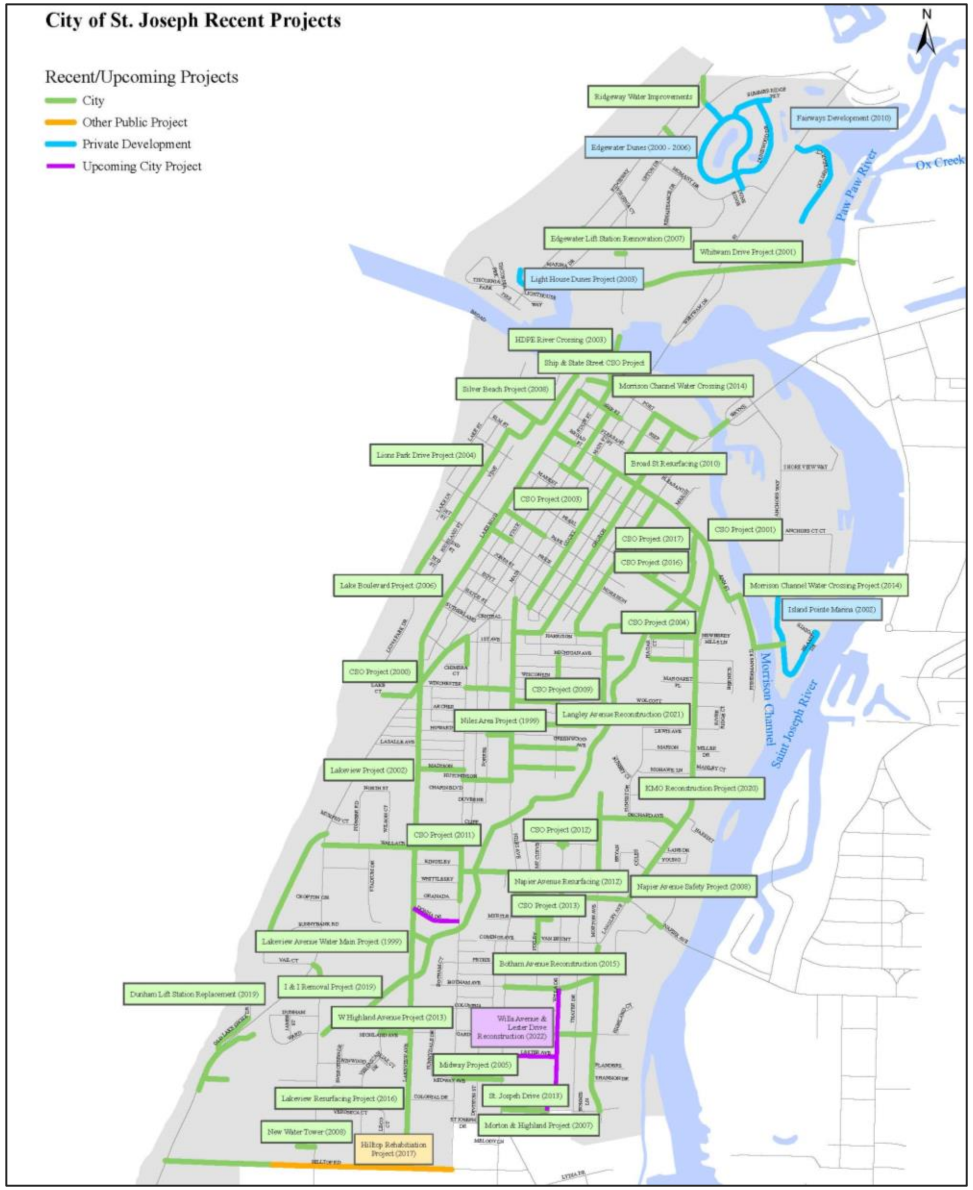
St. Joseph Infiltration and Inflow Mitigation Model Analysis

November 23, 2021

St. Joseph Major CSO Control Projects History

1. 2000 – Sewer separation (Lake Court, Pixley Ave. Port Street)
2. 2003 – Sewer Separation (Church, Court, Wayne)
3. 2004 - Sewer separation (Niles, Pearl, Michigan)
4. 2004 – CSO interceptor replacement
5. 2007 – S2 Grant - Flow monitoring and model development
6. 2009 – Sewer separation (Michigan)
7. 2010 – Sewer separation (Michigan)
8. 2011 – S2 Grant CSO projects
9. 2013 – S2 Grant – Flow monitoring and model update
10. 2017 – Central interceptor I/I study
11. 2018 – Flow monitoring and modeling
12. 2019 – I/I removal along central ravine interceptor
13. 2020 – Flow monitoring and modeling – SSO basin sizing
14. 2020 – CSO-003 was certified as fully controlled
15. 2021 – I/I mitigation analysis – micro metering and field investigation

Location of Major Projects



Infiltration and Inflow Mitigation Model Analysis Project Goals

1. Identify areas with high Infiltration and Inflow (I/I)
2. Quantify I/I volume reductions for I/I mitigation
3. Determine reduction in SSO basin size due to I/I mitigation
4. Determine if I/I mitigation is cost effective
5. Develop recommendations for I/I removal or basin construction

Infiltration and Inflow Mitigation Model Analysis
Major Project Steps (completed)

