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**Evaluating River-Influenced
Groundwater Infiltration and Sewer
Rehabilitation Effectiveness**

Hazen

Agenda

- Background
- Flow Monitoring Analysis
- Representing River-Influenced Infiltration
- Model Calibration
- Capacity Analysis
- Sewer Rehabilitation Effectiveness
- Conclusions

Miami Shores LS Study Area

Montgomery County, OH

- 575 acres
- 10 miles gravity sewer
- 1,400 customers
- 0.90 MGD ADF

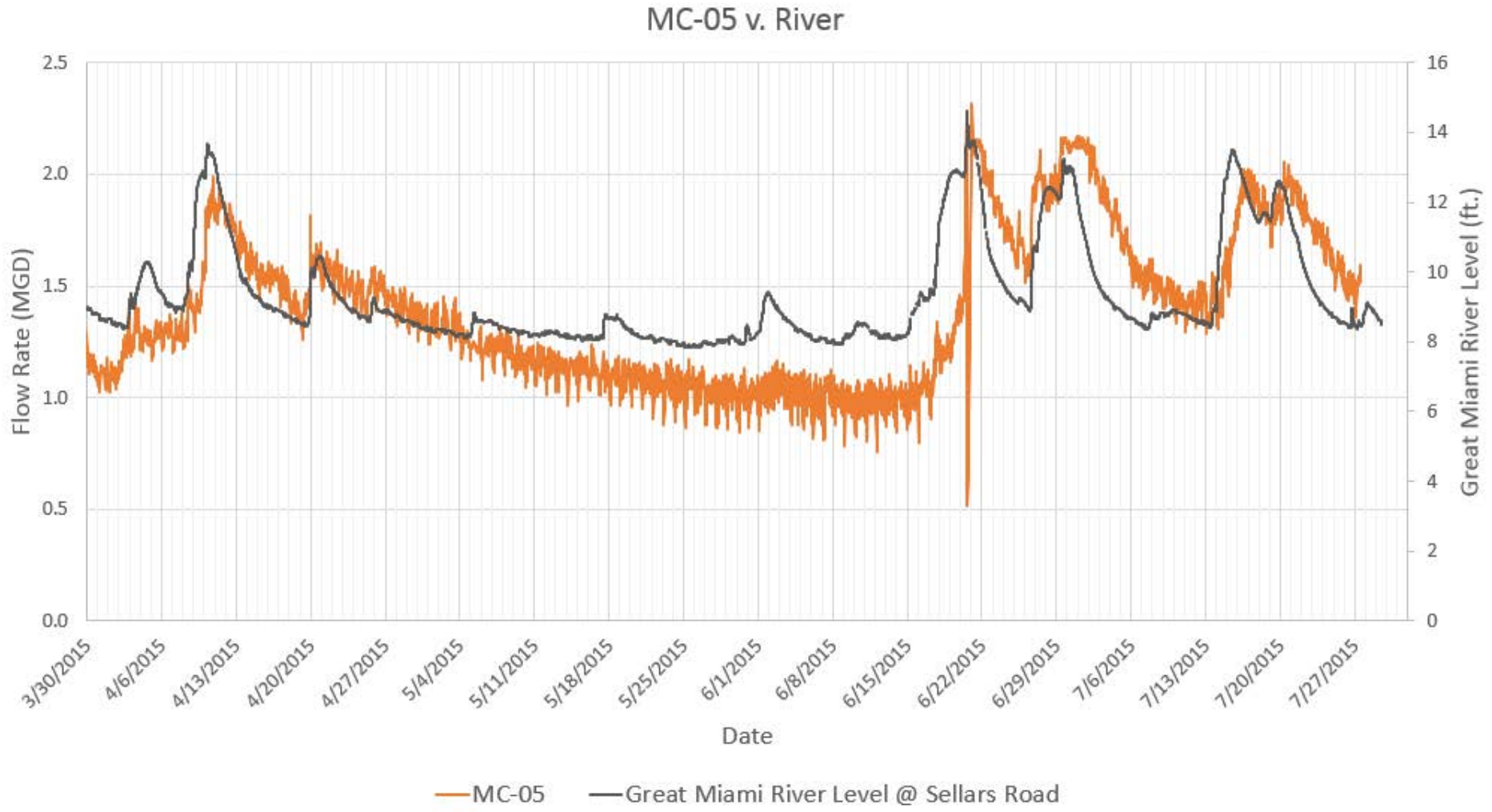


Miami Shores LS

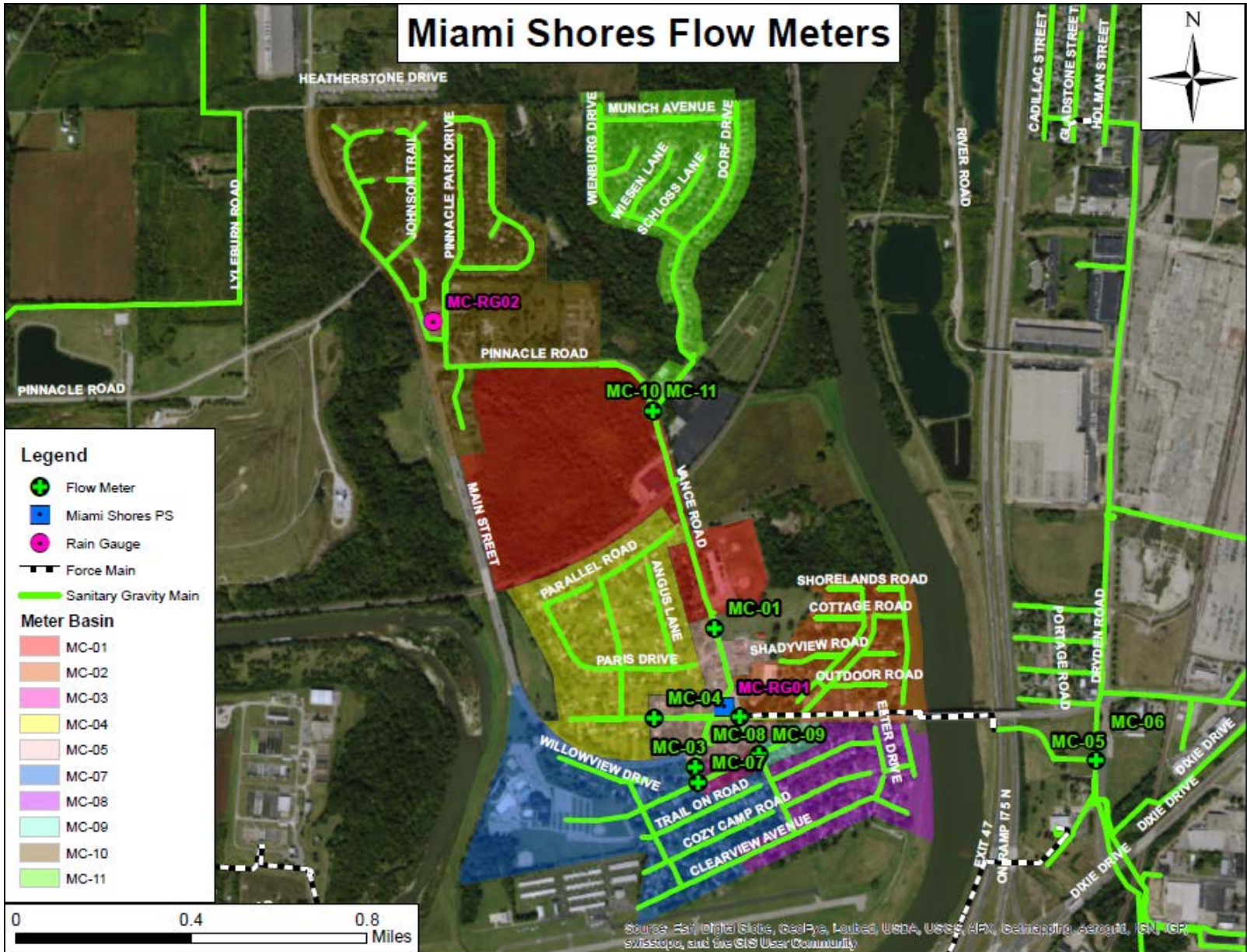
- Significant I/I upstream due to high groundwater exceeding LS capacity.
- Only 1 pump operated at a time due to electrical and force main capacity limitations
- Some sewers upstream/downstream of LS undersized
- Sewer and manhole rehab work previously done upstream of LS



