Metropolitan Water Reclamation District of Greater Chicago

Welcome to the December Edition of the 2022 M&R Seminar Series

NOTES FOR SEMINAR ATTENDEES

- Remote attendees' audio lines have been muted to minimize background noise. For attendees in the auditorium, please silence your phones.

- A question and answer session will follow the presentation.

- For remote attendees, Please use the "**Chat**" feature to ask a question via text to "Host". For attendees in the auditorium, please raise your hand and wait for the microphone to ask a verbal question.

- The presentation slides will be posted on the MWRD website after the seminar.

- This seminar has been approved by the ISPE for one PDH and approved by the IEPA for one TCH. Certificates will only be issued to participants who attend the entire presentation.

Dustin Gallagher, Senior Aquatic Biologist
Metropolitan Water Reclamation District of Greater Chicago

Dustin Gallagher has worked for the District since 2000 and was recently promoted to Senior Aquatic Biologist. Dustin currently manages the Continuous Dissolved Oxygen Monitoring (CDOM) program and until recently he managed the biological component of the Ambient Water Quality Monitoring (AWQM) program. Prior to the District, he worked for the Illinois Natural History Survey at the Illinois River Biological Station, in Havana Illinois, where he started as a Field Technician, then a Large River Ecologist. Mr. Gallagher does not have spare time outside of work, because he has a daughter that is an elite level competitive dancer, and a son that plays hockey.

Nicholas Kollias, Aquatic Biologist
Metropolitan Water Reclamation District of Greater Chicago

Nicholas Kollias began his career at the District as an Aquatic Biologist in the Aquatic Ecology Section in 2010. During that time, he has acted as the Project leader for the Ambient Water Quality Monitoring Program and Whole Effluent Toxicity Testing Program to ensure the District remains compliant with NPDES permit requirements. Nick has conducted numerous biological field surveys consisting of electrofishing, sediment and invertebrate sample collections, and habitat assessments. Nick has assisted on research projects, including a large-scale collaborative study which assessed concentrations of endocrine active compounds and their reproductive impacts on fish populations in the Chicago area waterways. He also supported the Chicago River Microbiome project collaboration with Argonne National Laboratory and the development of District's Phosphorus Assessment and Reduction Plan (PARP).

Metropolitan Water Reclamation District of Greater Chicago

Water Quality in the Calumet Waterway System after the Thornton Composite Reservoir Went Online

By Nick Kollias and Dustin Gallagher

Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

REPORT NO. 19-13

POST-CONSTRUCTION MONITORING REPORT FOR THE CALUMET TUNNEL AND RESERVOIR PLAN SYSTEM

Metropolitan Water Reclamation District of Greater Chicago

Outline

- Background
- Thornton Composite Reservoir
- Post-Construction Monitoring Report
  - Study area
  - Objectives
  - Methods
  - Results
  - Conclusions
- Recent Trends in Water Quality
  - Other Studies
- Acknowledgements
- Questions?

Metropolitan Water Reclamation District of Greater Chicago

Background

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Background

- The Tunnel and Reservoir Plan (TARP) was chosen out of 23 alternatives, on October 20,1972 TARP was adopted by the District.
  - Happy 50th Anniversary!
- TARP prioritized flooding and water quality.
- In 1975 construction began on huge underground tunnels to intercept Combined Sewer Overflows (CSOs) and conveys them to storage reservoirs.
- This massive undertaking was in response to growing water quality and flooding problems that came with aging infrastructure and rapid development.
- Portions of the Calumet tunnel system began operation in 1986, and the entire Calumet tunnel system was completed in 2006.

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Background (Continued)

- Thornton Transitional Reservoir (4.5 BG) –Completed in 2003
  - Provided overbank flood relief for 9 communities during 83 fill events.
  - Captured more than 58 BG gallons of floodwater from Thorn Creek.
  - Decommissioned in 2022 and is no longer leased by MWRD.
  - Flood waters have been rerouted via Thorn Creek Overflow Tunnel to the Thornton Composite Reservoir.

