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# APPLICATION OF REAL-TIME WEATHER FORECAST IN COLLECTION SYSTEM OPERATION

Hazem Gheith, Qiuli Julie Lu and Tiantian Xiang

OWEA Annual Conference 2019

Huron, OH

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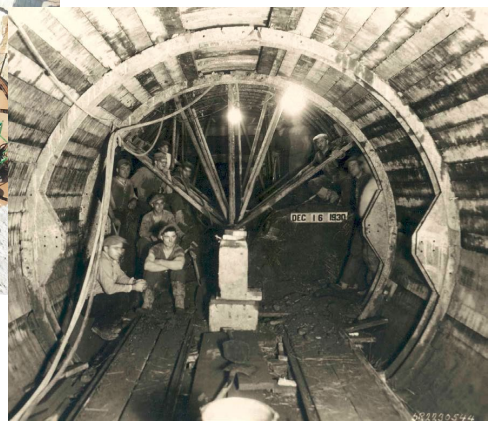
Hazem Gheith, Ph.D., P.E.
Qiuli Julie Lu, Ph.D., P.E.
Tiantian Xiang, Ph.D., EIT

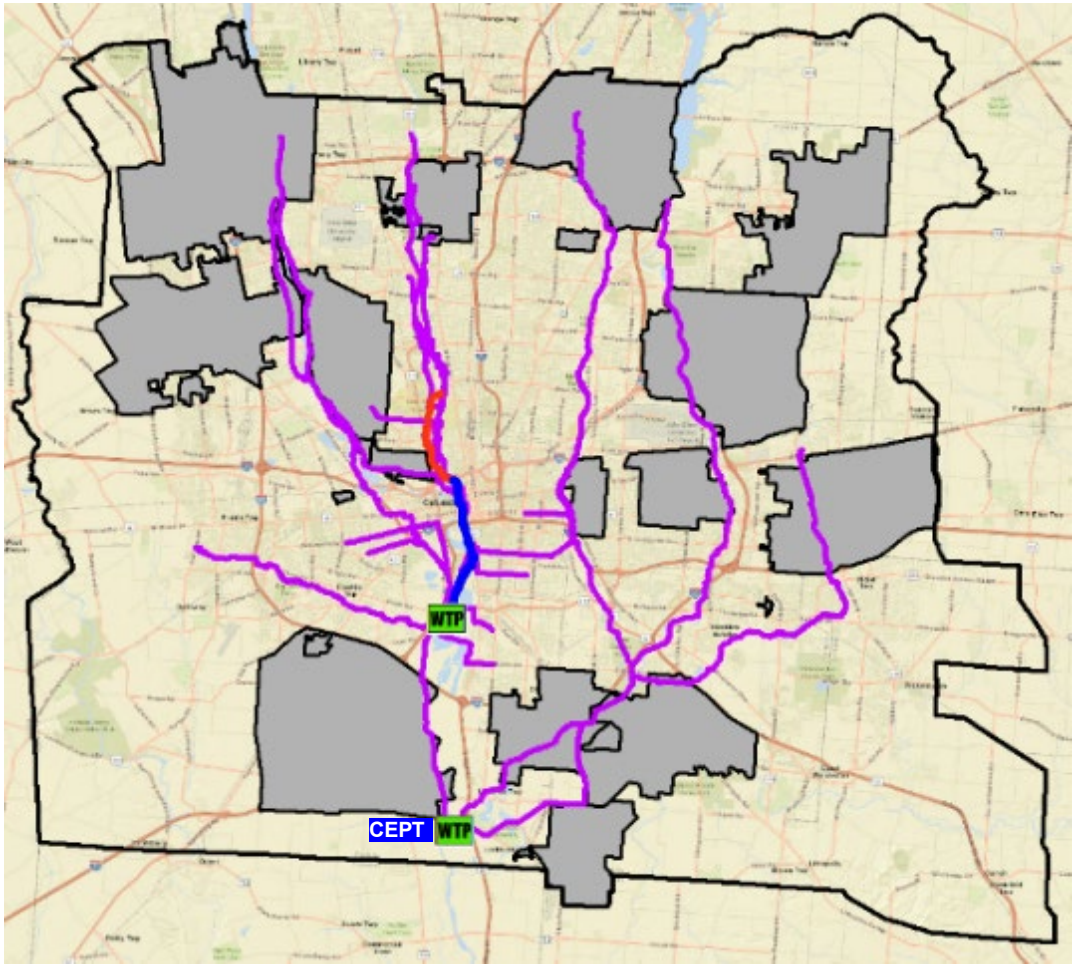


OARS Tunnel Shaft

# Agenda

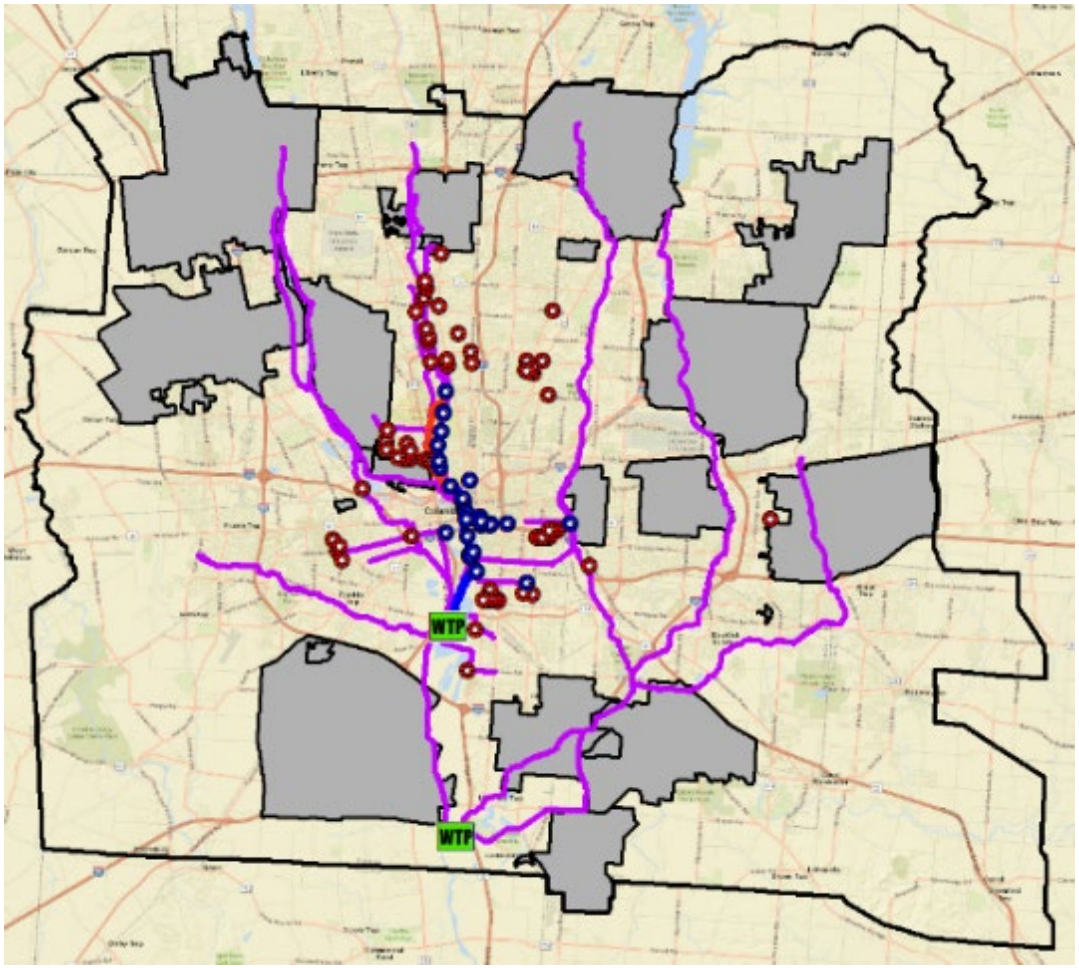
- Columbus Collection System
- OARS Tunnel
- Collection System Operation
- Conclusion and Next Steps

# City of Columbus Collection System




- 432,000 Acres
- 24 Contract Service Areas
- One Deep Tunnel
- Two Storm Tanks
  - Whittier St
  - Alum Creek
- Two WWTPs
  - Jackson Pike
  - Southerly
- One CEPT
  - In service end 2019

# City of Columbus Current Challenges



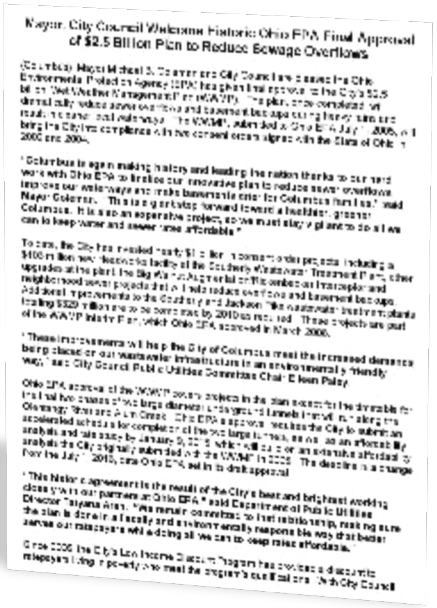

- 29 CSOs
- 69 SSOs
- Basement backup complaint areas
- High population growth

# Wet Weather Management Plan

## Background/Timeline

**Wet Weather Management Plan (WWTP Upgrade and 3 Tunnels)**

- August 2002 SSO CO
- Sept 2004 CSO CO
- July 2005
- July 2010
- Sept 2010
- July 2012
- Jan 2013
- Dec 2015
- Sept 2016
- July 2017



Mayor, City Council Welcome Historic Ohio EPA Final Approval of $2.5 Billion Plan to Reduce Sewage Overflows