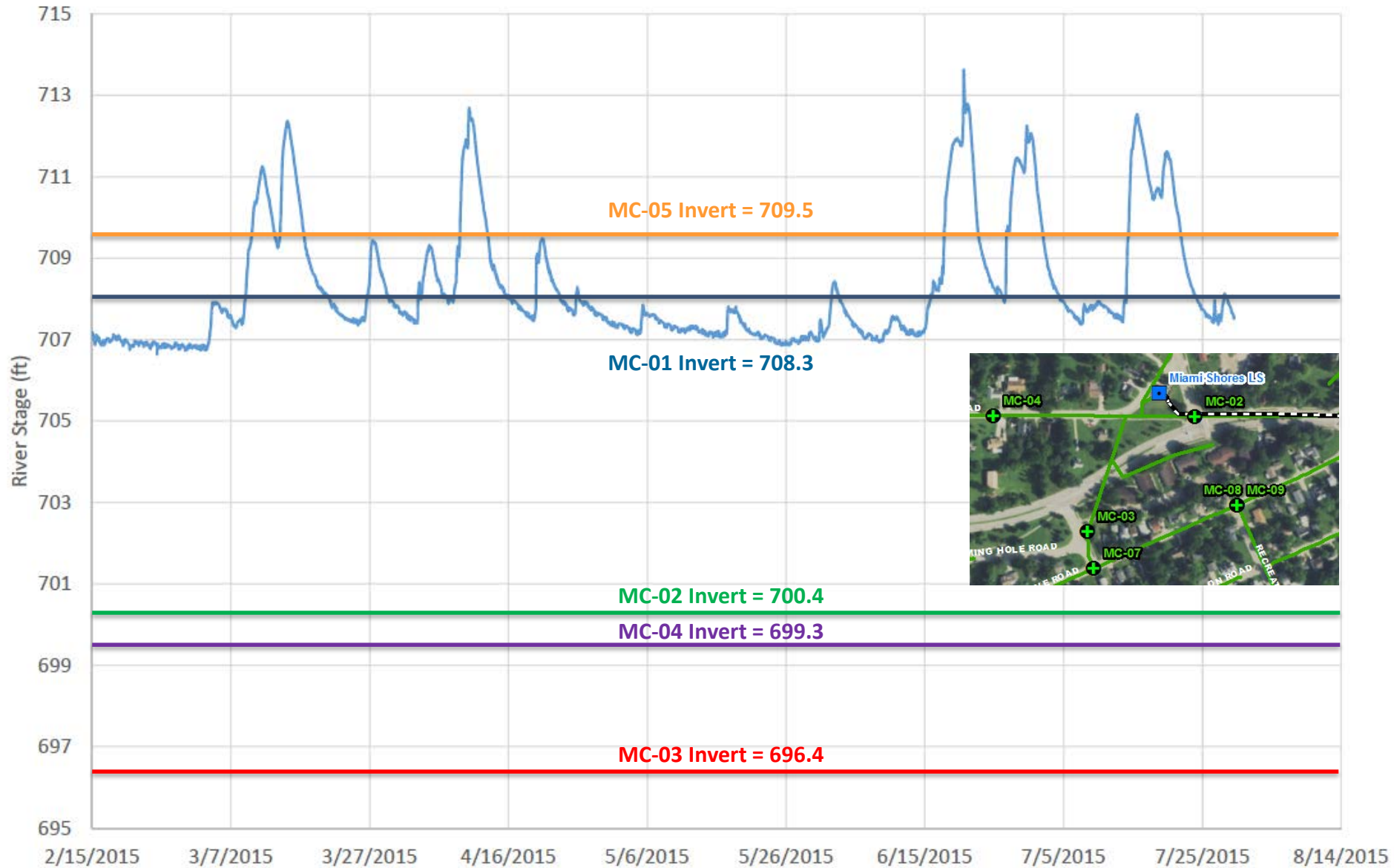
Miami Shores LS Flow Rate



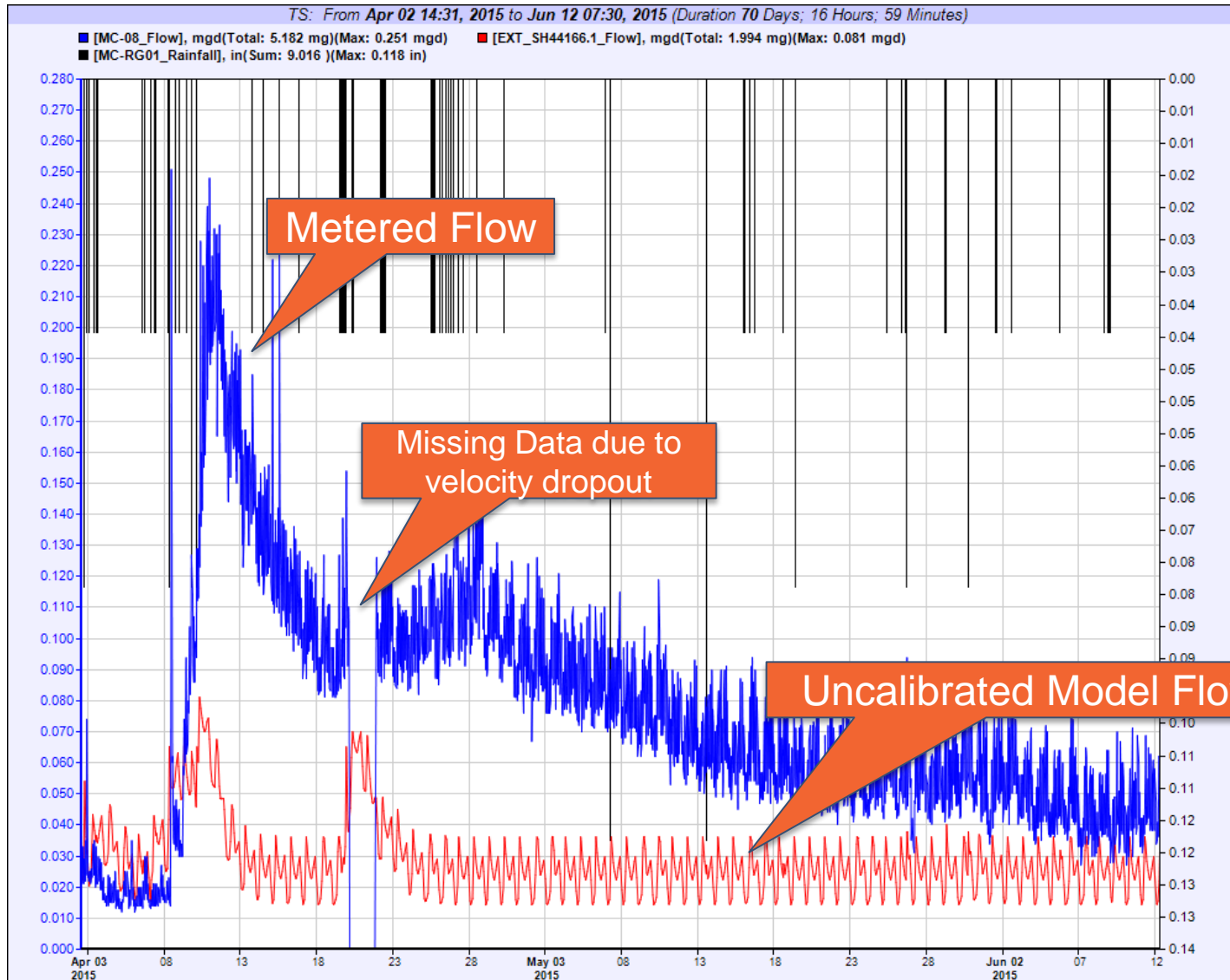
Miami Shores Flow Meters



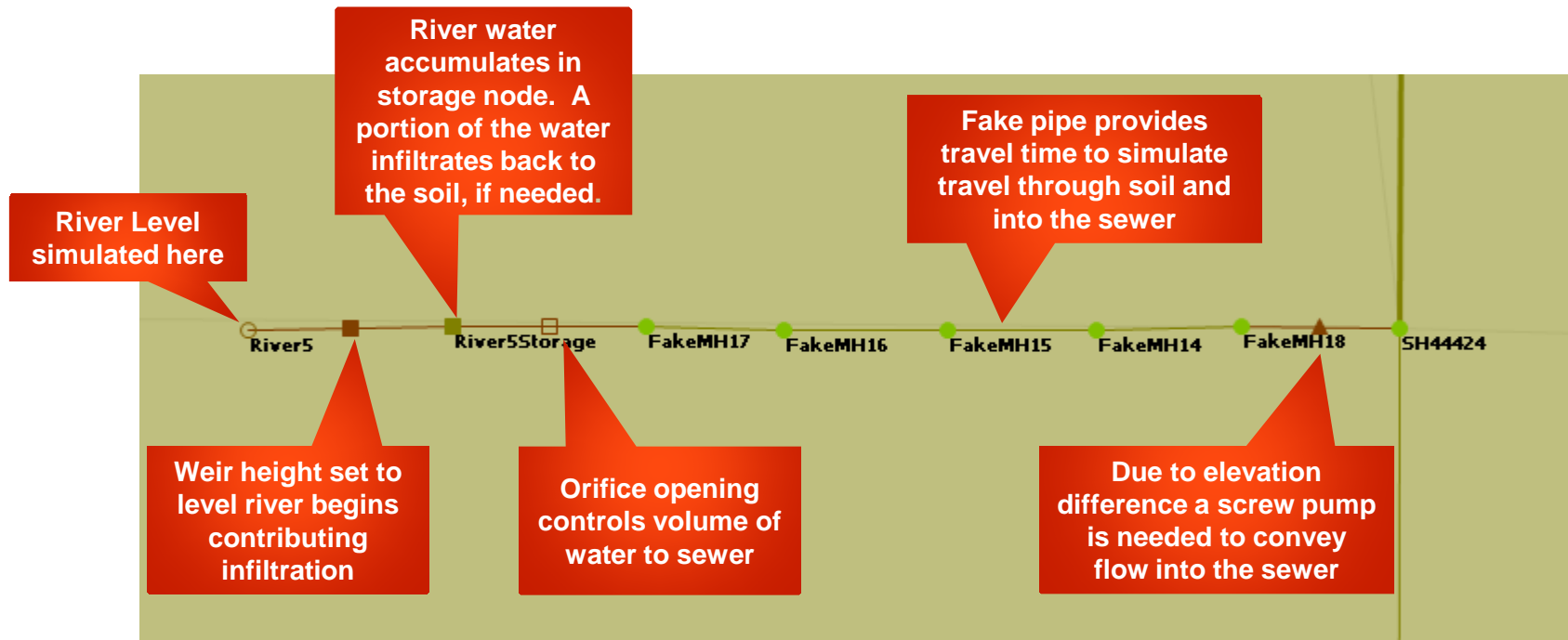
USGS 03271207 – Great Miami River at Sellars Rd.