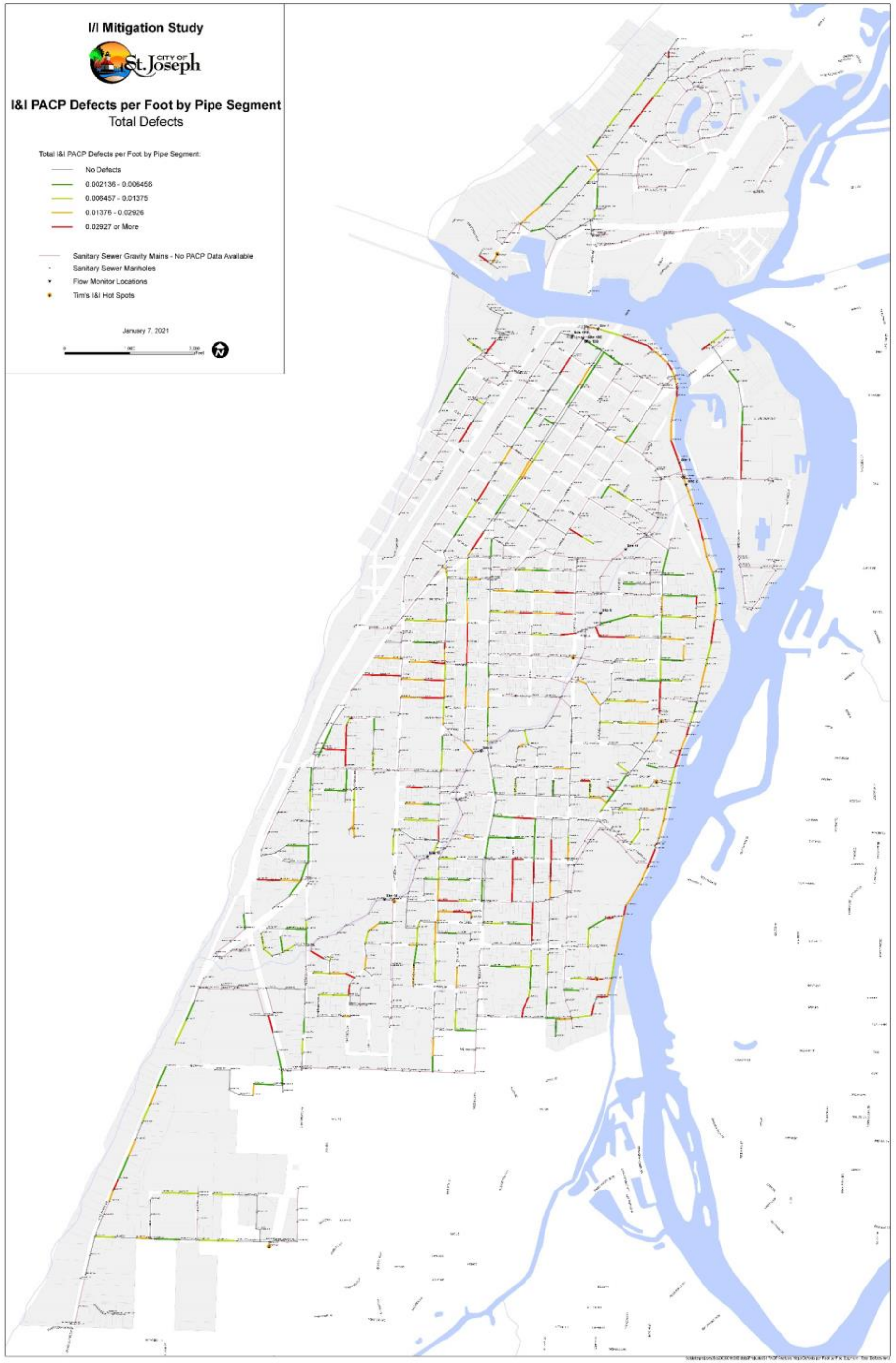
1. Utilize existing Pipeline Assessment and Certification Program (PACP) data to identify pipe defects related to high I/I
2. Identify suspect areas with high I/I based on PACP data, previous flow monitoring, and institutional knowledge
3. Develop micro-metering program
4. Isolate areas with high I/I based on flow meter field investigation data
5. Develop collection system model to quantify I/I volume reductions
6. Develop benefit cost relationships for I/I mitigation
7. Develop conceptual I/I mitigation projects

PACP Data Analysis

1. List of PACP codes related to I/I were identified
2. Field investigations supplemented the PACP data
3. I/I related defects were mapped as defect per foot of sewer
4. This analysis alone did not reveal any obvious concentrations of I/I

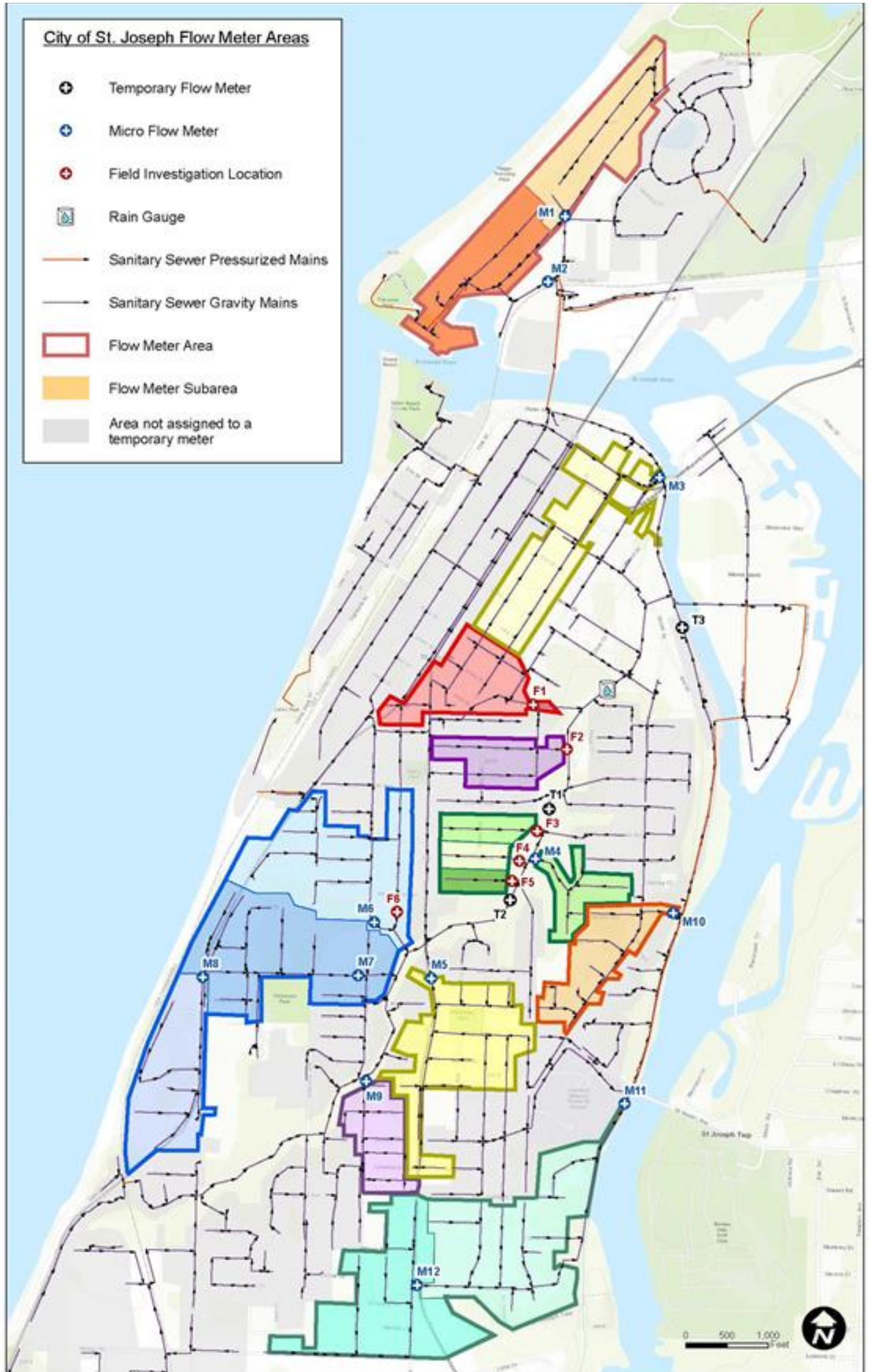
I/I Focused PACP Codes

Defect Description	PACP Code
Broken Soil Visible	BSV
Fracture (large)	FL
Hole	HSV
Infiltration Dripper	ID
Infiltration Gusher	IG
Infiltration Runner	IR
Joint Angular (large)	JAL
Joint Angular (medium)	JAM
Joint Angular (small)	JAS
Joint Offset (large)	JOL
Joint Offset (medium)	JOM
Joint Offset (small)	JOS
Joint Separation (large)	JSL
Joint Separation (medium)	JSM
Joint Separation (small)	JSS
Obstacles Obstructions	OBI
Root Ball	RBJ
Root Tap	RTB



