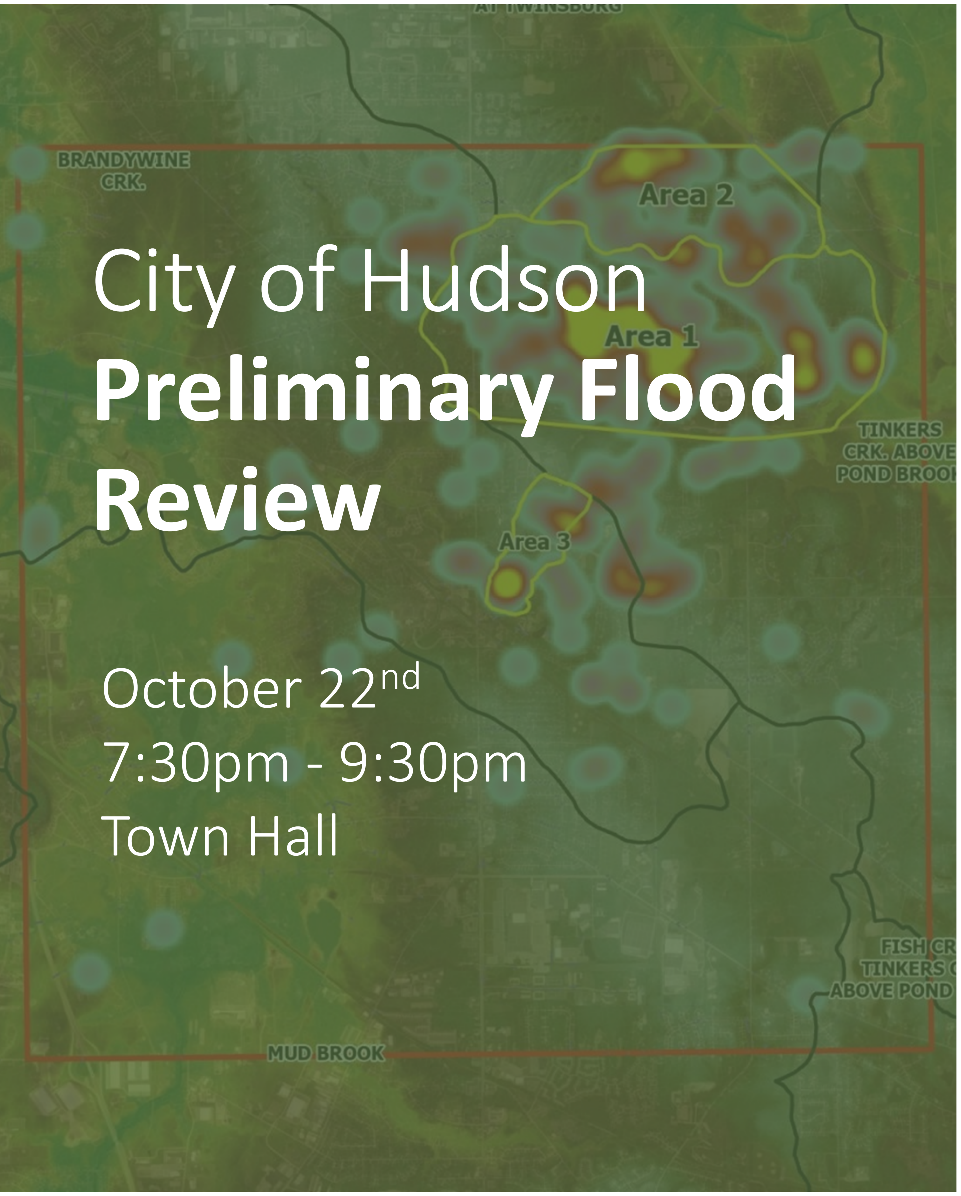


City of Hudson **Preliminary Flood Review**

October 22nd
7:30pm - 9:30pm
Town Hall

ms consultants, inc.
engineers, architects, planners

OHIO HUDSON

Agenda

- Introductions
- Discussion of August 8th Flooding
- Review of Current Hudson Stormwater Standards
- Recommended Improvements to Storm Management Standards
- Discussion of Potential Watershed Studies
- Next Steps

INTRODUCTIONS

Anil Tangirala, PE, CFM, ENV SP

Director, Water Resources

ms consultants Inc.