- The District entered into a Consent Decree on January 6, 2014 with USEPA and Illinois EPA.
  - Required amounts of Green Infrastructure (GI).
  - Enforceable schedule for construction of TARP.
  - Debris removal
  - Reporting

- From 2015 to 2021, TARP captured over 153 BG of combined sewer overflows (CSOs)

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Thornton Composite Reservoir (TCR)

Thornton Composite Reservoir

- Excavation was complete in 2013.
- The Calumet TARP System's Thornton Composite Reservoir (TCR) became operational on November 26, 2015, when it took water for the first time, and was fully operational one year after that date.
- TCR measures approximately 2,500 by 1,600 feet with a maximum water depth of 292 feet, and has a total capacity of 7.9 billion gallons (BG).
- Benefits 556,000 people in 14 communities throughout south Chicago and south suburbs.
- Protects 182,000 homes businesses and other facilities by collecting combined sewer overflows (CSOs) before entering CRS waterways.
- Wastewater from within the TCR flows to the Calumet WRP for treatment and then discharged into the Little Calumet River (LCR).

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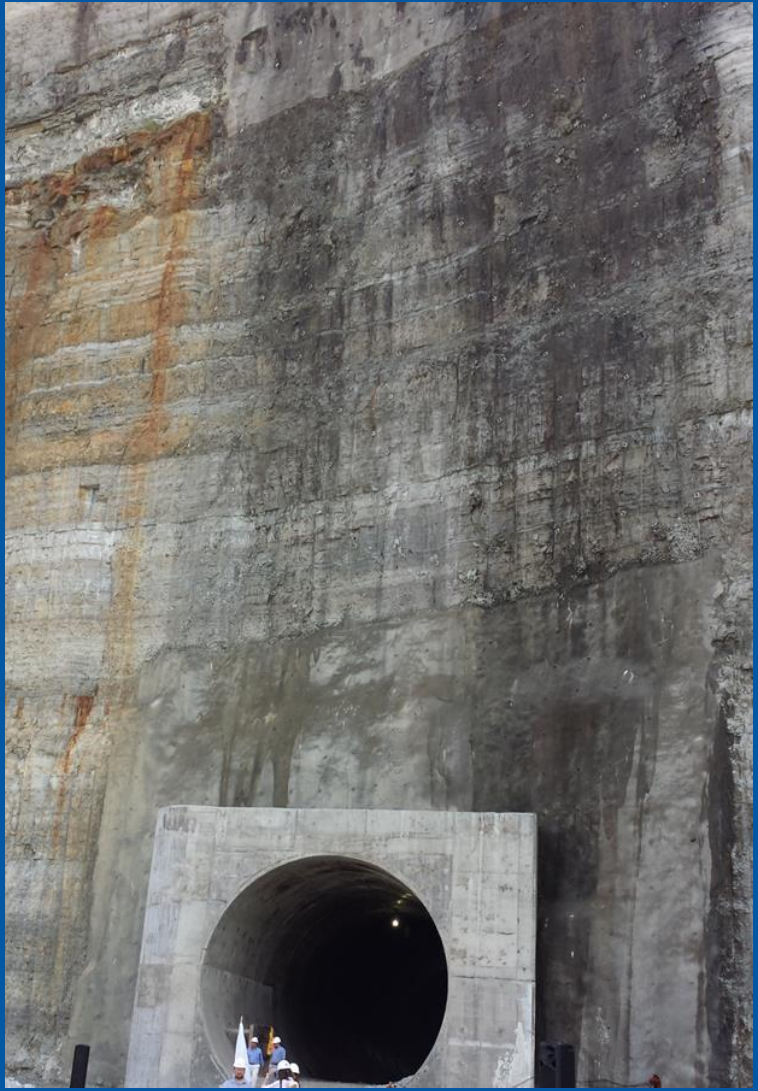
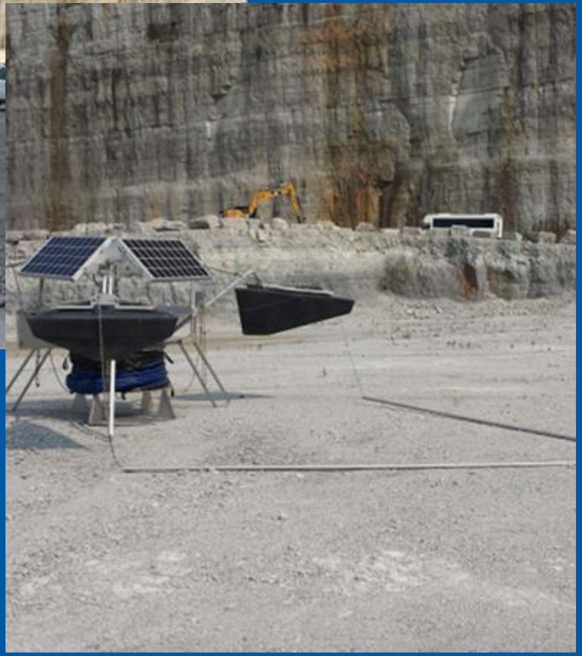
TCR (Before Online)





