

## APPENDIX 14

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### *Arcadis Flow Characterization Study*

**SUBJECT**  
Preliminary Modeling of SRP Impacts

**TO**  
KISS Program Team

**DATE**  
October 31, 2022

**OUR REF**  
30151292

**DEPARTMENT**  
[Department]

**PROJECT NUMBER**  
LCA 602

**COPIES TO**  
AECOM

**NAME** Jim Shelton

After the KISS model was expanded and calibrated using 2021 flow and rainfall data, Arcadis ran an extended simulation under both 2021 and projected 2050 new development sewer use conditions. This work was done without making any modifications to the physical KISS (i.e., no new pipes, pumps, or tanks) but did consider slowly increasing I&I and slowly decrease water consumption. To broadly assess peak flows to KIIWWTP, we ran these under both open and closed system assumptions.

- A Close System run does nothing to the pipes and pumps. Overflows occur where they would occur if nothing was done to alleviate the HGLs. To broadly assess peak flows to KIIWWTP, the peak hourly flow rates from all the overflow locations were added to the peak hourly flow rate to hit KIIWWTP. This overestimates flow by adding all the peak overflows without consideration of flow transit time if/when the SSOs are captured/addressed. **This resulted in a peak hourly flow to KIIWWTP of 207 MGD.**
- An Open System run replaces all the pipes in the system with large replacements so no flow overflows. This underestimates flow because the oversized pipes provide huge in-line storage that dampens out true peak flows. **This resulted in a peak hourly flow to KIIWWTP of 178 MGD.**

The actual peak flow to KIIWWTP is *likely between these two flow rates* and can only be determined by right-sizing the pipes and pumps. This work is being done now as part of the PSOA.

Ahead of doing the actual PSOA modelling, analyses were completed to roughly estimate the value and cost of a range of Source Reduction Program approaches using the *207 MGD Closed System Run* as a benchmark. For this work, sewers, cleanouts, and manholes were split into rehabilitation cohorts based on each of the 943 catchments' RDII characteristics. Where Night-Time Weiring (NTW) results were available, these data were also considered. Manholes in know floodplains were specifically identified as a separate group of assets. These were split into the cohorts shown below. Otherwise, data from each meter basin I&I characterization was used (Pink, Red, Orange, and Yellow).

| INFLOW 1                            |                                                  |                                          | INFLOW 2                                                     | RII 1                                  |                                         |                                         | RII 2                                  | CO                              |
|-------------------------------------|--------------------------------------------------|------------------------------------------|--------------------------------------------------------------|----------------------------------------|-----------------------------------------|-----------------------------------------|----------------------------------------|---------------------------------|
| Stream based M <input type="text"/> | Peaking Factor >6 Basin MHS <input type="text"/> | PK>5 Basin Manholes <input type="text"/> | Peaking Factor <5 but >4 Sheet Flow MHS <input type="text"/> | Priority 1 Sewers <input type="text"/> | Priority 1A Sewers <input type="text"/> | Priority 1B Sewers <input type="text"/> | Priority 2 Sewers <input type="text"/> | Clean outs <input type="text"/> |

The math for how each asset was characterized was presented in the August and September KISS meetings and is in the Subcatchment Data Summary spreadsheet and in the RDII Reductions SOP. These are summarized below:



|               | SEWERS                   |                     |                            |                                       | MANHOLES |                          | Cleanouts |                          |
|---------------|--------------------------|---------------------|----------------------------|---------------------------------------|----------|--------------------------|-----------|--------------------------|
|               | Basins with NTW results  |                     | Basins without NTW results |                                       |          |                          |           |                          |
| PINK BASINS   | NTW>10 gpd/lf            | 100% as Priority 1  |                            |                                       | 75%      | Peaking Factor >=6       | 75%       | Peaking Factor >=6       |
|               | NTW>5 gpd/lf             | 100% as Priority 1A |                            |                                       |          |                          |           |                          |
|               | RDII >8 gpd/lf or BI>45% | 25% as Priority 1B  | RDII >8 gpd/lf or BI>45%   | 30% as Priority 1, 10% as Priority 2  |          |                          |           |                          |
| RED BASINS    | NTW>10 gpd/lf            | 100% as Priority 1  |                            |                                       | 75%      | Peaking Factor >=6       | 75%       | Peaking Factor >=6       |
|               | NTW>5 gpd/lf             | 100% as Priority 1A |                            |                                       |          |                          |           |                          |
|               | RDII >8 gpd/lf or BI>45% | 25% as Priority 1B  | RDII >8 gpd/lf or BI>45%   | 30% as Priority 1a, 10% as Priority 2 |          |                          |           |                          |
| ORANGE BASINS | NTW>10 gpd/lf            | 100% as Priority 1  |                            |                                       | 50%      | Peaking Factor >=5       | 50%       | Peaking Factor >=5       |
|               | NTW>5 gpd/lf             | 100% as Priority 1A |                            |                                       |          |                          |           |                          |
|               | RDII >4 gpd/lf or BI>33% | 15% as Priority 1B  | RDII >4 gpd/lf or BI>33%   | 25% as Priority 1B, 10% as Priority 2 |          |                          |           |                          |
| YELLOW BASINS |                          |                     | RDII >2 gpd/lf or BI>20%   | 5% as Priority 1B, 10% as Priority 2  | 25%      | Peaking Factor <5 but >4 | 25%       | Peaking Factor <5 but >4 |
|               |                          |                     |                            |                                       |          |                          |           |                          |
|               |                          |                     |                            |                                       |          |                          |           |                          |

We modelled 4 different SRP scenarios (WMS 1 – 4).

1. WMS1 - Inflow 1+Inflow2 + CO + Priority 1+ Priority 1A+ Priority 1B
2. WMS2 - Inflow 1+Inflow2 + CO+ Priority 1+ Priority 1A+ Priority 1B + Priority 2
3. WMS3 - Inflow 1+ Priority 1+Priority 1A
4. WMS4 - Streambased MH + PF >6

The impact of these various reduction efforts using Closed Run model is shown in the below table.

| Storm          | 2050 Total SSO Volume (MG) | 2050 Number of Overflow Locations | 2050 Peak Flow to KI (MGD) | Manholes Sealed | Sewer Rehab Miles | Approximately SRP Cost (\$M) |
|----------------|----------------------------|-----------------------------------|----------------------------|-----------------|-------------------|------------------------------|
| Ida NOAA       | 38                         | 79                                | 207                        | 0               | 0                 | \$0                          |
| Ida NOAA WMS 1 | 25                         | 52                                | 164                        | 9200            | 235               | \$94M                        |
| Ida NOAA WMS 2 | 23                         | 47                                | 161                        | 9200            | 273               | \$113M                       |
| Ida NOAA WMS 3 | 28                         | 63                                | 176                        | 5800            | 170               | \$62M                        |
| Ida NOAA WMS 4 | 34                         | 69                                | 192                        | 4400            | 0                 | \$2M                         |

Of the Miles Sewer Rehab, 78 of these miles (UMT, LMT, and Alburdis) are already mainline rehabilitated; only their taps and risers remain to be grouted, and that work will be completed in the next two years.

If we ran a WMS scenario that sealed all leaking frames/covers/chimneys in basins with peaking factors greater than 4 (9200 manholes vs. the 4400 manholes in WMS 4), peak flow to KIWWTP would likely drop to ~185 MGD (these lower leaking basins will produce less peak flow reduction upon sealing).

The WMS 1 and WMS2 Sewer Rehab work has 15-20 MGD impact on the peak flow rate. Keep in mind that this work address RII much more than it impacts inflow, so the impact for RII work is reflected in both total RDII volume reduction and baseline infiltration reduction (allocation scavenging) than in peak flows.

Based on this work, **Arcadis recommends the SRP benchmark be WMS 1.** This work is:

1. Identify and make watertight 100% of manholes in floodplains
  2. Identify and make watertight 75% of manholes in basins with peaking factors >6
  3. Identify and make watertight 50% of manholes in basins with peaking factors <6 but >5
  4. Identify and make watertight 25% of manholes in basins with peaking factors <5 but >4
  5. Identify and make watertight 10% of manholes in basins with peaking factors <4
  6. Identify and make watertight 5% of cleanouts in all basins
  7. Rehabilitate all mains, taps, and risers for sewer with NTW >5 gpd/lf
  8. Identify and rehabilitate 25% of mains, taps, and risers for sewers with RDII >8 gpd/lf or BI>45%
  9. Identify and rehabilitate 25% of mains, taps, and risers for sewers with RDII >8 gpd/lf or BI>45%
  10. Identify and rehabilitate 15% of mains, taps, and risers for sewers with RDII >4 gpd/lf or BI>33%
  11. Identify and rehabilitate 5% of mains, taps, and risers for sewers with RDII >2 gpd/lf or BI>20%
- Items 1-5 will be identified via specific manhole inspection program of 100% of system manholes.
  - Item 6 will be identified via yard inspections of 100% of system properties.
  - Item 7 are already identified.
  - Items 8-11 will be identified via multiple rounds of NTW or micrometering.



# KLING'S ISLAND SEWER SYSTEM (KISS) 2021 MODEL

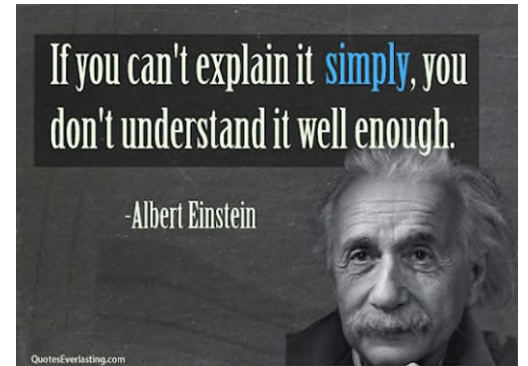
Calibration Overview – LCA Board

August 8, 2022



# Agenda

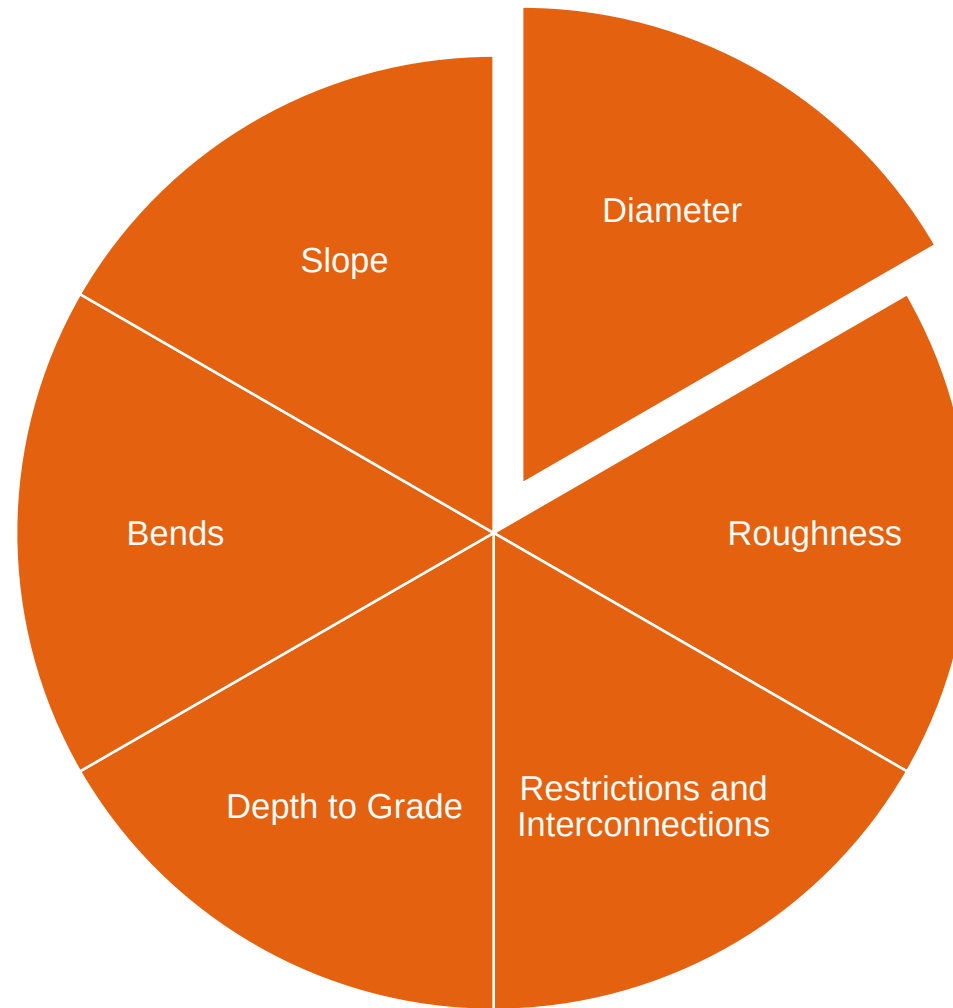
- What is a dynamic hydraulic sewer model?
- What is a model used for?
- What are steps to modeling?
- Where is model strong and weak?
- What are the things we are doing now with the calibrated model?
- What are future modeling efforts?



# What is a dynamic hydraulic sewer model?

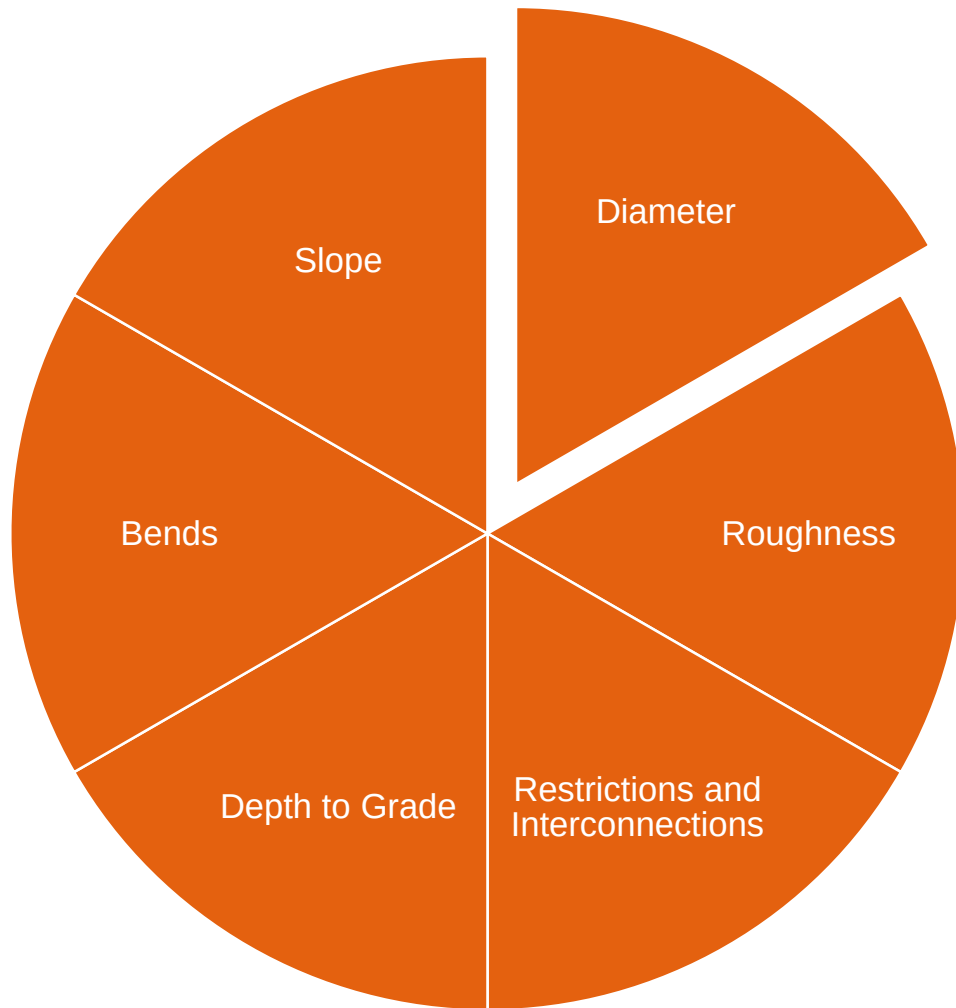


# A sewer model is a digital twin of sewer system

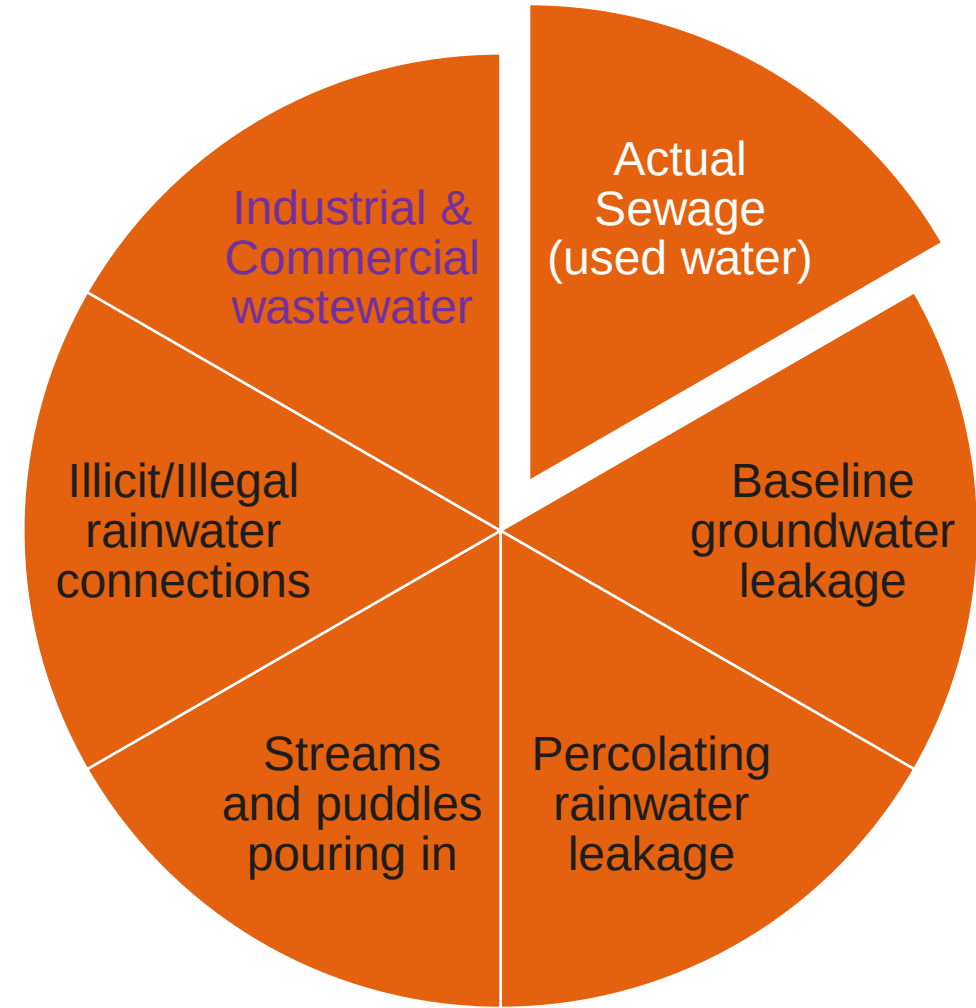


Physical Attributes of Pipes

# A sewer model is a digital twin of sewer system



Physical Attributes of Pipes



What's in the Pipe

# What is a model used for?





# Current Performance

- Blockages
- Flow restrictions
- Undersized pipes
- Available capacity
- Pump station demand
- Basement backups
- Dry weather backups
- Wet weather overflow locations, volumes, and durations
- Inflow locations
- Reliability

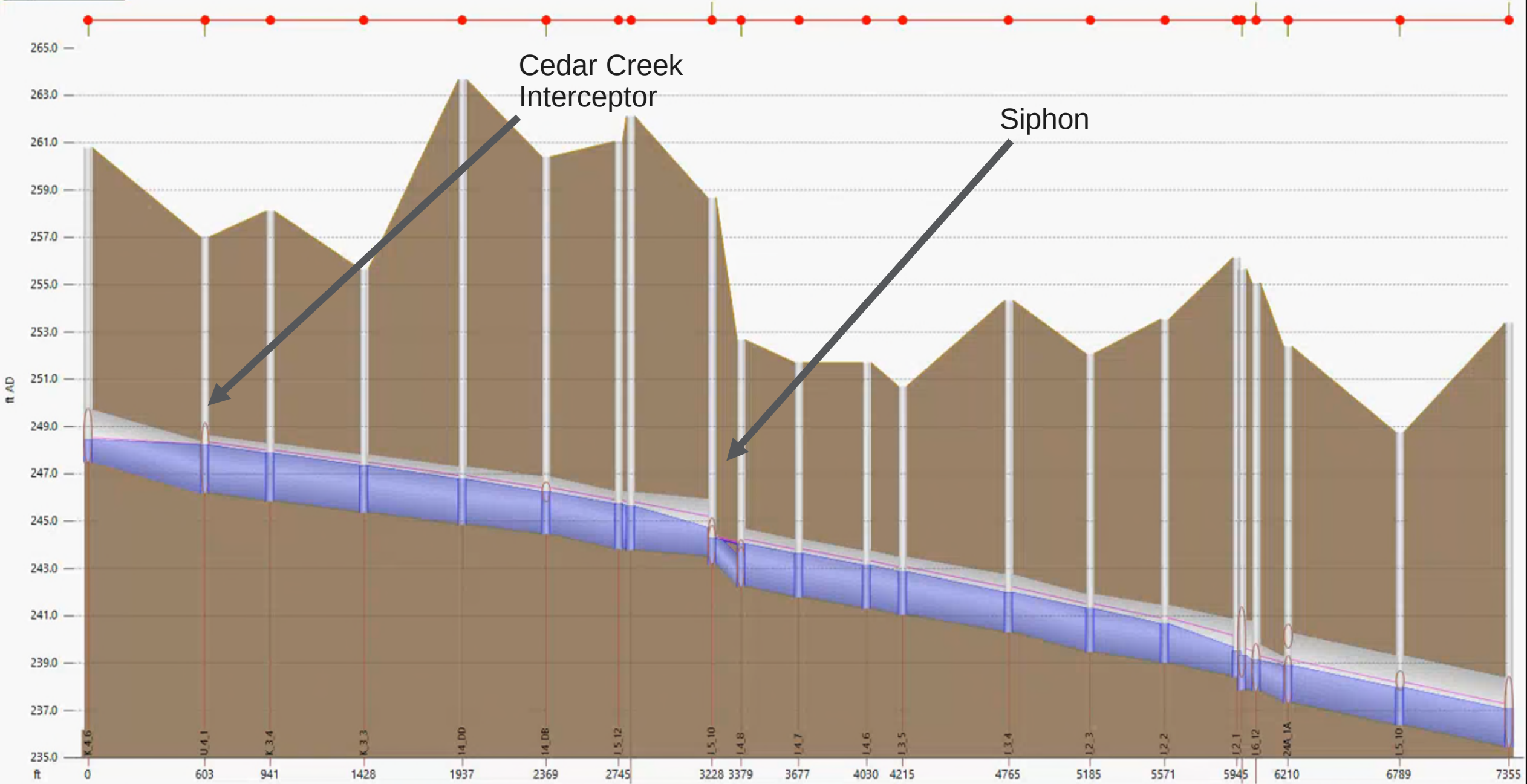
What is response to large rain events?

How does it handle extended wet periods?

How good is its **Level of Protection**?



**Current performance is function of base load and rainfall frequency/intensity**



|      |         |         |         |         |         |         |   |          |        |         |         |       |         |         |         |         |       |   |          |          |       |
|------|---------|---------|---------|---------|---------|---------|---|----------|--------|---------|---------|-------|---------|---------|---------|---------|-------|---|----------|----------|-------|
| Link | K_4_6.1 | U_4_1.1 | K_3_4.1 | K_3_3.1 | 14_DD.1 | 14_DB.1 | - | J_5_11.1 | -      | J_4_8.1 | J_4_7.1 | -     | J_3_5.1 | J_3_4.1 | J_2_3.1 | J_2_2.1 | -     | - | 24A_1A.1 | I_5_10.1 |       |
| Node | K_4_6   | U_4_1   | K_3_4   | K_3_3   | 14_DD   | 14_DB   | - | J_5_11   | J_5_10 | J_4_8   | J_4_7   | J_4_6 | J_3_5   | J_3_4   | J_2_3   | J_2_2   | J_2_1 | - | 24A_1A   | I_5_10   | I_4_9 |

# Future Performance



- Converting farms to houses and warehouses
- Revelopment
- Expanding service area
- Adding more hauled waste
- Losing industry
- Adding industry
- Aging (leaking) pipes
- Weather changes
- Water conservation

# Future infrastructure needs

- Estimating reductions from sewer collection system rehab
- Estimating reductions from private property leakage reductions
- What and where are conveyance capacity improvements needed
- When to install capacity improvements
- Replacement vs parallel
- Correctly sizing interceptors, pump station, tanks
- Determining impact on treatment plants
- Determining impact on downstream signatories



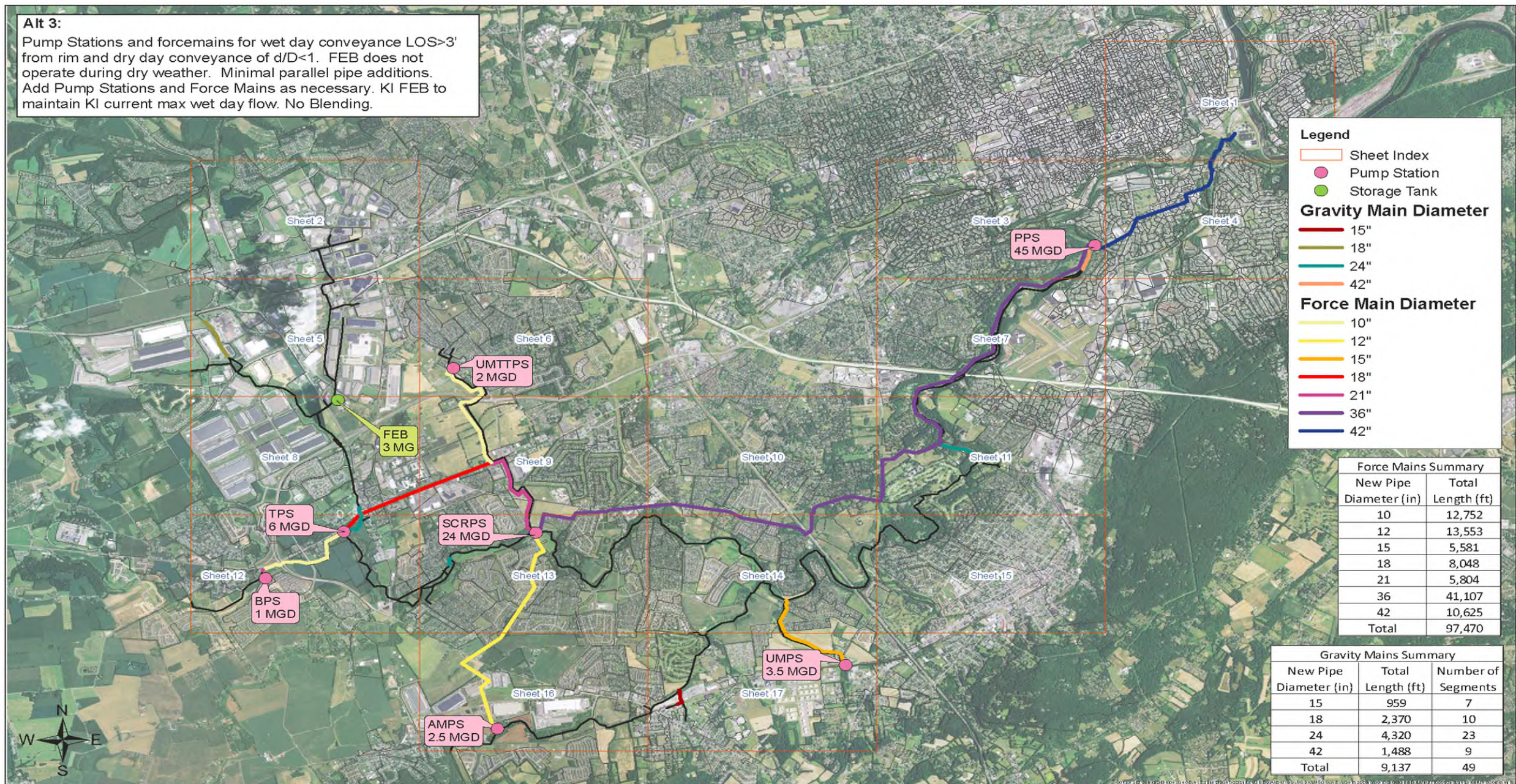
pppst.com

**Alternative analyses are like experimenting to find best formula**



**Alt 3:**

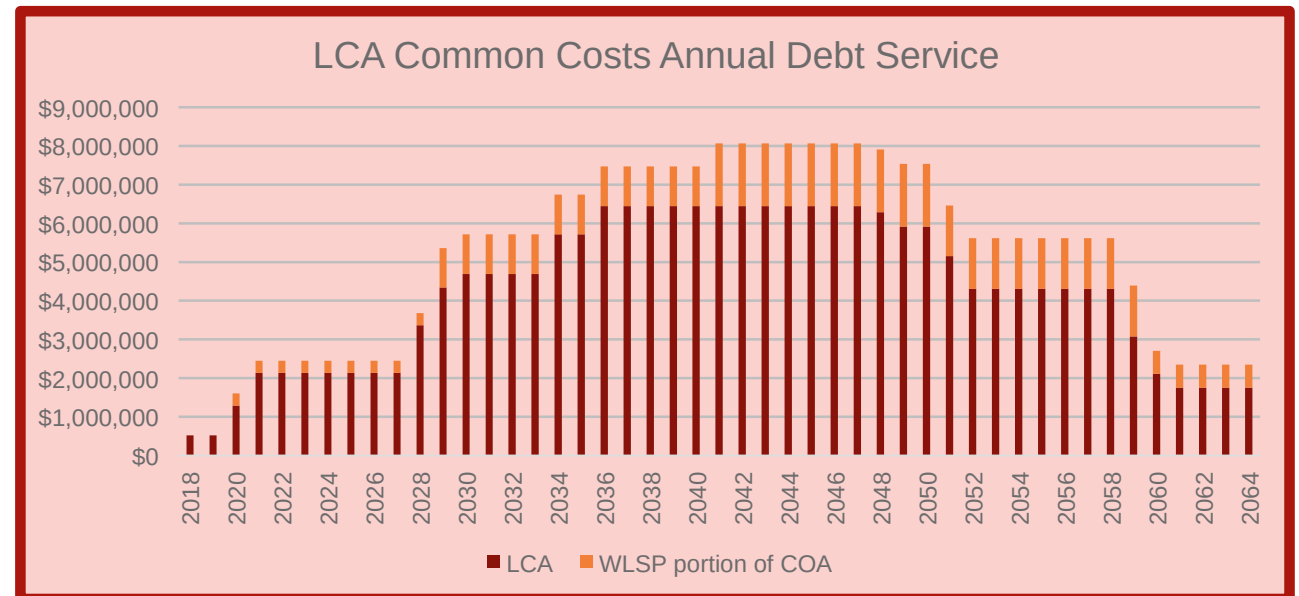
Pump Stations and forcemains for wet day conveyance LOS>3' from rim and dry day conveyance of d/D<1. FEB does not operate during dry weather. Minimal parallel pipe additions. Add Pump Stations and Force Mains as necessary. KI FEB to maintain KI current max wet day flow. No Blending.