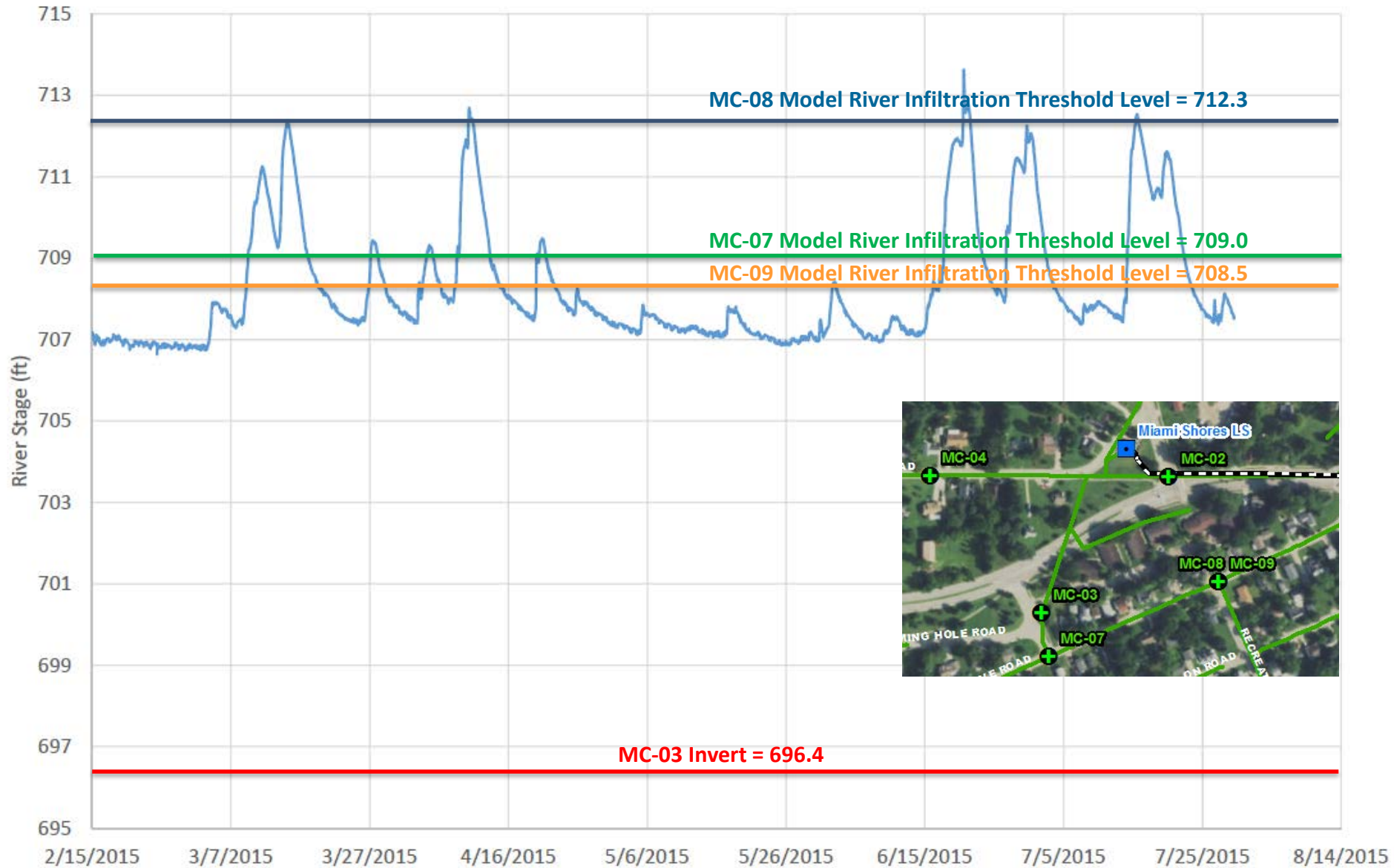
River-Influenced Infiltration – MC-08



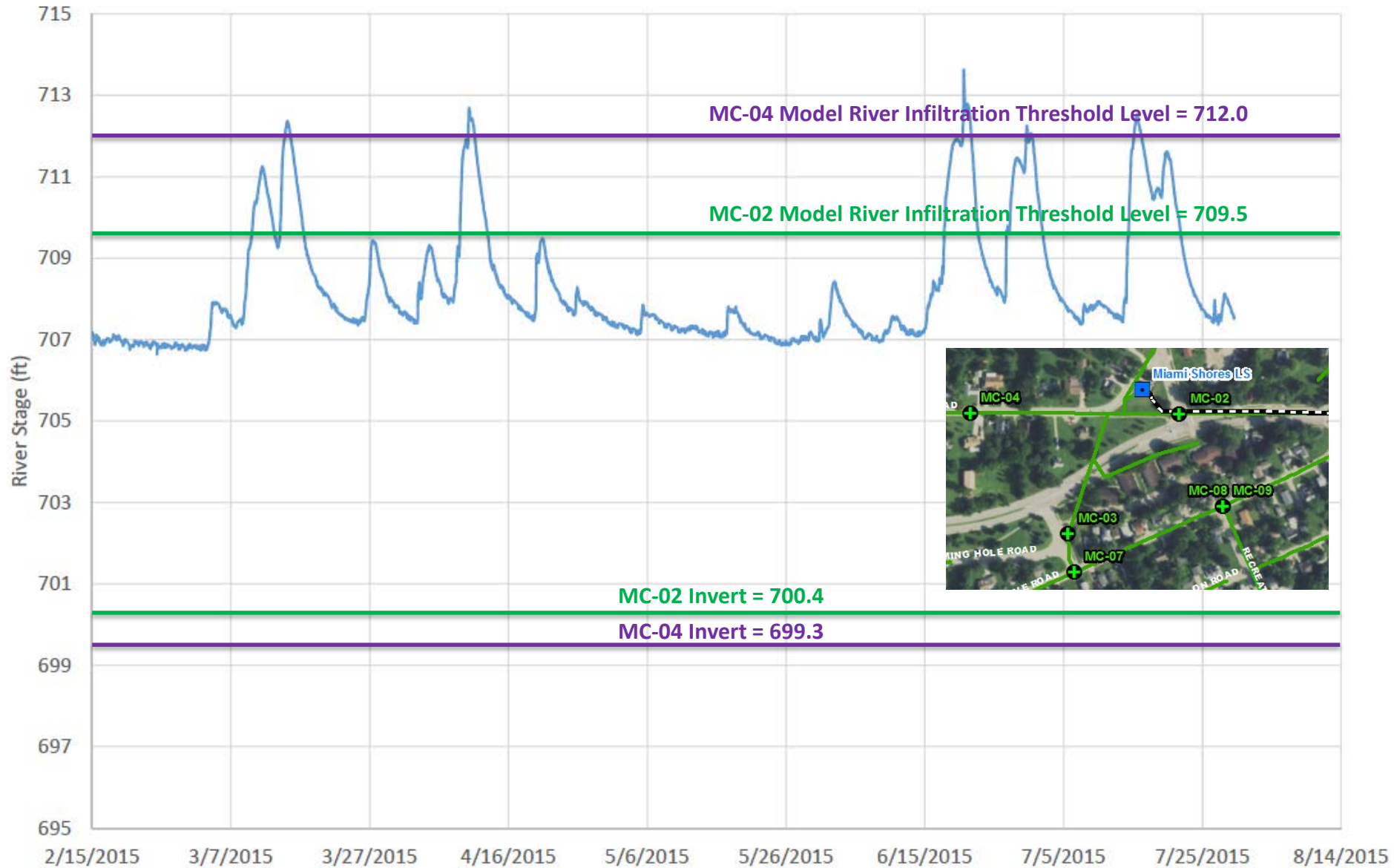
Model Representation of River Influence



