CITY OF BEXLEY

Flow Metering Analysis & Next Steps

09/09/2025

BURGESS & NIPLE

BIO

John Swartzbaugh, PE
Section Director – Collections & Distributions

Years of Experience: 26
Education: BS-Civil Engineering Ohio Northern University
Licensed: OH & FL
Registrations: PACP, MACP, LACP
Office: Columbus

RELEVANT EXPERIENCE

Pipeline Condition Assessments

Scioto Main Trunk Sewer Rehabilitation
- 120” Pipe Totaling 7,700 LF, City of Columbus, OH

West Side Trunk & Interceptor LDCA
- 42”-156” Pipe Totaling 98,000 LF, City of Columbus, OH

Sanitary Sewer Evaluation Surveys (SSES)

City of Columbus, OH - West 5th Avenue I/I Remediation
City of Upper Arlington, OH - SSES Part I & II and Phases I-VII
Village of Marble Cliff, OH - SSES Phase I
Village of Riverlea, OH - SSES Year 1, 2, & 3

Rehabilitation Design

Big Walnut Outfall (South) Rehabilitation
- 108” Pipe Totaling 29,400 LF, City of Columbus, OH

Rudd Avenue Brick Sewer Rehabilitation Design-Build
- 90” Shotcrete 850 LF, 108” Sliplining 2,050 LF, Louisville MSD, KY

BIO

Caleb Zmith, PE
Project Manager

Years of Experience: 10
Education: BS-Civil Engineering
The Ohio State University
Licensed: OH
Registrations: PACP, MACP, LACP
Office: Columbus

RELEVANT EXPERIENCE

Pipeline Condition Assessment

St. Clair Street LDCA Storm Sewer Evaluation

- 84”-90” Pipe Totaling 3,000 LF, City of Hamilton, OH

West Mill Creek Trunk Sewer Assessment

- 36”-60” Pipe Totaling 24,000 LF, Butler County W&SD, OH

Sanitary Sewer Evaluation Surveys (SSES)

City of Upper Arlington, OH - SSES Part II and Phase VII
City of Gahanna, OH - Western Gahanna SSES Phase 1 Evaluation Survey
City of Wilmington, OH - Smoke & Dye Testing

Rehabilitation Design

Alum Creek Middle (Phase D) Sewer Rehabilitation

- 84”-90” Shotcrete Totaling 14,400 LF, City of Columbus, OH

Blacklick Creek Sanitary Subtrunk Rehabilitation

- 42” CIPP Totaling 13,800 LF, City of Columbus, OH

Project Team & Sanitary Sewer Evaluation Survey (SSES) Work

PRINCIPAL-IN-CHARGE
Robbie Cameruca, PE

PROJECT MANAGER
John Swartzbaugh, PE

LEAD ENGINEER
Caleb Zmith, PE

UTILITY PLANNING, CRITICALITY & CONSEQUENCE OF FAILURE, BUSINESS CASE EVALUATION
Kevin Campanella, PE

FIELD OPERATIONS
Zach Shinn, EI

SENIOR MODELER
Aran Whisler, PE

TECHNICAL ADVISOR
Brenton Hasenhour, PE

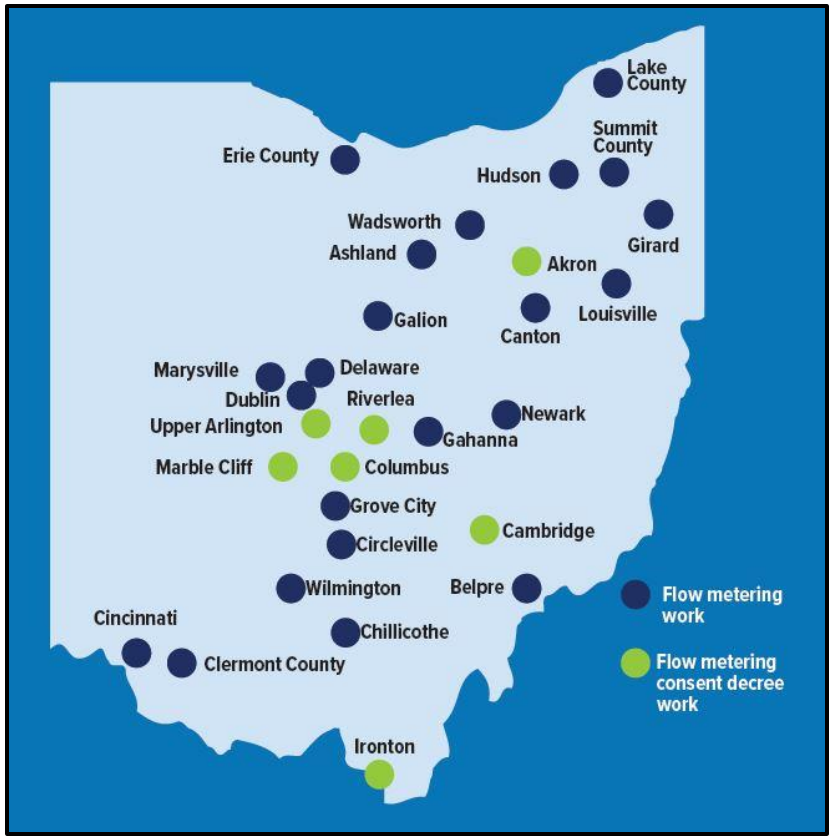
FLOW METERING
Zach Shinn, EI
Brayden Reynolds, EI

SEWER CLEANING
FeeCorp

CCTV
FeeCorp

DYE TESTING
FeeCorp

Subconsultant - FeeCorp



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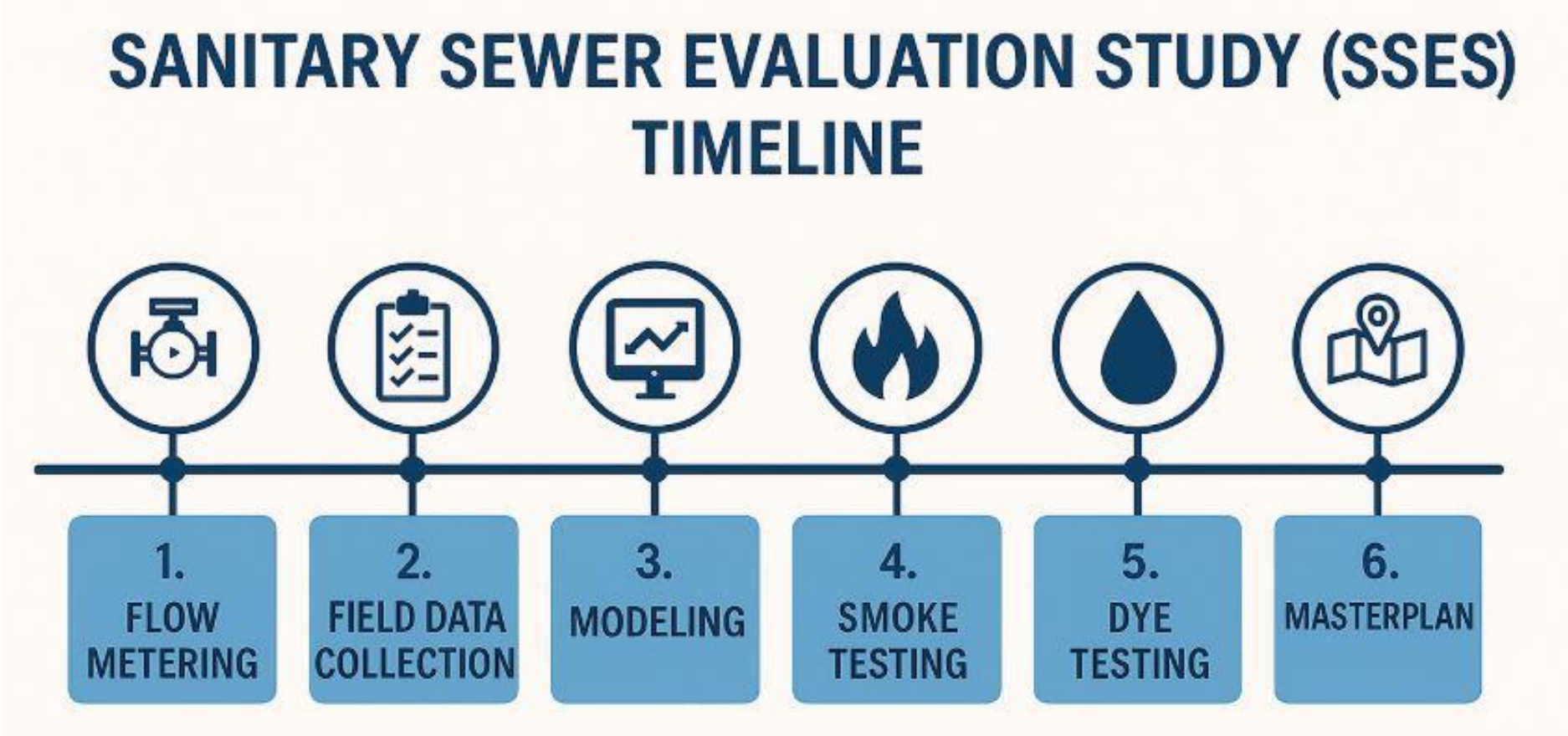
SSES Process



Why Bother with Flow Monitoring?