# WWTP Improvement

**WWTP Improvement**

August 2002

Sept 2004

July 2005

July 2010

Sept 2010

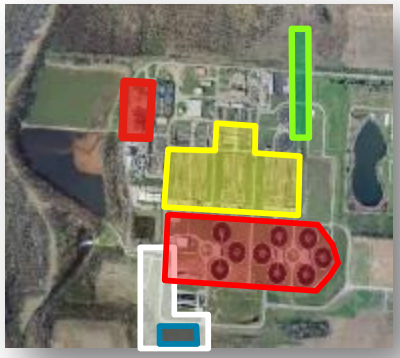
July 2012

Jan 2013

Dec 2015

Sept 2016

July 2017

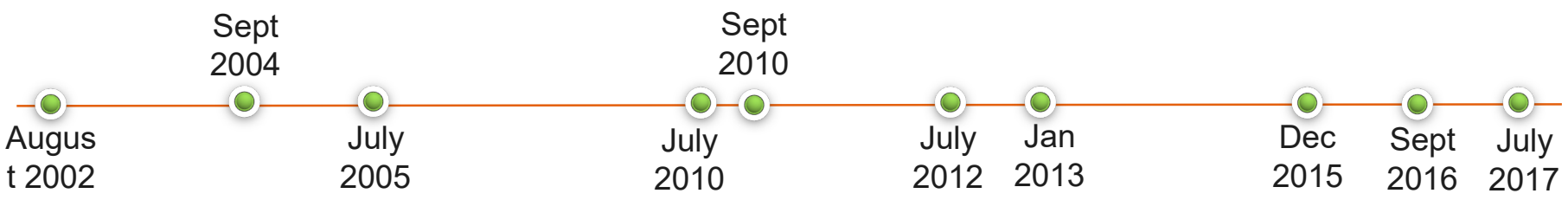


SWWTP: 200 → 330 MGD

JPWWTP: 102 → 150 MGD

# OARS Construction

**OARS Construction Begins**

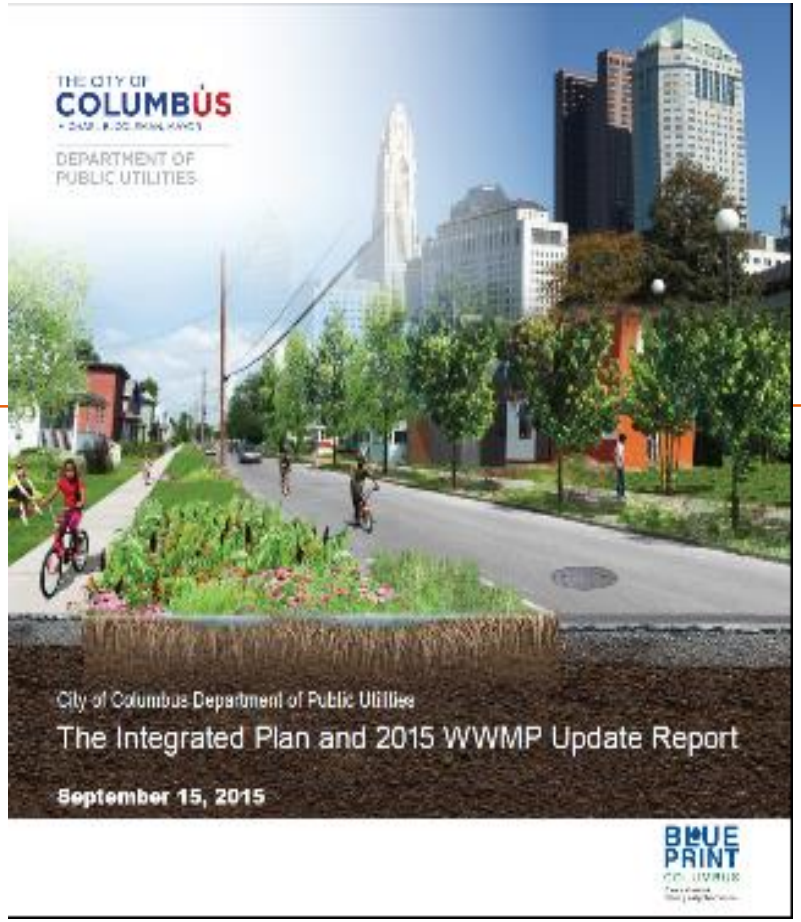


# WWMP Update to Integrated Plan

**Request to Explore Integrated Planning**


**OEPA Approved Request**

# Blueprint Columbus




Comprehensive I/I Reduction program from public sewers and private properties

August 2002

July 2012

Jan 2013

**BP Approval**

Dec 2015

Sept 2016

July 2017

**BP Implementation Starts**

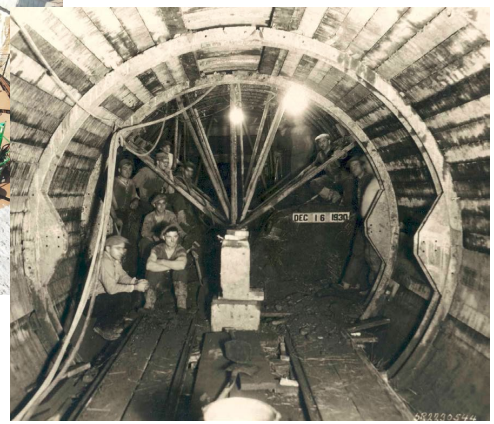
# OARS in Service - 2017

**OARS Construction Begins**

August 2002 — Sept 2004 — July 2005 — Sept 2010 — July 2010 — July 2012 — Jan 2013 — Dec 2015 — Sept 2016 — July 2017

**OARS Construction Completed**

OARS Tunnel Shaft



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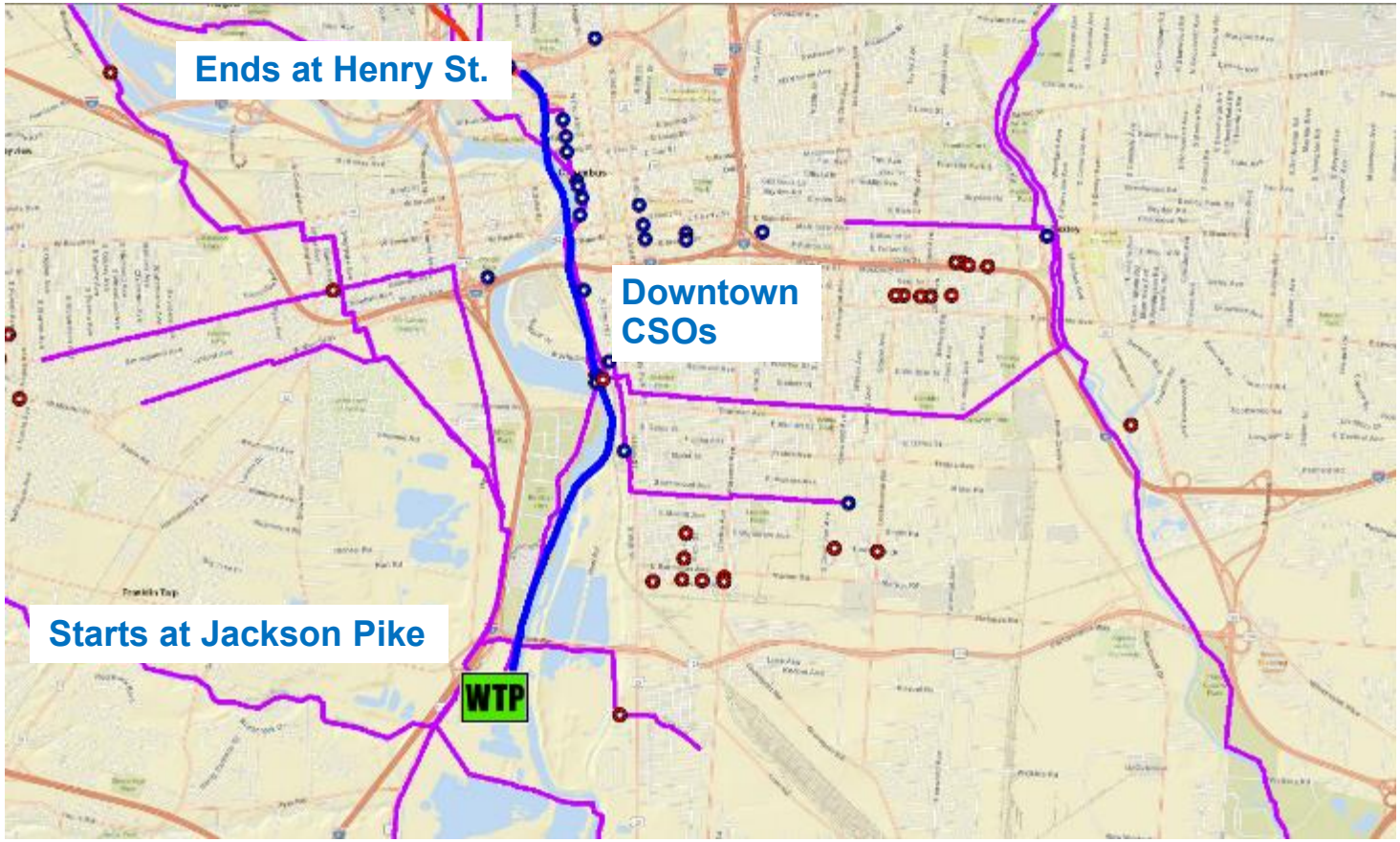
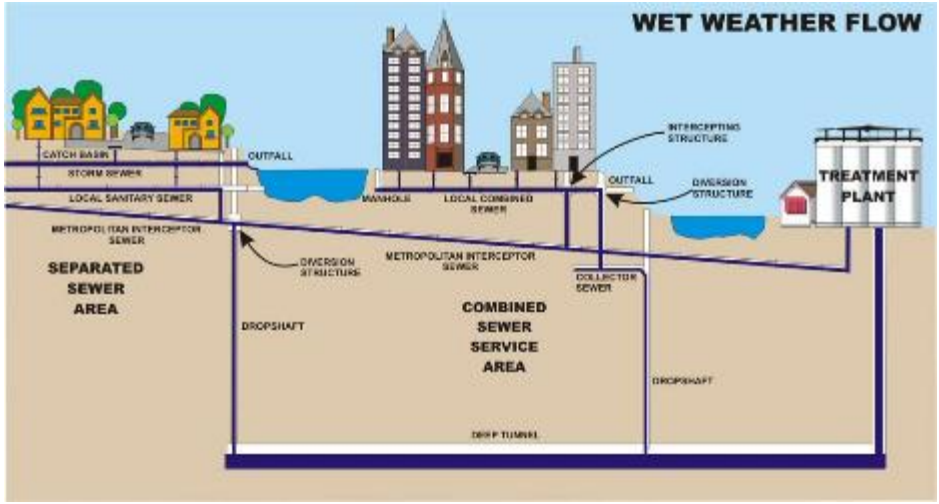
# OARS Extent