# Capital Planning and Cash Flow

|                                 | Spend Year | LCA's Portion of Spend Year Capital |
|---------------------------------|------------|-------------------------------------|
| WLI Trunkline Rehab             | 2016       | \$ 820,000                          |
| Park Pump Station Refurbishment | 2018       | \$ 2,842,991                        |
| WLI Main Rehab 2                | 2018       | \$ 3,446,050                        |
| Park Force Main Refurbishment   | 2019       | \$ 3,201,057                        |
| Park Force Main Extension       | 2020       | \$ 2,551,597                        |
| Phase 1 COA EQ Tanks            | 2020       | \$ 5,657,041                        |
| Park Force Main                 | 2027       | \$ 23,554,139                       |
| Park Pump Station               | 2028       | \$ 18,816,676                       |
| Phase 2 COA EQ Tanks            | 2029       | \$ 14,129,738                       |
| Kecks Bridge Park Interceptor   | 2030       | \$ 27,779,985                       |
| Upper Milford Relief Trunk Line | 2032       | \$ 7,424,496                        |
| AMTL Relief Trunk Line          | 2034       | \$ 8,879,518                        |
| Ancient Oaks Interceptor        | 2036       | \$ 37,146,122                       |
| Phase 3 COA EQ Tanks            | 2040       | \$ 12,977,609                       |

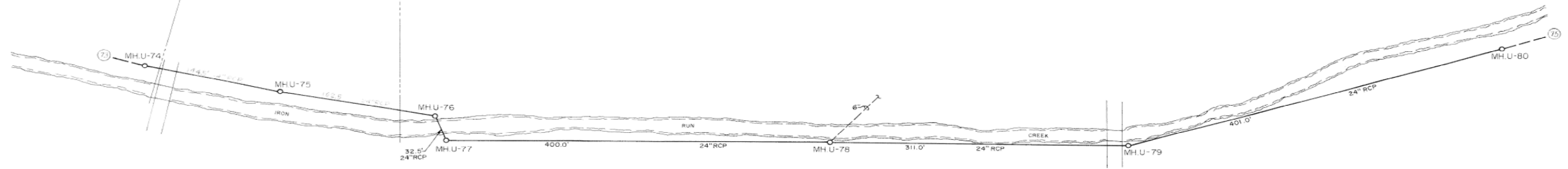


# What are steps to modeling?

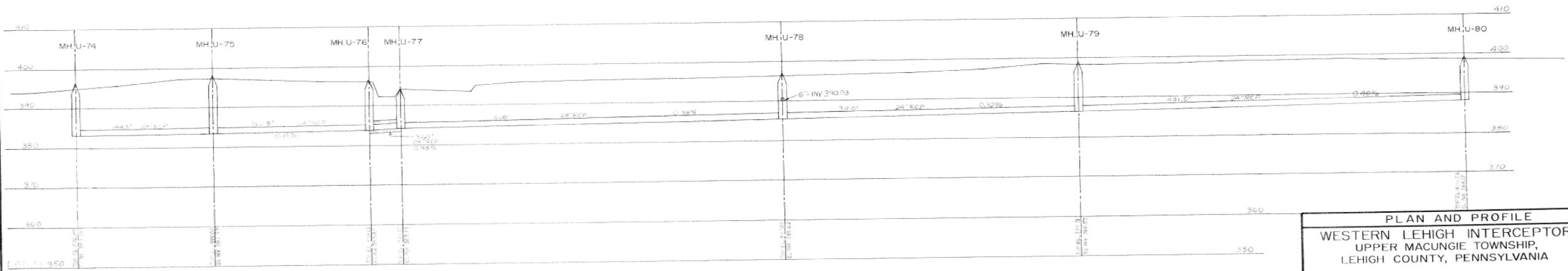




COUNTY OF LEHIGH



• PLAN •  
SCALE: 1" = 50'



• PROFILE •  
SCALE: HORIZ - 1" = 50'  
VERT. - 1" = 10'

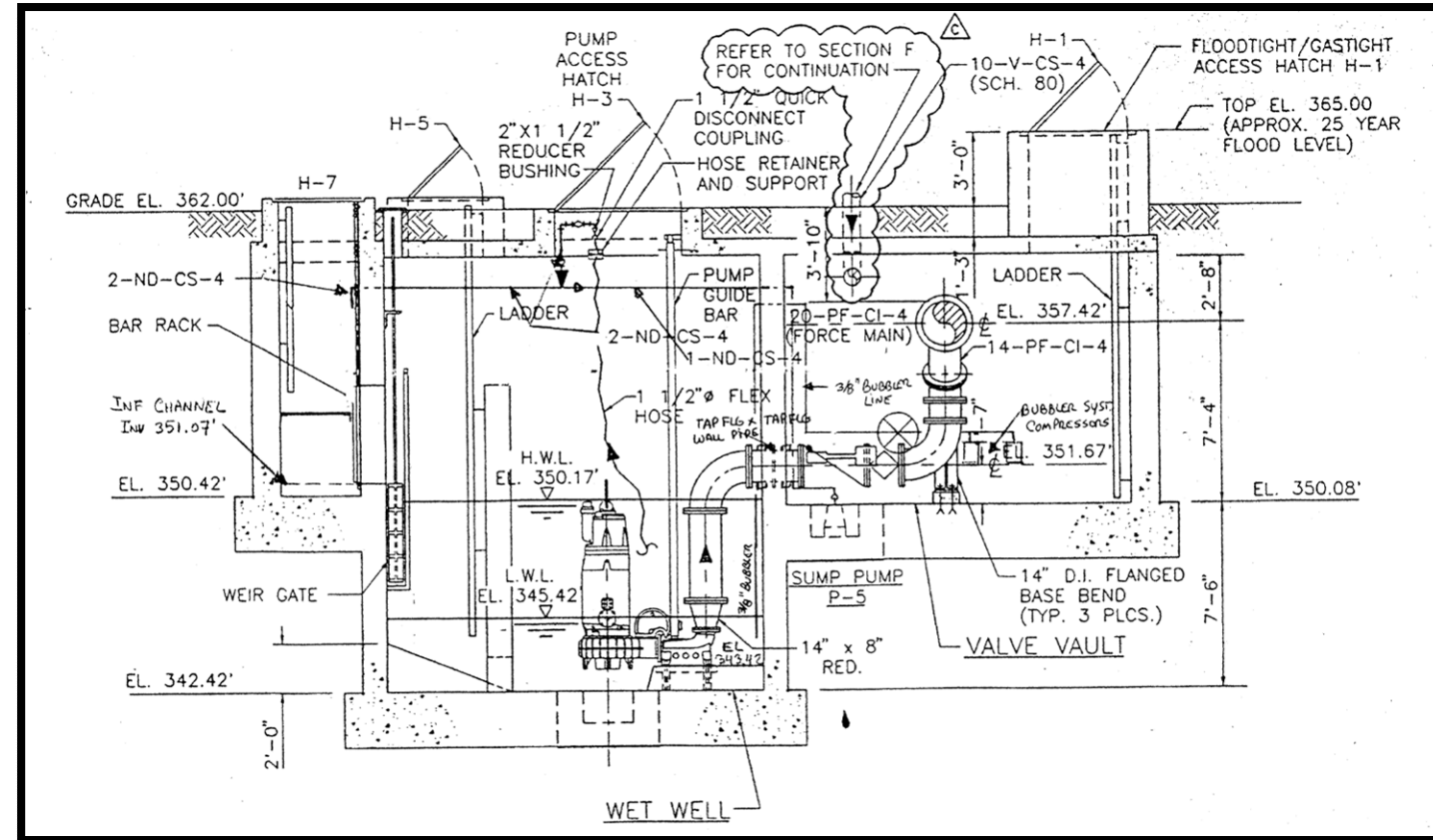
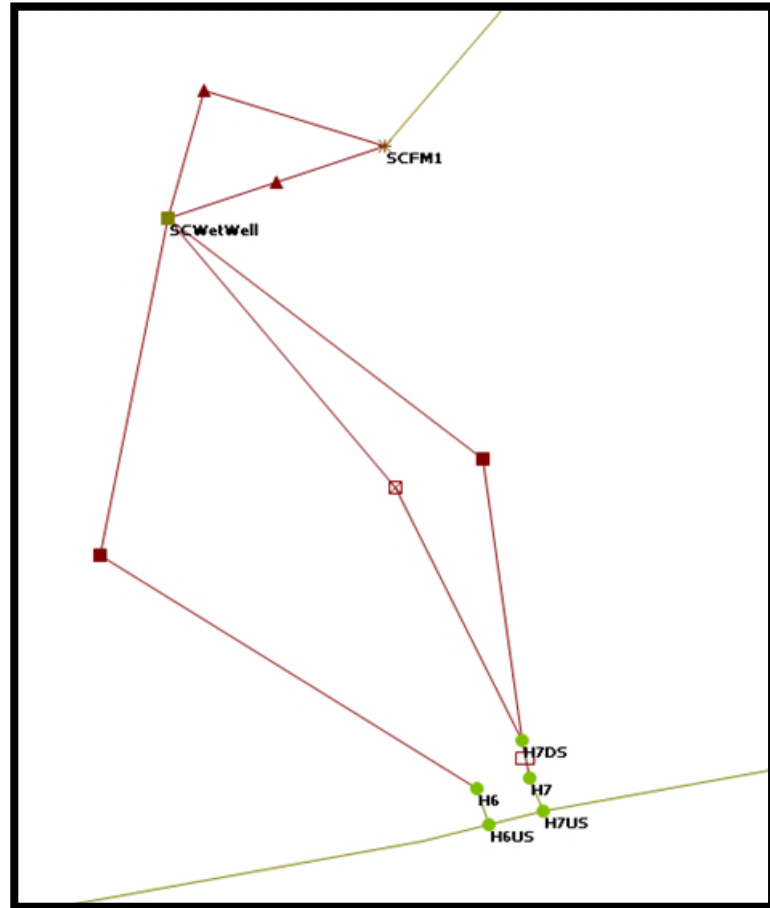
NOTE:  
PIPELINE INVERTS & SLOPES  
ARE BASED ON L.C.A. FIELD SURVEY,  
COMPLETED SUMMER OF 1989. SEE  
SHEET NO. FOR ORIGINAL  
AS-BUILT INFORMATION.

PLAN AND PROFILE  
WESTERN LEHIGH INTERCEPTOR  
UPPER MACUNGIE TOWNSHIP,  
LEHIGH COUNTY, PENNSYLVANIA

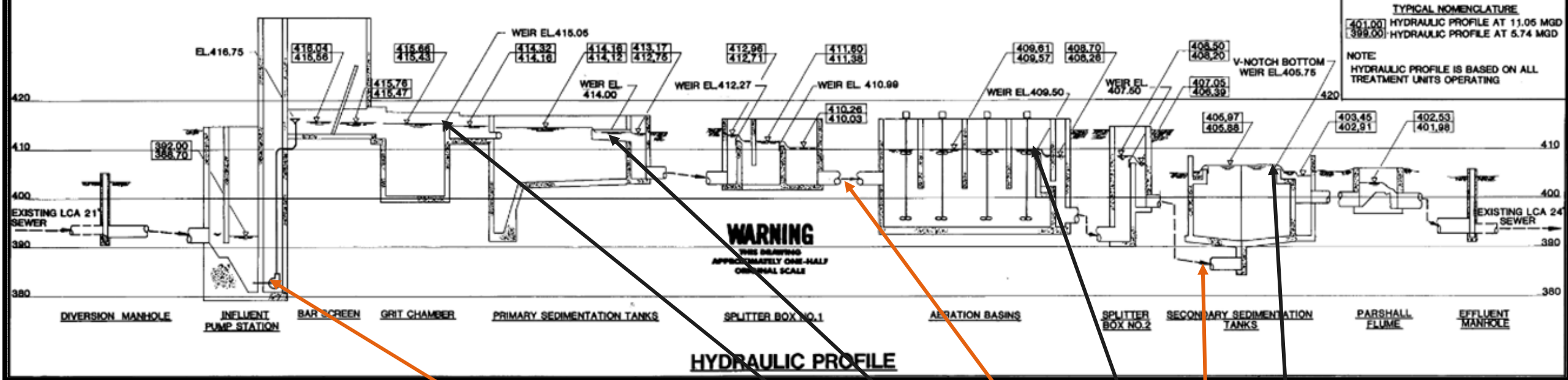
|                   |       |                                                                                        |          |                    |
|-------------------|-------|----------------------------------------------------------------------------------------|----------|--------------------|
| SCALE<br>AS SHOWN |       | LEHIGH COUNTY AUTHORITY<br>P. O. BOX 3348<br>1053 SPRUCE ROAD<br>WESCOVILLE, PA. 18108 |          | PROJECT NO.        |
| DWN BY: C.R.D.    |       | DATE<br>5/2/91                                                                         |          |                    |
| CKD BY: S.R.      | REV 1 | REV 2                                                                                  | DWG. NO. |                    |
| REV 3             | REV 4 | REV 5                                                                                  | REV 6    |                    |
|                   |       |                                                                                        |          | SHEET NO. 74 OF 81 |



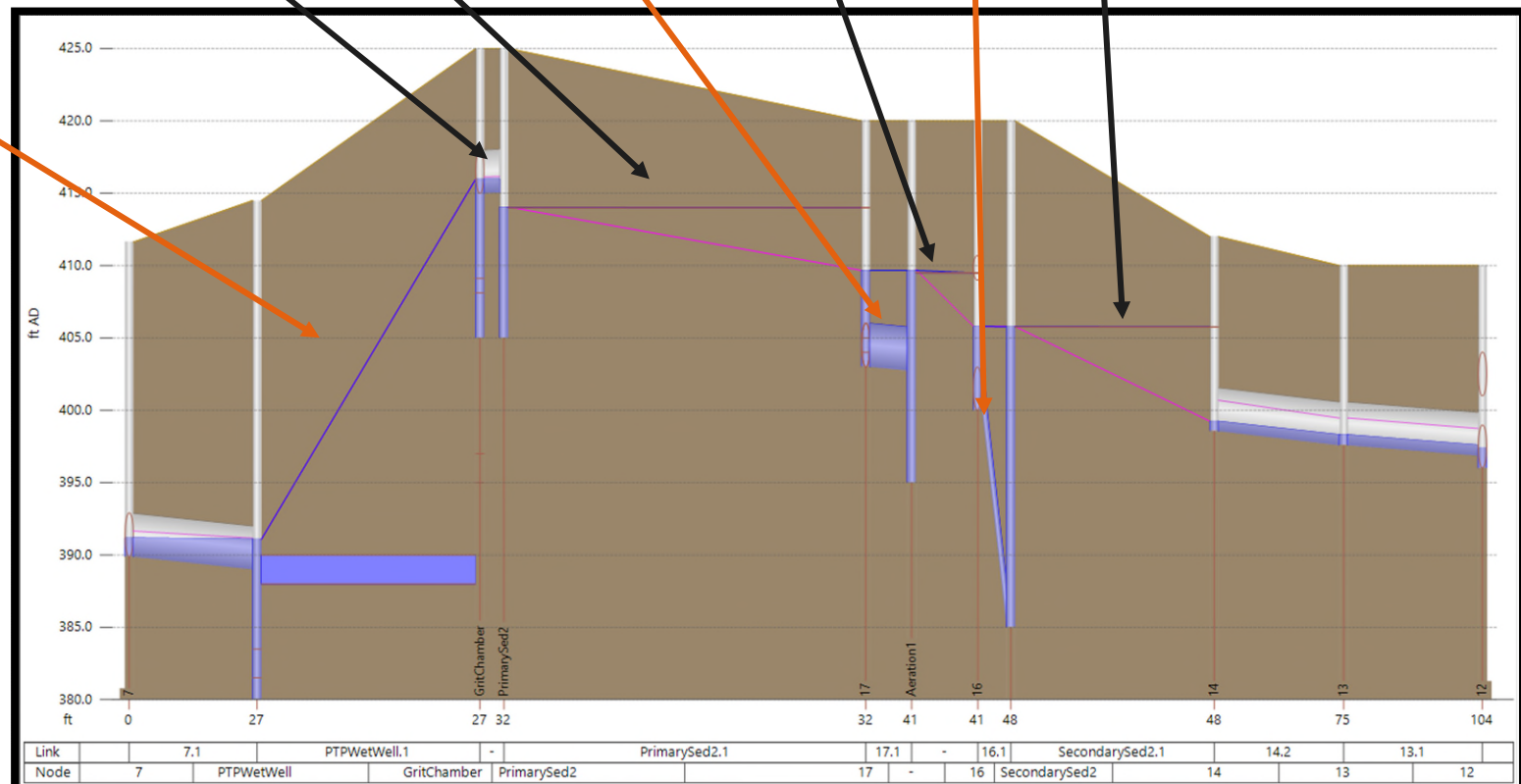
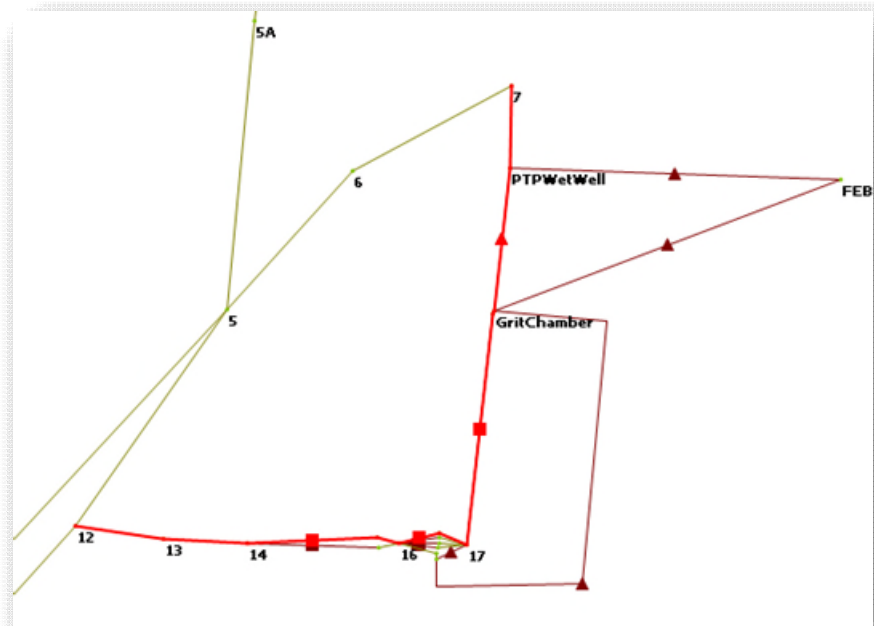
# Spring Creek Pump Station



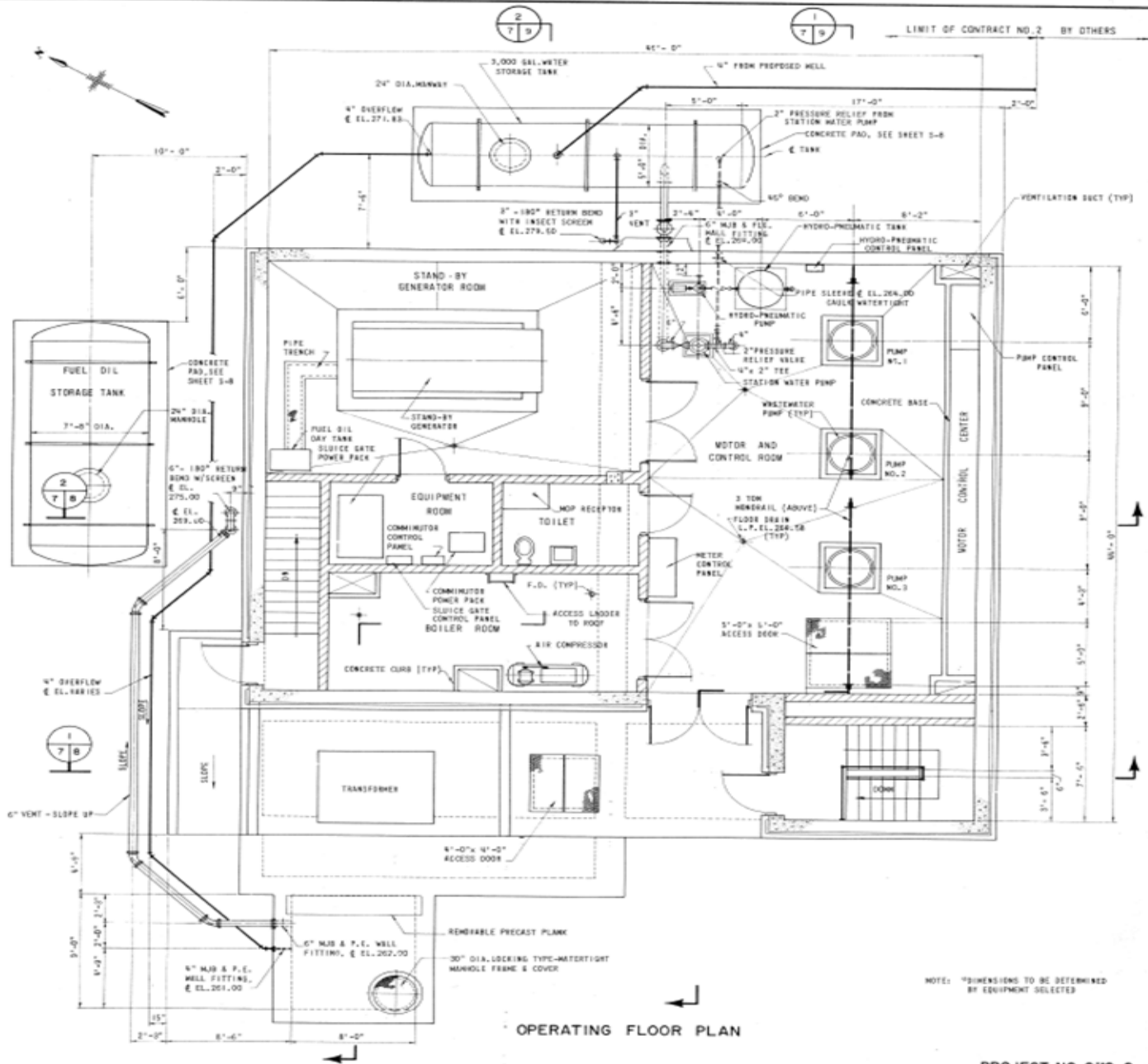
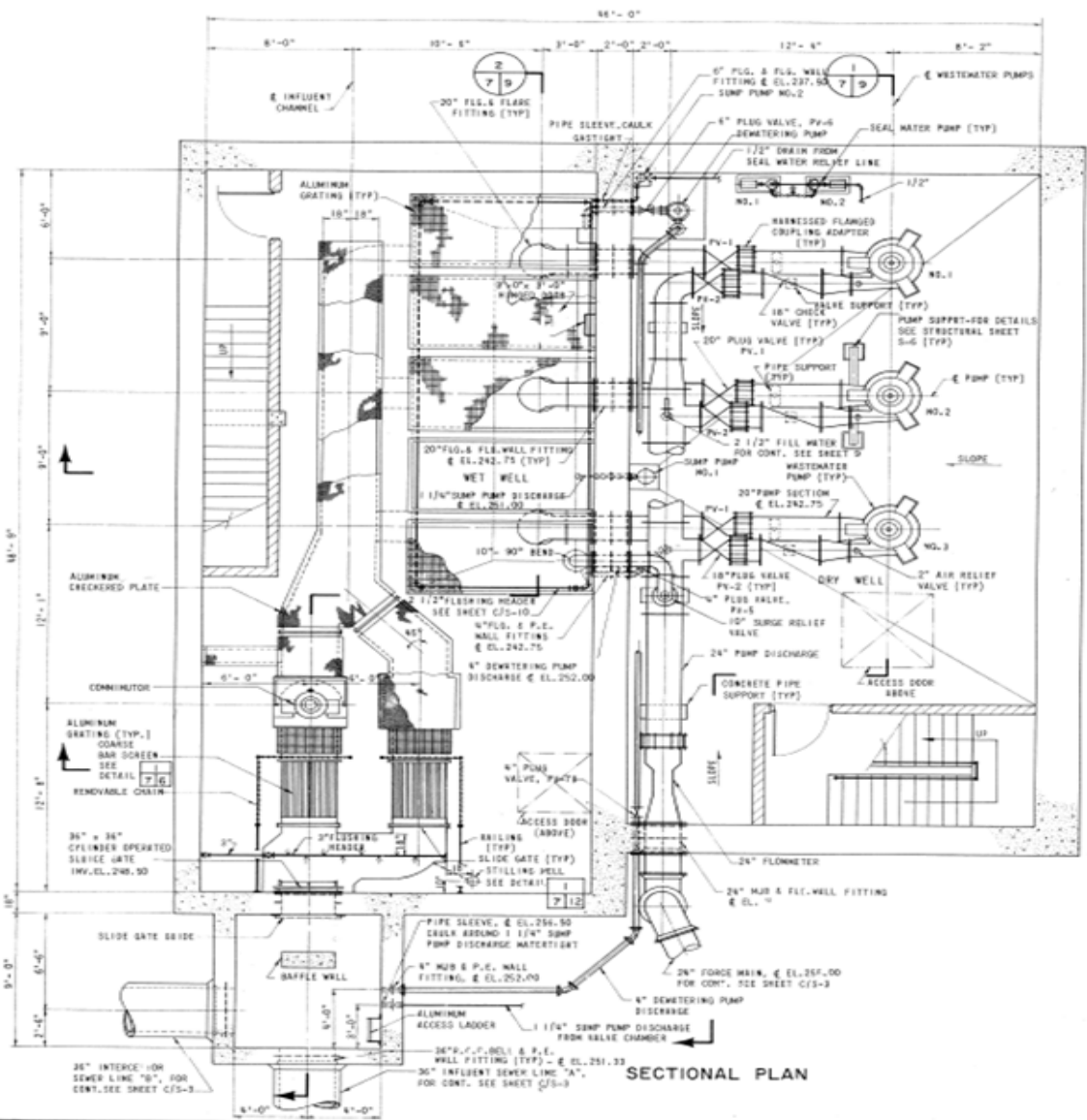
**No RTC Control**  
**Wet Well and Pump Curves**



