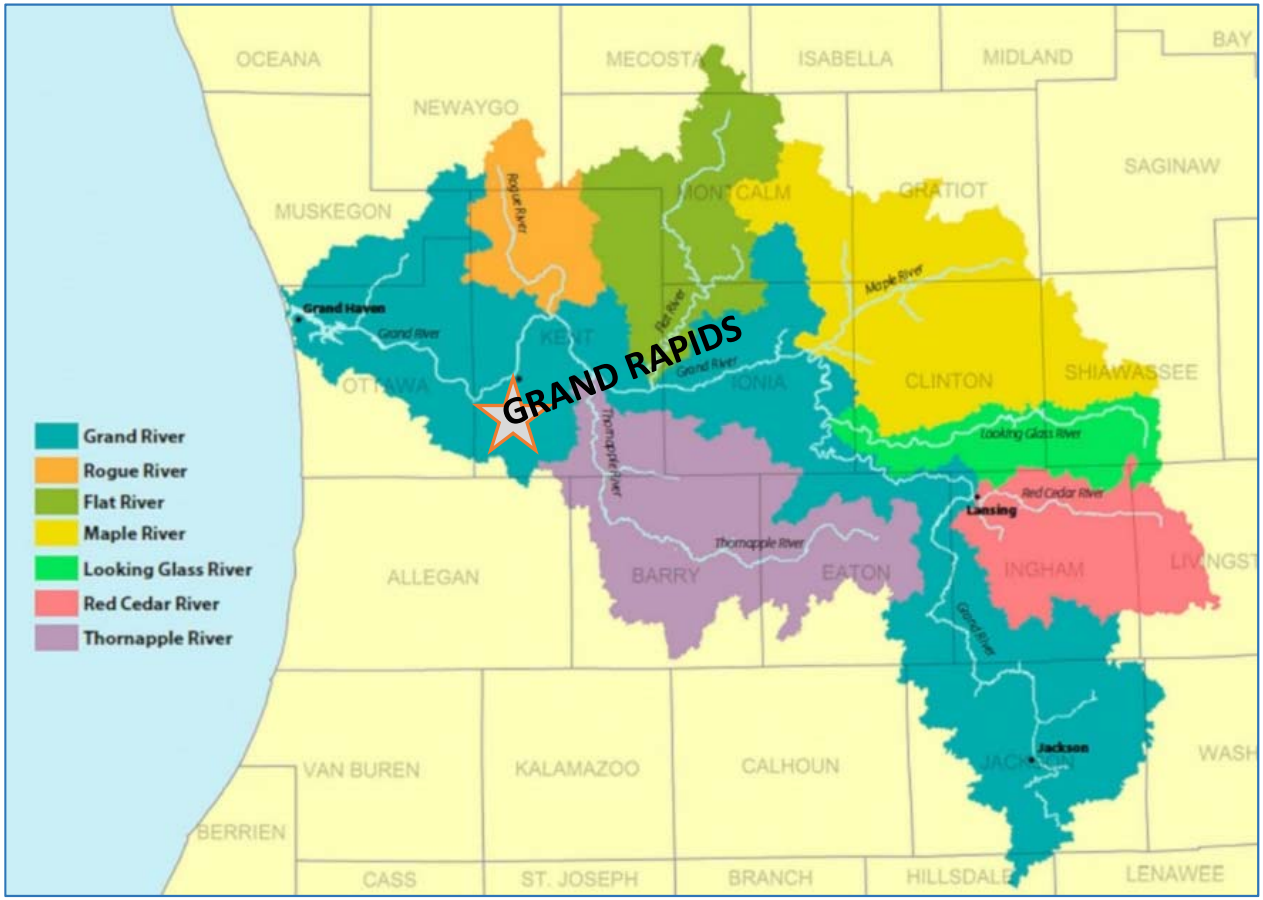
Changing the Paradigm for Water Pollution Monitoring

Mike Lunn
Utilities Director
City of Grand Rapids

CITY OF GRAND RAPIDS

Grand Rapids, MI



Environmental Services

Sanitary Sewer

- Water Resource Recovery Facility (40 mgd average flow)
- 54 Lift Stations
- Retention/Treatment Basin (1 bgd treatment capacity)
- 1100 miles Sanitary Sewer

Stormwater

- 11 Stormwater Pump Stations
- 400 miles of drainage system

Water

- Maintenance of 12 Pumping Stations

Energy, Lighting, and Communications

- 18,000 Streetlights
- Primary Circuit
- Fiber

Air Quality

- Maintain 7 AQ Monitoring Stations in West Michigan

Quadruple Bottom Line

River Restoration Project goals

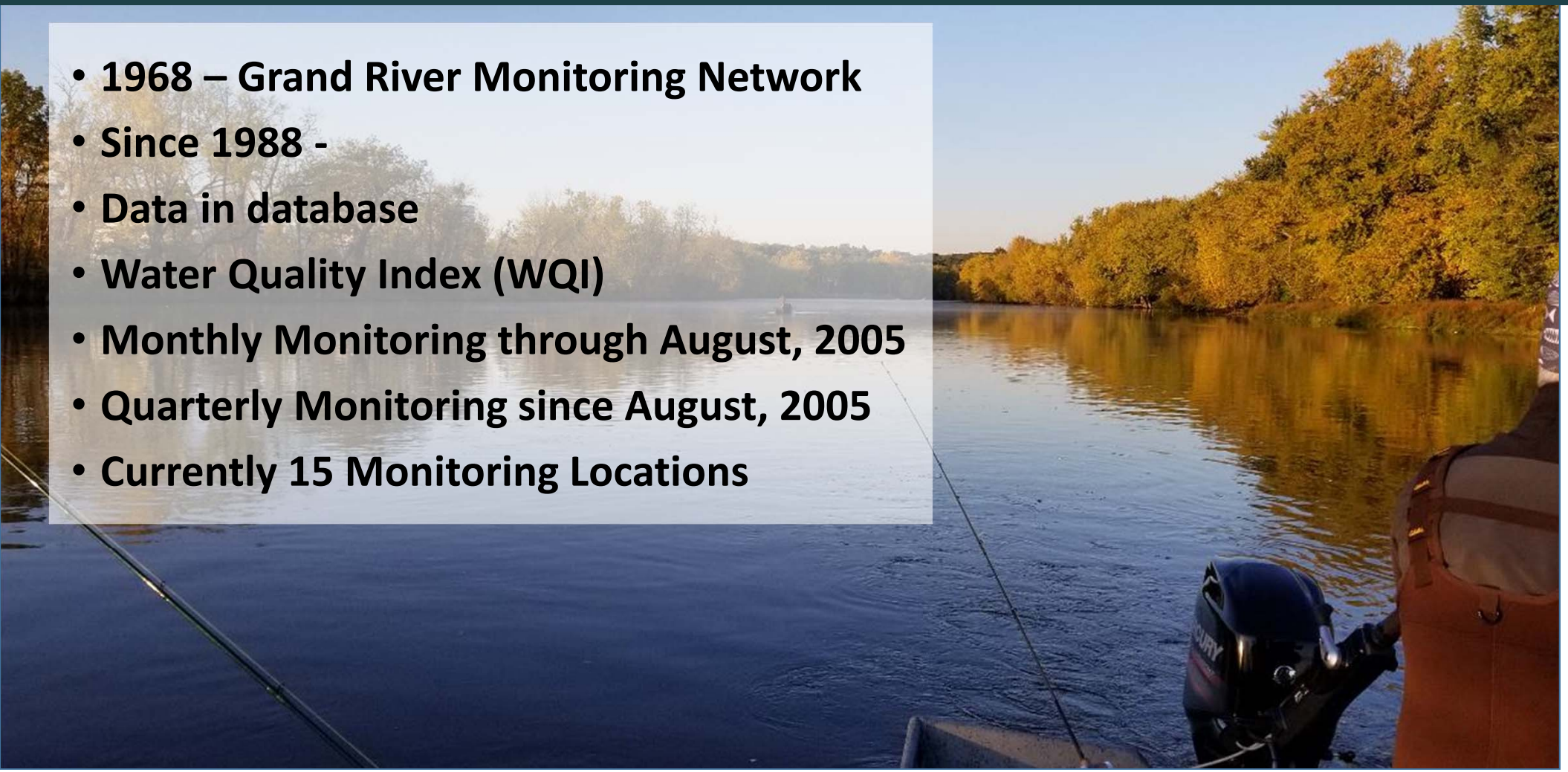
- Restore the rapids to the Grand River for everyone, with enhanced access and recreational opportunities
- Improve habitat and connectivity, water quality, riparian functions and aesthetics
- Create economic opportunities, enhance underserved communities and instill stewardship ethic

A Watershed Approach

A Watershed approach must be taken to improve water quality. By implementing the following programs we are making better water quality an integral part of our future:

- Lower Grand Watershed Organization
- Green Grand Rapids Master Plan Update
- Sustainability Plan
- Renewable Energy
- Green Infrastructure Portfolio Standards
- Energy Efficiency Projects
- Stormwater Master Plan
- Soil Erosion and Sedimentation Control
- Grand River Water Quality Monitoring

Grand River Monitoring History



- 1968 – Grand River Monitoring Network
- Since 1988 -
- Data in database
- Water Quality Index (WQI)
- Monthly Monitoring through August, 2005
- Quarterly Monitoring since August, 2005
- Currently 15 Monitoring Locations

Michigan Grand River Watershed Council

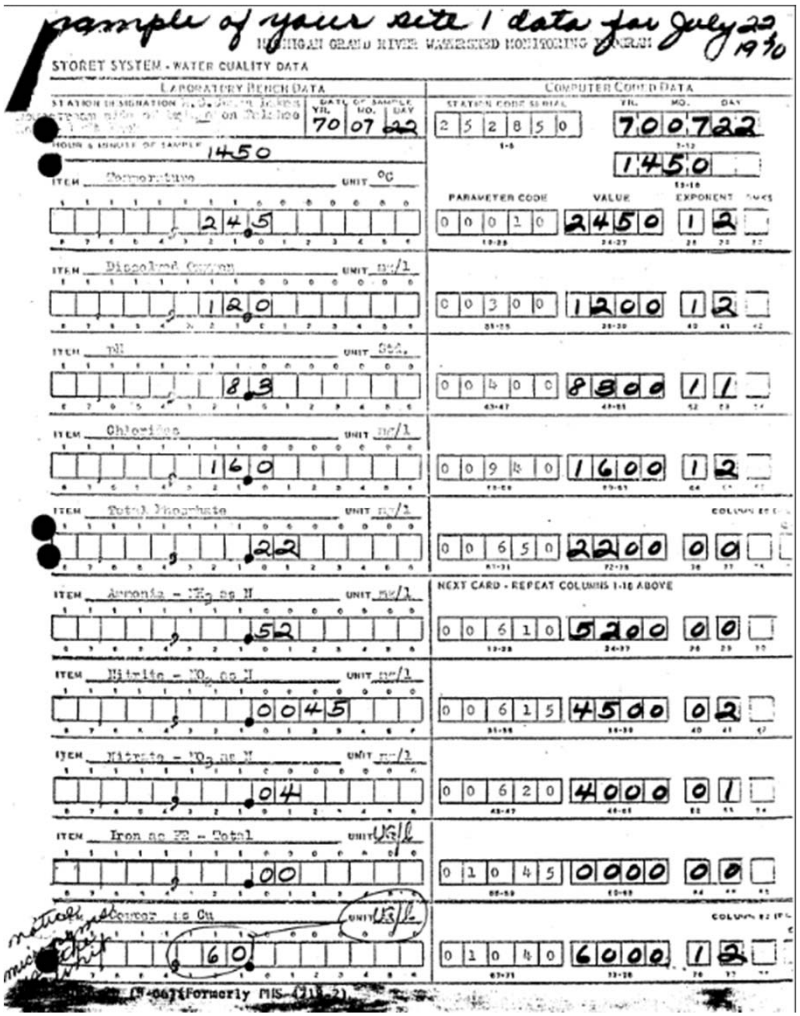
- Authorized under The Local River Management Act 253 of the Public Acts of 1964 (Michigan Legislature)
- Formed in 1966 and second organized under this Act
- Council's purpose
  - Study
  - Plan
  - Be the coordinating agency

Initial River Monitoring

- Established a monitoring network in 1968, collecting monthly samples at 100 sampling locations
- Conclusions from a 2 year study
  - "DO was acceptable all along the river *except* below Lansing and Jackson (fish life cannot be sustained at times)."
  - "Chlorides (salt) – Acceptable all along river."
  - "Total bacteria – Acceptable all along river"
  - "Fecal coliforms – Not acceptable all along river. (This matter under study.)"
  - "Metals Wastes – Acceptable – Under supervision of control agencies."

Michigan Grand River Watershed Monitoring Program

Report for 7/22/1970



sample of your site 1 data for July 22 1970

MICHIGAN GRAND RIVER WATERSHED MONITORING PROGRAM

STORET SYSTEM - WATER QUALITY DATA

LABORATORY BENCH DATA

COMPUTER CODED DATA

ITEM	UNIT	LAB VALUE	PARAMETER CODE	COMPUTER VALUE	EXPONENT
Temperature	°C	24.5	00010	2450	1 2
Dissolved Oxygen	mg/l	12.0	00300	1200	1 2
pH	std.	8.3	00400	8800	1 1
Chlorides	mg/l	16.0	00980	1600	1 2
Total Phosphate	mg/l	.22	00650	2200	0 0
Ammonia - NH_3 as N	mg/l	.52	00610	5200	0 0
Nitrite - NO_2 as N	mg/l	.0045	00615	4500	0 2
Nitrate - NO_3 as N	mg/l	.04	00620	4000	0 1
Iron as Fe - Total	ug/l	00	01045	0000	0 0
Copper as Cu	ug/l	60	01040	6000	1 2

NEXT CARD - REPEAT COLUMNS 1-16 ABOVE

(Formerly MIS (71)-2)

MICHIGAN GRAND RIVER WATERSHED MONITORING PROGRAM - SAMPLING RESULTS ON THE GRAND RIVER - DATE August 19, 1970

Station Code Serial	Time Sample Taken	Temp. °F	D.O. mg/l	BOD mg/l	pH	Coliform Total	Coliform Fecal	Total PO_4 mg/l	Ortho PO_4 mg/l	Chlorides mg/l	NH_3 as N mg/l	NO_3 as N mg/l	SS mg/l	VSS mg/l	Fe mg/l	Cu mg/l	Tot. Cr mg/l	Zn mg/l	Ni mg/l
250390	10:50	23 C	7.9	4.3	7.8			.10	-	8.5	.12	.17	8.4	-	.00	.00	-	-	-
250378	11:15	24 C	6.0	2.8	7.9			.10	-	14.0	.34	.15	7.1	-	.00	.02	-	-	-
250370	09:55	25 C	7.5	3.9	7.8			.14	-	20.5	.29	.09	6.6	-	.00	.02	-	-	-
250360	08:26	67	5.4	5.8	8.6	4300	340	.30	-	21.0	.30	.60	-	-	-				
250350	08:35	68	5.2	2.0	8.4	2300	160	-	-	20.0	.50	-	-	-	-				
250340	08:46	67	5.6	3.6	8.4	140,000	3000	-	-	35.0	.60								
250330	08:55	67	5.0	2.2	8.3	140,000	20,000	-	-	36.0	.50								
250320	09:07	67	1.4	8.2	8.3	140,000	20,000	.9	-	52.0	1.7	.60							
250310	09:35	66	2.8	7.6	8.0	140,000	20,000	.9	-	80.0	1.6	.60							
250300	10:00	66	2.8	6.4	8.1	140,000	20,000	1.5	-	79.0	1.9	.80							
250290	10:17	66	4.0	3.2	8.1	4300	200	1.0	-	69.0	1.8	.60							
250280	10:37	65	6.0	3.4	8.1	730	160	1.0	-	48.0	0.4	.80							
250270																			
250260																			
250250																			
250240	09:45	77	9.4	2.2	8.5	46,000		9.5	.35										
250230	10:30	79	5.0	12.3	7.7	110,000		1.6	1.3										
250220	10:45	79	4.0	9.3	7.6	110,000		1.8	1.6										
250210	-	78	2.6	14.7	7.5	110,000		2.7	2.1										
250200	08:15	70	4.6	2.8	8.0	15,600		.54											
250190	09:00	71	5.8	2.0	8.0	13,500		.43											
250180																			
250170																			
250160																			
250150																			
250140																			
250130																			
250120	08:50	74	8.0	3.3	8.0	500	40	.23	.11	30.0	.32	.13	19	13	.08	0	0	.06	0
250110	09:42	68	8.0	4.9	8.3	300	50	.23	.09	26.0	.12	.40	9	9	.06	0	0	.02	0
250100	07:30	75	-	-	8.5	-	-	-	-	28.0	-	.49	-	-	.25	-	-	-	-
250090	10:17	73	8.3	3.6	8.3	850	160	.10	.10	40.0	.37	.40	25	14	.03	0	0	.02	0
250071	11:11	74	7.6	3.9	8.2	1400	200	.24	.17	56.0	1.2	.40	34	19	.07	0	0	.07	0
250070	11:02	74	7.8	5.9	8.2	2200	220	.32	.20	56.0	.67	.13	26	7	.06	.01	.0	.02	0
250061	11:36	74	7.6	5.5	8.2	2000	250	.28	.23	58.0	.57	.13	30	23	.04	0	0	.04	0
250060	11:45	74	7.1	3.5	8.2	5800	520	.18	.17	58.0	.77	.40	27	16	.05	0	0	.03	0
250050	9:00	75	4.6	4.4	8.1	60,000	-	.28	.27	54.0	1.1	.25	21	16	.05	0	0	.02	0
250040																			
250030	10:20	69	6.5	2.7	8.1	2,200	-	1.7	1.2			27	12						
250020	09:50	68	5.9	4.8	8.0	1,750	-	1.5	1.1			21	12						
250010	09:20	68	4.5	1.0	8.0	1,800	-	.65	.24			19	10						

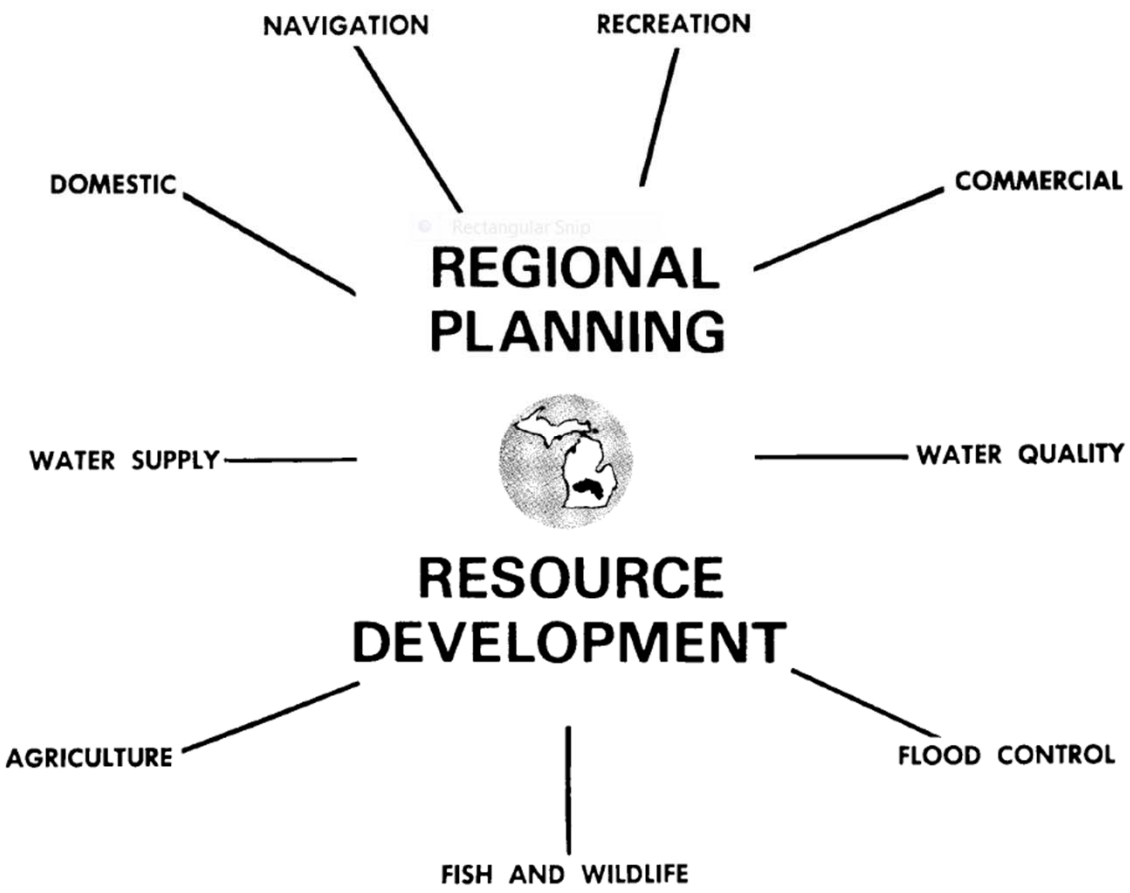
Grand River Watershed Council
Special report, November 1971

- "The Watershed Council considers **monthly sample data inadequate** for water quality management purposes. Therefore, it has developed plans, in cooperation with the Grand Rapids Center for Environmental Study, for a **network of continuous analyzers** connected to a computer in Grand Rapids for immediate data readout."
- "In order that the people within the watershed can be kept better informed about water quality, the Watershed Council is participating in a study in cooperation with the National Sanitation Foundation in Ann Arbor to establish a **Water Quality Index**."