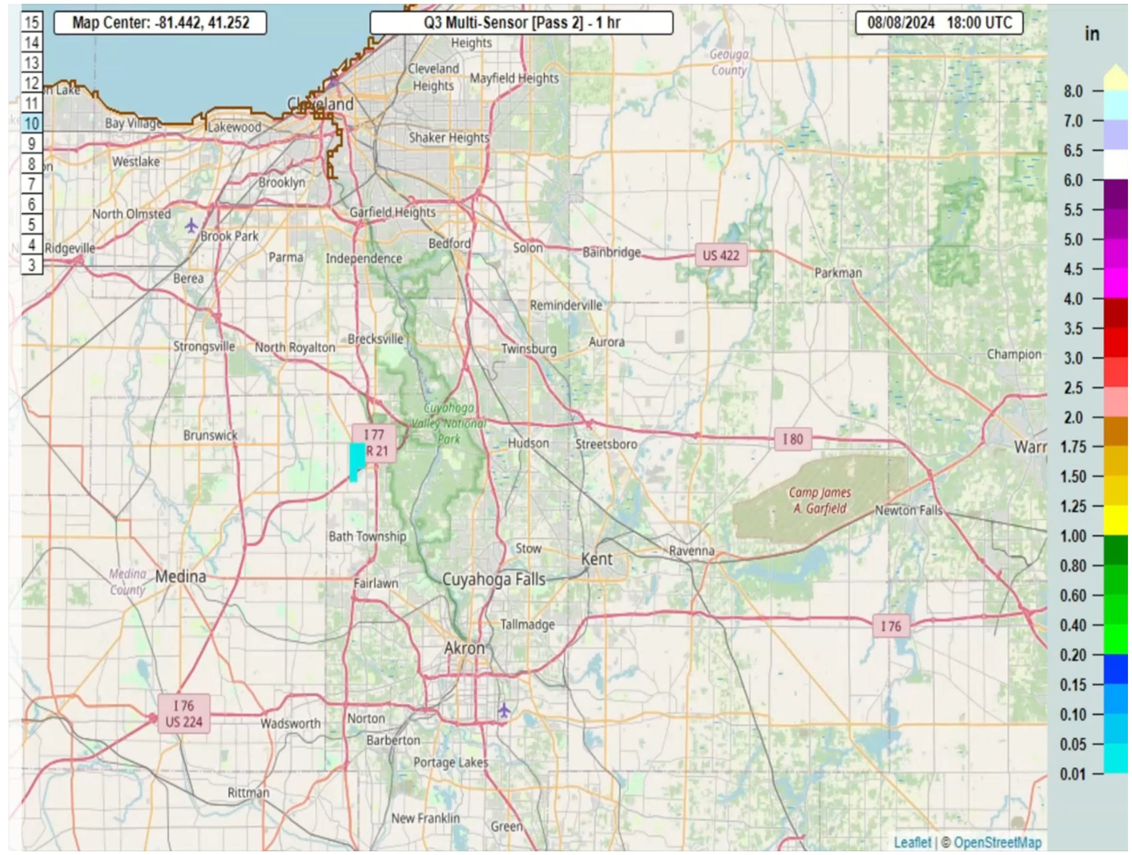
Bradley Kosco, PE, PS

City Engineer,
City of Hudson OH

August 8th, 2024 Rainfall

- NOAA National Weather Service Reported 6.97 inches of rainfall in less than 8 hours
  - Gage located just West of Hudson High School