# Pretreatment Plant

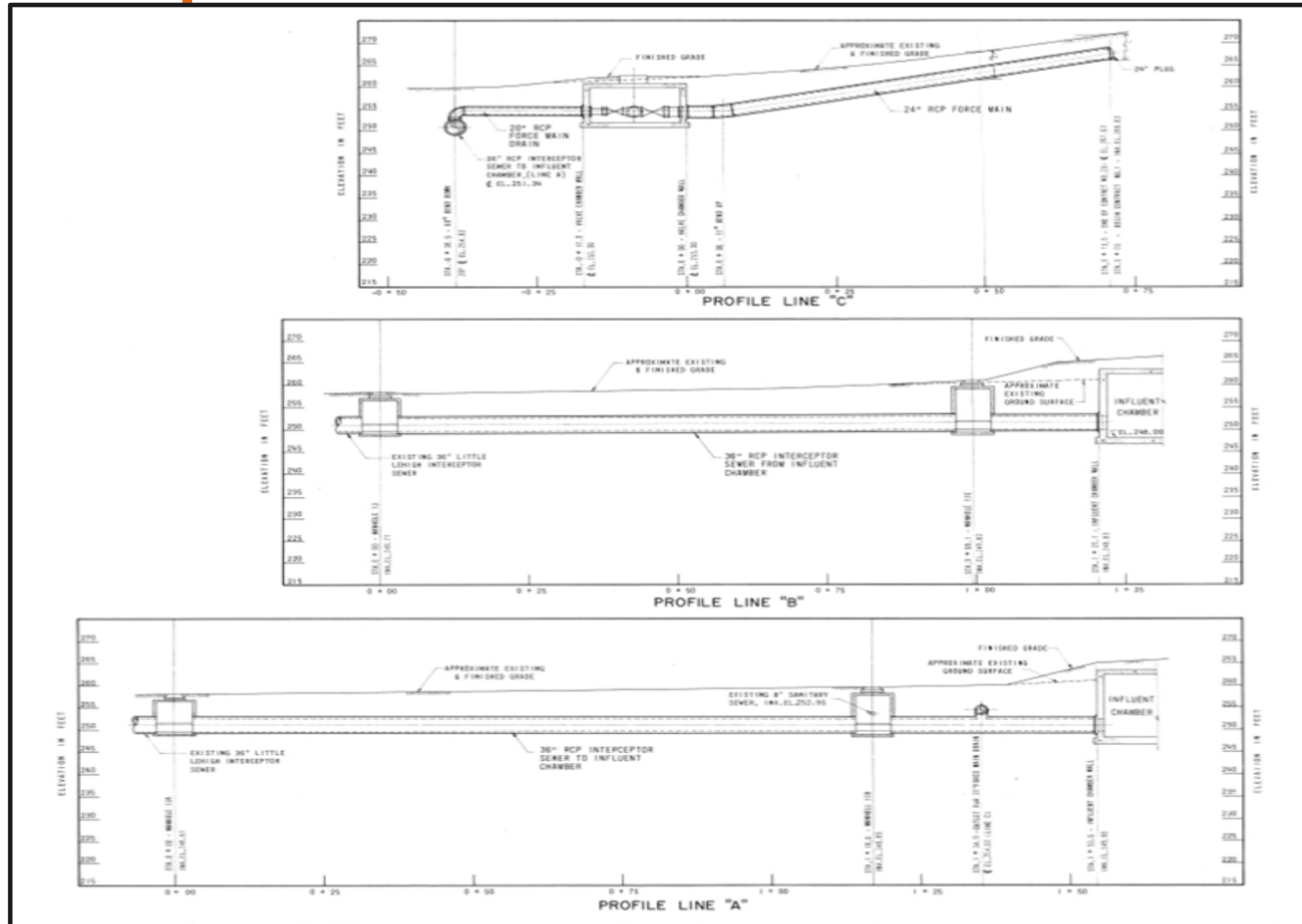


# Park Pump Station

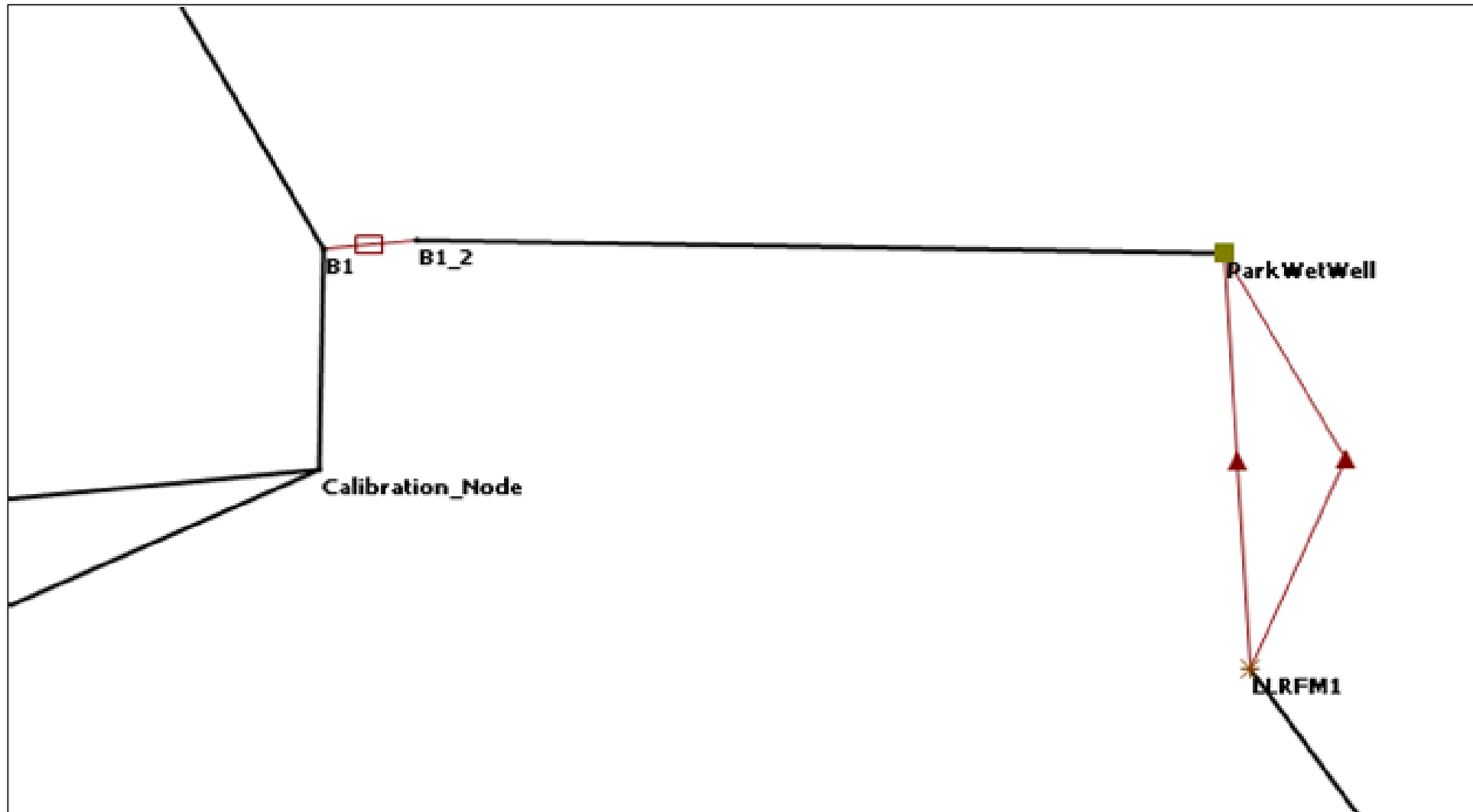


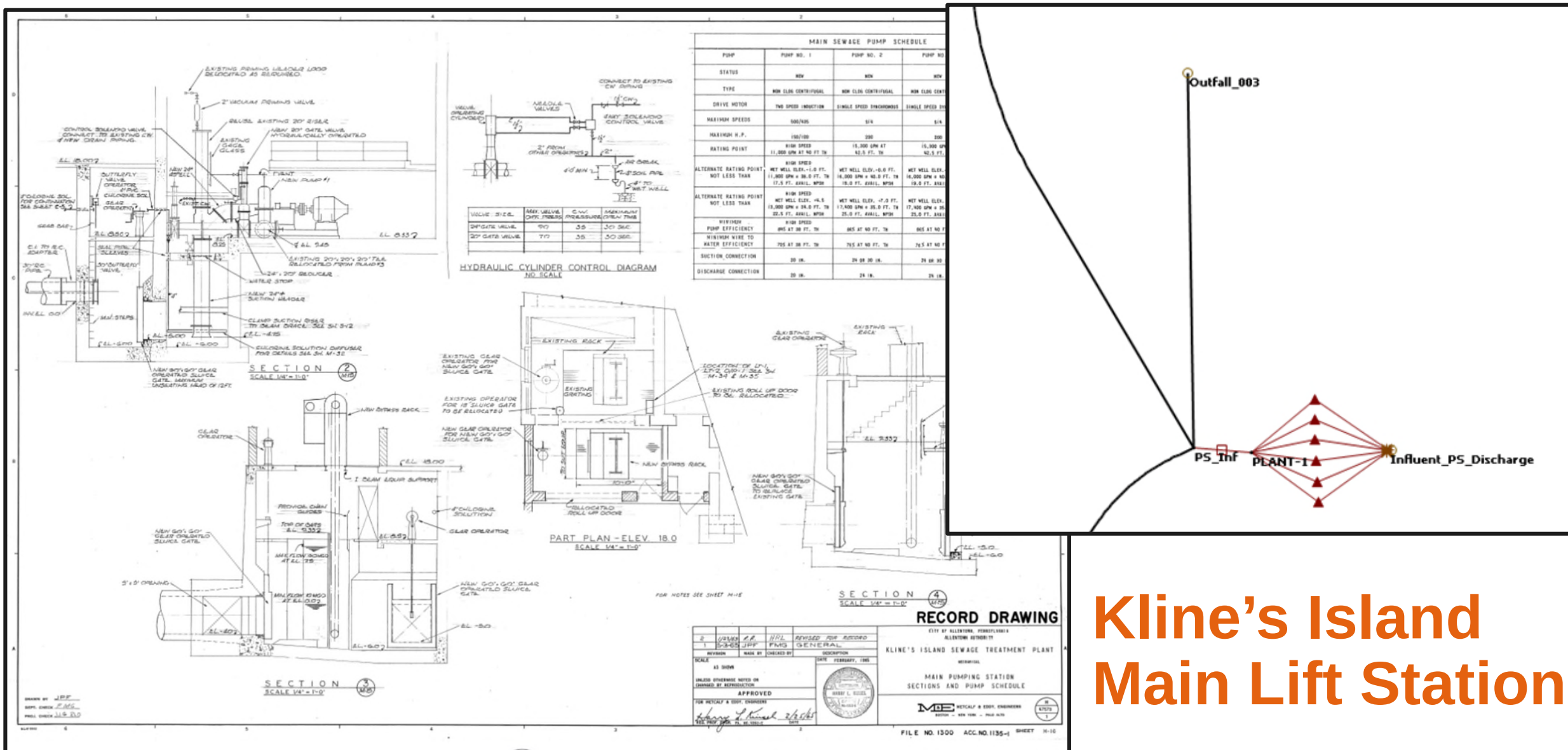


# Park Pump Station









# Kline's Island Main Lift Station

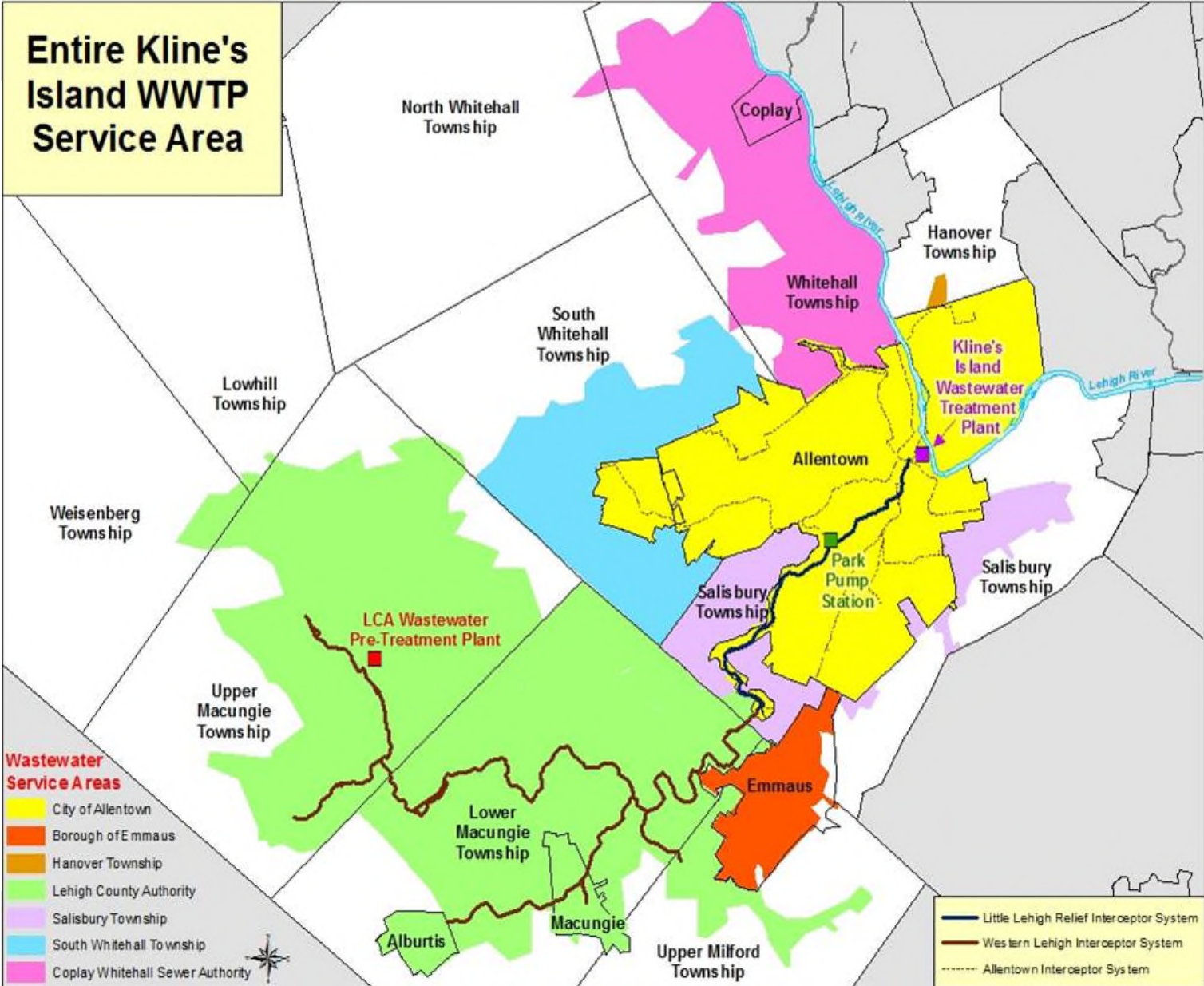
# As-Is vs. Should Be

Key components are not operated or are not able to be operated according to typical or design-intent control logic

- FEB
  - Completely manual on and off
  - Fill rate is function of effluent flow meter, which is impacted by submergence
- Spring Creek Pump Station
  - Wet well gates are continually broken, so left in open position
  - Interceptor flow level control logic not working
- Park Pump Station
  - Wet Well sluice gate actuator is not compatible with control logic, so preset manually by operator
  - Pumps run longer than necessary to reduce surges at KI WWTP
- KI Main Lift Station
  - Turning on of auxiliary pump station is manual
  - Rock media recirc and sludge digester reject are manual operations



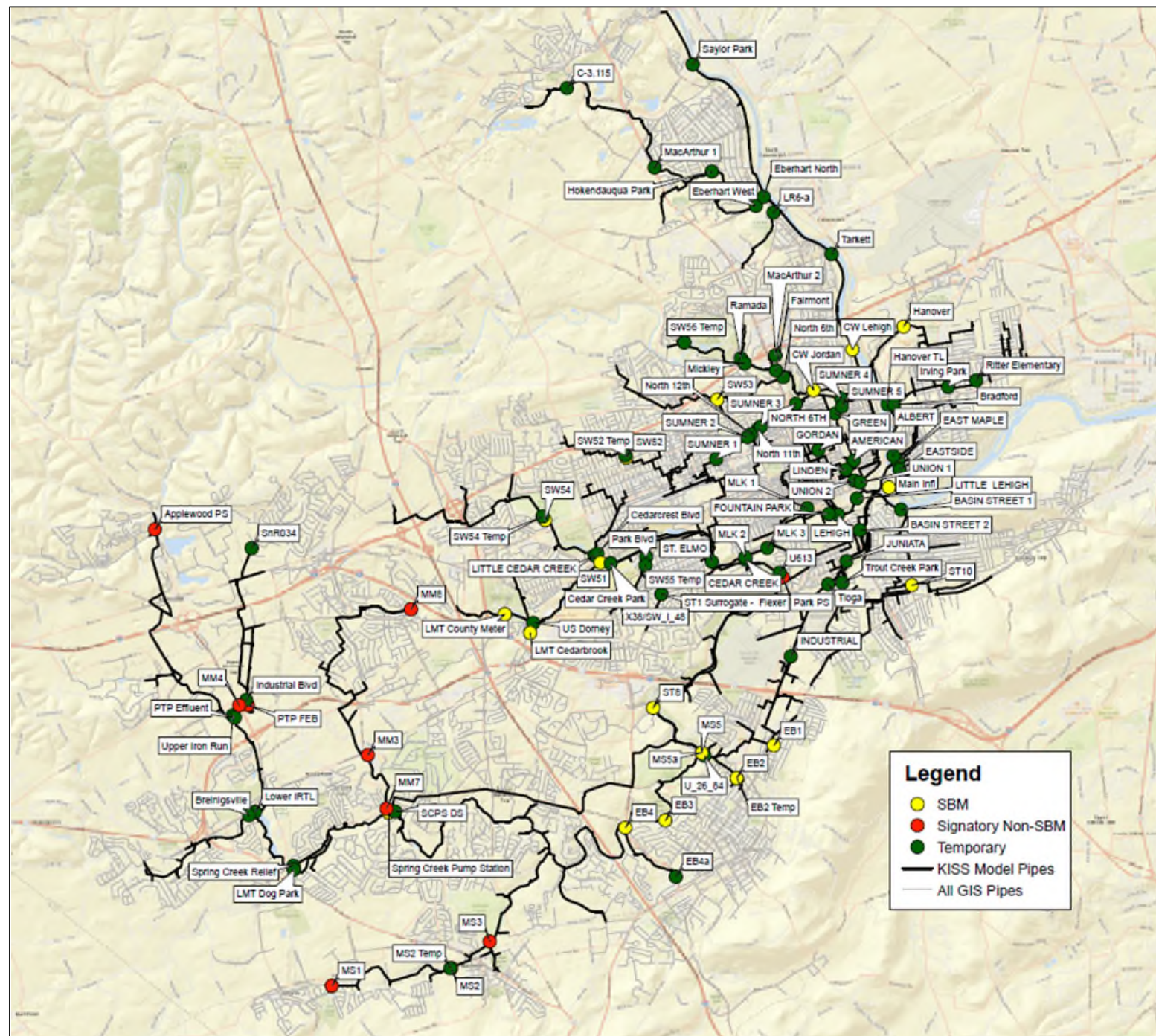
# Model Extents





# 2021 Flow Meters for Calibration

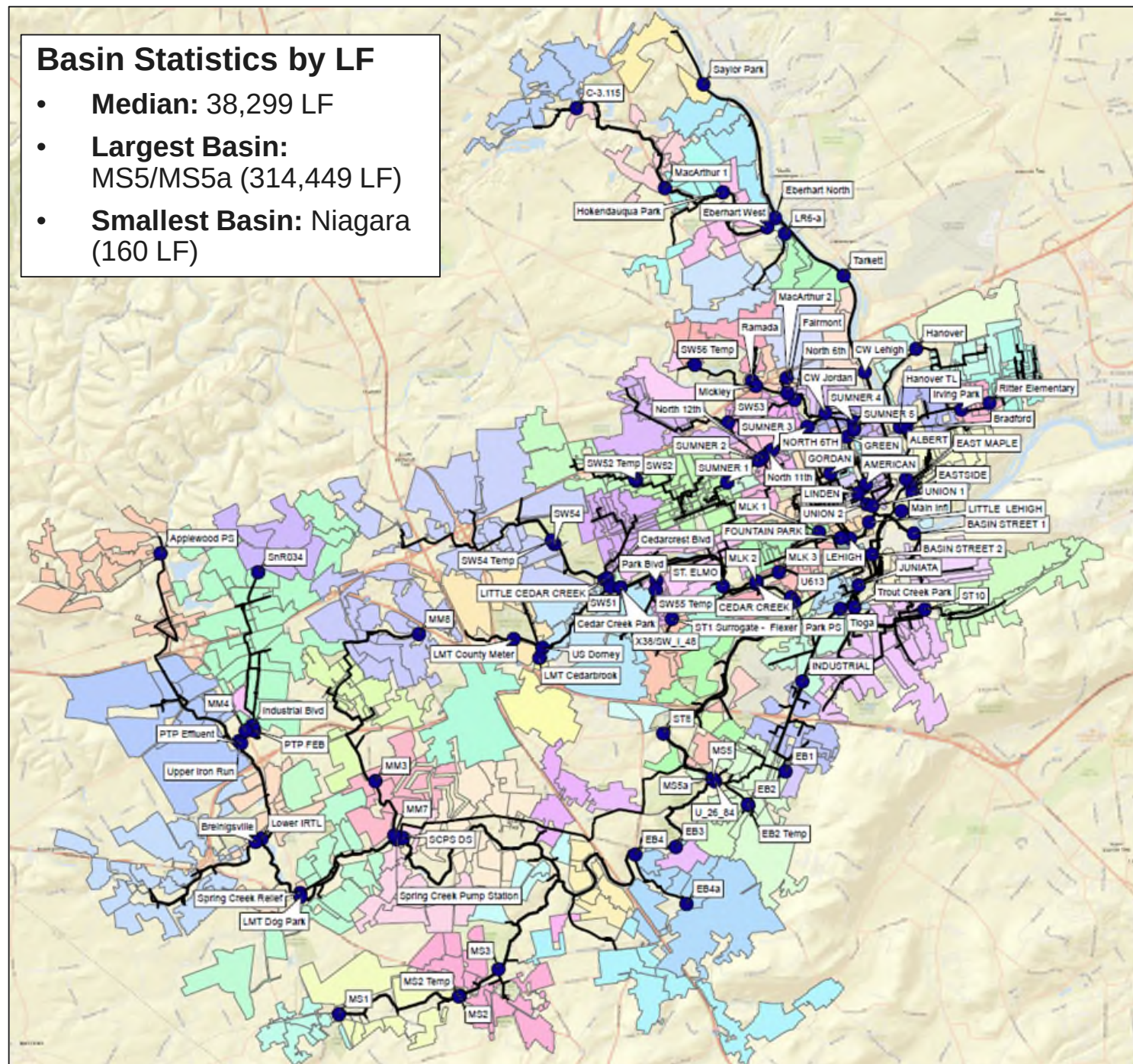
- Signatory Billing Meters
  - Signatory Non-Billing Meters
  - Temporary Stations
- 
- 97 total meters used for calibration





# Basins and Catchments

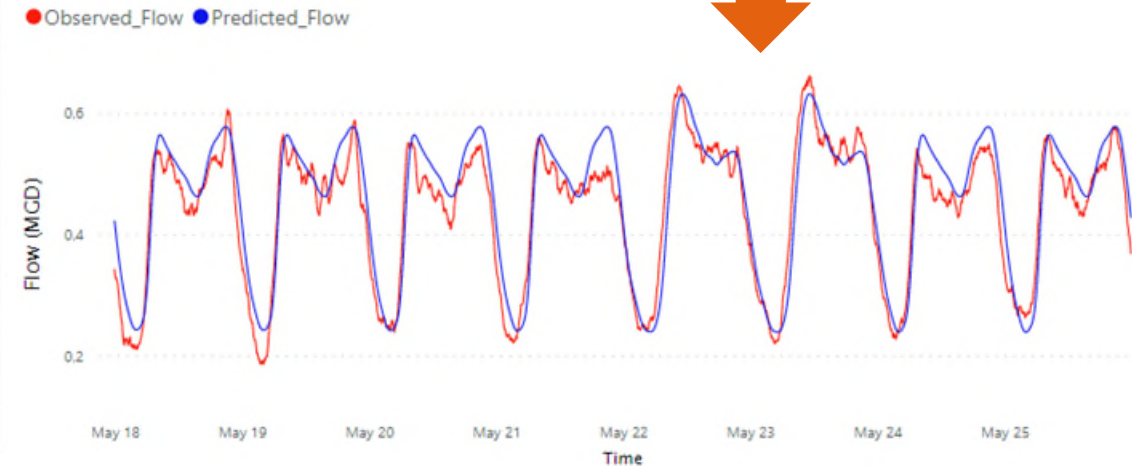
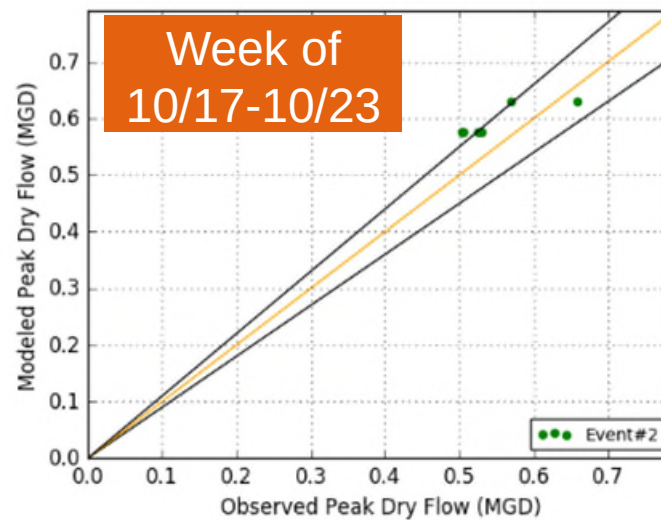
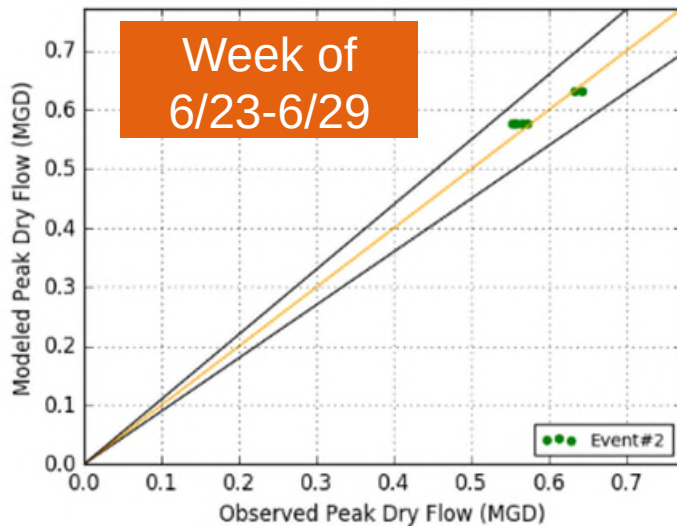
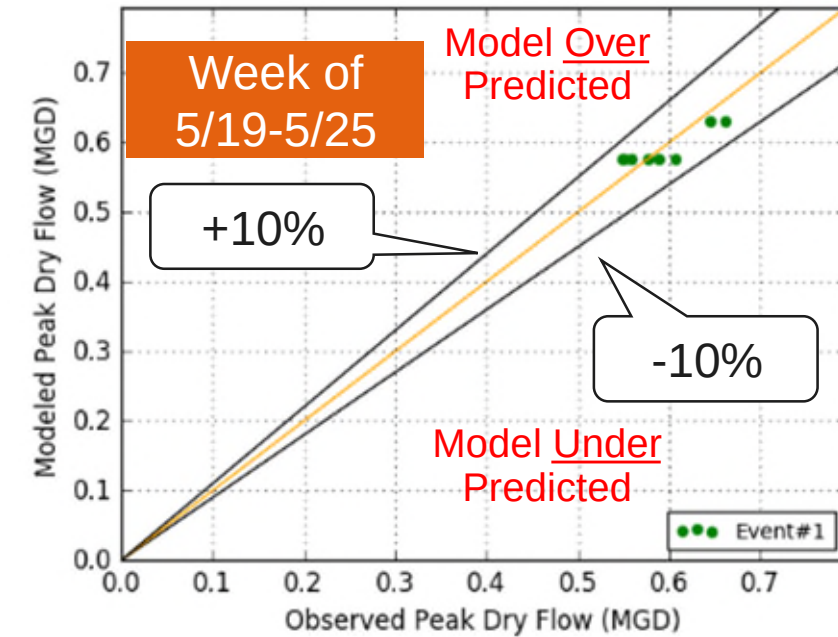
- 87 Basins in model
- 933 Catchments in model
- Catchments broken out by area, type of user, and location (bottomlands)



# Dry Weather Calibration Guidelines

| Parameter      | Guidelines                                                                            |
|----------------|---------------------------------------------------------------------------------------|
| Peak Flow Rate | -10% to +10% of measured                                                              |
| Flow Volume    | -10% to +10% of measured                                                              |
| Peak Depth     | ± 0.33 ft at non-surcharged locations<br>-0.33 ft to +1.67 ft at surcharged locations |
| Shape          | The shape of modeled and metered curves should be similar for flow.                   |

MacArthur 1  
(C-3.57)