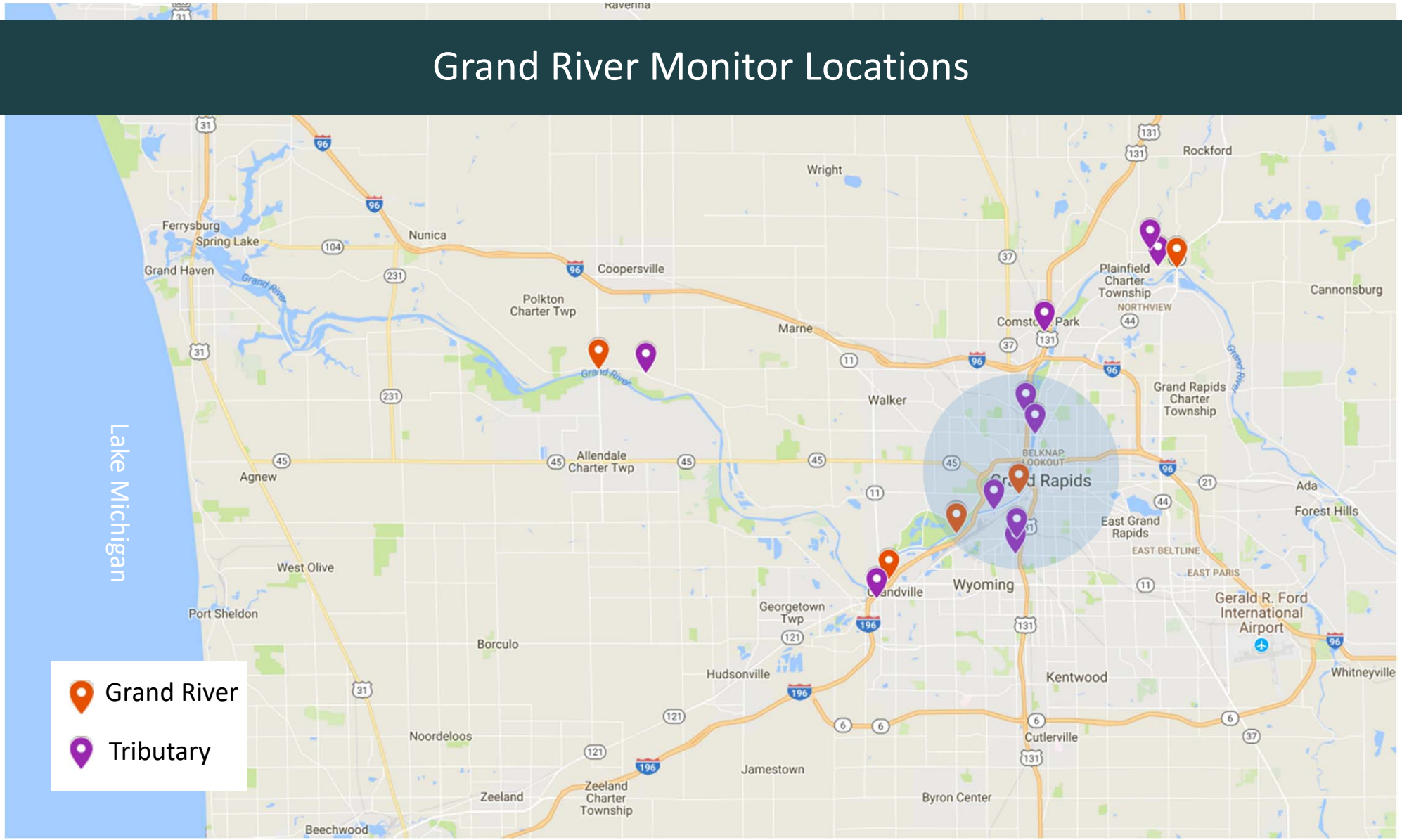
The Water Quality Index (WQI)

- An informational tool
- Available via the media
- Common understanding
- Identify trends in a single body of water
- Compare different bodies of water
- Become a “daily household word”
- Yardstick for measuring water quality
- Uniform method for measuring water quality
- Surveyed 142 water quality experts to develop WQI

Regional Planning ???



Grand River Monitor Locations



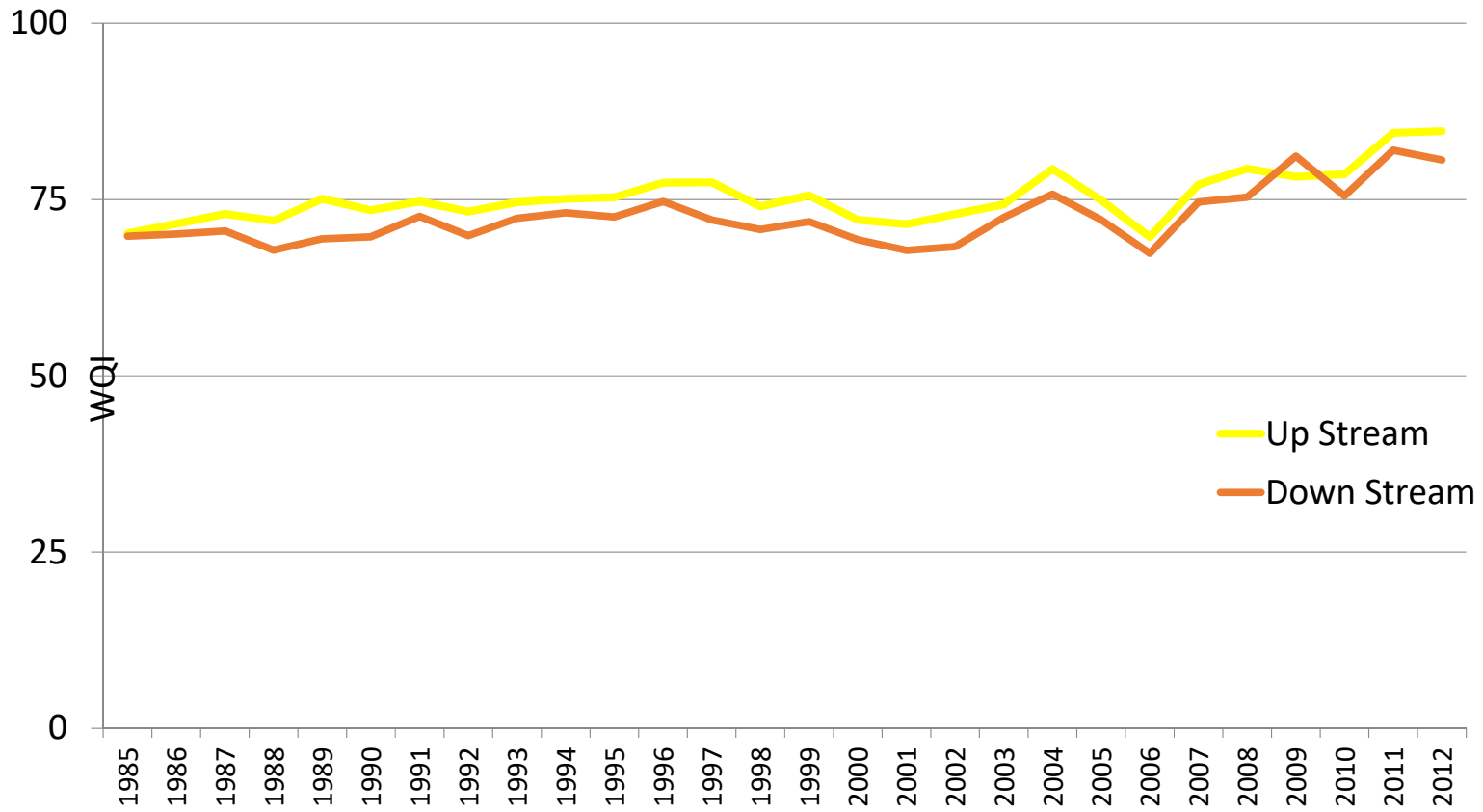
Water Quality Index

Parameter	Weight (old)	Weight (modified)
Dissolved Oxygen	.17	.18
Fecal coliform	.16	.17
pH	.11	.12
BOD	.11	.12
Temperature change	.10	.11
Total phosphate	.10	.11
Nitrates	.10	.11
Turbidity	.10	Not measured
Total solids	.07	.08 *(+ chlorides instead of Total solids)*

Water Quality Index Legend

Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

Water Quality Index
Upstream vs Downstream



Example River Run without any rainfall in previous 3 days

RIVER SURVEY REPORT **DATE: 10/12/2011** **CITY OF GRAND RAPIDS EPSD**

LOCATIONS	TIME	TEMP	DO	pH	BOD	TSS	FC	EC	CHLORIDE	CON	TP	NH3-N	NO2-N	NO3-N
Grand River														
201103997 Northland Drive Bridge (250120)	8:48	14.8	9.5	7.86	<2.0	5.0	35	38	46	665	0.016	<0.20	0.001	0.5
201103998 Wealthy Street Bridge (250090)	9:42	16.1	9.2	7.96	<2.0	4.0	52	48	64	724	0.012	<0.20	0.003	0.5
201103999 Railroad Bridge South (250070)	13:10	18.6	8.8	7.62	<2.0	3.0	52		67	736	0.030	<0.20	0.006	0.5
201104000 Railroad Bridge North (250071)	13:10	18.2	9.3	7.68	<2.0	2.8	32	40	63	727	0.060	<0.20	0.010	0.6
201104001 M-11, Wilson Avenue (250062)	10:39	16.6	8.5	7.87	<2.0	3.4	40	24	61	741	0.034	<0.20	0.007	0.8
201104002 Eastmanville (250040)	12:04	18.0	9.2	7.74	<2.0	3.6	40	44	68	765	0.043	<0.20	0.011	1.0
Streams														
201104003 Rogue River at West River Drive	8:23	13.0	9.0	7.72	<2.0	4.4	73		40	635	0.013	<0.20	0.006	0.5
201104004 Mill Creek at West River Drive	8:06	12.4	9.7	7.73	<2.0	1.8	36		49	712	<0.009	<0.20	0.005	0.5
201104005 Indian Mill Creek at Turner Aven	7:53	12.6	9.3	7.54	<2.0	16.6	200		95	953	0.017	<0.20	0.005	0.9
201104006 Silver Creek at Crofton/Roy	9:26	15.1	9.5	7.84	<2.0	0.8	530		187	1210	0.214	<0.20	0.006	1.1
201104007 Plaster 1 at Burton	9:16	14.3	7.2	7.59	<2.0	2.8	200		187	1260	0.023	0.23	0.036	0.4
201104008 Plaster 2 at Market	9:59	14.9	8.7	7.69	<2.0	1.4	173		199	1360	<0.009	<0.20	0.027	0.6
201104009 Buck Creek at Chicago Drive	20:52	14.7	8.8	7.77	<2.0	2.4	210		135	1140	0.009	<0.20	0.004	0.1
201104010 Deer Creek	12:15	15.7	4.2	7.43	<2.0	2.2	64		39	697	0.117	<0.20	0.004	<0.1
201104011 Coldbrook Storm Drain	7:36	14.5	9.9	7.68	<2.0	4.0	300		188	1260	0.026	<0.20	0.009	0.3

LOCATIONS	Cr	Cu	Fe	Hg	Ni	Ag	Zn	Hard	WQI
Grand River									
201103997 Northland Drive Bridge (250120)	<2	2	120	<0.2	<1	<0.3	<5	307	85.1
201103998 Wealthy Street Bridge (250090)	<2	2	80	<0.2	1	<0.3	<5	306	84.0
201103999 Railroad Bridge South (250070)	<2	1	80	<0.2	1	<0.3	<5	317	83.8
201104000 Railroad Bridge North (250071)	<2	2	70	<0.2	2	<0.3	<5	324	85.2
201104001 M-11, Wilson Avenue (250062)	<2	1	70	<0.2	1	<0.3	<5	317	83.4
201104002 Eastmanville (250040)	<2	1	90	<0.2	1	<0.3	7	326	82.4
Streams									
201104003 Rogue River at West River Drive	<2	2	150	<0.2	<1	<0.3	<5	311	82.3
201104004 Mill Creek at West River Drive	<2	<1	90	<0.2	<1	<0.3	<5	341	84.9
201104005 Indian Mill Creek at Turner Aven	<2	2	510	<0.2	<1	<0.3	9	388	77.0
201104006 Silver Creek at Crofton/Roy	7	15	140	<0.2	8	<0.3	42	352	70.7
201104007 Plaster 1 at Burton	<2	1	150	<0.2	<1	<0.3	9	381	73.7
201104008 Plaster 2 at Market	<2	1	120	<0.2	1	<0.3	7	442	76.7
201104009 Buck Creek at Chicago Drive	<2	1	200	<0.2	<1	<0.3	10	436	77.9
201104010 Deer Creek	<2	2	160	<0.2	<1	<0.3	<5	326	70.4
201104011 Coldbrook Storm Drain	<2	2	280	<0.2	1	<0.3	9	405	76.7

Miscellaneous Information and Test Descriptions:

Weather conditions: Sunny.

Air Temperature: 17 °C

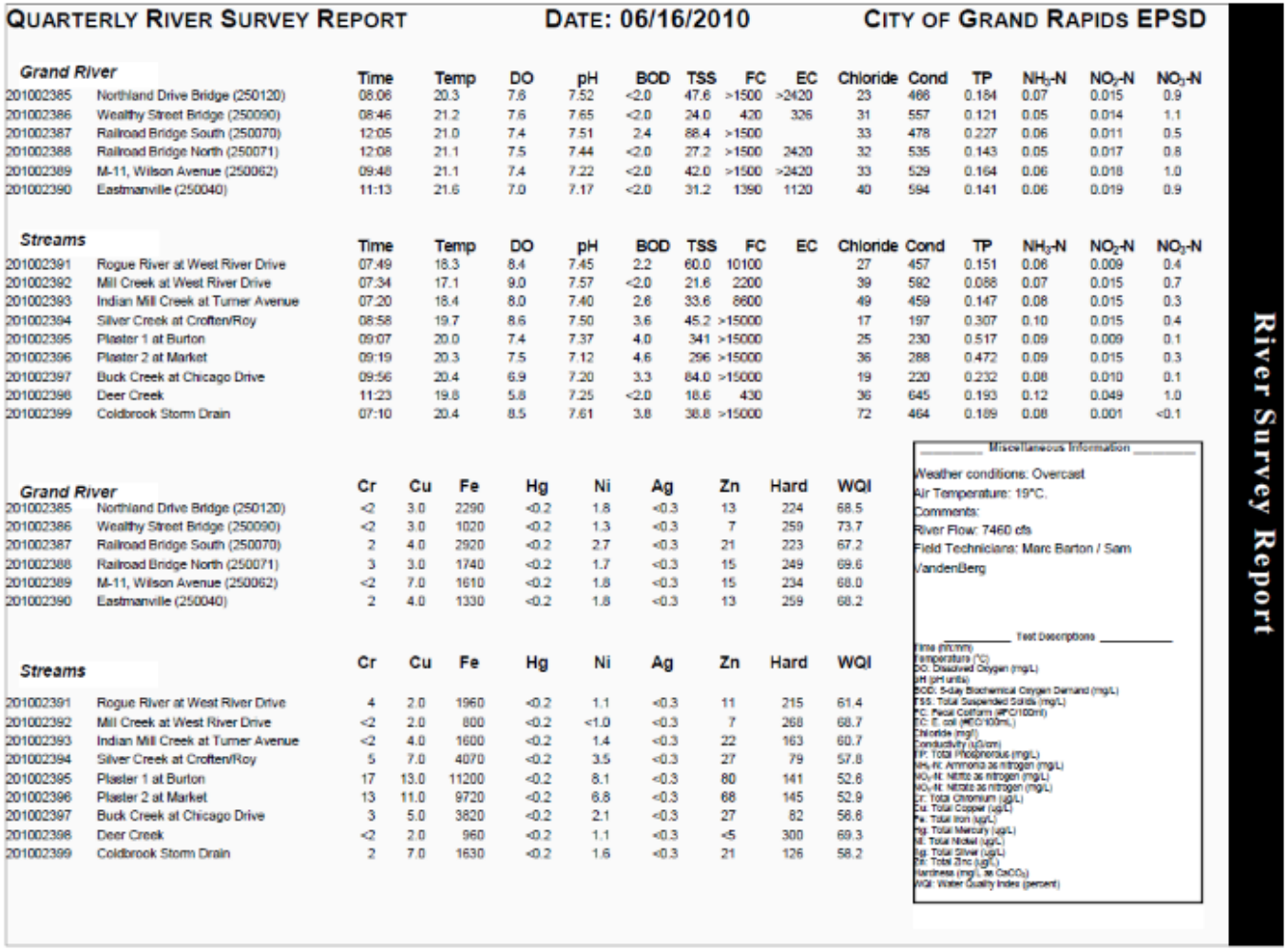
Comments:

River Flow: 1800 cfs

Field Technicians: Kurt Anderson / Kathy Makarewicz (before 10:11AM)/Mike Bussey (after 10:11AM)

Time samples (hh:mm)
Sample temperature (°C)
Dissolved oxygen (mg/L)
pH (pH units)
BOD-5 (mg/L)
Total suspended solids (mg/L)
Fecal coliform (#FC/100mL)
E. coli (#EC/100mL)
Chlorides (mg/L)
Conductivity (µS/cm)
Total phosphorous (mg/L)
Ammonia as nitrogen (mg/L)
Nitrites as nitrogen (mg/L)
Nitrates as nitrogen (mg/L)
Total chromium (µg/L)
Total Copper (µg/L)
Total iron (µg/L)
Total mercury (µg/L)
Total nickle (µg/L)
Total silver (µg/L)
Total zinc (µg/L)
Hardness (mg/L CaCO3)
Water Quality Index (percent)

Example River Run with recent rainfall exceeding 1”



QUARTERLY RIVER SURVEY REPORT — **DATE: 06/16/2010** — **CITY OF GRAND RAPIDS EPSD**

Grand River		Time	Temp	DO	pH	BOD	TSS	FC	EC	Chloride	Cond	TP	NH_3-N	NO_2-N	NO_3-N
201002385	Northland Drive Bridge (250120)	08:06	20.3	7.6	7.52	<2.0	47.6	>1500	>2420	23	466	0.184	0.07	0.015	0.9
201002386	Wealthy Street Bridge (250090)	08:46	21.2	7.6	7.65	<2.0	24.0	420	326	31	557	0.121	0.05	0.014	1.1
201002387	Railroad Bridge South (250070)	12:05	21.0	7.4	7.51	2.4	88.4	>1500		33	478	0.227	0.06	0.011	0.5
201002388	Railroad Bridge North (250071)	12:08	21.1	7.5	7.44	<2.0	27.2	>1500	2420	32	535	0.143	0.05	0.017	0.8
201002389	M-11, Wilson Avenue (250062)	09:48	21.1	7.4	7.22	<2.0	42.0	>1500	>2420	33	529	0.164	0.06	0.018	1.0
201002390	Eastmanville (250040)	11:13	21.6	7.0	7.17	<2.0	31.2	1390	1120	40	594	0.141	0.06	0.019	0.9