Take Care of Your COMMUNITY By:

- Preventing Sanitary Sewer Overflows (SSO)
- Verify and predict Water-in-Basement (WIBs)
- Anticipating capacity issues

Save MONEY By:

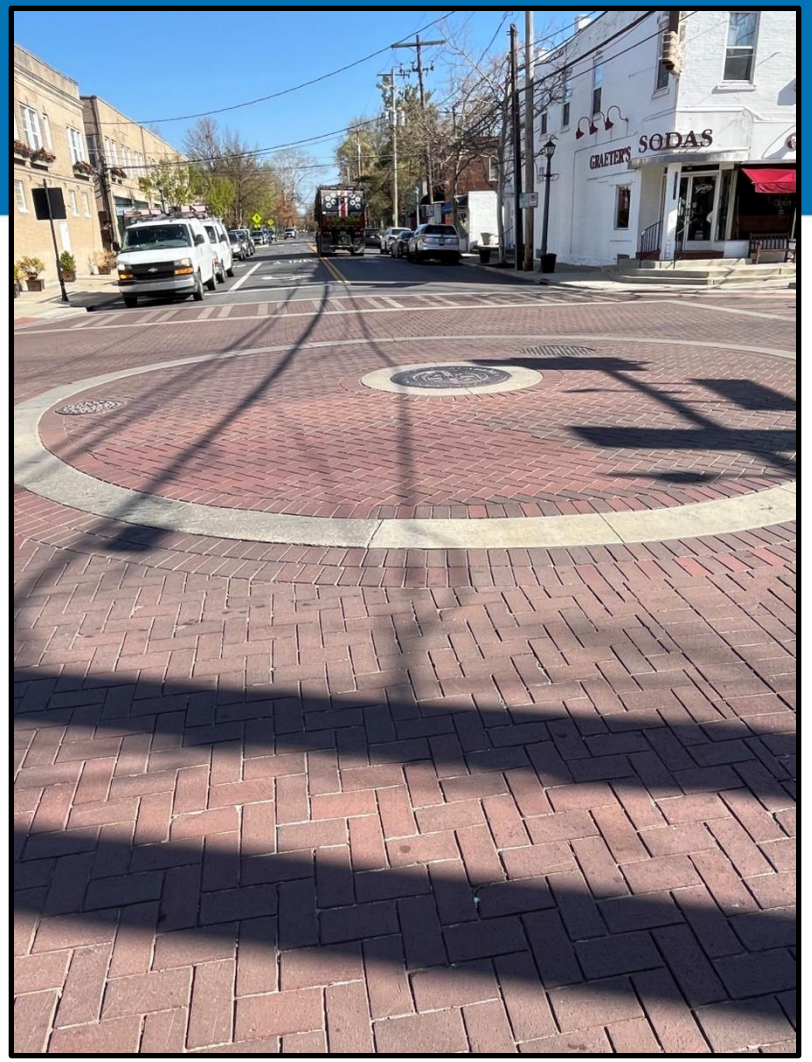
- Planning for future development areas
- Focusing future improvements
- Isolating Infiltration & Inflow problems

Avoid PENALTIES By:

- Complying with Overflow Monitoring
- Complying with EPA Consent Decrees

Flow Metering Overview

1. Review GIS information and cut tributary boundaries
2. Rent 13 Hach flow meters
3. Installation and maintenance of equipment
4. Monitor rainfall and storm categories
5. Develop dry weather flow projections
6. Analysis of I/I data and sewer response to rainfall
7. Technical memo & recommendations



Bexley Sanitary Sewer Statistics

Sewer System Summary:

- 9 Outfall locations into COC (6 along Alum Creek, 3 along Gould)
- 12 Inflow locations from COC all along Gould
- 7 Relief connections
- Approximately 215,000’ of pipe & 750 manholes in GIS system
- Approximately 700 sanitary WIBs from 2020-2024 (428 unique)

Category	Size (in)	Length (ft)	Length (mi)	Percentage of Total
1	8	156,211	29.6	72.6%
2	10 - 15	39,129	7.4	18.2%
3	18 - 24	16,195	3.1	7.5%
4	27 - 36	2,969	0.6	1.4%
5	36+	771	0.1	0.4%
TOTAL	-	215,275	40.8	-

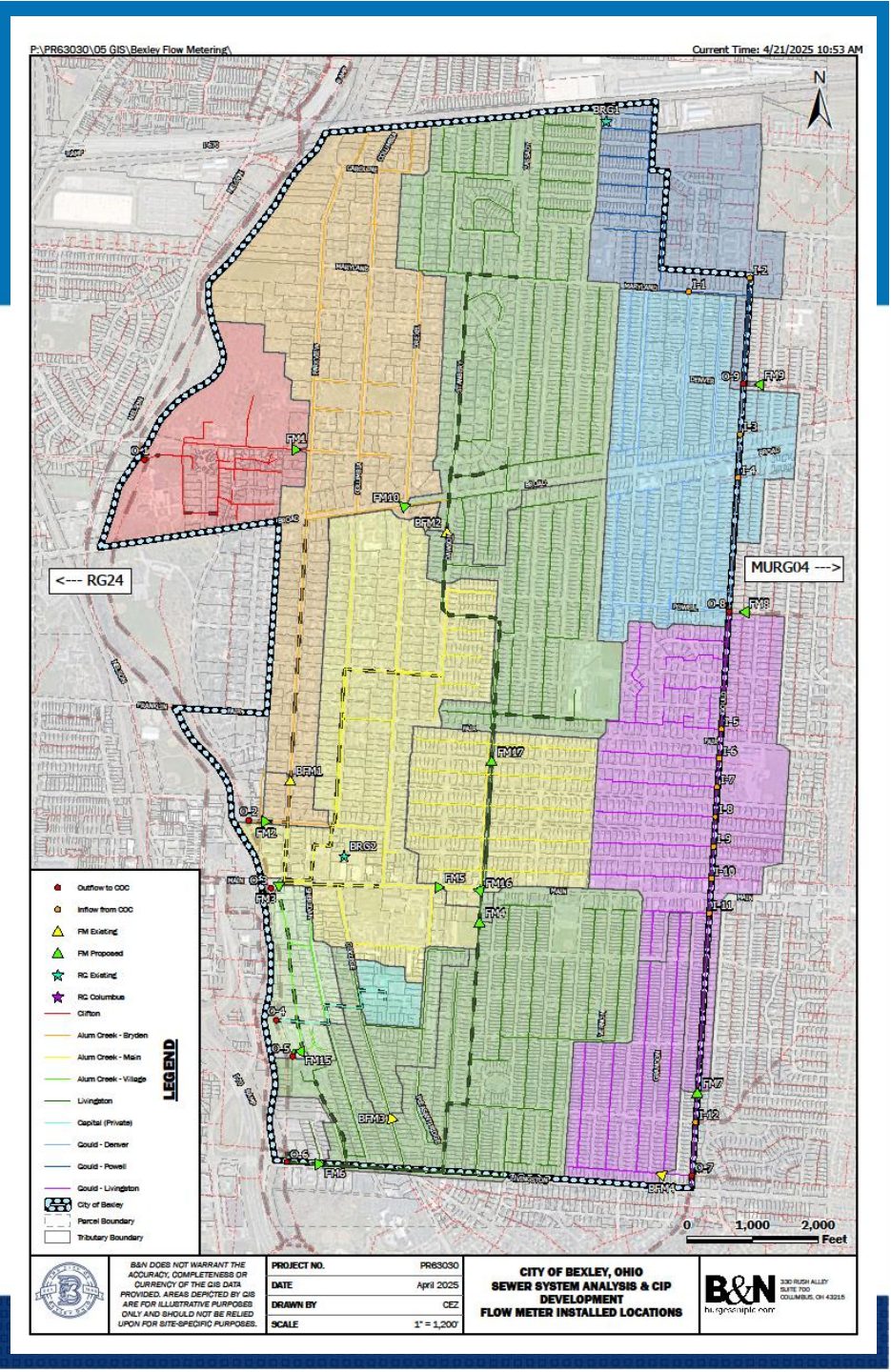
GIS Tributaries

Equipment Summary:

- City owns 4 ADS flow meters and 2 rain gauges
- City rented 13 Hach flow meters for 5 months
- Utilized 2 City of Columbus rain gauges

GIS data limited to just ID, size, & length.