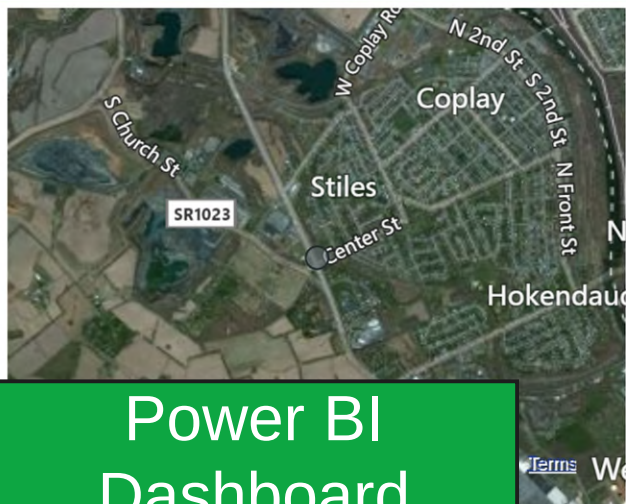
# Dry Weather Flow Calibration

Modeler

Meter

5/18/2021 5/25/2021

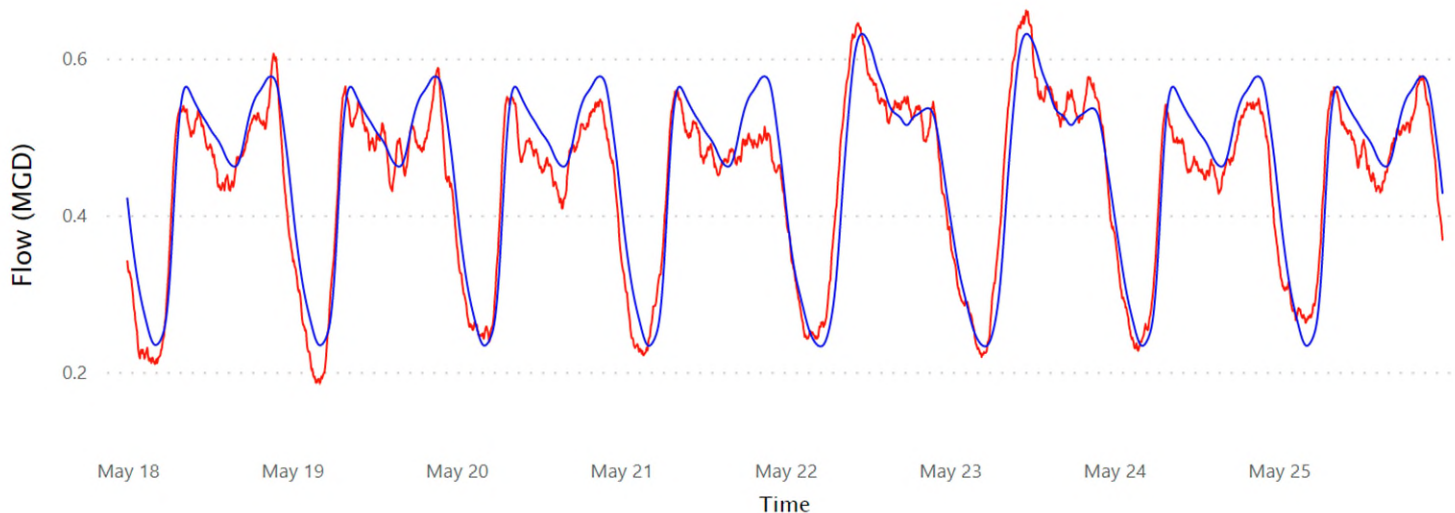
## Meter Location



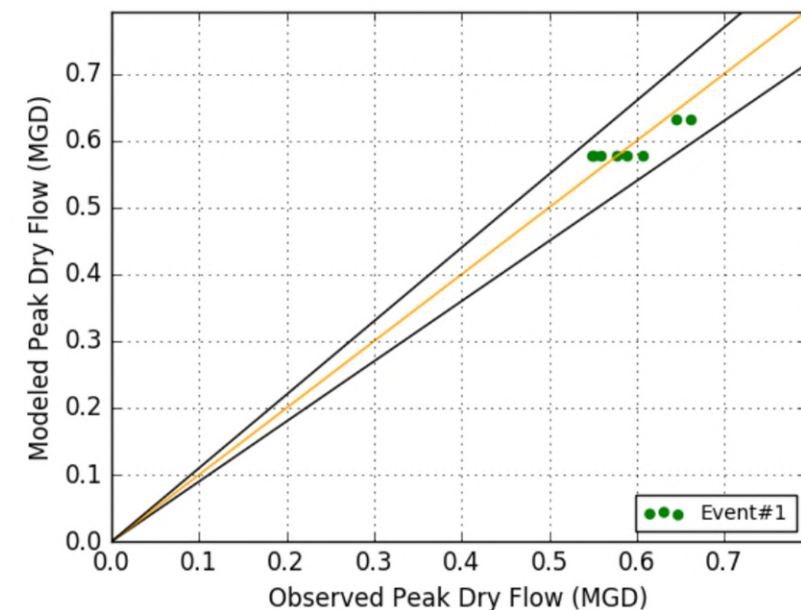
## Event#1

Start 05/18/2021 End 05/25/2021

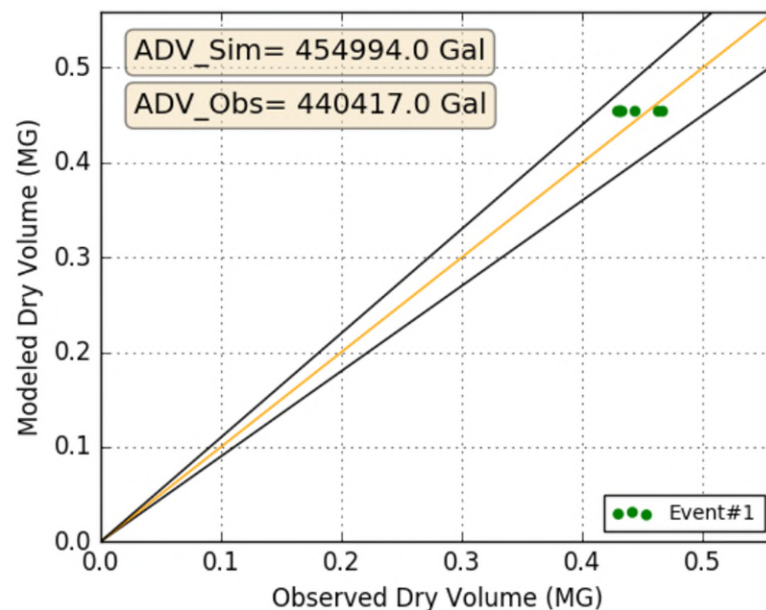
● Observed\_Flow ● Predicted\_Flow



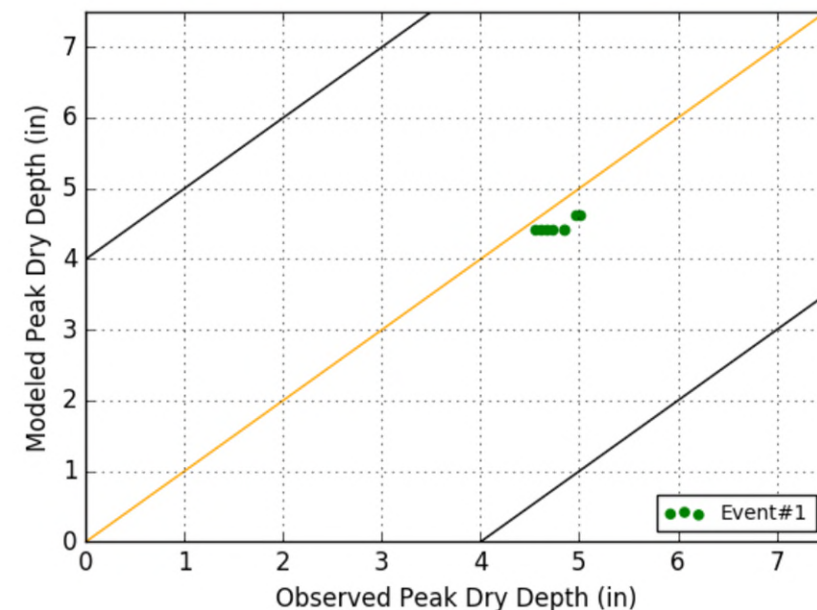
## Peak Flow (MGD), -/+ 10%



## Volume (MG) -/+ 10%



## Peak Depth (in), -/+ 4 inches





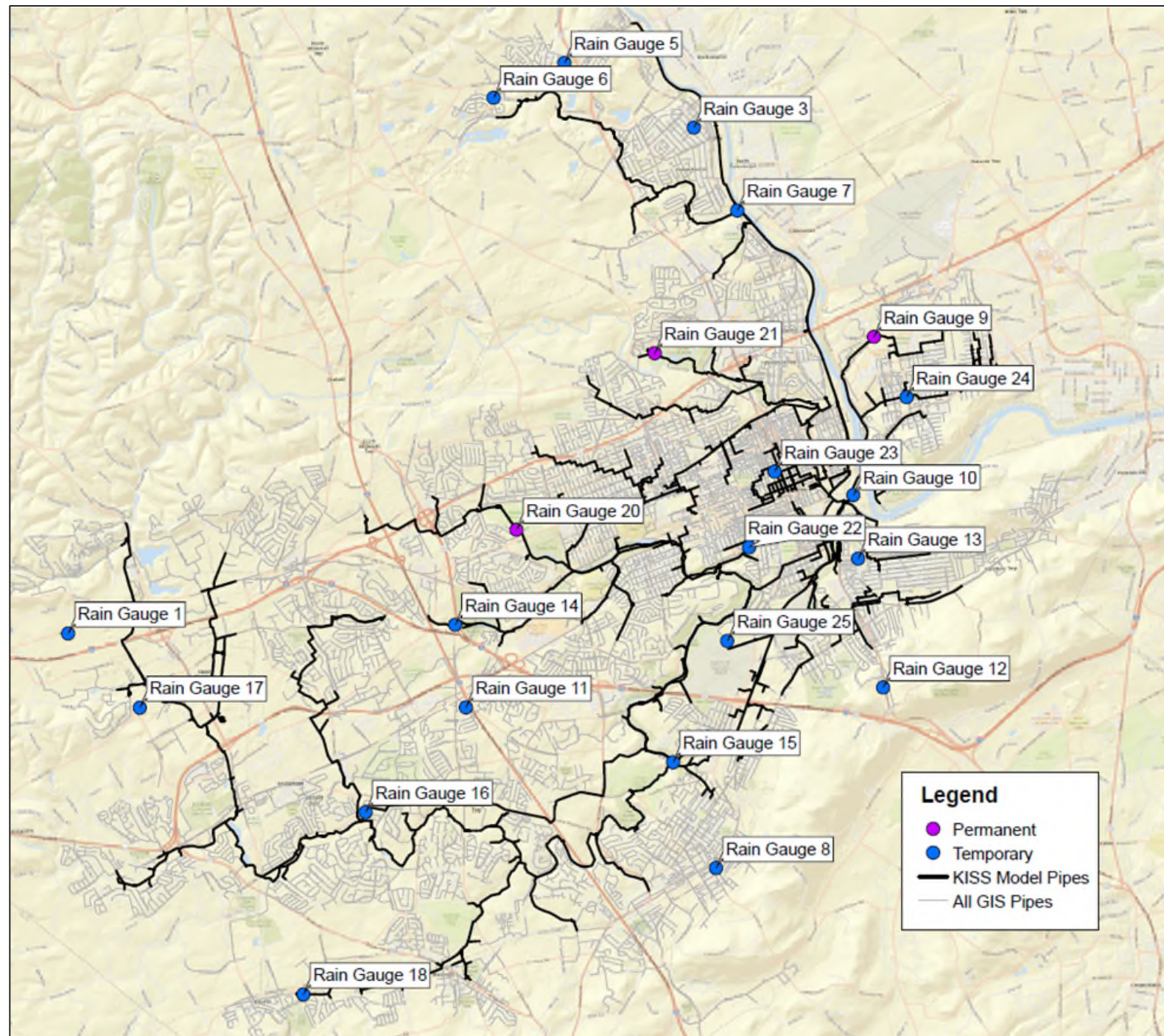
# But sometimes, it rains



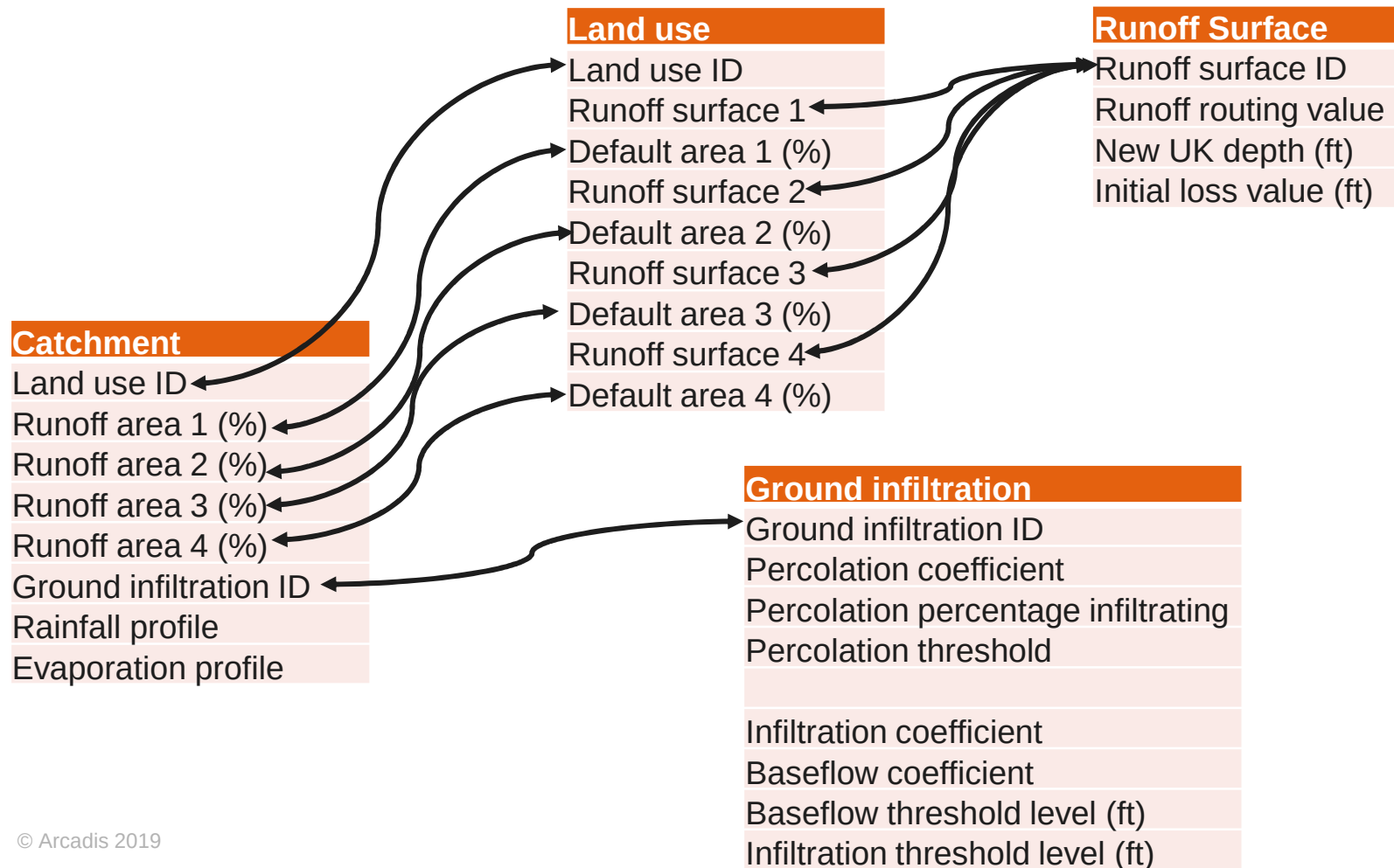


# Rain Gauge Data Source and Locations

- 29 total rain gauges
- Permanent gauges
- Temporary gauges



# ICM Catchments Grid - Rainfall derived inflow and infiltration (RDII)



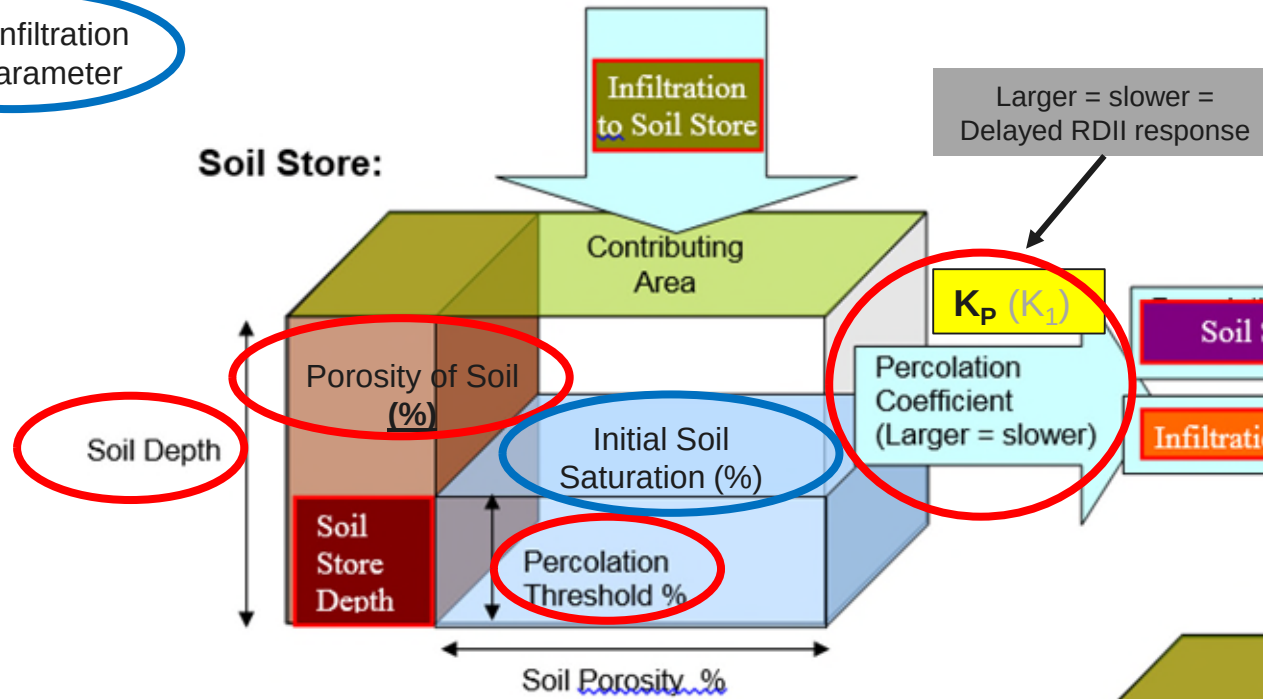


# Groundwater Model

GW Infiltration ID Input

Ground Infiltration Event Parameter

**Soil Store:**

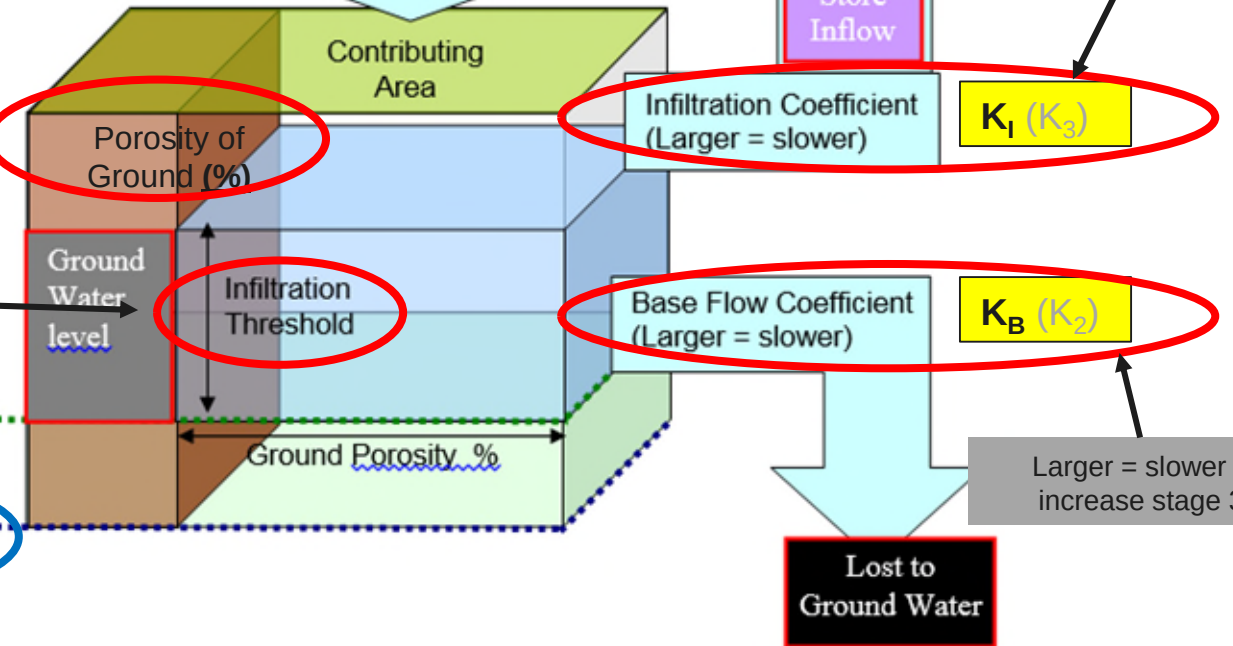


.01% means that all the flow leaving the Soil Store goes to the Ground store, and none goes to the network

**Ground Water Inflow**

Percolation % Infiltrating

**Ground Store:**



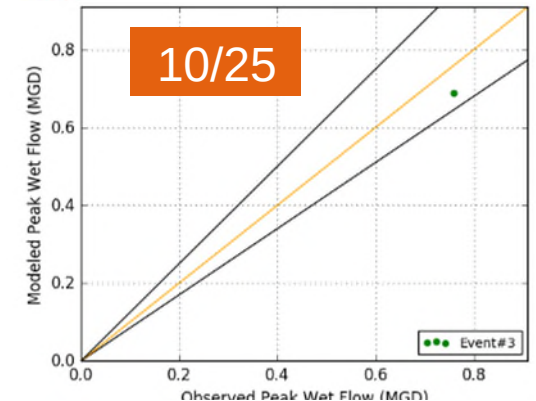
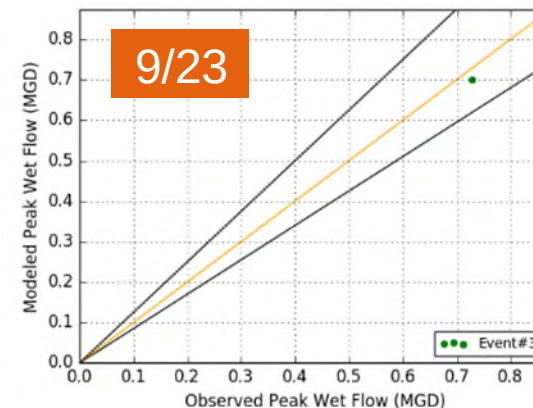
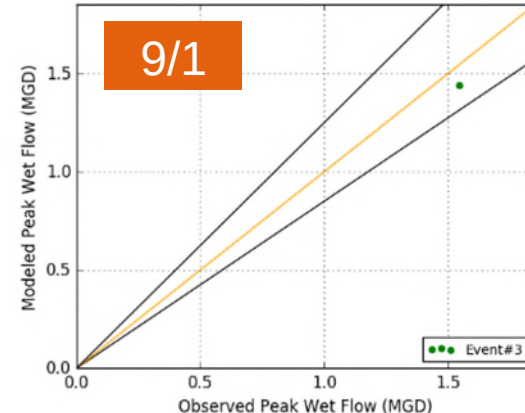
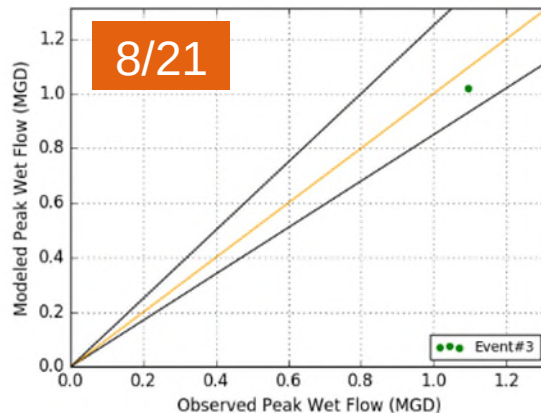
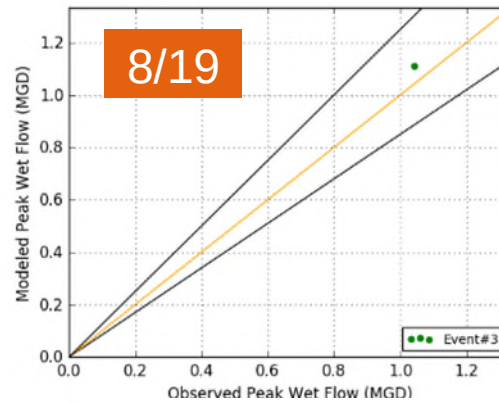
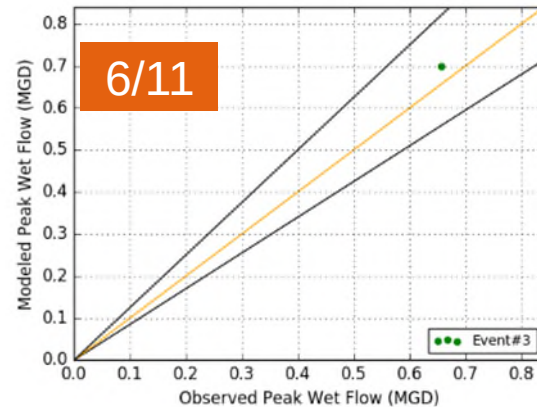
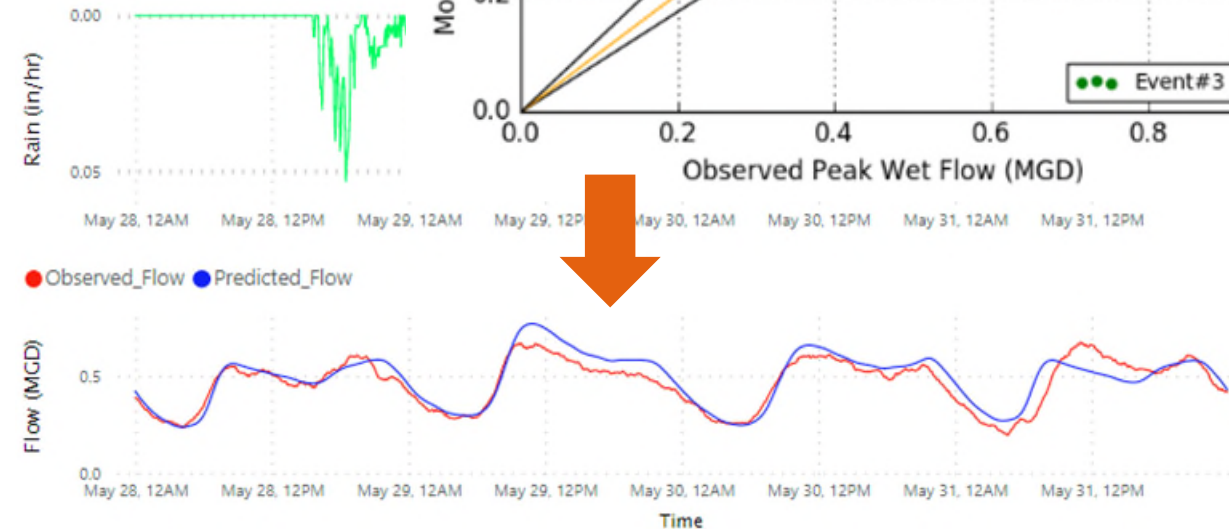
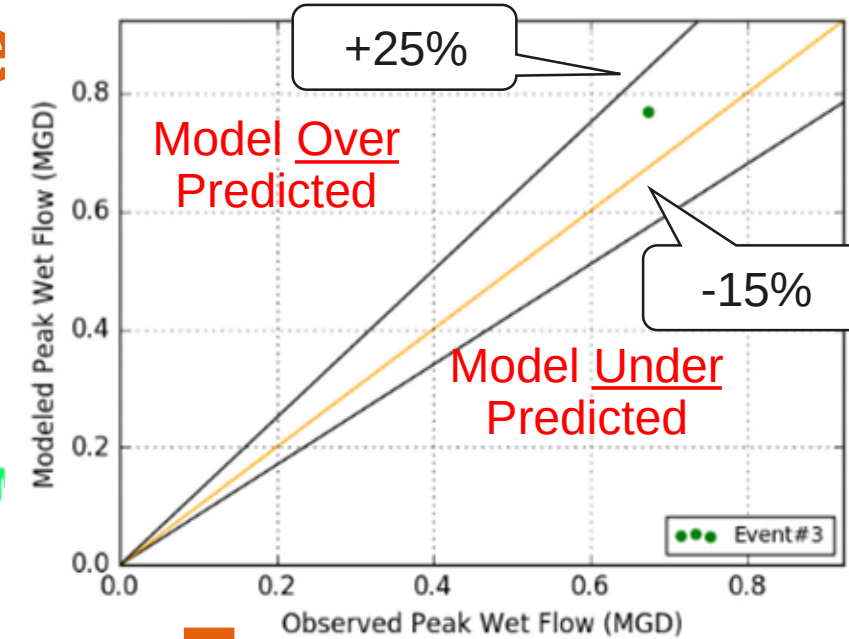
Larger = slower = reduce hydrograph peak

Larger = slower = increase stage 3

- 1- The base flow and infiltration threshold levels (ft) can be defined as relative to the manhole invert or the model datum.
- 2- They are the levels at which base flow losses begin and infiltration to the network begins.
- 3- To have baseflow start below the pipe invert, set it as negative.
- 4- Initial GW level is set in the event properties. There is no total "height" to the GW reservoir.

# Wet Weather Calibration Guideline

| Parameter      | WaPUG (Used in 2021)     |
|----------------|--------------------------|
| Peak Flow Rate | -15% to +25% of measured |
| Flow Volume    | -10% to +20% of measured |
| Peak Depth     | No Change                |
| Shape          | No Change                |





# Wet Weather Flow Calibration

Modeler  
All

Meter  
MacArthur\_1

Date  
8/22/2021 8/24/2021

## Meter Location



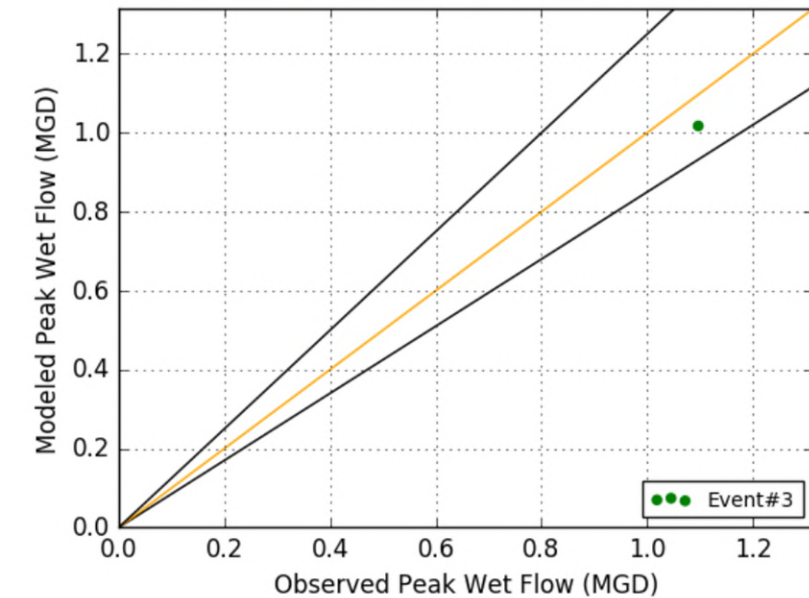
Power BI  
Dashboard

## Event#4

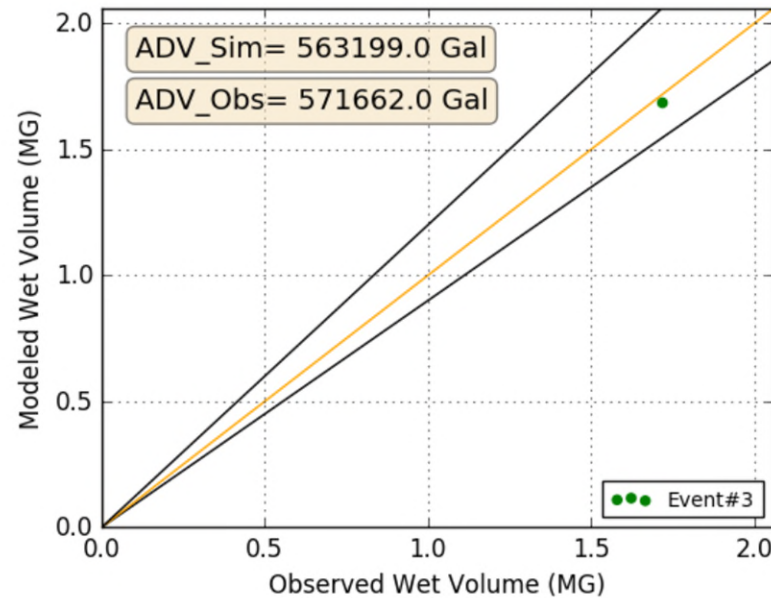
Start 08/22/2021 End 08/24/2021



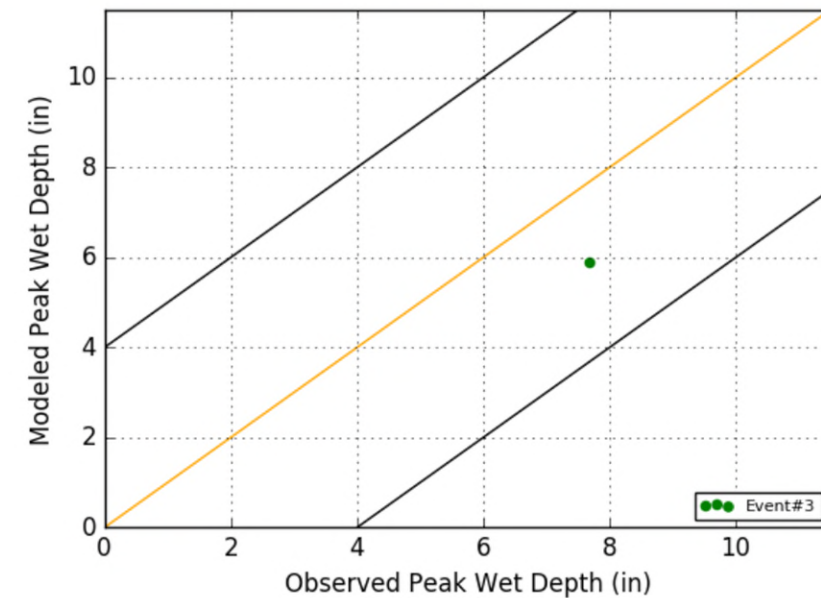
## Peak Flow (MGD), -15% to +25%



## Volume (MG) -10% to +20%



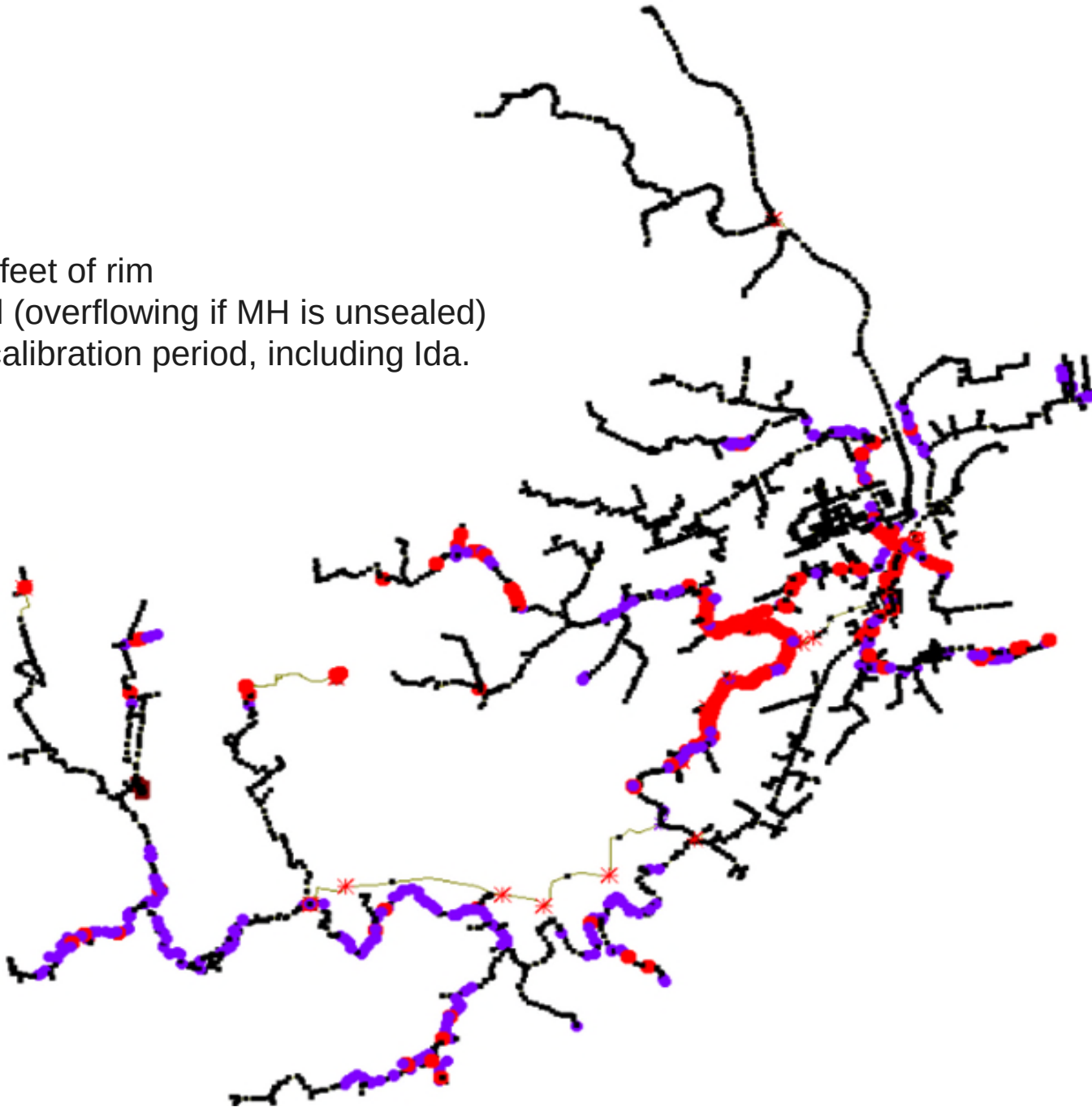
## Peak Depth (in), -/+ 4 inches





# Results

Purple is within 3 feet of rim  
Red is at rim level (overflowing if MH is unsealed)  
This is for entire calibration period, including Ida.