Streams		Time	Temp	DO	pH	BOD	TSS	FC	EC	Chloride	Cond	TP	NH_3-N	NO_2-N	NO_3-N
201002391	Rogue River at West River Drive	07:49	18.3	8.4	7.45	2.2	60.0	10100		27	457	0.151	0.06	0.009	0.4
201002392	Mill Creek at West River Drive	07:34	17.1	9.0	7.57	<2.0	21.6	2200		39	592	0.088	0.07	0.015	0.7
201002393	Indian Mill Creek at Turner Avenue	07:20	18.4	8.0	7.40	2.6	33.6	8600		49	459	0.147	0.08	0.015	0.3
201002394	Silver Creek at Crofton/Roy	08:58	19.7	8.6	7.50	3.6	45.2	>15000		17	197	0.307	0.10	0.015	0.4
201002395	Plaster 1 at Burton	09:07	20.0	7.4	7.37	4.0	341	>15000		25	230	0.517	0.09	0.009	0.1
201002396	Plaster 2 at Market	09:19	20.3	7.5	7.12	4.6	296	>15000		36	288	0.472	0.09	0.015	0.3
201002397	Buck Creek at Chicago Drive	09:56	20.4	6.9	7.20	3.3	84.0	>15000		19	220	0.232	0.08	0.010	0.1
201002398	Deer Creek	11:23	19.8	5.8	7.25	<2.0	18.6	430		36	645	0.193	0.12	0.049	1.0
201002399	Coldbrook Storm Drain	07:10	20.4	8.5	7.61	3.8	38.8	>15000		72	464	0.189	0.08	0.001	<0.1

Grand River		Cr	Cu	Fe	Hg	Ni	Ag	Zn	Hard	WQI
201002385	Northland Drive Bridge (250120)	<2	3.0	2290	<0.2	1.8	<0.3	13	224	68.5
201002386	Wealthy Street Bridge (250090)	<2	3.0	1020	<0.2	1.3	<0.3	7	259	73.7
201002387	Railroad Bridge South (250070)	2	4.0	2920	<0.2	2.7	<0.3	21	223	67.2
201002388	Railroad Bridge North (250071)	3	3.0	1740	<0.2	1.7	<0.3	15	249	69.6
201002389	M-11, Wilson Avenue (250062)	<2	7.0	1610	<0.2	1.8	<0.3	15	234	68.0
201002390	Eastmanville (250040)	2	4.0	1330	<0.2	1.8	<0.3	13	259	68.2

Streams		Cr	Cu	Fe	Hg	Ni	Ag	Zn	Hard	WQI
201002391	Rogue River at West River Drive	4	2.0	1960	<0.2	1.1	<0.3	11	215	61.4
201002392	Mill Creek at West River Drive	<2	2.0	800	<0.2	<1.0	<0.3	7	268	68.7
201002393	Indian Mill Creek at Turner Avenue	<2	4.0	1600	<0.2	1.4	<0.3	22	163	60.7
201002394	Silver Creek at Crofton/Roy	5	7.0	4070	<0.2	3.5	<0.3	27	79	57.8
201002395	Plaster 1 at Burton	17	13.0	11200	<0.2	8.1	<0.3	80	141	52.6
201002396	Plaster 2 at Market	13	11.0	9720	<0.2	6.8	<0.3	68	145	52.9
201002397	Buck Creek at Chicago Drive	3	5.0	3820	<0.2	2.1	<0.3	27	82	56.6
201002398	Deer Creek	<2	2.0	960	<0.2	1.1	<0.3	<5	300	69.3
201002399	Coldbrook Storm Drain	2	7.0	1630	<0.2	1.6	<0.3	21	126	58.2

Miscellaneous Information

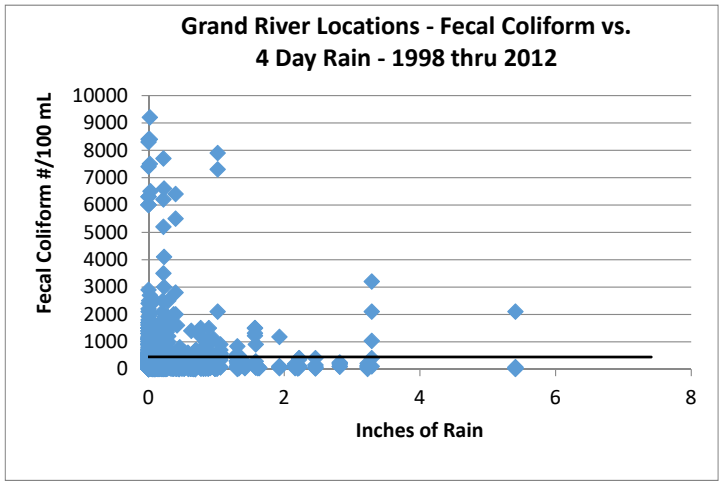
Weather conditions: Overcast
Air Temperature: 19°C.
Comments:
River Flow: 7460 cfs
Field Technicians: Marc Barton / Sam VandenBerg

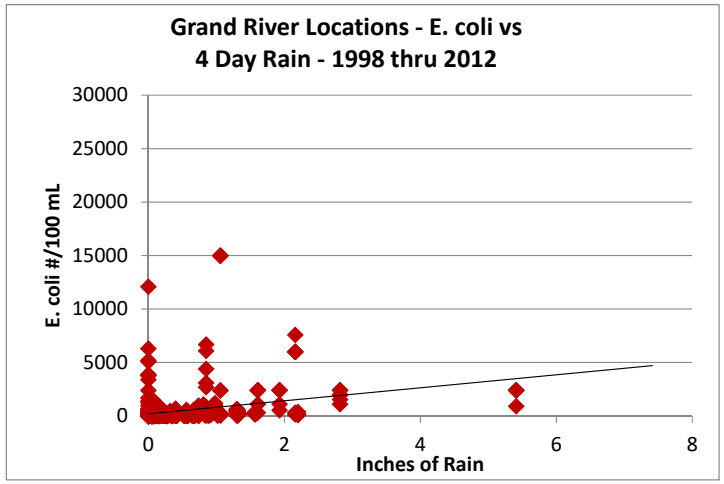
Test Descriptions

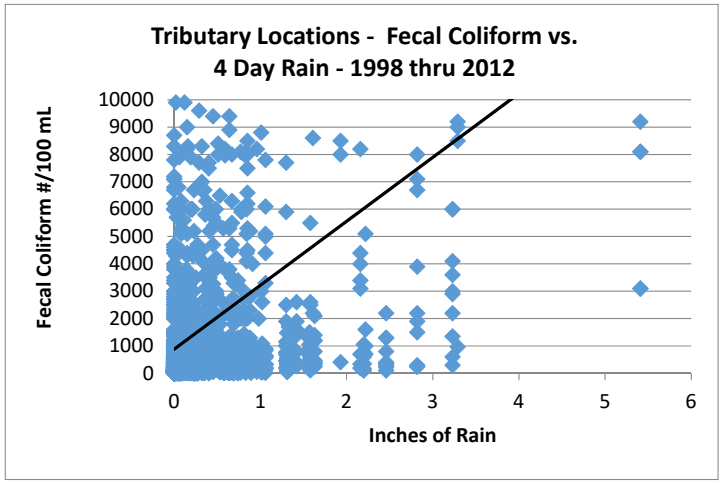
Time (hh:mm)
Temperature (°C)
DO: Dissolved Oxygen (mg/L)
pH (pH units)
BOD: 5-day Biochemical Oxygen Demand (mg/L)
TSS: Total Suspended Solids (mg/L)
FC: Fecal Coliform (#FC/100ml)
EC: E. coli (#EC/100mL)
Chloride (mg/l)
Conductivity (µS/cm)
TP: Total Phosphorous (mg/L)
NH_3-N: Ammonia as nitrogen (mg/L)
NO_2-N: Nitrite as nitrogen (mg/L)
NO_3-N: Nitrate as nitrogen (mg/L)
Cr: Total Chromium (µg/L)
Cu: Total Copper (µg/L)
Fe: Total Iron (µg/L)
Hg: Total Mercury (µg/L)
Ni: Total Nickel (µg/L)
Ag: Total Silver (µg/L)
Zn: Total Zinc (µg/L)
Hardness (mg/L as $CaCO_3$)
WQI: Water Quality Index (percent)