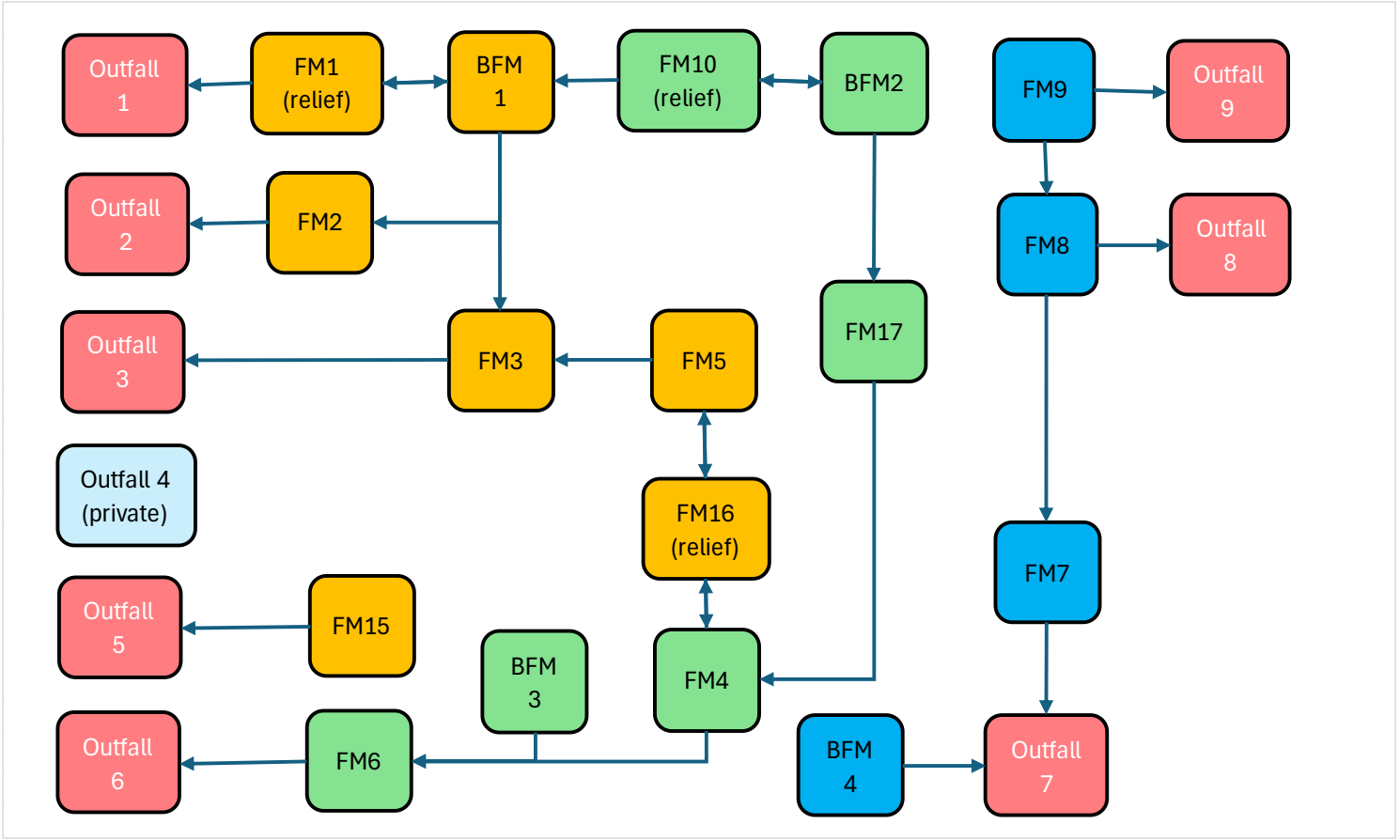
- Divided system into tributaries per outfall
- System intermixes with Columbus along Gould



Tributary Analysis

Collection systems can be broken into tributary areas with measurable characteristics for further analysis like:

- Linear footage of contributing sewer
- Age of construction
- Pipe Material
- Depth of sewer
- Surface permeability
- Soil types
- Water consumption records



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Rain Gauges & Storm Selection

Rain gauges are used to correlate the amount of rainfall with the response in the sewer.

Rainfall Intensity-Duration-Frequency (IDF) Table									
Date	48 hour	24 hour	18 hour	12 hour	★6 hour★	3 hour	2 hour	1 hour	30 min
4/4/2025	2.54	2.11	1.41	1.41	1.37	0.99	0.75	0.48	0.38
	2-year	1.5-year	6-month	8-month	11-month	7-month	4-month	2-month	2-month
5/3/2025	2.51	1.83	1.42	1.08	0.80	0.53	0.40	0.29	0.23
	2-year	11-month	6-month	3-month	2-month	<2-month	<2-month	<2-month	<2-month
5/20/2025	0.74	0.56	0.51	0.51	0.35	0.35	0.35	0.35	0.34
	<2-month	<2-month	<2-month	<2-month	<2-month	<2-month	<2-month	<2-month	<2-month
5/30/2025	0.73	0.71	0.71	0.67	0.51	0.34	0.28	0.18	0.11
	<2-month	<2-month	<2-month	<2-month	<2-month	<2-month	<2-month	<2-month	<2-month
6/9/2025	1.63	1.13	1.06	1.05	1.05	0.99	0.86	0.67	0.66
	6-month	3-month	3-month	3-month	5-month	7-month	6-month	5-month	10-month
7/27/2025	2.16	1.87	1.60	0.98	0.97	0.96	0.95	0.85	0.66
	1.25-year	1-year	9-month	3-month	4-month	6-month	8-month	11-month	11-month

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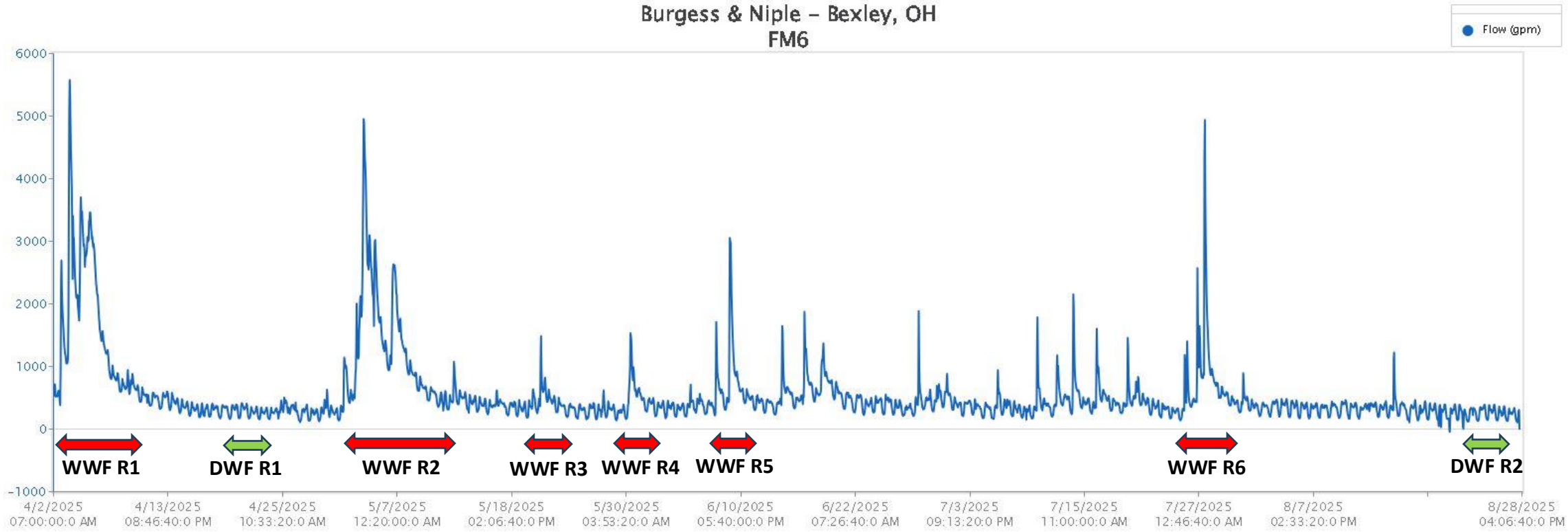
Flow Summary