# OARS Tunnel Information

- 4.4 miles of 20’ Diameter Tunnel, 64 MG Storage Capacity
- 180’ Invert Depth
- 6 Shafts – 4 receive flow with special drop shaft structures
- 1 CSO at downstream end of the tunnel
- Dewatering Pumps

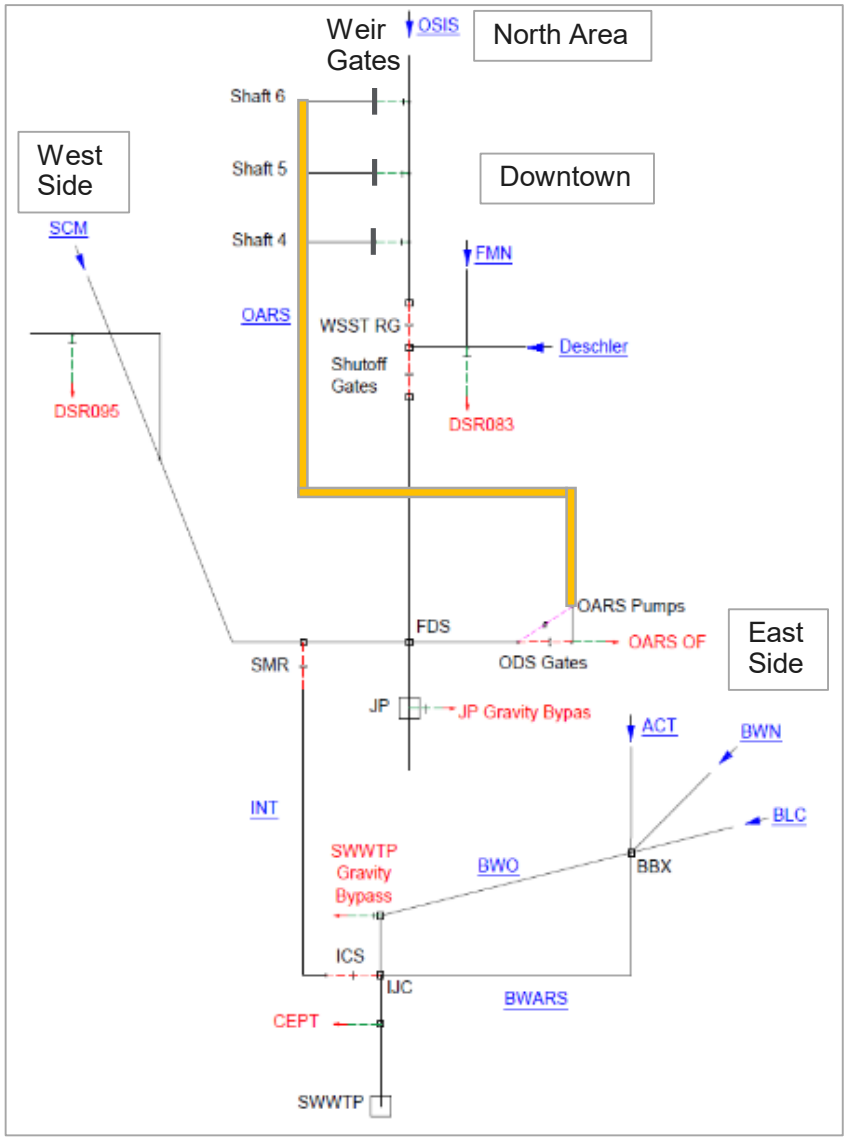
- If treatment capacity is available, tunnel can also work as a siphon to convey flow back to the system during large events




Source: https://www.columbus.gov/utilities/projects/OARS-Deep-Sewer-Tunnel/

# OARS Tunnel - Level of Service

- Mitigate 10 downtown CSOs points up to 10-year LOS
- Reduce 2 billion gallons of CSOs at Whittier St Storm Tanks during typical year storm (2005 condition)
- Limit CSO overflow to 4 activations (typical year) at OARS downstream end



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  - Operation Controls
  - OARS Weir Gates RTC
  - Rainfall Forecast Operation
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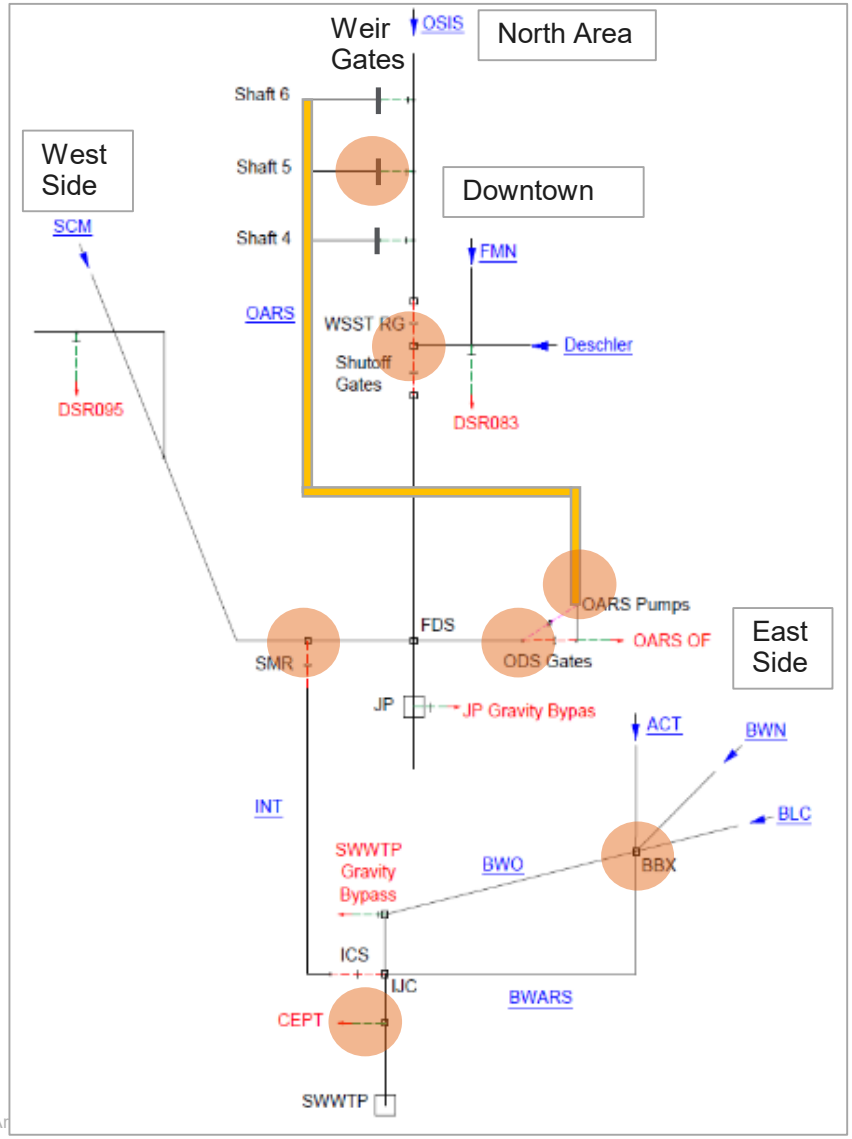
# Operation Controls




## Key Control Structures:

- OARS Weir Gates (static)
- WSST Gates
- OARS Dewatering Pumps
- OARS West Gates
- Scioto Main Relief Weir
- Big Walnut/BWARI Gates
- CEPT (2019)

# Collection System Operation Matrix

| Control Structures /Monitoring Points | WSST Reg Gates | SMR Weir | ODS Gate | OARS Pumps | FDS Gate |
|---|---|---|---|---|---|
| Purpose | Protect OSIS MHs at Berliner, avoid SSO at DSR083 and avoid bypass at Southerly | Maintain JP wet well at 14' after FDS reaches 689 or IJC reaches 671 | Control OARS flow to avoid bypass at JP and Southerly and avoid flow backup into OARS | Dewater OARS during and after the storm | Avoid bypass at JP |
| Default Setting | Open | Setting = 1 | Closed | Off | Closed |
| IJC Head | Close WSST Gates if IJC Head >= 678; If IJC Head is between 673.5 and 678, modulate to maintain DSR 083 Head at 696; If IJC Head is between 669.5 and 673.5, modulate to maintain DSR 083 Head at 700; If IJC Head < 669.5, modulate to maintain DSR 083 Head at 702 | If IJC Head >= 671, maintain FDS Head at 691.5 | Close ODS gates if IJC Head >= 678 | Turn Pumps off when IJC Head > 678<br>Turn Pumps on when IJC Head <= 677.5 | |
| DSR 083 Head | | | | | |
| FDS Head | | If FDS Head >= 689, maintain FDS Head at 691.5 | Close ODS gates if FDS Head >= 693.3 | Turn Pumps off when FDS Head > 693.3<br>Turn Pumps on when FDS Head <= 692 | One FDS gate 50% open if FDS Head >= 694.3<br>**Priority 1** |
| ODS Head | | | Open ODS gate at ODS Head 692, close at ODS Head 691.6; When open, initially open 5% and then open up further if ODS Head continues to build | Turn Pumps on when ODS Head between 533.6 and 692.5 | Open one FDS gate 5% if ODS Head > 580, and IJC Head < 678 |