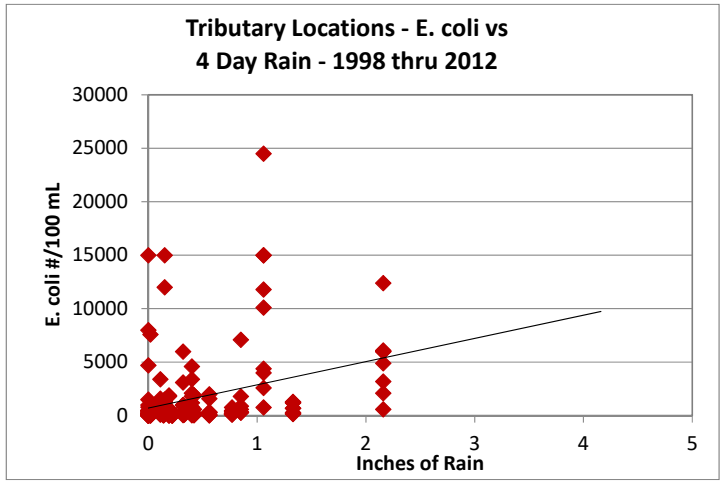
River Survey Report

Rain events and water quality

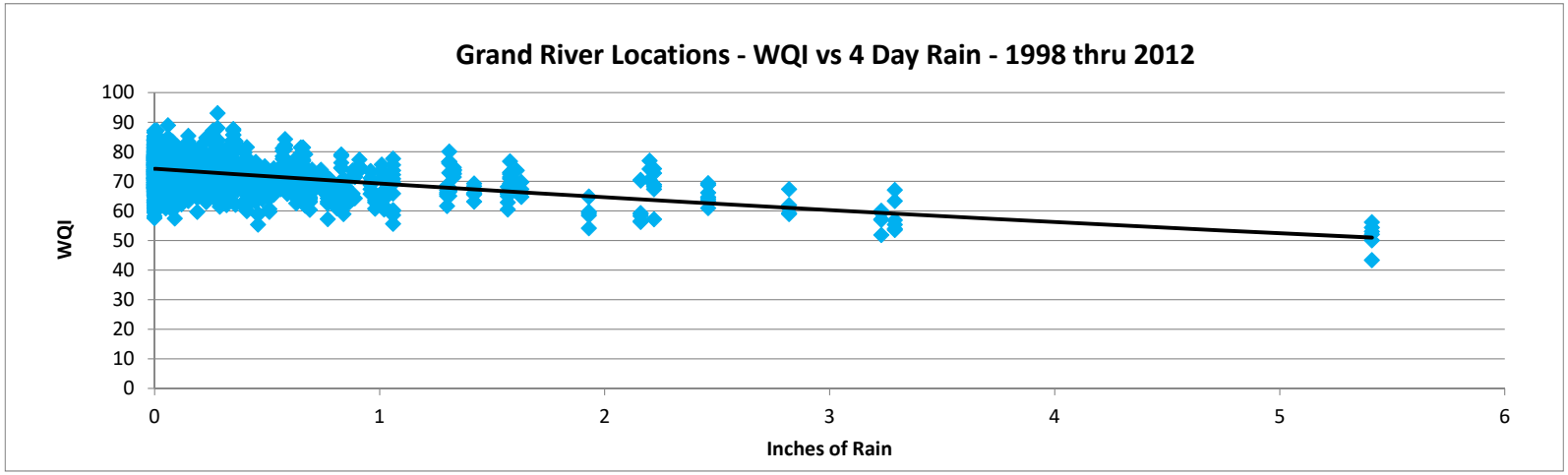


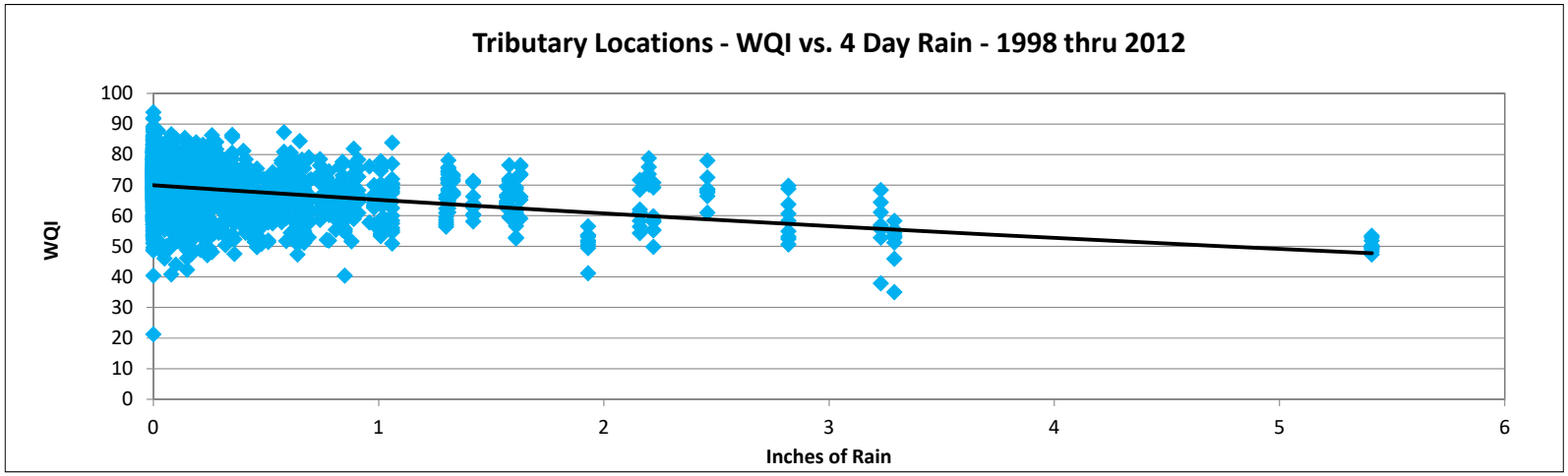






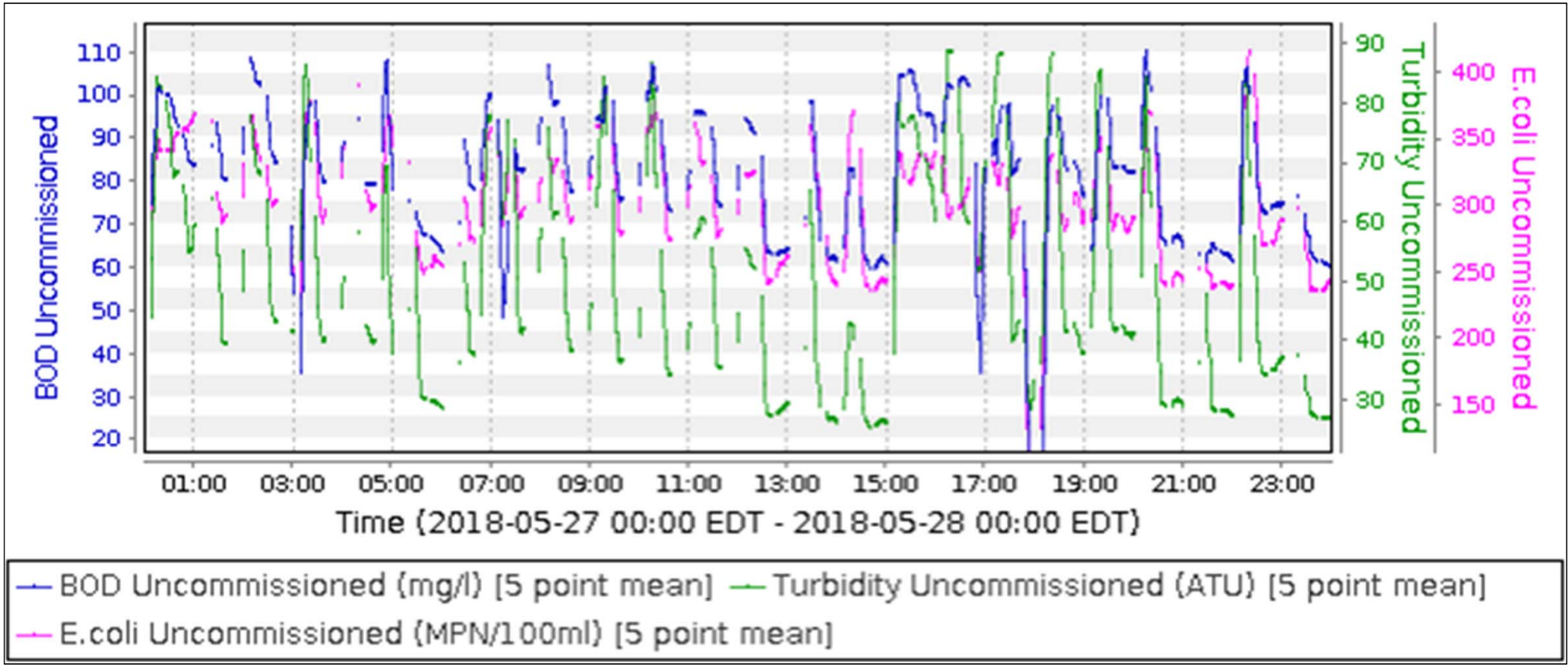
Rain events and water quality





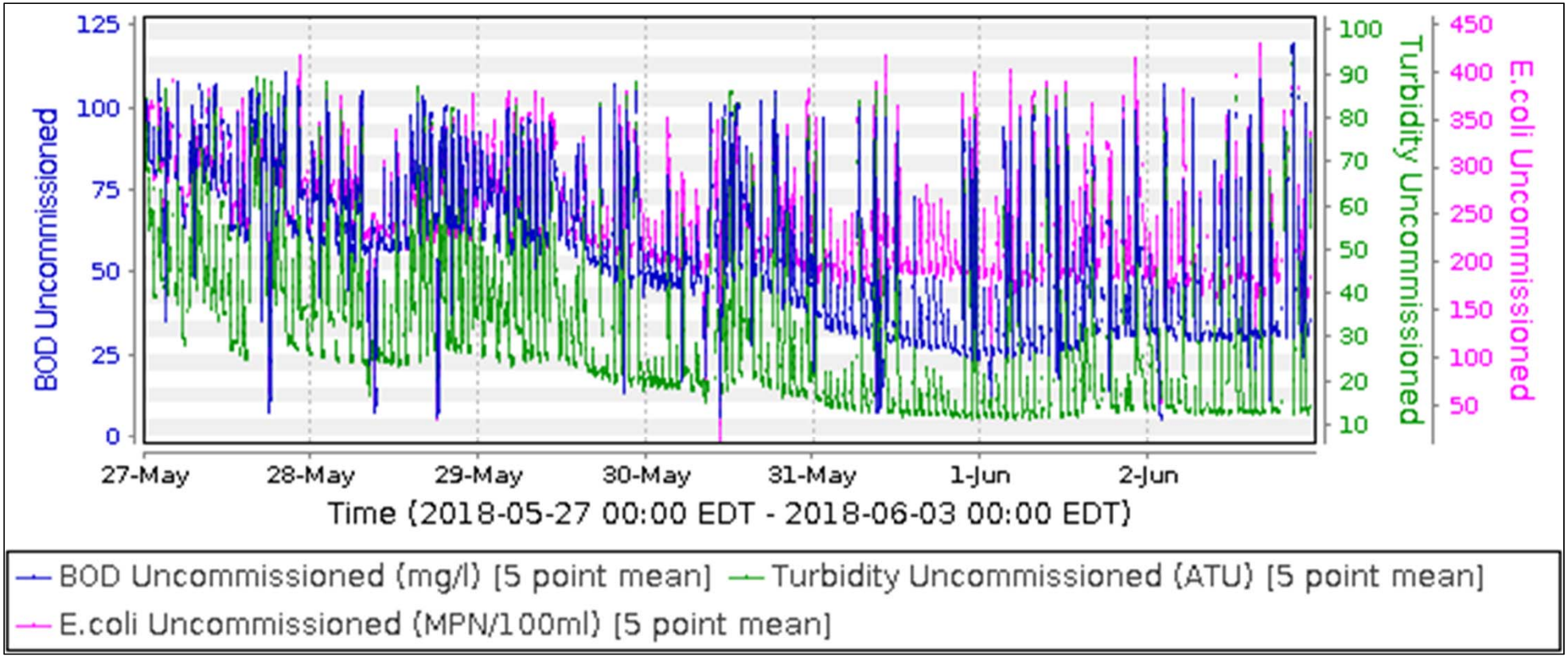
Grand River at Upstream City Limits

Riverside Park Sample



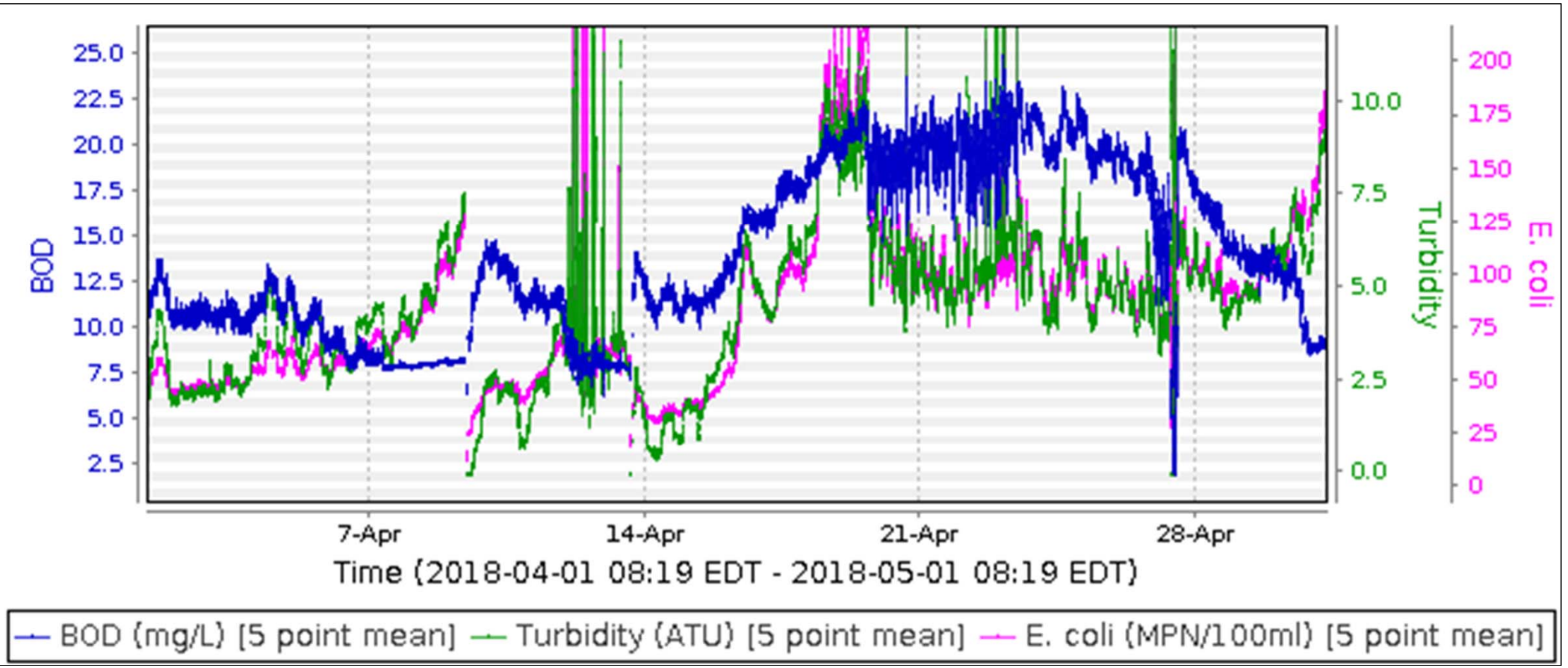
Grand River at Upstream City Limits

Riverside Park Sample

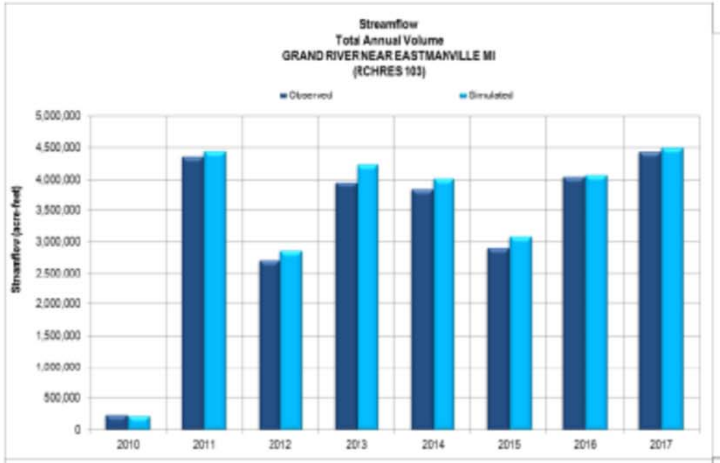


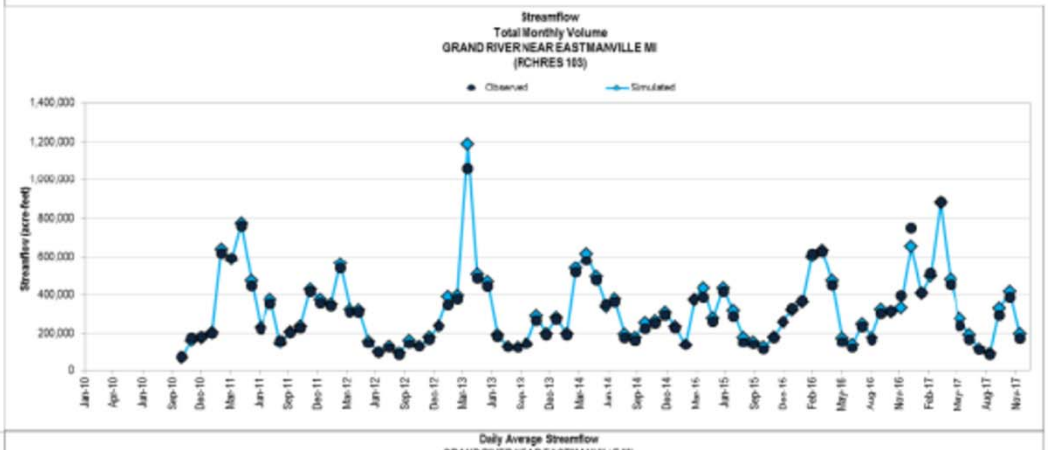
Grand River Downstream from Downtown

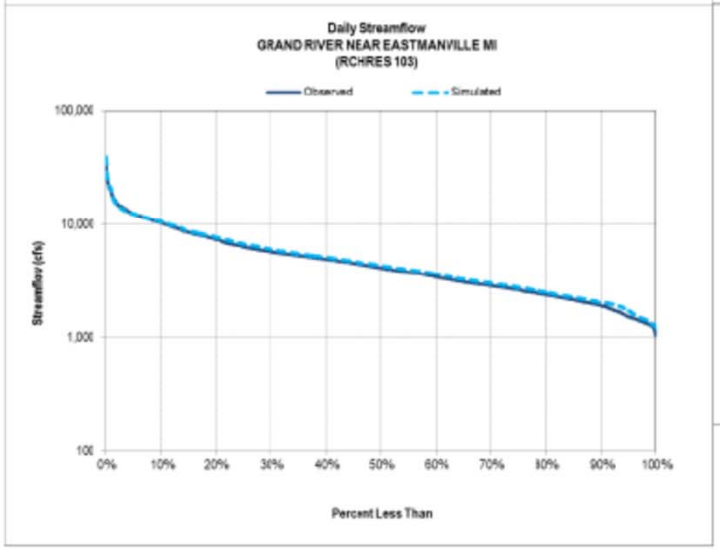
MAPS sample

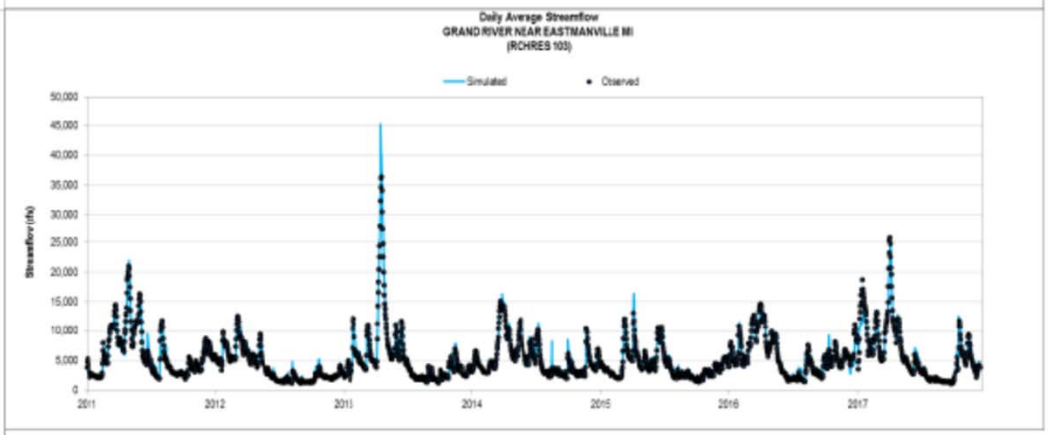


Calibration Plots – Grand River





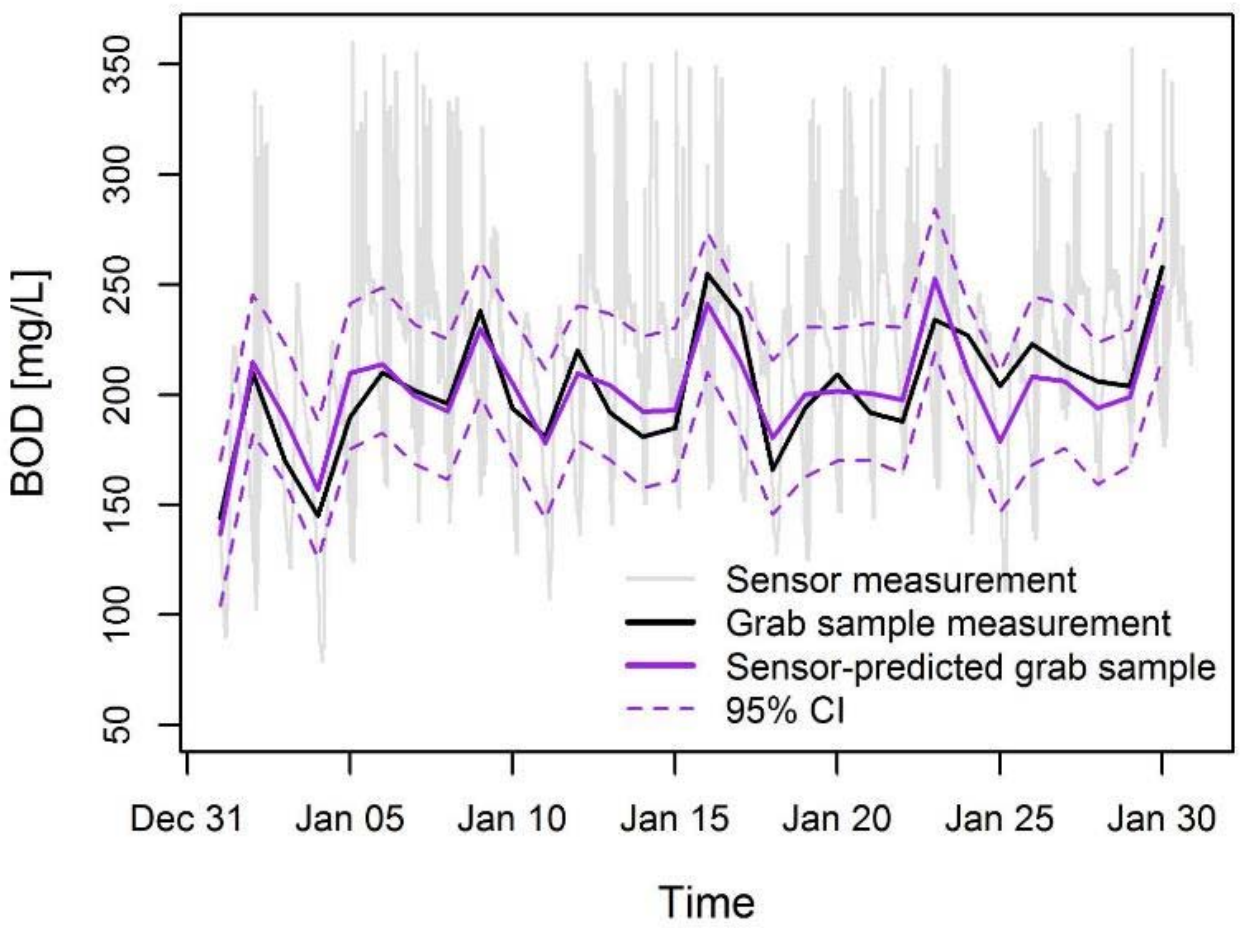


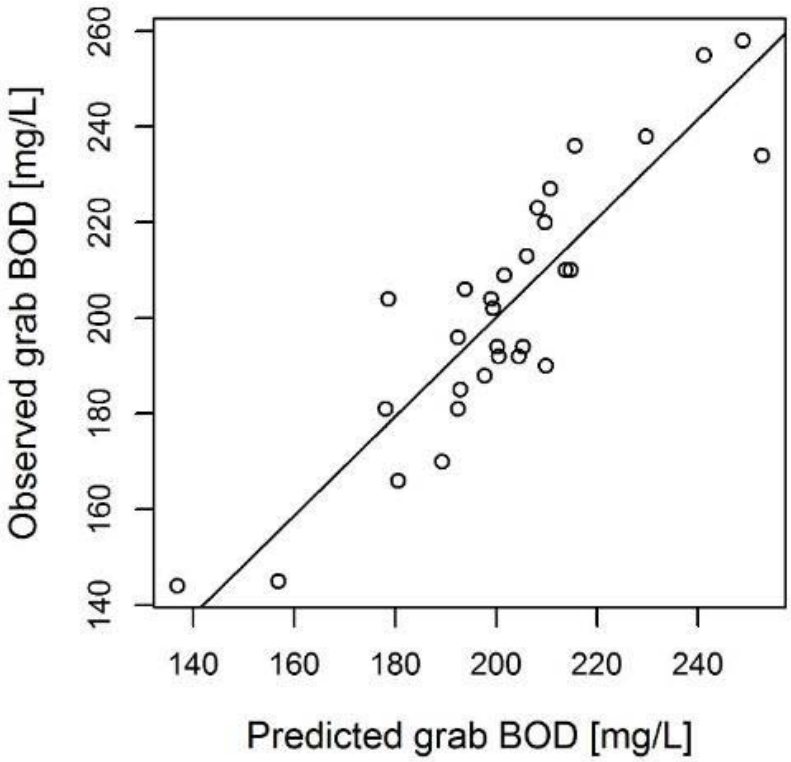


Water Resource Recovery Facility

- Design 61.1 MGD
- Wet Weather Peak 90 MGD
- Avg. Daily 40 MGD
- 270,000 served
- 80,000 retail customers
- 11 Customer Communities

Bayesian time series modeling of sensor and grab sample observations





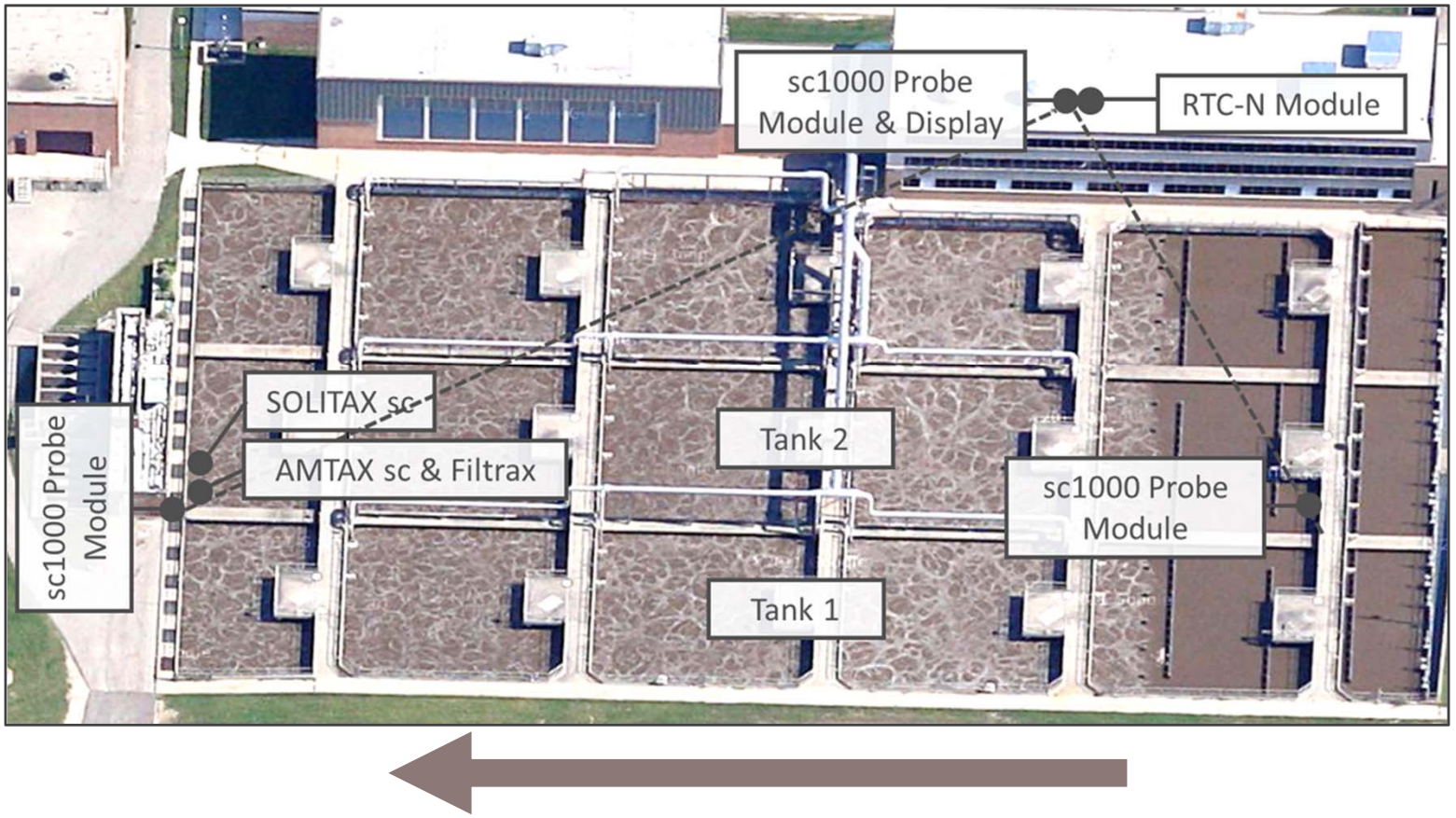
University of Michigan & Tetra Tech

Sensors

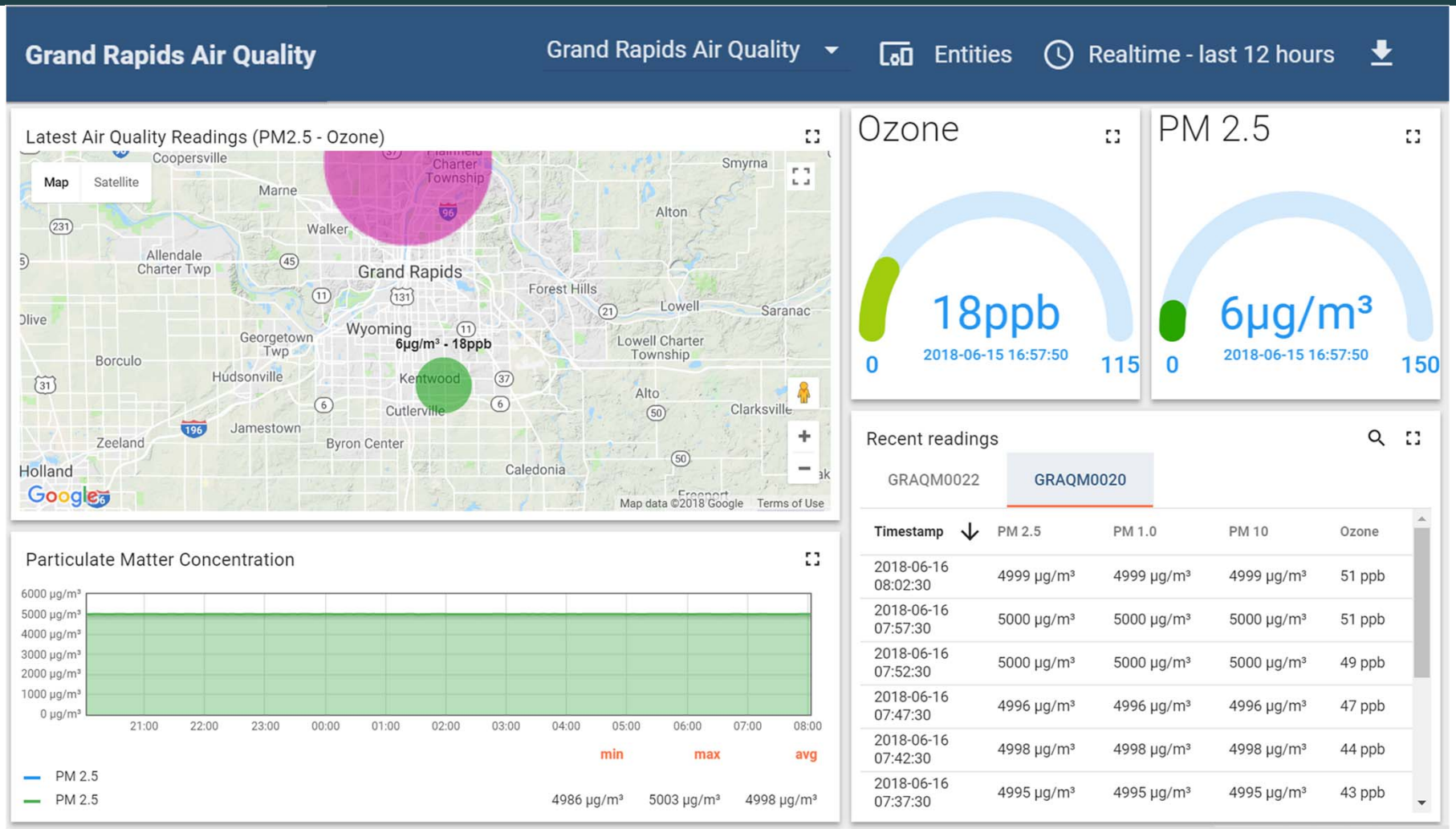
Location	D.O.	pH	ZAPS	Ortho-P	Ammonia	Solids
Influent		1	1			
Primary Effluent			1			
Aeration Tank	8		1		3	7
Secondary Effluent	2		1	2		
Final Effluent	1		1	1		
WAS/RAS						2
Biosolids						1
Grand River			2			

Sensor Matric

- ChemScan – Ortho Phosphate
- Hach Solids Probes
- Hach Amtex Ammonia
- Hach Ammonia ISE Probe
- Metso Microwave – Inline Solids
- D.O. LDO



Real-time Air Quality



emnet Welcome, Mike Lunn!