Initial Target I&I Areas

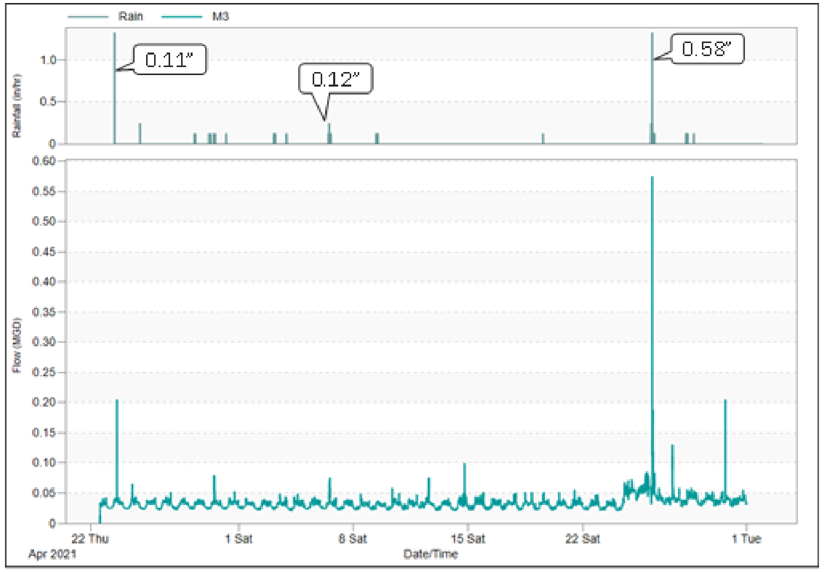
1. Target high I/I areas were developed based on:
   - Previous flow monitoring
   - Institutional knowledge
   - PACP data
2. Monitoring included:
   - 3-temporary system meters
   - 12-micro-meters
   - 7-wet weather investigation areas
   - April 22 through June 24, 2021



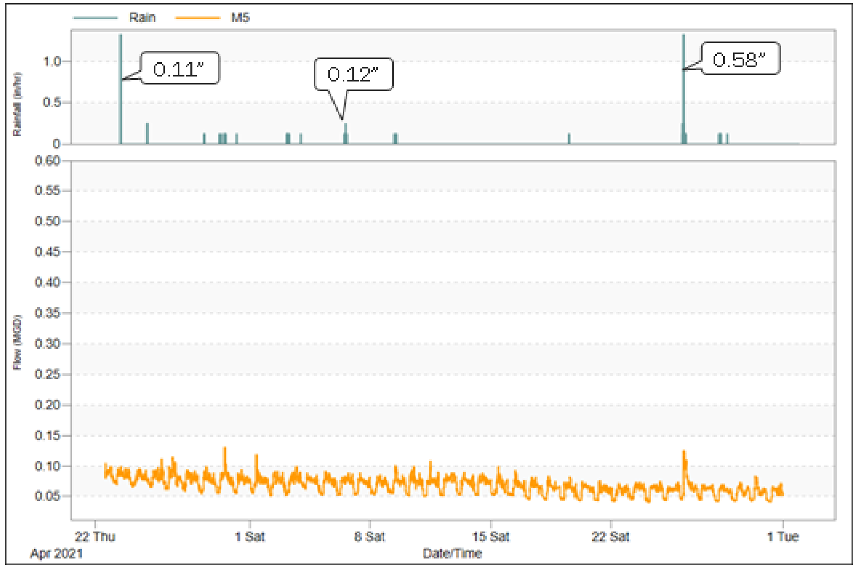
Micro-Metering Initial Results

1. Initial monitoring was during a very dry spring period
2. Single event was captured at initial meter locations
3. Secondary micro-meter locations were developed based on this initial event