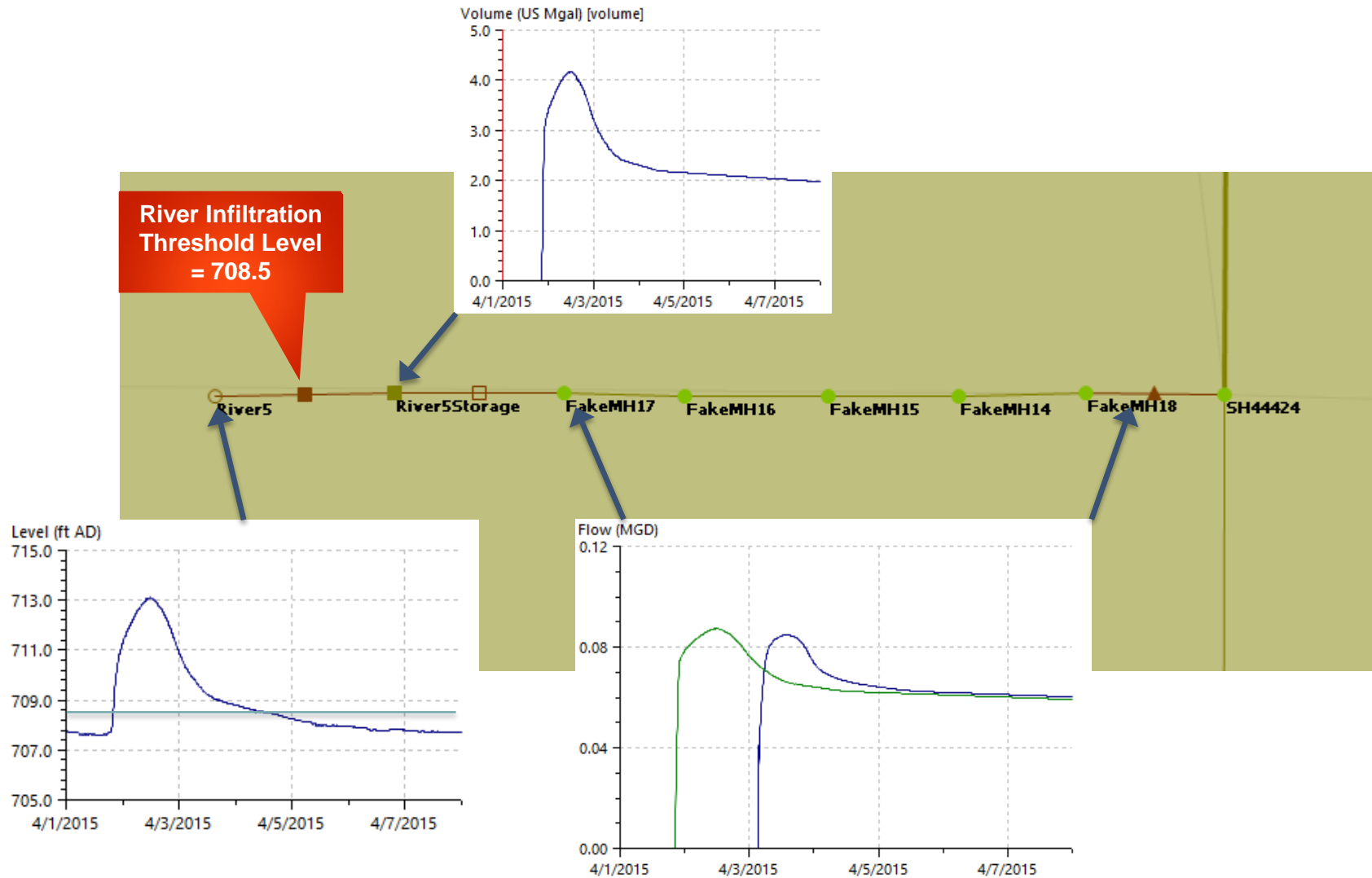
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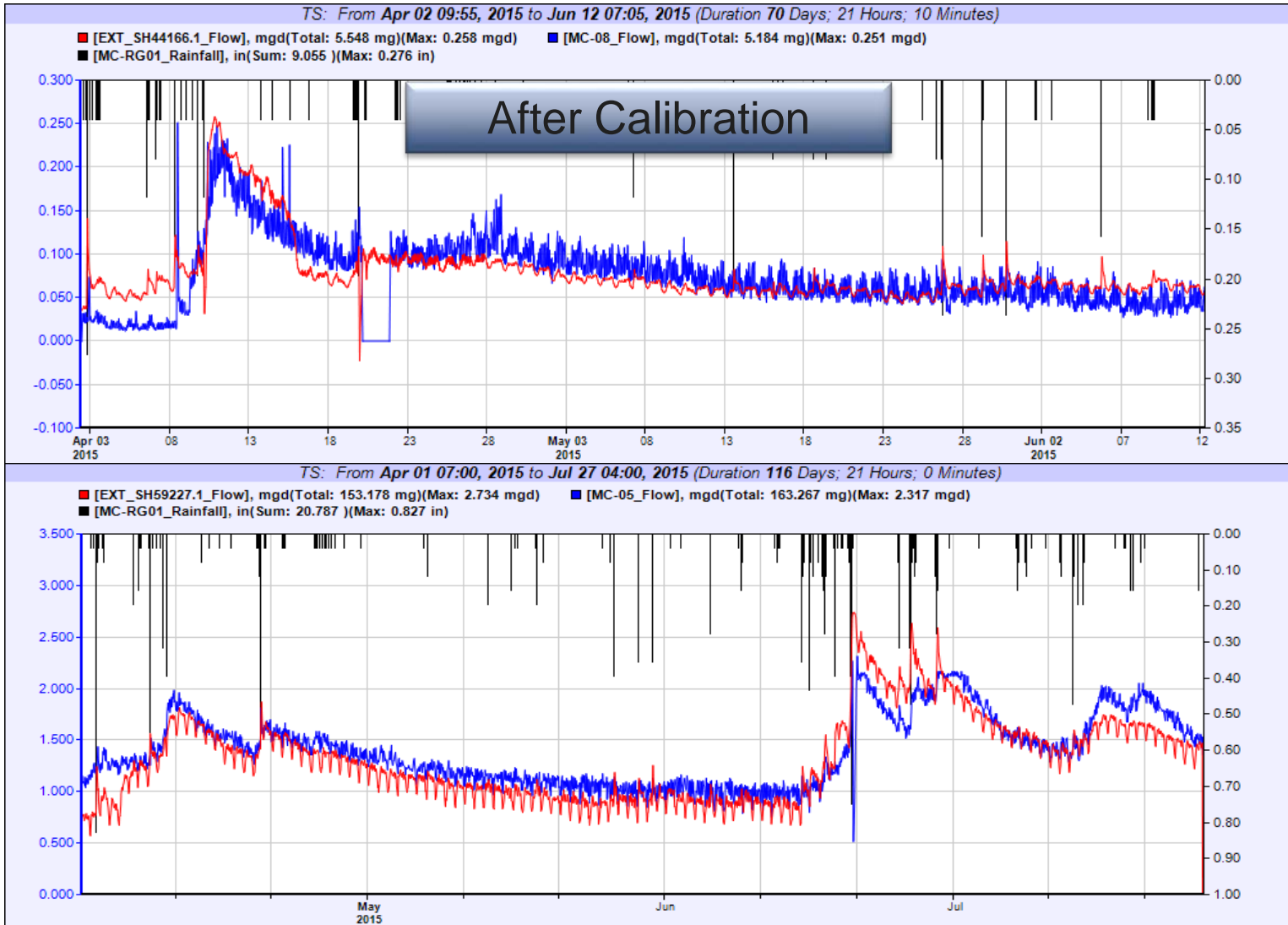
Model Representation of River Influence – MC-09