Apps | Site Installation Forms | Health Report | My Views | Clear View

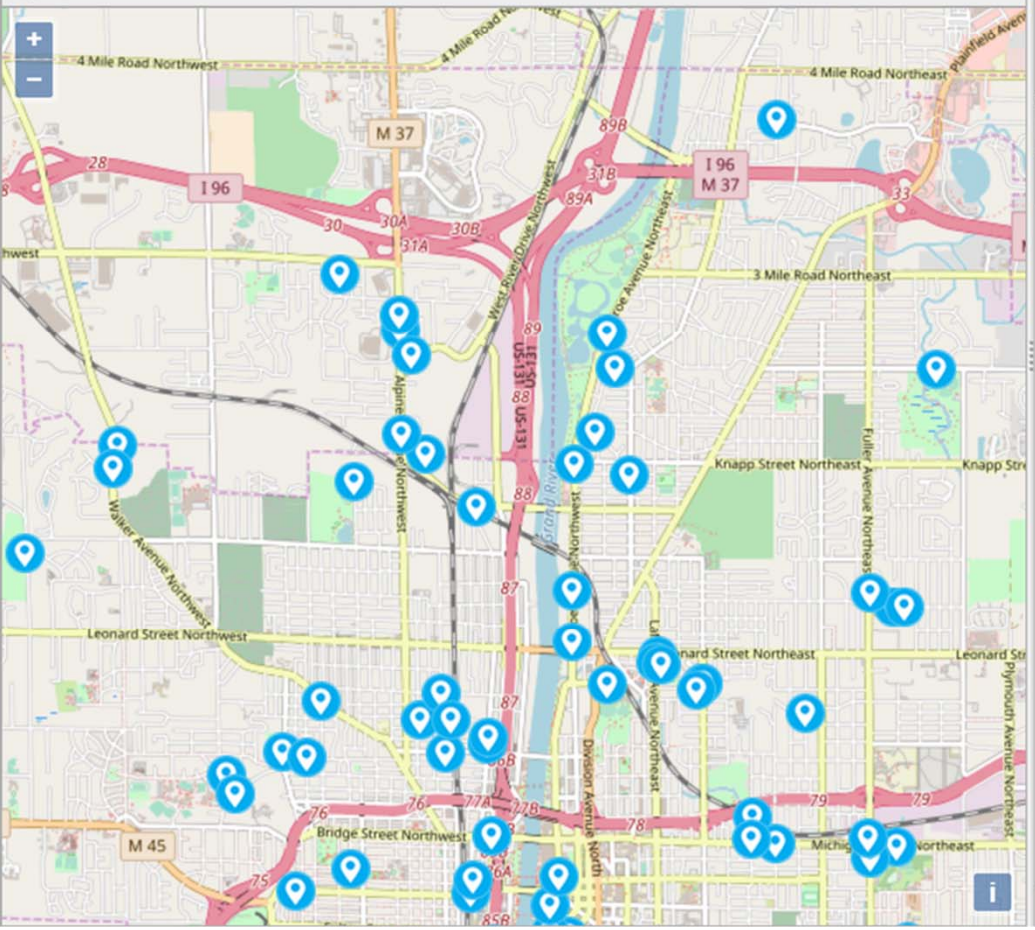
Area Sensors

Grand Rapids, MI

Groups

Alerts

Map View



Current Readings

Title	Sensor Type	Critical Low	Critical High	Reading	Utilization	Last Collected
MH 22448 Depth	Depth	-1 in	14.5 in	2.55034 in	17.59%	2018-06-11 00:27
MH 22448 De…	Depth	-1 in	38 in	6.468 in	17.02%	2018-05-30 15:58

Historical Readings

GET DATA | Custom Date Range | 02/01/2018 00:00 - 02/28/2018 23:59 | Search Data

Set dates to new extremes

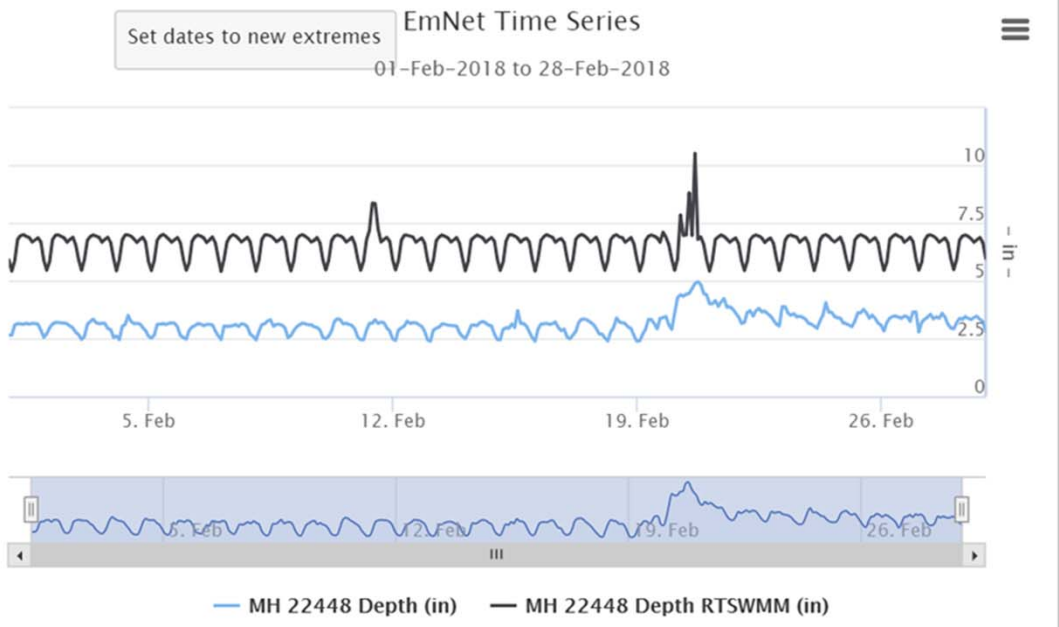


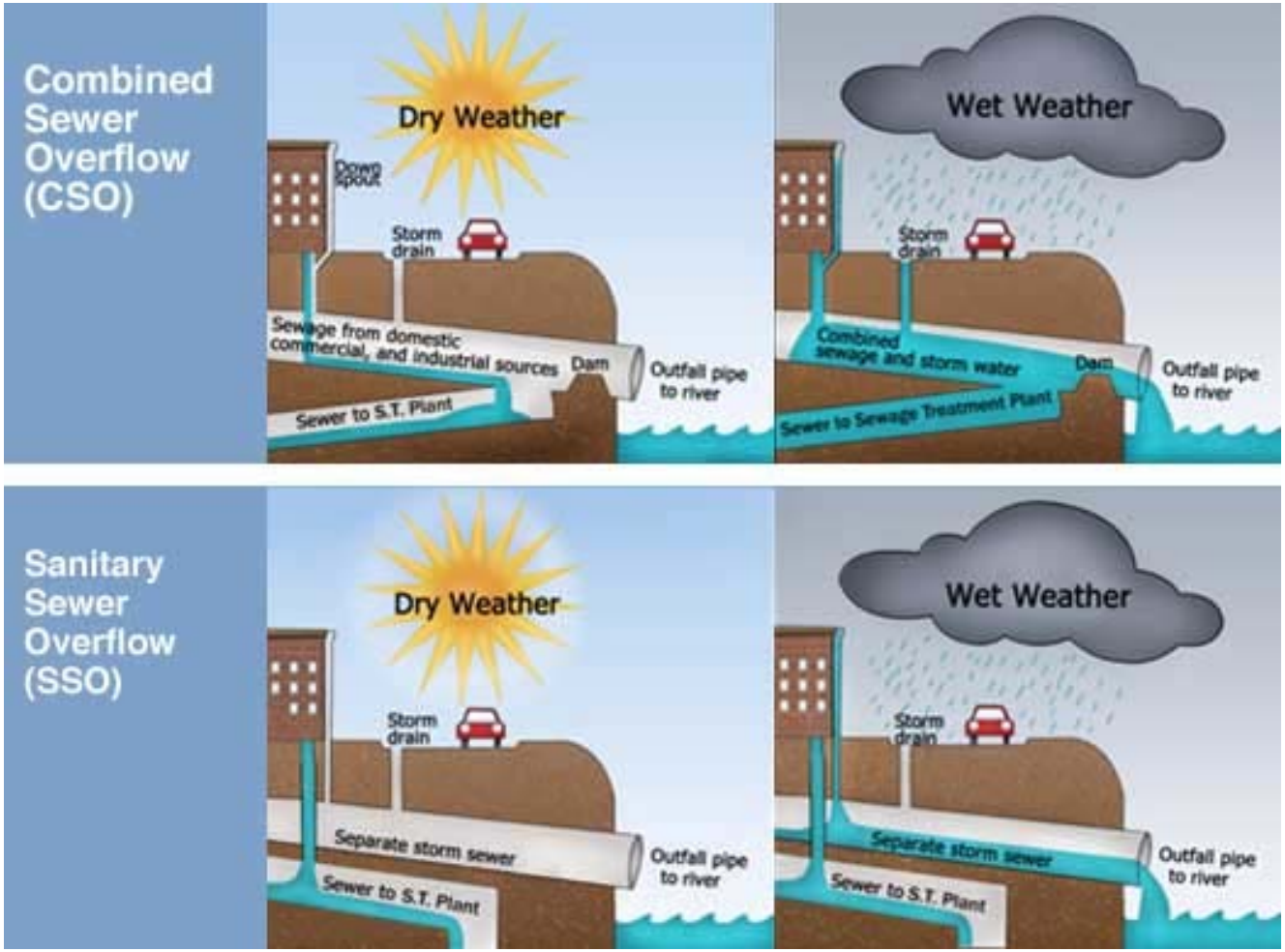
Chart | Grid

Device status

Block 2 Device Table | Entities | Realtime - last hour

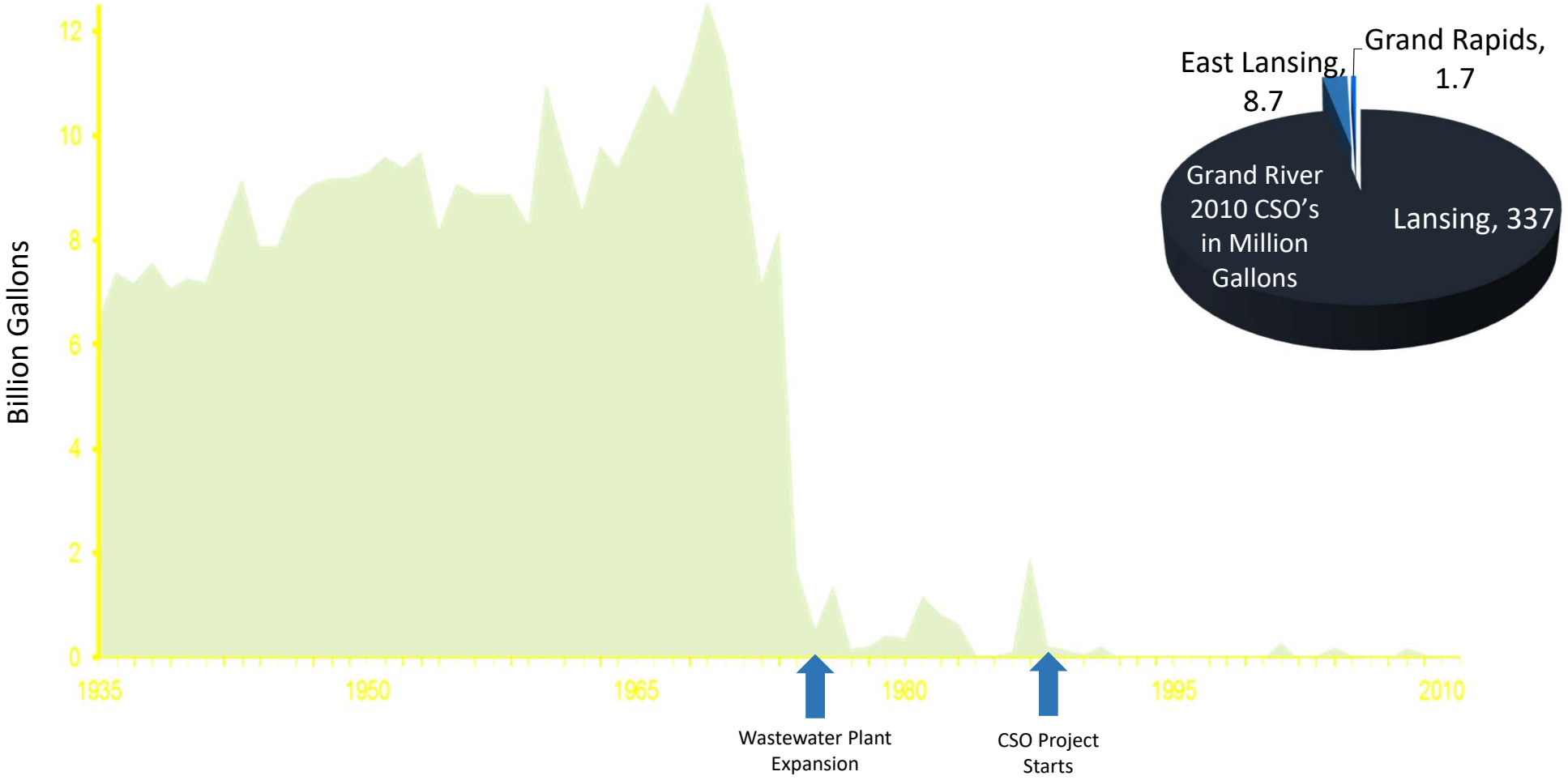
Entity name	pm25Average	pm25Count	specO3Average	specO3Count	hdop	gatewayrssi	gatewayid	gpsFix	gpsStatus
benchtest01	11	14	9	12	100	-55	loragw01	No Fix	Online
graqm0100	24	21	72	18	100	-39	mgrlora_6_v1mt	No Fix	Online
graqm0101	23	21	70	17	100	-37	mgrlora_6_v1mt	No Fix	Online
graqm0102	23	21	22	18	100	-42	mgrlora_6_v1mt	No Fix	Online
graqm0103	21	21	65	18	100	-27	mgrlora_6_v1mt	No Fix	Online
graqm0104	14	39	37	34	1.6	-49	loragw01	Fixed	Online
graqm0105	8	21	5	17	100	-55	loragw01	No Fix	Online
graqm0106	8	20	9	18	100	-51	loragw01	No Fix	Online
graqm0107	7	21	11	18	100	-45	loragw01	No Fix	Online
graqm0108	8	20	2	18	100	-55	loragw01	No Fix	Online
graqm0113	8	20	5	17	100	-63	loragw01	No Fix	Online
graqm0114	10	21	7	17	100	-70	loragw01	No Fix	Online

Combined Sewers vs Separated Sewers

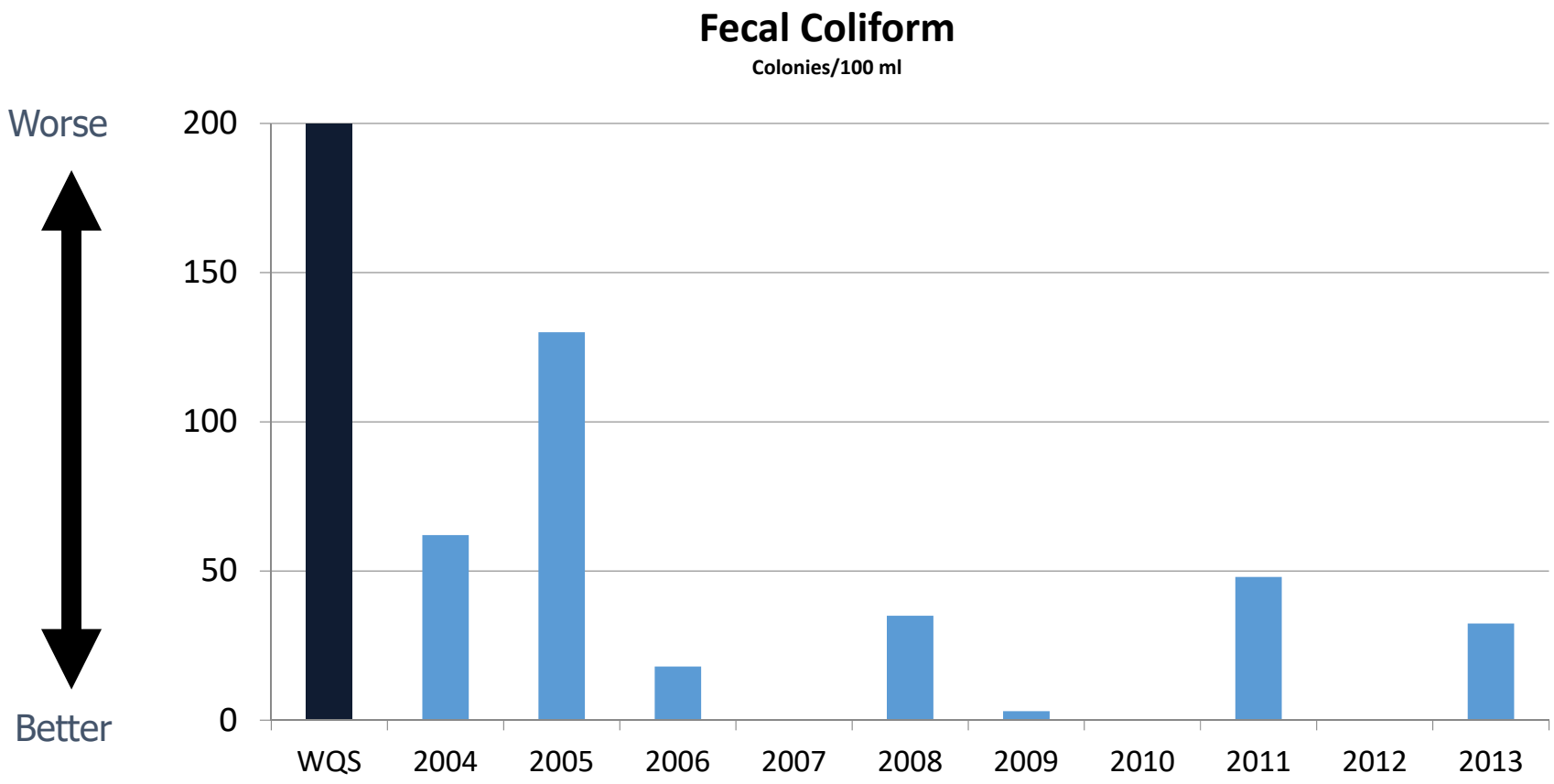


* Source: U.S. EPA

Grand Rapids Combined Sewer Overflows



Market Avenue Retention Basin (MARB)
Effluent Quality 2004 - 2013



Water Quality Standard – 7-Day 400 colonies per 100/mL, 30-Day 200 colonies per 100/mL