- 5.24 inches fell between 7:30 pm and 9:30 pm



NOAA ATLAS 14

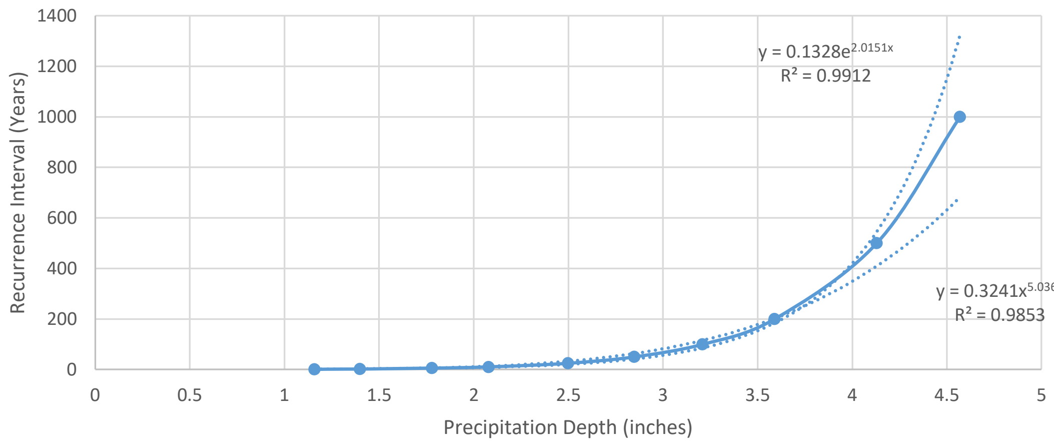
PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]											
Duration	Average recurrence interval (years)										
	1	2	5	10	25	50	100	200	500	1000	??
5-min	0.323 (0.295-0.354)	0.386 (0.352-0.424)	0.466 (0.424-0.511)	0.528 (0.480-0.578)	0.607 (0.548-0.664)	0.667 (0.600-0.729)	0.726 (0.651-0.793)	0.785 (0.699-0.859)	0.865 (0.764-0.948)	0.923 (0.809-1.01)	
10-min	0.502 (0.458-0.550)	0.603 (0.550-0.661)	0.725 (0.659-0.793)	0.815 (0.741-0.892)	0.928 (0.838-1.02)	1.01 (0.909-1.11)	1.09 (0.980-1.19)	1.17 (1.04-1.28)	1.27 (1.12-1.39)	1.34 (1.18-1.48)	
15-min	0.615 (0.561-0.675)	0.737 (0.672-0.809)	0.890 (0.810-0.974)	1.00 (0.911-1.10)	1.15 (1.04-1.25)	1.25 (1.12-1.37)	1.36 (1.22-1.48)	1.46 (1.30-1.60)	1.59 (1.40-1.74)	1.68 (1.47-1.84)	
30-min	0.814 (0.743-0.893)	0.986 (0.900-1.08)	1.22 (1.11-1.33)	1.39 (1.26-1.52)	1.62 (1.46-1.77)	1.79 (1.61-1.96)	1.96 (1.76-2.14)	2.13 (1.89-2.33)	2.35 (2.08-2.58)	2.52 (2.21-2.76)	
60-min	0.994 (0.907-1.09)	1.21 (1.10-1.33)	1.53 (1.39-1.67)	1.77 (1.61-1.94)	2.10 (1.90-2.30)	2.36 (2.12-2.58)	2.62 (2.35-2.86)	2.88 (2.57-3.16)	3.25 (2.87-3.56)	3.54 (3.10-3.88)	
2-hr	1.16 (1.05-1.27)	1.40 (1.28-1.54)	1.78 (1.63-1.96)	2.08 (1.89-2.28)	2.50 (2.26-2.74)	2.85 (2.56-3.12)	3.21 (2.87-3.52)	3.59 (3.19-3.94)	4.13 (3.63-4.53)	4.57 (3.97-5.02)	5.24
3-hr	1.23 (1.12-1.35)	1.50 (1.36-1.64)	1.90 (1.72-2.09)	2.22 (2.01-2.44)	2.68 (2.41-2.94)	3.06 (2.74-3.35)	3.45 (3.07-3.79)	3.88 (3.42-4.25)	4.48 (3.91-4.92)	4.98 (4.30-5.47)	
6-hr	1.48 (1.35-1.63)	1.79 (1.63-1.96)	2.25 (2.05-2.47)	2.64 (2.39-2.88)	3.19 (2.88-3.49)	3.66 (3.28-3.99)	4.16 (3.70-4.54)	4.70 (4.14-5.13)	5.49 (4.76-6.01)	6.15 (5.27-6.76)	
12-hr	1.74 (1.59-1.92)	2.09 (1.91-2.31)	2.60 (2.37-2.87)	3.04 (2.76-3.35)	3.68 (3.31-4.04)	4.21 (3.77-4.63)	4.79 (4.25-5.26)	5.43 (4.77-5.96)	6.36 (5.51-7.00)	7.15 (6.12-7.88)	