WWF R = Wet Weather Flow Range

DWF R = Dry Weather Flow Range

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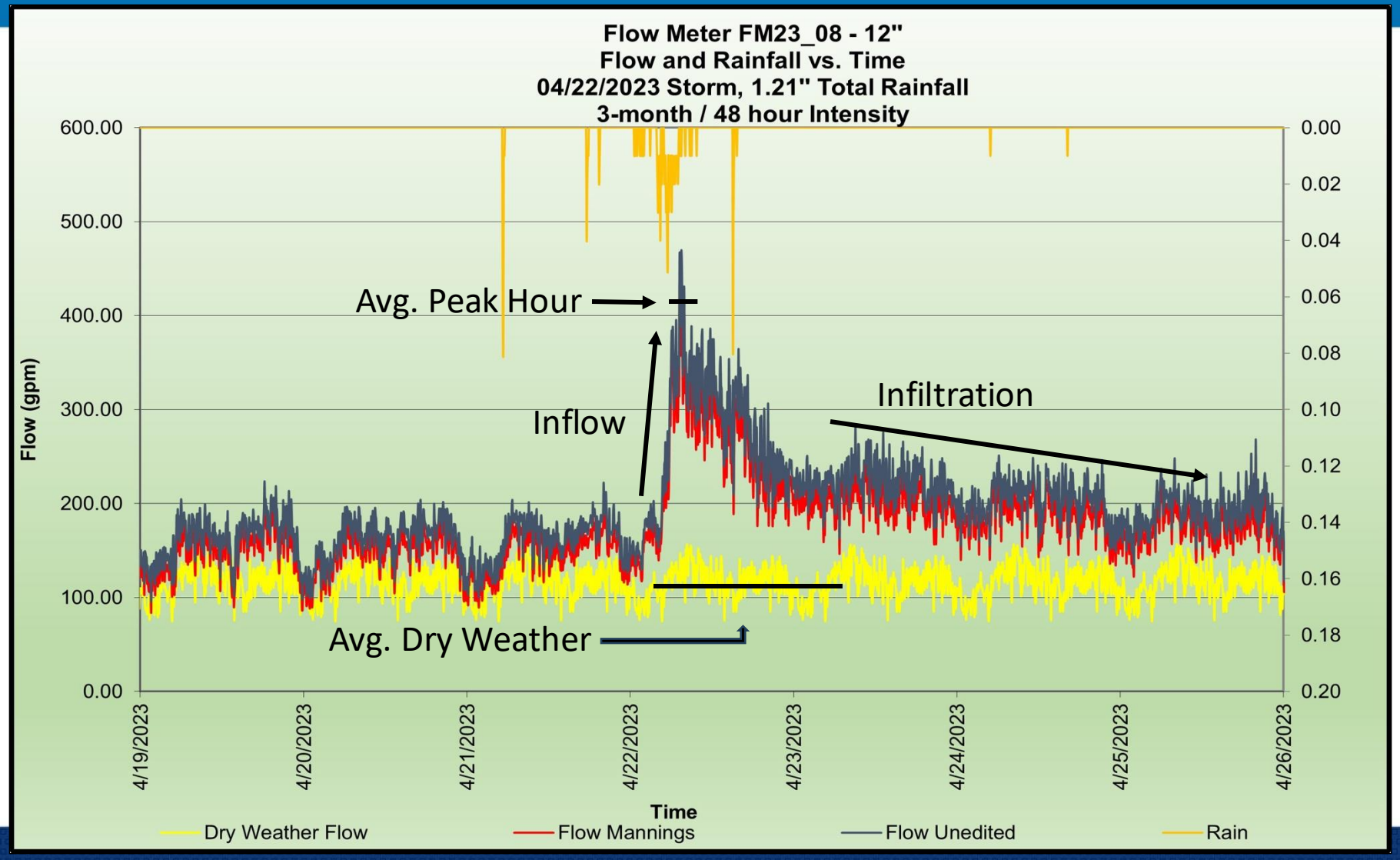
Hydrographs → Flow vs. Time



- $Peaking\ Factor = \frac{Average\ Peak\ Hour\ Flow\ (gpm)}{Average\ Dry\ Weather\ Flow\ (gpm)}$
- $Flow_{I/I} = Blue - Yellow$

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Overall System Performance

- Dry Weather Flow is around 1.20-1.35 MGD
- Wet Weather Flow averaged 4.30 MGD~350 gpcd
- EPA excessive I/I threshold is 275 gpcd

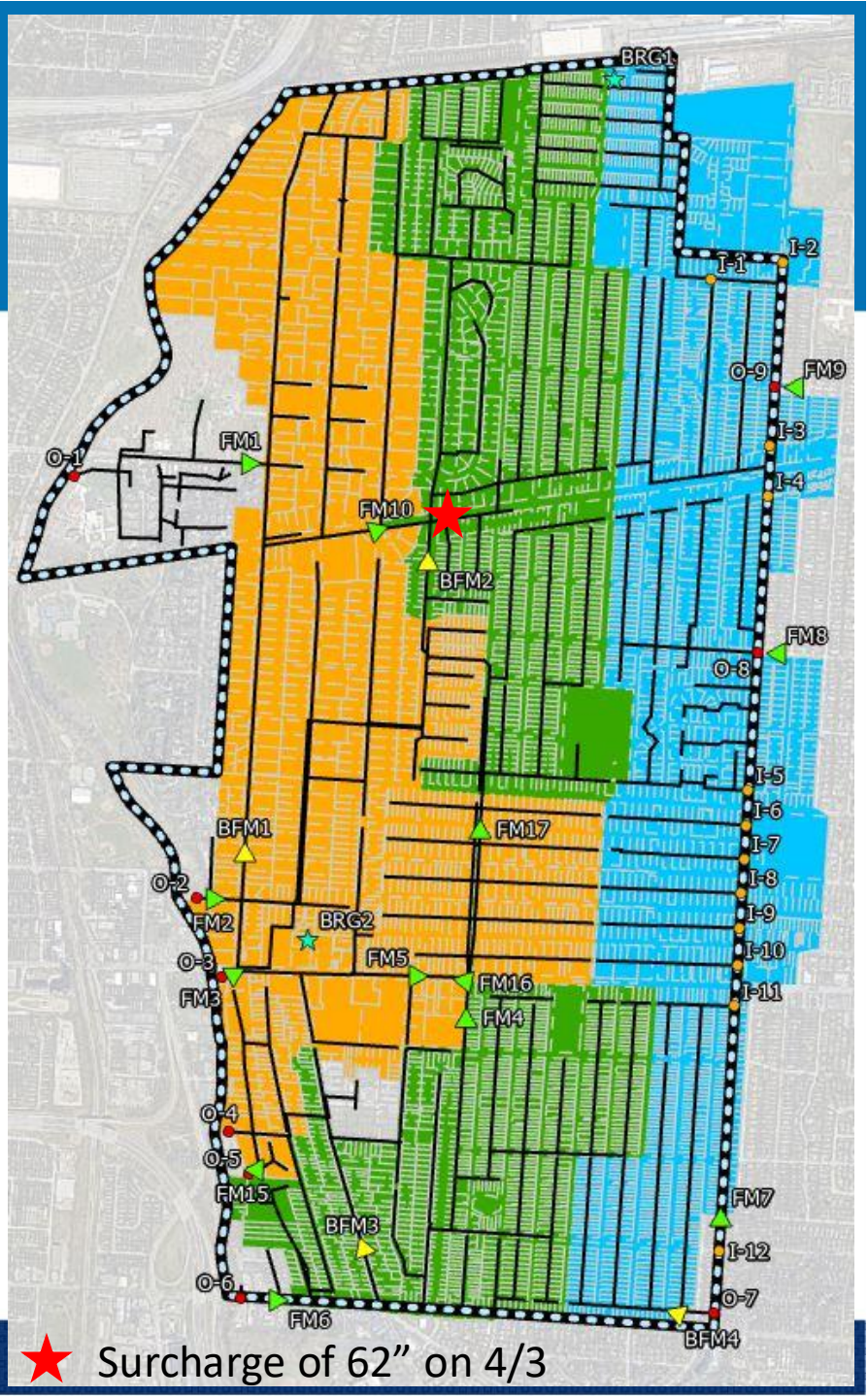
Wet Weather Flow Analysis Per Storm Event							
Event ID	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Start WWF Period	4/2/2025	5/1/2025	5/20/2025	5/30/2025	6/8/2025	7/24/2025	
End WWF Period	4/9/2025	5/10/2025	5/23/2025	6/2/2025	6/11/2025	7/30/2025	
Days	7	9	3	3	3	5	**30**
Rainfall (in)	3.63	3.97	0.75	0.71	1.64	2.61	**13.31**
Recorded Volume (gal)	44,993,539	44,712,895	6,101,250	6,742,734	9,581,801	16,576,614	**128,708,834**
Theoretical Dry Weather Volume (gal)	8,342,203	10,725,689	3,575,230	3,575,230	3,575,230	5,958,716	**35,752,297**
Calculated I/I Volume (gal)	36,651,337	33,987,206	2,526,020	3,167,504	6,006,572	10,617,898	**92,956,537**
I/I Per Inch of Rainfall (gal/in)	10,103,745	8,555,621	3,345,722	4,445,620	3,673,744	4,073,310	**6,984,382**
I/I Per Inch Per LF of Sewer (gal/in/ft)	46	39	15	20	17	19	**26**
Dry Weather Average Flow (gpm)	829						
Peak Flow (gpm)	14,862	11,397	3,715	3,680	7,401	11,700	**8,793**
Peak Factor	18	14	4	4	9	14	**11**

Comparison Metrics

Peaking Factors indicate significant inflow sources in the Livingston (green) tributary - most likely from relation of storm sewer location to sanitary

I/I/Inch/LF indicates Gould (blue) and Livingston (green) areas have significant infiltration based on the elevated rate on events 3 & 4.