Wet Weather Model Calibration Results

Flow Meter	Model Volume (MG)	Meter Volume (MG)	% Difference	Model Peak Flow (MGD)	Meter Peak Flow (MGD)	% Difference	Model Level (ft.)	Meter Level (ft.)	Difference (ft.)
April 10 – May 25, 2015 (high river levels)									
MC-01	14.76	11.43	+29%	0.62	0.79	-22%	0.47	0.88	-0.41
MC-02	3.41	3.81	-10%	0.226	0.225	0%	0.34	0.39	-0.05
MC-03	Bad Meter Data								
MC-04	1.03	0.91	+13%	0.08	0.09	-11%	0.18	0.25	-0.07
MC-05	51.44	60.35	-15%	1.90	2.22	-14%	0.80	0.79	0.01
MC-07	21.59	18.91	+14%	0.73	0.70	+4%	5.09	5.09	0.01
MC-08	3.91	4.05	-3%	0.26	0.25	+4%	3.99	3.87	0.11
MC-09	4.70	4.09	+15%	0.16	0.37	-57%	1.98	1.81	0.17
June 19 – June 22, 2015 (nearly 2YR6HR storm)									
MC-01	1.69	1.48	+14%	1.22	1.00	+22%	1.32	0.84	0.48
MC-02	0.51	0.48	+6%	0.35	0.27	+30%	0.69	0.40	0.29
MC-03	3.27	2.83	+16%	1.37	1.44	-5%	8.90	6.17	2.72
MC-04	0.10	0.07	+43%	0.08	0.10	-20%	1.82	0.22	1.60
MC-05	5.49	4.92	+12%	2.42	2.60	-7%	8.42	10.71	-2.29
MC-10	0.86	0.74	+16%	1.29	1.25	+3%	0.33	0.46	-0.14
MC-11	0.79	0.66	+20%	0.63	0.47	+34%	1.04	0.91	0.13
June 28 – July 26, 2015 (high river levels)									
MC-01	10.77	8.51	+27%	1.05	0.71	+48%	0.73	0.55	0.18
MC-02	4.39	4.44	-1%	0.26	0.30	-13%	0.35	0.44	-0.09
MC-03	25.90	25.46	+2%	1.18	1.26	-6%	5.91	6.94	-1.04
MC-04	1.34	1.40	-4%	0.09	0.12	-25%	0.18	0.22	-0.03
MC-05	42.79	48.86	-12%	2.40	2.30	+4%	0.80	0.80	0.00
MC-10	6.39	6.72	-5%	0.76	0.47	+62%	0.24	0.25	-0.01
MC-11	4.00	4.05	-1%	0.37	0.51	-27%	0.59	0.51	0.08

MC-05 & MC-08 Calibration Results



Miami Shores Modeled I/I

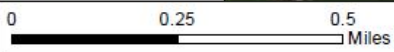


Legend

- Miami Shores PS
- Sanitary Gravity Main
- Force Main

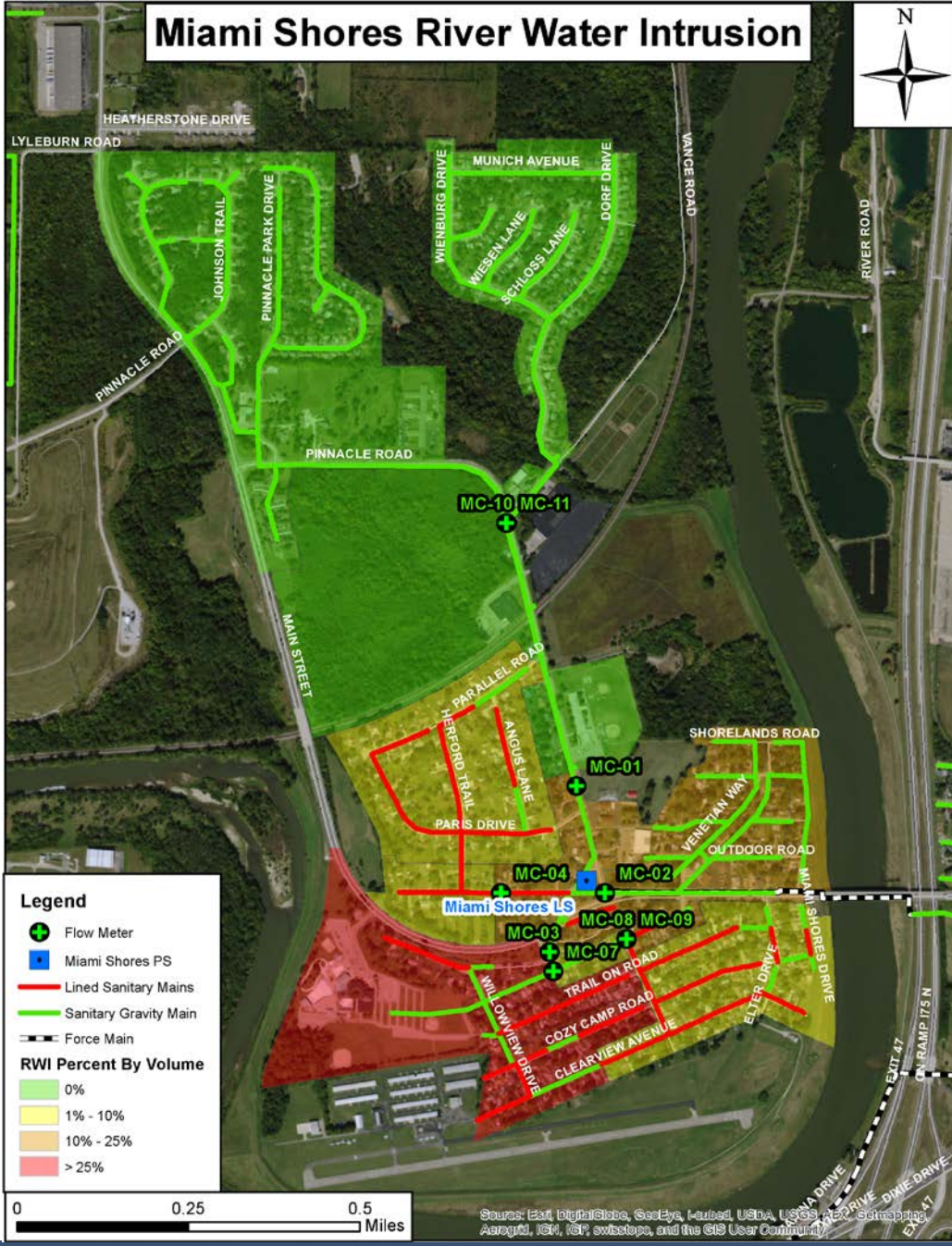
Model R-Value

- < 2%
- 2% - 5%
- 5% - 10%
- > 10%



Source: Esri, DigitalGlobe, GeoEye, Earthstar (USA), USGS, AeroGRID, IGN, SIA, Airphoto, and the G.I.S. User Community