24-hr	2.04 (1.89-2.21)	2.44 (2.26-2.65)	3.03 (2.80-3.29)	3.52 (3.25-3.82)	4.24 (3.88-4.58)	4.84 (4.40-5.23)	5.48 (4.95-5.93)	6.19 (5.53-6.70)	7.21 (6.35-7.83)	8.06 (7.02-8.78)	
2-day	2.35 (2.18-2.54)	2.82 (2.62-3.05)	3.46 (3.21-3.74)	3.99 (3.69-4.31)	4.76 (4.38-5.14)	5.40 (4.93-5.84)	6.09 (5.52-6.59)	6.82 (6.12-7.40)	7.88 (6.96-8.58)	8.75 (7.63-9.59)	
3-day	2.52 (2.34-2.72)	3.01 (2.80-3.25)	3.68 (3.42-3.97)	4.24 (3.92-4.56)	5.02 (4.63-5.42)	5.67 (5.20-6.12)	6.36 (5.79-6.87)	7.09 (6.40-7.69)	8.13 (7.24-8.86)	9.01 (7.92-9.86)	
4-day	2.68 (2.50-2.89)	3.20 (2.99-3.45)	3.90 (3.64-4.20)	4.48 (4.16-4.82)	5.28 (4.88-5.69)	5.94 (5.47-6.40)	6.63 (6.06-7.16)	7.36 (6.68-7.98)	8.39 (7.52-9.13)	9.27 (8.22-10.1)	
7-day	3.23 (3.02-3.46)	3.84 (3.60-4.11)	4.64 (4.34-4.96)	5.29 (4.93-5.66)	6.20 (5.75-6.63)	6.93 (6.40-7.43)	7.70 (7.06-8.26)	8.50 (7.75-9.14)	9.61 (8.66-10.4)	10.5 (9.37-11.4)	
10-day	3.72 (3.49-3.97)	4.41 (4.15-4.71)	5.28 (4.95-5.63)	5.96 (5.59-6.35)	6.91 (6.45-7.36)	7.65 (7.12-8.16)	8.41 (7.79-8.99)	9.19 (8.46-9.85)	10.3 (9.35-11.0)	11.1 (10.0-12.0)	
20-day	5.15 (4.88-5.46)	6.08 (5.76-6.45)	7.16 (6.77-7.58)	8.00 (7.55-8.47)	9.10 (8.57-9.65)	9.95 (9.34-10.6)	10.8 (10.1-11.5)	11.6 (10.8-12.4)	12.7 (11.7-13.6)	13.5 (12.4-14.5)	
30-day	6.49 (6.16-6.84)	7.64 (7.25-8.06)	8.89 (8.43-9.37)	9.83 (9.32-10.4)	11.1 (10.5-11.7)	12.0 (11.3-12.7)	12.9 (12.1-13.6)	13.8 (12.9-14.6)	14.9 (13.8-15.8)	15.7 (14.5-16.7)	
45-day	8.32 (7.94-8.72)	9.76 (9.31-10.2)	11.2 (10.7-11.7)	12.3 (11.7-12.9)	13.7 (13.0-14.3)	14.7 (13.9-15.4)	15.6 (14.8-16.4)	16.5 (15.6-17.4)	17.7 (16.6-18.6)	18.5 (17.3-19.5)	
60-day	10.1 (9.61-10.5)	11.8 (11.3-12.3)	13.4 (12.8-14.0)	14.6 (14.0-15.3)	16.1 (15.4-16.9)	17.2 (16.4-18.1)	18.2 (17.3-19.1)	19.1 (18.2-20.2)	20.3 (19.1-21.4)	21.1 (19.8-22.3)	