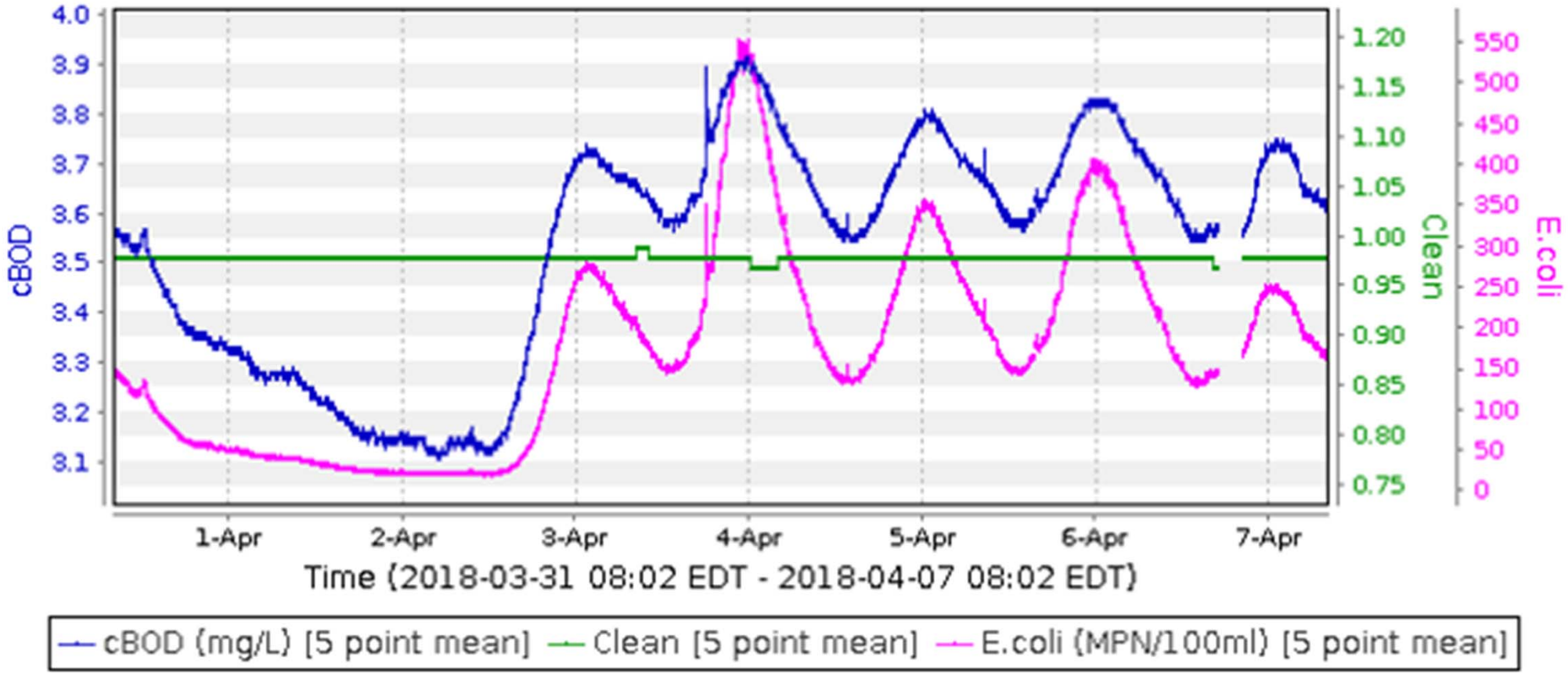
Parameter	Maximum Limits for Quantity or Loading				Maximum Limits for Quality or Concentration				Monitoring Frequency	Sample Type
	Monthly	7-Day	Daily	Units	Monthly	7-Day	Daily	Units		
Flow	(report)	---	(report)	MGD	---	---	---	---	Daily	Report Total Daily Flow
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)										
June 1 – September 30	8,200	9,700	(report)	lbs/day	16	---	21	mg/l	5x Weekly	24-Hr Composite
October 1 – May 31	12,000	19,000	(report)	lbs/day	23	38	(report)	mg/l	5x Weekly	24-Hr Composite
Total Suspended Solids	15,000	22,000	(report)	lbs/day	29	44	(report)	mg/l	5x Weekly	24-Hr Composite
Ammonia Nitrogen (as N)										
June 1 - September 30	---	4,600	(report)	lbs/day	---	---	8.5	mg/l	5x Weekly	24-Hr Composite
October 1 – May 31	---	9,200	(report)	lbs/day	---	---	18	mg/l	5x Weekly	24-Hr Composite
Total Phosphorus (as P)	510	---	(report)	lbs/day	1.0	---	(report)	mg/l	3×Weekly	24-Hr Composite
Fecal Coliform Bacteria	---	---	---	---	200	400	(report)	ct/100 ml	5x Weekly	Grab

Interim Guidance for Performance – Based Reductions of NPDES Permit Monitoring Frequencies

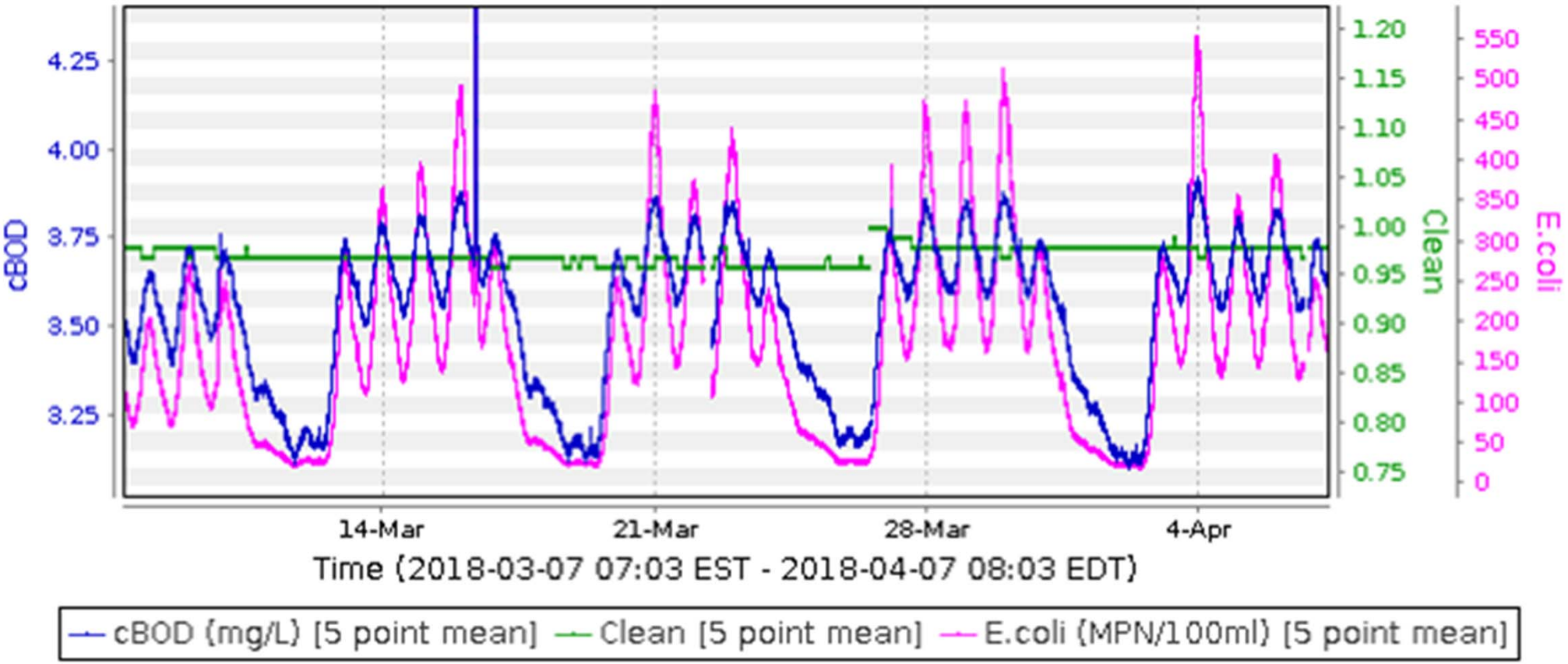
April 1996

"EPA has done a statistical analysis on the effect of sampling frequency on compliance assessment. The basic premise underlying a performance-based reduction approach is that maintaining a low average discharge relative to the permit limit results in a low probability of the occurrence of a violation for a wide range of sampling frequencies."

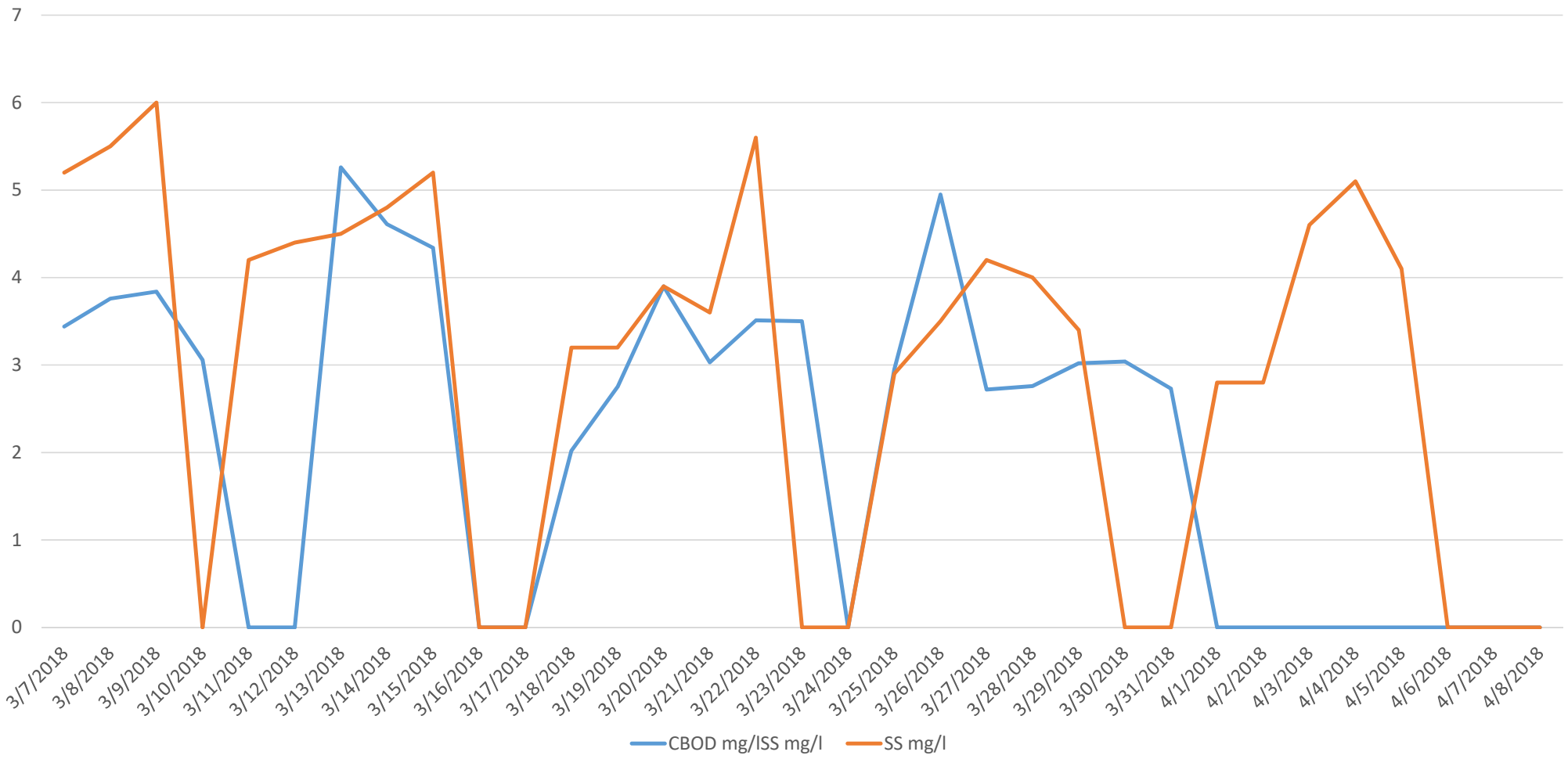
FE Sample


4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
cBOD
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
Clean
550
500
450
400
350
300
250
200
150
100
50
0
E.coli
1-Apr
2-Apr
3-Apr
4-Apr
5-Apr
6-Apr
7-Apr
Time (2018-03-31 08:02 EDT - 2018-04-07 08:02 EDT)
cBOD (mg/L) [5 point mean]
Clean [5 point mean]
E.coli (MPN/100ml) [5 point mean]

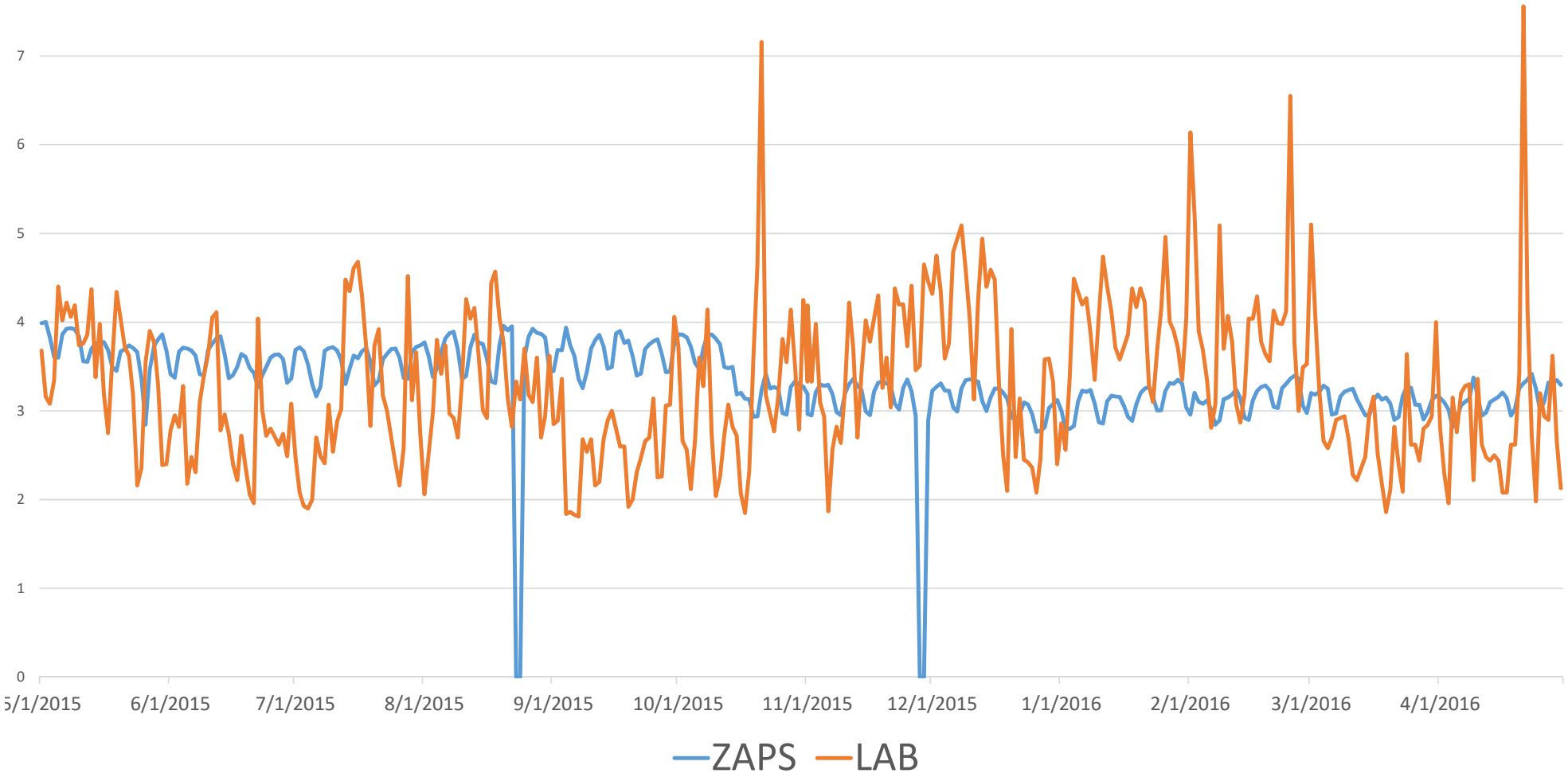
FE Sample


cBOD
4.25
4.00
3.75
3.50
3.25
Clean
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
E.coli
550
500
450
400
350
300
250
200
150
100
50
0
14-Mar
21-Mar
28-Mar
4-Apr
Time (2018-03-07 07:03 EST - 2018-04-07 08:03 EDT)
cBOD (mg/L) [5 point mean]
Clean [5 point mean]
E.coli (MPN/100ml) [5 point mean]

Final Effluent – CBOD and Solids



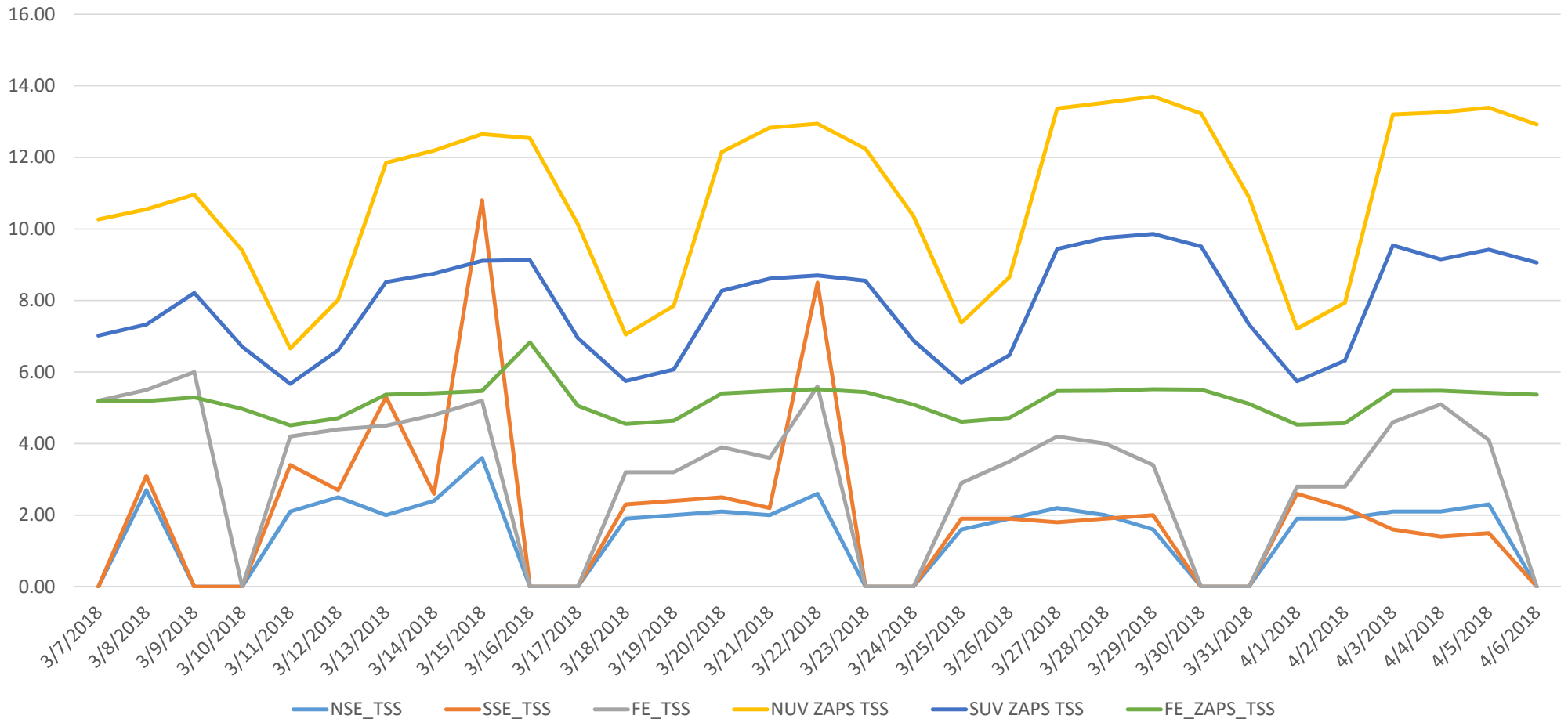
cBOD 5/1/2015 - 4/30/2016



DMR-QA cBOD

	GR Results	Target	Acceptable Range	
	mg/l	mg/l	mg/l	mg/l
2013	63.20	71.90	32.20	112.00
2014	52.40	57.10	25.70	88.50
2015	32.30	41.50	18.10	64.90
2016	60.20	55.30	24.80	85.80
2017	104.00	84.30	38.90	130.00