Five Control Structures

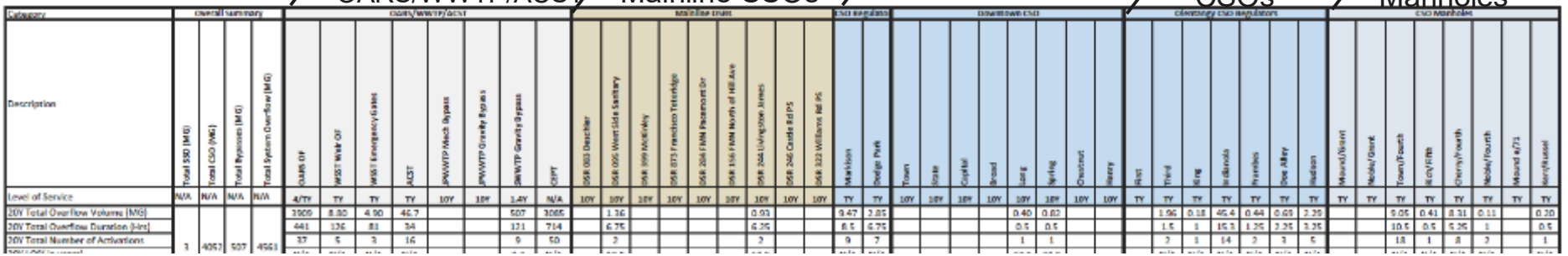
Four Monitoring Locations

# System Performance Metric Sheet

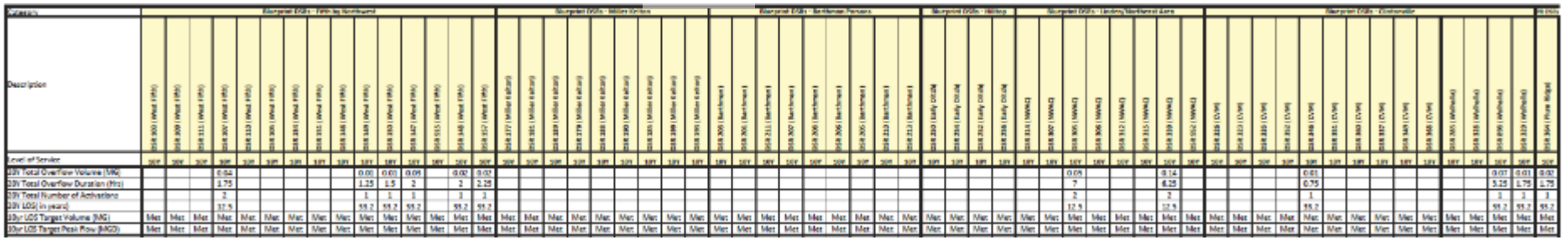
20 Year Model Simulation

Number of Overflow Activations
Overflow Volume
Overflow Duration

OARS/WWTP/ACST | Mainline SSOs | Downtown CSOs | Olentangy CSOs | CSOs Manholes



SSOs



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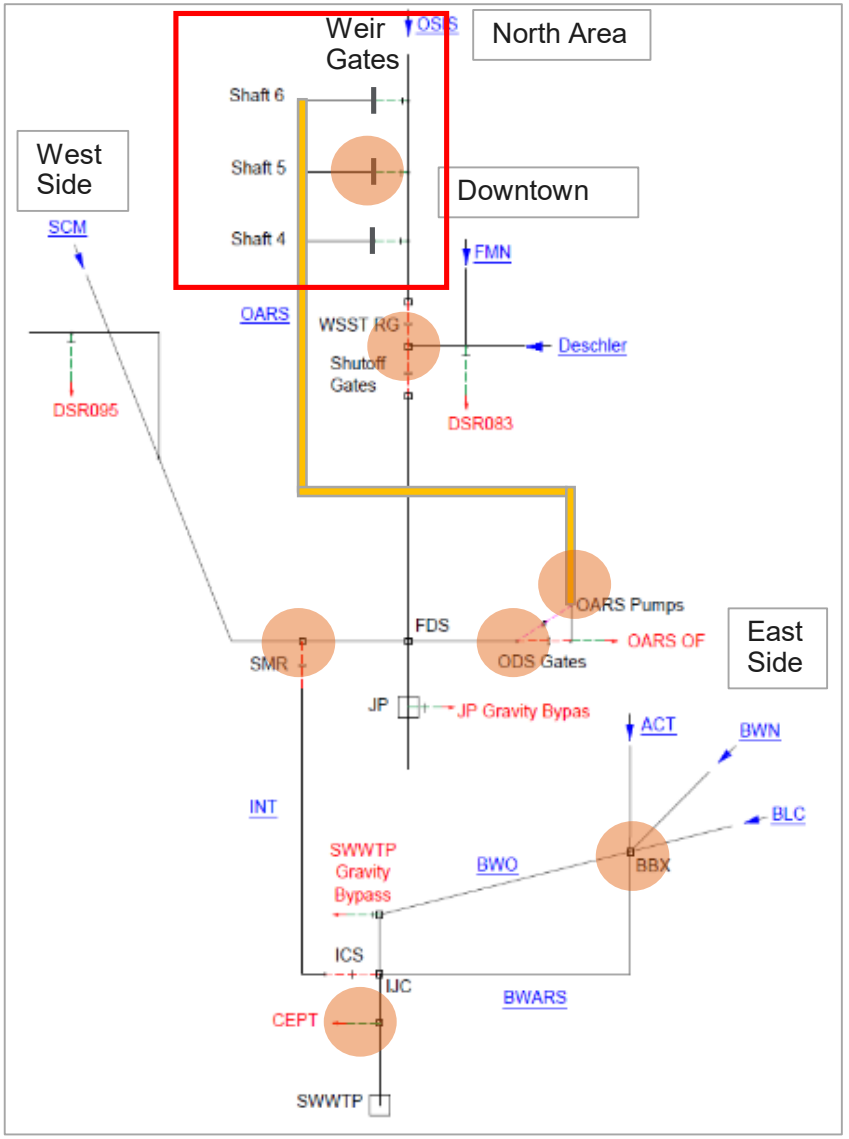
# Real Time Control – OARS Weir Gates

## Modulate the weir gates

- Convey first flush via surface sewers for treatment
- Save tunnel storage for the peak flow duration
- Avoid CSO activation at 10 downtown regulators



# OARS Weir Gates Setting – RTC vs Static

Averages Annual

(from 20Y Simulation Results)

| OARS Fill / Dewater (MG) | OSIS-S6 | OSIS-S5 | OSIS-S4 | Total Inflow | OARS Pumps |
|---|---|---|---|---|---|
| Static Setting | 95 | 73 | 600 | 768 | 555 |
| RTC | 90 | 438 | 212 | 750 | 524 |

| Overflow/CEPT (MG) | OARS OF | SWWTP Bypass | CEPT |
|---|---|---|---|
| Static Setting | 206 | 43 | 245 |
| RTC | 204 | 41 | 245 |

| Activation Frequancy | OARS OF | SWWTP Bypass | CEPT |
|---|---|---|---|
| Static Setting | 2.20 | 1.60 | 4.10 |
| RTC | 2.15 | 1.55 | 4.15 |

Static weirs setting performs as good as a comprehensive weir gates modulation program

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# OARS Tunnel Operation Modes

## Storage Mode

- Dewater after the storm
- Start dewatering when flow at WWTPs has been less than treatment capacity for 30 minutes

## Conveyance Mode

- Dewater during the storm
  - Use dewater pumps as the tunnel is filling
  - Switch to a siphon mode when tunnel is full

# Storage vs Conveyance Operation Modes

Averages Annual

(from 20Y Simulation Results)

| Operation Mode | OARS Overflow (MG) | Gravity Bypass (MG) | CEPT (MG) |
|---|---|---|---|
| Storage | 317 | 26 | 98 |
| Conveyance | 292 | 26 | 104 |

| Activation Frequancy | # OARS Overflow | Gravity Bypass | CEPT |
|---|---|---|---|
| Storage | 3.2 | 1 | 3 |
| Conveyance | 3 | 1 | 4 |

Conveyance mode could reduce OARS overflow by sending more water to CEPT

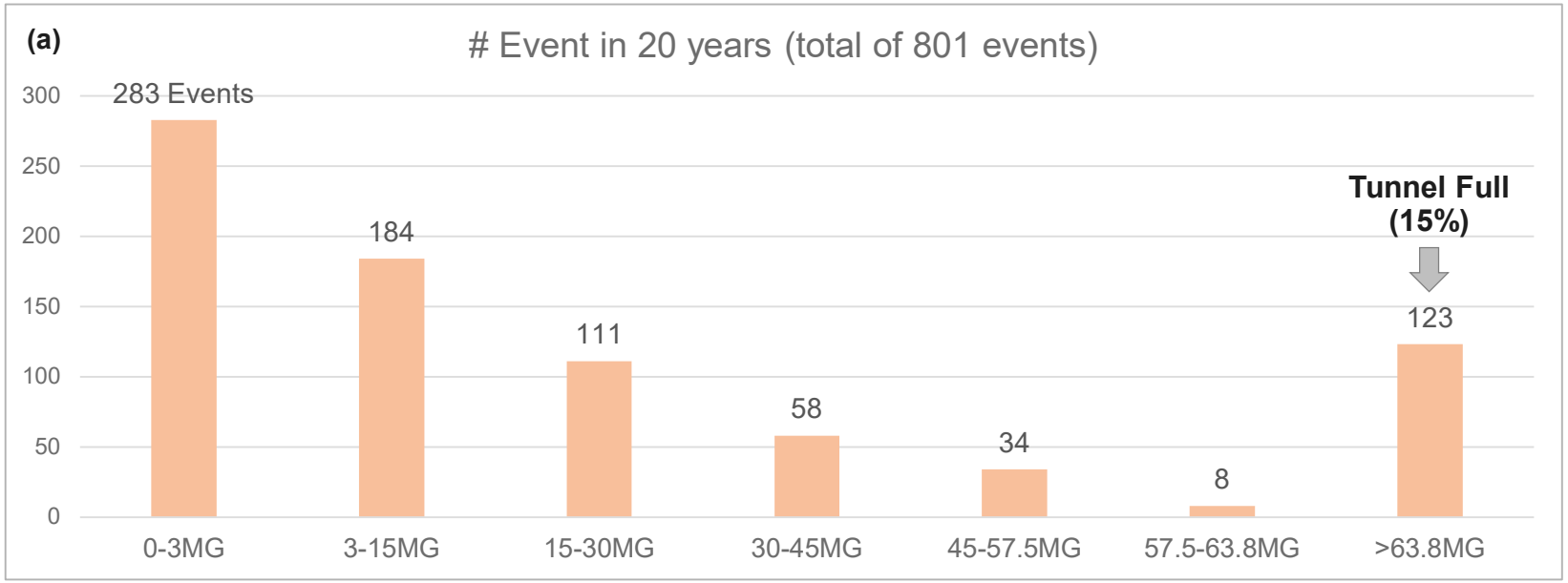
# OARS Tunnel Operation Improvement

Can we use rainfall forecast to switch between operation modes?