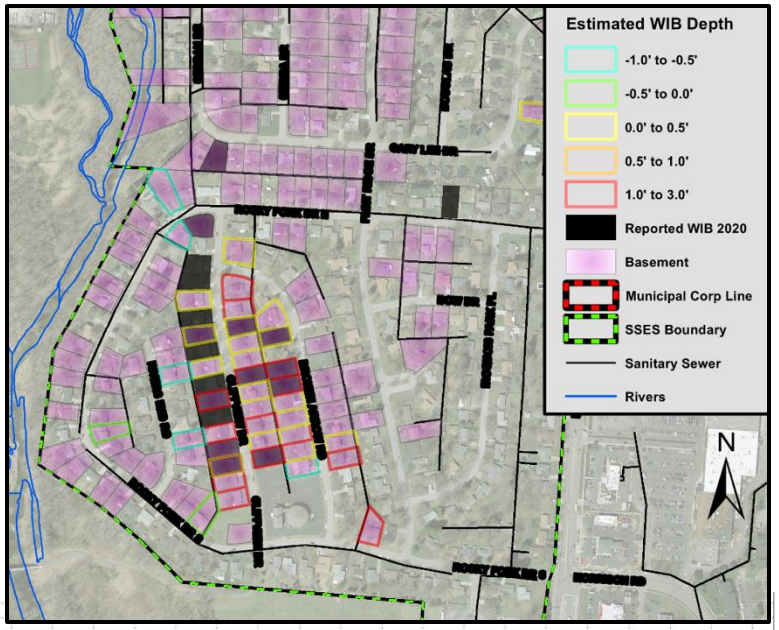
Evaluation Metrics							
Rainfall/Storm Event	**1 4/2 - 4/9 3.63" Rain 2-YR / 48-HR**	**2 5/1 - 5/10 3.97" Rain 2-YR / 48-HR**	**3 5/20 - 5/23 0.75" Rain <2-MO / 12-HR**	**4 5/30 - 6/2 0.71" Rain <2-MO / 12-HR**	**5 6/8 - 6/11 1.64" Rain 10-MO / 30-MIN**	**6 7/25 - 7/30 2.61" Rain 1.25 YR / 48-HR**	**Averages**
Tributary	**Peaking Factors**						**City Avg = 11**
Alum Creek: FM1+FM2+FM3+(FM4-FM17)-FM10+FM15	12	8	3	3	5	9	**7**
Livingston: FM10+FM6-(FM4-FM17)	25	22	7	7	15	22	**16**
Gould: FM7+FM8+FM9+BFM4	20	16	5	4	8	17	**12**
Rainfall/Storm Event	**1 4/2 - 4/9 3.63" Rain 2-YR / 48-HR**	**2 5/1 - 5/10 3.97" Rain 2-YR / 48-HR**	**3 5/20 - 5/23 0.75" Rain <2-MO / 12-HR**	**4 5/30 - 6/2 0.71" Rain <2-MO / 12-HR**	**5 6/8 - 6/11 1.64" Rain 10-MO / 30-MIN**	**6 7/25 - 7/30 2.61" Rain 1.25 YR / 48-HR**	**Averages**
Sanitary Tributary Area	**I/I per Inch of Rainfall per Foot of Sewer**						**City Avg = 26**
Alum Creek: FM1+FM2+FM3+(FM4-FM17)-FM10+FM15	41	28	10	13	7	16	**19**
Livingston: FM10+FM6-(FM4-FM17)	56	47	15	22	24	17	**30**
Gould: FM7+FM8+FM9+BFM4	49	47	22	28	18	25	**32**

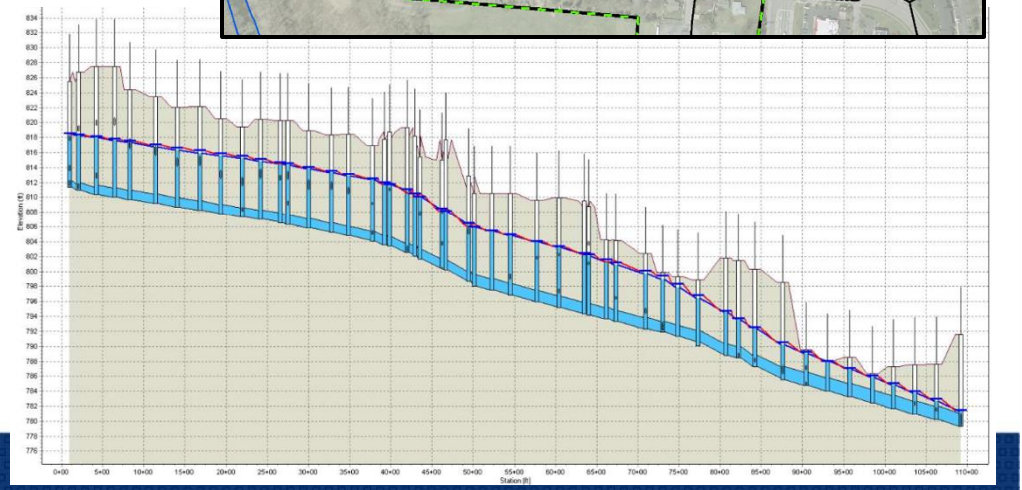


★ Surcharge of 62” on 4/3

Recommendations

1. Field inspections to pinpoint I/I & remediation type
   - Inspect & survey storm/sanitary infrastructure
   - Smoke Test for infiltration on private side
   - Dye Test for inflow from public/private storm structures
2. Update hydraulic sanitary sewer model
   - Continue using ADS equipment and relocate for model
   - Geolocate WIB's & predict SSO's
   - Build storm sewer GIS network & define LOS goal
3. Develop Master Plan
   - Rate study to verify utility sustainability
   - Rehabilitation plan for CIPP





Next Steps

Public Outreach

- Letter and Questionnaire to Residents

CITY OF | UPPER ARLINGTON

ENGINEERING DIVISION
4100 Roberts Road | Columbus, OH 43228
Phone: 614.583.5360 | Fax: 614.442.3219 | www.uaoh.net

March 27, 2013

Dear Owner or Current Tenant:

Re: Sanitary Sewer District Sanitary Sewer Evaluation Survey, Phase 7

The City of Upper Arlington is conducting an area-wide evaluation of the stormwater and sanitary sewer system in the study area in which your home is located to determine the need for future improvements. Specific improvements will be determined, in part, through this evaluation; please see the highlighted study areas on the attached map. The engineering firm of Burgess & Niple, Inc. has been contracted by the City to perform this evaluation.

Please be advised that it will be necessary for Burgess & Niple personnel and their subconsultants' crews to access the City's sanitary sewer system within your area during the next few months. In some areas, workers may need to enter yards to access manholes and sewer lines located within the City easement.

Field investigations for this phase of the study consist of manhole inspections, surveying, and flow monitoring. A crew may be in the neighborhood during significant rain events to observe the impacts of wet weather on the sanitary sewer system. This may require the crew to observe the neighborhood drainage conditions during nighttime or early morning hours. If you are uncertain as to their identity, don't hesitate to ask for identification. The map on the back of this letter identifies the area where crews will work during this study.

Enclosed is a questionnaire that will help us identify areas of particular concern. Please fill out this survey on either the enclosed paper copy or on the SurveyMonkey® website at address http://www.surveymonkey.com/s/TGMD7ND. Please return the questionnaire to Burgess & Niple using the self-addressed, stamped envelope we have provided or complete the survey on line by May 30, 2013. If you have any questions, please call John Swartzbaugh at Burgess & Niple at (614) 459-2050 or email john.swartzbaugh@burgessniple.com; or Jim Palmer, Upper Arlington Engineering Division at (614) 583-5360 or email jpalmer@uaoh.net.