Solids mg/l


16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
3/7/2018
3/8/2018
3/9/2018
3/10/2018
3/11/2018
3/12/2018
3/13/2018
3/14/2018
3/15/2018
3/16/2018
3/17/2018
3/18/2018
3/19/2018
3/20/2018
3/21/2018
3/22/2018
3/23/2018
3/24/2018
3/25/2018
3/26/2018
3/27/2018
3/28/2018
3/29/2018
3/30/2018
3/31/2018
4/1/2018
4/2/2018
4/3/2018
4/4/2018
4/5/2018
4/6/2018
NSE_TSS
SSE_TSS
FE_TSS
NUV ZAPS TSS
SUV ZAPS TSS
FE_ZAPS_TSS

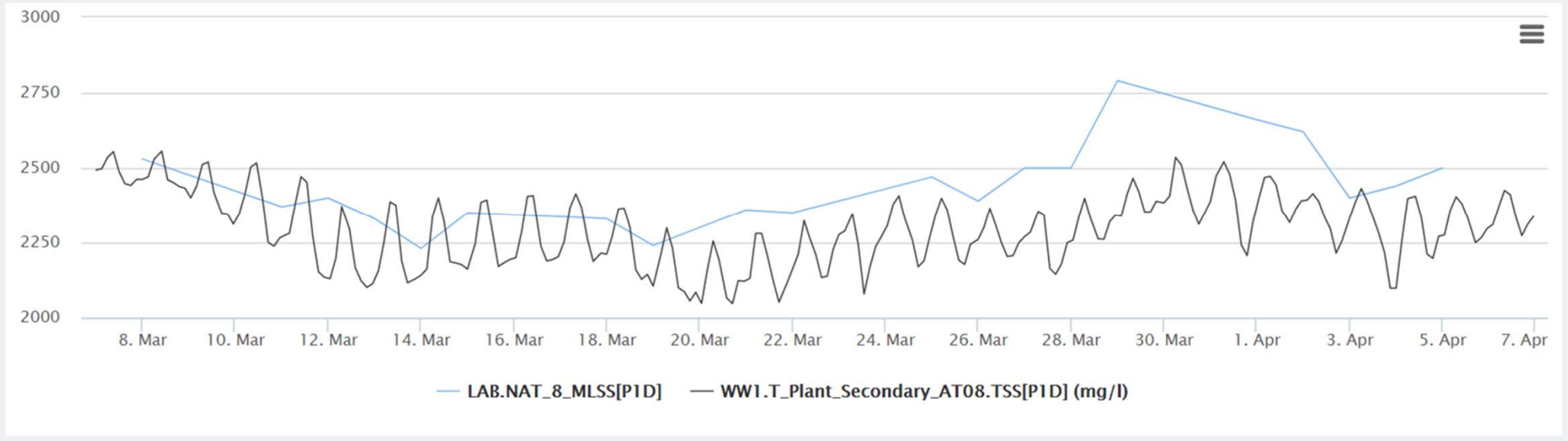
Duration: 1 month Start: 2018-03-07 00:00:00 End: 2018-04-07 00:00:00 < > Clear cache? Send

Data Query

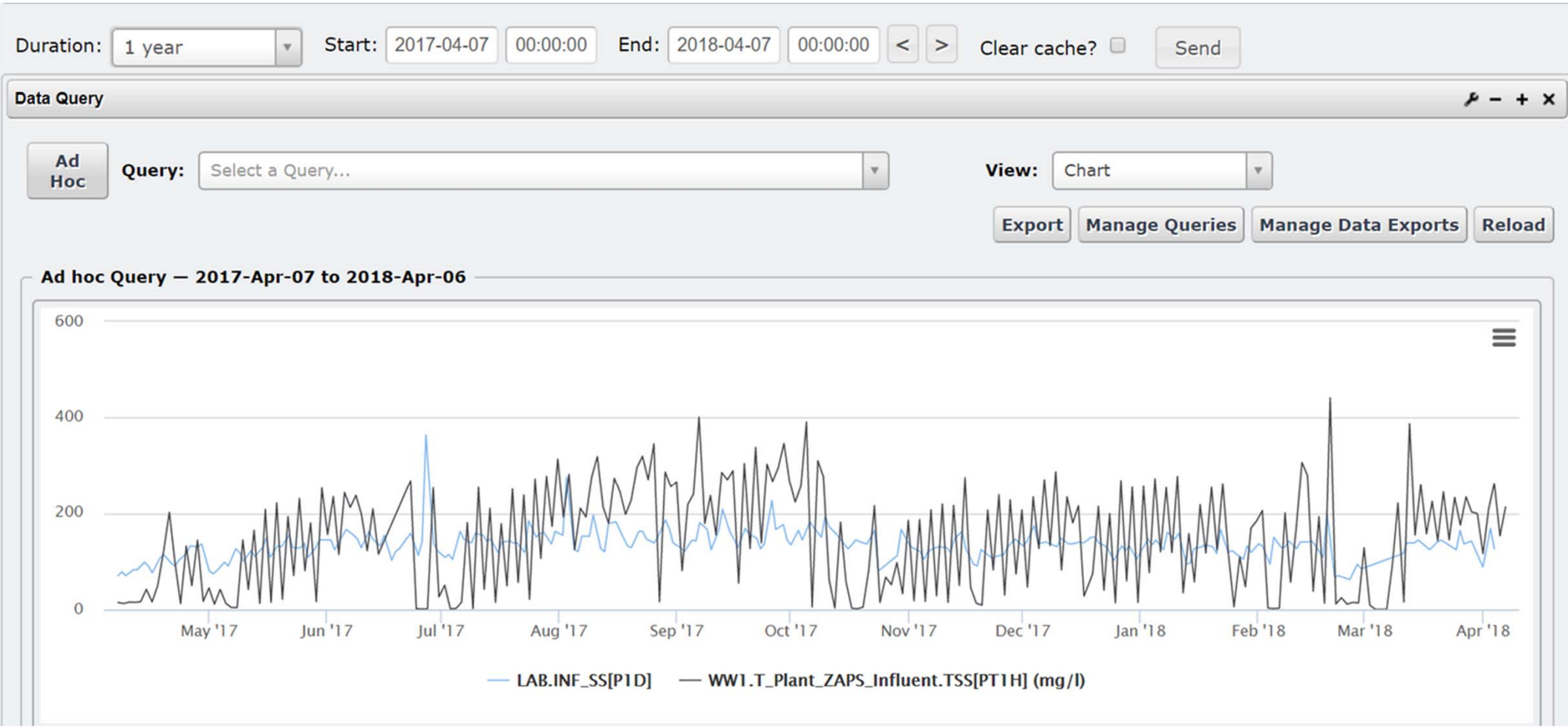
Ad Hoc Query: Select a Query... View: Chart

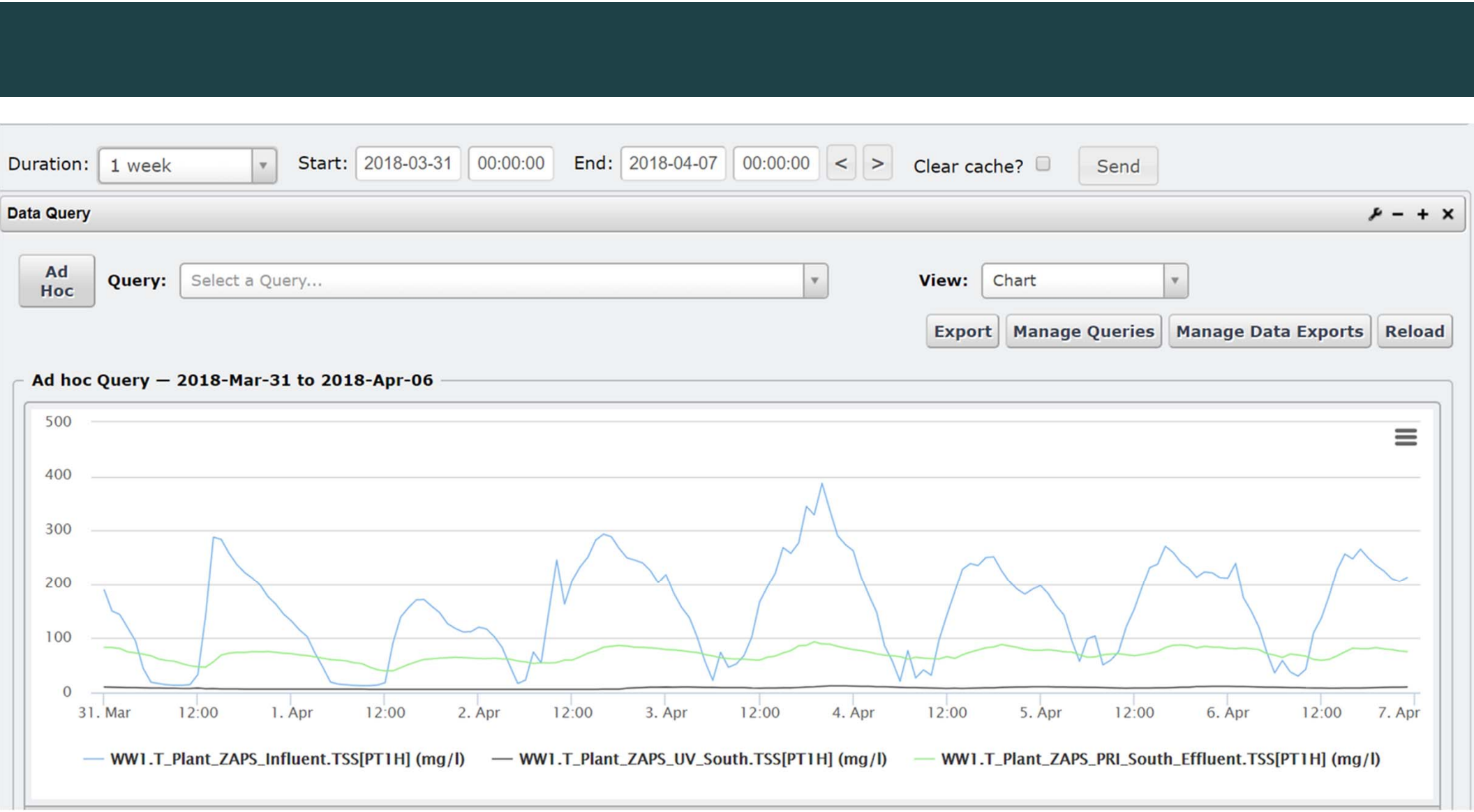
Export Manage Queries Manage Data Exports Reload

Ad hoc Query — 2018-Mar-07 to 2018-Apr-06



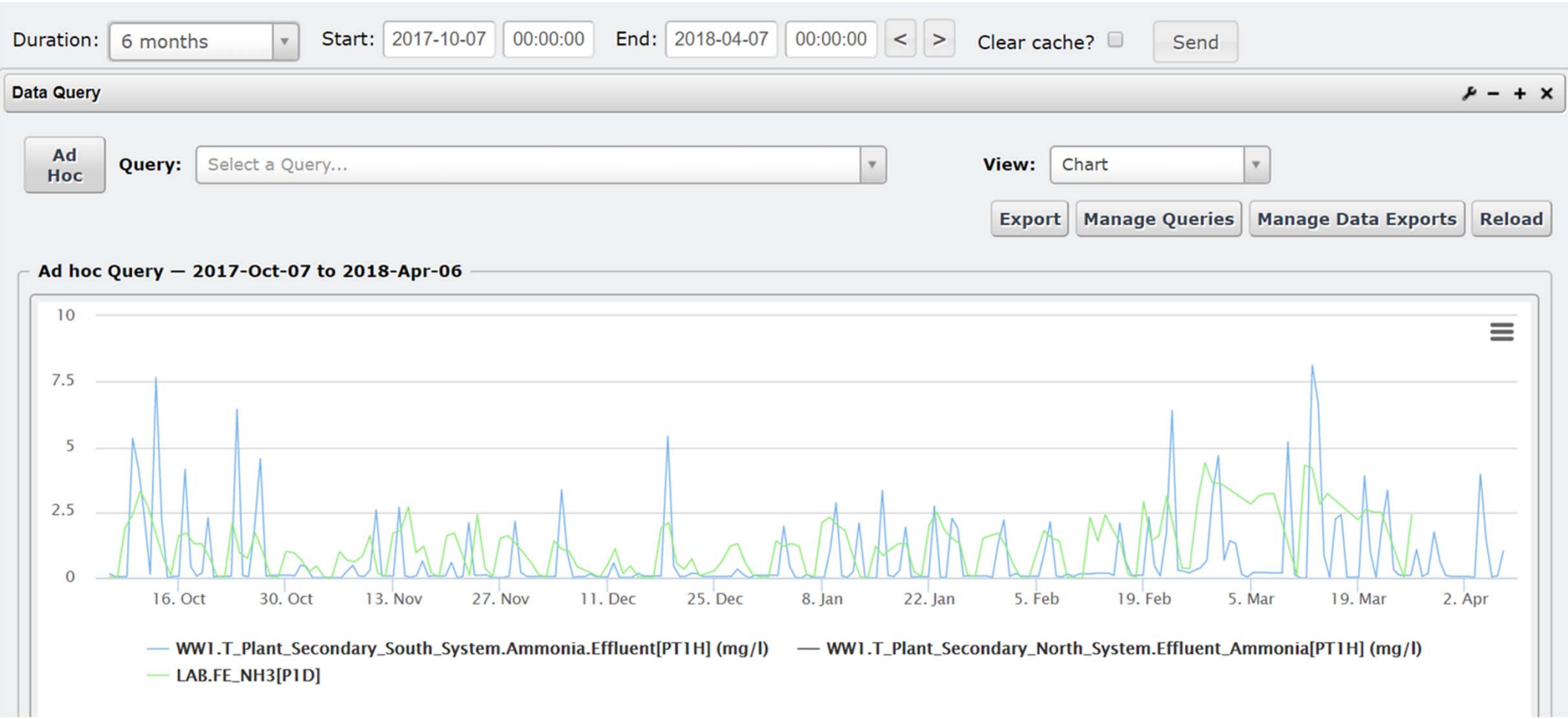
Showing 240 of 743 entries


Duration: 1 year
Start: 2017-04-07 00:00:00
End: 2018-04-07 00:00:00
Clear cache?
Send
Data Query
Ad Hoc
Query: Select a Query...
View: Chart
Export
Manage Queries
Manage Data Exports
Reload
Ad hoc Query — 2017-Apr-07 to 2018-Apr-06
600
400
200
0
May '17
Jun '17
Jul '17
Aug '17
Sep '17
Oct '17
Nov '17
Dec '17
Jan '18
Feb '18
Mar '18
Apr '18
LAB.INF_SS[P1D]
WW1.T_Plant_ZAPS_Influent.TSS[PT1H] (mg/l)


Duration: 1 week
Start: 2018-03-31 00:00:00
End: 2018-04-07 00:00:00
Clear cache?
Send
Data Query
Ad Hoc
Query: Select a Query...
View: Chart
Export
Manage Queries
Manage Data Exports
Reload
Ad hoc Query — 2018-Mar-31 to 2018-Apr-06
500
400
300
200
100
0
31. Mar
12:00
1. Apr
12:00
2. Apr
12:00
3. Apr
12:00
4. Apr
12:00
5. Apr
12:00
6. Apr
12:00
7. Apr
WW1.T_Plant_ZAPS_Influent.TSS[PT1H] (mg/l)
WW1.T_Plant_ZAPS_UV_South.TSS[PT1H] (mg/l)
WW1.T_Plant_ZAPS_PRI_South_Effluent.TSS[PT1H] (mg/l)

DMR-QA TSS

	GR Results	Target	Acceptable Range	
	mg/l	mg/l	mg/l	mg/l
TSS	54.20	56.60	44.60	64.20
TSS	41.00	44.60	34.00	51.50
TSS	62.00	71.70	57.90	80.30
TSS	32.50	35.10	25.60	41.40
TSS	79.80	85.00	69.70	94.40


Duration: 6 months
Start: 2017-10-07 00:00:00
End: 2018-04-07 00:00:00
Clear cache?
Send
Data Query
Ad Hoc
Query: Select a Query...
View: Chart
Export
Manage Queries
Manage Data Exports
Reload
Ad hoc Query — 2017-Oct-07 to 2018-Apr-06
10
7.5
5
2.5
0
16. Oct
30. Oct
13. Nov
27. Nov
11. Dec
25. Dec
8. Jan
22. Jan
5. Feb
19. Feb
5. Mar
19. Mar
2. Apr
WW1.T_Plant_Secondary_South_System.Ammonia.Effluent[PT1H] (mg/l)
WW1.T_Plant_Secondary_North_System.Effluent_Ammonia[PT1H] (mg/l)
LAB.FE_NH3[P1D]

Ammonia

- HACH ISE Probe
- HACH AMTAX
  - Same chemistry as lab

DMR-QA Ammonia

	GR Results	Target	Acceptable Range	
	mg/l	mg/l	mg/l	mg/l
2013	13.20	13.50	10.00	16.80
2014	7.35	7.34	5.78	8.90
2015	10.30	10.20	8.12	12.20
2016	11.90	11.40	9.10	13.60

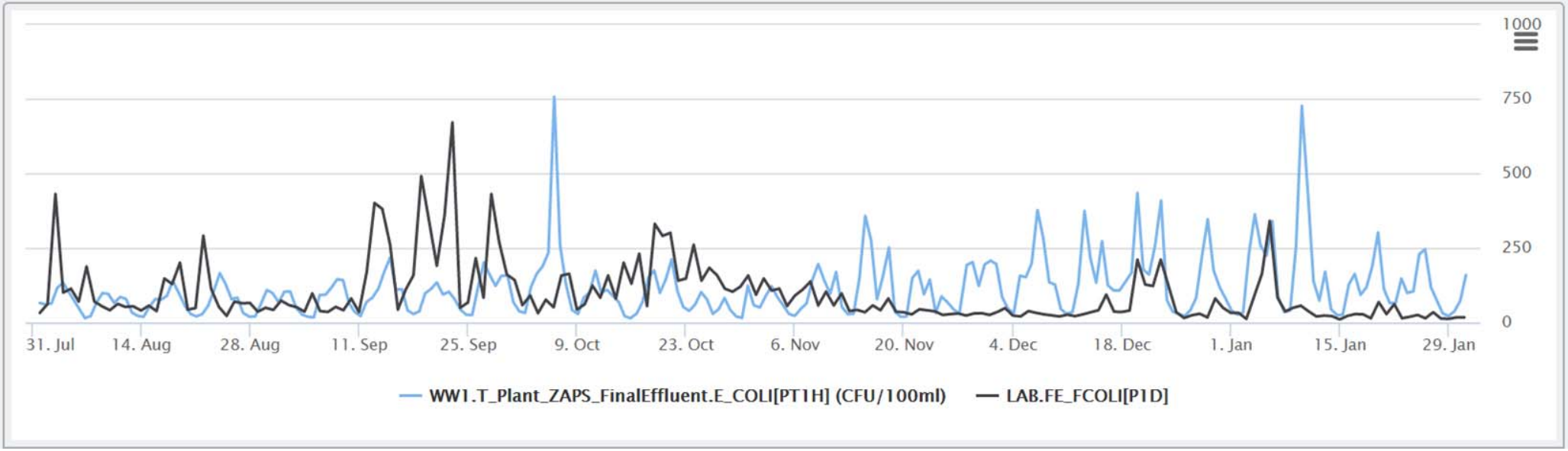
Duration: 6 months Start: 2017-08-01 00:00:00 End: 2018-02-01 00:00:00 < > Clear cache? Send