Large Response

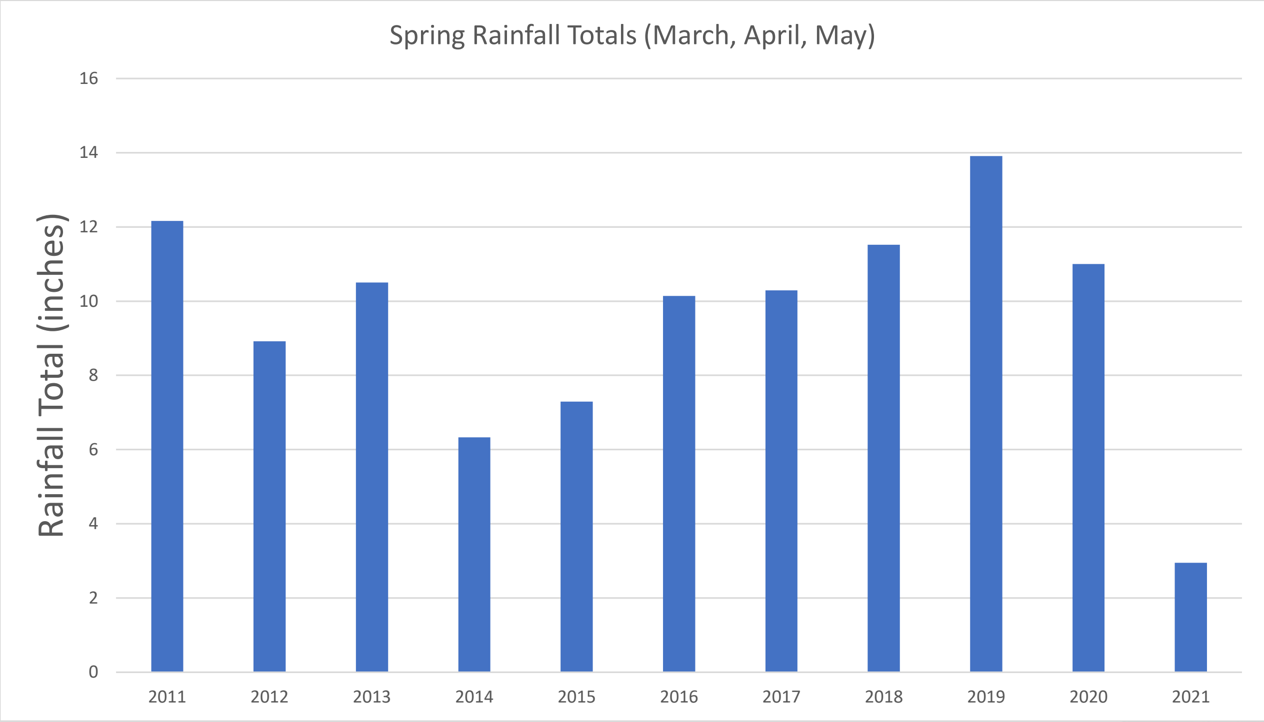


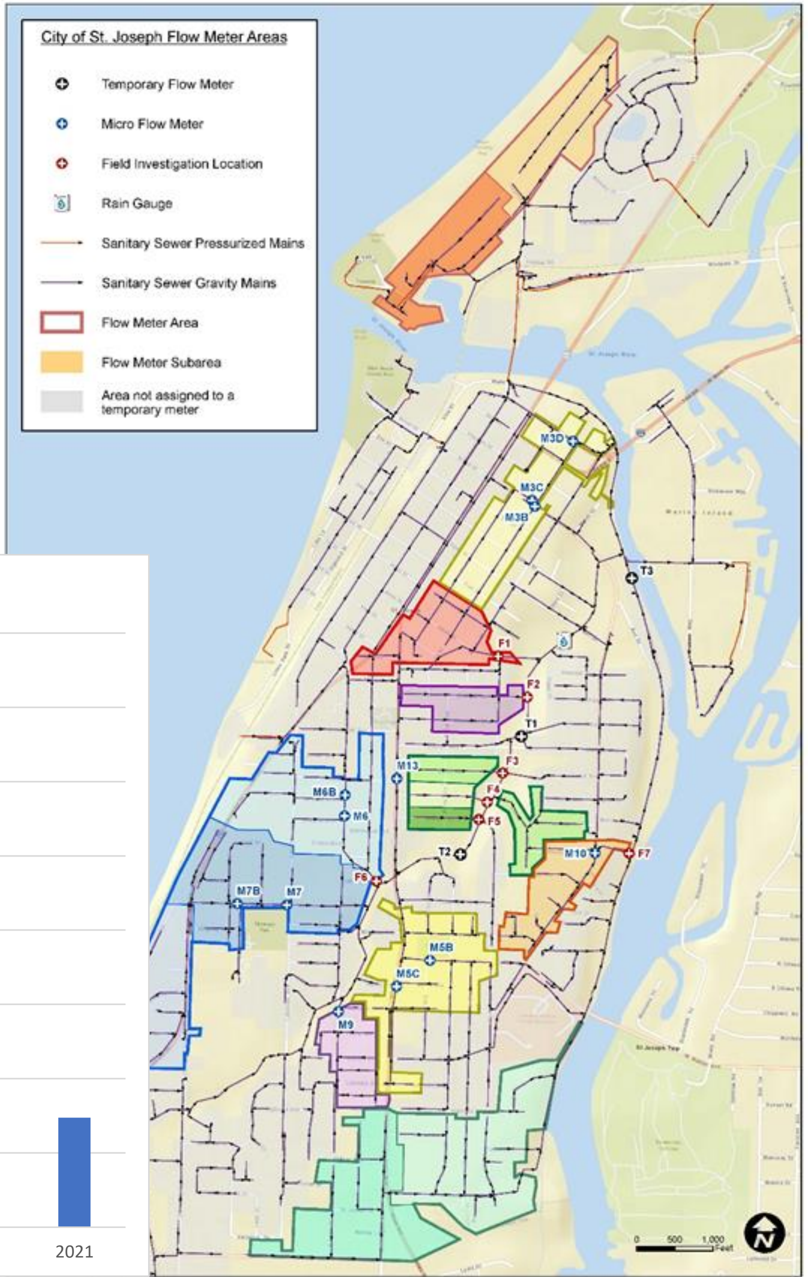
Limited Response



Micro-Metering Secondary Monitoring Locations

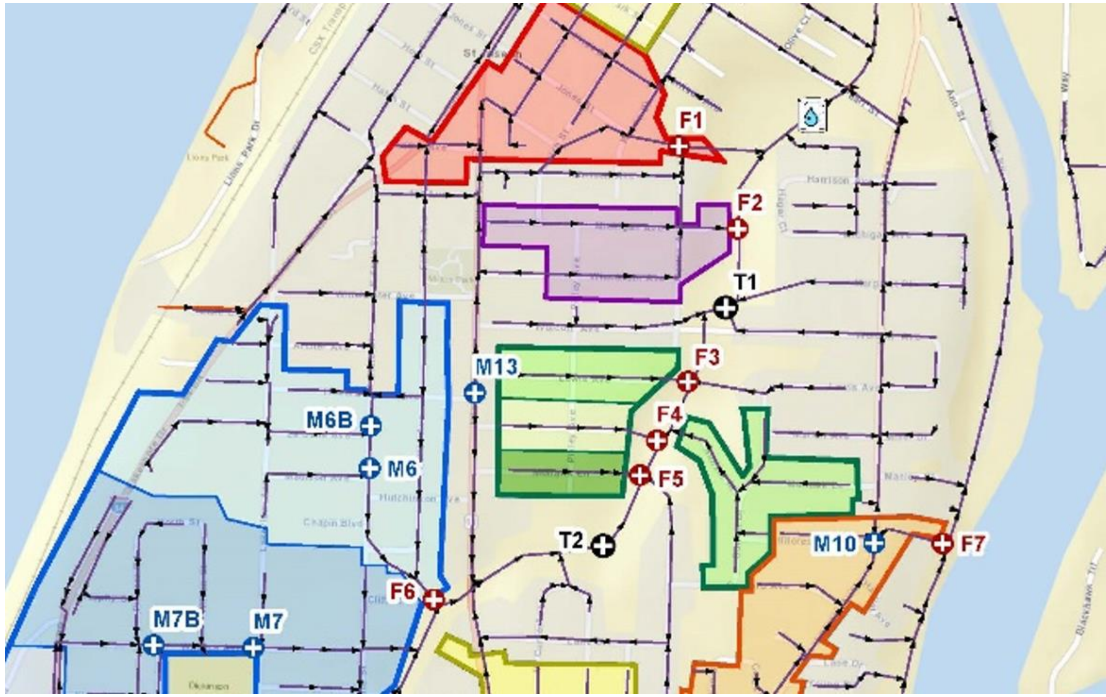
1. 2021 was the driest spring in 10-years
2. Monitoring period extended 4-weeks to capture events at the end of June
3. 3-Large events were captured at end of June
   - 6/21/2021 (1.65”)
   - 6/25/2021 (1.92”)
   - 6/26/2021 (2.50”)





I/I Field Investigation

1. 7-Locations
2. 2-Events monitored
3. Pre-event and during event observations
4. Field investigation area F6 was compared to meter area M6. This provided a relative comparison to calibrate field observations to measured flow data response
5. Documented with still and video images
6. Generally, the field investigation areas showed limited response to wet weather