RAINFALL OFF THE CHARTS

- Estimating from NOAA Atlas 14 Precipitation Frequencies, the probability of 5.24 inches in 2-hours is 0.005% annual chance in any given year
- This corresponds to a Return Period of approximately a 2000-year recurrence
- The 6.97 inches of rainfall in 24 hours corresponds to a 500-year recurrence
- Based on the rainfall analysis the August 8th 2024 was anywhere between 500-year and 2000-year recurrence

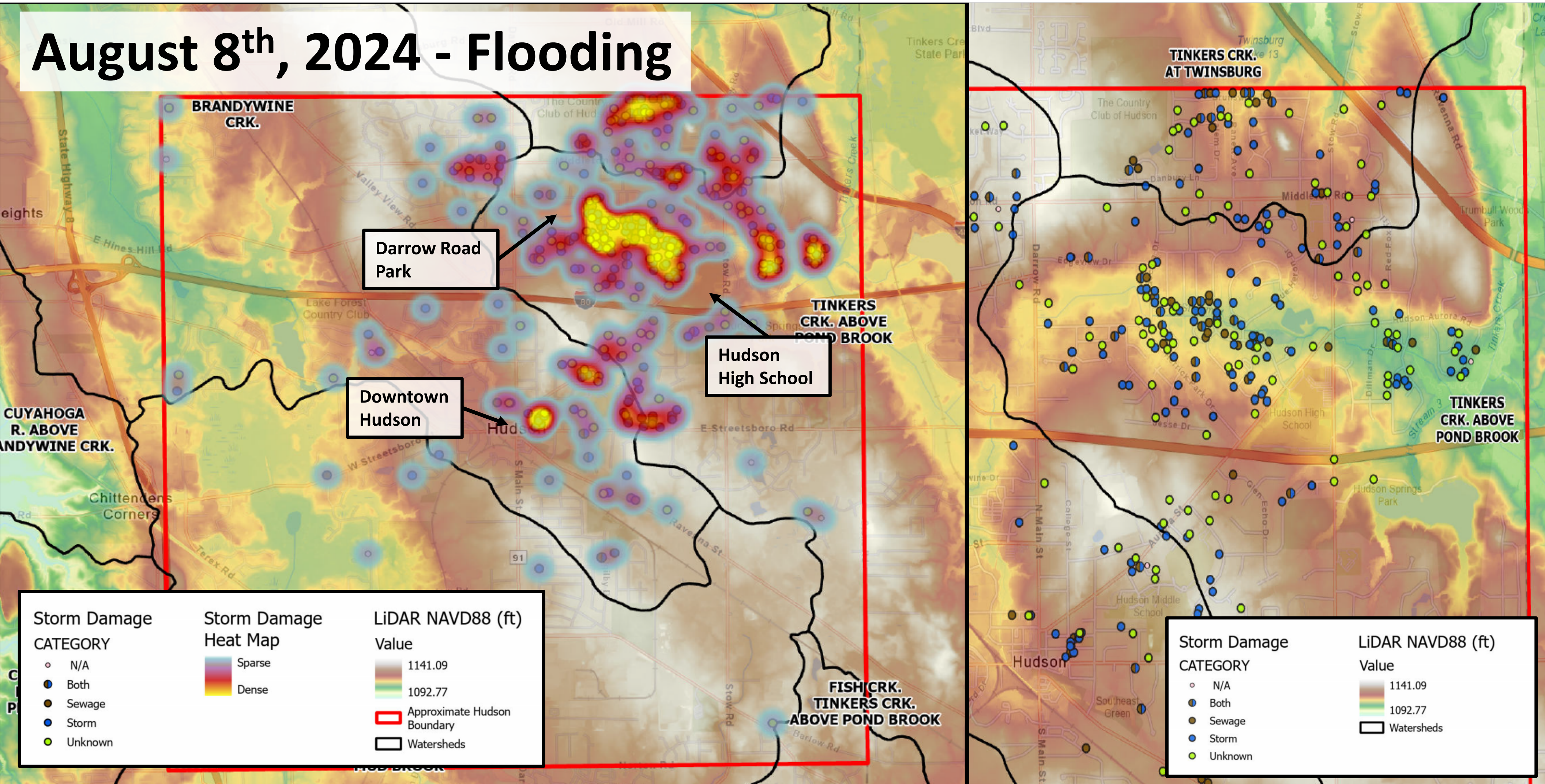
2HR Duration	
Precipitation Depth (inches)	Recurrence Interval (Years)
1.16	1
1.4	2
1.78	5
2.08	10
2.5	25
2.85	50
3.21	100
3.59	200
4.13	500
4.57	1000