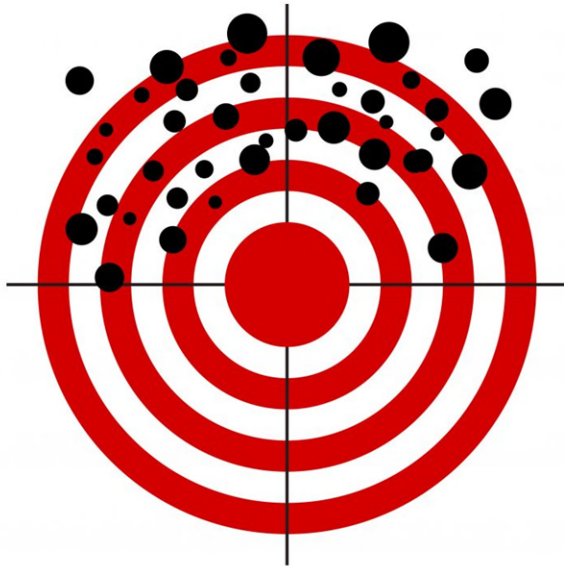
# Where are KISS model's strengths and weaknesses?



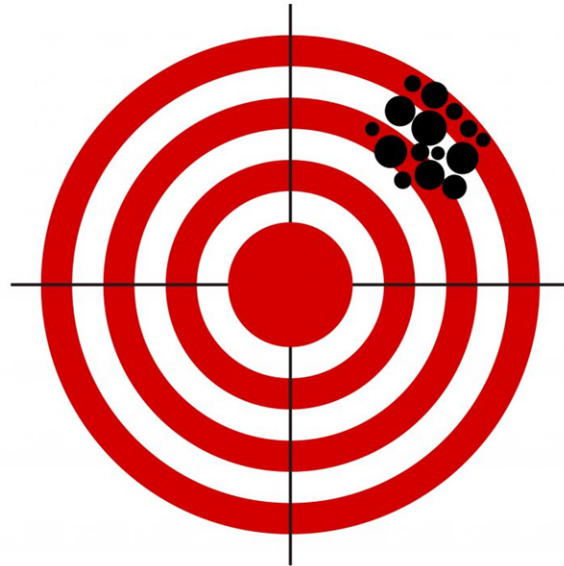


# WLSP PORTION OF MODEL

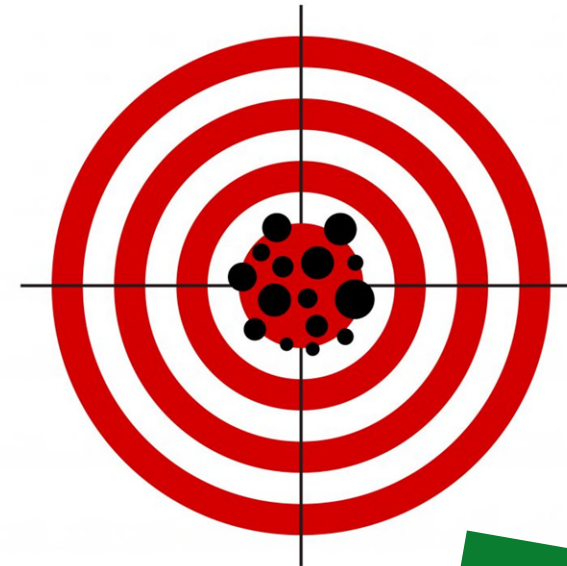




***Neither reliable  
nor valid***

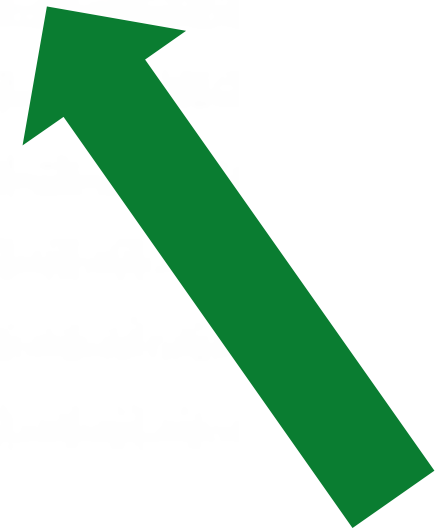


***Reliable, but not  
valid***



***Valid***

***CITY  
MODEL***

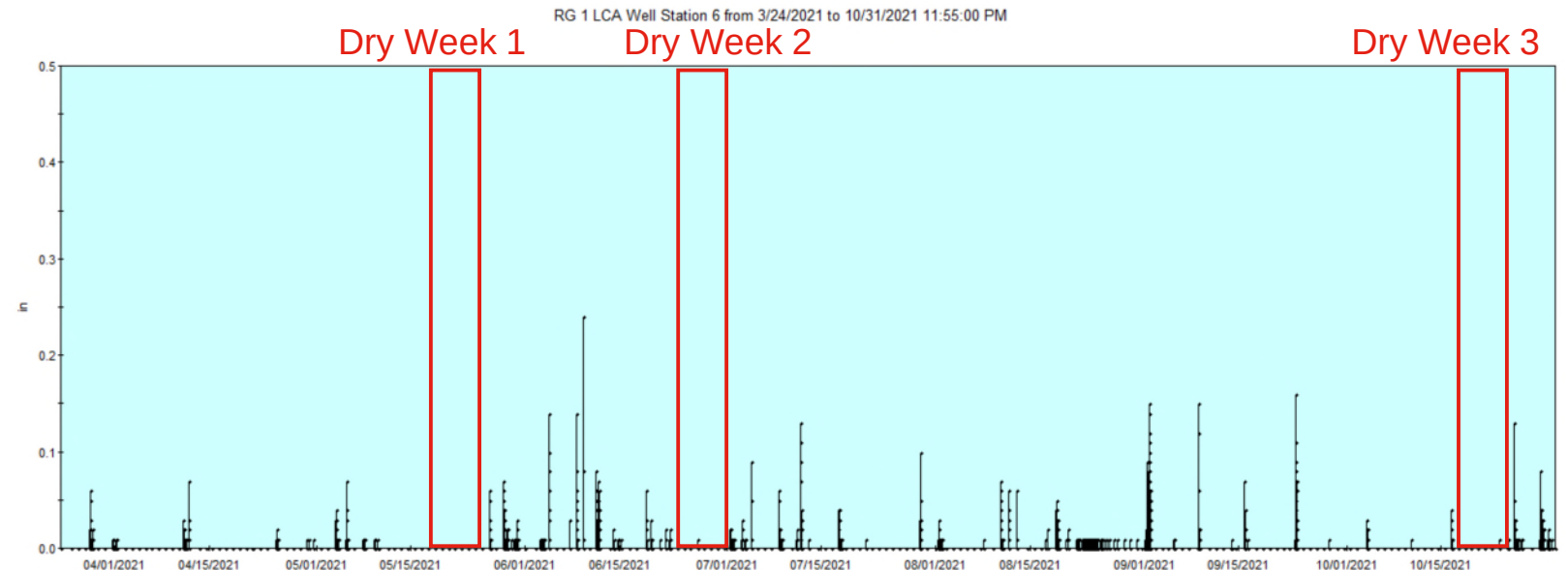
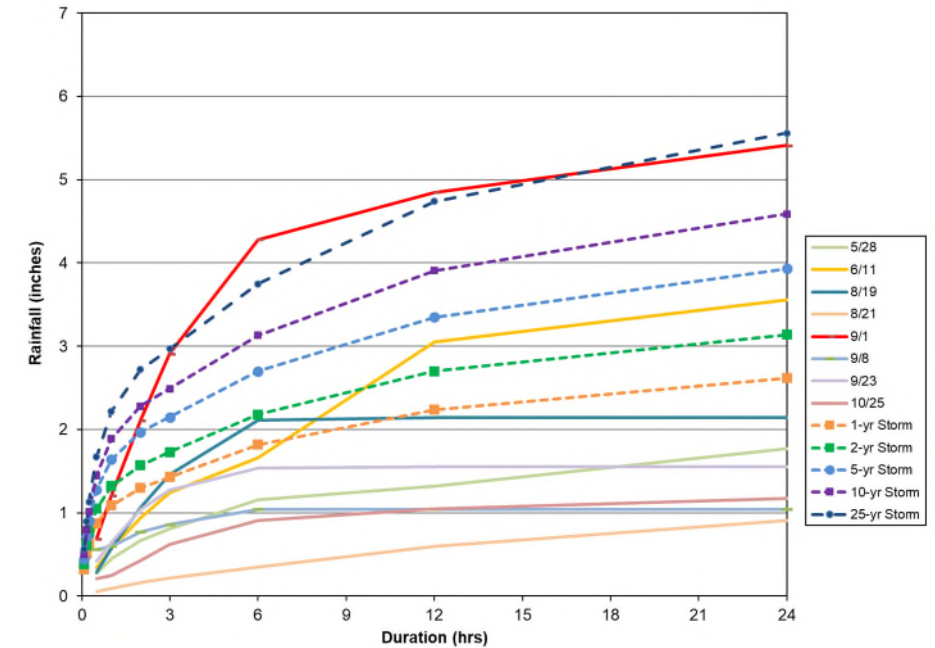




ENTIRE  
KISS  
MODEL

# Strengths – Great Dry and Wet Weather Periods

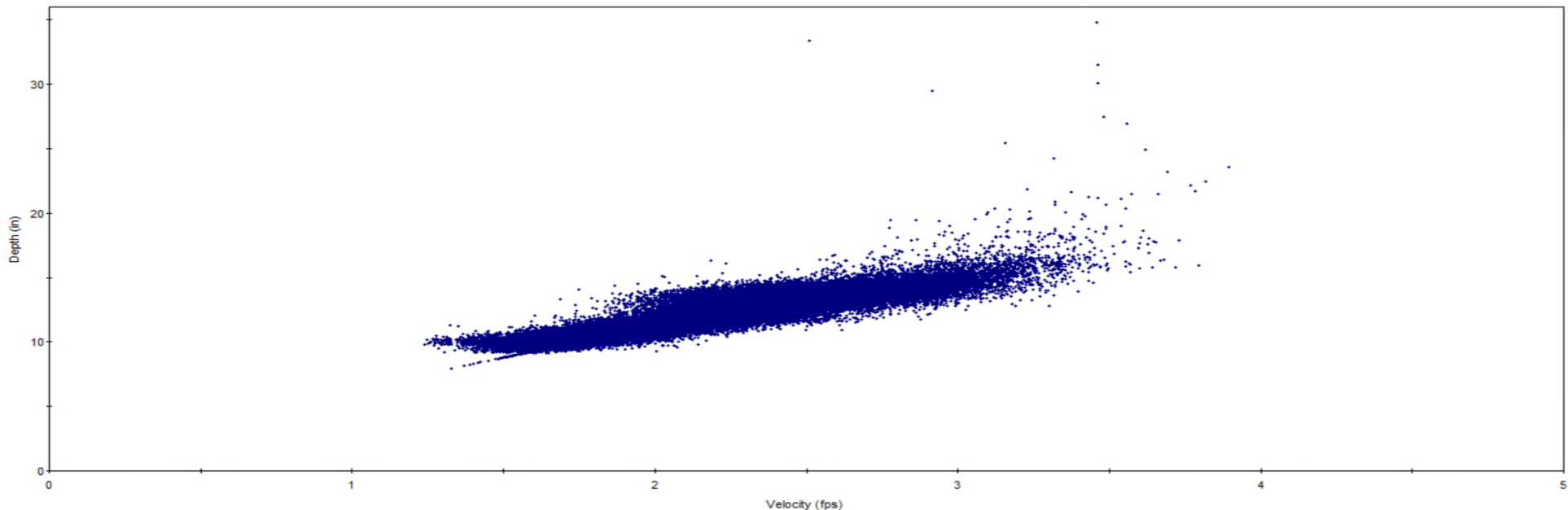
- Multiple significant storms for calibration during metering period
- Due to large groundwater fluctuation throughout the year, able to use several periods for dry weather calibration to calibrate groundwater module well





# Strengths – Flow Meter Data Validation

- Very high quality flow data
  - Independent meter installation checks led to ~15% of meters being replaced or reset, adding of meters, and abandoning of meters
  - 4 rounds of data validation led to high data confidence
  - Majority of data (temporary and permanent) collected in 5-minute increments for very good data resolution

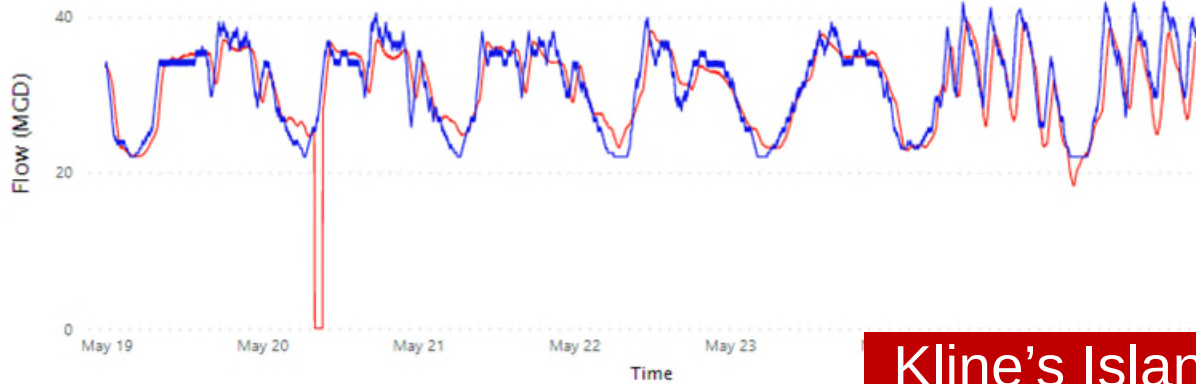




# Strengths – Strong Dry Weather Calibration

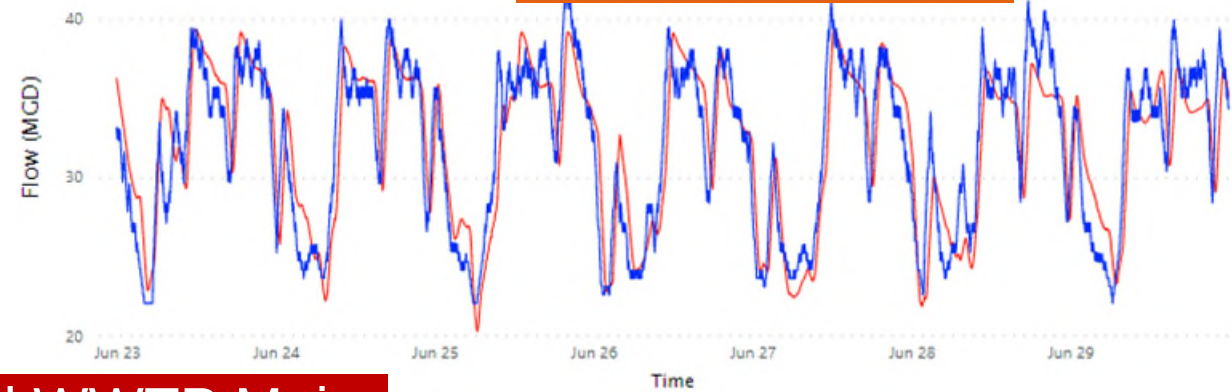
Dry Week 5/18-5/25

● Observed\_Flow ● Predicted\_Flow



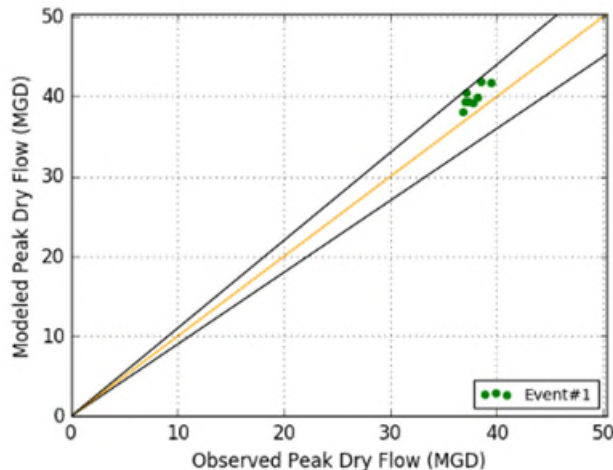
Dry Week 6/23-6/29

● Observed\_Flow ● Predicted\_Flow

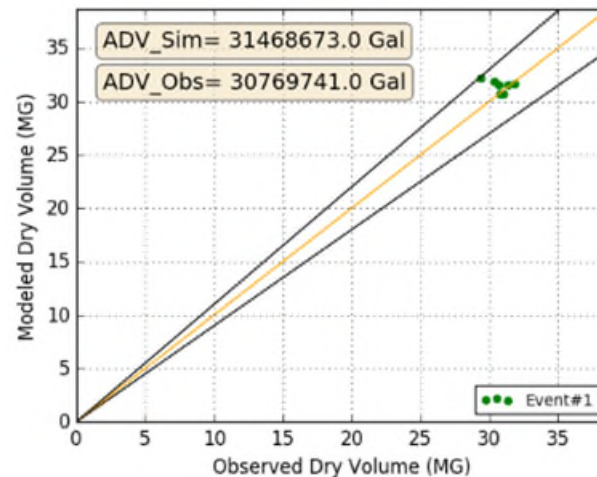


**Kline's Island WWTP Main Influent- Excellent Match**

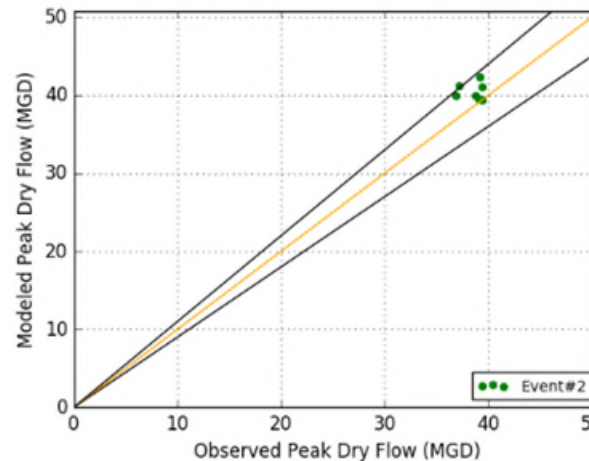
Peak Flow



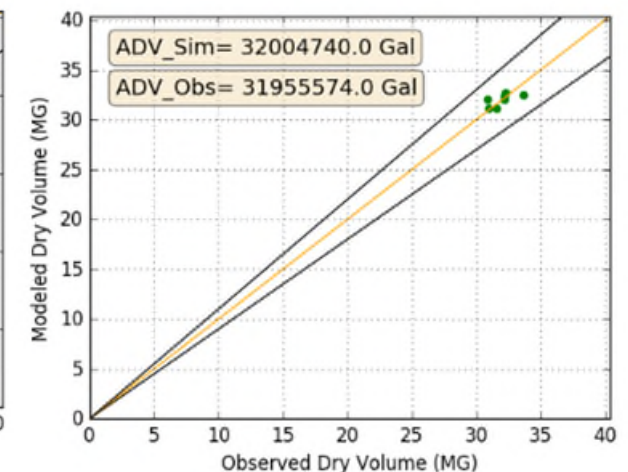
Volume



Peak Flow



Volume

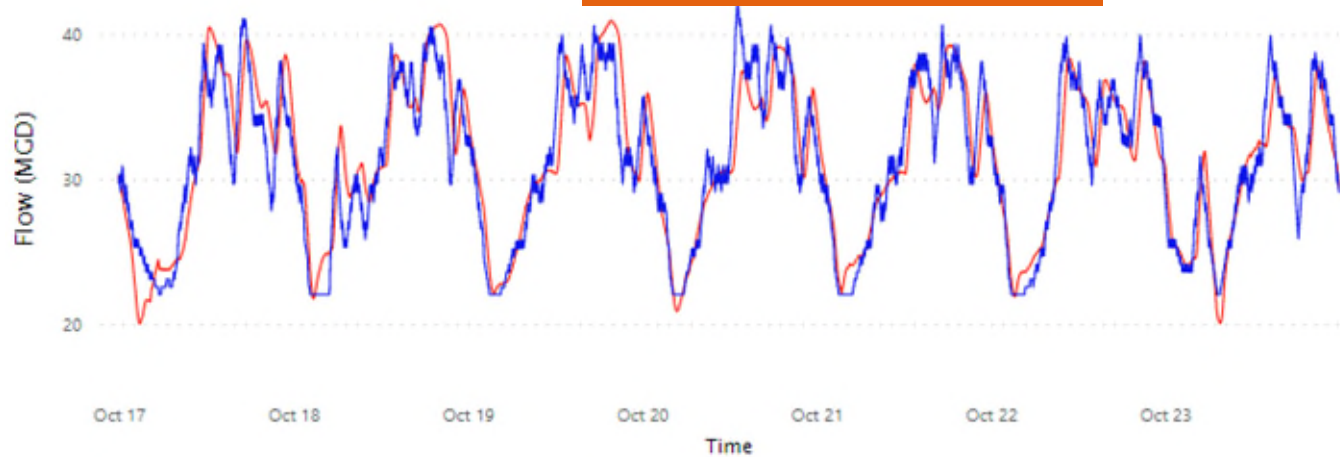




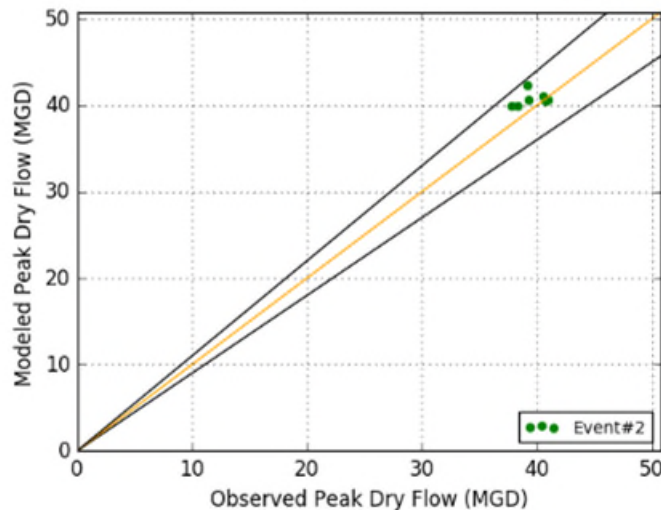
# Strengths – Strong Dry Weather Calibration

● Observed\_Flow ● Predicted\_Flow

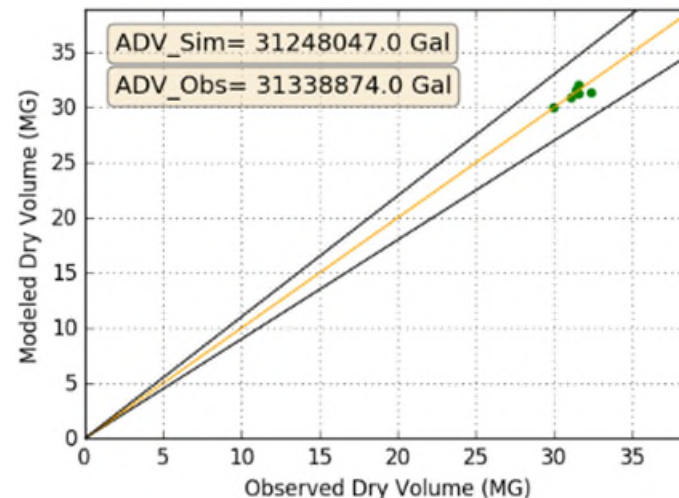
Dry Week 10/17-10/23



Peak Flow



Volume



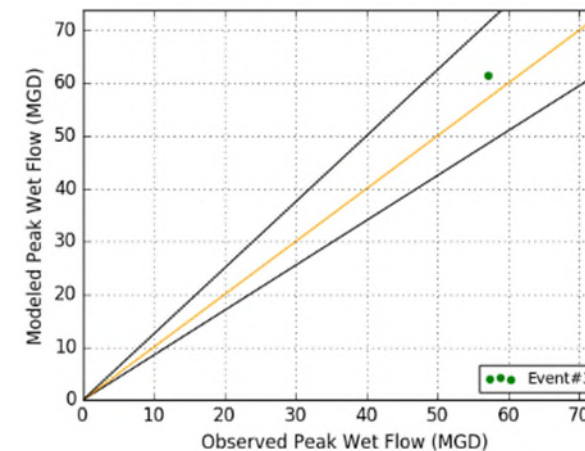
Kline's Island WWTP Main Influent- Excellent Match

# Strengths – Strong Storm Calibrations

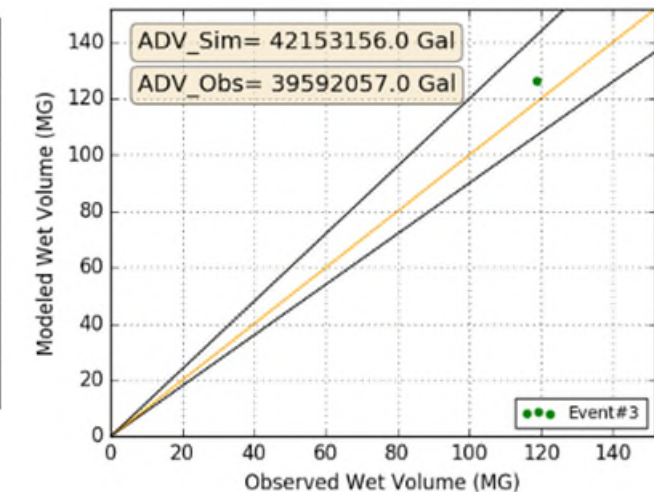
**Kline's Island WWTP Main Influent- Excellent Match**



Peak Flow



Volume

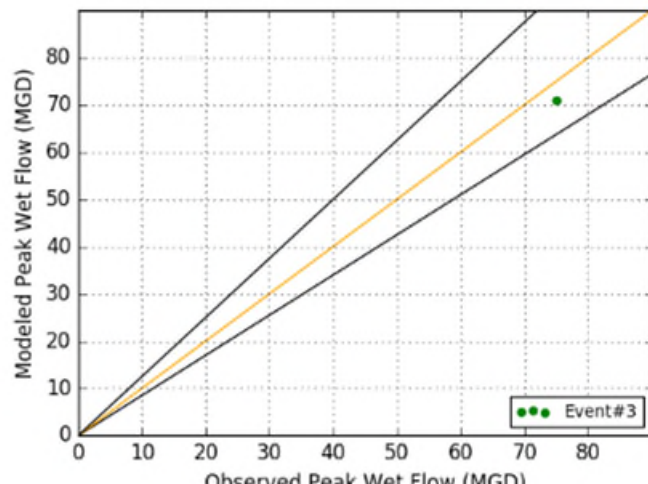


# Strengths – Strong Storm Calibrations

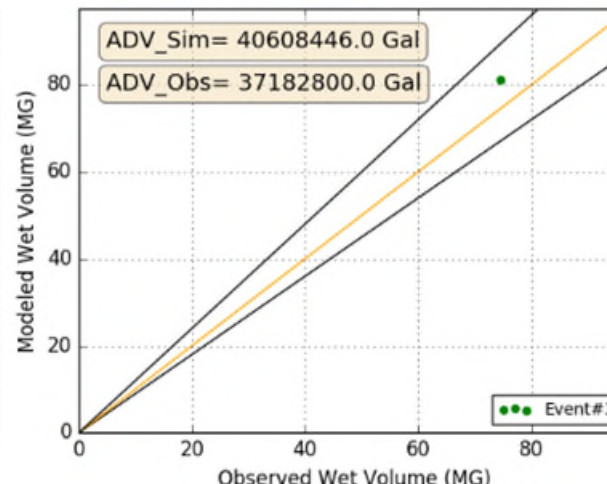


**Kline's Island WWTP Main Influent- Excellent Match**

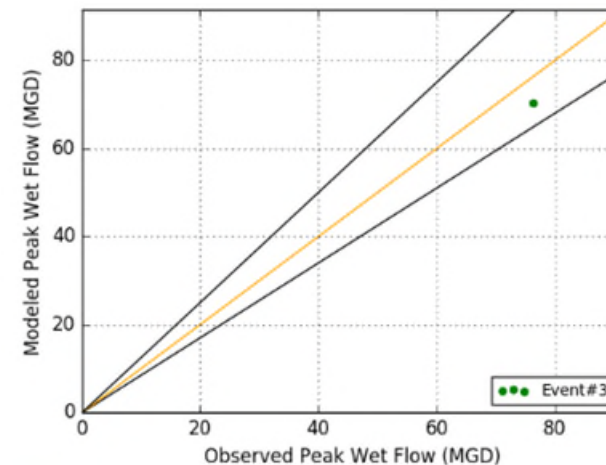
Peak Flow



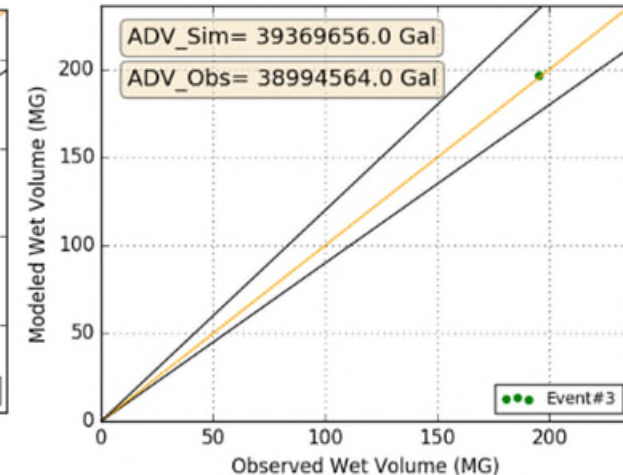
Volume



Peak Flow



Volume





# Strengths – Strong Storm Calibrations



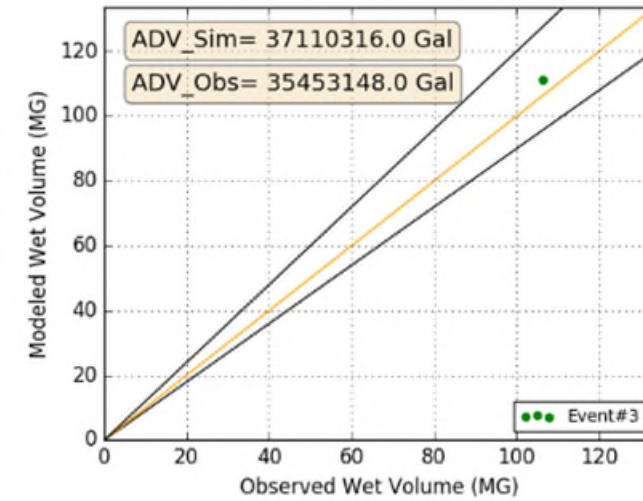
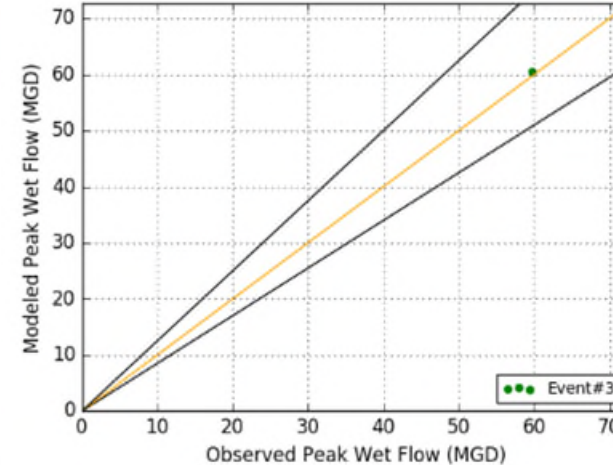
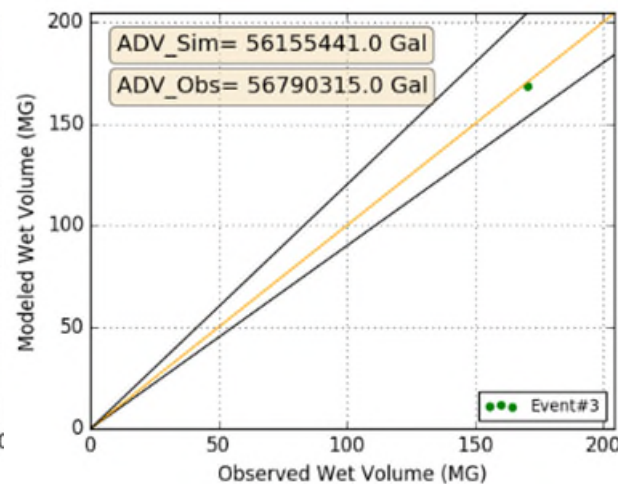
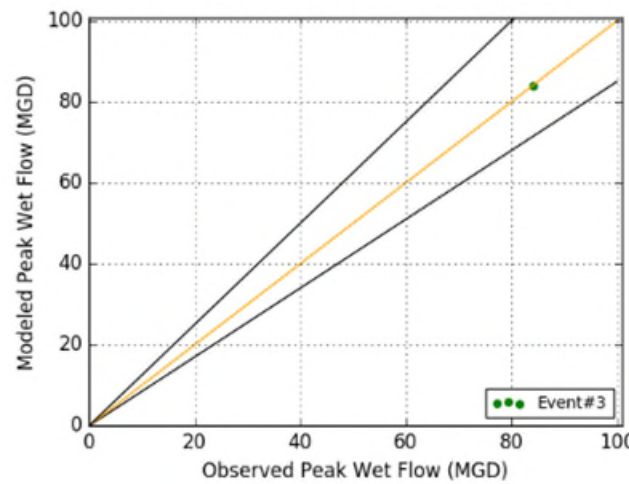
**Kline's Island WWTP Main Influent- Excellent Match**

