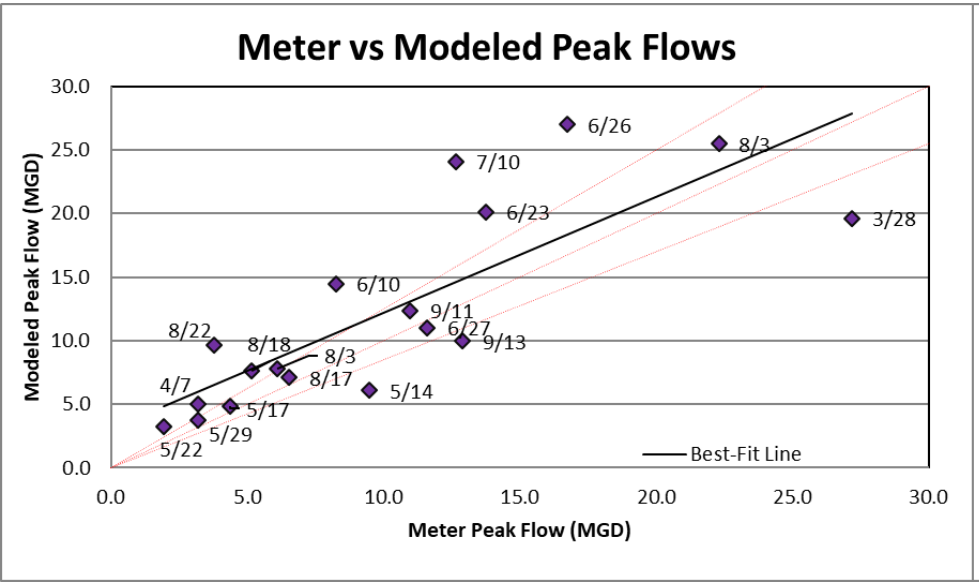
- Validated tributary area based on as-builts
- Updated hydraulics per as-built drawings
- Assessed basin operation per FMP data

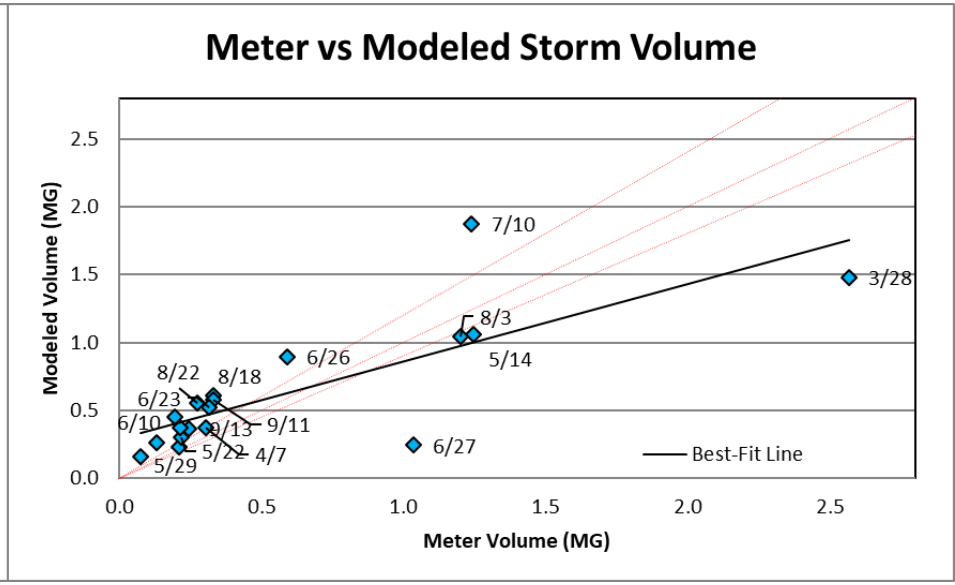
Calibrate updates

- Removed baseflow from Storm subcatchments where appropriate.
  - Base storm flow was removed from storm subcatchments which where not previously monitored during past calibration efforts
- Infiltration was added to Page basin
  - Extrapolated infiltration to all E140CRS GI basins

Summary findings post model updates:

- Model updates improve GI representation from original model
- Model peak discharge and total volume to Page basin show good correlation with metered peak discharge and total volume at ES-01
- Lessons learned from calibration effort applied to other 2 E140CRS GI basins as described in Calibration updates





Buckeye GI & E140CRS GI PCMP Site-Specific Performance Summary of Findings

- Buckeye GI
  - E 102nd West Basin, which connects back to combined system, appears to operate within an acceptable range of designed for storms with peak intensity similar to Storm 86 and exceeds performance for larger events.
  - Head discharge curve from E 102nd west basin was able to be applied to E 99th basin which was not monitored.

- E140CRS GI
  - Page Basin operates with observed peak release flow rates lower than the design release rate for the majority of events; meeting design performance
  - Minimal changes made to model representation as part of calibration
  - Model updates such as basin Infiltration and removal of base storm flow was able to be reasonably extrapolated to other E140CRS GI facilities

Buckeye GI & E140CRS GI PCMP Site-Specific Performance Next Steps

- Required site specific monitoring by GI PCMP is now completed (next slide)
- Complete/finalize site specific reporting
- Complete Easterly GI Sewershed post construction monitoring effort (August 5th, 2020 through August 4th, 2021)
- Perform model assessment of the Easterly Sewershed
- Evaluate the GI performance using the model-based approach in the GI PCMP
  - Final report by December 2021

GI PCMP Site-Specific Performance Summary of Findings

GI Project	CSO District	GI Technology	Site Specific Monitoring Status	Notes
E 140th St Consolidation & Relief Sewer GI	Easterly	Dry detention Basin; overflow to receiving water; capture 10-yr 6-hr event	Completed August 2020	Updates based on GIPCMP effort; No storm baseflow and limited infiltration applied to 2nd and Scioto basin
Buckeye GI	Easterly	Detention Basin; attenuate flow to CSS; overflow to receiving water	Completed August 2020	Updated based on GIPCMP effort; head discharge relationship applied to E99th basin outlet
Green Ambassador - Fairhill/MLK	Easterly	Bioretention with overflow to CSS; Capture typical year	Completed March 2018	Updated based on GIPCMP effort
University Circle GI Demonstration	Easterly	Permeable paver/detention storage/infiltration overflow to CSS	Complete	Technology unique to University circle
Union GI	Southerly	Detention Basin; attenuate flow to CSS; overflow to receiving water	Not required	Buckeye hydrologic changes not applicable; Outlet head discharge would be unique due to size
Fleet Ave GI	Southerly	Infiltration basin with overflow to CSS	Completed March 2018	Updated based on GIPCMP effort
Green Ambassador - Urban Agriculture	Southerly	Detention basin in series to capture first 1”	Completed March 2018	Updated based on GIPCMP effort
Woodland central GI	Southerly	Detention basin with overflow to CSS	Not required	Characteristics unique to site; impervious liner, no storm baseflow, outlet conveyed to drop structure
Slavic Village	Southerly	Bioretention with overflow to CSS (Demonstration project)	Complete September 2016	Characteristics unique to site; not transferable from other GIPCMP monitoring efforts