- Is there a storm threshold above which OARS is expected to overflow?
- What is the condition during the back-to-back storms?
- What are the pros and cons for different OARS dewatering strategies?

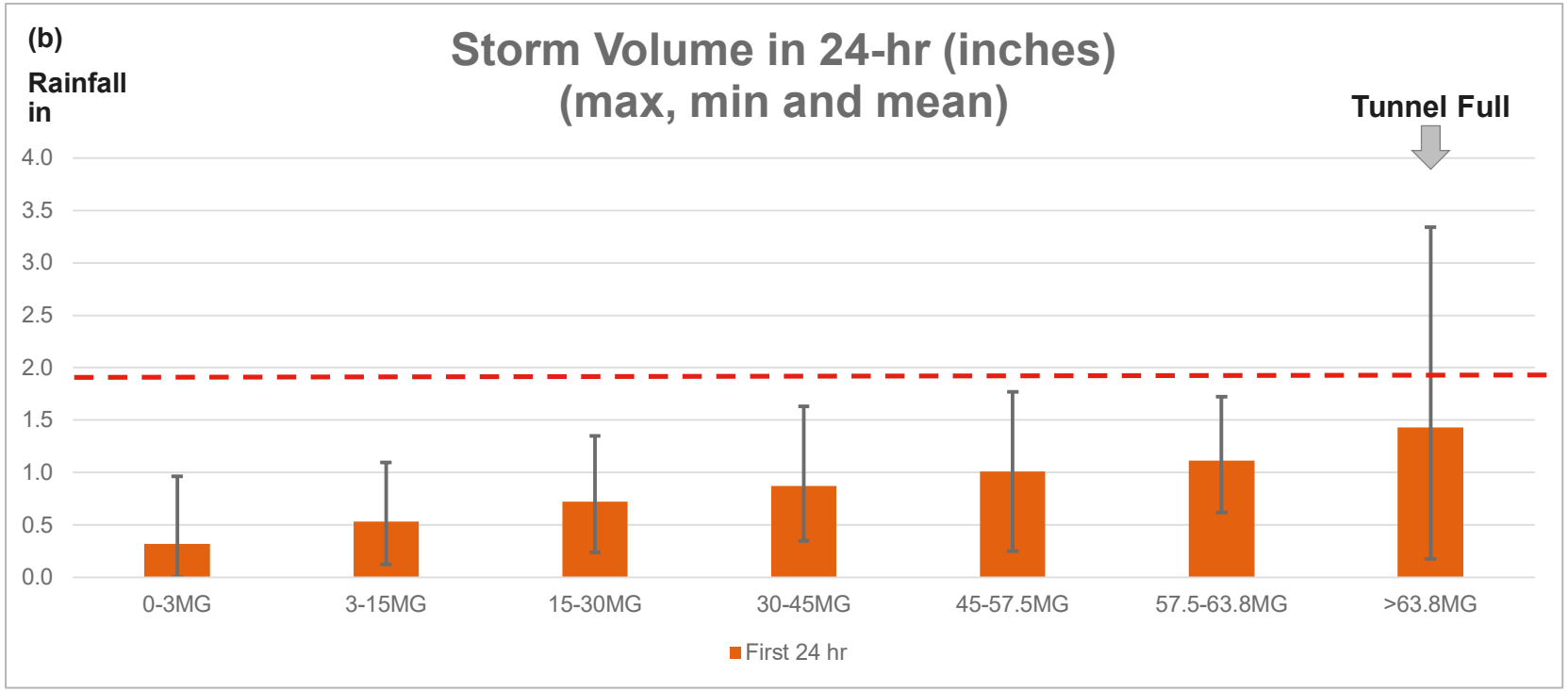
# OARS Inflow

- 20Y Simulation Results
- Tunnel is expected to be activated 801 times in 20 years
- Tunnel storage capacity is 63.8 MG (123 times tunnel is filled)




Number of events the tunnel is filled with volume range

# Storm range Filling OARS



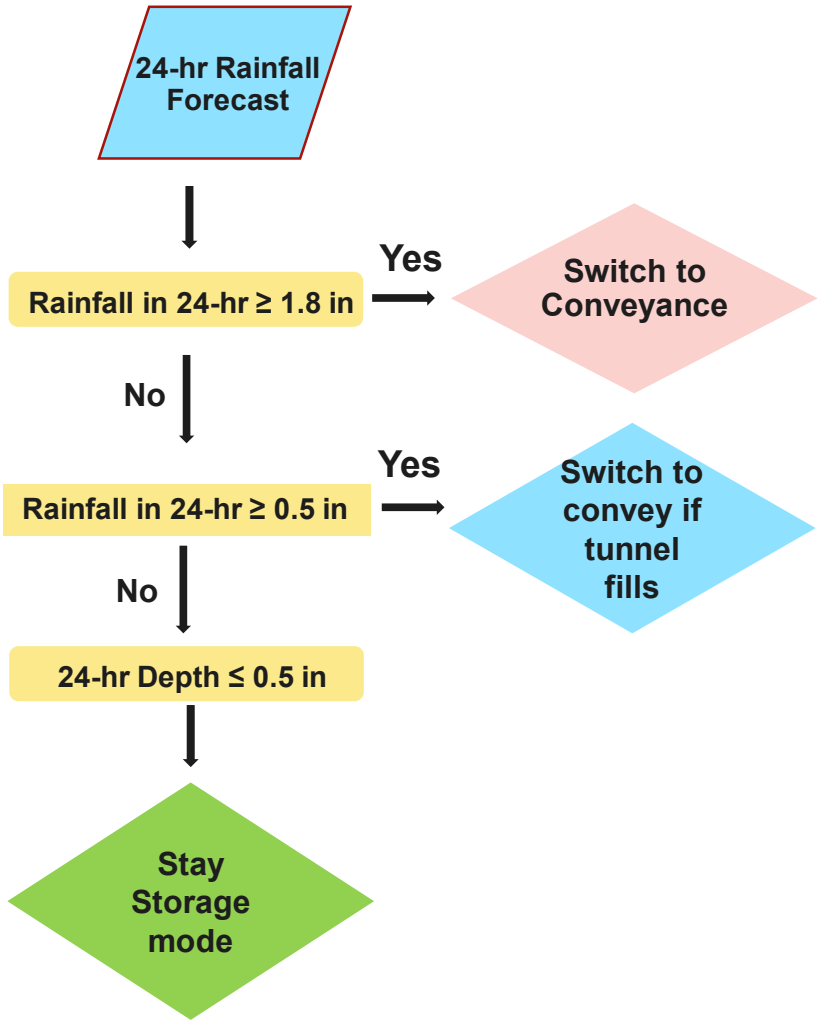

- Tunnel fills when rainfall > 1.8 inches in 24 hours (31 events in 20 years)
- Of the remaining 770 events, tunnel was filled 93 times (12%)

# Storms Causing OARS Overflow

31 events of those filled the tunnel, rainfall was > 1.8 inches (in 20 years)

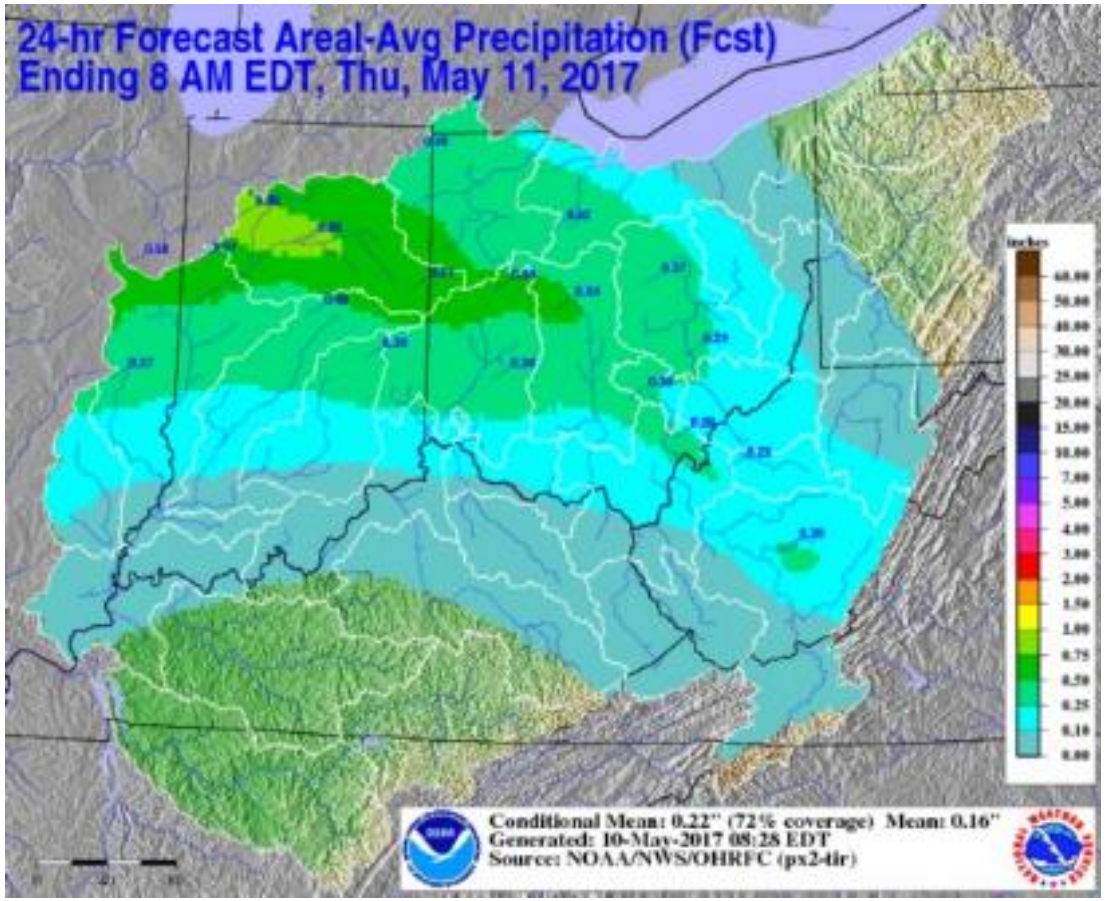
| 24-hr Rainfall | # OARS Filling | # OARS Overflow | |
|---|---|---|---|
| ≥1.8 in | 31 | 29 | Use conveyance mode |
| 0.5 - 1.8 in | 87 | 31 | If OARS fills, switch to conveyance |
| <0.5 in | 5 | 0 | Stay storage mode |

