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The Future of Sewers - Get Smart! Control and Optimization Strategies for the 21st Century – Part II

Thursday, December 3, 2020
1:00 – 2:30 PM ET

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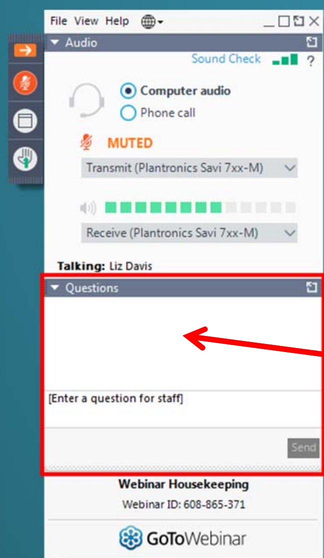
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

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Today's Moderator

Maureen Durkin
Managing Civil Engineer

Metropolitan Water Reclamation District of Greater Chicago

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Today's Presenters

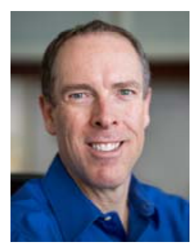
- Jefferson County System-Wide Optimization
  - Daniel White, Joel Wilson, Sean FitzGerald
- Columbus Ohio's Waze App for Guiding Operations with Decision Intelligence
  - Holly Boyer, Dax Blake
- Get Your Mind in the Gutter: Adding Intelligence to Optimize Wastewater Management in Combined and Separate Systems
  - Erin Rothman

Introduction

Daniel White, P.E.
Deputy Director of Environmental Services
Jefferson County, Alabama

Joel Wilson, CpE
Asia/Pacific Director
WCS Engineering

David F. Garcia, Jr, P.E.
President, US Operations
WCS Engineering



Sean FitzGerald, P.E.
Vice President
Conveyance Practice Leader
Hazen and Sawyer

Jefferson County Alabama

WCS Engineering

Hazen

Jefferson County System-Wide Optimization

Best practice application of Optimatics software for collection system master planning

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Jefferson County, Alabama

- 480,000 residents served
- 3,107 mi sewer lines
- 176 pump stations
- 9 water reclamation facilities
- 103 MGD ADF

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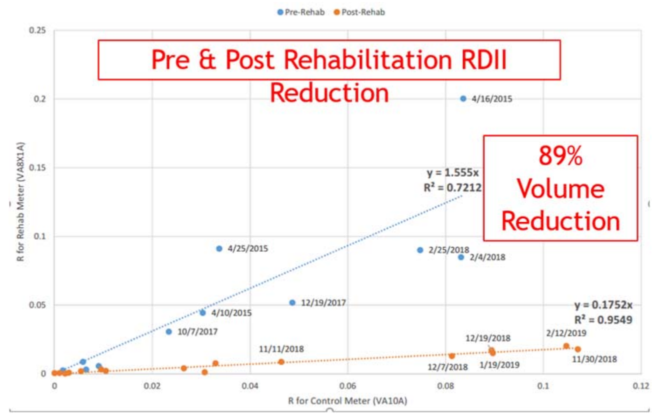
Project Background

- 1996 Consent Decree
  - $2.4 Billion
  - Over 3 million LF of CIPP
  - "too much money, too quickly, and spent the money on many of the wrong projects"
- 2011-2013 Bankruptcy
  - Limited capital funding
- Asset Management
  - Hydraulic Modeling
  - Existing Remedial Measures Plan (prior to optimization and consideration of I/I rehabilitation alternatives)
- 2018 Lateral Lining Success



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Why Optimization?

Challenges

- Significant capital expenditure required to resolve SSOs
- Large range of alternatives for consideration
- Complex hydraulics and system-wide interdependencies
- Limited budget

Solutions

- System-wide optimization of SSO remedial measure alternatives.
- Intelligent algorithm optimization and cloud computing to find the system-wide planning strategy that meets the design criteria at least cost.
- Prioritize the sequence of implementation to maximize return on investment.

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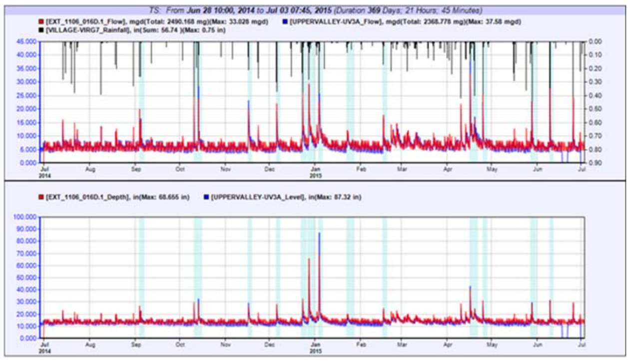
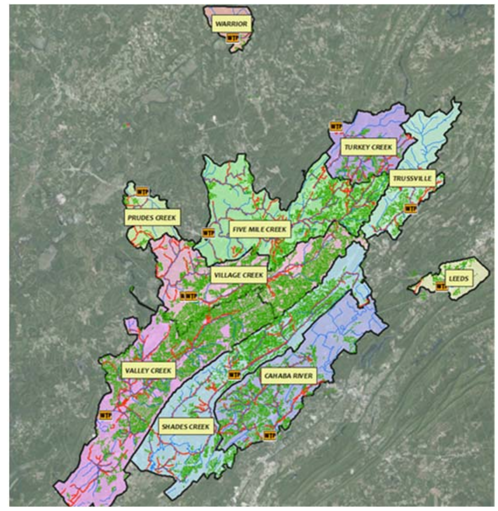
Model Calibration – Critical First Step

- 10 Hydraulic models
- Calibrated to 12 months of continuous rainfall and flowmeter data – over 500 flowmeter locations
- Models simulate seasonal and antecedent moisture variations for accurate extended period simulations





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Optimization Objectives

1. System-wide optimization of SSO remedial measure alternatives based on life-cycle cost.
2. Includes a total of five basins (150 square miles / 750 miles of modeled sewer)
3. Evaluate conveyance, storage, inflow and infiltration (I/I) reduction, treatment and inter-basin diversion alternatives.
4. Apply intelligent algorithm & cloud computing optimization to evaluate alternatives.
5. Develop an adaptive planning strategy that addresses I/I reduction assumptions.
6. Prioritize implementation schedule to maximize ROI

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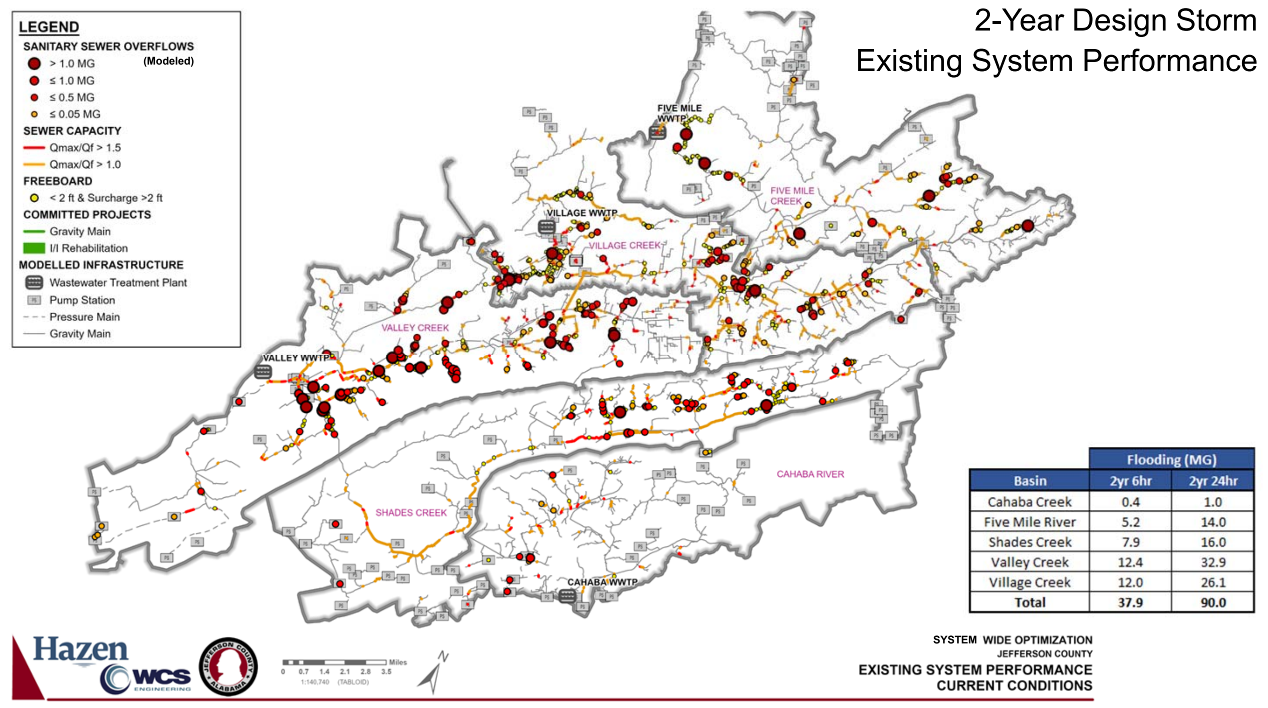
2-Year Design Storm Existing System Performance



Basin	Flooding (MG) 2yr 6hr	2yr 24hr
Cahaba Creek	0.4	1.0
Five Mile River	5.2	14.0
Shades Creek	7.9	16.0
Valley Creek	12.4	32.9
Village Creek	12.0	26.1
Total	**37.9**	**90.0**

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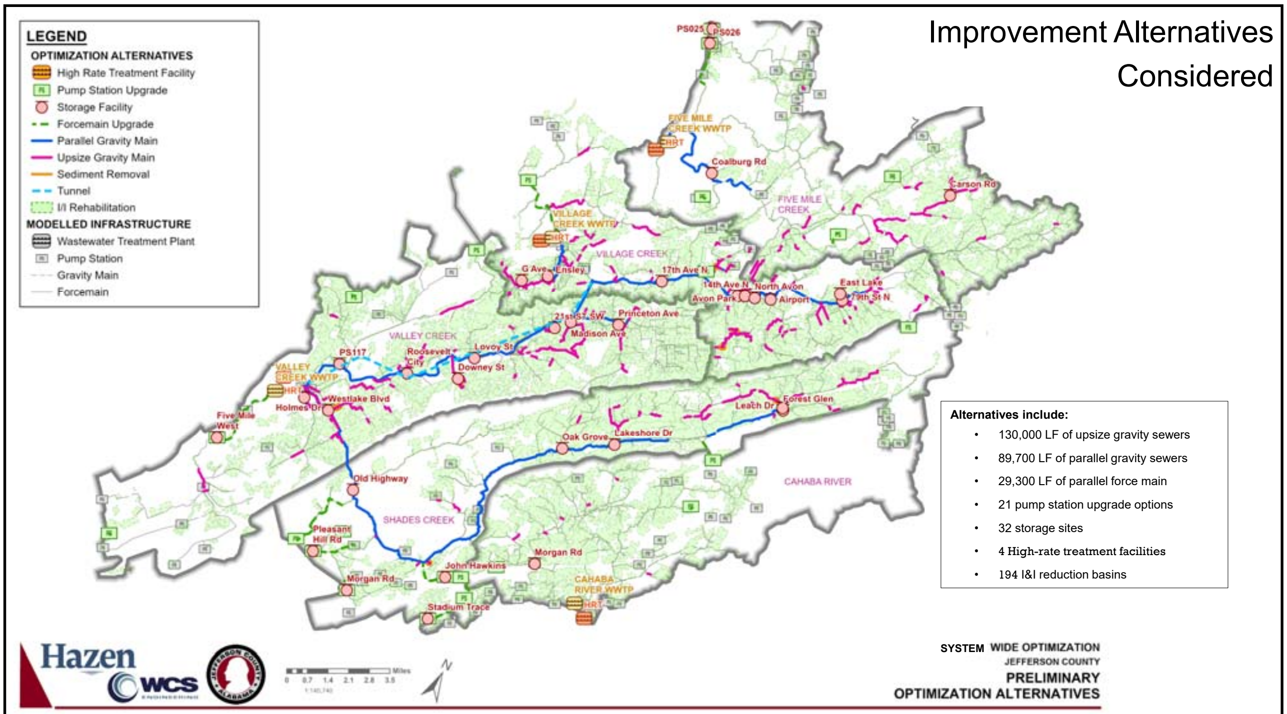
Improvement Alternatives Considered



Alternatives include:
- 130,000 LF of upsize gravity sewers
- 89,700 LF of parallel gravity sewers
- 29,300 LF of parallel force main
- 21 pump station upgrade options
- 32 storage sites
- 4 High-rate treatment facilities
- 194 I&I reduction basins

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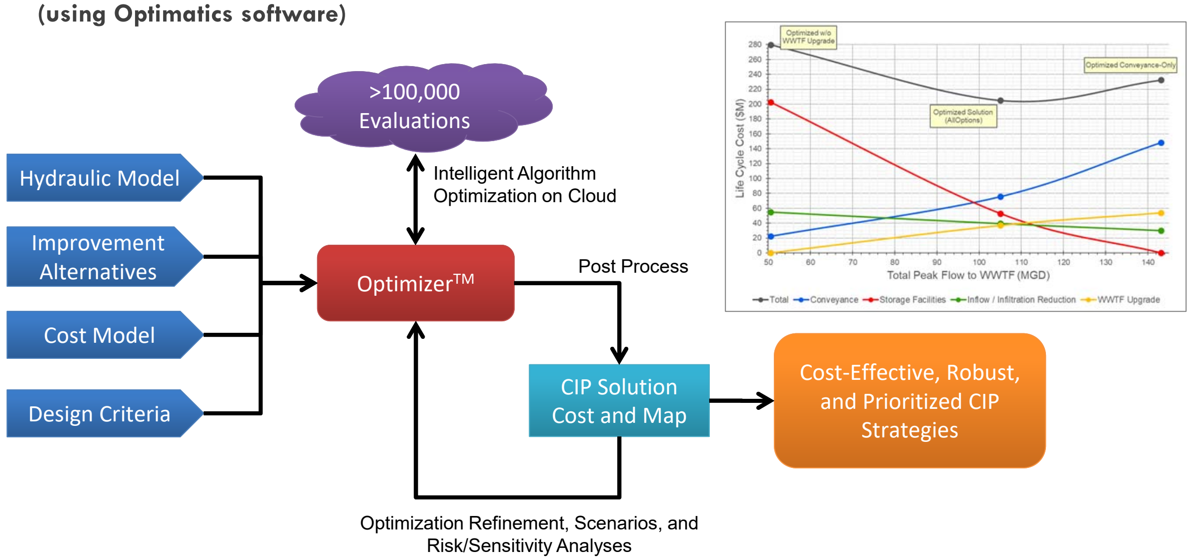
Optimization Based CIP Development

(using Optimatics software)



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Optimization Planning Criteria and Assumptions

- Eliminate SSOs and reduce surcharge to less than 2 feet freeboard.
- Design scenario – future conditions (2040) and worst case of 2-year, 6-hour and 2-year, 24-hour design storm.
- New gravity sewers to be designed to satisfy either no surcharge or capacity greater than design flow.
- Force main maximum velocity of 7 fps.
- Life-cycle cost analysis

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Unit Cost Rates – Basis of Cost

Total Life Cycle Cost = Capital Cost + PV O&M + PV Replacement

Present Value Variables		
Analysis Period (years)	n	100
Effective Discount Rate	ER	5.0%
100-Yr PV Annual Cost Multiplier	PV	19.85

Annual O&M Costs	
Storage Facilities	1.5%
Gravity & Pressure Mains	0.3%
Pump Stations ($/MGD)	$4,820

Asset Life		
Asset	Expected life (yr)	PV Replacement Cost over Lifespan (% capital)
Gravity Pipes	80	2.04%
Pressure pipes	60	5.61%
Storage Tank	60	5.61%
Pumps stations	35	21.98%

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Unit Cost Rates – Example Pipe Unit Costs

Total Life Cycle Cost = Capital Cost + PV O&M + PV Replacement

Capital Costs for Gravity Sewers - Trenched No Surf Rest (New)		
Pipe Diameter (feet)	<15'	>15'
0.67	$468	$584
0.83	$488	$610
1.00	$512	$640
1.25	$555	$693
1.50	$606	$758
1.75	$665	$831
2.00	$731	$914
2.25	$805	$1,006
2.50	$884	$1,105
3.00	$1,061	$1,326
3.50	$1,258	$1,572
4.00	$1,471	$1,839
4.50	$1,698	$2,123
5.00	$1,935	$2,418
5.50	$2,178	$2,722
6.00	$2,423	$3,029
6.50	$2,668	$3,335
7.00	$2,908	$3,635
7.50	$3,140	$3,925
8.00	$3,361	$4,201
8.67	$3,632	$4,540
9.17	$3,812	$4,765

+

Life Cycle O&M for Gravity Sewers - Trenched No Surf Rest (New)		
Pipe Diameter (feet)	<15'	>15'
0.67	$28	$35
0.83	$29	$36
1.00	$30	$38
1.25	$33	$41
1.50	$36	$45
1.75	$40	$50
2.00	$44	$54
2.25	$48	$60
2.50	$53	$66
3.00	$63	$79
3.50	$75	$94
4.00	$88	$110
4.50	$101	$126
5.00	$115	$144
5.50	$130	$162
6.00	$144	$180
6.50	$159	$199
7.00	$173	$216
7.50	$187	$234
8.00	$200	$250
8.67	$216	$270
9.17	$227	$284

+

Life Cycle Rep. for Gravity Sewers - Trenched No Surf Rest (New)		
Pipe Diameter (feet)	<15'	>15'
0.67	$4	$4
0.83	$4	$5
1.00	$4	$5
1.25	$4	$5
1.50	$5	$6
1.75	$5	$6
2.00	$6	$7
2.25	$6	$8
2.50	$7	$8
3.00	$8	$10
3.50	$10	$12
4.00	$11	$14
4.50	$13	$16
5.00	$15	$18
5.50	$17	$21
6.00	$18	$23
6.50	$20	$25
7.00	$22	$28
7.50	$24	$30
8.00	$26	$32
8.67	$28	$35
9.17	$29	$36

=

Total Project Cost for Gravity Sewers - Trenched No Surf Rest		
Pipe Diameter (feet)	<15'	>15'
0.67	$499	$624
0.83	$520	$650
1.00	$546	$682
1.25	$592	$740
1.50	$647	$808
1.75	$710	$887
2.00	$780	$976
2.25	$859	$1,073
2.50	$943	$1,179
3.00	$1,132	$1,415
3.50	$1,342	$1,677
4.00	$1,570	$1,963
4.50	$1,812	$2,265
5.00	$2,065	$2,581
5.50	$2,324	$2,905
6.00	$2,586	$3,232
6.50	$2,847	$3,559
7.00	$3,103	$3,879
7.50	$3,351	$4,189
8.00	$3,587	$4,484
8.67	$3,875	$4,844
9.17	$4,068	$5,085

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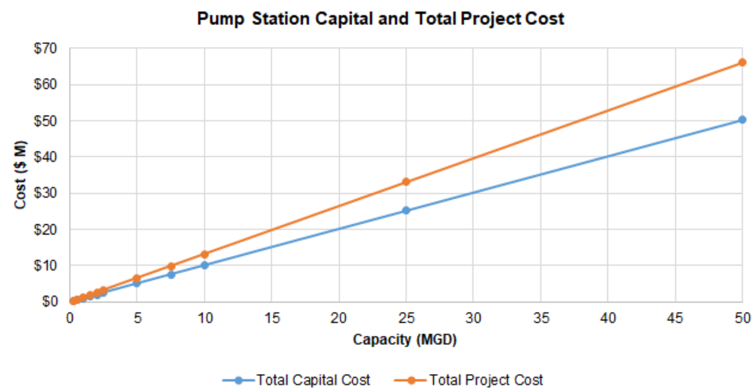
Unit Cost Rates – Pump Station Upgrade