1000 YEAR + RAINFALLS IN OHIO

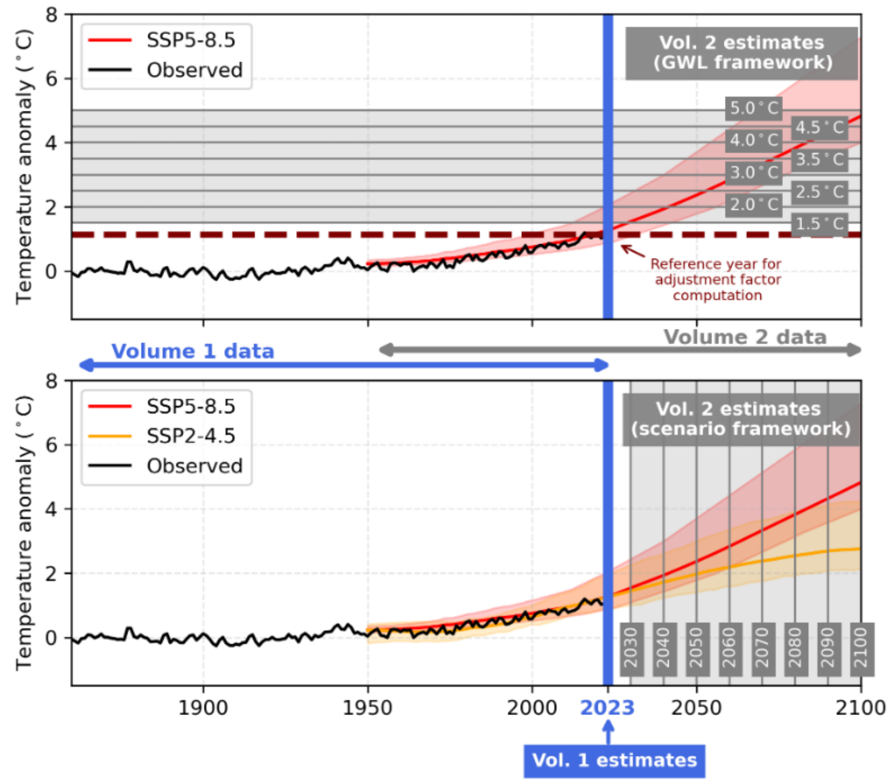
Date	Location	Description
August 2023	Northeast Ohio (Akron, Cleveland)	Severe flooding in Summit, Cuyahoga, and Lorian Counties, with over 5 inches of rain in a few hours.
May 2019	Dayton and Miami Valley	Intense rainfall during the Memorial Day storms, leading to localized flooding, with rainfall totals reaching 1,000-year recurrence interval.
July 2017	Cincinnati Metro Area	Torrential downpours in Hamilton and surrounding counties, casuing road closures and property damage. Nearly 1,000-year event.
June 2015	Northwest Ohio (Findlay)	Major rainstorm caused the Blanchard River to overflow, leading to flash flooding and damage, with recorded rainfall levels at 1,000-year recurrence intervals.

August 8th, 2024 - Flooding



NOAA Altas 15 (Future Release)

- Will replace NOAA Atlas 14 Volume 2 Precipitation Frequency Atlas of the US, Ohio River Basin and Surrounding States (Released 2004, Latest Revision 2006)
- Will account for precipitation events changing over time
- Will provide projections of future precipitation
- Scheduled to be available in 2026



Benefits to Upgrading Standards

- Flood Risk Reduction
- Resiliency of the Natural System
- Faster recovery after flood events = improved economic recovery
- More sustainable development & community
- Potential for lower Flood Insurance Premium

Regulatory Standards / Guidelines Summary						
	Stormwater Drainage Design Criteria	**Critical Detention Requirements**	**Green Infrastructure / Promote Infiltration**	**Stream Corridor Protection**	**Compensatory Floodplain Storage**	**Regional Stormwater Management**
City of Hudson, OH[3]	10-YR Storm Sewer 10-YR Open Ditch	25-YR Post to 1-YR Pre		✓		✓
City of Columbus, OH[4]	10-YR Major Arterial 5-YR Minor Arterial	100-YR Post to 10-YR Pre	✓	✓	✓	✓
City of Delaware, OH[5]	2-YR Storm Sewer 10-YR Open Ditch	100-YR Post to 1-YR Pre		✓		
City of Dublin, OH[6]	5-YR Public 2-YR Private	100-YR Post to 1-YR Pre	✓	✓	✓	
City of Stow, OH[7]	5-YR Storm Sewer 10-YR Open Ditch	25-YR Post to 2-YR Pre		✓		