# Operation Based on Real-Time Rainfall Forecast



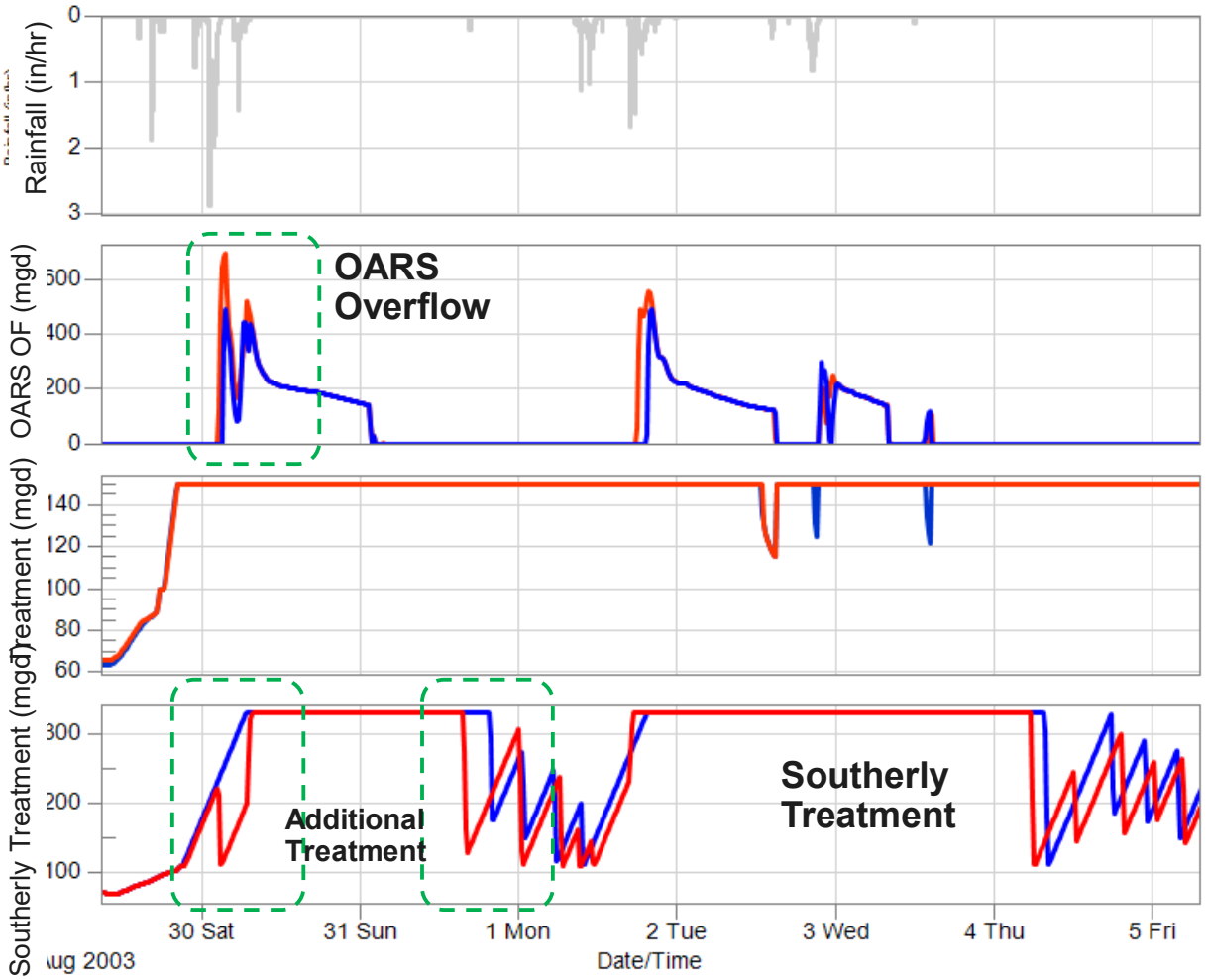
# Rainfall Forecast Source

National Weather Service Ohio River Forecast Center



# Example of Improvements

Event of August 29, 2013 (Rank 1 Event for 24-hr Rainfall)



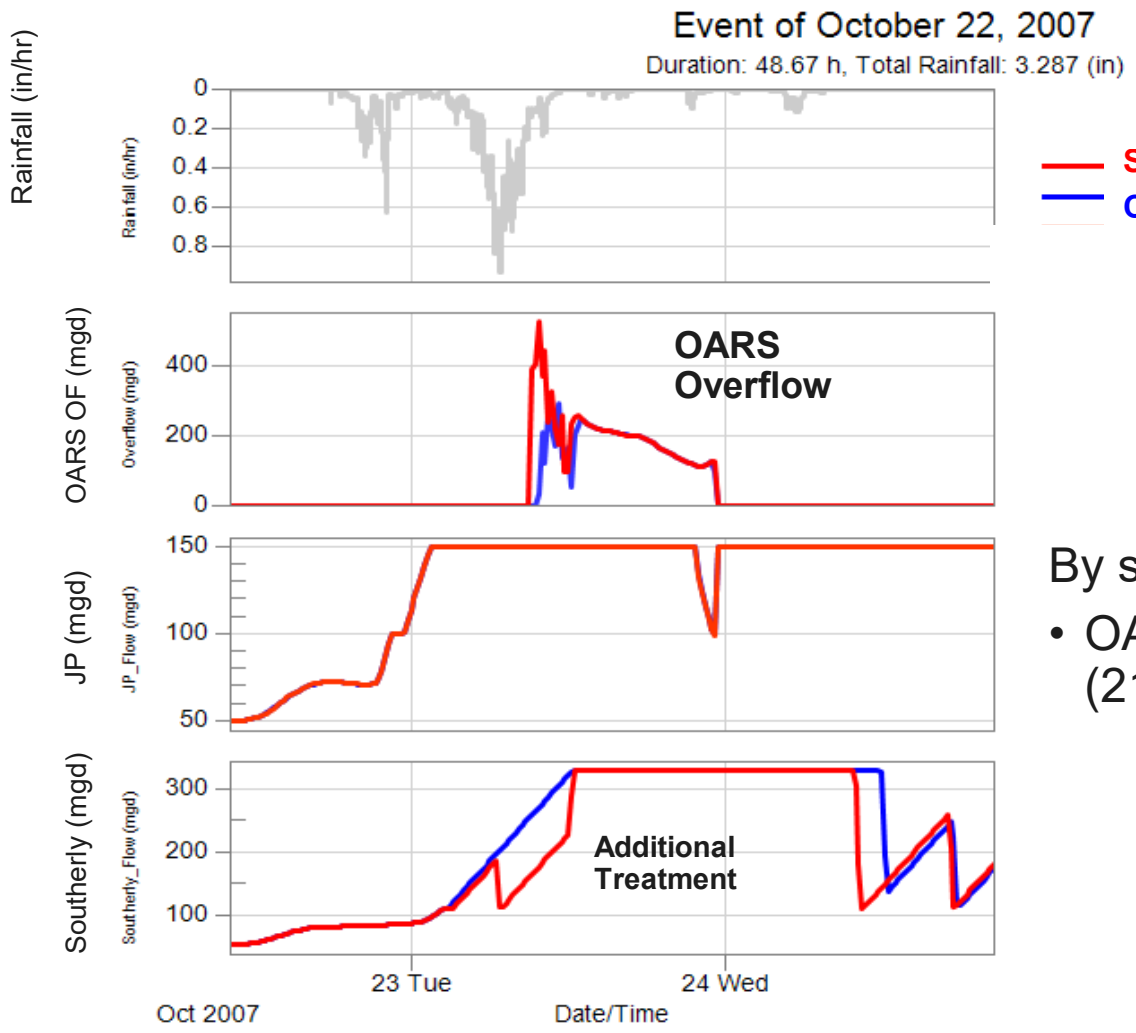

Storage Mode

Improved Mode

By switching to Conveyance:

- OARS OF reduced 60 MG (12%)

# Example of Improvements




Storage Mode

Conveyance Mode

By switching to Conveyance:

- OARS OF reduced 27 MG (21% reduction)

# Agenda

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# Conclusion

| Operation Mode | Pros | Cons |
|---|---|---|
| Storage | • Easy Operation Plan<br>• Less Stress on WWTPs | • Under usage of available treatment at start if events<br>• Large overflow volume could have been reduced |
| Conveyance (no rainfall forecast) | • Keep tunnel storage available for the high peak period of the runoff | • Stressing the WWTPs<br>• Increased potential for bypass |
| Conveyance with Rainfall Forecast | • Avoid stressing the WWTPs as possible<br>• Allows time for operators to prepare for high flow conditions | • Change operation mode during the storm<br>• Potential need to accelerate dewatering to avoid back-to-back storms condition |