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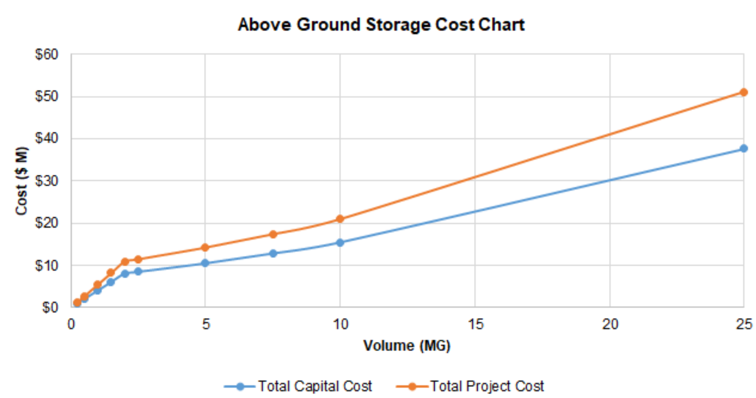
Unit Cost Rates – Storage Tanks



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Example of I/I Reduction Options

Consolidated Flow Meter Catchment (FMC) ID	Average R	Max I/I Red. Aggressive	Max I/I Red. Conserv. V2	Average Diameter (")	$/LF	Av. Age	Av. Remain. Life (yrs)	Discount $/LF	Total FMC Length (LF)	I/I Opt. 1	I/I Opt. 1 Cost	I/I Opt. 2	I/I Opt. 2 Cost	I/I Opt. 3	I/I Opt. 3 Cost	I/I Opt. 4	I/I Opt. 4 Cost	I/I Opt. 5	I/I Opt. 5 Cost
BN_CAHABA-C1X1	22%	50%	30%	12	99	38	42	$ 93	848,756	0%	$ -	10%	$ 15,786,862	20%	$ 31,573,723	30%	$ 47,360,585		
BN_CAHABA-C7	2%			10	97	30	50	$ 93	52,663										
BN_CAHABA-CSTP1A	1%			9	96	20	60	$ 93	28,986										
BN_CAHABA-CSTP1B	10%	30%	30%	9	96	24	56	$ 93	14,885	0%	$ -	10%	$ 461,435	20%	$ 922,870	30%	$ 1,384,305		
BN_FIVEMILE-9D-Phase1	31%	60%	40%	8	95	38	42	$ 89	223,094	0%	$ -	10%	$ 3,309,228	20%	$ 6,618,455	30%	$ 9,927,683	40%	$ 13,236,911
BN_FIVEMILE-F01D	14%	40%	30%	14	129	32	48	$ 123	61,387	0%	$ -	10%	$ 1,887,650	20%	$ 3,775,301	30%	$ 5,662,951		
BN_FIVEMILE-F01E	43%	60%	40%	9	96	38	42	$ 90	41,119	0%	$ -	10%	$ 616,785	20%	$ 1,233,570	30%	$ 1,850,355	40%	$ 2,467,140
BN_FIVEMILE-F02A	38%	60%	40%	9	96	42	38	$ 88	51,439	0%	$ -	10%	$ 754,439	20%	$ 1,508,877	30%	$ 2,263,316	40%	$ 3,017,755
BN_FIVEMILE-F02B	10%	40%	30%	11	99	41	39	$ 91	68,596	0%	$ -	10%	$ 1,560,559	20%	$ 3,121,118	30%	$ 4,681,677		
BN_FIVEMILE-F07X1E	15%	40%	30%	8	95	58	22	$ 79	29,285	0%	$ -	10%	$ 578,379	20%	$ 1,156,758	30%	$ 1,735,136		
BN_FIVEMILE-F08A	53%	60%	40%	8	95	54	26	$ 82	43,484	0%	$ -	10%	$ 594,281	20%	$ 1,188,563	30%	$ 1,782,844	40%	$ 2,377,125
BN_FIVEMILE-F09B1	24%	60%	40%	10	97	54	26	$ 83	61,273	0%	$ -	10%	$ 847,610	20%	$ 1,695,220	30%	$ 2,542,830	40%	$ 3,390,439
BN_FIVEMILE-F09C	20%	50%	30%	8	95	59	21	$ 78	20,660	0%	$ -	10%	$ 322,296	20%	$ 644,592	30%	$ 966,888		
BN_FIVEMILE-F09E	68%	60%	40%	8	95	61	19	$ 76	108,115	0%	$ -	10%	$ 1,369,457	20%	$ 2,738,913	30%	$ 4,108,370	40%	$ 5,477,827
BN_FIVEMILE-F09I	17%	50%	30%	9	96	53	27	$ 83	18,032	0%	$ -	10%	$ 299,331	20%	$ 598,662	30%	$ 897,994		
BN_FIVEMILE-F09J	19%	50%	30%	9	96	47	33	$ 86	63,467	0%	$ -	10%	$ 1,091,632	20%	$ 2,183,265	30%	$ 3,274,897		
BN_FiveMile-F09L	27%	60%	40%	9	96	50	30	$ 85	48,040	0%	$ -	10%	$ 680,567	20%	$ 1,361,133	30%	$ 2,041,700	40%	$ 2,722,267
BN_FIVEMILE-F09N	20%	50%	30%	8	95	52	28	$ 83	33,421	0%	$ -	10%	$ 554,789	20%	$ 1,109,577	30%	$ 1,664,366		
BN_FIVEMILE-F09O	19%	50%	30%	9	96	41	39	$ 89	87,251	0%	$ -	10%	$ 1,553,068	20%	$ 3,106,136	30%	$ 4,659,203		
BN_FIVEMILE-F1	27%	60%	40%	14	129	32	48	$ 123	175,616	0%	$ -	10%	$ 3,600,128	20%	$ 7,200,256	30%	$ 10,800,384	40%	$ 14,400,512
BN_FIVEMILE-F3X2B	28%	60%	40%	8	95	69	11	$ 67	36,197	0%	$ -	10%	$ 404,200	20%	$ 808,400	30%	$ 1,212,600	40%	$ 1,616,799
BN_FIVEMILE-F3X2C	153%	60%	40%	10	97	73	10	$ 67	21,438	0%	$ -	10%	$ 239,391	20%	$ 478,782	30%	$ 718,173	40%	$ 957,564
BN_FIVEMILE-F3X2D	52%	60%	40%	10	97	73	10	$ 67	38,075	0%	$ -	10%	$ 425,171	20%	$ 850,342	30%	$ 1,275,513	40%	$ 1,700,683
BN_FIVEMILE-F3X2D1	45%	60%	40%	9	96	73	10	$ 67	22,638	0%	$ -	10%	$ 252,791	20%	$ 505,582	30%	$ 758,373	40%	$ 1,011,164
BN_FIVEMILE-F3X2D3	54%	60%	40%	10	97	85	10	$ 67	35,981	0%	$ -	10%	$ 401,788	20%	$ 803,576	30%	$ 1,205,364	40%	$ 1,607,151
BN_FiveMile-F3X2F1n	31%	60%	40%	8	95	60	20	$ 77	31,698	0%	$ -	10%	$ 406,791	20%	$ 813,582	30%	$ 1,220,373	40%	$ 1,627,164
BN_PATTON-PA1X1	32%	60%	40%	10	97	39	41	$ 90	104,096	0%	$ -	10%	$ 1,561,440	20%	$ 3,122,880	30%	$ 4,684,320	40%	$ 6,245,760
BN_PATTON-PA1X1C	24%	60%	40%	10	97	28	52	$ 93	80,512	0%	$ -	10%	$ 1,247,936	20%	$ 2,495,872	30%	$ 3,743,808	40%	$ 4,991,744
BN_PATTON-PA1X2	31%	60%	40%	10	97	46	34	$ 88	724,876	0%	$ -	10%	$ 10,631,515	20%	$ 21,263,029	30%	$ 31,894,544	40%	$ 42,526,059
BN_SHADES-OX1	10%	30%	30%	8	95	32	48	$ 90	88,748	0%	$ -	10%	$ 2,662,440	20%	$ 5,324,880	30%	$ 7,987,320		
BN_SHADES-RICE	11%	40%	30%	9	96	31	49	$ 92	159,136	0%	$ -	10%	$ 3,660,128	20%	$ 7,320,256	30%	$ 10,980,384		
BN_SHADES-S12A	14%	40%	30%	9	96	54	26	$ 83	47,908	0%	$ -	10%	$ 994,091	20%	$ 1,988,182	30%	$ 2,982,273		
BN_SHADES-S12B	15%	50%	30%	9	96	54	26	$ 83	55,984	0%	$ -	10%	$ 929,334	20%	$ 1,858,669	30%	$ 2,788,003		
BN_SHADES-S12C	18%	50%	30%	9	96	56	24	$ 81	96,192	0%	$ -	10%	$ 1,558,310	20%	$ 3,116,621	30%	$ 4,674,931		
BN_SHADES-S13A	41%	60%	40%	9	96	46	34	$ 87	61,734	0%	$ -	10%	$ 895,143	20%	$ 1,790,286	30%	$ 2,685,429	40%	$ 3,580,572
BN_SHADES-S16A	30%	60%	40%	10	97	58	22	$ 81	92,232	0%	$ -	10%	$ 1,245,132	20%	$ 2,490,264	30%	$ 3,735,396	40%	$ 4,980,528
BN_SHADES-S16B	16%	50%	30%	9	96	48	32	$ 86	58,188	0%	$ -	10%	$ 1,000,834	20%	$ 2,001,667	30%	$ 3,002,501		
BN_SHADES-S1A	9%	30%	30%	17	157	40	40	$ 146	200,669	0%	$ -	10%	$ 9,765,891	20%	$ 19,531,783	30%	$ 29,297,674		

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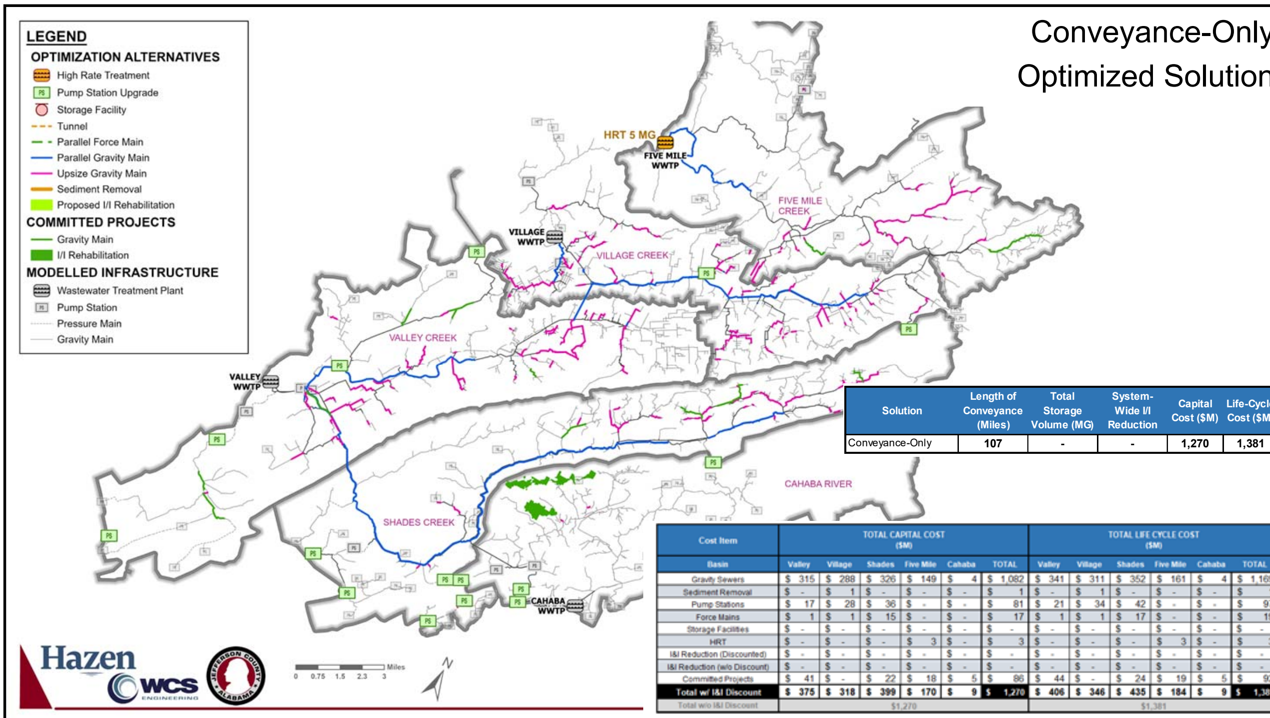
Conveyance-Only Optimized Solution



Solution	Length of Conveyance (Miles)	Total Storage Volume (MG)	System-Wide I/I Reduction	Capital Cost ($M)	Life-Cycle Cost ($M)
Conveyance-Only	**107**	**-**	**-**	**1,270**	**1,381**

Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 315	$ 288	$ 326	$ 149	$ 4	$ 1,082	$ 341	$ 311	$ 352	$ 161	$ 4	$ 1,169
Sediment Removal	$ -	$ 1	$ -	$ -	$ -	$ 1	$ -	$ 1	$ -	$ -	$ -	$ 1
Pump Stations	$ 17	$ 28	$ 36	$ -	$ -	$ 81	$ 21	$ 34	$ 42	$ -	$ -	$ 97
Force Mains	$ 1	$ 1	$ 15	$ -	$ -	$ 17	$ 1	$ 1	$ 17	$ -	$ -	$ 19
Storage Facilities	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
HRT	$ -	$ -	$ -	$ 3	$ -	$ 3	$ -	$ -	$ -	$ 3	$ -	$ 3
I&I Reduction (Discounted)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
I&I Reduction (w/o Discount)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Committed Projects	$ 41	$ -	$ 22	$ 18	$ 5	$ 86	$ 44	$ -	$ 24	$ 19	$ 5	$ 92
Total w/ I&I Discount	**$ 375**	**$ 318**	**$ 399**	**$ 170**	**$ 9**	**$ 1,270**	**$ 406**	**$ 346**	**$ 435**	**$ 184**	**$ 9**	**$ 1,381**
Total w/o I&I Discount	$1,270						$1,381					

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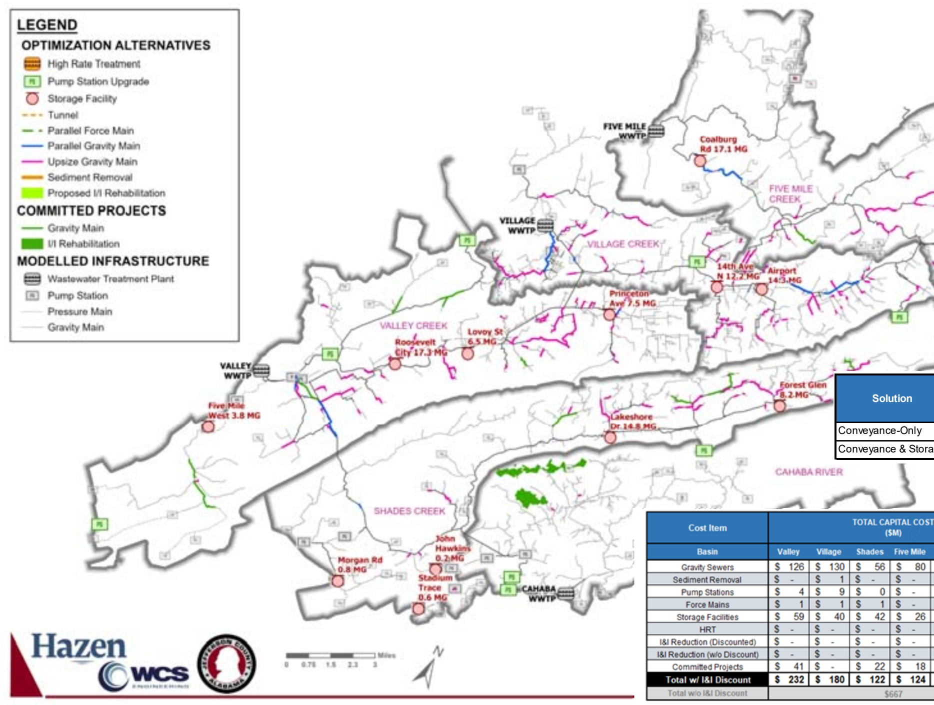
Conveyance & Storage Optimized Solution



Solution	Length of Conveyance (Miles)	Total Storage Volume (MG)	System-Wide I/I Reduction	Capital Cost ($M)	Life-Cycle Cost ($M)
Conveyance-Only	107	-	-	1,270	1,381
Conveyance & Storage	**59**	**104**	**-**	**667**	**768**

Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 126	$ 130	$ 56	$ 80	$ 4	$ 395	$ 136	$ 140	$ 60	$ 87	$ 4	$ 427
Sediment Removal	$ -	$ 1	$ -	$ -	$ -	$ 1	$ -	$ 1	$ -	$ -	$ -	$ 1
Pump Stations	$ 4	$ 9	$ 0	$ -	$ 2	$ 15	$ 5	$ 10	$ 0	$ -	$ 2	$ 17
Force Mains	$ 1	$ 1	$ 1	$ -	$ -	$ 3	$ 1	$ 1	$ 1	$ -	$ -	$ 3
Storage Facilities	$ 59	$ 40	$ 42	$ 26	$ -	$ 167	$ 80	$ 54	$ 57	$ 35	$ -	$ 226
HRT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
I&I Reduction (Discounted)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
I&I Reduction (w/o Discount)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Committed Projects	$ 41	$ -	$ 22	$ 18	$ 5	$ 86	$ 44	$ -	$ 24	$ 19	$ 5	$ 92
Total w/ I&I Discount	**$ 232**	**$ 180**	**$ 122**	**$ 124**	**$ 10**	**$ 667**	**$ 267**	**$ 206**	**$ 143**	**$ 141**	**$ 11**	**$ 768**
Total w/o I&I Discount	$667						$768					

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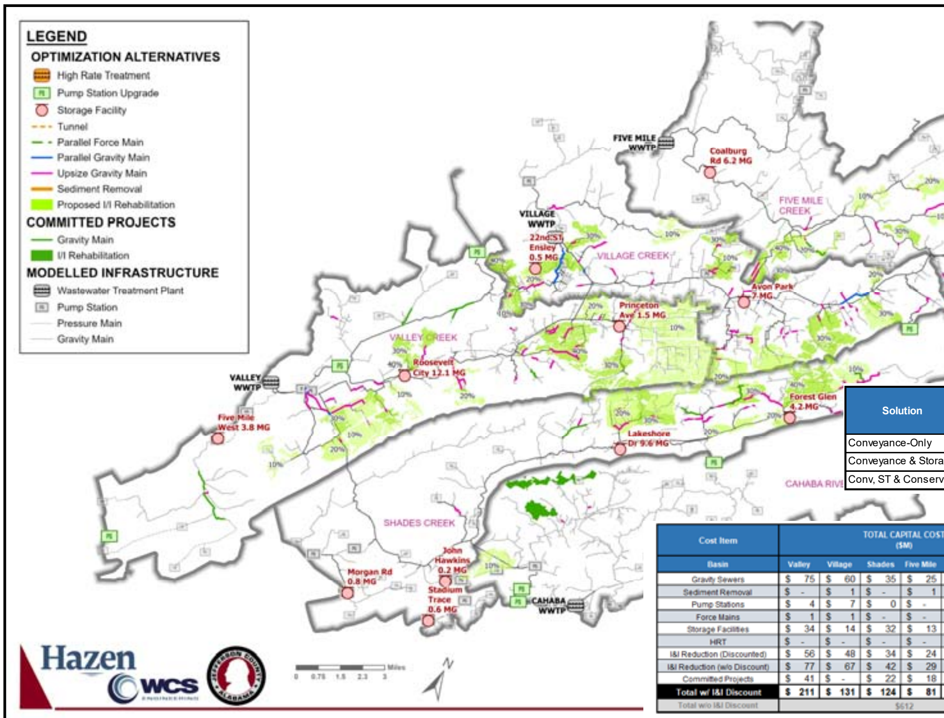
Conveyance, Storage & **Conservative I/I Solution**



Solution	Length of Conveyance (Miles)	Total Storage Volume (MG)	System-Wide I/I Reduction	Capital Cost ($M)	Life-Cycle Cost ($M)
Conveyance-Only	107	-	-	1,270	1,381
Conveyance & Storage	59	104	-	667	768
Conv, ST & Conserv. I/I	**33**	**47**	**9%**	**559**	**617**

Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 75	$ 60	$ 35	$ 25	$ 4	$ 199	$ 81	$ 65	$ 38	$ 27	$ 4	$ 215
Sediment Removal	$ -	$ 1	$ -	$ 1	$ -	$ 2	$ -	$ 1	$ -	$ 1	$ -	$ 2
Pump Stations	$ 4	$ 7	$ 0	$ -	$ 2	$ 13	$ 5	$ 8	$ 0	$ -	$ 2	$ 15
Force Mains	$ 1	$ 1	$ -	$ -	$ -	$ 2	$ 1	$ 1	$ -	$ -	$ -	$ 2
Storage Facilities	$ 34	$ 14	$ 32	$ 13	$ -	$ 93	$ 46	$ 19	$ 44	$ 18	$ -	$ 127
HRT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
I&I Reduction (Discounted)	$ 56	$ 48	$ 34	$ 24	$ 2	$ 164	$ 56	$ 48	$ 34	$ 24	$ 2	$ 164
I&I Reduction (w/o Discount)	$ 77	$ 67	$ 42	$ 29	$ 2	$ 216	$ 77	$ 67	$ 42	$ 29	$ 2	$ 216
Committed Projects	$ 41	$ -	$ 22	$ 18	$ 5	$ 86	$ 44	$ -	$ 24	$ 19	$ 5	$ 92
Total w/ I&I Discount	**$ 211**	**$ 131**	**$ 124**	**$ 81**	**$ 12**	**$ 559**	**$ 233**	**$ 143**	**$ 140**	**$ 89**	**$ 13**	**$ 617**
Total w/o I&I Discount	$612						$670					

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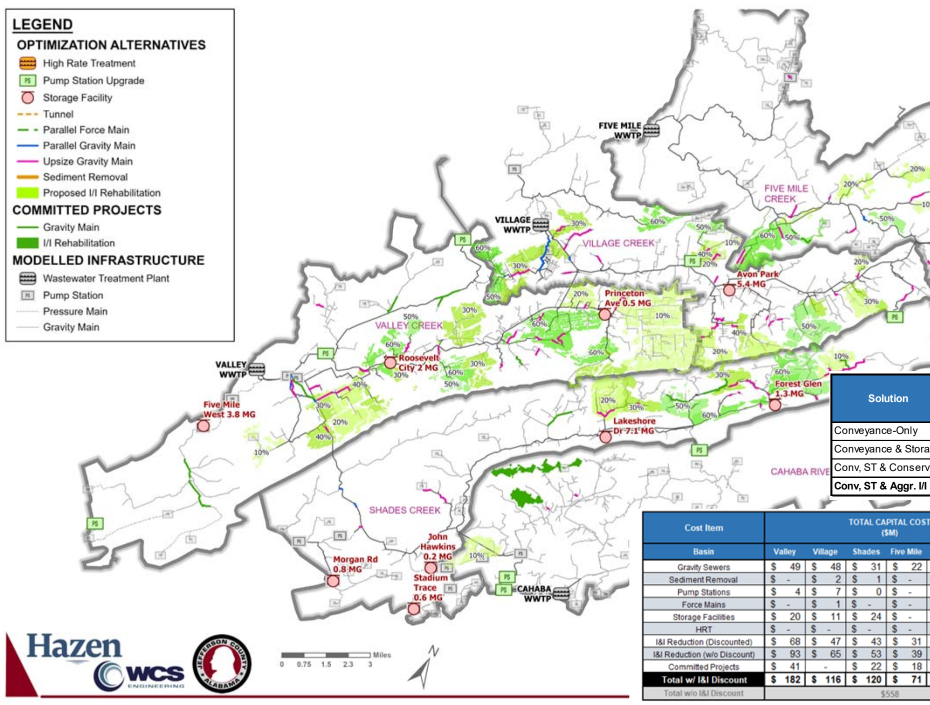
Conveyance, Storage & Aggressive I/I Solution (ICM)



Solution	Length of Conveyance (Miles)	Total Storage Volume (MG)	System-Wide I/I Reduction	Capital Cost ($M)	Life-Cycle Cost ($M)
Conveyance-Only	107	-	-	1,270	1,381
Conveyance & Storage	59	104	-	667	768
Conv, ST & Conserv. I/I	33	47	9%	559	617
Conv, ST & Aggr. I/I	**24**	**22**	**16%**	**498**	**538**

Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 49	$ 48	$ 31	$ 22	$ 1	$ 150	$ 53	$ 52	$ 33	$ 23	$ 1	$ 162
Sediment Removal	$ -	$ 2	$ 1	$ -	$ -	$ 3	$ -	$ 2	$ 1	$ -	$ -	$ 3
Pump Stations	$ 4	$ 7	$ 0	$ -	$ 2	$ 13	$ 5	$ 8	$ 0	$ -	$ 2	$ 15
Force Mains	$ -	$ 1	$ -	$ -	$ -	$ 1	$ -	$ 1	$ -	$ -	$ -	$ 1
Storage Facilities	$ 20	$ 11	$ 24	$ -	$ -	$ 54	$ 27	$ 15	$ 32	$ -	$ -	$ 73
HRT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
I&I Reduction (Discounted)	$ 68	$ 47	$ 43	$ 31	$ 1	$ 190	$ 68	$ 47	$ 43	$ 31	$ 1	$ 190
I&I Reduction (w/o Discount)	$ 93	$ 65	$ 53	$ 39	$ 1	$ 251	$ 93	$ 65	$ 53	$ 39	$ 1	$ 251
Committed Projects	$ 41	-	$ 22	$ 18	$ 5	$ 86	$ 44	-	$ 24	$ 19	$ 5	$ 92
Total w/ I&I Discount	**$ 182**	**$ 116**	**$ 120**	**$ 71**	**$ 10**	**$ 498**	**$ 196**	**$ 125**	**$ 133**	**$ 74**	**$ 10**	**$ 538**
Total w/o I&I Discount	$558						$598					

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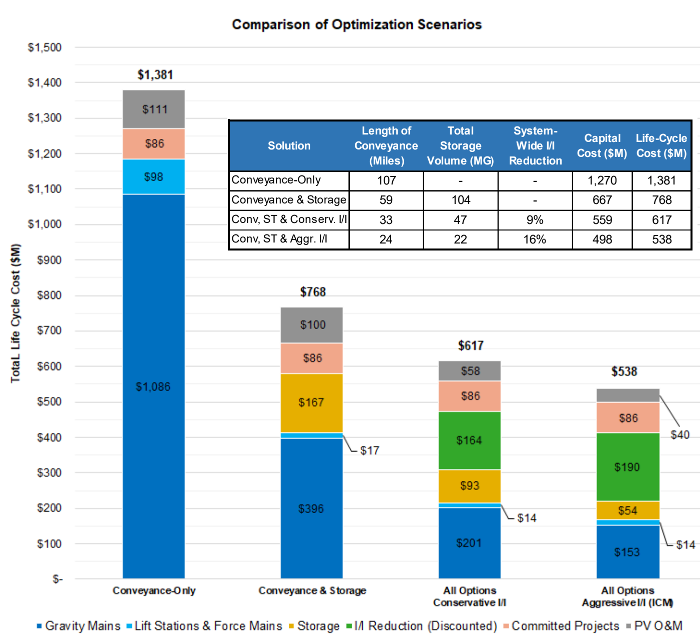
Key Points

- Optimized storage and I/I reduction eliminates extensive conveyance upgrades.
- Conveyance improvements sized conservatively based on I/I reduction sensitivity.
- Conservative I/I reduction scenario provides flexibility for an adaptive planning strategy.
- Savings on the order of 20% to 30% compared to RMP developed using traditional modeling and without considering I/I reduction



Solution	Length of Conveyance (Miles)	Total Storage Volume (MG)	System-Wide I/I Reduction	Capital Cost ($M)	Life-Cycle Cost ($M)
Conveyance-Only	107	-	-	1,270	1,381
Conveyance & Storage	59	104	-	667	768
Conv, ST & Conserv. I/I	33	47	9%	559	617
Conv, ST & Aggr. I/I	24	22	16%	498	538

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Prioritization

- Select projects from the optimized RMP (aggressive I/I scenario with conservative pipe sizing) to develop a schedule of implementation that maximizes ROI.
- ROI is defined as maximum reduction in total 2-year 6h and 24h design storm SSO volume/count at least cost.
- Reduction of SSOs at confirmed SSO locations weighted higher than reduction of unconfirmed modeled SSOs.

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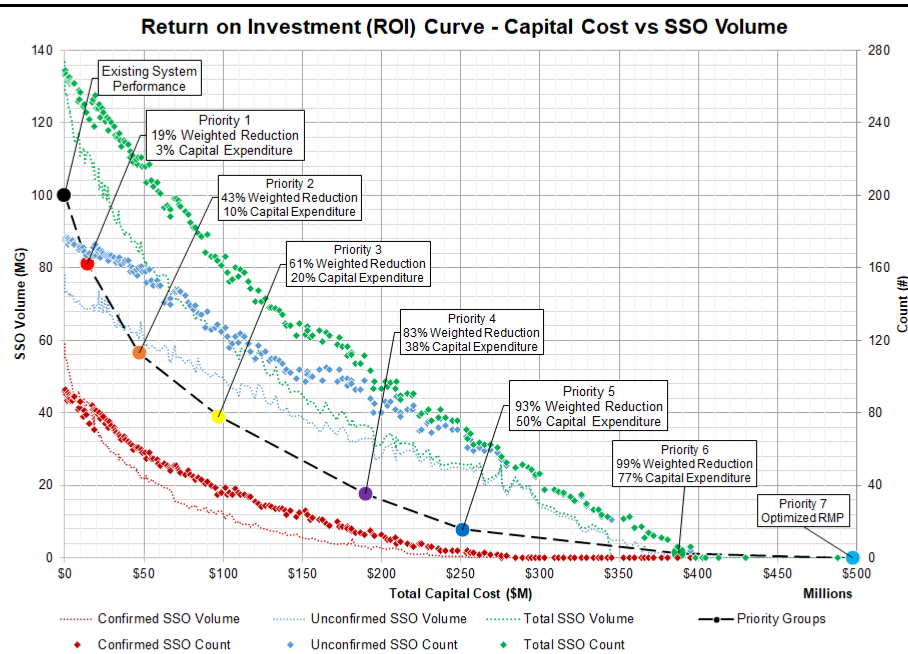

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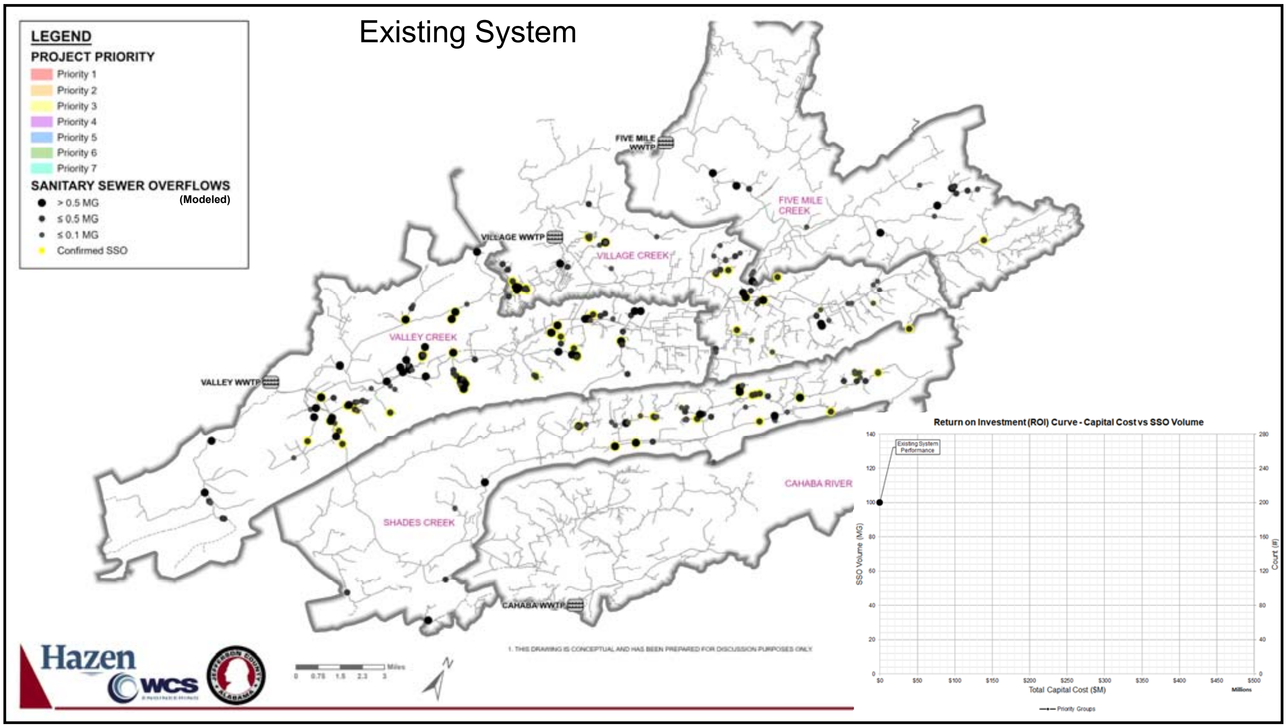

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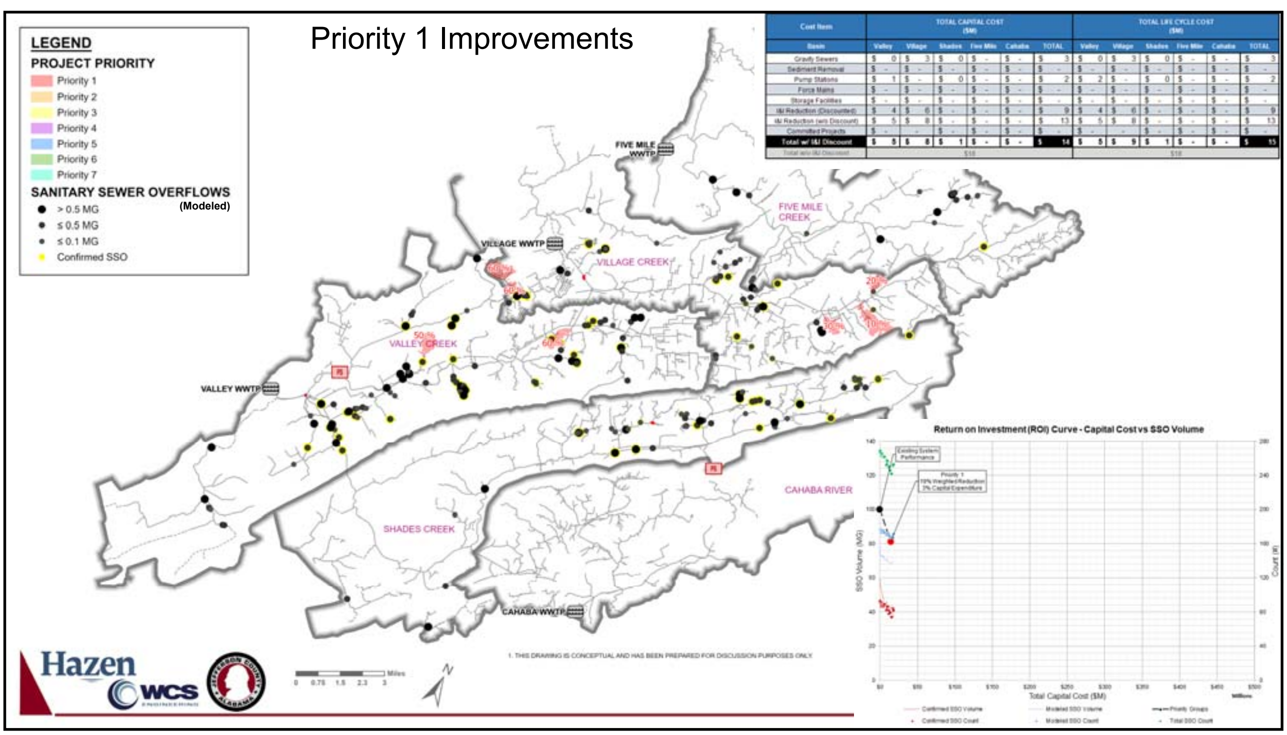

Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 0	$ 3	$ 0	$ -	$ -	$ 3	$ 0	$ 3	$ 0	$ -	$ -	$ 3
Sediment Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Pump Stations	$ 1	$ -	$ 0	$ -	$ -	$ 2	$ 2	$ -	$ 0	$ -	$ -	$ 2
Force Mains	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Storage Facilities	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
I&I Reduction (Discounted)	$ 4	$ 6	$ -	$ -	$ -	$ 9	$ 4	$ 6	$ -	$ -	$ -	$ 9
I&I Reduction (w/o Discount)	$ 5	$ 8	$ -	$ -	$ -	$ 13	$ 5	$ 8	$ -	$ -	$ -	$ 13
Committed Projects	$ -	-	$ -	$ -	$ -	$ -	$ -	-	$ -	$ -	$ -	$ -
Total w/ I&I Discount	$ 5	$ 8	$ 1	$ -	$ -	$ 14	$ 5	$ 9	$ 1	$ -	$ -	$ 15
Total w/o I&I Discount	$18						$18					

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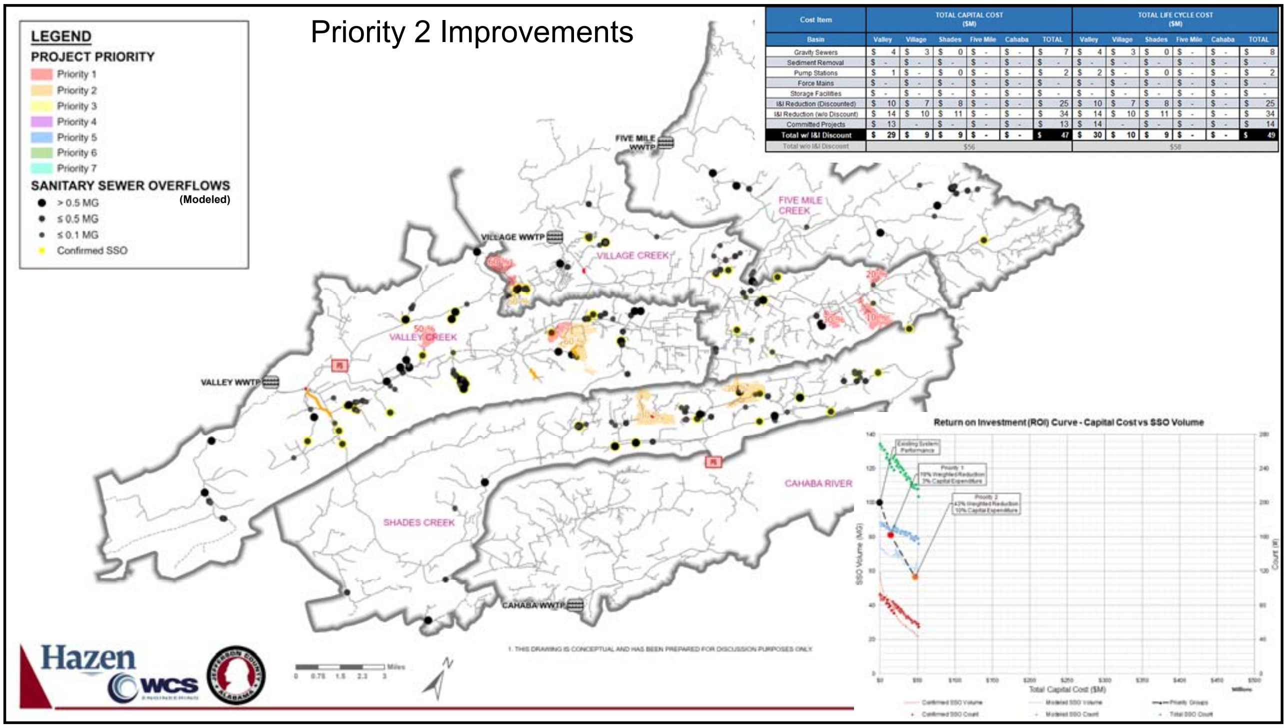

Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 4	$ 3	$ 0	$ -	$ -	$ 7	$ 4	$ 3	$ 0	$ -	$ -	$ 8
Sediment Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Pump Stations	$ 1	$ -	$ 0	$ -	$ -	$ 2	$ 2	$ -	$ 0	$ -	$ -	$ 2
Force Mains	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Storage Facilities	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
I&I Reduction (Discounted)	$ 10	$ 7	$ 8	$ -	$ -	$ 25	$ 10	$ 7	$ 8	$ -	$ -	$ 25
I&I Reduction (w/o Discount)	$ 14	$ 10	$ 11	$ -	$ -	$ 34	$ 14	$ 10	$ 11	$ -	$ -	$ 34
Committed Projects	$ 13	-	$ -	$ -	$ -	$ 13	$ 14	-	$ -	$ -	$ -	$ 14
Total w/ I&I Discount	**$ 29**	**$ 9**	**$ 9**	**$ -**	**$ -**	**$ 47**	**$ 30**	**$ 10**	**$ 9**	**$ -**	**$ -**	**$ 49**
Total w/o I&I Discount	$56						$58					

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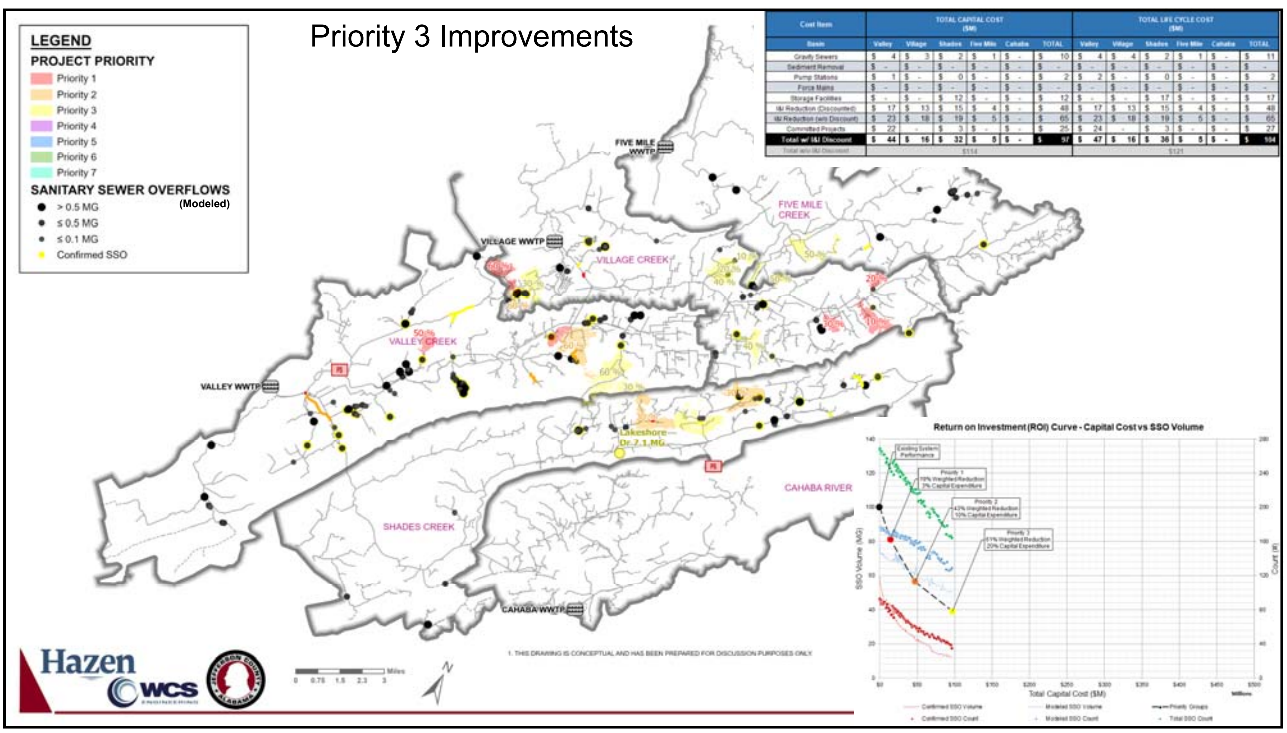

Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 4	$ 3	$ 2	$ 1	$ -	$ 10	$ 4	$ 4	$ 2	$ 1	$ -	$ 11
Sediment Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Pump Stations	$ 1	$ -	$ 0	$ -	$ -	$ 2	$ 2	$ -	$ 0	$ -	$ -	$ 2
Force Mains	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Storage Facilities	$ -	$ -	$ 12	$ -	$ -	$ 12	$ -	$ -	$ 17	$ -	$ -	$ 17
I&I Reduction (Discounted)	$ 17	$ 13	$ 15	$ 4	$ -	$ 48	$ 17	$ 13	$ 15	$ 4	$ -	$ 48
I&I Reduction (w/o Discount)	$ 23	$ 18	$ 19	$ 5	$ -	$ 65	$ 23	$ 18	$ 19	$ 5	$ -	$ 65
Committed Projects	$ 22	-	$ 3	$ -	$ -	$ 25	$ 24	-	$ 3	$ -	$ -	$ 27
Total w/ I&I Discount	**$ 44**	**$ 16**	**$ 32**	**$ 5**	**$ -**	**$ 97**	**$ 47**	**$ 16**	**$ 36**	**$ 5**	**$ -**	**$ 104**
Total w/o I&I Discount	$114						$121					

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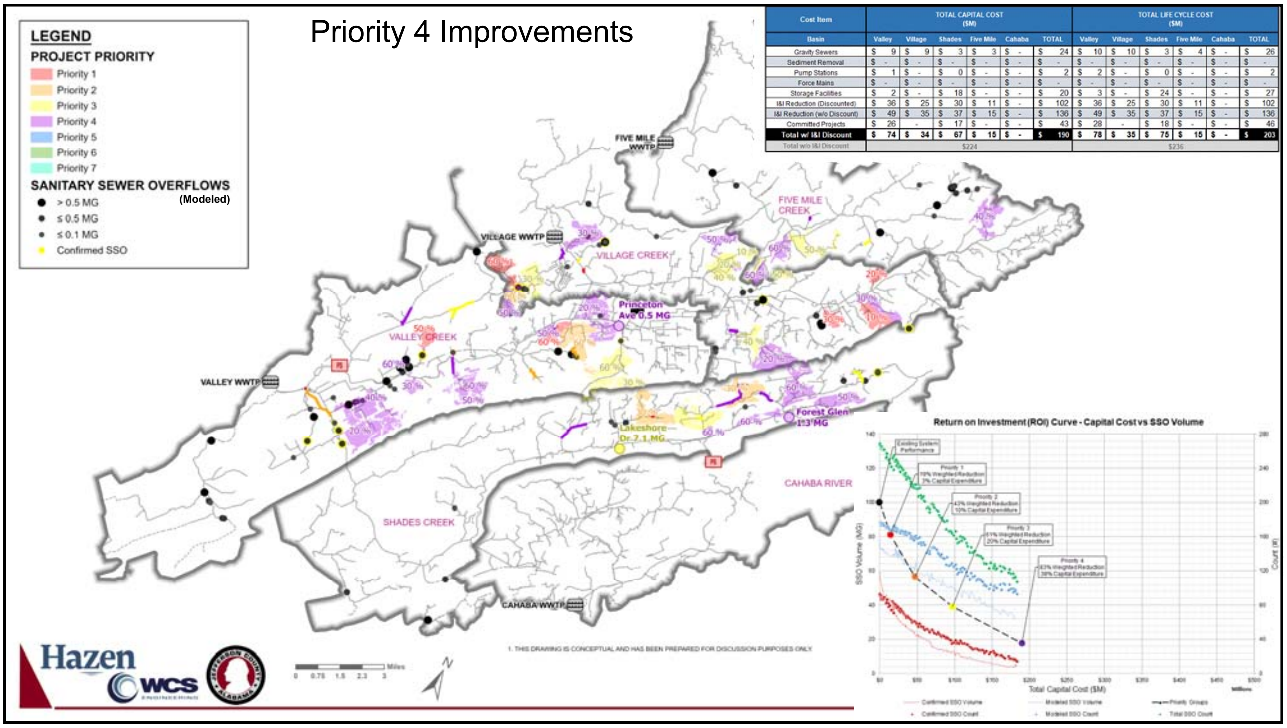
Priority 4 Improvements



Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 9	$ 9	$ 3	$ 3	$ -	$ 24	$ 10	$ 10	$ 3	$ 4	$ -	$ 26
Sediment Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Pump Stations	$ 1	$ -	$ 0	$ -	$ -	$ 2	$ 2	$ -	$ 0	$ -	$ -	$ 2
Force Mains	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Storage Facilities	$ 2	$ -	$ 18	$ -	$ -	$ 20	$ 3	$ -	$ 24	$ -	$ -	$ 27
I&I Reduction (Discounted)	$ 36	$ 25	$ 30	$ 11	$ -	$ 102	$ 36	$ 25	$ 30	$ 11	$ -	$ 102
I&I Reduction (w/o Discount)	$ 49	$ 35	$ 37	$ 15	$ -	$ 136	$ 49	$ 35	$ 37	$ 15	$ -	$ 136
Committed Projects	$ 26	-	$ 17	$ -	$ -	$ 43	$ 28	-	$ 18	$ -	$ -	$ 46
Total w/ I&I Discount	**$ 74**	**$ 34**	**$ 67**	**$ 15**	**$ -**	**$ 190**	**$ 78**	**$ 35**	**$ 75**	**$ 15**	**$ -**	**$ 203**
Total w/o I&I Discount	$224						$236					

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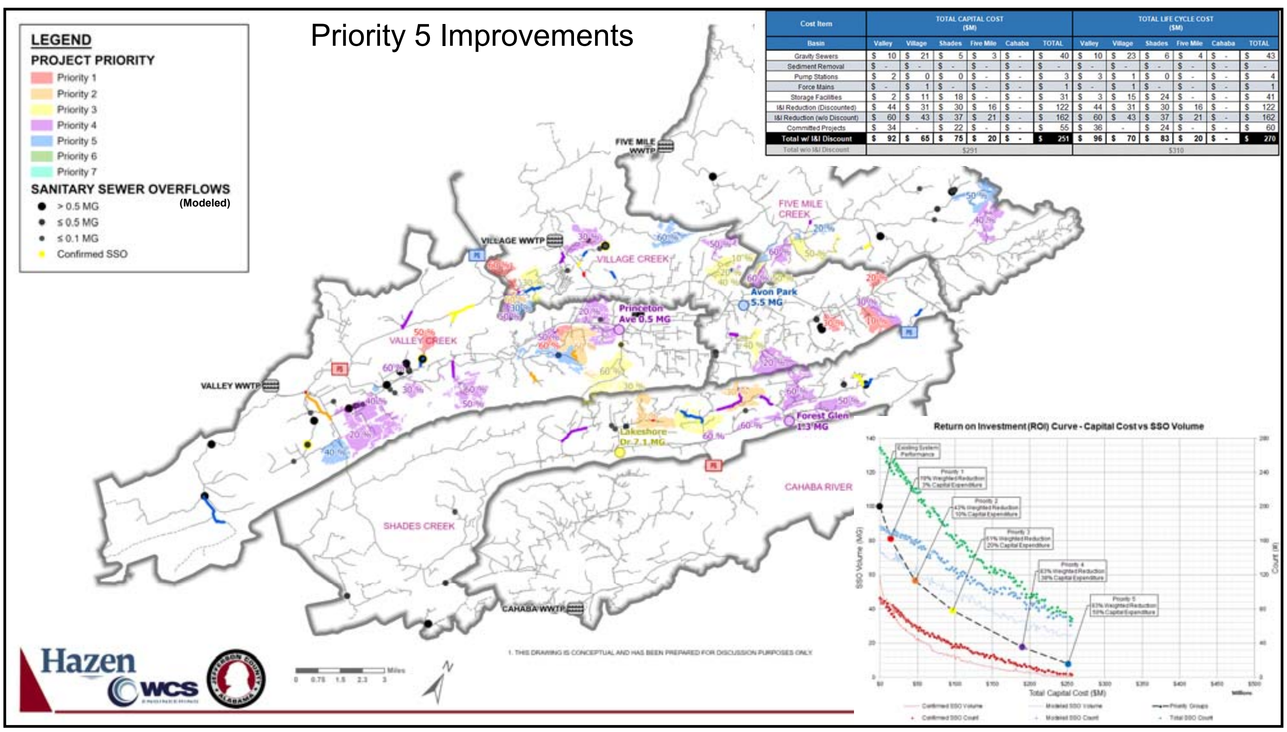
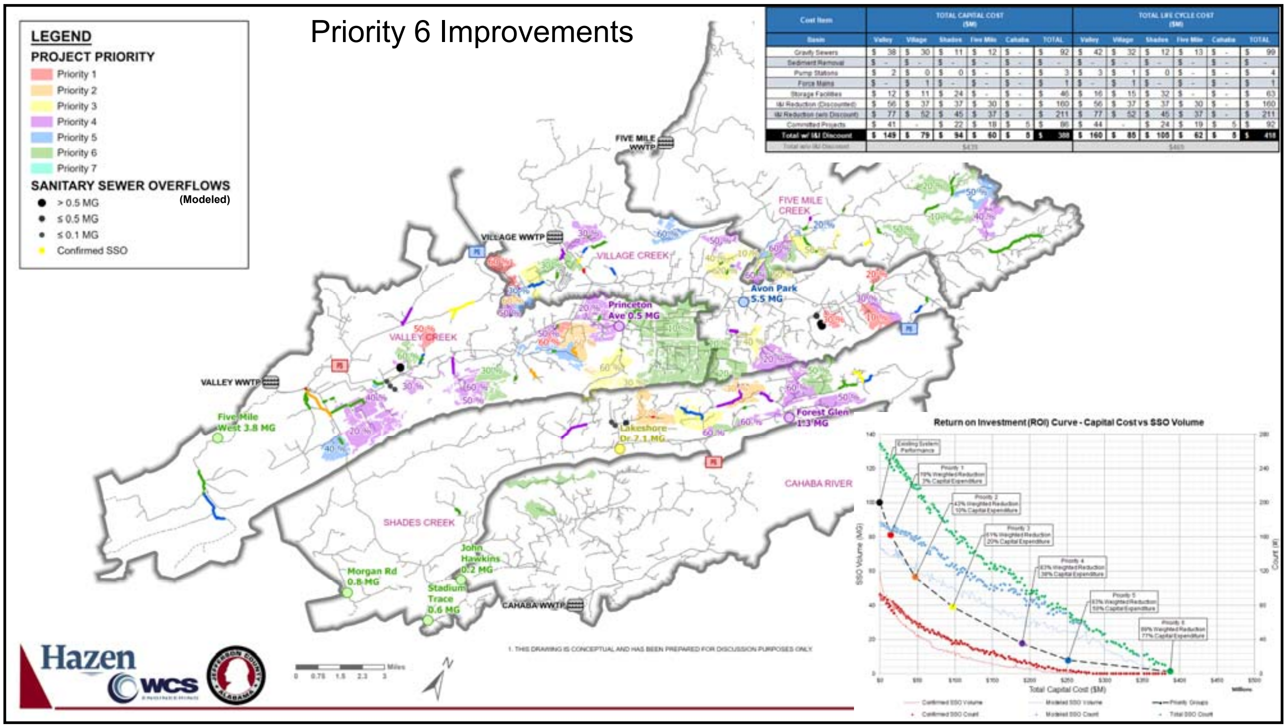
Priority 5 Improvements



Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 10	$ 21	$ 5	$ 3	$ -	$ 40	$ 10	$ 23	$ 6	$ 4	$ -	$ 43
Sediment Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Pump Stations	$ 2	$ 0	$ 0	$ -	$ -	$ 3	$ 3	$ 1	$ 0	$ -	$ -	$ 4
Force Mains	$ -	$ 1	$ -	$ -	$ -	$ 1	$ -	$ 1	$ -	$ -	$ -	$ 1
Storage Facilities	$ 2	$ 11	$ 18	$ -	$ -	$ 31	$ 3	$ 15	$ 24	$ -	$ -	$ 41
I&I Reduction (Discounted)	$ 44	$ 31	$ 30	$ 16	$ -	$ 122	$ 44	$ 31	$ 30	$ 16	$ -	$ 122
I&I Reduction (w/o Discount)	$ 60	$ 43	$ 37	$ 21	$ -	$ 162	$ 60	$ 43	$ 37	$ 21	$ -	$ 162
Committed Projects	$ 34	-	$ 22	$ -	$ -	$ 55	$ 36	-	$ 24	$ -	$ -	$ 60
Total w/ I&I Discount	**$ 92**	**$ 65**	**$ 75**	**$ 20**	**$ -**	**$ 251**	**$ 96**	**$ 70**	**$ 83**	**$ 20**	**$ -**	**$ 270**
Total w/o I&I Discount	$291						$310					

34



Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 38	$ 30	$ 11	$ 12	$ -	$ 92	$ 42	$ 32	$ 12	$ 13	$ -	$ 99
Sediment Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Pump Stations	$ 2	$ 0	$ 0	$ -	$ -	$ 3	$ 3	$ 1	$ 0	$ -	$ -	$ 4
Force Mains	$ -	$ 1	$ -	$ -	$ -	$ 1	$ -	$ 1	$ -	$ -	$ -	$ 1
Storage Facilities	$ 12	$ 11	$ 24	$ -	$ -	$ 46	$ 16	$ 15	$ 32	$ -	$ -	$ 63
I&I Reduction (Discounted)	$ 56	$ 37	$ 37	$ 30	$ -	$ 160	$ 56	$ 37	$ 37	$ 30	$ -	$ 160
I&I Reduction (w/o Discount)	$ 77	$ 52	$ 45	$ 37	$ -	$ 211	$ 77	$ 52	$ 45	$ 37	$ -	$ 211
Committed Projects	$ 41	-	$ 22	$ 18	$ 5	$ 86	$ 44	-	$ 24	$ 19	$ 5	$ 92
Total w/ I&I Discount	**$ 149**	**$ 79**	**$ 94**	**$ 60**	**$ 5**	**$ 388**	**$ 160**	**$ 85**	**$ 105**	**$ 62**	**$ 5**	**$ 418**
Total w/o I&I Discount	$439						$469					