Examples of Resiliency Strategies	
City	**Description of Strategy**
Madison, WI 14	**Increase design storm** for **Culverts from 25/50 YR to 100YR**, **Drainage in Depressions from 25 YR to 100YR**, **Detention Basins from 100YR to 200YR**, **Flood Protection of Structures for 500 YR event.**
Virginia Beach, VA 15	**Increase** Atlas 14 rainfall values by **20%** for design of new infrastructure.
Boston, MA 7	Utilize **projected rainfall** for design of new infrastructure, with the **projection time horizon** based on **useful life** of assets. Projected increased of approximately **7% for 2035**, **15% for 2060**, and **27% for 2100**.
New York, NY 8	Utilize **projected rainfall** for design of new infrastructure with the **projection time horizon** based on **useful life** of assets. Considerations for **cloudburst management,** mitigating events with intensities of **up to 2.3 inches / hour.**
Washington D.C. 16	Utilize **projections** tied to future emissions scenarios to design new infrastructure. For example, the **100YR – 24HR** accumulation **projection for 2080** is an **increase** of approximately **58% for low emissions scenario** and **64% for high emissions scenario***. Considers **criticality of facilities** to set design standards.

What are some higher standards that we should consider?

- Increasing rainfall estimates for storm infrastructure design
- Promoting LID/Green Infrastructure
- Incorporating regulations such as riparian setback and compensatory storage in flood hazard areas
- Maximizing detention requirements

NOAA Atlas 14

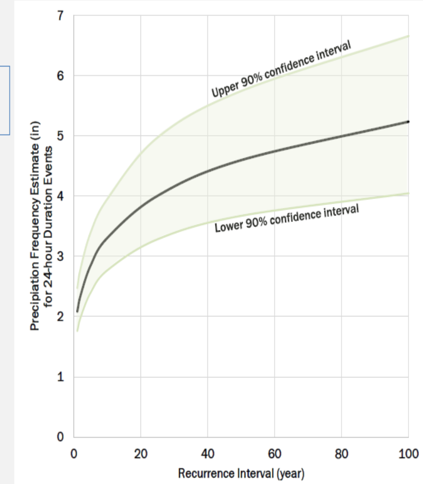
- Statistical summary of past events
- Assumes stationarity

4.5.4. Trend analysis
Precipitation frequency analysis methods used in NOAA Atlas 14 volumes are based on the assumption of a stationary climate over the period of observation (and application). Statistical tests for trends in AMS and the main findings for this project area are described in more detail in Appendix A.2. Briefly, the stationarity assumption was tested by applying a parametric *t*-test and non-

Precipitation Frequency Estimates (90% Confidence Interval)

Duration	1-year	2-year	5-year	10-year	25-year	50-year	100-year
5-min	0.30	0.36	0.45	0.53	0.64	0.73	0.82
	0.25 - 0.38	0.29 - 0.45	0.36 - 0.56	0.42 - 0.66	0.5 - 0.82	0.55 - 0.94	0.60 - 1.07
10-min	0.44	0.52	0.66	0.77	0.94	1.06	1.20
	0.36 - 0.55	0.42 - 0.65	0.53 - 0.82	0.62 - 0.97	0.73 - 1.20	0.81 - 1.38	0.88 - 1.57
15-min	0.54	0.64	0.80	0.94	1.14	1.30	1.46
	0.44 - 0.67	0.52 - 0.8	0.65 – 1.00	0.76 - 1.18	0.89 - 1.47	0.99 - 1.68	1.07 - 1.92
30-min	0.75	0.89	1.12	1.32	1.59	1.81	2.04
	0.61 - 0.93	0.72 - 1.11	0.90 - 1.40	1.06 - 1.65	1.24 - 2.04	1.38 - 2.35	1.50 - 2.68
60-min	0.96	1.14	1.44	1.70	2.08	2.38	2.69
	0.78 - 1.19	0.92 - 1.42	1.16 - 1.8	1.37 - 2.13	1.62 - 2.67	1.81 - 3.09	1.99 - 3.55
2-hr	1.17	1.39	1.76	2.08	2.56	2.94	3.35
	0.96 - 1.44	1.13 - 1.71	1.43 - 2.17	1.69 - 2.58	2.02 - 3.27	2.27 - 3.79	2.49 - 4.38
3-hr	1.30	1.53	1.94	2.31	2.85	3.29	3.76
	1.07 - 1.59	1.26 - 1.88	1.59 - 2.39	1.88 - 2.84	2.26 - 3.63	2.55 - 4.22	2.82 - 4.91
6-hr	1.54	1.79	2.24	2.65	3.27	3.79	4.35
	1.28 - 1.87	1.49 - 2.18	1.85 - 2.72	2.18 - 3.23	2.63 - 4.14	2.97 - 4.83	3.30 - 5.64
12-hr	1.81	2.06	2.52	2.94	3.6	4.16	4.77
	1.52 - 2.17	1.72 - 2.48	2.10 - 3.03	2.44 - 3.56	2.93 - 4.52	3.30 - 5.26	3.65 - 6.13
24-hr	2.08	2.35	2.85	3.31	4.00	4.60	5.24
	1.76 - 2.47	1.99 - 2.80	2.40 - 3.40	2.77 - 3.95	3.28 - 4.97	3.67 - 5.74	4.05 - 6.66