# Next Steps: Summer vs Winter Storms

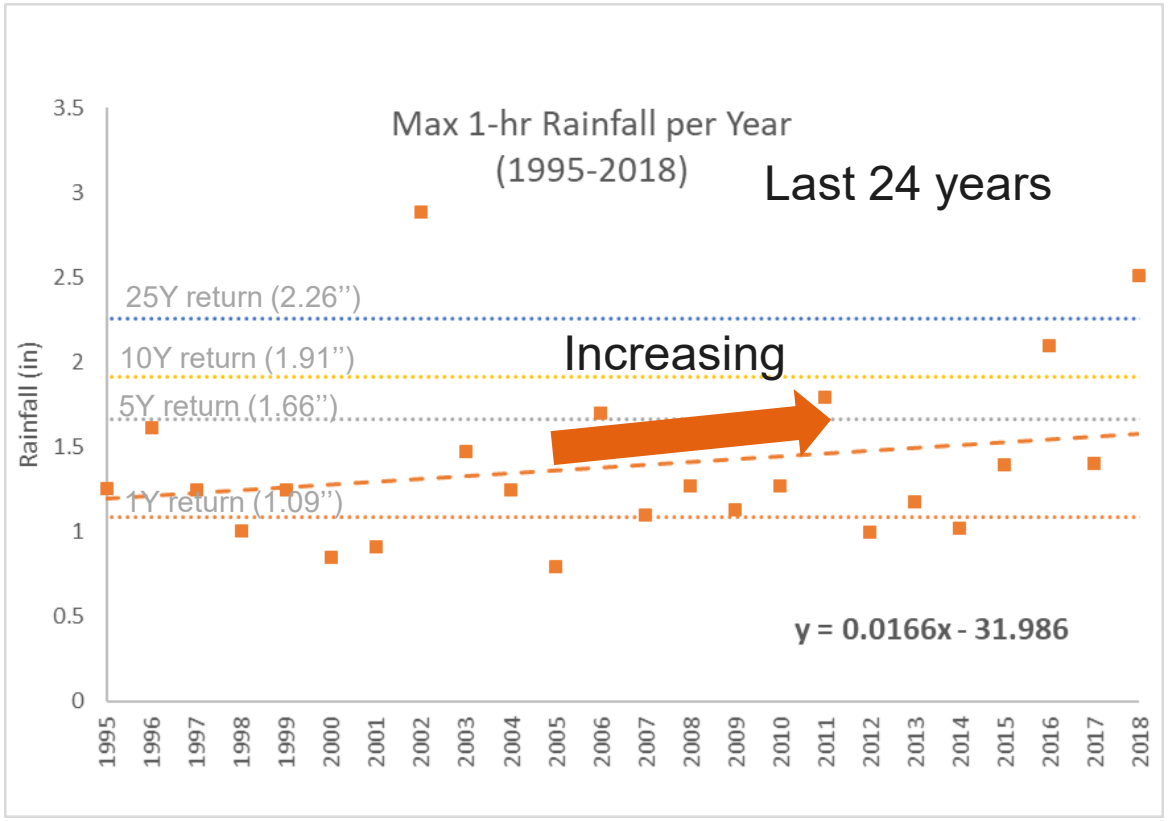
Summer Storms

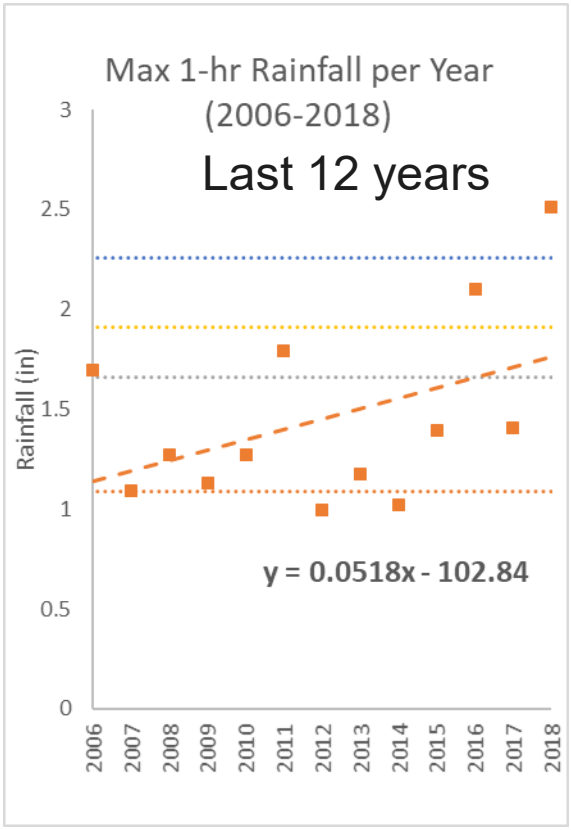
- Sharp peak intensities
- Isolated specially distribution cells

Winter Storms

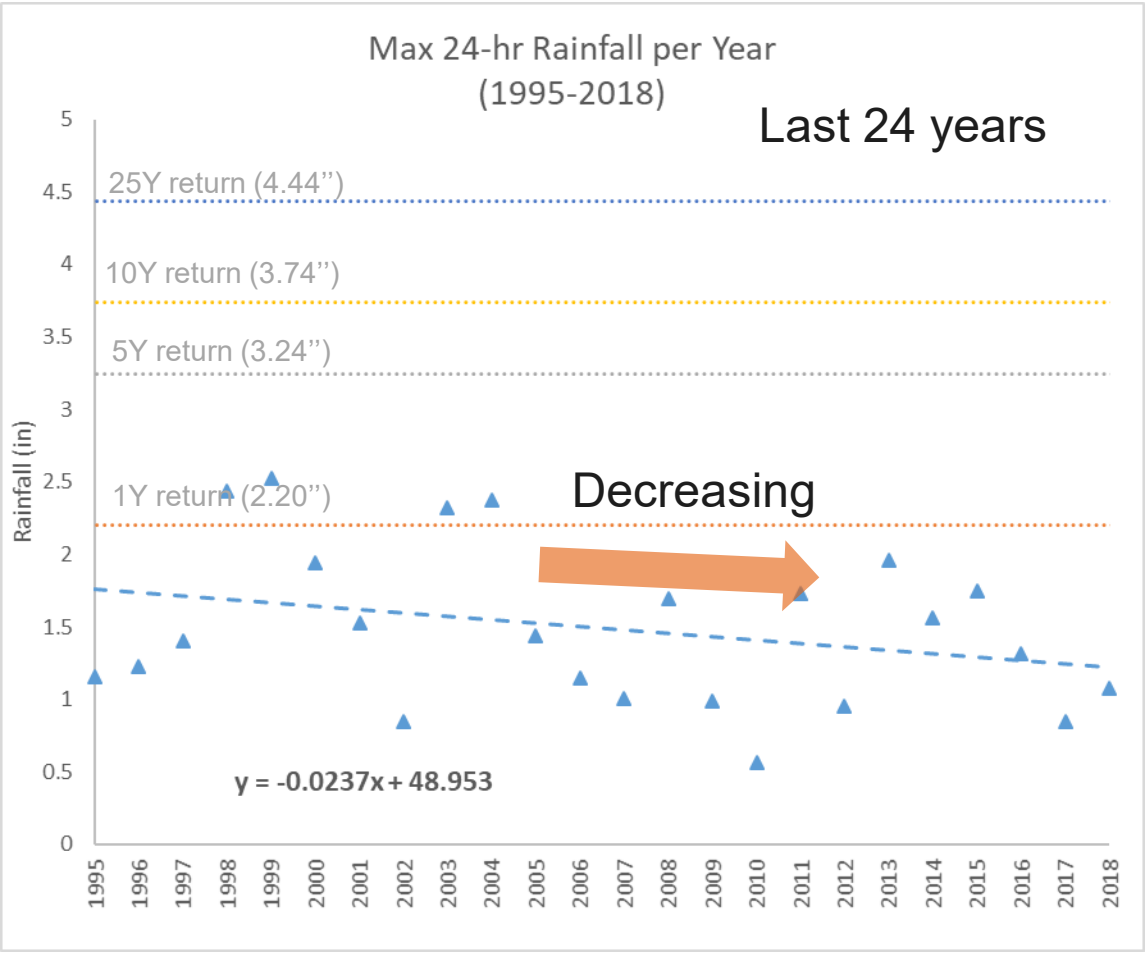
- Low intensity, large volume
- Extends over the entire City

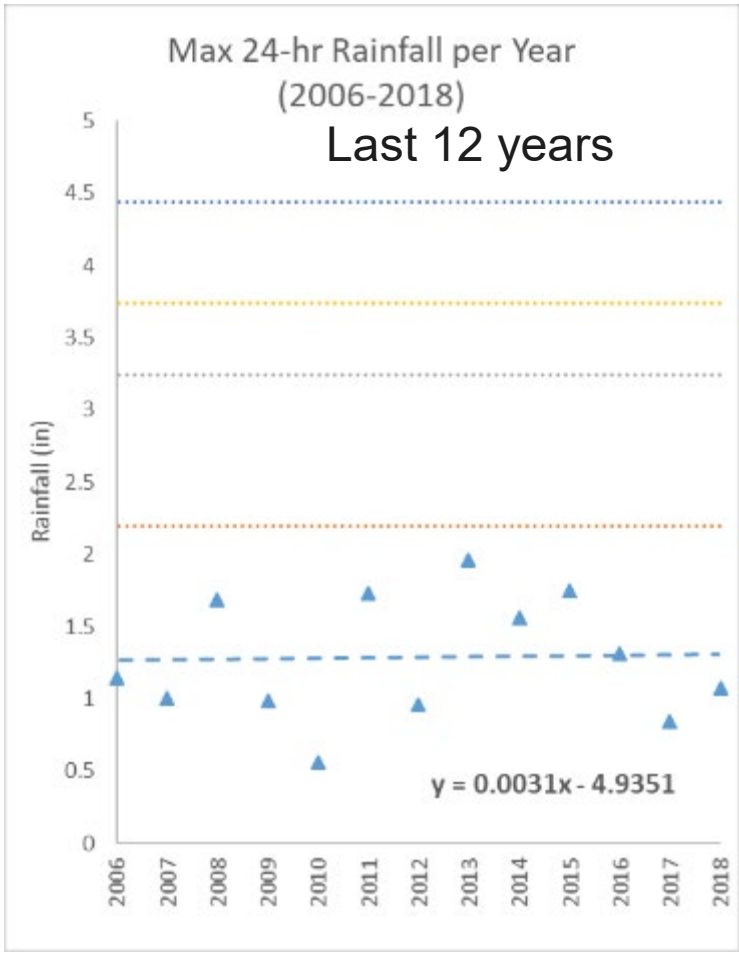
# Next Steps: Summer vs Winter Storms
## Summer (June-Sept) Rainfall Trend