Miami Shores River Water Intrusion

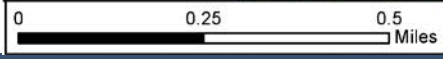


Legend

- Flow Meter
- Miami Shores PS
- Lined Sanitary Mains
- Sanitary Gravity Main
- Force Main

RWI Percent By Volume

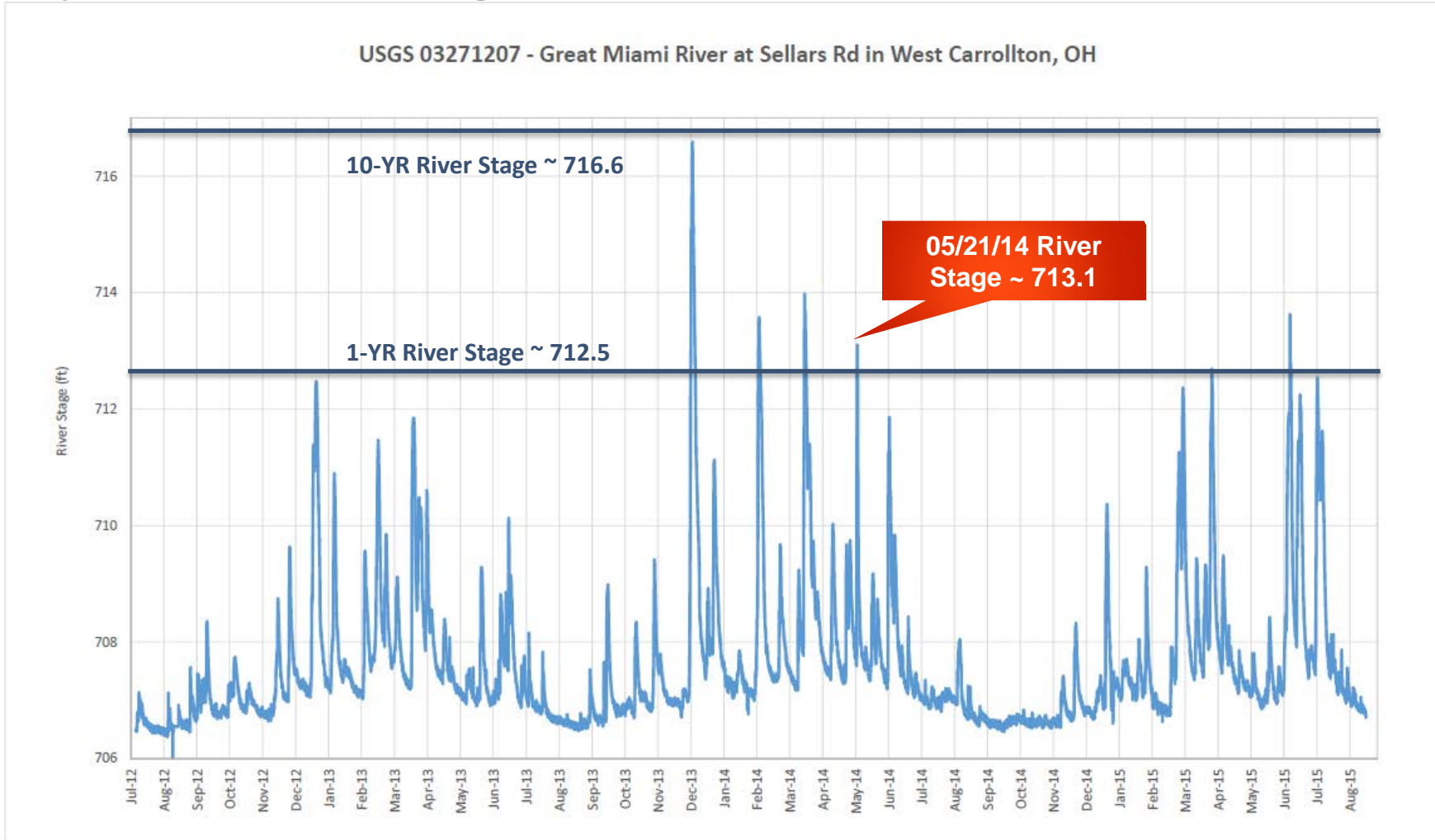
- 0%
- 1% - 10%
- 10% - 25%
- > 25%



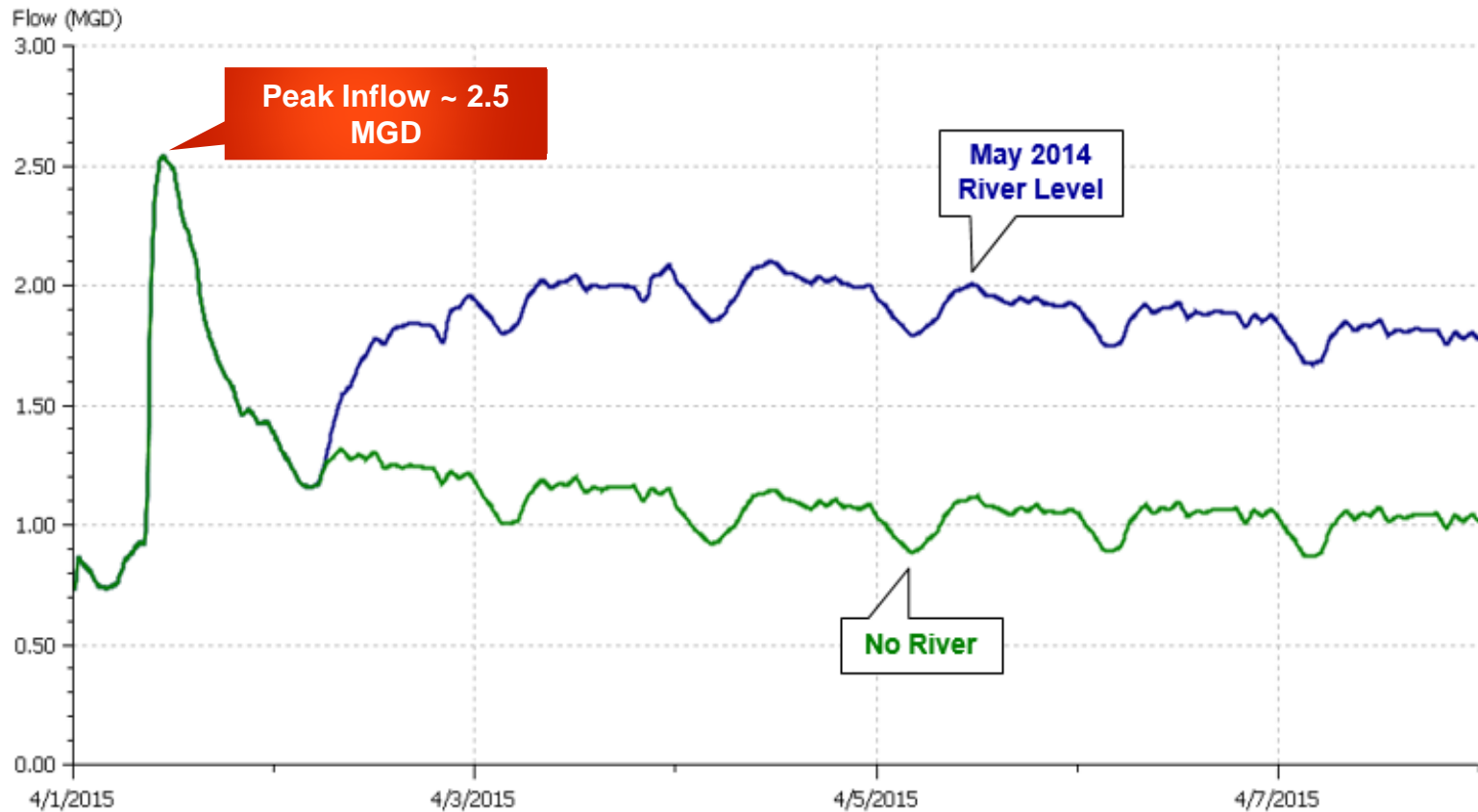
Source: Esri, DigitalGlobe, GeoEye, Earthstar (USA), USGS, AeroGRID, IGN, iSat, Swisstopo, and the GIS User Community