* Averaged data for SEMCOG region

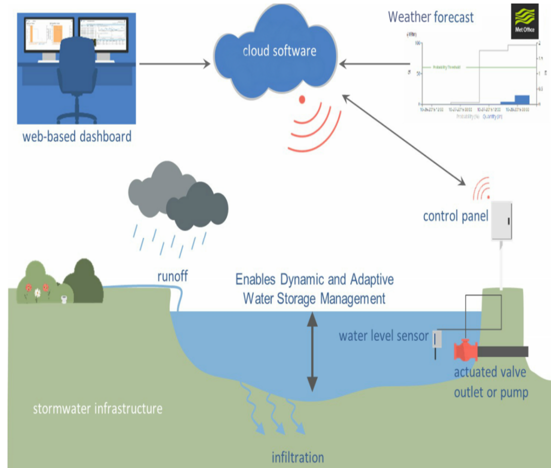


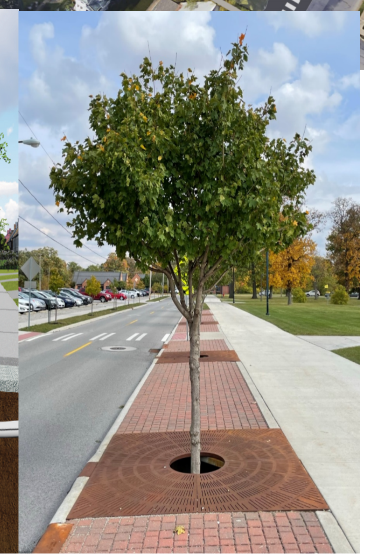
Potential Costs of Upgrading Standards

- Increase in volume required for detention
  - Estimates from a recent example project:
    - 25YR post to 2YR pre → 100YR post to 10YR pre results in a 3% increase in required detention
    - 25YR post to 2YR pre → 25YR post to 1YR pre results in a 5% increase in required detention
- More dedication of land by developers to meet requirements
- Larger pipes in storm sewer network
  - 12” ODOT Type B Conduit – $110 / LF
  - 18” ODOT Type B Conduit - $170 / LF
  - 24” ODOT Type B Conduit - $210 / LF
  - 36” ODOT Type B Conduit - $230 / LF
  - 48” ODOT Type B Conduit - $440 / LF
- *Benefit Cost Analysis is recommended for upgrading standards and future studies for evaluating alternatives.*

How to improve resiliency for these events?

- Incorporating low impact development/green infrastructure practices
- Using Continuous Monitoring and Adaptive Control (CMAC) for Optimizing Stormwater Management
- Identifying/acquiring repetitive loss properties for potential buyouts/acquisitions
- Developing special flood hazard areas and creating a flood overlay district for flood prone areas
- Increasing level of service for storm infrastructure
- Developing a flood warning system for flood prone watersheds in the City
- *Performing a comprehensive flood mitigation study*





Detailed Watershed-Scale Flood Mitigation Study

- Data Collection
- Existing Conditions H&H Modeling
  - Determine existing conditions so we can accurately compare flood mitigation alternatives
- Flood Mitigation Alternatives Analysis
  - Hydrologic Improvements
    - Additional Regional Detention, Cloudburst management
  - Hydraulic Improvements
    - Addressing Hydraulic bottleneck, Bridge/Culvert capacity
  - Low Impact Development Implementation
    - Green infrastructure, Stormwater retrofits
  - Storm Sewer Network Improvements
    - Increased pipe/inlet Capacity
  - Non-Structural Solutions
    - Acquisition of flood prone areas

Although preventing all flood damages from a storm such as the August 8th event may not be feasible, a combination of approaches can significantly increase flood resilience.

- CIP Project Prioritization
  - Benefit Cost Analysis for proposed alternatives
  - Creation of project scoring matrix to prioritize improvements

Questions?