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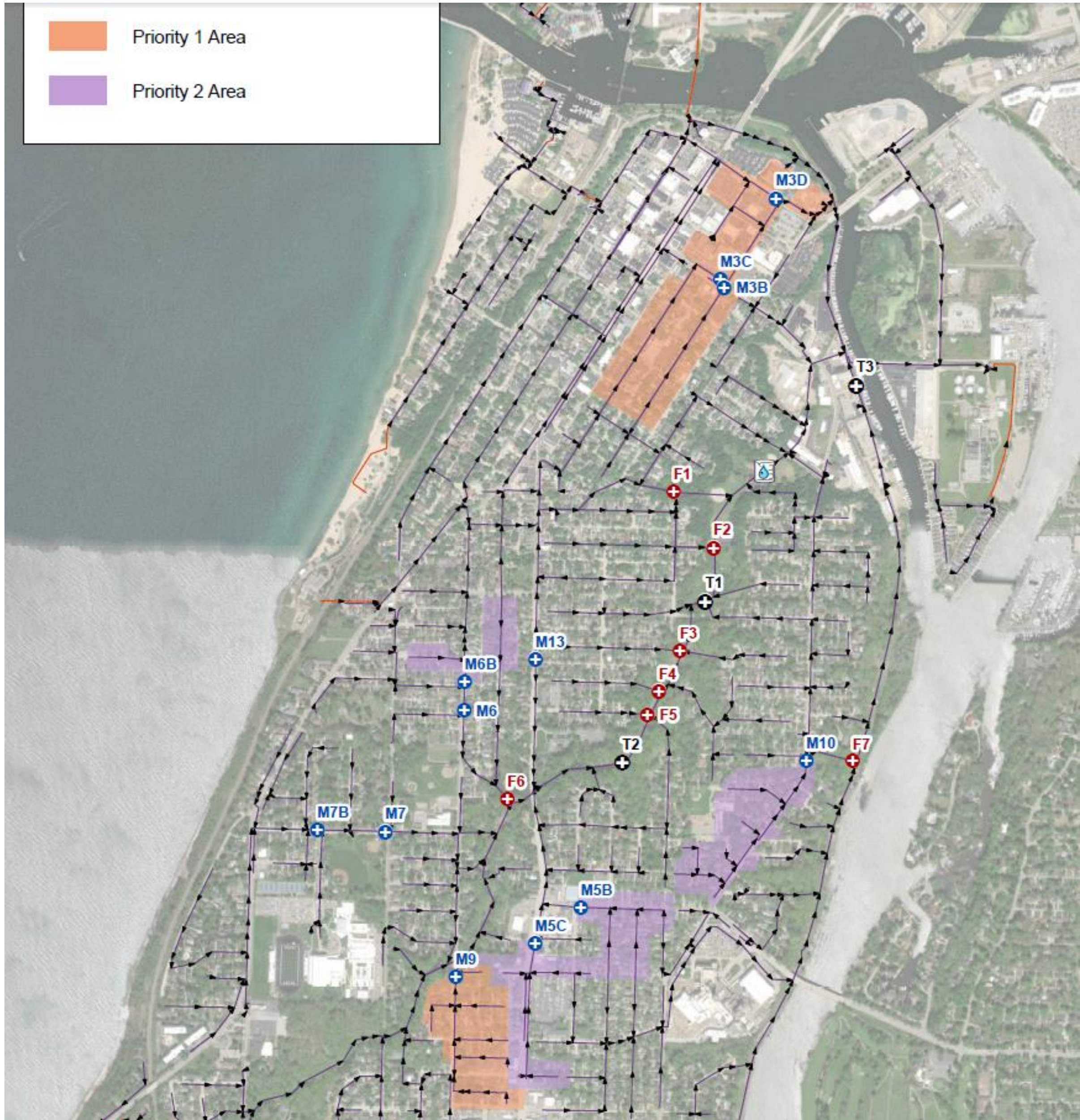
Monitoring and Field Investigation Conclusions

1. 9 areas were identified as having high I/I
2. These areas were moved forward as part of a model evaluation for I/I mitigation
3. Areas identified included: M3B, M3C, M3D, M5, M5B, M5C, M6B, M9, and M10



Model Update and Continuous Model Analysis

1. Model was updated to reflect reductions in I/I in the targeted areas
2. Capture coefficients were reduced to reflect reductions in I/I
3. Existing and updated conditions were run as a continuous 50year model simulation including 1960–1996 and 2006–2020

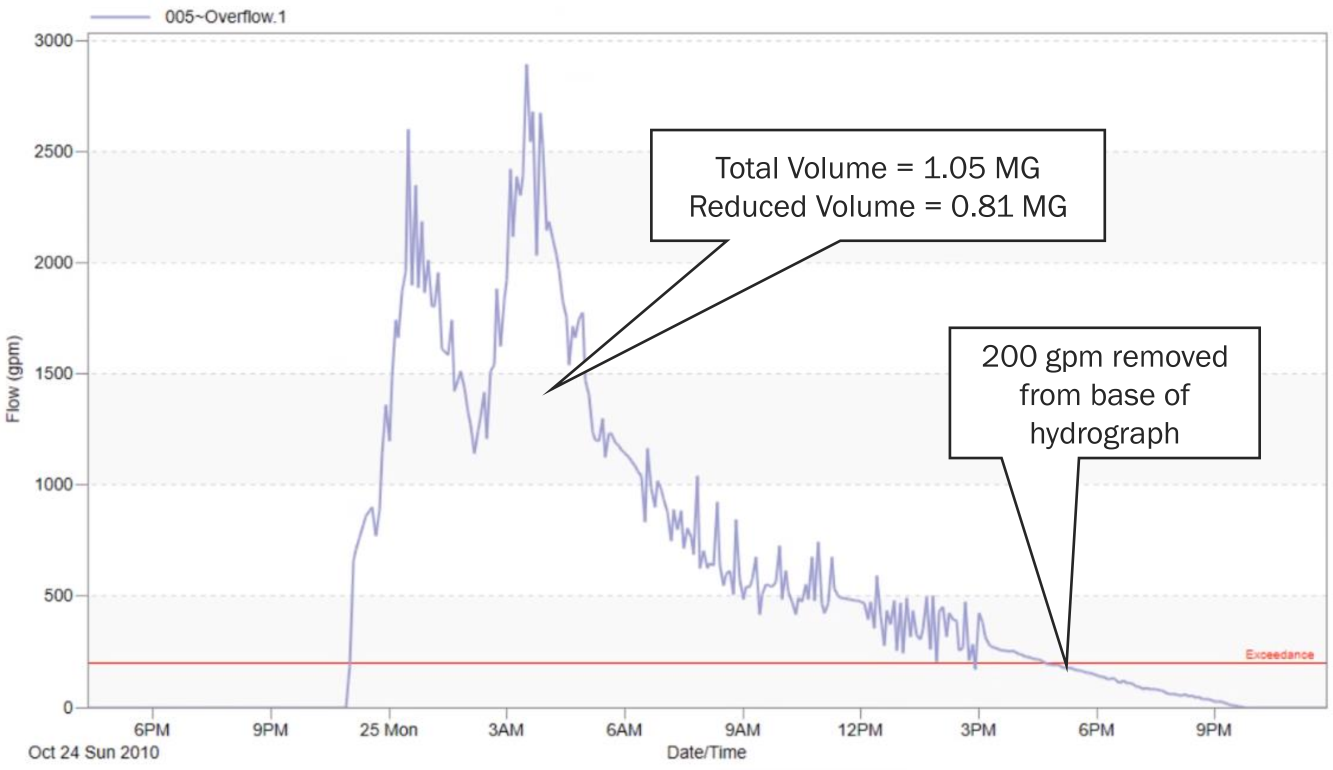
Continuous Model Simulation Results CSO-005 Overflow

1. 10 largest overflow events were ranked
2. 5th largest event was targeted as the control event
3. Existing conditions volume 1.2 MG basin
4. Reduced I/I conditions volume 1.05 MG
5. 12.7% reduction in basin volume

Rank	Overflow Event Date	Total Rainfall (in)	Overflow Volume - Original Model (gal)	Overflow Volume - Adjusted Model (gal)	Reduction (gal)	Reduction (%)
1	10/14/2017	5.40	5,820,000	5,262,000	558,000	9.6
2	10/30/2009	3.17	1,645,000	1,426,000	219,000	13.3
3	5/26/1968	3.65	1,422,000	1,185,000	237,000	16.7
4	10/31/2013	3.49	1,394,000	1,150,000	244,000	17.5
5	10/24/2010	3.00	1,203,000	1,050,000	153,000	12.7
6	10/18/2011	3.19	1,071,000	900,600	170,400	15.9
7	6/7/1986	2.23	974,200	817,900	156,300	16.0
8	10/19/1985	2.57	864,600	734,400	130,200	15.1
9	6/14/1960	2.76	647,700	529,200	118,500	18.3
10	5/1/2019	2.00	728,700	617,100	111,600	15.3
Total					2,098,000	
Average						14.1