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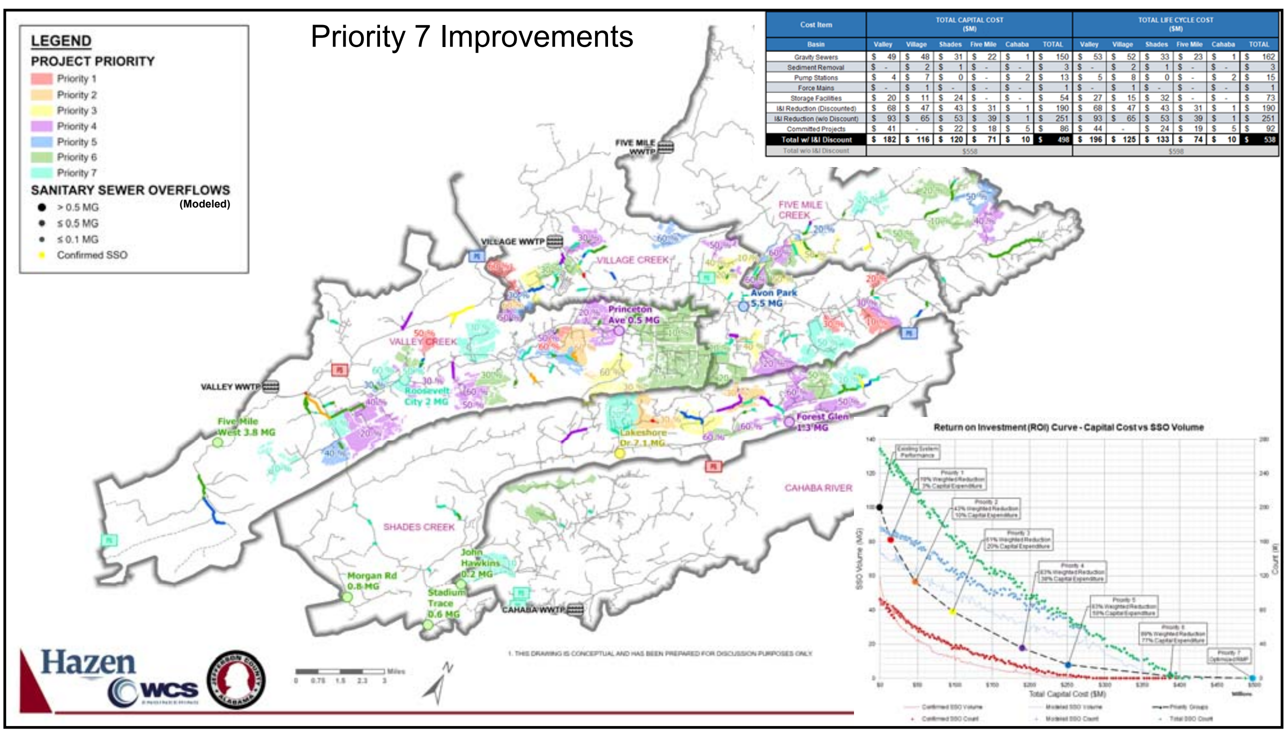
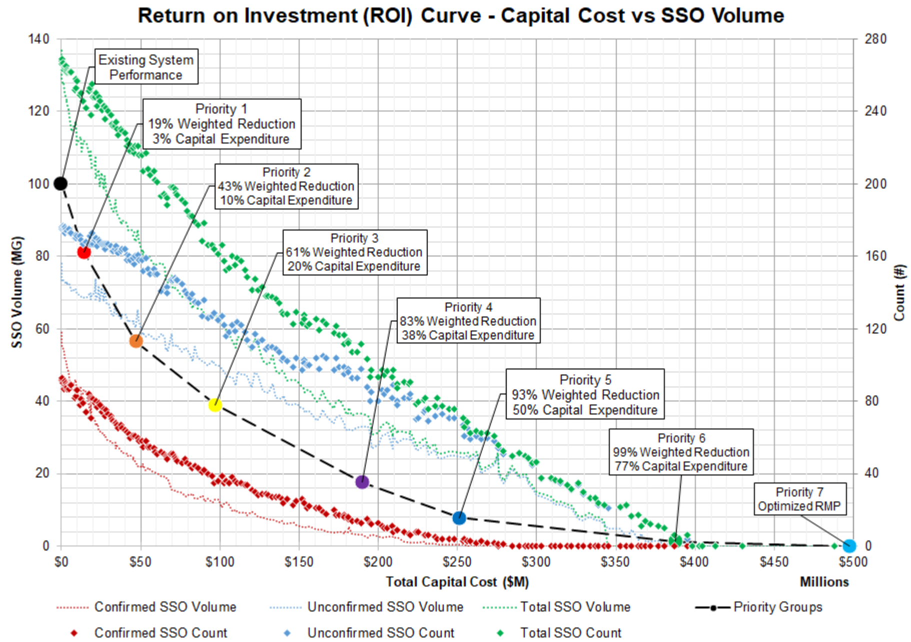


Cost Item	TOTAL CAPITAL COST ($M)						TOTAL LIFE CYCLE COST ($M)					
Basin	Valley	Village	Shades	Five Mile	Cahaba	TOTAL	Valley	Village	Shades	Five Mile	Cahaba	TOTAL
Gravity Sewers	$ 49	$ 48	$ 31	$ 22	$ 1	$ 150	$ 53	$ 52	$ 33	$ 23	$ 1	$ 162
Sediment Removal	$ -	$ 2	$ 1	$ -	$ -	$ 3	$ -	$ 2	$ 1	$ -	$ -	$ 3
Pump Stations	$ 4	$ 7	$ 0	$ -	$ 2	$ 13	$ 5	$ 8	$ 0	$ -	$ 2	$ 15
Force Mains	$ -	$ 1	$ -	$ -	$ -	$ 1	$ -	$ 1	$ -	$ -	$ -	$ 1
Storage Facilities	$ 20	$ 11	$ 24	$ -	$ -	$ 54	$ 27	$ 15	$ 32	$ -	$ -	$ 73
I&I Reduction (Discounted)	$ 68	$ 47	$ 43	$ 31	$ 1	$ 190	$ 68	$ 47	$ 43	$ 31	$ 1	$ 190
I&I Reduction (w/o Discount)	$ 93	$ 65	$ 53	$ 39	$ 1	$ 251	$ 93	$ 65	$ 53	$ 39	$ 1	$ 251
Committed Projects	$ 41	-	$ 22	$ 18	$ 5	$ 86	$ 44	-	$ 24	$ 19	$ 5	$ 92
Total w/ I&I Discount	**$ 182**	**$ 116**	**$ 120**	**$ 71**	**$ 10**	**$ 498**	**$ 196**	**$ 125**	**$ 133**	**$ 74**	**$ 10**	**$ 538**
Total w/o I&I Discount	$558						$598					

36



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Summary

- On the order of 20% to 30% cost savings relative to trial-and-error modeling without considering I/I alternatives.
- Prioritized investment schedule achieving approximately 80% reduction in SSOs within 40% of total capital expenditure.
- Conveyance improvements sized conservatively based on I/I reduction sensitivity analysis results.
- Conservative I/I reduction scenario provides flexibility for an adaptive planning strategy.

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Incorporating Optimization Results into the CIP

- Optimization results will be reviewed and prioritized
- Projects with highest return on investment will be done first
- I/I reduction is focus of early implementation as part of adaptive management approach
- Approach has enabled County to better focus and plan spending of limited dollars to address multiple needs

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DEPARTMENT OF PUBLIC UTILITIES

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Let's Solve Water

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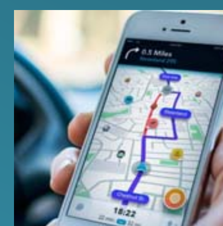
Columbus Ohio's Waze App for Guiding Operations with Decision Intelligence

Looking into the Future: Columbus, Ohio's Real Time Decision Support System



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Columbus Background…

- Columbus – 14th largest US city
- Two treatment plants: Jackson Pike @ 150 MGD & Southerly @ 330 MGD + 110 MGD Chemically Enhanced Primary Treatment (CEPT)
  - Two plants are interconnected by a 13-foot diameter pipe
- 2002 SSO and 2005 CSO Consent Decrees
  - > $1Billion spent and more to go

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Top Two Challenges, or Opportunities!

#1 – How do we send just the right amount of flow from Jackson Pike to Southerly?

- Too much = Treatment Plant Bypass,
- Too little = Excessive CSO

#2 – How do we use CEPT when needed and be prepared for it

- Many variables to consider
- Always prefer to maximize secondary treatment over CEPT, but CEPT is better than untreated discharge

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RT-DSS - Sense, Predict, Act….. Optimize

Add Sensors, Observe, Analyze

Digital Copy or Copies, Predictions

Urban Watershed

Quantitative Recommendations, Action

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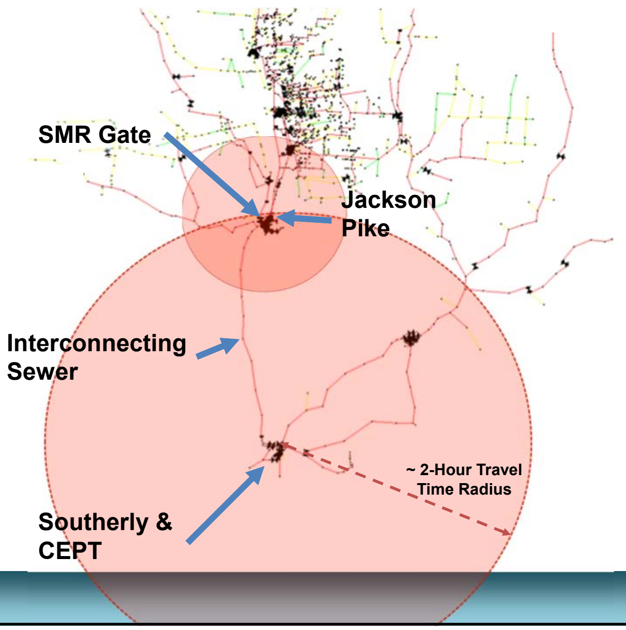
Analysis - Break down the challenge



- Jackson Pike – Serves the central and north west area incl. nearly all the combined area
- Southerly – Serves east side and west/southwest areas
- Control point to balance flow is located at Jackson Pike – SMR Gate
  - 2-hour travel time

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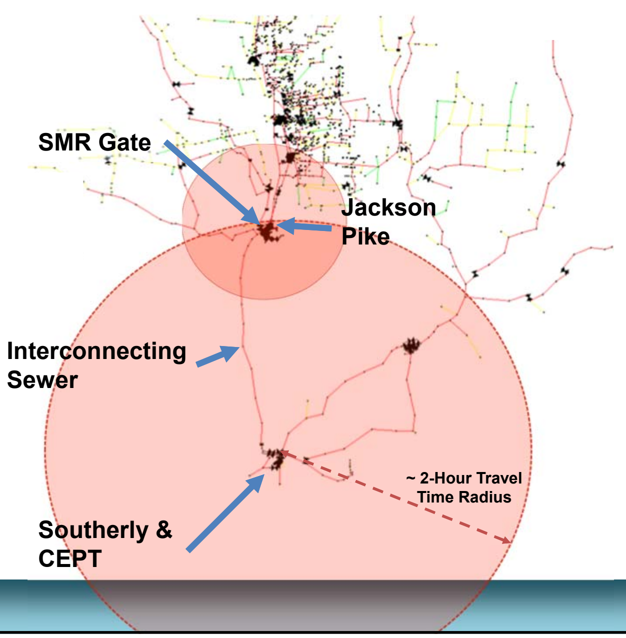
Analysis - Break down the challenge



- Travel time from the gate at Jackson Pike to Southerly is ~2 hours
- Identify and sense all the major flow streams in the 2-hour window

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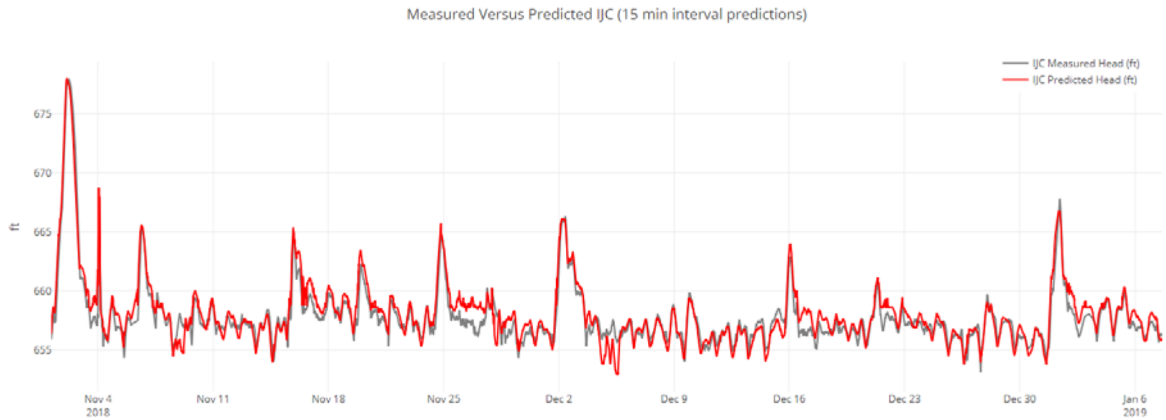
Build the Digital Twin – Augmented SWMM



- 2-Hr level and flow prediction generated every 15 minutes
- 96 forecasts per day or 2900 in a month

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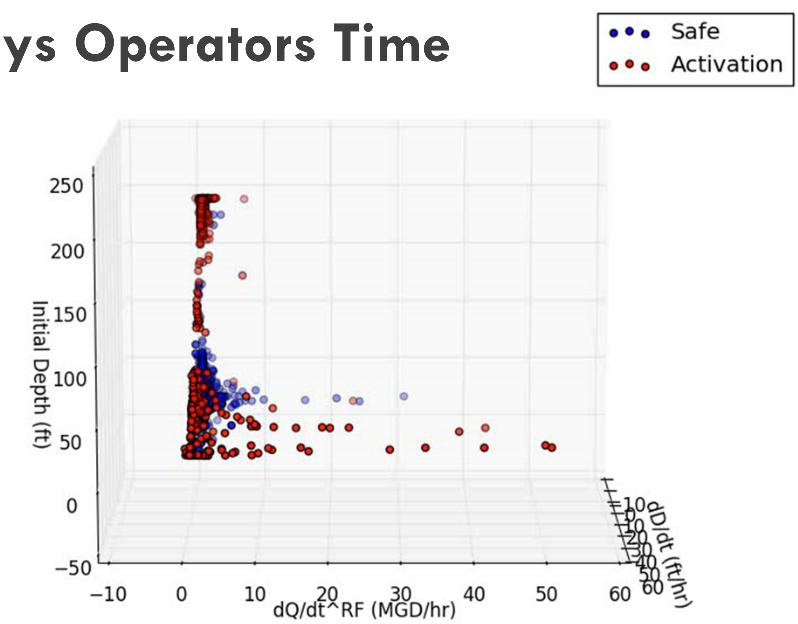
CEPT Prediction Buys Operators Time

- Statistical Model Ensemble using multiple sensors and rates generate probability of activation
- 97% accurate prediction



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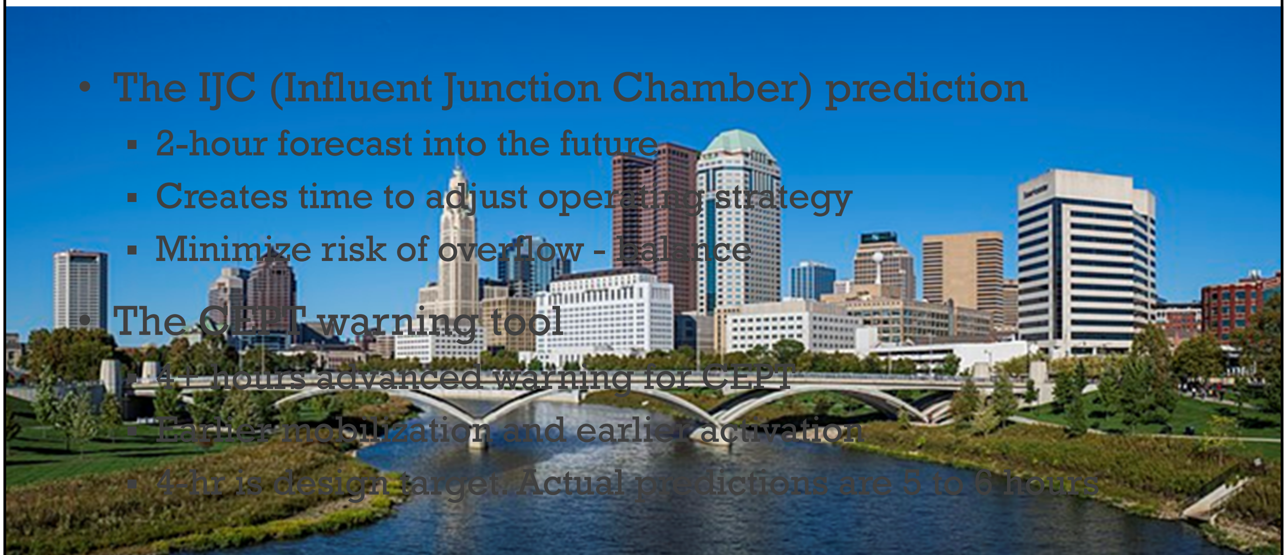
Prediction Tools Buy You Time

- The IJC (Influent Junction Chamber) prediction
  - 2-hour forecast into the future
  - Creates time to adjust operating strategy
  - Minimize risk of overflow - balance
- The CEPT warning tool
  - 4+ hours advanced warning for CEPT
  - Earlier mobilization and earlier activation
  - 4-hr is design target. Actual predictions are 5 to 6 hours



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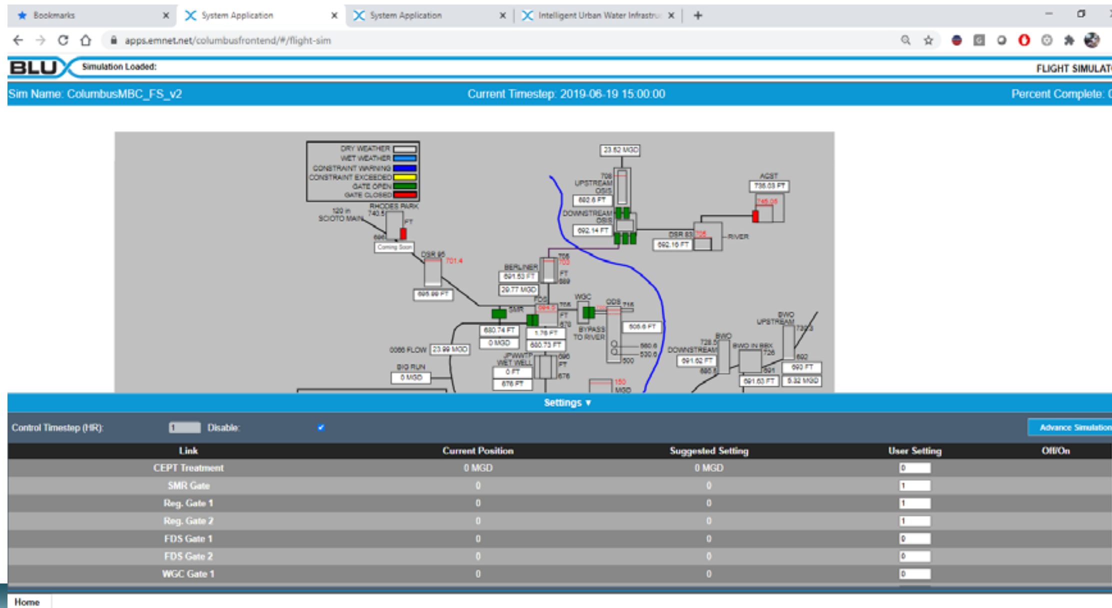
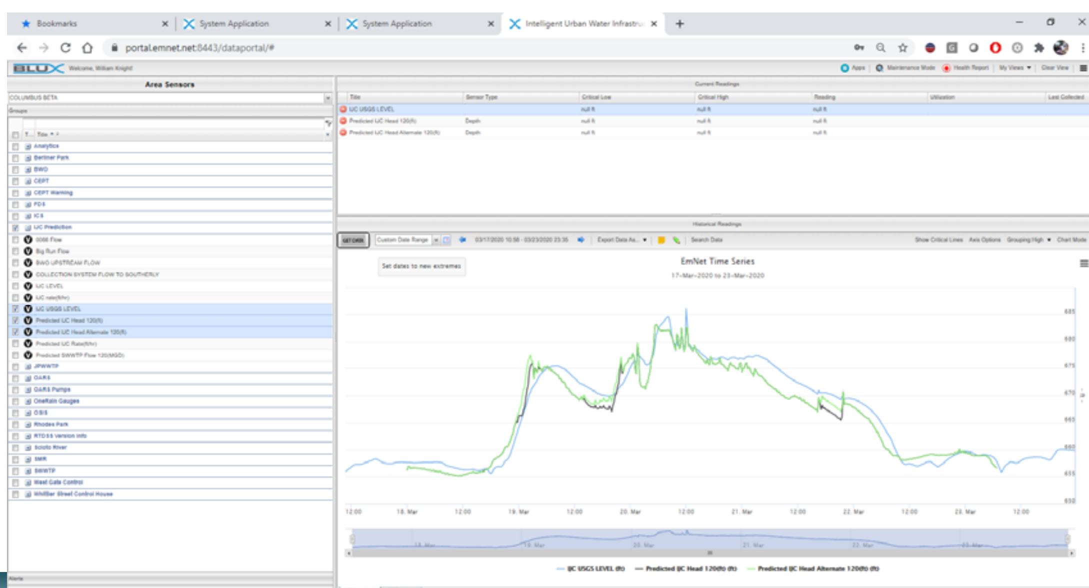
Flight Simulator – Operators Running the Model