Thank you for taking a few moments to complete and return the enclosed survey. We appreciate your cooperation so that this worthwhile project can be completed at the earliest possible date.

Sincerely,

David R. Parkinson, P.E.
City Engineer

CITY OF | UPPER ARLINGTON

ENGINEERING DIVISION
4100 Roberts Road | Columbus, OH 43228
Phone: 614.583.5360 | Fax: 614.442.3219 | www.uaoh.net

FLOODI NG QUESTIONNAIRE

Please Return By 05/30/2013

The City of Upper Arlington is conducting an area-wide evaluation of the stormwater and sanitary sewer system in the study area to identify and resolve problems. In order for us to better serve you, it is important that we are made aware of stormwater and sanitary sewer problems your property may be experiencing. Please take the time to fill out this survey and return it to us in the self-addressed, stamped envelope. Thank you for working with us to address these issues.

Name: *(optional)* _____

PROPERTY ADDRESS:
IMPORTANT

Verify Address: *Check one*
☐ Address is correct.
☐ Address is incorrect. *(Mark changes on address)*

1. How long have you been located at this address? (years) _____

2. Do you have:
☐ Basement ☐ Split level ☐ Crawl space ☐ Slab
☐ A yard that slopes away from the building?
☐ A yard that slopes toward the building?
☐ A depressed trench or low area in the yard?
☐ Large established trees near the building?

3. Do you experience any type of flooding in/on your property? *Check all that apply.*
☐ Basement ☐ Front Yard ☐ Back Yard ☐ Street ☐ Other ☐ None
*Comment: _____

4. If flooding occurs on your street:
What is the usual depth of water (inches)? _____
How long does the water stand (hours)? _____
Was there standing water in your yard? ☐ Yes ☐ No
When? ☐ During average rain ☐ During heavy rain

5. If basement flooding occurs, what is the usual depth of water? *(inches)* _____

6. How does water enter your basement? *Check all that apply.*
☐ Basement floor drains
☐ From drains in window wells
☐ Through basement walls
☐ From perimeter of basement floor
☐ From sump overflowing
☐ Don't know
☐ Other _____

7. How many times have you had water in your basement? *List dates if known.*
☐ In the past 5 years: _____
☐ In the past 2 years: _____
☐ Not applicable

8. Describe water in basement. *Check all that apply.*
☐ Clear
☐ Muddy
☐ Murky (gray or black)
☐ Odor
☐ No odor
☐ Not applicable

9. If you have experienced flooding, when does it occur?
☐ During an average rain event
☐ Only during a heavy rain event
☐ Immediately after a rain event
☐ The rain event is not a factor
☐ Have not noticed
Cause if other than rain: _____

10. Have you ever used a private contractor/plumber to remove blockage, clean or replace your plumbing/drains?
Roof Drains: ☐ Yes ☐ No
If yes:
How often? _____
When was the last time *(month/year)*? _____
Sanitary Service: ☐ Yes ☐ No
If yes:
How often? _____
When was the last time *(month/year)*? _____

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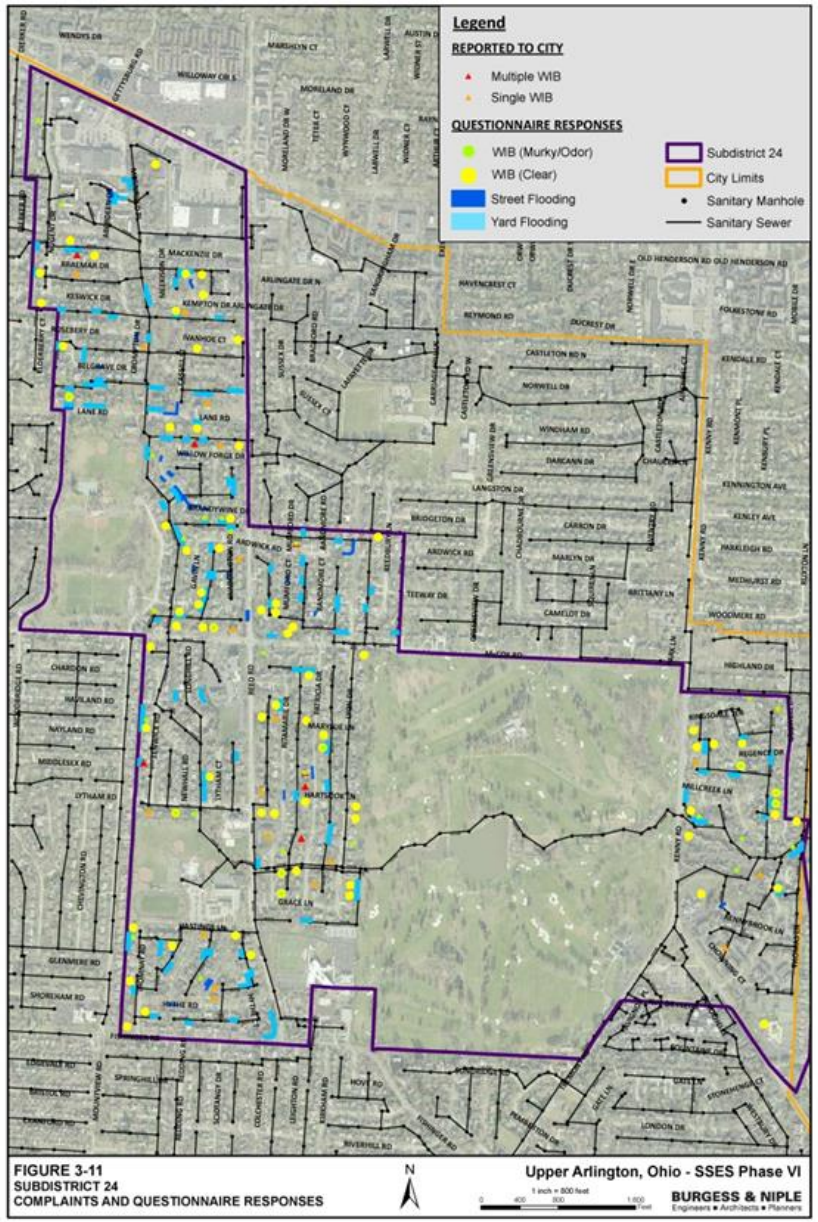
*Add additional pages if necessary



Field Data Collection: Smoke Testing

- Uses a non-toxic smoke and a high-capacity blower to force air throughout the sewer. Smoke then rises into the air to indicate I/I pathways.
- Needs to be performed during dry periods of the year (i.e., dry ground conditions).
- Also need to isolate sewer regions with sandbags & inflatable plugs.

Vented lids are easily fixed, preventing I/I if located in depressed areas or in drainage flow paths.

Field Data Collection: Dye Testing

Uses a non-toxic fluorescent dye and a CCTV camera to trace water infiltration through various public and private sources, such as:

- Storm sewers adjacent to sanitary lines
- Ponding areas over sanitary sewers
- Around manhole castings in pervious areas
- Rear yard sewers with heavy roots
- Sump pump, downspout, or home foundation drain connections
- Yard/driveway drain connections
- Depressed private laterals
- Sunken sidewalks over sewers

Rehabilitation Recommendations

Mainlines:

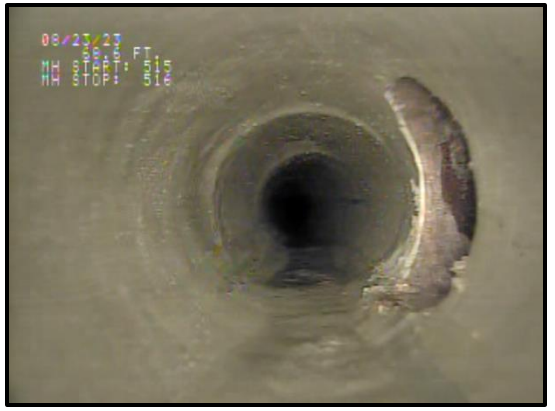
- CIPP
- Point Repairs

Laterals:

- CIPP
- Point Repairs

Manholes:

- Swap lids
- Chimney Seals
- Raise to Grade
- Rehabilitate



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Sewer Criticality & Consequence of Failure (COF)

- COF ratings can provide insights on how to spend funds to prevent future high-cost repairs proactively.
- Helps prioritize sewers that will be costlier if failure occurs down the road.
  - Typically focuses on larger diameters
  - Preventative sewer rehabilitation could stave off expensive future point repairs.