Continuous Model Simulation 10/24/2010 Event

1. Areas M3B, M3C, M3D, and M10 are not directly tributary to CSO-005.
2. These areas will reduce peak flow to the WWTP by 200 gpm
3. Assume underflow from CSO-005 to WWTP can be increased by 200 gpm
4. Required basin volume can be further reduced from 1.05 MG to 0.81 MG



Basin Options and Cost Data

Option A – Below Grade

- At skating park
- Below grade concrete tank
- Gravity in, pumped dewatering
- $17.3M
- $14.42/gallon of storage

Option B – Above Grade

- At basketball courts
- Above grade
- Pumped in, gravity dewatering
- $9.8M
- $8.17/gallon of storage

Targeted Area I/I Mitigation Cost Analysis

90% Sewer Lining Required

Meter ID	Tributary Sewer Length (ft)	Number of Upstream Manholes	Sewer Rehab Fraction Rehab	Sewer Rehab Cost	Manhole Rehab Fraction Rehab	Manhole Rehab Cost
Ravine Interceptor						
M5	7218	27	0.9	$974,430	0.5	$27,000
M5B	2404	8	0.9	$324,540	0.5	$8,000
M5C	3271	13	0.9	$441,585	0.5	$13,000
M6B	1144	6	0.9	$154,440	0.5	$6,000
M9	4014	20	0.9	$541,890	0.5	$20,000
Subtotal	18051	74		$2,436,885		$74,000
Other Areas						
M3	6802	26	0.9	$918,270	0.5	$26,000
M3B	1715	7	0.9	$231,525	0.5	$7,000
M3C	2067	6	0.9	$279,045	0.5	$6,000
M3D	1437	7	0.9	$193,995	0.5	$7,000
M10	3665	20	0.9	$494,775	0.5	$20,000
Subtotal	15686	66		$2,117,610		$66,000
Total	33737	140		$4,554,495		$140,000

60% Sewer Lining Required

Meter ID	Tributary Sewer Length (ft)	Number of Upstream Manholes	Sewer Rehab Fraction Rehab	Sewer Rehab Cost	Manhole Rehab Fraction Rehab	Manhole Rehab Cost
Ravine Interceptor						
M5	7218	27	0.6	$649,620	0.5	$27,000
M5B	2404	8	0.6	$216,360	0.5	$8,000
M5C	3271	13	0.6	$294,390	0.5	$13,000
M6B	1144	6	0.6	$102,960	0.5	$6,000
M9	4014	20	0.6	$361,260	0.5	$20,000
Subtotal	18051	74		$1,624,590		$74,000
Other Areas						
M3	6802	26	0.6	$612,180	0.5	$26,000
M3B	1715	7	0.6	$154,350	0.5	$7,000
M3C	2067	6	0.6	$186,030	0.5	$6,000
M3D	1437	7	0.6	$129,330	0.5	$7,000
M10	3665	20	0.6	$329,850	0.5	$20,000
Subtotal	15686	66		$1,411,740		$66,000
Total	33737	140		$3,036,330		$140,000

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WWTP Treatment Cost Reduction

1. Average Annual Rainfall = 32.17-inches (Bulletin 71)
2. Sewer Charge Rate = $3.59/100cft
3. Life Cycle Return Period = 20 years
4. Interest Rate = 3%

Site Area	Meter Districts	Site Area (acres)	Original		Reduced		Annual Volume Reduction ft^3	Annual Cost Savings $	Present Worth $
			Capture Coefficient	Annual Inflow Volume ft^3	Capture Coefficient	Annual Inflow Volume ft^3			
1 (Other)	M3	75	0.077	674,612	0.052	451,990	222,622	7,992	$118,903
2 (Other)	M10	335	0.112	4,388,498	0.109	4,256,843	131,655	4,726	$70,317
6 (Ravine)	M5, M5B, M5C	192	0.246	5,515,616	0.231	5,184,679	330,937	11,881	$176,754
8 (Ravine)	M6b, M9	276	0.013	434,698	0.010	308,636	126,062	4,526	$67,330
Ravine Area Subtotal									$244,084
All Area Total									$433,304

Benefit Cost Analysis

90% Sewer Lining Required

Basin Cost Version	No Rehab	Rehab Ravine Only		Rehab Ravine and Other Areas	
	1.2 MG Basin	1.05 MG Basin		0.81 MG Basin	
	Cost $M	Cost $M	Reduction $M	Cost $M	Reduction $M
Below Grade	$17.30	$15.57	$1.73	$11.68	$5.62
Above Grade	$9.80	$8.82	$0.98	$6.62	$3.19
I/I Removal Cost (90% Sewers)			$2.51		$4.69
CSO-005 capacity increase cost					$0.25
WWTP treatment reduction savings			$0.24		$0.43
Benefit Cost Ratio					
Below Grade			0.76		1.25
Above Grade			0.43		0.71

60% Sewer Lining Required

Basin Cost Version	No Rehab	Rehab Ravine Only		Rehab Ravine and Other Areas	
	1.2 MG Basin	1.05 MG Basin		0.81 MG Basin	
	Cost $M	Cost $M	Reduction $M	Cost $M	Reduction $M
Below Grade	$17.30	$15.57	$1.73	$11.68	$5.62
Above Grade	$9.80	$8.82	$0.98	$6.62	$3.19
I/I Removal Cost (60% Sewers)			$1.70		$3.18
CSO-005 capacity increase Cost					$0.25
WWTP treatment reduction savings			$0.24		$0.43
Benefit Cost Ratio					
Below Grade			1.19		1.88
Above Grade			0.67		1.06

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I/I Mitigation Conclusions & Recommendations