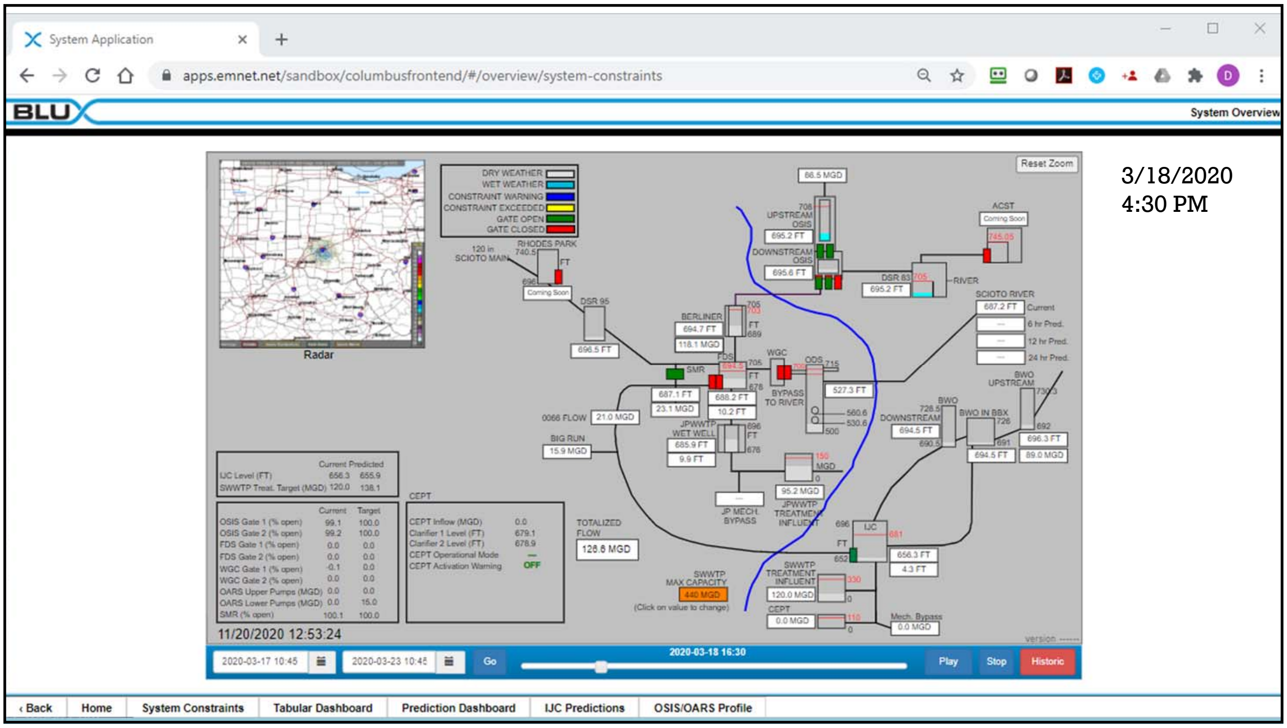


53

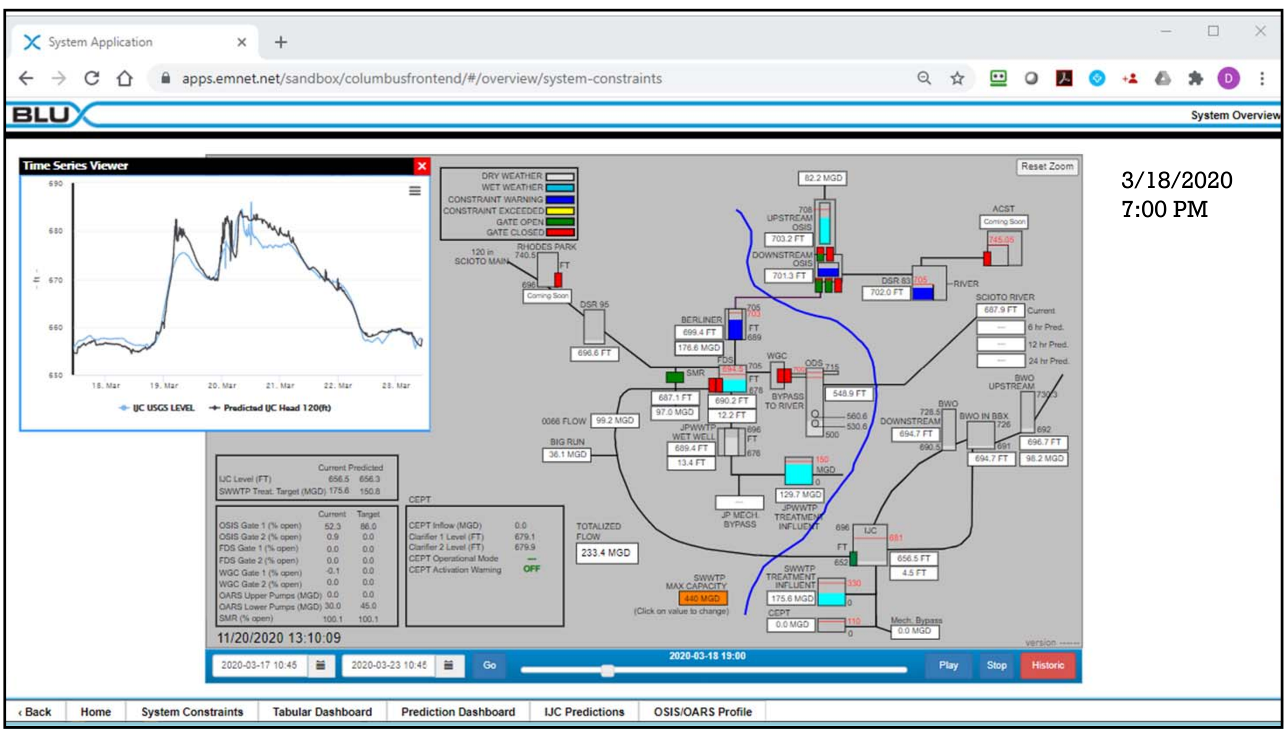
Data Portal – Aggregating Data Silos



54


System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/system-constraints
BLU
System Overview
3/18/2020
4:30 PM
Reset Zoom
Radar
DRY WEATHER
WET WEATHER
CONSTRAINT WARNING
CONSTRAINT EXCEEDED
GATE OPEN
GATE CLOSED
RHODES PARK
120 in SCIOTO MAIN
DSR 95
BERLINER
SMR
FDS
WGC
ODS
BYPASS TO RIVER
UPSTREAM OSIS
DOWNSTREAM OSIS
DSR 83
RIVER
ACST
SCIOTO RIVER
BWO UPSTREAM
BWO DOWNSTREAM
BWO IN BBX
0066 FLOW
BIG RUN
JPWWTP WET WELL
JP MECH. BYPASS
JPWWTP TREATMENT INFLUENT
IJC
TOTALIZED FLOW
128.8 MGD
SWWTP MAX CAPACITY
440 MGD
(Click on value to change)
SWWTP TREATMENT INFLUENT
CEPT
Mech. Bypass
11/20/2020 12:53:24
2020-03-17 10:45
2020-03-23 10:45
Go
2020-03-18 16:30
Play
Stop
Historic
‹ Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

55


System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/system-constraints
BLU
System Overview
3/18/2020
7:00 PM
Time Series Viewer
IJC USGS LEVEL
Predicted IJC Head 120(ft)
Reset Zoom
DRY WEATHER
WET WEATHER
CONSTRAINT WARNING
CONSTRAINT EXCEEDED
GATE OPEN
GATE CLOSED
TOTALIZED FLOW
233.4 MGD
SWWTP MAX CAPACITY
440 MGD
11/20/2020 13:10:09
2020-03-17 10:45
2020-03-23 10:45
Go
2020-03-18 19:00
Play
Stop
Historic
‹ Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

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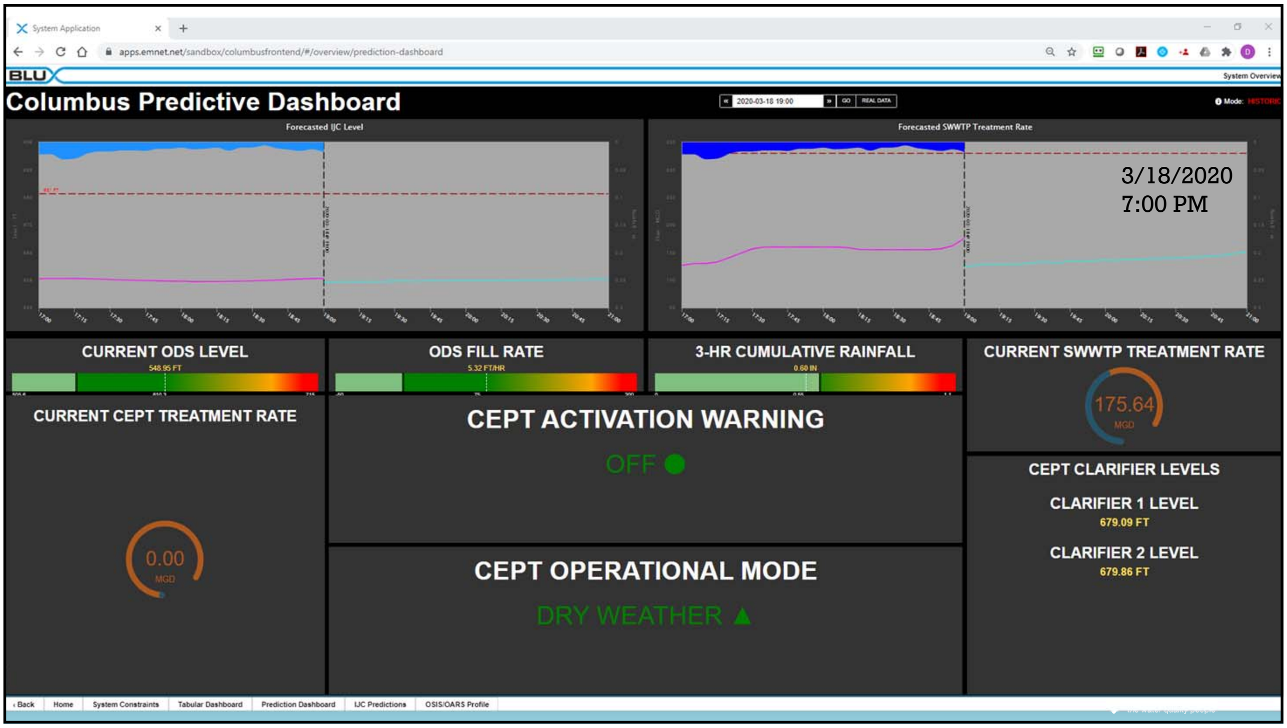
Columbus Predictive Dashboard
Forecasted IJC Level
Forecasted SWWTP Treatment Rate
3/18/2020
7:00 PM
CURRENT ODS LEVEL
548.95 FT
ODS FILL RATE
5.32 FT/HR
3-HR CUMULATIVE RAINFALL
0.60 IN
CURRENT SWWTP TREATMENT RATE
175.64
MGD
CURRENT CEPT TREATMENT RATE
0.00
MGD
CEPT ACTIVATION WARNING
OFF
CEPT OPERATIONAL MODE
DRY WEATHER
CEPT CLARIFIER LEVELS
CLARIFIER 1 LEVEL
679.09 FT
CLARIFIER 2 LEVEL
679.86 FT
‹ Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

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Columbus Predictive Dashboard
Forecasted IJC Level
Forecasted SWWTP Treatment Rate
3/18/2020
9:30 PM
CURRENT ODS LEVEL
561.78 FT
ODS FILL RATE
3.52 FT/HR
3-HR CUMULATIVE RAINFALL
0.40 IN
CURRENT SWWTP TREATMENT RATE
307.76
MGD
CURRENT CEPT TREATMENT RATE
0.00
MGD
CEPT ACTIVATION WARNING
ON
CEPT OPERATIONAL MODE
DRY WEATHER
CEPT CLARIFIER LEVELS
CLARIFIER 1 LEVEL
679.03 FT
CLARIFIER 2 LEVEL
679.16 FT
‹ Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

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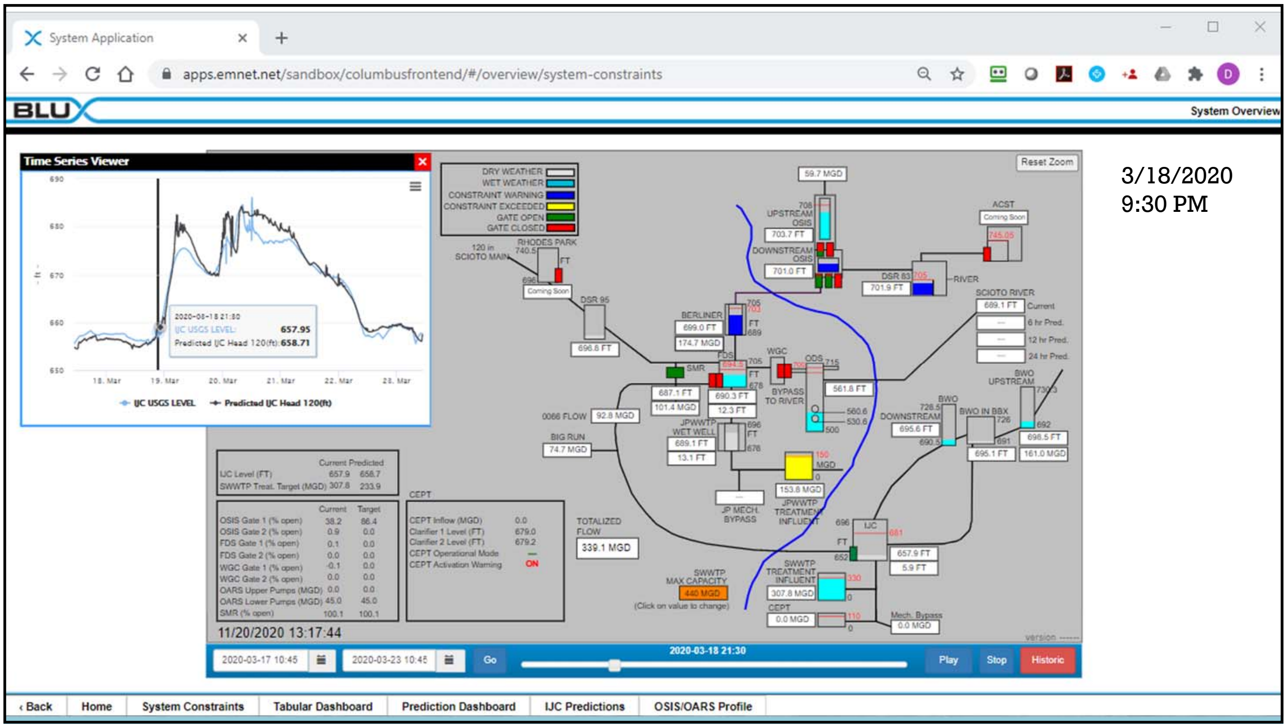
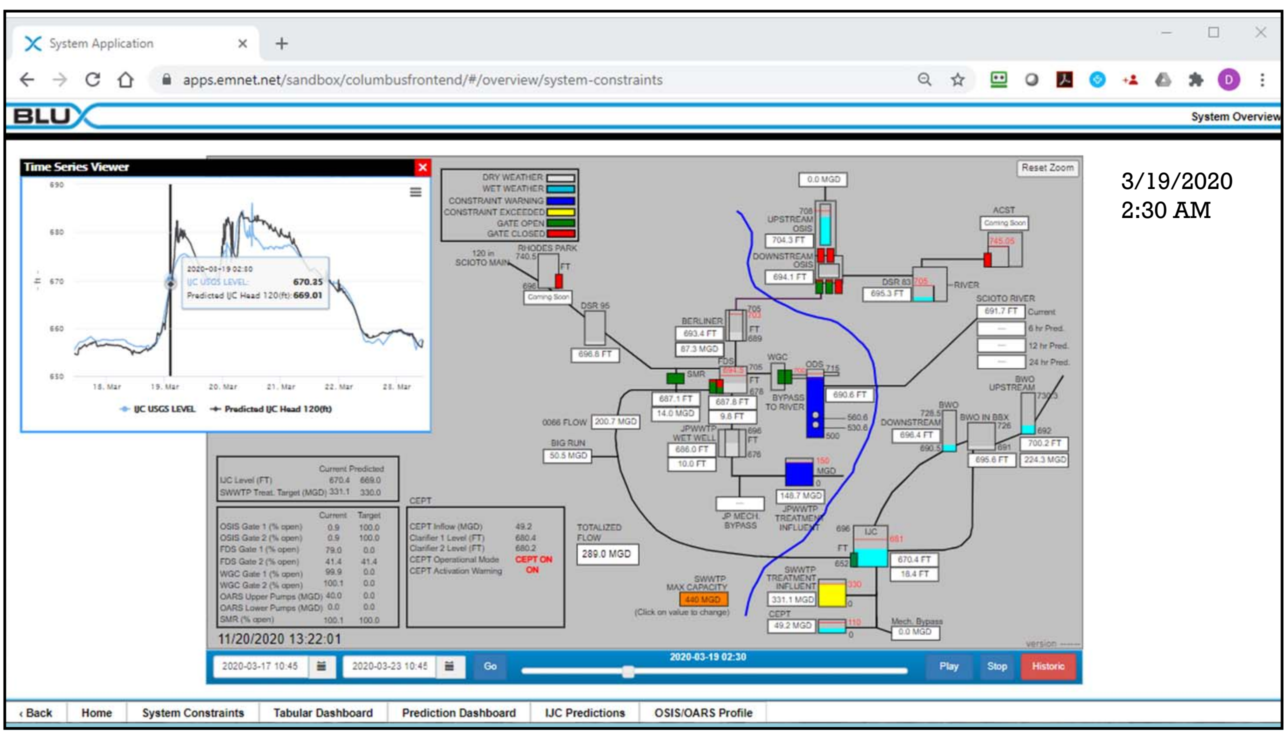
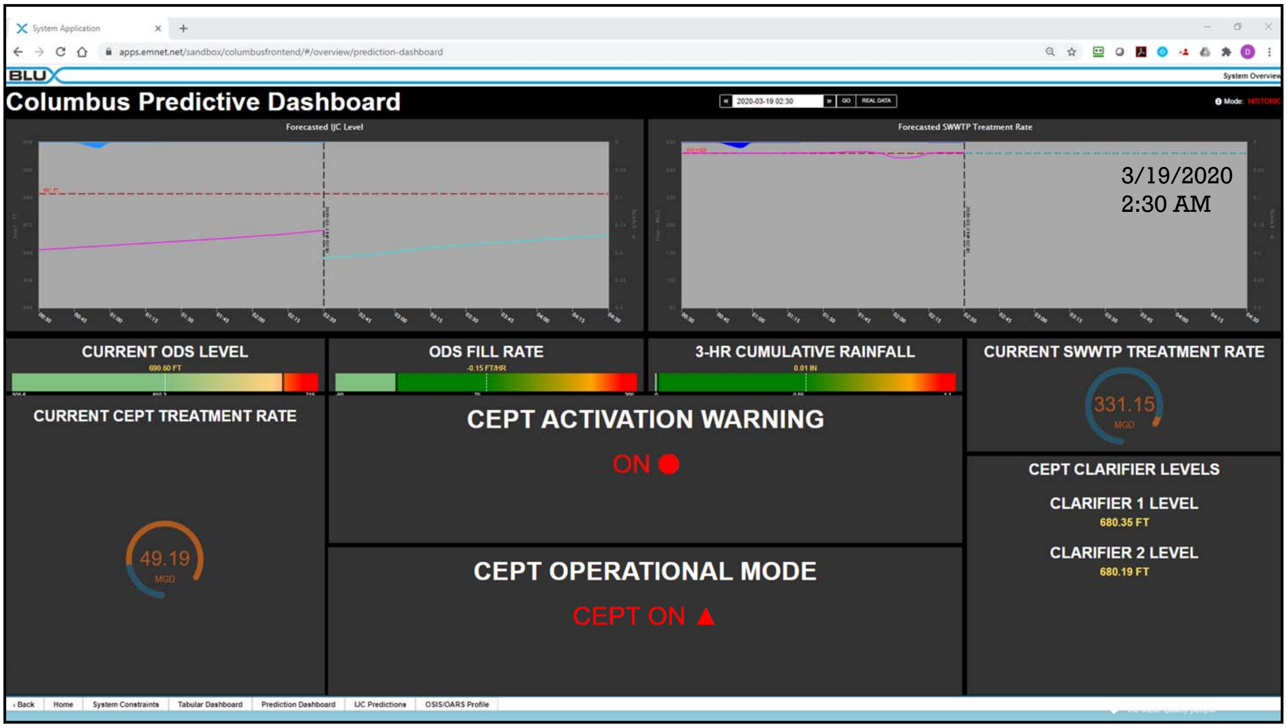