Peak Flow

Volume

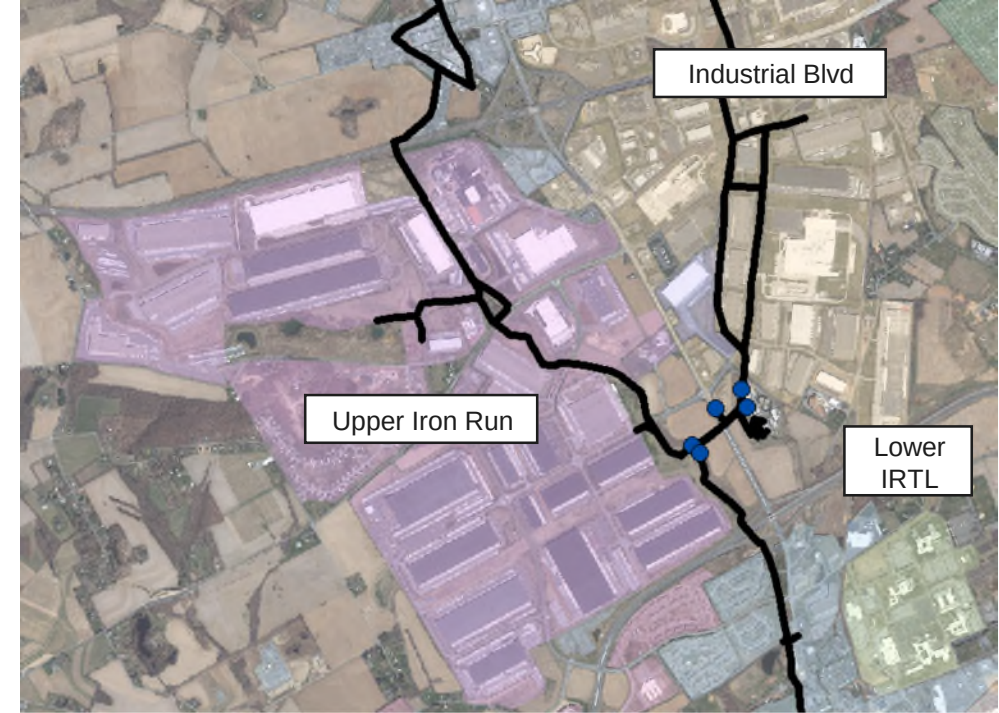
Peak Flow

Volume



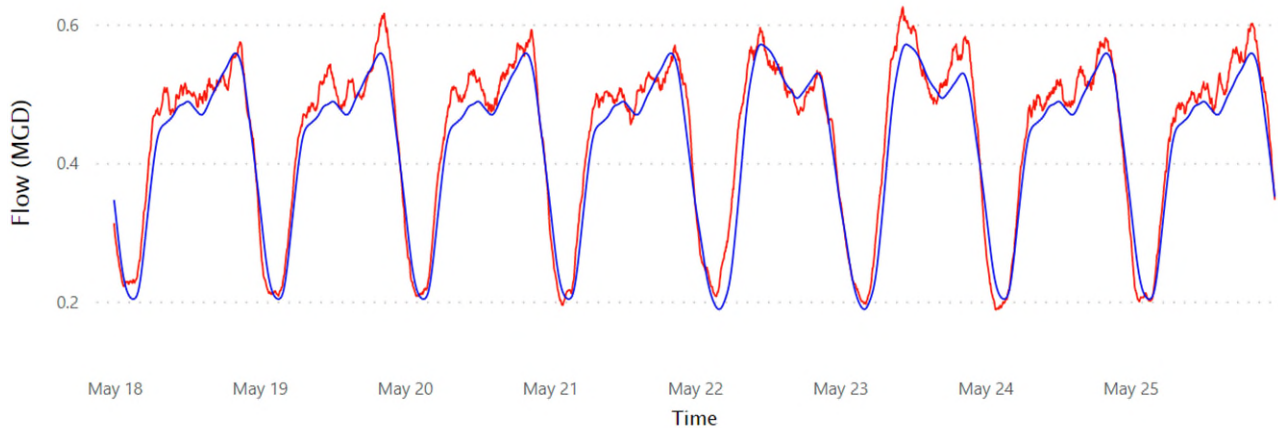
# Weakness – Highly Erratic Industrial Flows

- Industrial flows do not have pattern
  - Impacts Lower Iron Run Trunkline, Industrial Blvd, Upper Iron Run, EB2 (Cintas)
- Can only match volumes, not peaks or troughs from due to inconsistent industrial batch discharges
- Used average flow – means actuals during storms could be higher or lower...as much as 2 MGD at PTP



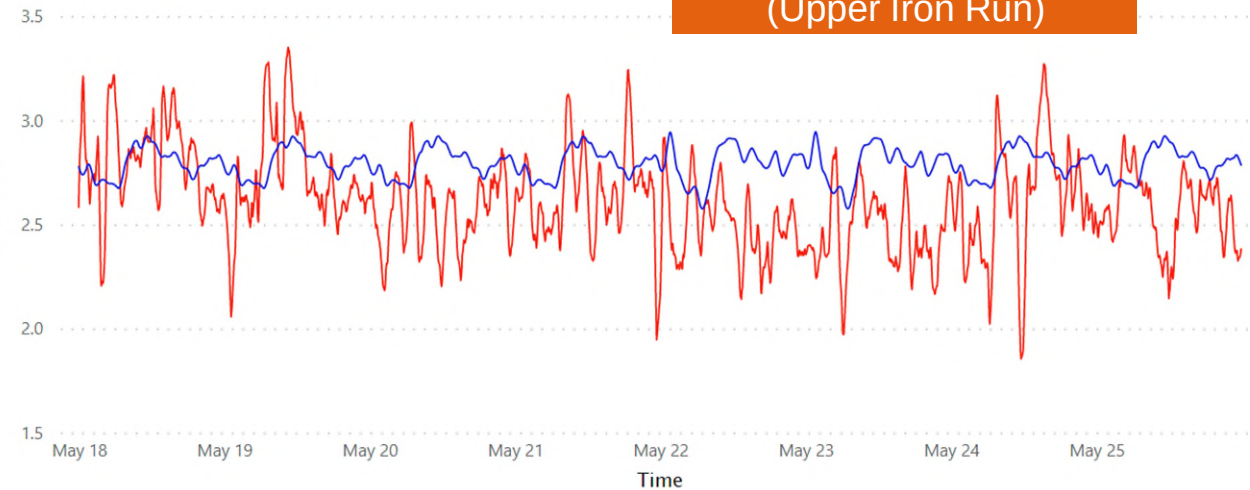
● Observed\_Flow ● Predicted\_Flow

Normal Diurnal Pattern



● Observed\_Flow ● Predicted\_Flow

Industrial Diurnal Pattern (Upper Iron Run)



# Weakness – Operating Logic

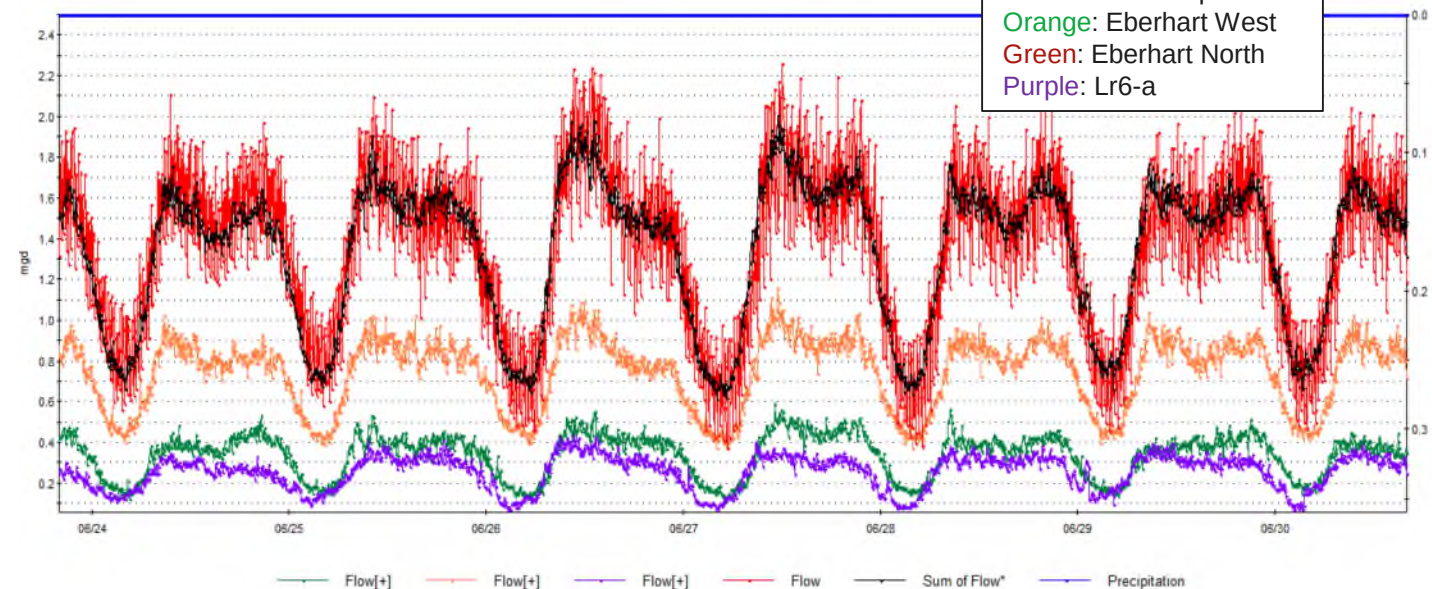
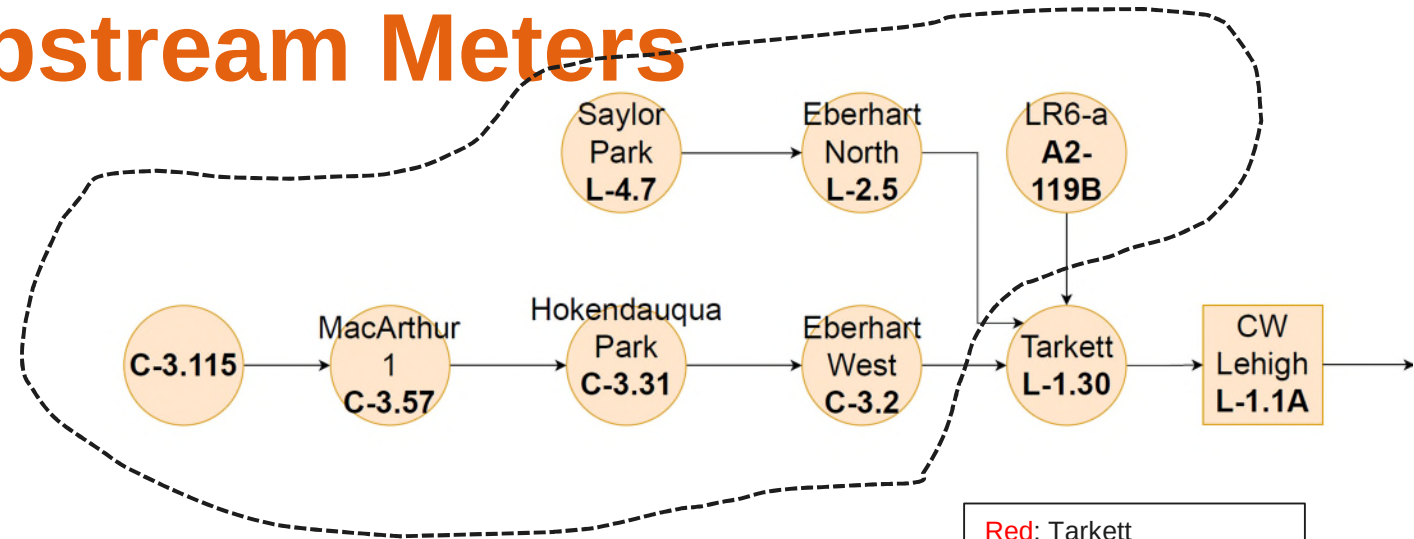
- Human operation for FEB Fill/Drain, Spring Creek Pump Station, Park Pump Station, and Kline's Island Wastewater Treatment Plant can't be replicated in model
  - Operation currently does not follow optimal real-time control logic





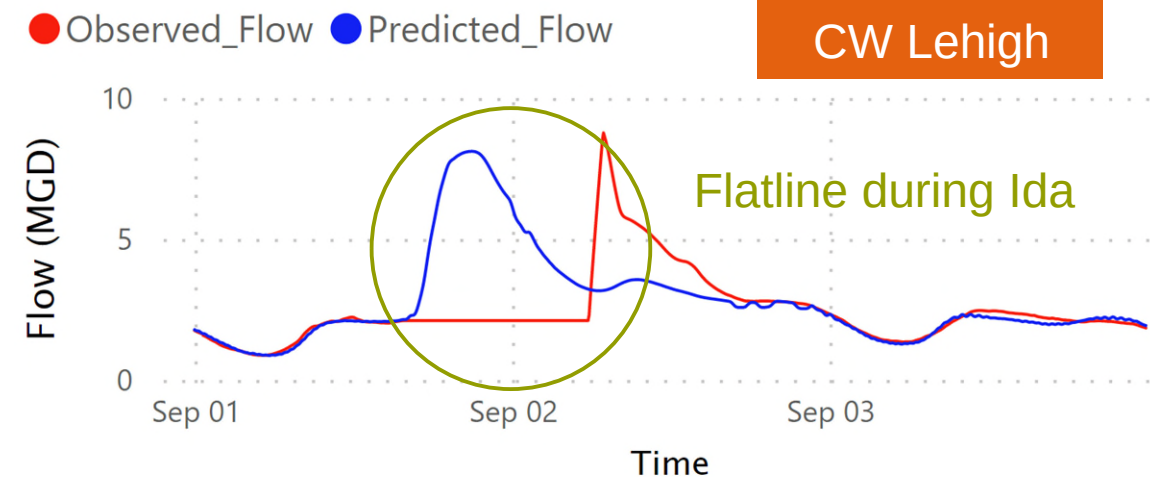
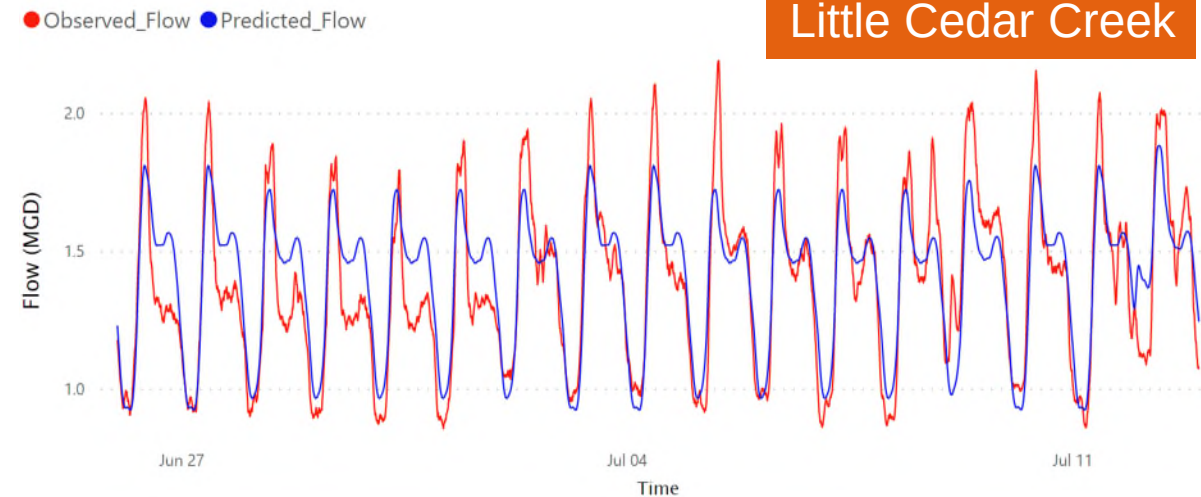
# Minor Weakness – Upstream Meters

- Multiple meters installed in series at various locations
- When upstream flows are >95% of flow at meter, reliability is lower
  - Generally, very well handled in the model



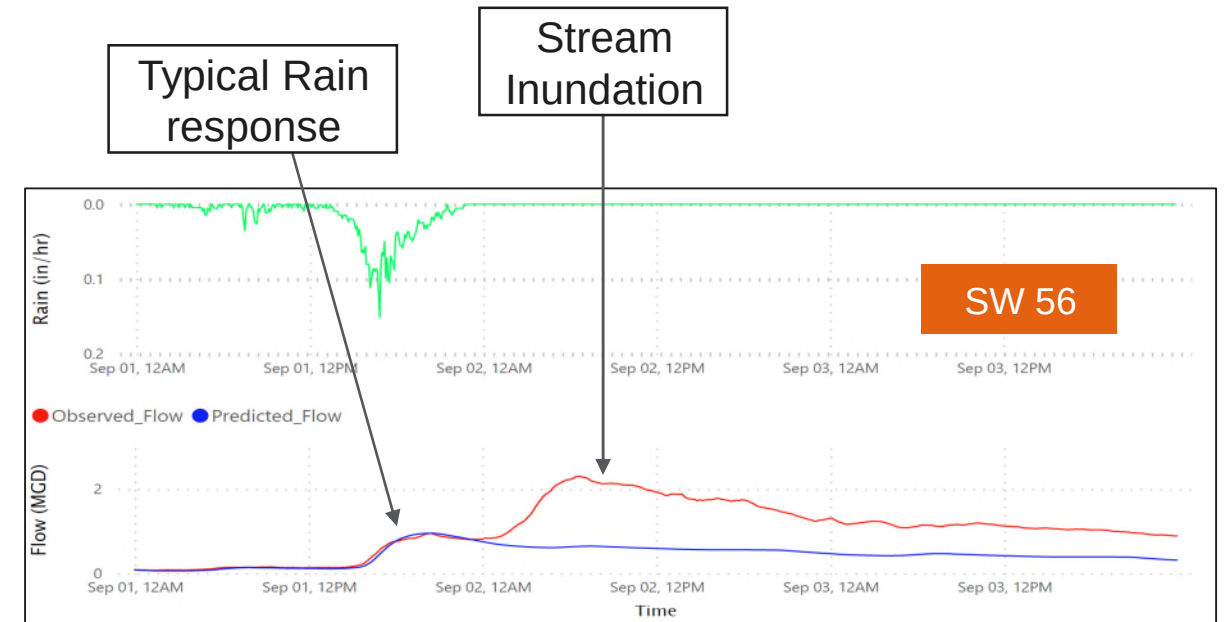
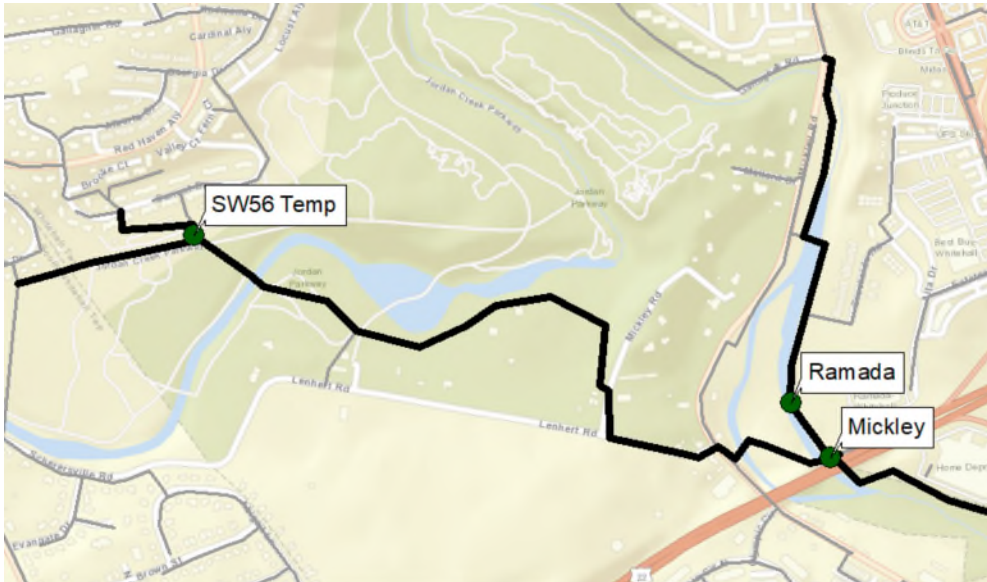
# Minor Weakness –Meter Maintenance and Data Issues

- Applewood PS installed late in monitoring period and data was irregular
  - Used legacy meter UMT01 data instead
- MM4 found to be unreliable
- MS5 partially blocked for two quarters, MS5/MS5a data fluctuates
- SW54 and Little Cedar Creek patterns are inconsistent and peaky, high amount of leakage
- Meters often flatlined or surcharged during larger storms (Hurricane Ida)
- Data quality issues with permanent meters *especially*



# Weakness – Stream Inundation

- Inflow flooding from streams creates a second non-rainfall peak following large storms (Ida)
- Impossible to model without stream data and multiple flooding events (\$\$\$\$)
  - i.e. SW56 Temp and Ramada





# Minor Weakness – Misc.

- Depth of flow at U8 (Breinigsville) is ~1' higher dry and wet weather than the model shows
- Depth of flow at L293 (LMT Dog Park) is 3'-4' higher than the model shows during large events
- U\_26\_84 dry weather data are good, but wet weather are impacted by MS5 siphons and high flows. Used wet weather characteristics of EB2a



U\_26\_84 Event 1

# Improvements

- Extreme surcharging in WLI from Schantz Road to Spring Creek Pump Station in 2019 calibrations led to muted wet weather responses during rainfall and lower confidence levels
- 2021 flows were not as surcharged, and this uncertainty has been removed



# Improvements



- LCA wet weather and dry weather flows to City interceptors
- Park Pump Station split of flows to Little Lehigh Interceptor
- Spring Creek Pump Station split of flows to Western Lehigh Interceptor
- Split in flow at South Whitehall junction box in Cedarcrest Park
- Little Lehigh Interceptor from Hump Bridge to KI

- Huge improvements over 2009 model
- Handles extreme variations in weather/groundwater (New Normal)
- Very well calibrated to 10 year storms (with caveats....)



# Thinks that need to be accounted for when using *Model for Design*



1. Industrial flow vary by 2 MGD from model
2. Depths and flow balances at major flow splits subject to fouling
3. In-line storage is both insignificant and significant, depending rain and pumps
4. Overflow locations wrt bolted covers
5. Stream inundation (inflow) issues during >5 year events (both unmeasured SSO and extreme inflow)
6. Depth of flow at flow convergences and turns >45°
7. Impact of manhole frame and cover sealing in floodplains

**What are the things we are doing now  
with the calibrated model?**



# Confirm sizing of Interim Relief Pumping from PTP to UMT Trunk Line



*Fall 2022*

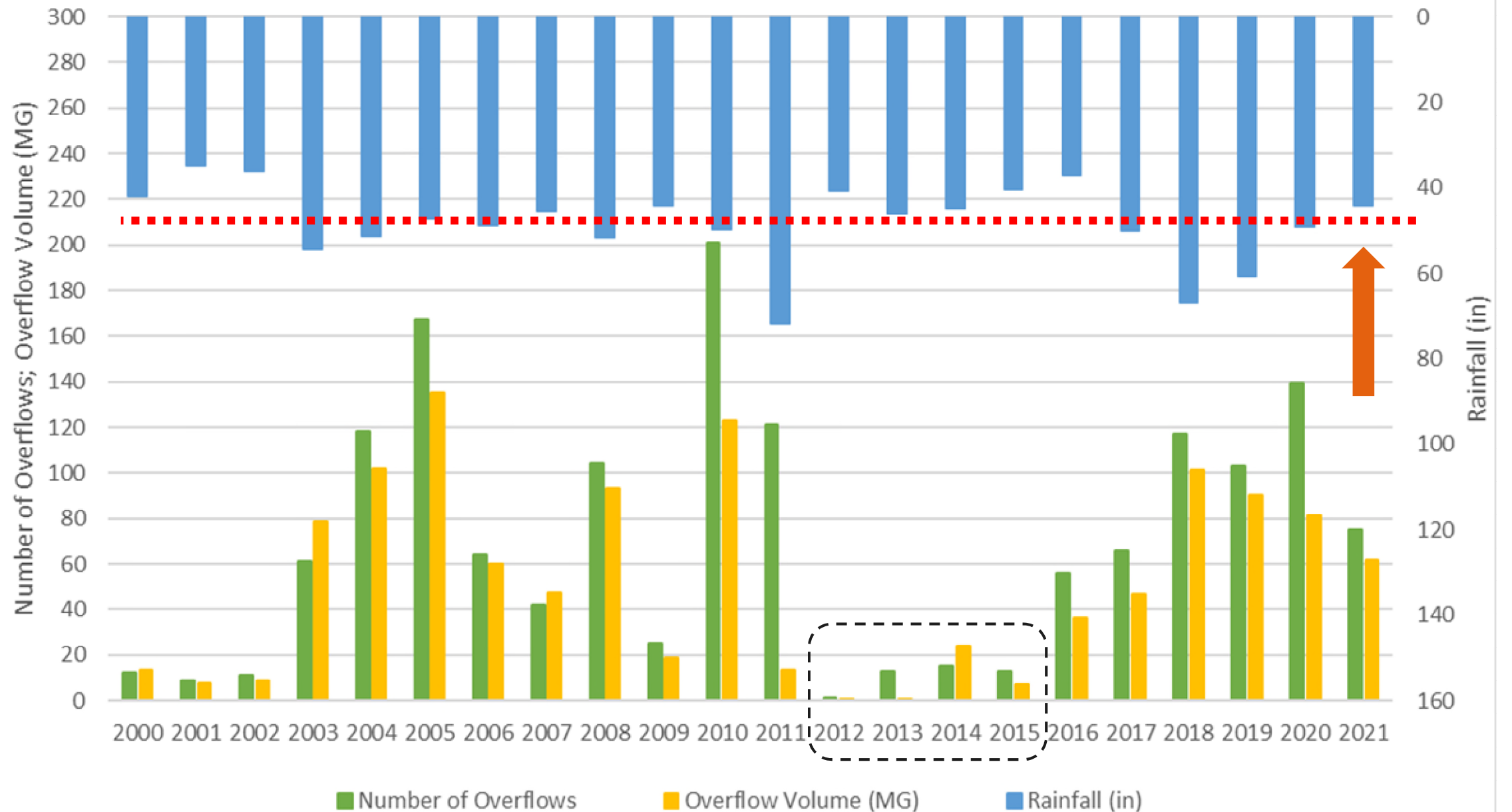


# Design Storm Evaluation

- 22 year model run to evaluate historic storm impact to flow
  - 2000-2022 rainfall
  - Evaluate flows from all large events
  - Pick typical 3 year, 5 year, 10 year, and 20 year storm event to facilitate alternative
- Full 24 year run will determine ultimate performance of selected solution(s)