Data Query

Ad Hoc Query: Select a Query... View: Chart

Export Manage Queries Manage Data Exports Reload

Ad hoc Query — 2017-Aug to 2018-Jan



Lab Number	Date and Time	E. coli (MPN/100 mL)	
		Lab	ZAPS
1304763	11/14/2013 9:22	14	6.1
1304772	11/14/2013 13:33	27	5.5
1304778	11/15/2013 9:09	15	9.3
1304788	11/15/2013 12:56	40	9
1304819	11/20/2013 7:16	25	17
1304834	11/21/2013 8:41	17	27.3
1304889	12/2/2013 8:22	17	2.4
1304935	12/3/2013 13:17	20	12.3
1304939	12/4/2013 7:37	39	7
1304972	12/5/2013 12:40	99	10.8
1304974	12/6/2013 7:48	28	18
1304983	12/9/2013 8:13	14	6.4
1305029	12/10/2013 13:11	34	22.8
1305145	12/12/2013 7:33	30	41.8
1305165	12/13/2013 13:18	35	32.9
1305169	12/16/2013 8:43	20	14.3
1305197	12/17/2013 13:34	30	41.5
1305202	12/18/2013 9:56	17	42.6
1400298	1/22/2014 12:53	21	6.3
1400318	1/23/2014 9:23	10	8.6
1400329	1/23/2014 8:15	20	13.3
1400361	1/28/2014 10:08	19	11
1400380	1/29/2014 8:22	16	18.1
1400488	2/5/2014 9:24	69	11.9
1400542	2/10/2014 8:56	28	5.7
1400679	2/12/2014 13:14	79	18.2
1400733	2/19/2014 7:22	99	27.8
1400760	2/21/2014 12:48	115	13.8

Lab Number	Date and Time	E. coli (MPN/100 mL)	
		Lab	ZAPS
1304762	11/14/2013 9:17	28	8.96
1304771	11/14/2013 13:26	30	9.22
1304777	11/15/2013 8:51	36	15.28
1304787	11/15/2013 12:50	42	14.88
1304818	11/20/2013 7:12	143	10.28
1304833	11/21/2013 8:37	27	16.74
1304860	11/22/2013 13:32		
1304888	12/2/2013 8:16	18	10.98
1304934	12/3/2013 13:13	26	9.46
1304938	12/4/2013 7:31	59	5.36
1304971	12/5/2013 12:46	36	9.22
1304973	12/6/2013 7:43	49	15.02
1304982	12/9/2013 8:07	28	6.1
1305028	12/10/2013 13:16	58	26.86
1305144	12/12/2013 7:28	55	8.26
1305164	12/13/2013 13:11	54	7.46
1305168	12/16/2013 8:47	22	7.72
1305196	12/17/2013 13:31	36	24.88
1305201	12/18/2013 9:50	36	28.36
1400297	1/22/2014 13:07	30	11.7
1400317	1/23/2014 9:29	28	7.1
1400328	1/24/2014 8:08	46	15.7
1400360	1/28/2014 10:00	30	7.7
1400379	1/29/2014 8:18	55	14.7
1400487	2/5/2014 9:16	69	18.7
1400540	2/10/2014 8:55	46	9.7
1400678	2/12/2014 13:11	156	31.3
1400732	2/19/2014 7:18	387	46
1400759	2/21/2014 12:44	162	5.7
1400792	2/26/2014 9:09	579	50.5

Lab Number	Date and Time	E. coli (MPN/100 mL)	
		Lab	ZAPS
1401596	4/24/2014 7:27	104	5.6
1401664	4/30/2014 9:47	58	7.2
1401684	5/1/2014 8:19	260	12.1
1401754	5/7/2014 12:48	126	4.7
1401775	5/8/2014 8:36	153	3.3
1401896	5/12/2014 8:57	649	1.1
1401952	5/15/2014 7:41	687	3.9
1402917	7/10/2014 9:59	166	10.3
1403127	7/23/2014 13:44	236	17.2
1403133	7/24/2014 8:37	261	26.6
1403189	7/28/2014 13:50	130	8.2
1403226	7/30/2014 8:57	225	21.5
1403652	8/13/2014 13:35	387	28.6

North UV

South UV

Final Effluent
(requires recommissioning)

DMR-QA Fecal Coliform

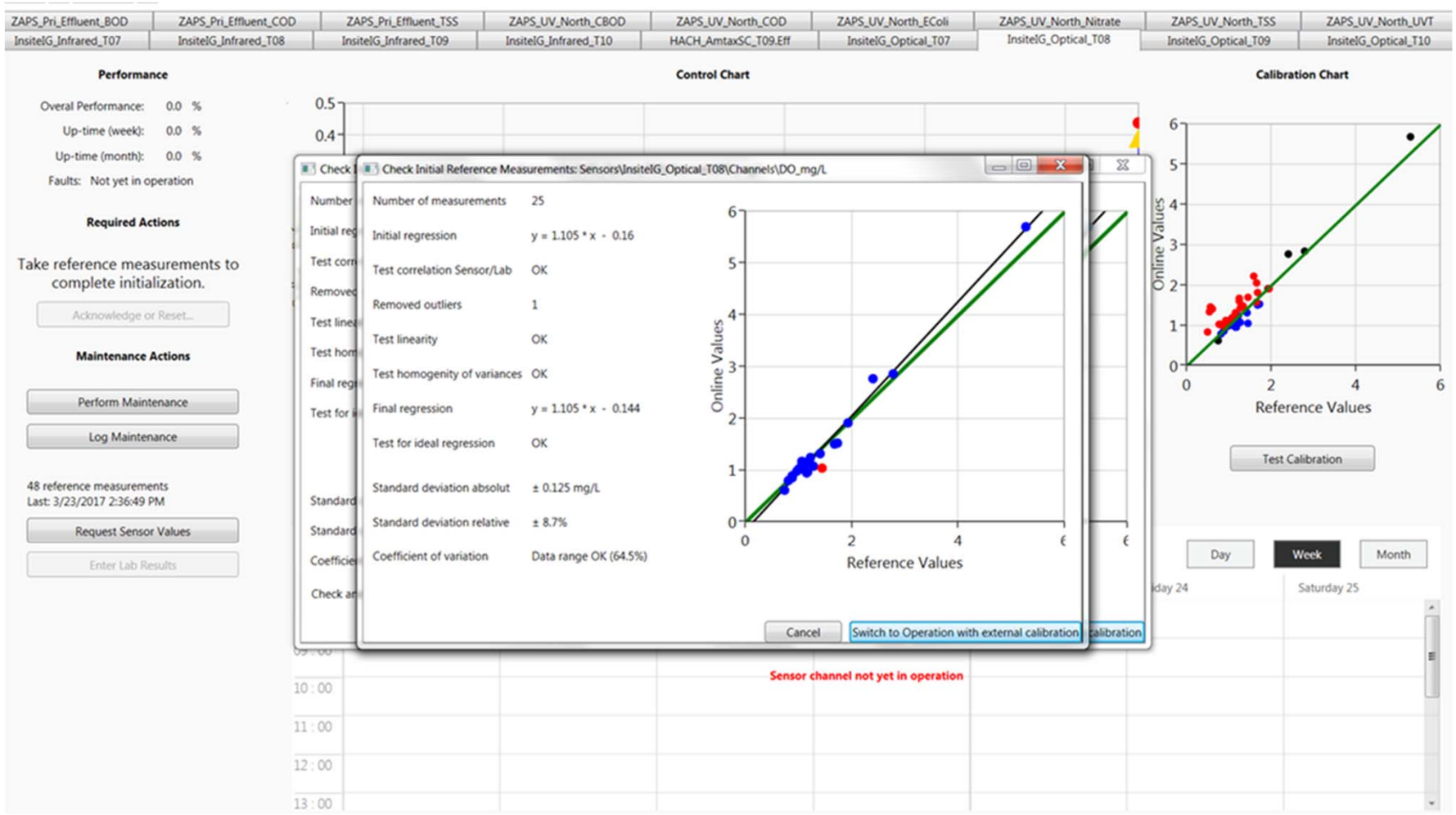
	GR Results	Target	Acceptable Range	
	c/100 ml	c/100 ml	c/100 ml	c/100 ml
2013	300.00	726.00	67.00	1450.00
2014	480.00	1510.00	15.00	3040.00
2015	68.00	354.00	4.00	1010.00
2016	750.00	1330.00	130.00	2690.00
2017	469.00	1090.00	143.00	1530.00

Last two permit parameters

- Dissolved Oxygen
  - Probes have been in use over 30 years
  - Approved for use with BOD analysis
  - Approved for use with grab
  - No option for on-line
- pH
  - Probes have been in use decades
  - Use for grab samples

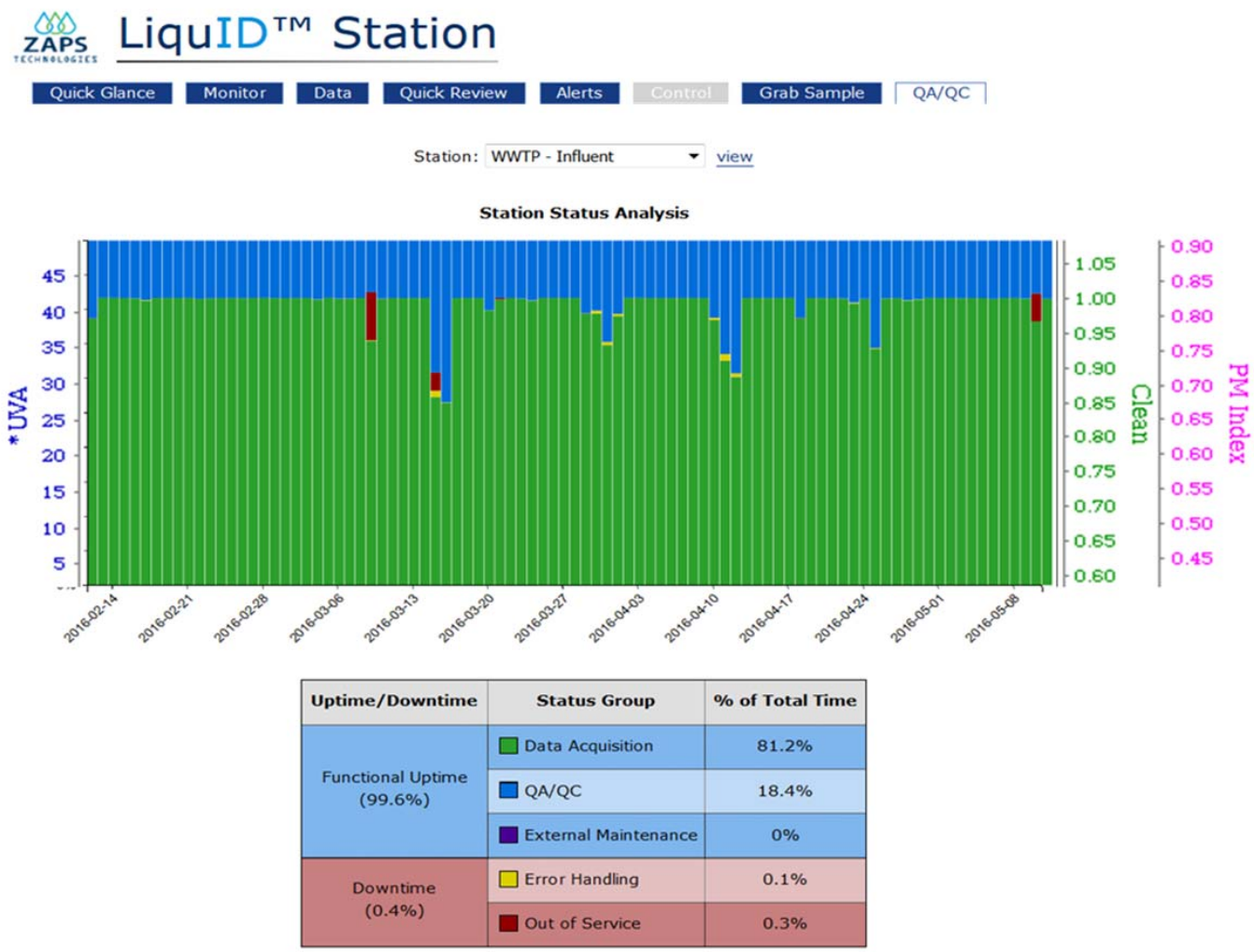
					Minimum Daily					
pH	---	---	---	---	6.0	---	9.0	S.U.	Daily	Grab
Dissolved Oxygen	---	---	---	---	5.0	---	---	mg/l	Daily	Grab

Sensor quality check – initialization - InCtrl



QA/QC

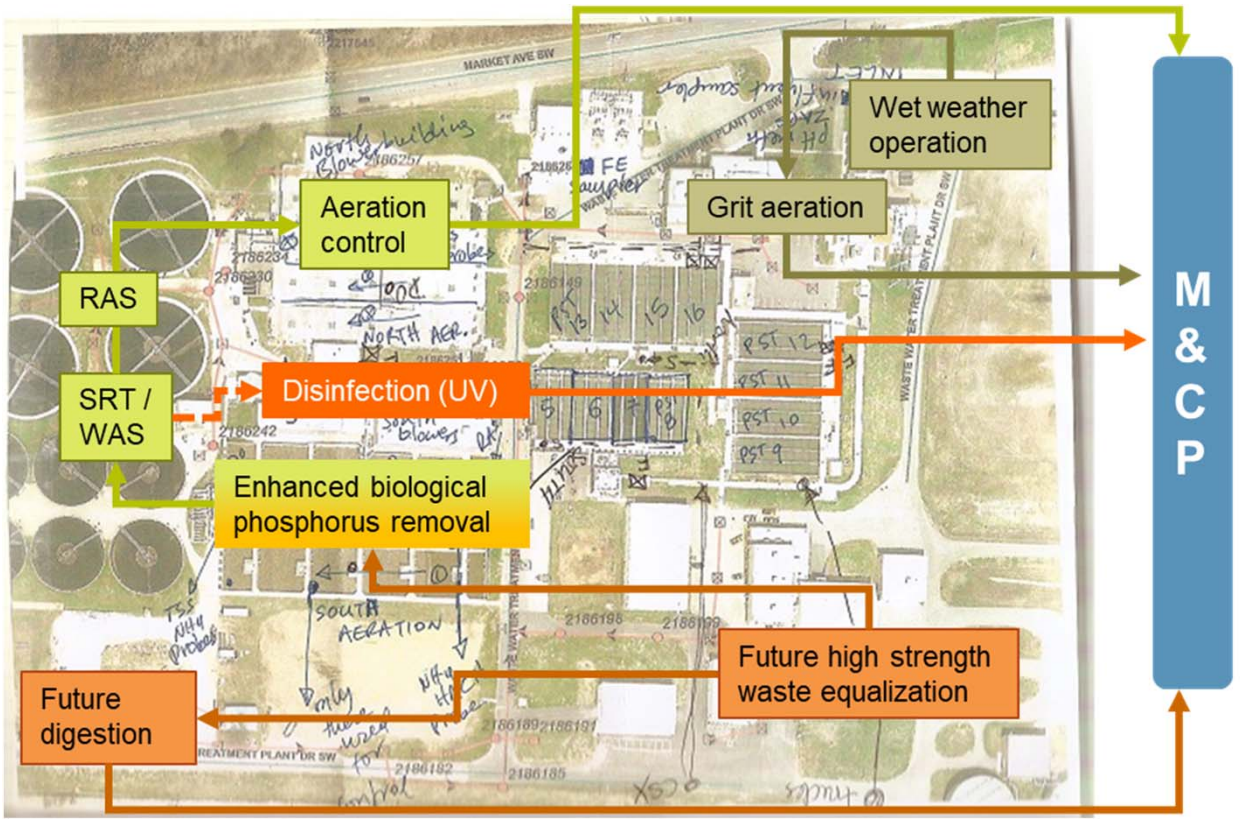
- InCtrl
- Hach - PROGNOSYS
- Xylem – Smart QC
- ZAPS - QA



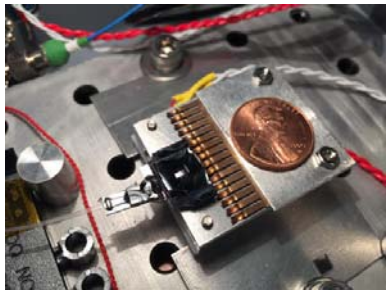
Uptime/Downtime	Status Group	% of Total Time
Functional Uptime (99.6%)	Data Acquisition	81.2%
	QA/QC	18.4%
	External Maintenance	0%
Downtime (0.4%)	Error Handling	0.1%
	Out of Service	0.3%

Opinion of Benefits

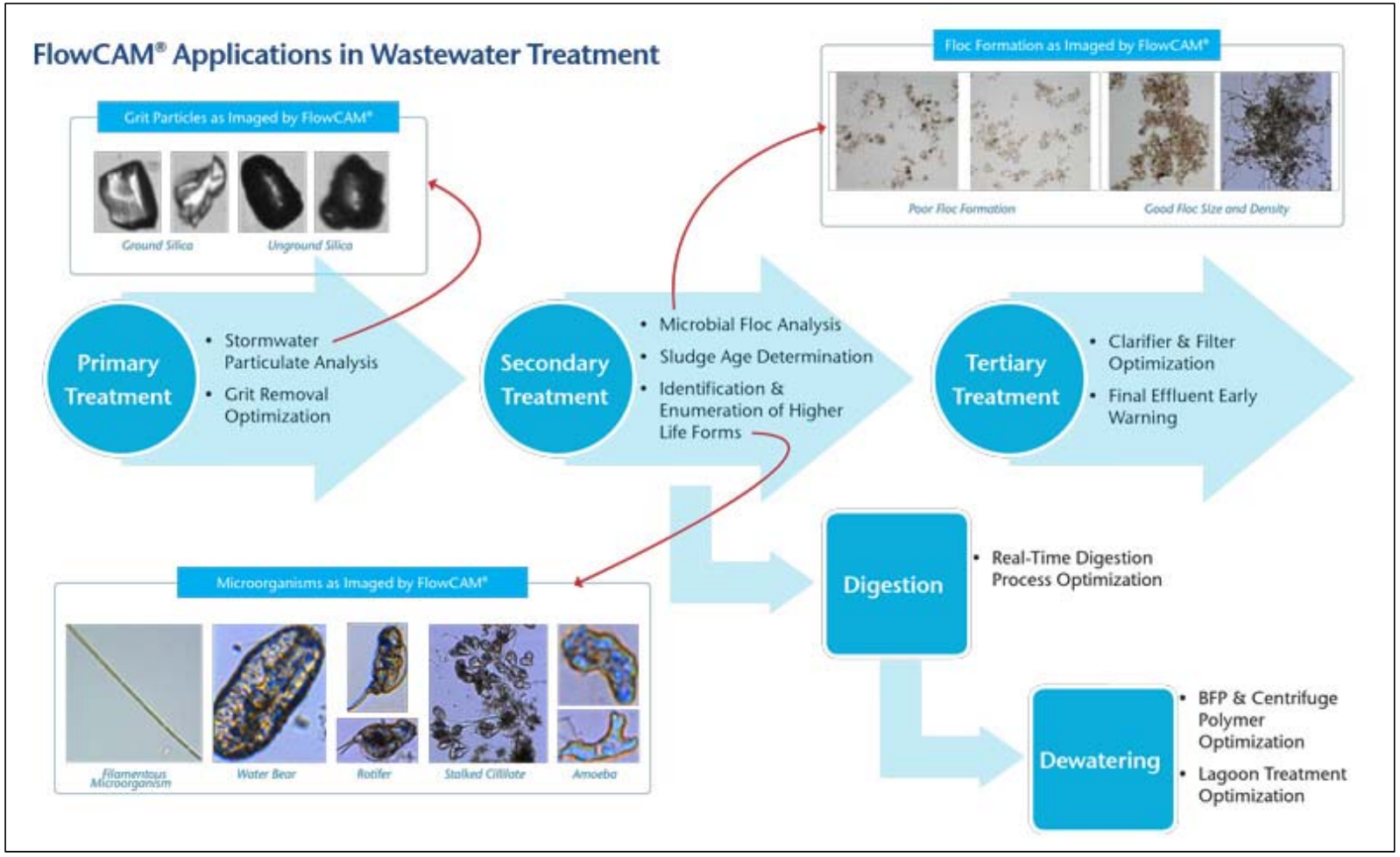
- Improved Operations Efficiency
  - eColi Control of UV – 675,000 KWH annual savings
  - Integrated Controls
- MAHL
  - BOD 160,000 lbs/day to 230,000 lbs/day
- Increased Knowledge for Resource Recovery
  - Digestion & CHP
  - Phosphorus Recovery
- Trunkline Sampling



Future



- 11 year-old creates lead sensing device
- Steve Corsi From USGS
  - E. Coli real time predictions from low cost instruments
- FlowCam
  - Counting the Organisms
- Optical
  - ZAPS
  - Hach
  - Endres
  - Xylem
- NIST - Quantum



Questions

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CITY OF GRAND RAPIDS