System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/system-constraints
System Overview
Time Series Viewer
IJC USGS LEVEL
Predicted IJC Head 120(ft)
Reset Zoom
11/20/2020 13:17:44
2020-03-18 21:30
Play
Stop
Historic
‹ Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile
3/18/2020
9:30 PM

59


System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/system-constraints
System Overview
Time Series Viewer
IJC USGS LEVEL
Predicted IJC Head 120(ft)
Reset Zoom
11/20/2020 13:22:01
2020-03-19 02:30
Play
Stop
Historic
‹ Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile
3/19/2020
2:30 AM

60


System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/prediction-dashboard
BLU
System Overview
Columbus Predictive Dashboard
2020-03-19 02:30
GO
REAL DATA
Mode: HISTORIC
Forecasted IJC Level
Forecasted SWWTP Treatment Rate
3/19/2020
2:30 AM
CURRENT ODS LEVEL
690.60 FT
ODS FILL RATE
-0.15 FT/HR
3-HR CUMULATIVE RAINFALL
0.01 IN
CURRENT SWWTP TREATMENT RATE
331.15
MGD
CURRENT CEPT TREATMENT RATE
49.19
MGD
CEPT ACTIVATION WARNING
ON
CEPT OPERATIONAL MODE
CEPT ON
CEPT CLARIFIER LEVELS
CLARIFIER 1 LEVEL
680.35 FT
CLARIFIER 2 LEVEL
680.19 FT
Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

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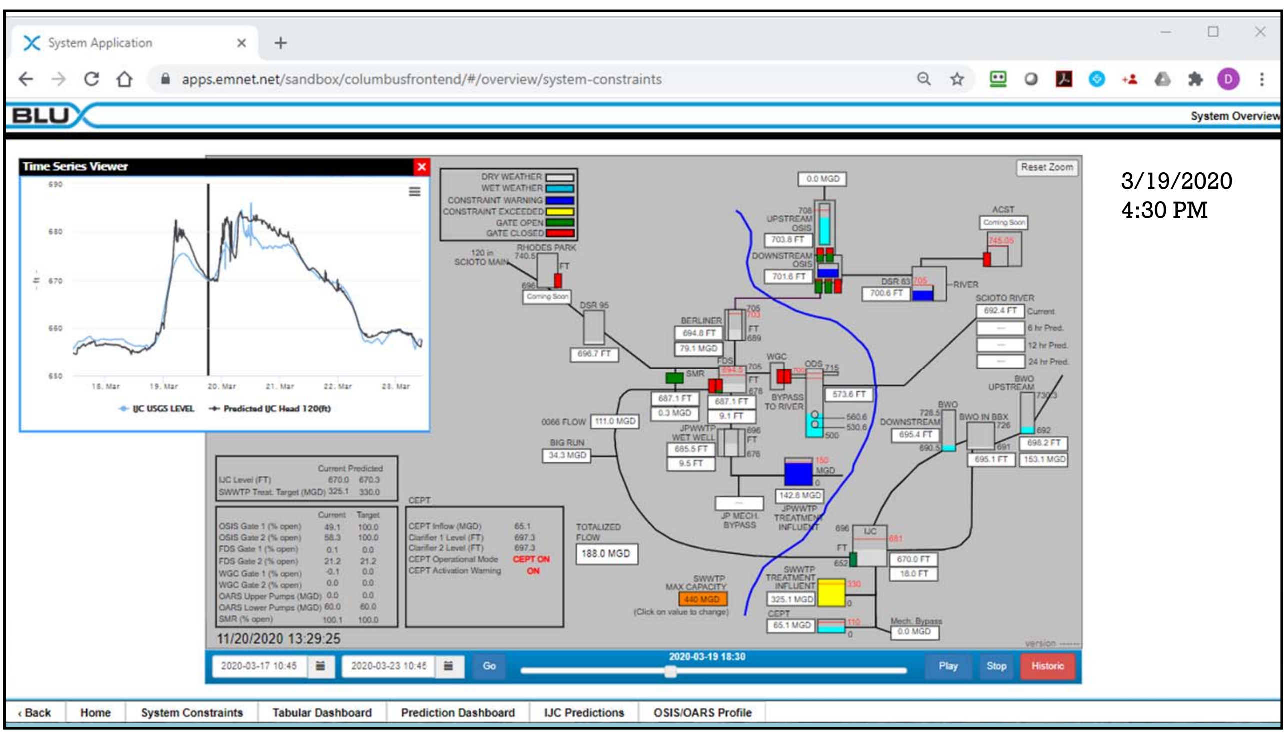
System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/system-constraints
BLU
System Overview
Time Series Viewer
IJC USGS LEVEL
Predicted IJC Head 120(ft)
DRY WEATHER
WET WEATHER
CONSTRAINT WARNING
CONSTRAINT EXCEEDED
GATE OPEN
GATE CLOSED
Reset Zoom
3/19/2020
4:30 PM
RHODES PARK
SCIOTO MAIN
DSR 95
BERLINER
SMR
WGC
ODS
BYPASS TO RIVER
UPSTREAM OSIS
DOWNSTREAM OSIS
ACST
SCIOTO RIVER
BWO UPSTREAM
BWO DOWNSTREAM
BWO IN BBX
0066 FLOW
BIG RUN
JPWWTP WET WELL
JP MECH. BYPASS
JPWWTP TREATMENT INFLUENT
IJC
SWWTP MAX CAPACITY
440 MGD
(Click on value to change)
SWWTP TREATMENT INFLUENT
325.1 MGD
CEPT
65.1 MGD
Mech. Bypass
0.0 MGD
TOTALIZED FLOW
188.0 MGD
11/20/2020 13:29:25
2020-03-17 10:45
2020-03-23 10:45
Go
2020-03-19 18:30
Play
Stop
Historic
Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

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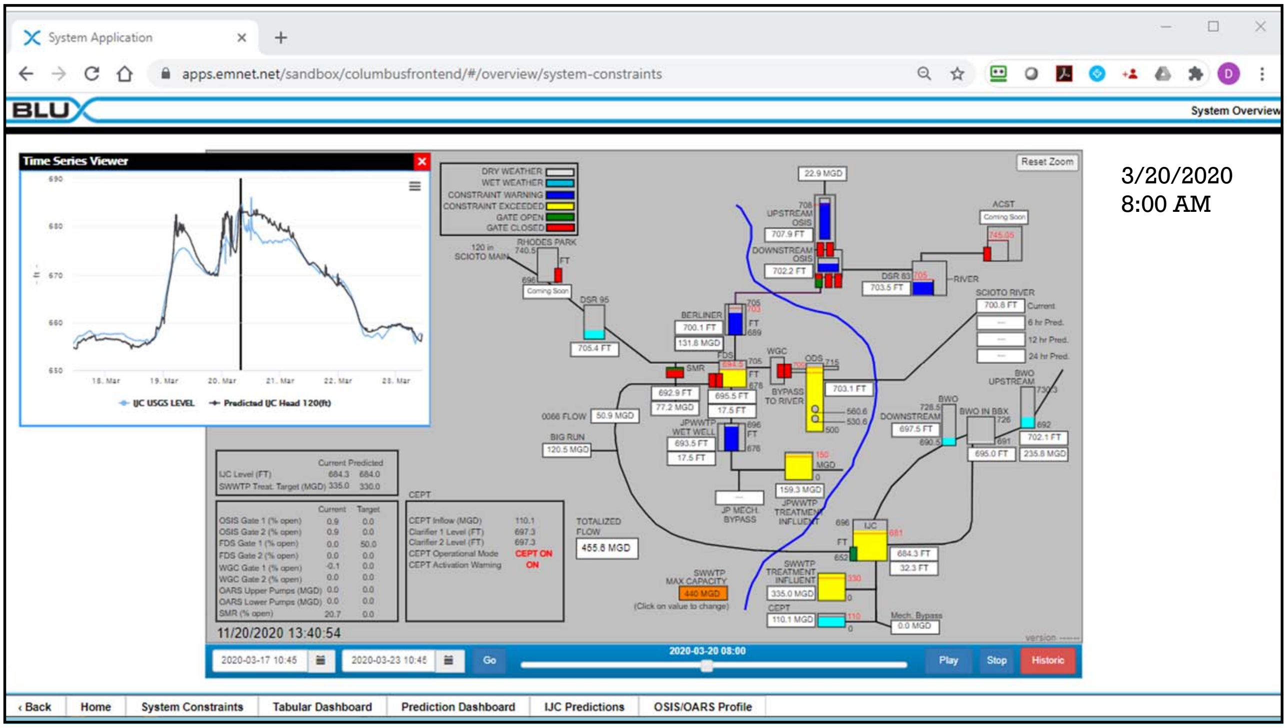
System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/system-constraints
BLU
System Overview
Time Series Viewer
IJC USGS LEVEL
Predicted IJC Head 120(ft)
Reset Zoom
3/20/2020
8:00 AM
11/20/2020 13:40:54
2020-03-17 10:45
2020-03-23 10:45
Go
2020-03-20 08:00
Play
Stop
Historic
‹ Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

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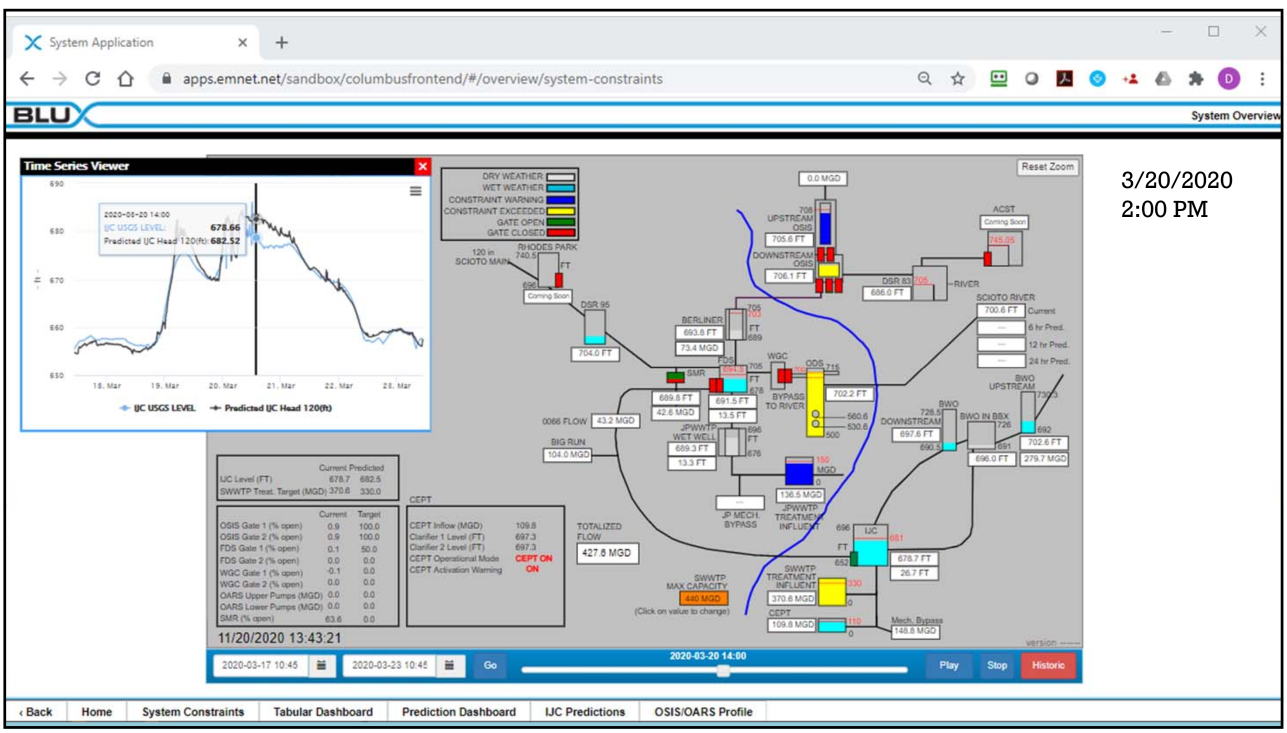
System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/system-constraints
BLU
System Overview
Time Series Viewer
IJC USGS LEVEL
Predicted IJC Head 120(ft)
Reset Zoom
3/20/2020
2:00 PM
11/20/2020 13:43:21
2020-03-17 10:45
2020-03-23 10:45
Go
2020-03-20 14:00
Play
Stop
Historic
‹ Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

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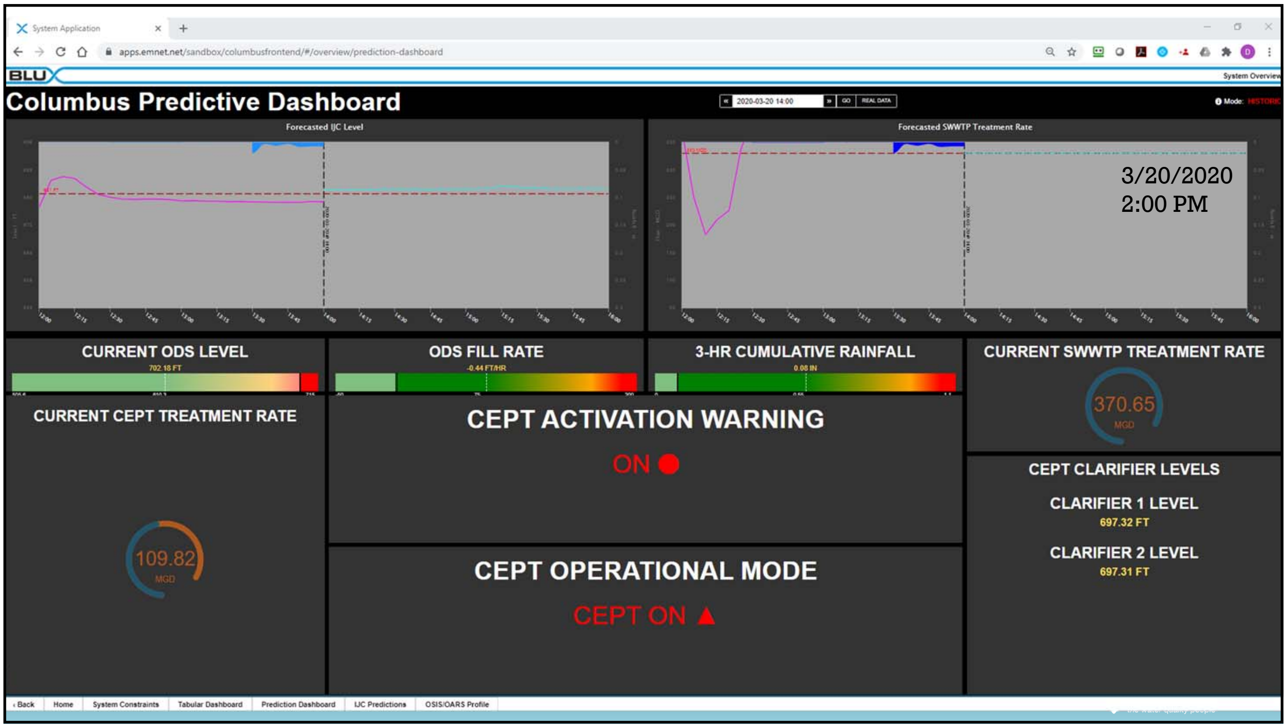
System Application
apps.emnet.net/sandbox/columbusfrontend/#/overview/prediction-dashboard
Columbus Predictive Dashboard
Forecasted IJC Level
Forecasted SWWTP Treatment Rate
3/20/2020
2:00 PM
CURRENT ODS LEVEL
702.18 FT
ODS FILL RATE
-0.44 FT/HR
3-HR CUMULATIVE RAINFALL
0.08 IN
CURRENT SWWTP TREATMENT RATE
370.65
MGD
CURRENT CEPT TREATMENT RATE
109.82
MGD
CEPT ACTIVATION WARNING
ON
CEPT OPERATIONAL MODE
CEPT ON
CEPT CLARIFIER LEVELS
CLARIFIER 1 LEVEL
697.32 FT
CLARIFIER 2 LEVEL
697.31 FT
Back
Home
System Constraints
Tabular Dashboard
Prediction Dashboard
IJC Predictions
OSIS/OARS Profile

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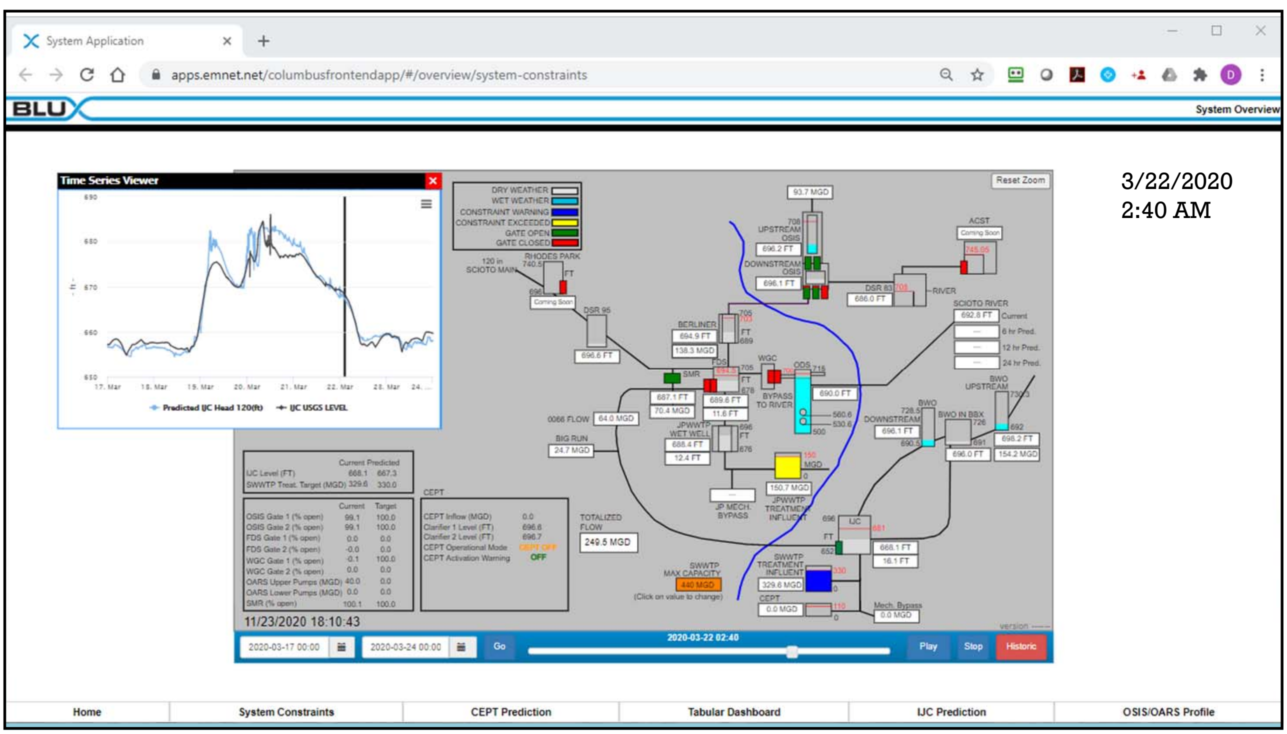
System Application
apps.emnet.net/columbusfrontendapp/#/overview/system-constraints
System Overview
Time Series Viewer
Predicted IJC Head 120(ft)
IJC USGS LEVEL
Reset Zoom
3/22/2020
2:40 AM
DRY WEATHER
WET WEATHER
CONSTRAINT WARNING
CONSTRAINT EXCEEDED
GATE OPEN
GATE CLOSED
TOTALIZED FLOW
249.5 MGD
SWWTP MAX CAPACITY
440 MGD
(Click on value to change)
11/23/2020 18:10:43
2020-03-17 00:00
2020-03-24 00:00
Go
2020-03-22 02:40
Play
Stop
Historic
Home
System Constraints
CEPT Prediction
Tabular Dashboard
IJC Prediction
OSIS/OARS Profile