*July 2022*





# 22 years of Storms

| Duration | Average recurrence interval (years) |                        |                        |                        |                        |                        |                        |
|----------|-------------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
|          | 1                                   | 2                      | 5                      | 10                     | 25                     | 50                     | 100                    |
| 5-min    | 0.324<br>(0.291-0.359)              | 0.385<br>(0.347-0.427) | 0.452<br>(0.407-0.500) | 0.502<br>(0.451-0.555) | 0.563<br>(0.503-0.621) | 0.607<br>(0.539-0.669) | 0.655<br>(0.578-0.723) |
| 10-min   | 0.516<br>(0.464-0.572)              | 0.615<br>(0.554-0.681) | 0.722<br>(0.650-0.799) | 0.803<br>(0.721-0.887) | 0.897<br>(0.801-0.989) | 0.966<br>(0.858-1.07)  | 1.03<br>(0.915-1.14)   |
| 15-min   | 0.645<br>(0.580-0.714)              | 0.772<br>(0.696-0.855) | 0.913<br>(0.822-1.01)  | 1.01<br>(0.909-1.12)   | 1.13<br>(1.01-1.25)    | 1.22<br>(1.08-1.35)    | 1.31<br>(1.15-1.44)    |
| 30-min   | 0.882<br>(0.793-0.976)              | 1.06<br>(0.959-1.18)   | 1.29<br>(1.16-1.43)    | 1.46<br>(1.31-1.62)    | 1.67<br>(1.49-1.85)    | 1.83<br>(1.63-2.02)    | 1.99<br>(1.76-2.20)    |
| 60-min   | 1.10<br>(0.988-1.22)                | 1.33<br>(1.20-1.48)    | 1.66<br>(1.49-1.83)    | 1.90<br>(1.71-2.10)    | 2.23<br>(1.99-2.45)    | 2.48<br>(2.20-2.73)    | 2.74<br>(2.42-3.02)    |
| 2-hr     | 1.31<br>(1.18-1.46)                 | 1.58<br>(1.43-1.76)    | 1.98<br>(1.78-2.20)    | 2.29<br>(2.05-2.54)    | 2.73<br>(2.43-3.02)    | 3.09<br>(2.73-3.42)    | 3.46<br>(3.04-3.84)    |
| 3-hr     | 1.44<br>(1.29-1.61)                 | 1.74<br>(1.56-1.94)    | 2.17<br>(1.95-2.42)    | 2.50<br>(2.24-2.79)    | 2.98<br>(2.65-3.31)    | 3.36<br>(2.97-3.73)    | 3.78<br>(3.31-4.19)    |
| 6-hr     | 1.82<br>(1.65-2.03)                 | 2.19<br>(1.99-2.44)    | 2.72<br>(2.45-3.02)    | 3.15<br>(2.83-3.49)    | 3.77<br>(3.37-4.18)    | 4.29<br>(3.80-4.74)    | 4.86<br>(4.27-5.37)    |
| 12-hr    | 2.25<br>(2.04-2.51)                 | 2.71<br>(2.45-3.02)    | 3.37<br>(3.05-3.75)    | 3.93<br>(3.53-4.37)    | 4.76<br>(4.24-5.26)    | 5.47<br>(4.83-6.04)    | 6.26<br>(5.47-6.91)    |
| 24-hr    | 2.63<br>(2.44-2.85)                 | 3.17<br>(2.94-3.40)    | 3.96<br>(3.68-4.26)    | 4.63<br>(4.28-4.99)    | 5.60<br>(5.18-6.03)    | 6.43<br>(5.88-6.91)    | 7.32<br>(6.68-7.99)    |

- 2 storms >8"
- 7 storms >5"
- 22 storms > 3.17"
- 34 storms > 2.63"



## Top 30 storms over 22 years

| Event Start Time | Event End Time | Storm Name   | Airport Rainfall (Inches) | Peak Hourly Intensity | Rain Duration (Hours) | Atlas 14 Event Return Period |
|------------------|----------------|--------------|---------------------------|-----------------------|-----------------------|------------------------------|
| 10/7/2005        | 10/9/2005      | Tammy        | 9.7                       | 1.2                   | 42                    | 351                          |
| 9/30/2010        | 10/1/2010      | Nicole       | 8.1                       | 2.1                   | 31                    | 259                          |
| 6/25/2006        | 6/28/2006      | Non-tropical | 5.8                       | 1.0                   | 67                    | 9.7                          |
| 7/10/2010        | 7/10/2010      | Alex         | 5.7                       | 2.6                   | 6                     | 405                          |
| 9/4/2011         | 9/7/2011       | Lee          | 5.6                       | 0.6                   | 58                    | 10.2                         |
| 8/27/2011        | 8/28/2011      | Irene        | 5.0                       | 0.8                   | 24                    | 12.8                         |
| 8/4/2020         | 8/4/2020       | Isaias       | 5.0                       | 1.3                   | 13                    | 28                           |
| 9/17/2004        | 9/18/2004      | Ivan         | 4.3                       | 1.1                   | 19                    | 10.6                         |
| 9/1/2021         | 9/1/2021       | Ida          | 4.2                       | 1.0                   | 21                    | 5.5                          |
| 8/13/2011        | 8/14/2011      | Gert         | 4.1                       | 1.0                   | 28                    | 5.4                          |
| 7/21/2003        | 7/23/2003      | Non-tropical | 3.9                       | 1.3                   | 33                    | 4.2                          |
| 9/28/2008        | 9/28/2008      | Kyle         | 3.8                       | 0.8                   | 15                    | 7.6                          |
| 4/2/2005         | 4/3/2005       | Winter       | 3.7                       | 0.4                   | 37                    | 2.0                          |
| 10/10/2002       | 10/12/2002     | Kyle         | 3.7                       | 0.3                   | 46                    | 2.1                          |
| 4/29/2014        | 5/1/2014       | Non-tropical | 3.6                       | 0.3                   | 40                    | 1.9                          |
| 2/12/2008        | 2/13/2008      | Winter       | 3.5                       | 0.3                   | 29                    | 3.0                          |
| 11/2/2018        | 11/3/2018      | Non-tropical | 3.5                       | 1.3                   | 22                    | 2.9                          |
| 12/10/2008       | 12/12/2008     | Non-tropical | 3.4                       | 0.4                   | 56                    | 1.6                          |
| 7/12/2004        | 7/12/2004      | Non-tropical | 3.4                       | 0.7                   | 11                    | 4.4                          |
| 8/3/2018         | 8/4/2018       | Non-tropical | 3.3                       | 0.9                   | 17                    | 4.1                          |
| 8/18/2021        | 8/19/2021      | Fred         | 3.2                       | 1.4                   | 4                     | 34                           |
| 4/15/2007        | 4/16/2007      | Non-tropical | 3.2                       | 0.3                   | 37                    | 1.3                          |
| 9/28/2011        | 9/29/2011      | Ophelia      | 3.1                       | 1.6                   | 24                    | 2.0                          |
| 9/14/2003        | 9/16/2003      | Isabel       | 3.0                       | 0.9                   | 32                    | 2.5                          |
| 2/23/2016        | 2/24/2016      | Winter       | 3.0                       | 0.9                   | 36                    | 1.8                          |
| 7/23/2008        | 7/24/2008      | Non-tropical | 3.0                       | 0.9                   | 13                    | 2.8                          |
| 8/28/2013        | 8/28/2013      | Non-tropical | 2.9                       | 1.6                   | 4                     | 20                           |
| 11/22/2011       | 11/23/2011     | Winter       | 2.9                       | 0.4                   | 30                    | 1.6                          |
| 11/30/2020       | 11/30/2020     | Non-tropical | 2.8                       | 0.7                   | 13                    | 2.2                          |

- 2 storms >8"
- 7 storms >5"
- 22 storms > 3.17"
- 34 storms > 2.63"

# Top 30 storms over 22 years

- 11 storms >10 year Atlas 14 frequency
- 15 storms >5 year Atlas 14 frequency

| Event Start Time | Event End Time | Storm Name   | Airport Rainfall (Inches) | Peak Hourly Intensit | Rain Duration (Hours) | Atlas 14 Event Return Perio |
|------------------|----------------|--------------|---------------------------|----------------------|-----------------------|-----------------------------|
| 7/10/2010        | 7/10/2010      | Alex         | 5.7                       | 2.6                  | 6                     | 405                         |
| 10/7/2005        | 10/9/2005      | Tammy        | 9.7                       | 1.2                  | 42                    | 351                         |
| 9/30/2010        | 10/1/2010      | Nicole       | 8.1                       | 2.1                  | 31                    | 259                         |
| 8/18/2021        | 8/19/2021      | Fred         | 3.2                       | 1.4                  | 4                     | 34                          |
| 8/18/2017        | 8/18/2017      | Non-tropical | 2.3                       | 2.2                  | 1                     | 32                          |
| 8/4/2020         | 8/4/2020       | Isaias       | 5.0                       | 1.3                  | 13                    | 28                          |
| 8/28/2013        | 8/28/2013      | Non-tropical | 2.9                       | 1.6                  | 4                     | 20                          |
| 8/27/2011        | 8/28/2011      | Irene        | 5.0                       | 0.8                  | 24                    | 12.8                        |
| 9/17/2004        | 9/18/2004      | Ivan         | 4.3                       | 1.1                  | 19                    | 10.6                        |
| 9/4/2011         | 9/7/2011       | Lee          | 5.6                       | 0.6                  | 58                    | 10.2                        |
| 6/25/2006        | 6/28/2006      | Non-tropical | 5.8                       | 1.0                  | 67                    | 9.7                         |
| 8/21/2018        | 8/22/2018      | Non-tropical | 2.4                       | 1.0                  | 3                     | 8.0                         |
| 9/28/2008        | 9/28/2008      | Kyle         | 3.8                       | 0.8                  | 15                    | 7.6                         |
| 9/1/2021         | 9/1/2021       | Ida          | 4.2                       | 1.0                  | 21                    | 5.5                         |
| 8/13/2011        | 8/14/2011      | Gert         | 4.1                       | 1.0                  | 28                    | 5.4                         |
| 7/12/2004        | 7/12/2004      | Non-tropical | 3.4                       | 0.7                  | 11                    | 4.4                         |
| 7/1/2017         | 7/1/2017       |              | 1.6                       | 1.2                  | 1                     | 4.3                         |
| 7/21/2003        | 7/23/2003      | Non-tropical | 3.9                       | 1.3                  | 33                    | 4.2                         |
| 8/3/2018         | 8/4/2018       | Non-tropical | 3.3                       | 0.9                  | 17                    | 4.1                         |
| 6/23/2011        | 6/24/2011      |              | 2.1                       | 1.4                  | 3                     | 4.0                         |
| 2/12/2008        | 2/13/2008      | Winter       | 3.5                       | 0.3                  | 29                    | 3.0                         |
| 11/2/2018        | 11/3/2018      | Non-tropical | 3.5                       | 1.3                  | 22                    | 2.9                         |
| 7/23/2008        | 7/24/2008      | Non-tropical | 3.0                       | 0.9                  | 13                    | 2.8                         |
| 10/16/2019       | 10/16/2019     |              | 2.3                       | 0.6                  | 9                     | 2.6                         |
| 9/14/2003        | 9/16/2003      | Isabel       | 3.0                       | 0.9                  | 32                    | 2.5                         |
| 11/30/2020       | 11/30/2020     | Non-tropical | 2.8                       | 0.7                  | 13                    | 2.2                         |
| 7/11/2019        | 7/11/2019      | Barry        | 2.8                       | 1.4                  | 10                    | 2.2                         |
| 7/25/2011        | 7/25/2011      |              | 2.2                       | 1.2                  | 6                     | 2.2                         |
| 7/30/2015        | 7/30/2015      |              | 1.4                       | 0.9                  | 1                     | 2.2                         |
| 10/10/2002       | 10/12/2002     | Kyle         | 3.7                       | 0.3                  | 46                    | 2.1                         |

| Event Start Time | Storm Name   | Airport Rainfall (Inches) | # MH SSOs | MH SSO Rank | MH SSO Frequency | Peak Flow Total (MG) | Peak Flow Rank | Peak Flow Frequency | Overflow Volume (MG) | Overflow Volume Rank | SSO Volume Frequency | Event Rank |
|------------------|--------------|---------------------------|-----------|-------------|------------------|----------------------|----------------|---------------------|----------------------|----------------------|----------------------|------------|
| 10/7/2005        | Tammy        | 9.7                       | 121       | 1           | 17.2             | 238                  | 1              | 28.7                | 94                   | 1                    | 26.1                 | 1          |
| 8/4/2020         | Isaias       | 5.0                       | 87        | 3           | 8.6              | 200                  | 3              | 13.1                | 47                   | 3                    | 5.6                  | 2          |
| 7/10/2010        | Alex         | 5.7                       | 108       | 2           | 13.2             | 216                  | 2              | 18.3                | 37                   | 5                    | 4.1                  | 3          |
| 9/30/2010        | Nicole       | 8.1                       | 78        | 4           | 7.2              | 181                  | 4              | 8.7                 | 75                   | 2                    | 14.0                 | 4          |
| 9/17/2004        | Ivan         | 4.3                       | 58        | 5           | 4.8              | 163                  | 5              | 5.9                 | 42                   | 4                    | 4.8                  | 5          |
| 11/2/2018        | Non-tropical | 3.5                       | 50        | 6           | 4.1              | 161                  | 6              | 5.6                 | 36                   | 6                    | 3.9                  | 6          |
| 9/1/2021         | Ida          | 4.2                       | 42        | 8           | 3.5              | 155                  | 7              | 5.0                 | 31                   | 8                    | 3.3                  | 7          |
| 4/2/2005         | Winter       | 3.7                       | 31        | 11          | 2.8              | 129                  | 10             | 2.9                 | 31                   | 7                    | 3.4                  | 8          |
| 9/28/2008        | Kyle         | 3.8                       | 42        | 9           | 3.5              | 145                  | 8              | 4.1                 | 24                   | 11                   | 2.7                  | 9          |
| 2/23/2016        | Winter       | 3.0                       | 28        | 12          | 2.6              | 129                  | 9              | 2.9                 | 22                   | 13                   | 2.5                  | 10         |
| 2/12/2008        | Winter       | 3.5                       | 27        | 14          | 2.6              | 124                  | 14             | 2.6                 | 30                   | 9                    | 3.2                  | 11         |
| 11/30/2020       | Non-tropical | 2.8                       | 28        | 13          | 2.6              | 127                  | 11             | 2.8                 | 20                   | 19                   | 2.3                  | 12         |
| 6/25/2006        | Non-tropical | 5.8                       | 24        | 18          | 2.4              | 115                  | 19             | 2.2                 | 29                   | 10                   | 3.1                  | 13         |
| 8/13/2018        | Non-tropical | 2.6                       | 19        | 21          | 2.2              | 120                  | 15             | 2.4                 | 24                   | 12                   | 2.6                  | 14         |
| 11/27/2004       | Non-tropical | 2.4                       | 25        | 16          | 2.5              | 124                  | 13             | 2.6                 | 18                   | 20                   | 2.2                  | 15         |
| 8/3/2018         | Non-tropical | 3.3                       | 25        | 15          | 2.5              | 116                  | 17             | 2.2                 | 20                   | 18                   | 2.3                  | 16         |
| 6/20/2003        | Non-tropical | 2.7                       | 22        | 19          | 2.3              | 120                  | 16             | 2.4                 | 20                   | 17                   | 2.4                  | 17         |
| 7/11/2019        | Barry        | 2.8                       | 25        | 17          | 2.5              | 125                  | 12             | 2.7                 | 15                   | 26                   | 2.0                  | 18         |
| 7/22/2019        | Non-tropical | 2.6                       | 15        | 23          | 2.0              | 112                  | 21             | 2.0                 | 17                   | 22                   | 2.2                  | 19         |
| 8/27/2011        | Irene        | 5.0                       | 50        | 7           | 4.1              | 116                  | 18             | 2.2                 | 8                    | 42                   | 1.6                  | 20         |
| 8/18/2017        | Non-tropical | 2.3                       | 19        | 22          | 2.2              | 112                  | 22             | 2.0                 | 16                   | 25                   | 2.0                  | 21         |
| 4/29/2014        | Non-tropical | 3.6                       | 9         | 30          | 1.8              | 100                  | 27             | 1.6                 | 21                   | 15                   | 2.4                  | 22         |
| 12/10/2008       | Non-tropical | 3.4                       | 9         | 31          | 1.8              | 97                   | 30             | 1.5                 | 20                   | 16                   | 2.4                  | 23         |
| 9/14/2003        | Isabel       | 3.0                       | 10        | 28          | 1.8              | 99                   | 28             | 1.5                 | 18                   | 21                   | 2.2                  | 24         |
| 8/18/2021        | Fred         | 3.2                       | 13        | 25          | 1.9              | 113                  | 20             | 2.1                 | 11                   | 33                   | 1.7                  | 25         |
| 12/16/2000       | Winter       | 2.5                       | 11        | 26          | 1.9              | 108                  | 25             | 1.8                 | 14                   | 28                   | 1.9                  | 26         |
| 7/12/2004        | Non-tropical | 3.4                       | 15        | 24          | 2.0              | 112                  | 23             | 2.0                 | 11                   | 32                   | 1.8                  | 27         |
| 8/21/2018        | Non-tropical | 2.4                       | 11        | 27          | 1.9              | 109                  | 24             | 1.9                 | 13                   | 29                   | 1.9                  | 28         |
| 4/15/2007        | Non-tropical | 3.2                       | 7         | 33          | 1.7              | 91                   | 35             | 1.3                 | 21                   | 14                   | 2.5                  | 29         |
| 9/28/2004        | Jeanne       | 2.6                       | 7         | 35          | 1.7              | 94                   | 31             | 1.4                 | 16                   | 24                   | 2.1                  | 30         |

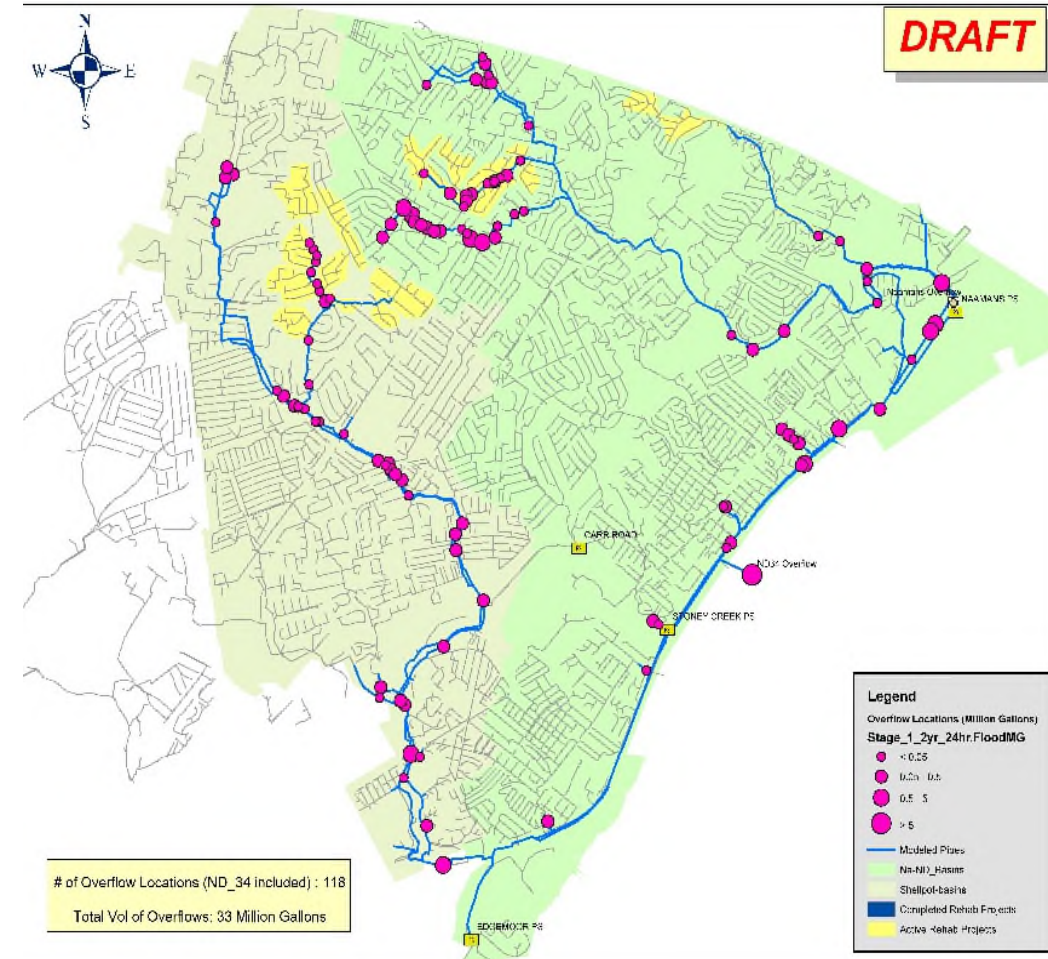
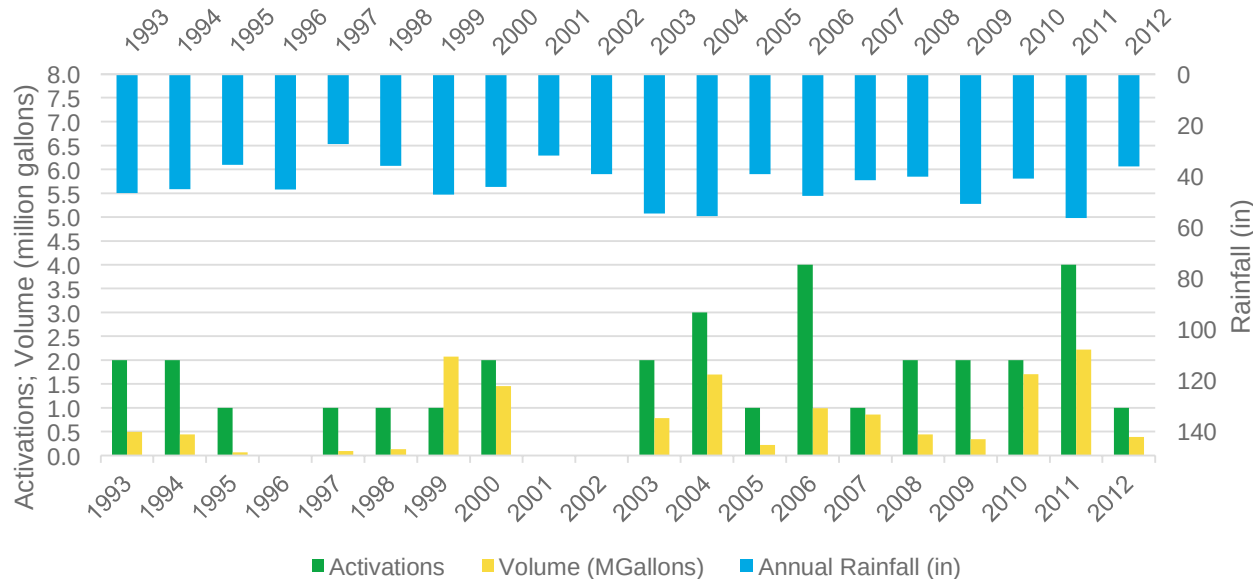


| Event Start<br>Time | Storm Name   | Airport<br>Rainfall<br>(Inches) | # MH<br>SSOs | MH SSO<br>Frequen | Peak Flow<br>Total (MG) | Peak Flow<br>Frequenc | Overflow<br>Volume<br>(MG) | SSO<br>Volume<br>Frequen | Event Ra | Event Description |
|---------------------|--------------|---------------------------------|--------------|-------------------|-------------------------|-----------------------|----------------------------|--------------------------|----------|-------------------|
|                     |              |                                 |              |                   |                         |                       |                            |                          |          |                   |
| 10/7/2005           | Tammy        | 9.7                             | 121          | 17.2              | 238                     | 28.7                  | 94                         | 26.1                     | 1        | > 20 year event   |
| 8/4/2020            | Isaias       | 5.0                             | 87           | 8.6               | 200                     | 13.1                  | 47                         | 5.6                      | 2        | 10 year event     |
| 7/10/2010           | Alex         | 5.7                             | 108          | 13.2              | 216                     | 18.3                  | 37                         | 4.1                      | 3        | 10 year event     |
| 9/30/2010           | Nicole       | 8.1                             | 78           | 7.2               | 181                     | 8.7                   | 75                         | 14.0                     | 4        | 10 year event     |
| 9/17/2004           | Ivan         | 4.3                             | 58           | 4.8               | 163                     | 5.9                   | 42                         | 4.8                      | 5        | 5 year event      |
| 11/2/2018           | Non-tropical | 3.5                             | 50           | 4.1               | 161                     | 5.6                   | 36                         | 3.9                      | 6        | 5 year event      |
| 9/1/2021            | Ida          | 4.2                             | 42           | 3.5               | 155                     | 5.0                   | 31                         | 3.3                      | 7        |                   |
| 4/2/2005            | Winter       | 3.7                             | 31           | 2.8               | 129                     | 2.9                   | 31                         | 3.4                      | 8        | 3 year event      |
| 9/28/2008           | Kyle         | 3.8                             | 42           | 3.5               | 145                     | 4.1                   | 24                         | 2.7                      | 9        | 3 year event      |
| 2/23/2016           | Winter       | 3.0                             | 28           | 2.6               | 129                     | 2.9                   | 22                         | 2.5                      | 10       | 3 year event      |
| 2/12/2008           | Winter       | 3.5                             | 27           | 2.6               | 124                     | 2.6                   | 30                         | 3.2                      | 11       | 3 year event      |
| 11/30/2020          | Non-tropical | 2.8                             | 28           | 2.6               | 127                     | 2.8                   | 20                         | 2.3                      | 12       |                   |
| 6/25/2006           | Non-tropical | 5.8                             | 24           | 2.4               | 115                     | 2.2                   | 29                         | 3.1                      | 13       |                   |
| 8/13/2018           | Non-tropical | 2.6                             | 19           | 2.2               | 120                     | 2.4                   | 24                         | 2.6                      | 14       |                   |
| 11/27/2004          | Non-tropical | 2.4                             | 25           | 2.5               | 124                     | 2.6                   | 18                         | 2.2                      | 15       |                   |
| 8/3/2018            | Non-tropical | 3.3                             | 25           | 2.5               | 116                     | 2.2                   | 20                         | 2.3                      | 16       |                   |
| 6/20/2003           | Non-tropical | 2.7                             | 22           | 2.3               | 120                     | 2.4                   | 20                         | 2.4                      | 17       |                   |
| 7/11/2019           | Barry        | 2.8                             | 25           | 2.5               | 125                     | 2.7                   | 15                         | 2.0                      | 18       |                   |
| 7/22/2019           | Non-tropical | 2.6                             | 15           | 2.0               | 112                     | 2.0                   | 17                         | 2.2                      | 19       |                   |
| 8/27/2011           | Irene        | 5.0                             | 50           | 4.1               | 116                     | 2.2                   | 8                          | 1.6                      | 20       |                   |
| 8/18/2017           | Non-tropical | 2.3                             | 19           | 2.2               | 112                     | 2.0                   | 16                         | 2.0                      | 21       |                   |
| 4/29/2014           | Non-tropical | 3.6                             | 9            | 1.8               | 100                     | 1.6                   | 21                         | 2.4                      | 22       |                   |
| 12/10/2008          | Non-tropical | 3.4                             | 9            | 1.8               | 97                      | 1.5                   | 20                         | 2.4                      | 23       |                   |
| 9/14/2003           | Isabel       | 3.0                             | 10           | 1.8               | 99                      | 1.5                   | 18                         | 2.2                      | 24       |                   |
| 8/18/2021           | Fred         | 3.2                             | 13           | 1.9               | 113                     | 2.1                   | 11                         | 1.7                      | 25       |                   |
| 12/16/2000          | Winter       | 2.5                             | 11           | 1.9               | 108                     | 1.8                   | 14                         | 1.9                      | 26       |                   |
| 7/12/2004           | Non-tropical | 3.4                             | 15           | 2.0               | 112                     | 2.0                   | 11                         | 1.8                      | 27       |                   |
| 8/21/2018           | Non-tropical | 2.4                             | 11           | 1.9               | 109                     | 1.9                   | 13                         | 1.9                      | 28       |                   |
| 4/15/2007           | Non-tropical | 3.2                             | 7            | 1.7               | 91                      | 1.3                   | 21                         | 2.5                      | 29       |                   |
| 9/28/2004           | Jeanne       | 2.6                             | 7            | 1.7               | 94                      | 1.4                   | 16                         | 2.1                      | 30       |                   |

# Existing System Performance

August - September 2022

- Without changes to system, under 4 design storms, what are flows and SSO with:
  - No new flows added
  - 2050 flow added



# Existing System Performance

- Without changes to system, what are dry day levels in interceptors:
  - No new flows added
  - 2050 flow added

*August - September 2022*





What's next?

WHAT  
NEXT ?

# Alternative Scenarios

## Storage

- a. Cedar Creek Park Tank
- b. Spring Creek Tank
- c. Lehigh Interceptor West Tank
- d. Jordan Creek Tank
- e. Kecks Bridge Tank
- f. Emmaus Cedar creek Boulevard Tank
- g. Trout Creek Tank
- h. Sumner Tank
- i. Alburtis Macungie Tank
- j. Hump Bridge Tank
- k. U6 Tank
- l. Brenigsville Tank

## Gravity Conveyance

- a. Replacements with larger pipes
- b. Parallels of existing pipes
- c. Removal of bottlenecks
  - Water Treatment Plant siphons
  - Confluence of Jordan Creek and Little Lehigh Interceptors
  - Eastside Interceptor Lehigh River siphon

## Pumped Conveyance

- a. Spring Creek Pump Station (as is and upgrade, and with various current and potential force mains discharging to LLRI (as currently), to Little Sister Pump Station, or to ahead of, at, or inside KIWWTP)
- b. Little Sister Pump Station (with force main alignments and discharge points ahead of, at, and inside KI WWTP)
- c. PTP Direct Discharge Pump Station and force main to Lehigh River outside KI WWTP
- d. PTP Pump Station and force main to KI WWTP headwork or inside KI WWTP
- e. Fogelsville Pump Station and forcemain capture ~1/2 the PTP flow before PTP treatment and conveying it to the Upper Macungie Trunk Line north of Grange Road
- f. Various other pump stations and force mains, including but not limited to:
  - Breinigsville Pump Station and Force Main
  - Kecks Bridge Pump Station and Force Main
  - Cedar Creek Pump Station and Force Main
  - Jordan Creek Pump Station and Force Main
  - Lehigh River West Pump Station and Force Main
  - Lehigh River East Pump Station and Force Main
  - Eberhart Pump Station Expanse and Force Main extension

# Alternative Scenarios

## Source Reductions

- a. Common-sense SRPs to significantly reduce peak inflow from the worst inflow-impacted areas of the KISS collection system
- b. Common-sense SRPs to significantly reduce baseline infiltration and rainfall induced infiltration from the worst leaking areas of the KISS collection system
- c. Signatory-proposed SRPs idiosyncratic to each Signatories' individual ideas about appropriate leakage rates and the need to control them
- d. Moderate SRPs to eliminate leakage from catchments with high inflow and infiltration leakage
- e. Aggressive public SRPs to eliminate leakage from catchments with moderately high and high inflow and infiltration leakage
- f. Private lateral and private sump pump programs to increase I&I removals

## Treatment

- a. Variations on treatment at Kline's Island
- b. Variations on full NPDES treatment as a direct discharge from PTP to Lehigh River (discharge to Jordan Creek and discharge via land application were reviewed and dismissed during SCAPR/AO work).
- c. Variations on partial treatment at PTP (8:30, 4:30, 0:30, and 0:40 dry:wet schemes) with multiple possible discharge points, including:
  - Iron Run
  - Spring Creek Pump Station wet well
  - Upper Macungie Trunkline
  - Park Pump Station wet well
  - Kline's Island headworks
  - Kline's Island expanded headworks
  - Kline's Island treatment system



# Preliminary Screening of Alternatives

## SRPs

0 – No RDII Reductions?