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Example: 10-Year CIP Summaries

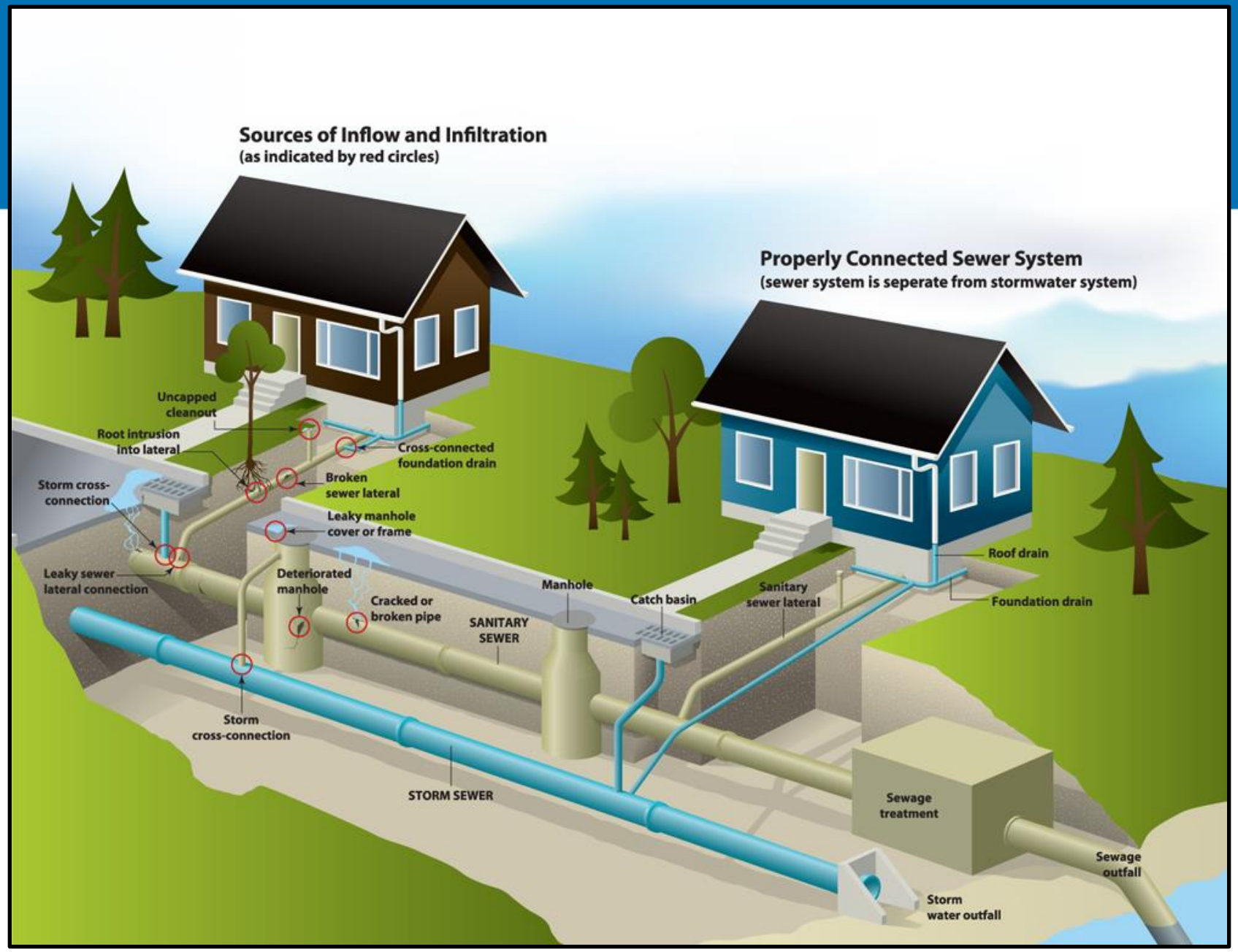
Upper Arlington SSES Proposed Annual Remediation Plan					
Year	Subtotal Construction Cost	Engineering Design	Engineering Inspection	Construction Contingency (10%)	Total Project Cost
2017	$2,009,871	$150,000	$80,000	$200,987	$2,440,858
2018	$1,050,890	$150,000	$80,000	$105,089	$1,385,979
2019	$1,095,206	$150,000	$80,000	$109,521	$1,434,727
2020	$1,008,400	$150,000	$80,000	$100,840	$1,339,240
2021	$986,300	$150,000	$80,000	$98,630	$1,314,930
2022	$1,074,705	$150,000	$80,000	$107,471	$1,412,176
2023	$1,045,458	$150,000	$80,000	$104,546	$1,380,004
2024	$1,012,116	$150,000	$80,000	$101,212	$1,343,328
2025	$997,800	$150,000	$80,000	$99,780	$1,327,580
2026	$1,042,200	$150,000	$80,000	$104,220	$1,376,420
2027	$875,700	$150,000	$80,000	$87,570	$1,193,270
2028	$770,114	$150,000	$80,000	$77,011	$1,077,125
Total	$12,968,760	$1,800,000	$960,000	$1,296,876	$17,025,636

2019 Estimated Project Cost					
Item		Quantity	Unit	Unit Cost	Total Cost
Public ROW	Sanitary Sewer Rehabilitation 8"	4,591	LF	$50	$229,550
	Sanitary Sewer Rehabilitation 10"	807	LF	$58	$46,806
	Manhole Rehabilitation	287	VF	$250	$71,750
	Manhole Casting Replacement	30	Each	$2,500	$75,000
Private	Lateral Rehabilitation	86	Each	$7,800	$670,800
Smoke Testing	Replace Manhole Casting	0	Each	$2,500	$0
	Downspout Disconnect	1	Each	$1,000	$1,000
	Area Drain Disconnect	0	Each	$1,000	$0
	Replace Cleanout	1	Each	$300	$300
				Subtotal Construction Cost	$1,095,206
				Engineering Design	$150,000
				Engineering Inspection	$80,000
				Construction Contingency (10%)	$109,521
				Total Project Cost	$1,434,727

Example: 20-Year CIP Staging

2024 IMPLEMENTATION STRATEGY																	
RANK	TIER	SCORE	EXTENSION AREA	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	PROJECT TOTAL
1	1	198	3A3C																$ 8,675,920.95
2	1	179	6A																$ 511,241.55
3	1	182	6B																$ 616,217.12
4	1	214	6C																$ 105,756.74
5	1	166	7																$ 1,411,177.55
6	1	170	21																$ 119,989.35
7	1	243	2B																$ 12,738,573.36
8	1	223	3B																$ 1,497,050.79
9	1	209	2A	$ 146,868.43	$ -	$ 1,396,337.86													$ 1,543,206.29
10	1	214	2C		$ 245,974.77	$ -	$ 2,347,259.30												$ 2,593,234.07
11	2	213	10D																$ -
12	2	198	10B			$ 145,678.56	$ 134,391.64	$ 1,390,157.05											$ 1,670,227.25
13	2	180	8B				$ 242,687.81	$ 5,375.67	$ 2,320,545.16										$ 2,568,608.64
14	2	171	12					$ 48,380.99	$ -	$ 459,363.76									$ 507,744.75
15	2	166	1D						$ 131,502.22	$ -	$ 1,250,685.40								$ 1,382,187.62
16	3	240	4Ap2																
17	3	223	10A																
18	3	223	9																
19	3	215	10C																
20	3	191	8C																
21	3	185	1A							$ 179,645.87	$ -	$ 1,712,963.39							$ 1,892,609.27
22	3	157	16								$ 126,293.90	$ 651,169.88	$ 1,210,504.23						$ 1,987,968.00
23	3	157	17									$ 36,302.15	$ 70,108.53	$ 353,732.34					$ 460,143.03
24	4	177	19																$ -
25	4	174	18										$ 18,695.61	$ 36,105.89	$ 173,168.85				$ 227,970.35
26	4	173	5																$ -
27	4	168	15											$ 25,675.30	$ 54,543.97	$ 250,100.18			$ 330,319.46
28	4	160	14B												$ 13,222.78	$ 69,799.76	$ 118,620.30		$ 201,642.84
29	4	154	20																$ -
30	4	142	13													$ 23,834.06	$ 41,207.39	$ 229,495.87	$ 294,537.33
31	5	227	8A																
32	5	159	4D																
33	5	134	22																
				$ 146,868.43	$ 245,974.77	$ 1,542,016.42	$ 2,724,338.75	$ 1,443,913.70	$ 2,452,047.38	$ 639,009.63	$ 1,376,979.30	$ 2,400,435.42	$ 1,299,308.37	$ 415,513.54	$ 240,935.60	$ 343,734.00	$ 159,827.69	$ 229,495.87	$ 41,336,326.29