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Observations – March 18 Event

- Southerly IJC 2-Hour Prediction was excellent
  - Sensor reliability can be improved
- CEPT predicted 5 hours in advance
  - Provided plant staff with time to get the facility online
- No overflow in the first wave of the event
  - Substantial volume of flow was diverted to Southerly
- Overall, secondary treatment is maximized by balancing flow between JP and Southerly
  - CEPT activation warning turns off as system is dewatering

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Outcomes and Conclusions

- The RT-DSS is the first time plant staff have had quantifiable forecasts for their complex system
- Integrating real time data with live models yields highly accurate predictions to inform operations
- Xylem decision intelligence has helped the City avoid overflows and maximize utilization of the community's massive investments

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THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR
DEPARTMENT OF PUBLIC UTILITIES

Dax J Blake, PE
dax.blake@xyleminc.com

+1 614.205.2476

xylem
Let's Solve Water

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Introduction

Erin K Rothman, CEO

STORMSENSOR®
A CLIMATE TECHNOLOGY COMPANY

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Get Your Mind in the Gutter: Adding Intelligence to Optimize Wastewater Management in Combined and Separate Systems

Applications in Jersey City and Boston

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UNLIMITED APPLICATIONS—WITH THREE KEY USE CASES

- Urban Flooding & Water-Level Rise
- Critical Infrastructure & Maintenance
- Stormwater Model Validation

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RETURN ON INVESTMENT IN DATA SERVICES

Quantifying the impact of data for cities' bottom lines

Use Case	ROI	Years to Recover Costs
Urban Flooding	4.0 to 6.6	0.2
Combined Sewer Overflows	4.8 to 5.7	0.4
Sanitary Sewer Overflows	9.0 to 12.3	0.1
Sea Level Rise	12.6	0.1
Operations & Maintenance	4.0	0.7

**Typically second order; costs and benefits include those associated with mitigation efforts*

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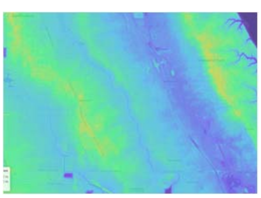
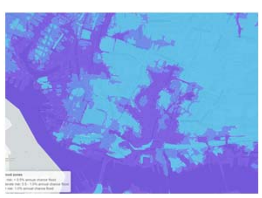
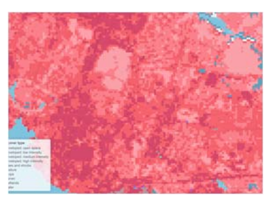
FLOOD RISK FACTORS



Elevation. Historically, the higher the elevation, the lower the risk of flooding. With heavier and more frequent storms, however, this is changing, and elevation is just one component of flood risk.



Mapped flood zones. Areas located within flood zones and that have >0.2% chance of flooding in a given year are generally higher risk than areas located at high elevations. However, many of our flood maps are outdated, so they only tell part of the story.



Land use/land cover (LULC). Although weather and climate are the main drivers of flooding, changes in land cover can also influence the occurrence and frequency of floods by changing the responsiveness of river flows to rainfall.

Impervious surface. Impervious/paved surfaces cause runoff to reach streams faster, and at greater quantities, dramatically enhancing the frequency and intensity of flooding in adjoining communities.

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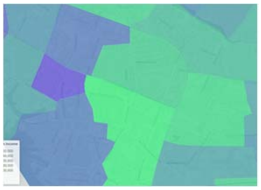
FLOOD RISK FACTORS



Median income. Full impacts of floods include more than property and infrastructure damage. Health, services, and jobs are impacted as well. Low-income communities are more often located in flood-prone areas and less able to recover quickly.

Population. Areas with more people tend to see the greatest cost impacts of flooding, with damages to homes, businesses, and infrastructure. Mental and physical health are often secondary risks associated with flooding.

Population density. Areas with more population density tend to be more prone to flood disasters as a result of several factors, including land use changes and greater impervious surfaces.

History. Much of the wastewater and stormwater infrastructure in the U.S. is reaching the end of its useful life. Older pipes have a higher risk of blockages, I/I, and collapse, and are often prioritized for upcoming capital improvements.

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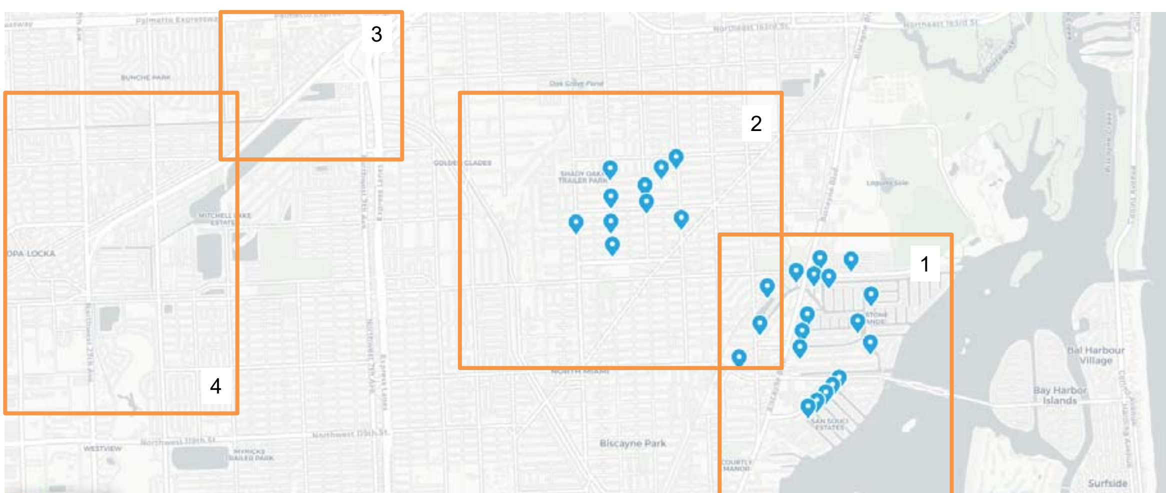
ACTUAL NETWORKS INSTALLED BASED ON RISK ASSESSMENT



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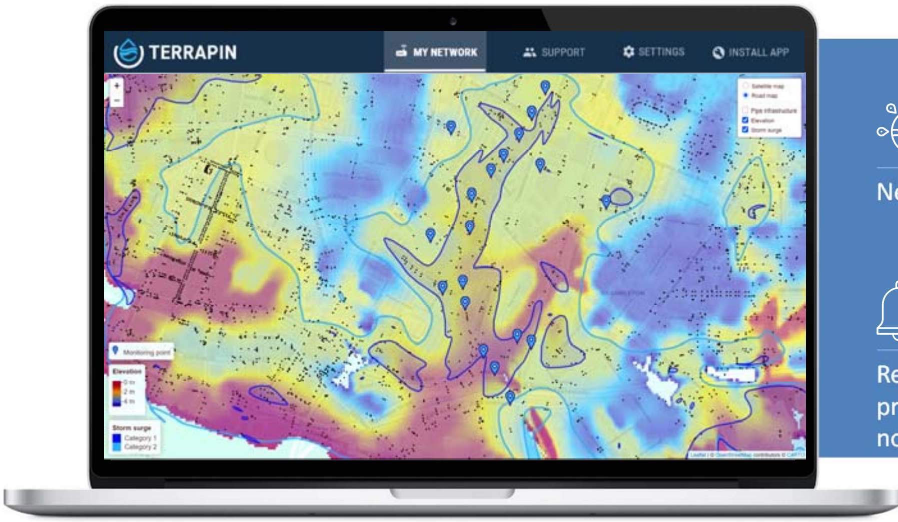
TERRAPIN-ADVANCED INSIGHTS (AI)



Networked sensors

Real-time & predictive system notifications

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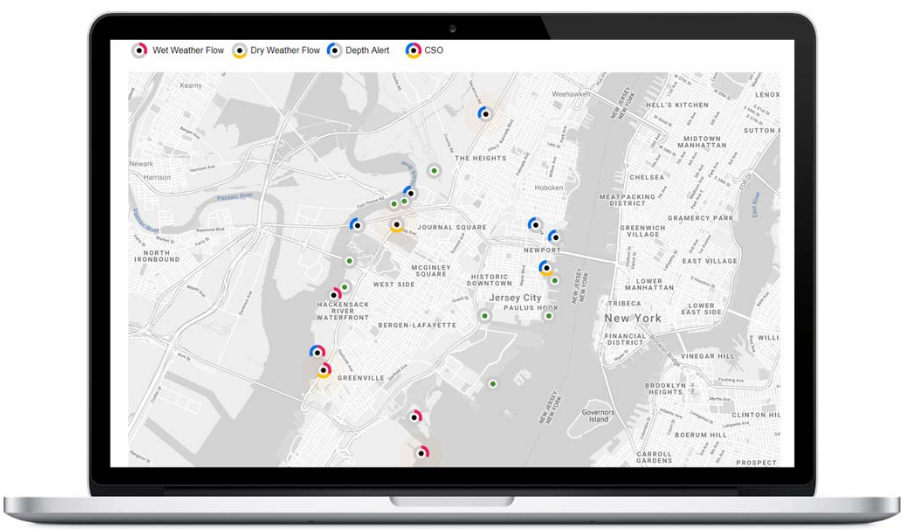
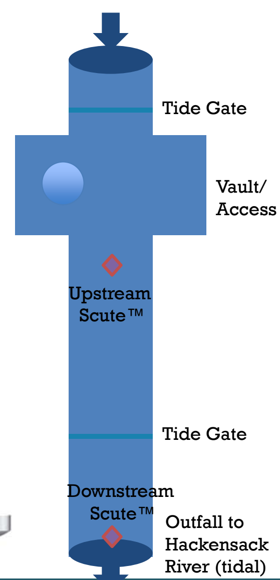
CASE STUDY 1: CSO TRACKING IN JERSEY CITY





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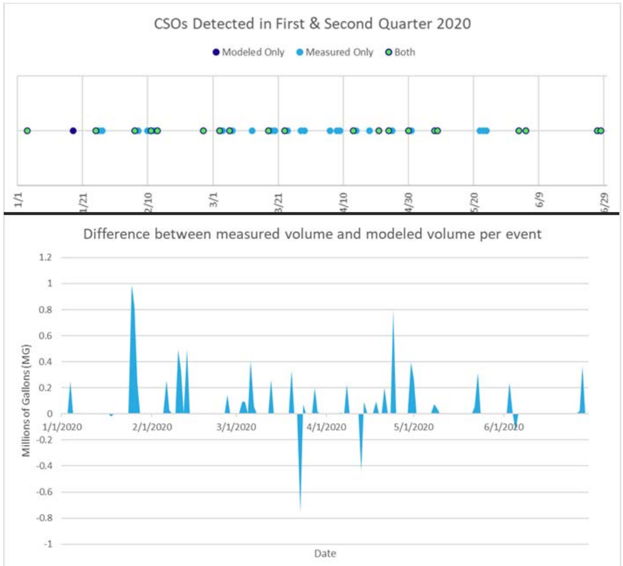
CASE STUDY 1: CSO TRACKING IN JERSEY CITY



The ***frequency*** of CSOs measured by StormSensor® exceeded the frequency of CSOs modeled by 2x.

The ***volume*** of CSOs measured by StormSensor® = 16.05 MG, compared to the 10.39 MG modeled over 2 quarters at one outfall.

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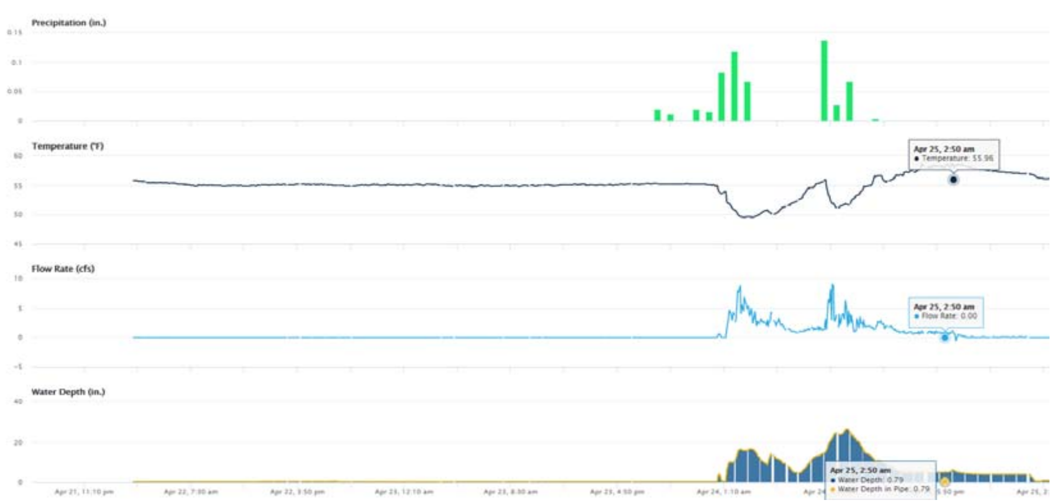
CASE STUDY 1: CSO TRACKING IN JERSEY CITY



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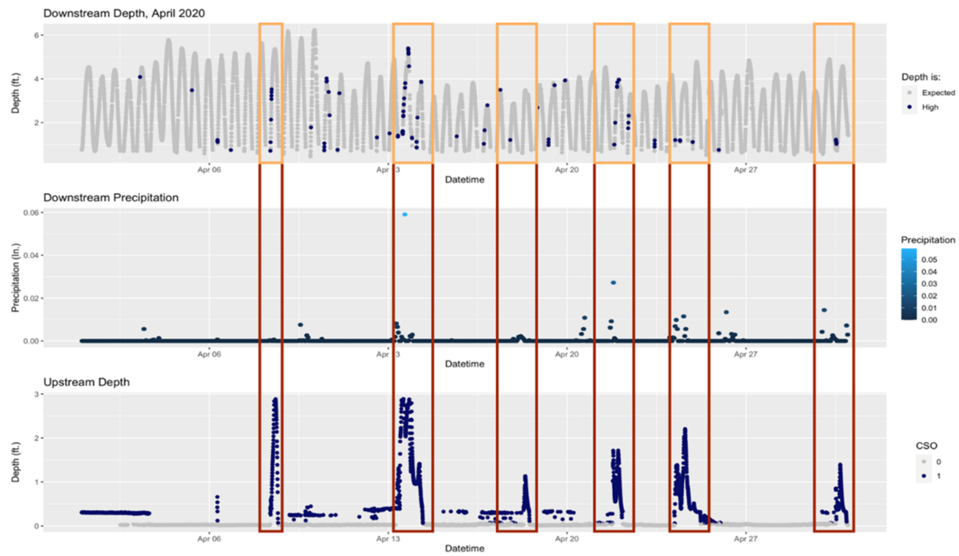
CASE STUDY 1: CSO TRACKING IN JERSEY CITY



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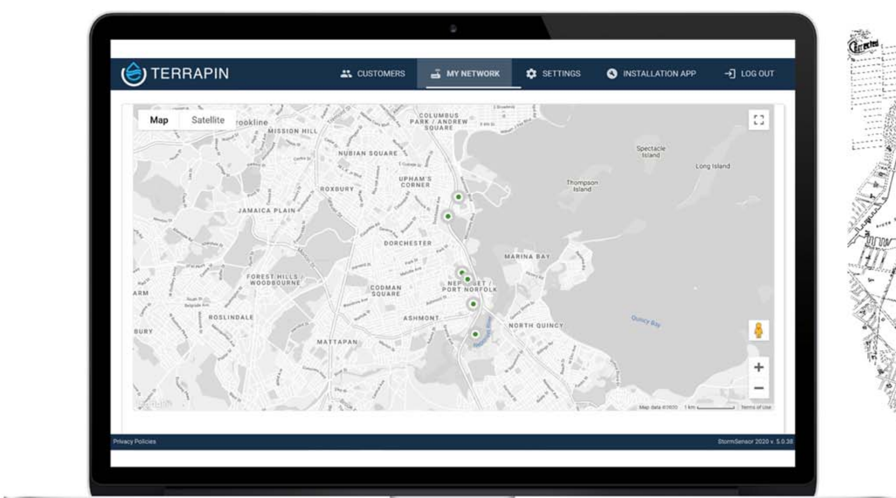
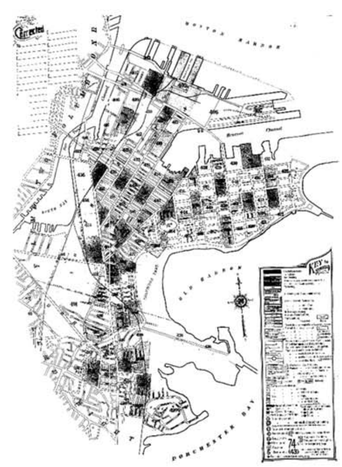
CASE STUDY 2: I/I IN A NEWLY-SEPARATED SANITARY INTERCEPTOR LINE





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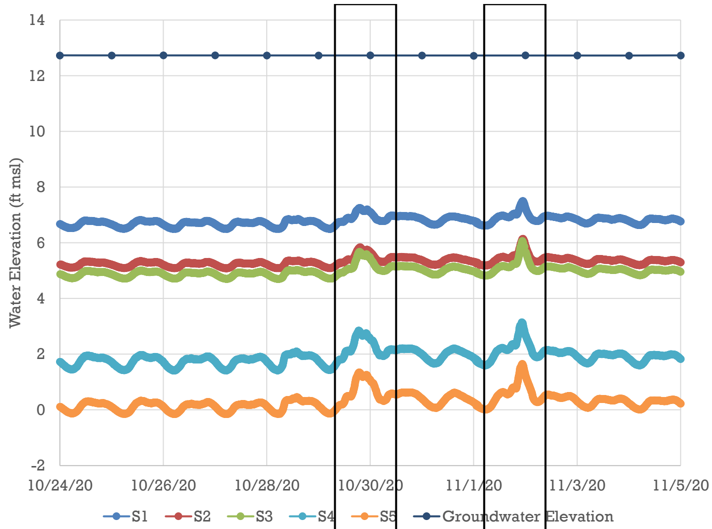
CASE STUDY 2: I/I IN A NEWLY-SEPARATED SANITARY INTERCEPTOR LINE



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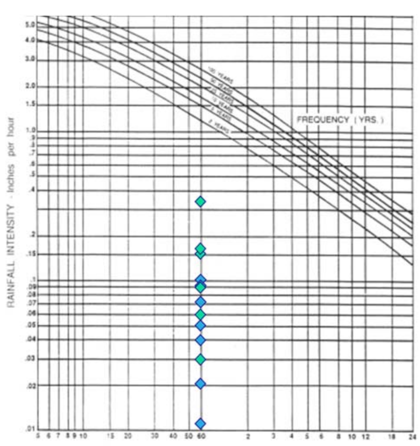
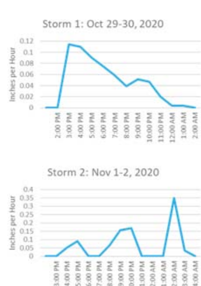
CASE STUDY 2: I/I IN A NEWLY-SEPARATED SANITARY INTERCEPTOR LINE





	S1	S2	S3	S4	S5
Storm 1	2.44	2.17	3.46	7.07	6.87
Baseflow 1	1.66	1.01	1.81	3.07	1.99
Inflow, Storm 1	*0.78*	*1.16*	*1.66*	*4.00*	*4.88*
Storm 2	2.26	1.84	2.64	4.66	4.93
Baseflow 2	1.60	1.17	1.81	2.60	2.66
Inflow, Storm 2	*0.66*	*0.67*	*0.83*	*2.06*	*2.27*
Total Inflow	**1.43**	**1.83**	**2.49**	**6.06**	**7.16**

data presented in millions of gallons (MG)

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Questions?

Thank you for joining us today!

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