Conclusions

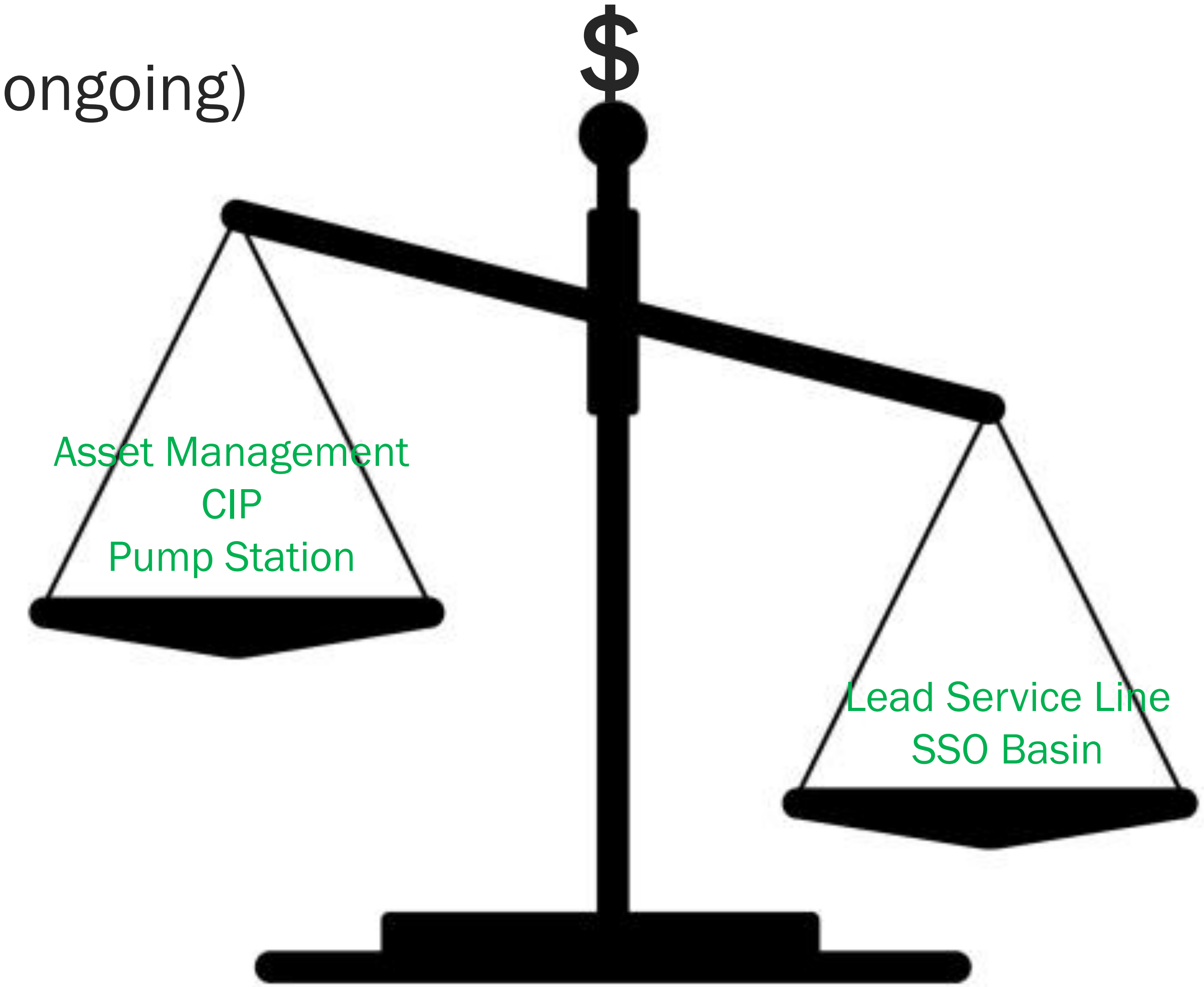
1. I/I mitigation cost effectiveness is dependent on:
   - Effectiveness of I/I mitigation (fraction of wet weather flow removed)
   - Number of targeted areas included in the I/I mitigation
   - Fraction of sewers and manholes requiring I/I mitigation
   - Storage basin cost (above or below grade structure)
2. Depending on assumptions, benefit/cost ratio ranged from:
   - Low 0.43 (not cost effective)
   - High 1.88 (yes cost effective)

Recommendations

1. Perform I/I mitigation in pilot area to determine effectiveness (Area 9 and Area 10)
2. Perform preliminary basin site investigation to better define basin cost information

St. Joseph Major Near Term Projects

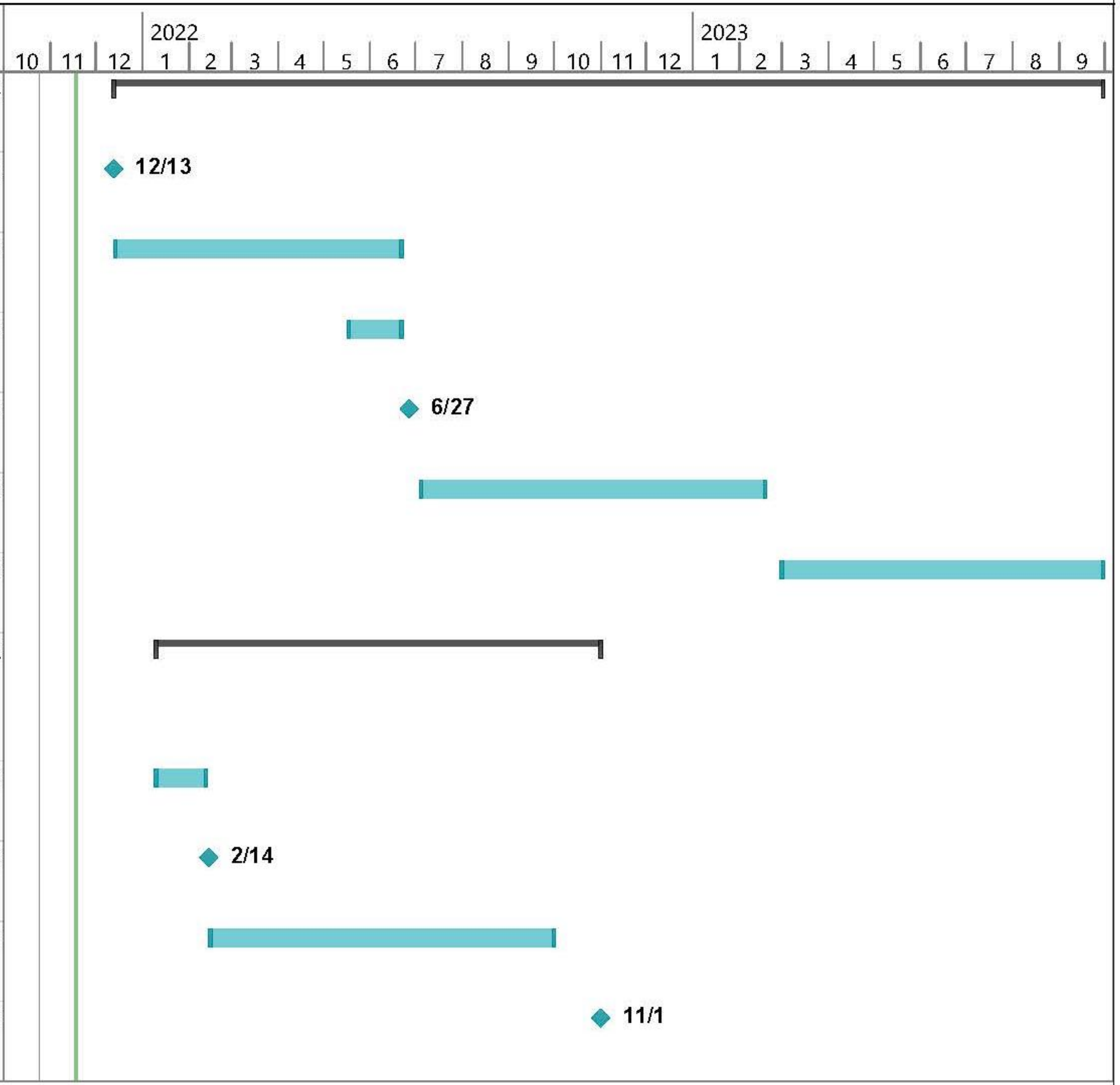
1. Asset management (ongoing)
2. Lead service line replacement (ongoing)
3. Pump station rehabilitation
4. Pilot project (Area 9)
5. Annual sewer replacement
6. SSO basin construction