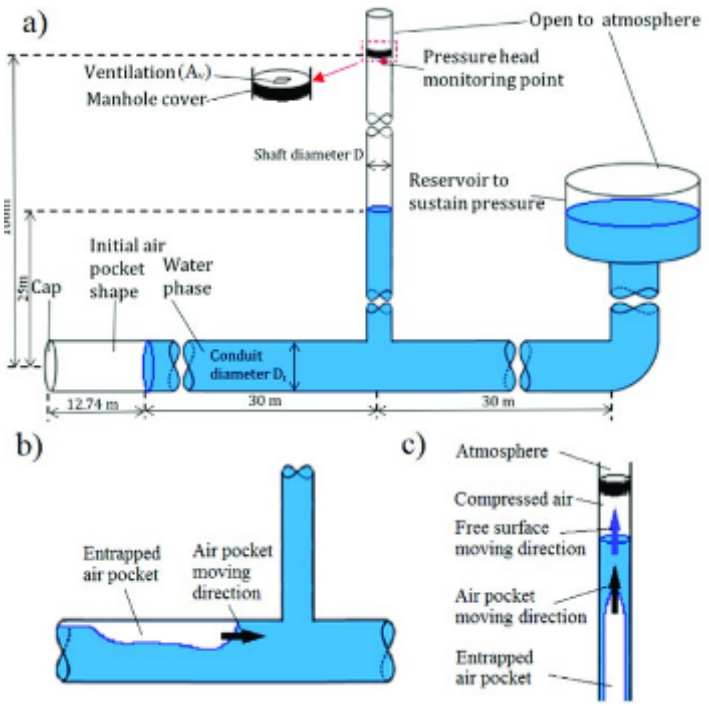
# Next Steps: Summer vs Winter Storms
## Winter (Dec-Jan) Rainfall Trend



# Next Steps: OARS Surge Condition

Delaying water in the tunnel could increase surge and air entrapment conditions in the tunnel due to the back-to-back storms

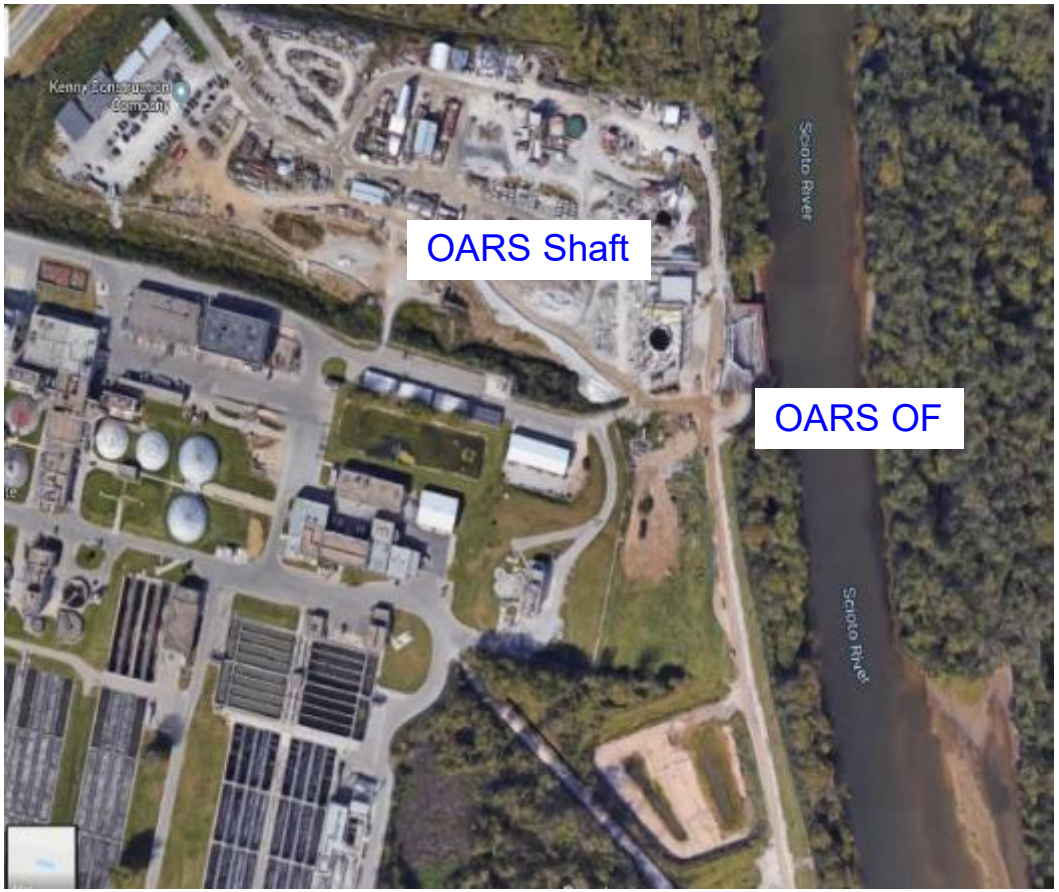



*Wang, J., and Vasconcelos, J., 2018, Manhole Cover Displacement Caused by the Release of Entrapped Air Pockets. Journal of Water Management Modeling, DOI: 10.14796/JWMM.C444*

# Next Steps: High River Operation

During high storms and high river conditions OARS excessive flow would not be able to overflow to the river, causing backup into the collection system

Emptying the tunnel at earlier stage could reduce the need to overflow at OARS and would reduce the backup negative impact

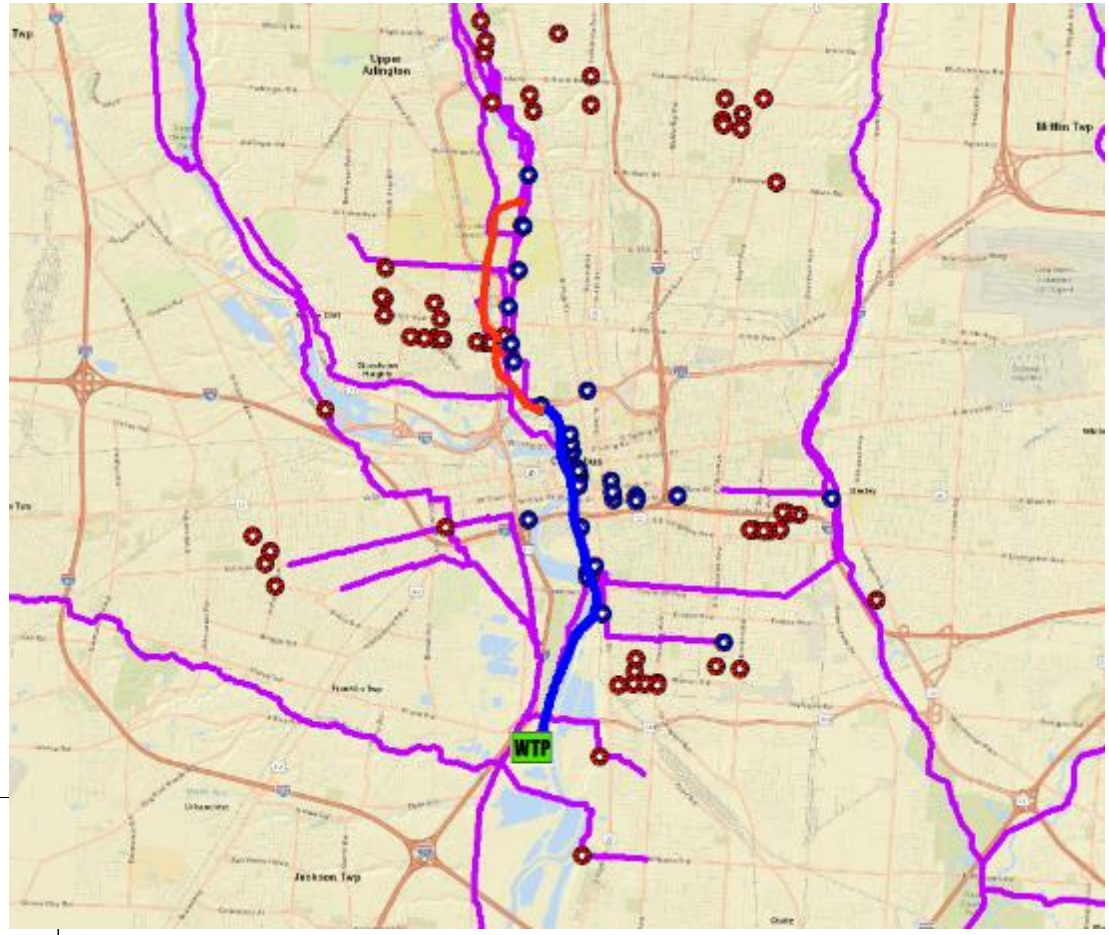


# Next Steps: Lower Olentangy Tunnel

City of Columbus is extending OARS with a 12 ft tunnel (LOT) to reduce CSO activation from 7 CSO points at upstream

LOT will be connected to OARS through a sluice gate and drop shaft

LOT can add additional storage that could improve the system operation and reduce OARS overflow



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# Thank You

Qiuli.Lu@arcadis.com
Hazem.Gheith@arcadis.com
Tiantian.Xiang@arcadis.com