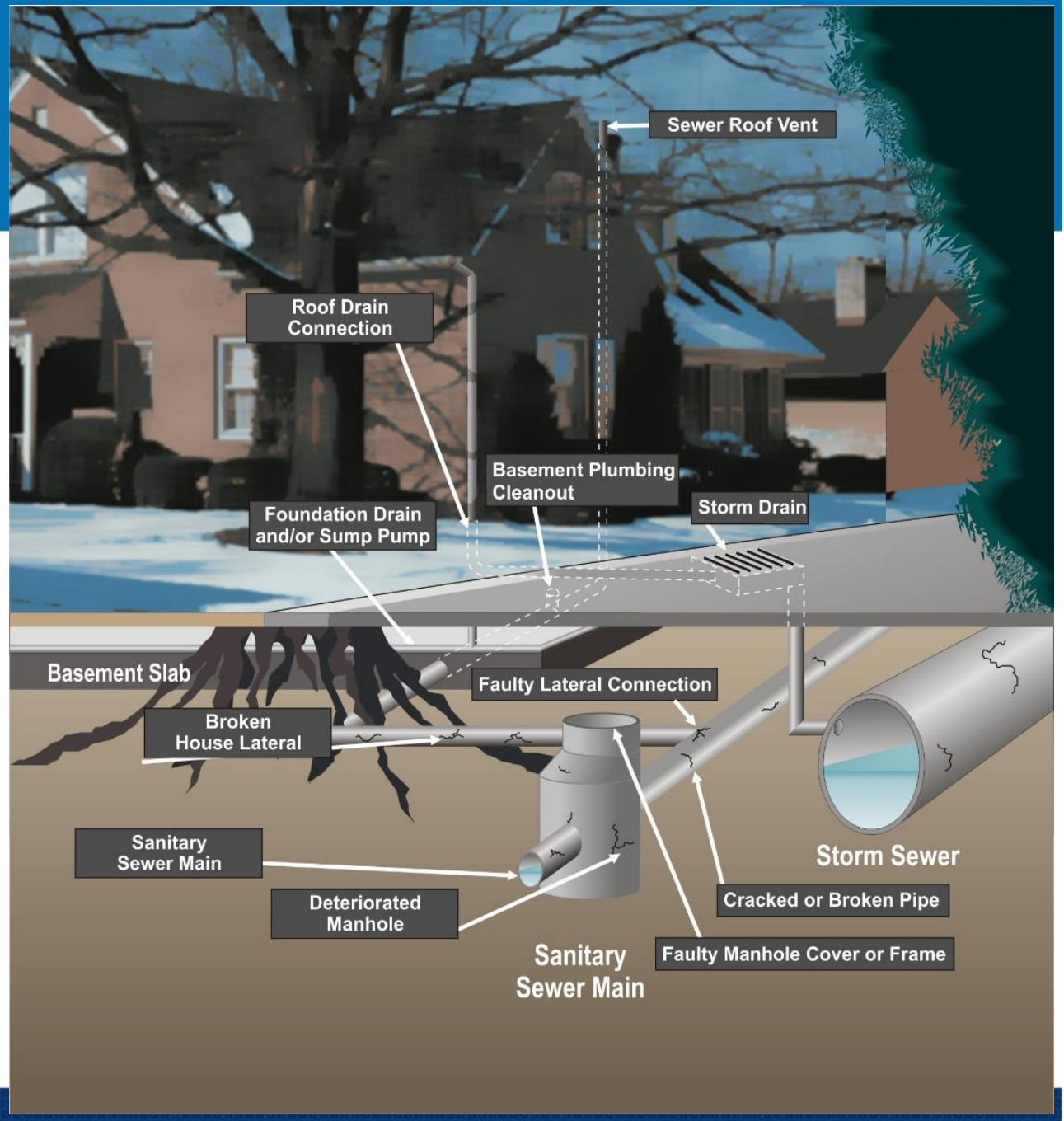
Questions?



BURGESS & NIPLE

Methods of Identification

- Maintenance Records
- Complaints (WIB's)
- Flow Metering Data
- Sewer CCTV
- Manhole Inspections
- Smoke Testing
- Public Dye Testing
- Private Dye Testing
- GIS Analysis
- Overland Rear Yard Drainage



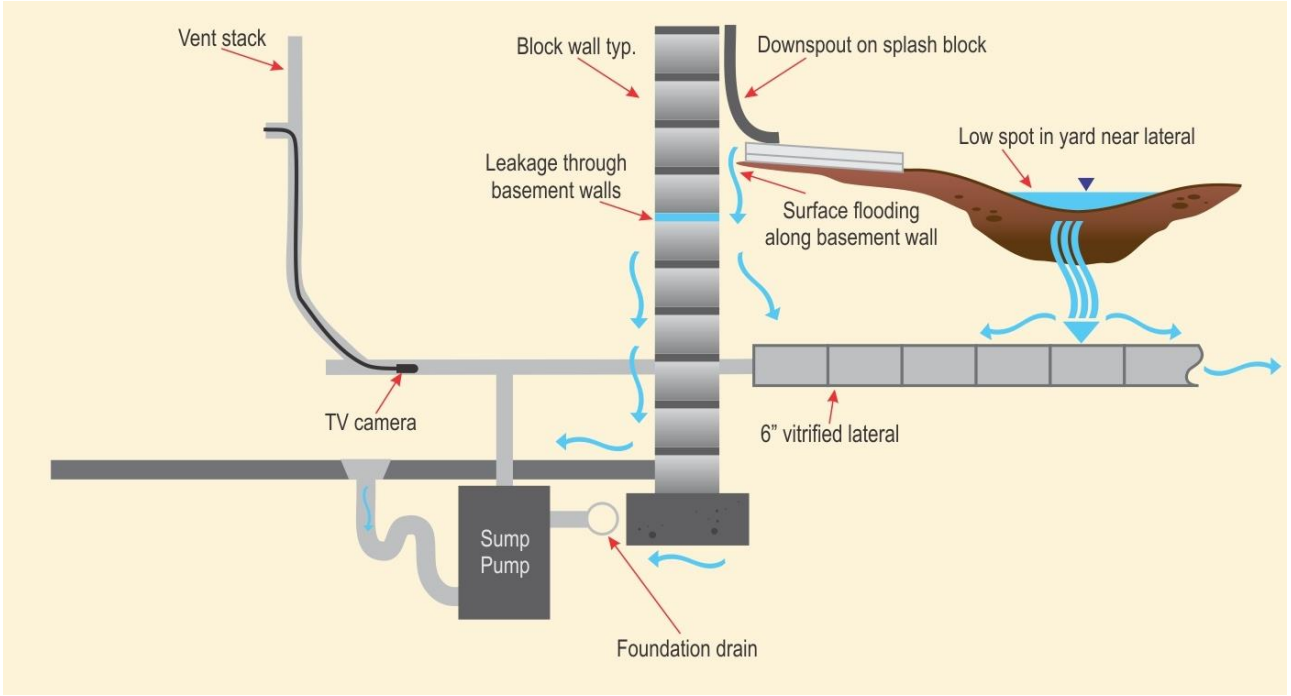
What is Inflow and Infiltration?

Inflow is a direct connection from non-sanitary infrastructure

- Sump pumps
- Downspouts
- Area Drains
- Cross connections

Infiltration is water intrusion through leaking sanitary infrastructure

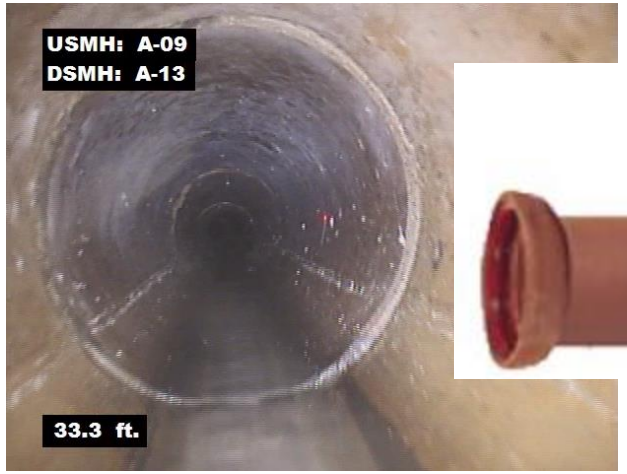
- Pipe joints, cracks, fractures, holes
- Manhole walls, pipe connections
- Private laterals
- Base groundwater (GW)
- Rainfall derived (RDII)



Sewer Pipe Installation: Then & Now

Pre 1960's Vitrified Clay Pipe was the primary material.

- Orange in Color, corrosion resistant
- Typically has joints every 2' to 4' feet
- Installed with a "bell & spigot"
- Mortar or Tar joints
- Located in rear yards post WW2



Currently PVC is most common for smaller diameters

- 20' sticks w/ gasketed joints
- Located in front yards whenever possible