Schedule – Near Term Area 9 Pilot I/I Mitigation

CSO Pilot-Ext-Storage Project.mpp

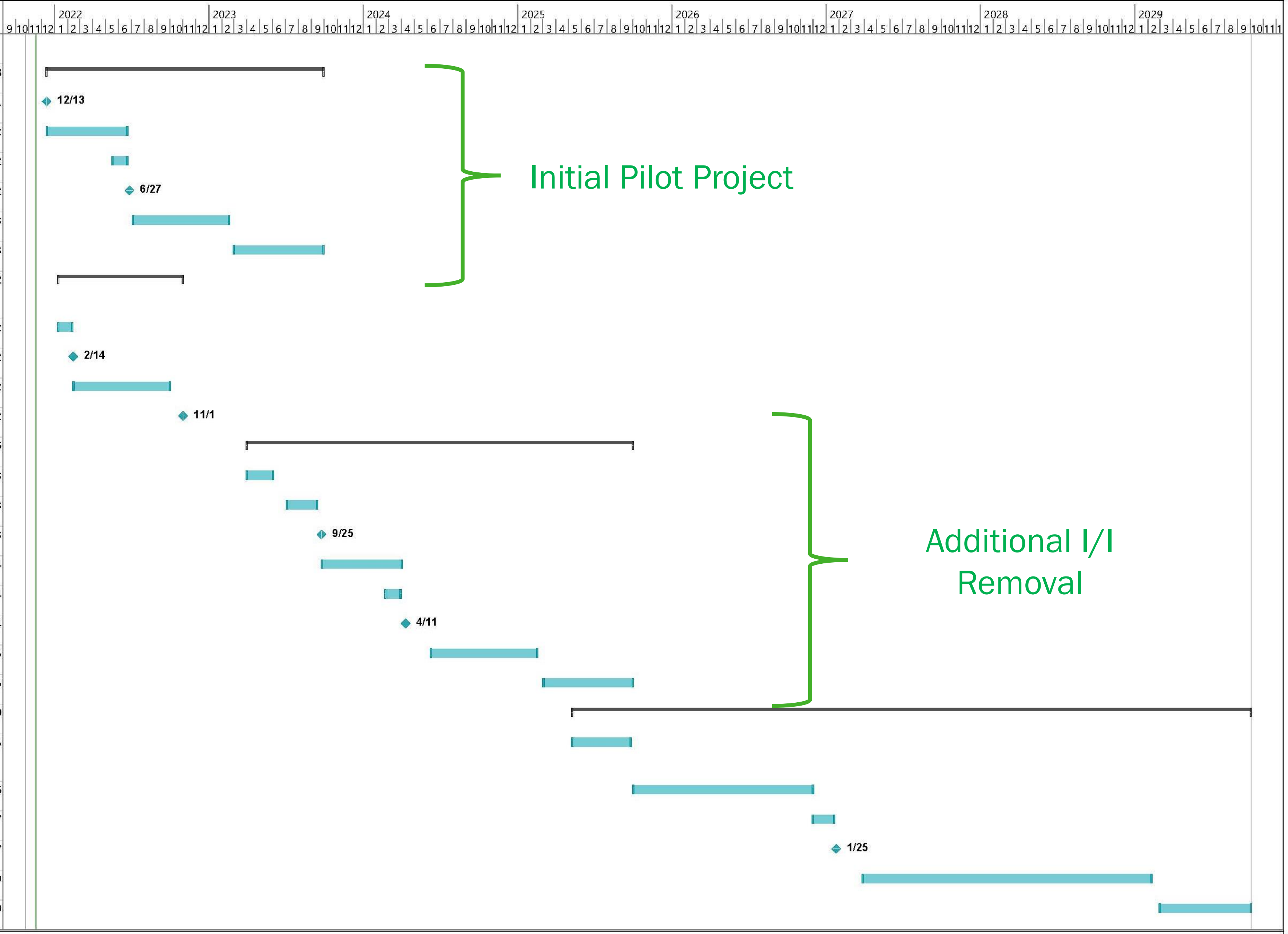
ID		Task Name	Duration	Start	Finish
2		**Pilot Project - No CWSRF**	**470 days**	**Mon 12/13/21**	**Fri 9/29/23**
3		Award Engineering	0 days	Mon 12/13/21	Mon 12/13/21
4		Design Phase	136 days	Tue 12/14/21	Tue 6/21/22
5		Bid Phase	25 days	Wed 5/18/22	Tue 6/21/22
6		Award	0 days	Mon 6/27/22	Mon 6/27/22
7		Construction	164 days	Tue 7/5/22	Fri 2/17/23
8		Flow Monitoring	153 days	Wed 3/1/23	Fri 9/29/23
9		**Preliminary Site Investigation/Geotech**	**211 days**	**Mon 1/10/22**	**Tue 11/1/22**
10		RFP Phase	25 days	Mon 1/10/22	Fri 2/11/22
11		Award Engineering	0 days	Mon 2/14/22	Mon 2/14/22
12		Investigation	164 days	Tue 2/15/22	Fri 9/30/22
13		Final Report	0 days	Tue 11/1/22	Tue 11/1/22



Schedule – Long Term

CSO Pilot-Ext-Storage Project.mpp

ID	Task Name	Duration	Start	Finish
1				
2	**Pilot Project - No CWSRF**	**470 days**	**Mon 12/13/21**	**Fri 9/29/23**
3	Award Engineering	0 days	Mon 12/13/21	Mon 12/13/21
4	Design Phase	136 days	Tue 12/14/21	Tue 6/21/22
5	Bid Phase	25 days	Wed 5/18/22	Tue 6/21/22
6	Award	0 days	Mon 6/27/22	Mon 6/27/22
7	Construction	164 days	Tue 7/5/22	Fri 2/17/23
8	Flow Monitoring	153 days	Wed 3/1/23	Fri 9/29/23
9	**Preliminary Site Investigation/Geotech**	**211 days**	**Mon 1/10/22**	**Tue 11/1/22**
10	RFP Phase	25 days	Mon 1/10/22	Fri 2/11/22
11	Award Engineering	0 days	Mon 2/14/22	Mon 2/14/22
12	Investigation	164 days	Tue 2/15/22	Fri 9/30/22
13	Final Report	0 days	Tue 11/1/22	Tue 11/1/22
14	**Ext. I&I Remove - Q3 CWSRF**	**652 days**	**Sat 4/1/23**	**Tue 9/30/25**
15	CWSRF PP Amendment	45 days	Sat 4/1/23	Thu 6/1/23
16	QBS Process	51 days	Wed 7/5/23	Wed 9/13/23
17	Award Engineering	0 days	Mon 9/25/23	Mon 9/25/23
18	Design Phase	135 days	Tue 9/26/23	Mon 4/1/24
19	Bid Phase	26 days	Fri 2/23/24	Fri 3/29/24
20	Tentative Award	0 days	Thu 4/11/24	Thu 4/11/24
21	Construction	181 days	Mon 6/10/24	Sat 2/15/25
22	Flow Monitoring	152 days	Mon 3/3/25	Tue 9/30/25
23	**Storage Project - Q2 CWSRF**	**1147 days**	**Sat 5/10/25**	**Tue 10/2/29**
24	Final Geo-Technical Investigation	100 days	Sat 5/10/25	Thu 9/25/25
25	Storage Design	303 days	Thu 10/2/25	Mon 11/30/26
26	Bid Phase	37 days	Mon 11/30/26	Tue 1/19/27
27	Award	0 days	Mon 1/25/27	Mon 1/25/27
28	Construction	490 days	Mon 3/29/27	Fri 2/9/29
29	PPC	154 days	Thu 3/1/29	Tue 10/2/29



Discussion/Questions?