- ① RED Only Common Sense only
- ② Individual SRPs
- ③ RED & ORANGE
- ④ AGGRESSIVE RDII

## TREATMENT

- ① KI Only
- ⑦ <sup>DRY</sup> 0:40 <sup>WET</sup>
- ⑥ 0:30
- ④ 4:30

This is all flow  
to PTP

This is all flow  
to PTP and  
SCPS without  
an EQ Tank

## CONVEYANCE

- ① PURE PARALLEL  
<sub>NEW</sub>
- ② LSPS/FM
  - ③ → All of LLRI & AEI
  - ⑤ → Some of LLRI & AEI
- ③ SCPS/FM
  - ① → To LLRI
  - ② → To PPS/LSPS
  - ③ → To KI WWTP

This will set  
MGD of T7

October 2022 – March 2023

4 2

4 3

6 3

# Operating Guidelines

- Interceptor pressurization / hydraulic grade line limits
- Pump station operation rules
- Basement protection rules
- Interceptor Parallel versus Enlargement
- Primacy rights to City Interceptors



*July 2022 – August 2022*



# Final Alternative Analyses

- Revised/Finalized Source Reduction Plan(s)
- Revisions to operating guidelines
- Capital, O&M, Energy (carbon footprint), and Net Present Worth
- Design storm sensitivity
- Climate change considerations
- Sequence of construction

*April 2023 – February 2024*



# Selection of Solution

- Short list of options
- Final proof of performance via 24 year simulation
- Project Sequence and Schedule
- Cash Flow Demand
- Who pays?
- Regionalization?
- Bond and Finance Strategy Development
- Rate Analyses

*March 2024 – December 2024*





# Achieving Consensus on Solution

- Stakeholder vetting
  - LCA Board
  - Signatory Boards
  - PADEP
  - Activists
  - Developers
  - County
  - Customers

*December 2024 – March 2025*



# Ratification

- Each board's formal adoption and signature

*OR*

- Dissenter's submit their own independent plan to PADEP

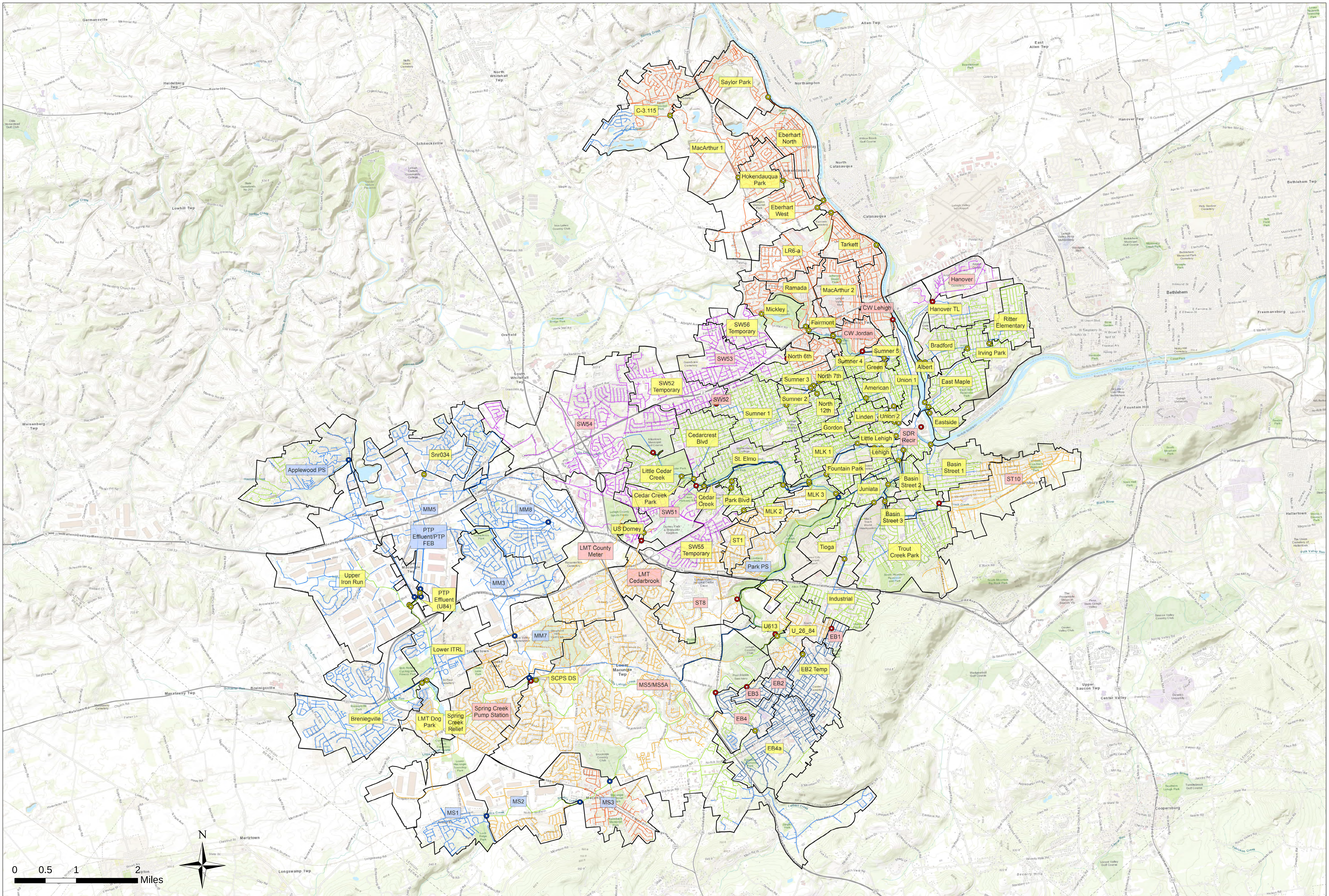
*March 2025 – June 2025*





## Discussion





**KISS Sewer Meters (106 Total)**

- Signatory Billing Meter (21)
- Signatory Non SBM (12)
- Temporary (73)

**KISS Sewer Basins**

- Signatory Billing Meter (21)
- Signatory Non SBM (12)
- Temporary (73)
- KISS Basin Boundaries

**LEHIGH COUNTY AUTHORITY**  
**ACT 537 / KISS BASINS**  
**LEHIGH COUNTY, PENNSYLVANIA**

**Remarks:**

The differing colors for the KISS Sewer Basin layer are only used to help delineate the extent of each basin.

**LEHIGH COUNTY AUTHORITY**  
**GIS**

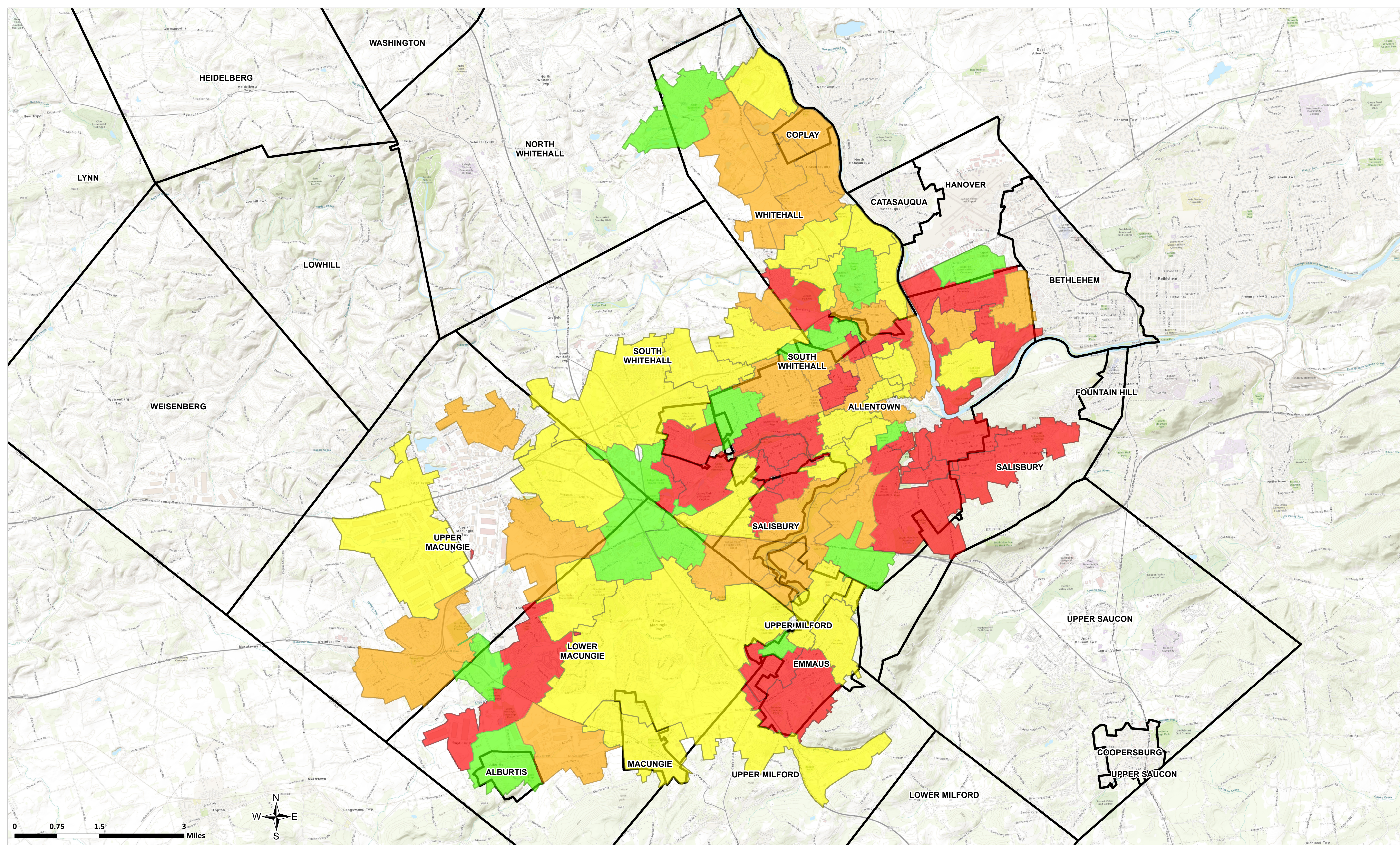
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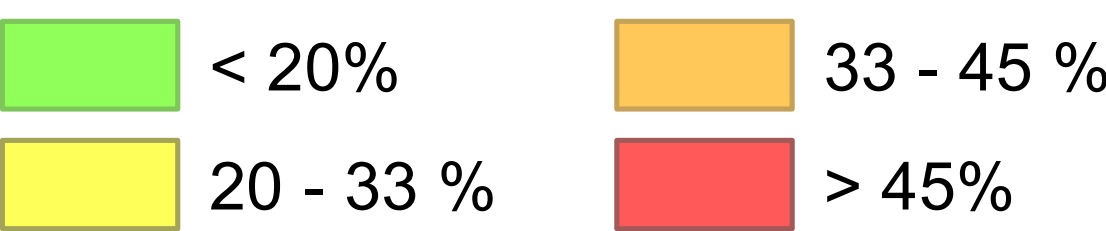
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CHECKED:





**Baseline Infiltration % Adjusted for Data Issues**



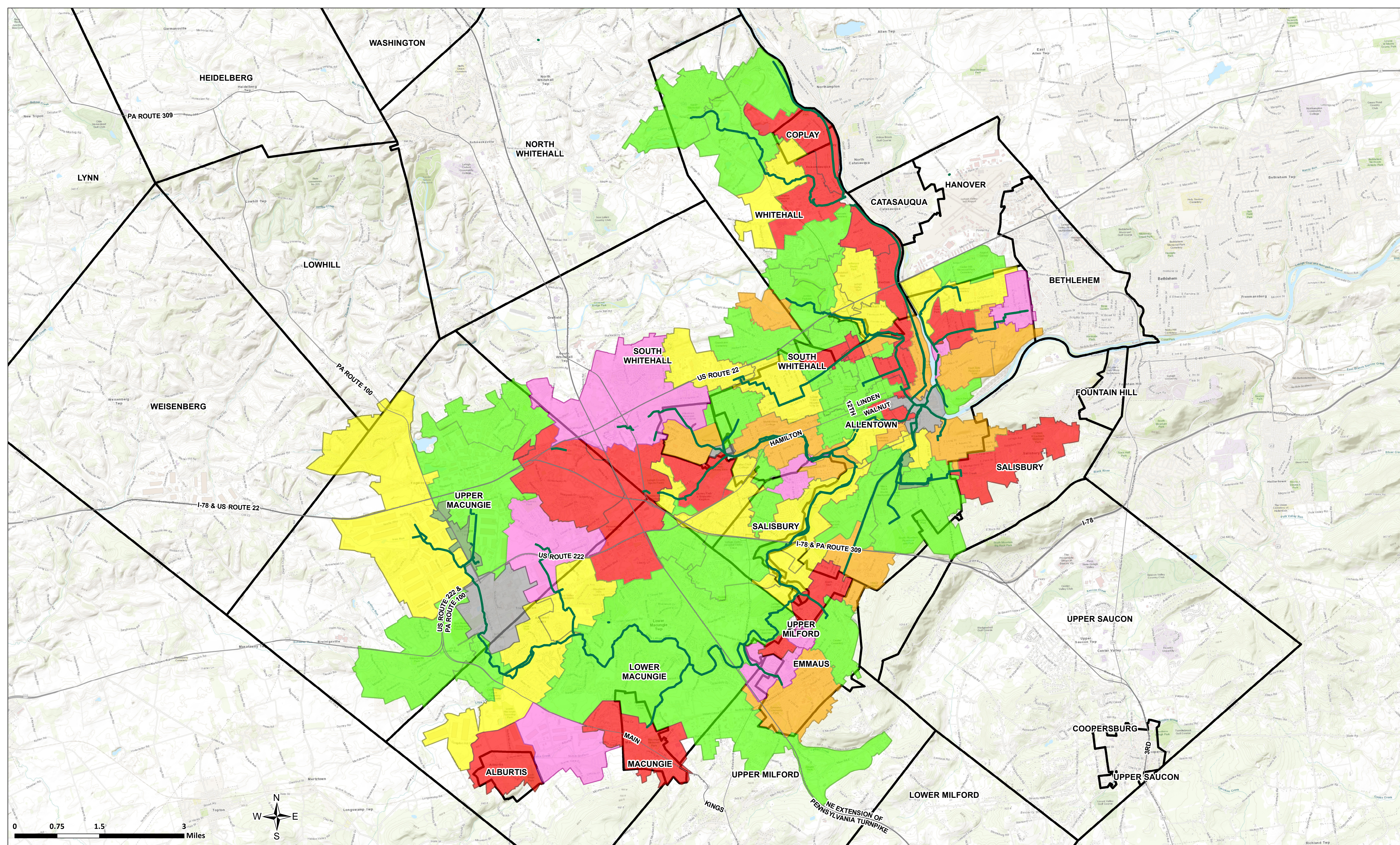
LEHIGH COUNTY AUTHORITY  
**KISS I&I SUMMARY**  
LEHIGH COUNTY, PENNSYLVANIA

Remarks:

**LEHIGH COUNTY AUTHORITY  
GIS**  
  
DATE: 4/4/2022      SCALE: 1:44,000  
CREATED:      CHECKED:







| Average Peaking Factor                                                                                            |       |                                                                                     |                    |
|-------------------------------------------------------------------------------------------------------------------|-------|-------------------------------------------------------------------------------------|--------------------|
|                                | < 4   |  | 6 - 10             |
|                                | 4 - 5 |  | > 10               |
|                                | 5 - 6 |  | No Study Conducted |
|  Interceptor Main 18" and Over |       |                                                                                     |                    |

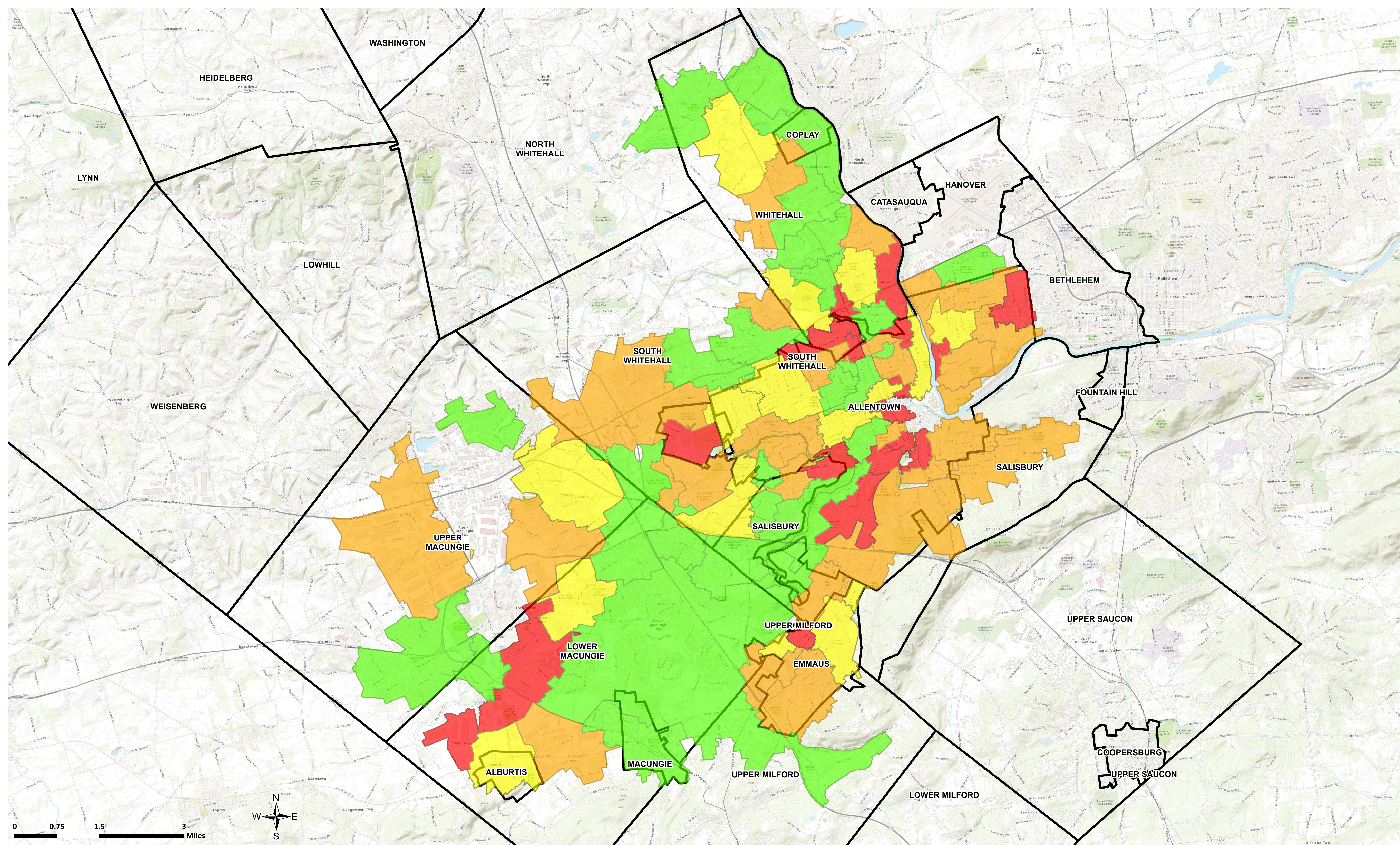
LEHIGH COUNTY AUTHORITY  
**KISS I&I SUMMARY**  
LEHIGH COUNTY, PENNSYLVANIA

Remarks:  
I&I studies were not able to be conducted in gray boundary areas

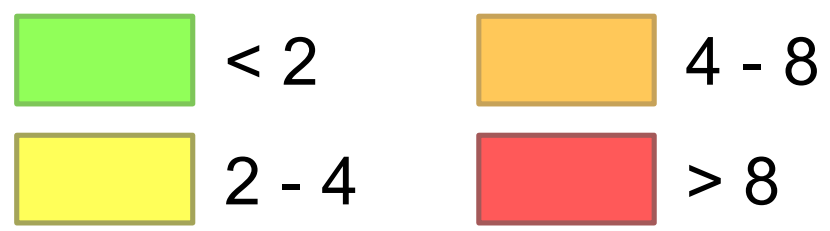
**LEHIGH COUNTY AUTHORITY  
GIS**

DATE: 4/6/2022      SCALE: 1:44,000  
CREATED:      CHECKED:





Length Normalized RDII



LEHIGH COUNTY AUTHORITY  
**KISS I&I SUMMARY**  
LEHIGH COUNTY, PENNSYLVANIA

Remarks:

LEHIGH COUNTY AUTHORITY  
GIS

DATE: 4/4/2022  
CREATED:

SCALE: 1:44,000  
CHECKED:



| METER                              | SIGNATORY | SEWER METER BASIN        | Basin Length (LF) | Approximate MHS | BASILINE<br>INFILTRATION<br>RANK | RAINFALL-DERIVED<br>INFILTRATION<br>RANK | INFLOW<br>RANK | WORST RANK |
|------------------------------------|-----------|--------------------------|-------------------|-----------------|----------------------------------|------------------------------------------|----------------|------------|
| ALBERT_Net                         | City      | Temporary                | 9,059             | 45              | 3                                | 1                                        | 1              | 1          |
| CEDAR CREEK RI_Net                 | SWT       | Temporary                | 15,526            | 70              | 1                                | 26                                       | 44             | 1          |
| UNION 2_Net                        | City      | Temporary                | 11,428            | 57              | 54                               | 2                                        | 15             | 2          |
| LITTLE CEDAR CREEK_Net             | City      | Temporary                | 40,306            | 202             | 2                                | 10                                       | 31             | 2          |
| EB4                                | EB        | Emmaus SBM #4            | 45,240            | 204             | 18                               | 17                                       | 2              | 2          |
| LITTLE LEHIGH_Net                  | City      | Temporary                | 20,278            | 101             | 45                               | 3                                        | 19             | 3          |
| SW54                               | SWT       | SWT SBM #54              | 168,942           | 761             | 72                               | 29                                       | 3              | 3          |
| North 6th 2_Net                    | City      | Temporary                | 12,585            | 63              | 7                                | 4                                        | 22             | 4          |
| Irving Park_Net                    | City      | Temporary                | 25,186            | 126             | 4                                | 21                                       | 29             | 4          |
| EB2_Net                            | EB        | Emmaus SBM #2            | 17,737            | 80              | 64                               | 15                                       | 4              | 4          |
| Hanover TL_Net                     | City      | Temporary                | 48,683            | 243             | 5                                | 32                                       | 41             | 5          |
| MLK 3_Net                          | City+ST   | Temporary                | 20,987            | 105             | 58                               | 5                                        | 34             | 5          |
| MM3 aka Phase 3_Net                | UMT       | Non-SBM Permanent        | 87,238            | 393             | 50                               | 18                                       | 5              | 5          |
| SUMNER 5_Net                       | City      | Temporary                | 18,509            | 93              | 10                               | 6                                        | 18             | 6          |
| North 12th                         | City      | Temporary                | 48,091            | 240             | 6                                | 81                                       | 83             | 6          |
| MLK 2_Net                          | City+ST   | Temporary                | 35,573            | 178             | 20                               | 19                                       | 6              | 6          |
| Tioga_Net                          | City      | Temporary                | 26,815            | 134             | 33                               | 7                                        | 74             | 7          |
| Ritter Elementary                  | City      | Temporary                | 59,725            | 299             | 42                               | 14                                       | 7              | 7          |
| Trout Creek Park                   | City      | Temporary                | 141,700           | 709             | 8                                | 47                                       | 59             | 8          |
| North 6th_Net                      | CWSA      | Temporary                | 47,742            | 215             | 81                               | 8                                        | 71             | 8          |
| MS2/MS2 Temp_Net                   | LMT       | LCA MS #2 (non-billing)  | 52,177            | 235             | 37                               | 31                                       | 8              | 8          |
| BASIN STREET 2_Net                 | City      | Temporary                | 39,222            | 196             | 12                               | 9                                        | 50             | 9          |
| SUMNER 4_Net                       | City      | Temporary                | 19,914            | 100             | 9                                | 30                                       | 39             | 9          |
| ST10                               | ST        | Salisbury SBM #10        | 104,982           | 473             | 16                               | 20                                       | 9              | 9          |
| U_26_84 (ST6)                      | ST        | Salisbury SBM #6         | 34,414            | 155             | 53                               | 48                                       | 10             | 10         |
| CW Lehigh_Net                      | CWSA      | CWSA SBM Lehigh          | 43,946            | 198             | 66                               | 11                                       | 13             | 11         |
| Eberhart West_Net                  | CWSA      | Temporary                | 46,901            | 211             | 32                               | 78                                       | 11             | 11         |
| Spring Creek PS + SCPS DS_Net      | LMT       | LCA Spring Creek FM SBM  | 116,879           | 526             | 11                               | 12                                       | 55             | 11         |
| Tarkett_Net                        | CWSA      | Temporary                | 47,775            | 215             | 67                               | 49                                       | 12             | 12         |
| EASTSIDE                           | City      | Temporary                | 11,651            | 58              | 14                               | 13                                       | 73             | 13         |
| Industrial Blvd_Net                | UMT       | Temporary                | 125,630           | 566             | 13                               | 56                                       | 82             | 13         |
| MM8                                | UMT       | Non-SBM Permanent        | 150,953           | 680             | 60                               | 40                                       | 14             | 14         |
| JUNIATA_Net                        | City      | Temporary                | 32,229            | 161             | 15                               | 16                                       | 69             | 15         |
| SW51                               | SWT       | SWT SBM #51              | 44,592            | 201             | 24                               | 25                                       | 16             | 16         |
| EB3                                | EB        | Emmaus SBM #3            | 15,447            | 70              | 77                               | 41                                       | 17             | 17         |
| US Dorney                          | SWT       | Temporary                | 55,608            | 250             | 17                               | 35                                       | 53             | 17         |
| EB4a                               | EB        | Emmaus SBM #4            | 99,644            | 449             | 19                               | 50                                       | 36             | 19         |
| Bradford                           | City      | Temporary                | 36,318            | 182             | 29                               | 42                                       | 20             | 20         |
| AMERICAN_Net                       | City      | Temporary                | 49,094            | 245             | 51                               | 39                                       | 21             | 21         |
| ST_ELMO_Net                        | City      | Temporary                | 83,039            | 415             | 21                               | 44                                       | 32             | 21         |
| Park Blvd                          | City      | Temporary                | 15,894            | 79              | 22                               | 60                                       | 60             | 22         |
| Fairmont_Net                       | CWSA      | Temporary                | 8,191             | 37              | 34                               | 22                                       | 46             | 22         |
| MS1                                | Alburtis  | LCA SBM #1 (non-billing) | 48,046            | 216             | 88                               | 43                                       | 23             | 23         |
| LEHIGH                             | City      | Temporary                | 8,685             | 43              | 87                               | 23                                       | 37             | 23         |
| ST1 Surrogate                      | ST        | Salisbury SBM #10        | 32,860            | 148             | 23                               | 84                                       | 87             | 23         |
| MS3_Net                            | Macungie  | LCA SBM #3 (non-billing) | 91,552            | 412             | 74                               | 57                                       | 24             | 24         |
| SW56                               | SWT       | SWT SBM #56              | 31,158            | 140             | 28                               | 24                                       | 38             | 24         |
| EAST MAPLE                         | City      | Temporary                | 64,042            | 320             | 59                               | 38                                       | 25             | 25         |
| BASIN STREET 1                     | City+ST   | Temporary                | 63,689            | 318             | 25                               | 37                                       | 35             | 25         |
| SUMNER 3_Net                       | City      | Temporary                | 23,509            | 118             | 39                               | 46                                       | 26             | 26         |
| Mickley_Net                        | CWSA      | Temporary                | 29,896            | 135             | 26                               | 67                                       | 81             | 26         |
| SUMNER 2_Net                       | City      | Temporary                | 14,633            | 73              | 35                               | 27                                       | 68             | 27         |
| CW Jordan_Net                      | CWSA      | CWSA SBM Jordan          | 49,937            | 225             | 27                               | 64                                       | 47             | 27         |
| Eberhart North_Net                 | CWSA      | Temporary                | 73,780            | 332             | 49                               | 76                                       | 27             | 27         |
| LMT County                         | LMT       | LMT SBM County           | 59,949            | 270             | 80                               | 58                                       | 28             | 28         |
| Upper Iron Run_Net                 | UMT       | Temporary                | 95,666            | 431             | 71                               | 28                                       | 54             | 28         |
| UNION 1_Net                        | City      | Temporary                | 41,990            | 210             | 48                               | 52                                       | 30             | 30         |
| MacArthur 1_Net                    | CWSA      | Temporary                | 42,100            | 190             | 30                               | 68                                       | 86             | 30         |
| Hokendauqua Park_Net               | CWSA      | Temporary                | 56,778            | 256             | 31                               | 51                                       | 51             | 31         |
| PPS+U613                           | City      | Temporary                | 44,778            | 224             | 46                               | 33                                       | 43             | 33         |
| EB1                                | EB        | Emmaus SBM #1            | 11,444            | 52              | 61                               | 53                                       | 33             | 33         |
| PPS+U613                           | ST        | Temporary                | 48,511            | 219             | 47                               | 34                                       | 45             | 34         |
| INDUSTRIAL                         | City      | Temporary                | 55,875            | 279             | 79                               | 36                                       | 40             | 36         |
| SUMNER 1_Net                       | City      | Temporary                | 124,566           | 623             | 36                               | 63                                       | 58             | 36         |
| GORDAN                             | City      | Temporary                | 57,915            | 290             | 38                               | 74                                       | 80             | 38         |
| North 11th                         | City      | Temporary                | 10,369            | 52              | 40                               | 73                                       | 84             | 40         |
| Breinigsville                      | UMT       | Temporary                | 147,759           | 666             | 41                               | 72                                       | 88             | 41         |
| FOUNTAIN PARK_Net                  | City      | Temporary                | 30,066            | 150             | 73                               | 45                                       | 42             | 42         |
| ST8                                | ST        | Salisbury SBM #8         | 40,862            | 184             | 43                               | 70                                       | 62             | 43         |
| SnR034                             | UMT       | Temporary                | 52,256            | 235             | 44                               | 85                                       | 78             | 44         |
| MM7 aka Mill Creek_Net             | UMT       | Non-SBM Permanent        | 61,397            | 277             | 75                               | 59                                       | 48             | 48         |
| MacArthur 2                        | CWSA      | Temporary                | 40,047            | 180             | 82                               | 66                                       | 49             | 49         |
| Cedarcrest Blvd                    | City      | Temporary                | 75,410            | 377             | 83                               | 69                                       | 52             | 52         |
| GREEN                              | City      | Temporary                | 10,851            | 54              | 52                               | 75                                       | 85             | 52         |
| MLK 1                              | City      | Temporary                | 59,512            | 298             | 55                               | 54                                       | 70             | 54         |
| EB2a                               | EB        | Emmaus SBM #2            | 68,562            | 309             | 76                               | 55                                       | 63             | 55         |
| LINDEN                             | City      | Temporary                | 27,721            | 139             | 56                               | 65                                       | 72             | 56         |
| SW52                               | SWT       | SWT SBM #52              | 65,448            | 295             | 65                               | 77                                       | 56             | 56         |
| Ramada                             | CWSA      | Temporary                | 32,089            | 145             | 57                               | 80                                       | 77             | 57         |
| SW55                               | SWT       | SWT SBM #55              | 71,764            | 323             | 70                               | 62                                       | 57             | 57         |
| SW53                               | SWT       | SWT SBM #53              | 72,963            | 329             | 62                               | 61                                       | 61             | 61         |
| MSS Total_Net                      | LMT       | LCA SBM #5               | 457,785           | 2062            | 63                               | 88                                       | 65             | 63         |
| LMT Dog Park + Spring Creek Relief | LMT       | Temporary                | 31,619            | 142             | 78                               | 71                                       | 64             | 64         |
| Hanover                            | HT        | Hanover SBM              | 20,384            | 92              | 86                               | 82                                       | 66             | 66         |
| Saylor Park                        | CWSA      | Temporary                | 40,493            | 182             | 69                               | 83                                       | 67             | 67         |
| LR6-a                              | CWSA      | Temporary                | 53,472            | 241             | 68                               | 79                                       | 76             | 68         |
| C-3.115                            | CWSA      | Temporary                | 83,665            | 377             | 84                               | 86                                       | 75             | 75         |
| LMT Cedarbrook                     | LMT       | LMT SBM Cedarbrook       | 48,183            | 217             | 85                               | 87                                       | 79             | 79         |