Capacity Analysis River Level

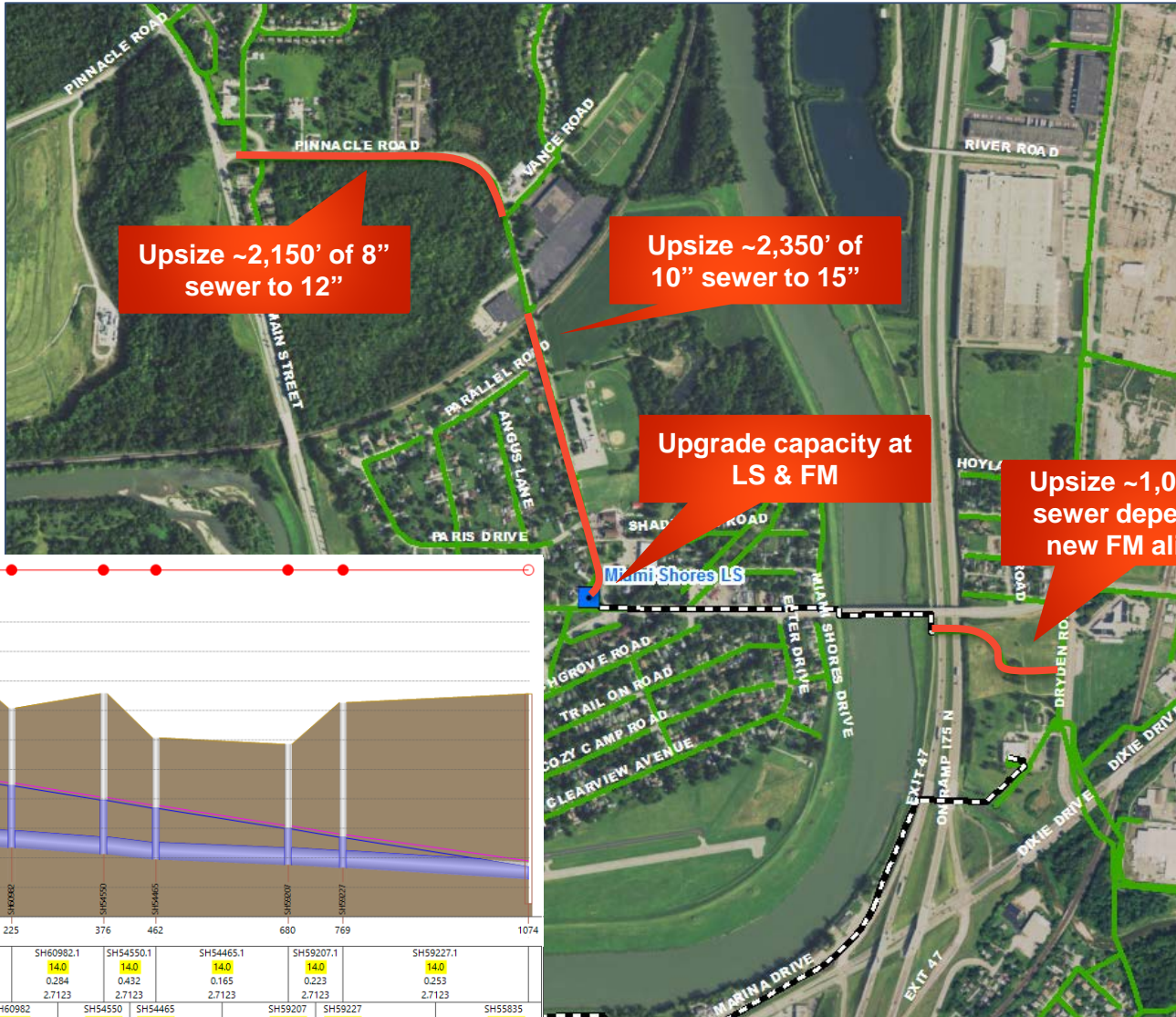
May 21, 2014 ~ 5YR River Stage



Miami Shores 5YR6HR Influent



Capacity Limited Areas – 5YR6HR



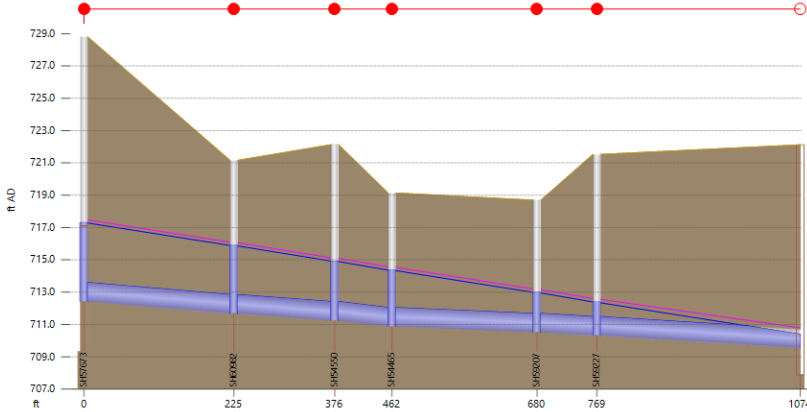
Upsize ~2,150' of 8" sewer to 12"

Upsize ~2,350' of 10" sewer to 15"

Upgrade capacity at LS & FM

Upsize ~1,050' of 14" sewer depending on new FM alignment

Miami Shores LS



Link	SH57673.1	SH60982.1	SH54550.1	SH54465.1	SH59207.1	SH59227.1	
width (in)	14.0	14.0	14.0	14.0	14.0	14.0	
grad (%)	0.333	0.284	0.432	0.165	0.223	0.253	
DS flow (MGD)	2.7123	2.7123	2.7123	2.7123	2.7123	2.7123	
Node	SH57673	SH60982	SH54550	SH54465	SH59207	SH59227	SH55835
ground (ft. AD)	728.800	721.160	722.130	719.140	718.700	721.530	722.120

Miami Shores LS Peak Inflows

5YR6HR Design Storm

Scenario	Peak Flow (MGD)
Existing Pipes, Existing Flows	2.54
Upsized Vance Rd, Existing Flows	2.75
Existing Pipes, Future Flows	2.82
Upsized Vance Rd, Future Flows	3.03

Notes:

- 1) DARF = 0.94 (same as Master Plan), antecedent rainfall = 3.5"
- 2) GWI SSD initially 5% below threshold (same as Master Plan)
- 3) Model simulation used outfall upstream of Miami Shores LS
- 4) Assuming sewer blockage upstream of Miami Shores LS is removed
- 5) Existing pipes used (not open system)
- 6) May 2014 River conditions
- 7) Required Vance Rd sewer upsizing is 12" for existing flows, 15" for future flows.

Capacity Evaluation Conclusions

- Unique approaches are required to model river-influenced infiltration.
- For this case, river water infiltration did not significantly impact system capacity limitations.

Sewer Rehabilitation Effectiveness

Prior Rehabilitation Efforts

- 14,600' of gravity sewer; 27 manholes upstream of Miami Shores LS.
- Full length CIPP with seals at each end
- Manholes lined with cementitious liner



Impact of Prior Rehabilitation Efforts

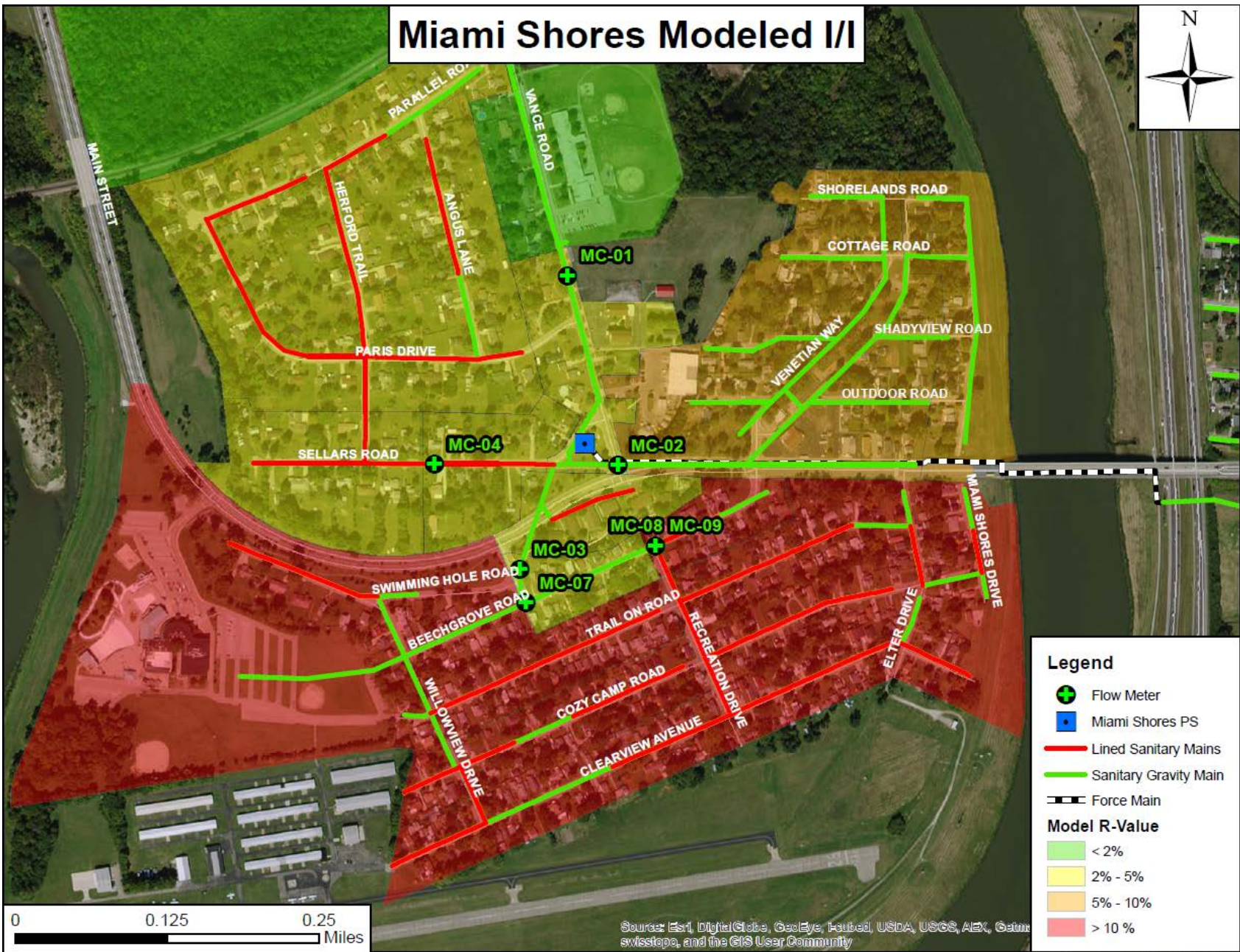
(14,600 ft. of sewer lined and 27 MHs rehabilitated)

- No flow data prior to rehab
- Pump run times not usable due to pump replacements and bypass pumping
- Prior rehabilitation appears effective at reducing RWI where >75% sewer length lined
- I/I (R-values and RWI) still high, even in most basins with < 75% lined sewers
- Other than grouting first 3', laterals were not rehabilitated, which reduced effectiveness

Miami Shores River Water Intrusion

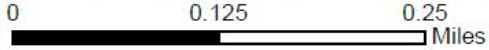


Miami Shores Modeled I/I



Legend

- Flow Meter
 - Miami Shores PS
 - Lined Sanitary Mains
 - Sanitary Gravity Main
 - Force Main
- Model R-Value**
- < 2%
 - 2% - 5%
 - 5% - 10%
 - > 10%



Source: Esri, DigitalGlobe, GeoEye, Earthstar, USBA, USGS, AEX, Getac, swisstopo, and the GIS User Community

Develop Comprehensive Rehabilitation Costs

Develop Meter Basin Statistics:

Meter Basin	Total Gravity Sewer (ft)	Percent Unlined Sewers (%)	Number of Manholes	Non-Rehabed Manholes (%)	Number of Services	Length of Laterals (ft)
MC-02	7,959	100%	39	90%	86	4,251

Determine Additional Rehabilitation Methods:

Meter Basin	Sewer Lining	Manhole Rehab	Full Lateral Rehab	Partial Lateral Rehab	Add Cleanouts	Remove Direct Connections	Anticipated Non River I/I Reduction (%)	Anticipated RWI Reduction (%)
MC-02	X	X	X		X	X	50%	50%

Calculate Rehabilitation Quantities:

Meter Basin	8" Sewer Lining (ft)	10" Sewer Lining (ft)	MH Chimney Seals & Solid Lids	MH Rehab (Vertical ft)	Lateral Rehab & Cleanout (Qty)	Lateral Rehab (ft)	Remove Direct Connections
MC-02	6,222	1,737	35	243	86	4,251	9

Comprehensive Rehabilitation Costs

	Testing Cost		Rehabilitation Cost									Contingency (30%)	TOTAL Testing & Rehabilitation Costs
Meter Basin	Smoke Testing	Dye Testing	8" Sewer Lining	10" Sewer Lining	12" Sewer Lining	15" Sewer Lining	MH Chimney Seals & Solid Lids	MH Rehab	Lateral Rehab	Add Cleanouts	Remove Direct Connections		
MC-01	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
MC-02	\$ 3,980	\$ -	\$ 279,999	\$ 86,850	\$ -	\$ -	\$ 17,500	\$ 30,431	\$ 419,555	\$ 172,000	\$ 31,500	\$ 311,350	\$ 1,353,165
MC-03	\$ -	\$ -	\$ -	\$ 38,500	\$ -	\$ -	\$ -	\$ -	\$ 65,577	\$ 34,000	\$ -	\$ 41,423	\$ 179,500
MC-04	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
MC-05	\$ -	\$ -	\$ 27,180	\$ 69,550	\$ -	\$ -	\$ -	\$ -	\$ 111,157	\$ 54,000	\$ -	\$ 78,566	\$ 340,453
MC-07	\$ 3,430	\$ 46,200	\$ 99,990	\$ 54,350	\$ -	\$ -	\$ 10,000	\$ 20,211	\$ 663,955	\$ 264,000	\$ 24,500	\$ 341,102	\$ 1,527,738
MC-08	\$ 2,786	\$ 40,950	\$ 52,785	\$ -	\$ -	\$ -	\$ 12,500	\$ 28,369	\$ 593,242	\$ 234,000	\$ 21,000	\$ 282,569	\$ 1,268,200
MC-09	\$ 406	\$ 4,550	\$ 10,845	\$ -	\$ -	\$ -	\$ 1,500	\$ 3,433	\$ 61,532	\$ 26,000	\$ 3,500	\$ 32,043	\$ 143,809
MC-10	\$ 6,388	\$ 62,650	\$ 326,655	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 721,598	\$ 358,000	\$ 63,000	\$ 440,776	\$ 1,979,067
MC-11	\$ 4,138	\$ 67,900	\$ 259,898	\$ -	\$ 2,600	\$ 40,280	\$ -	\$ -	\$ 766,026	\$ 388,000	\$ 136,500	\$ 477,991	\$ 2,143,332
TOTAL	\$21,126	\$222,250	\$1,057,352	\$249,250	\$ 2,600	\$ 40,280	\$ 41,500	\$ 82,444	\$3,402,641	\$1,530,000	\$ 280,000	\$ 2,005,820	\$ 8,935,263

Cost Savings From Potential Rehabilitation

Meter Basin	Annual O&M Savings			Capital Improvements Avoided (Alt. 1B)		20-Year Present Worth Savings
	Miami Shores LS	Dryden Rd PTF	Western Regional	Vance Rd. Sewer Replacement	Miami Shores FM Upsize	
MC-02	\$ 320	\$ 120	\$ 880			\$ 21,600
MC-03	\$ 50	\$ 20	\$ 140			\$ 3,400
MC-05	\$ 560	\$ 220	\$ 1,580			\$ 38,700
MC-07	\$ 1,620	\$ 620	\$ 4,530			\$ 111,000
MC-08	\$ 460	\$ 180	\$ 1,280			\$ 31,500
MC-09	\$ 610	\$ 230	\$ 1,720			\$ 42,000
MC-10	\$ 170	\$ 70	\$ 470			\$ 11,600
MC-11	\$ 240	\$ 90	\$ 670			\$ 16,400
Total System	\$ 4,030	\$ 1,550	\$ 11,270	\$ 754,650	\$ 31,200	\$ 1,062,100

Rehabilitation Conclusions

- Prior CIPP Lining was somewhat effective at reducing I/I in areas where nearly all sewers were lined.
- Comprehensive rehabilitation does not appear cost effective for purposes of I/I reduction.
- Rehabilitation should still be considered to extend remaining useful life of assets.



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