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TCR

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Post-Construction Monitoring Report for the Calumet Tunnel and Reservoir Plan System

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Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

REPORT NO. 19-13

POST-CONSTRUCTION MONITORING REPORT FOR THE CALUMET TUNNEL AND RESERVOIR PLAN SYSTEM

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Study Area

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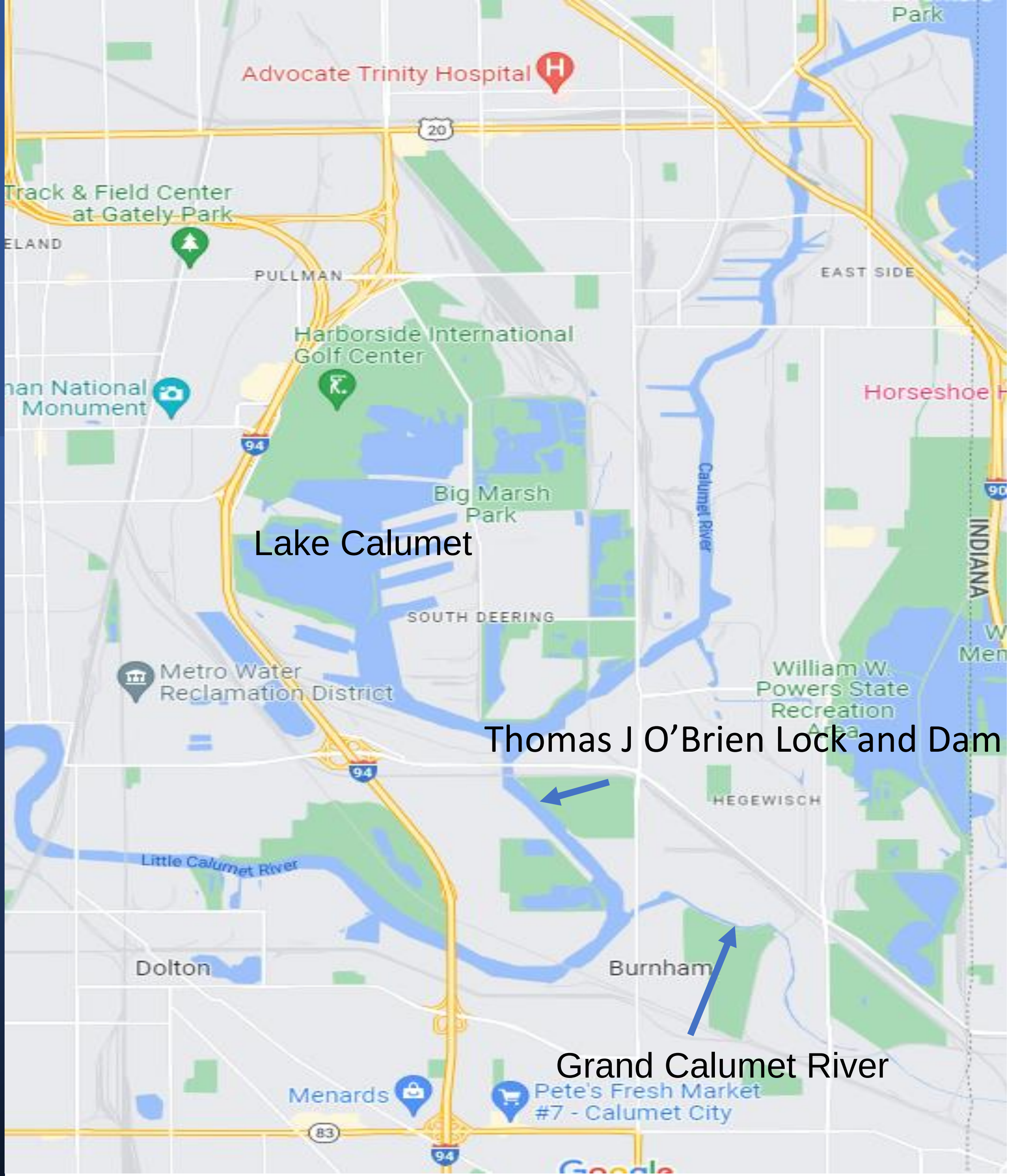
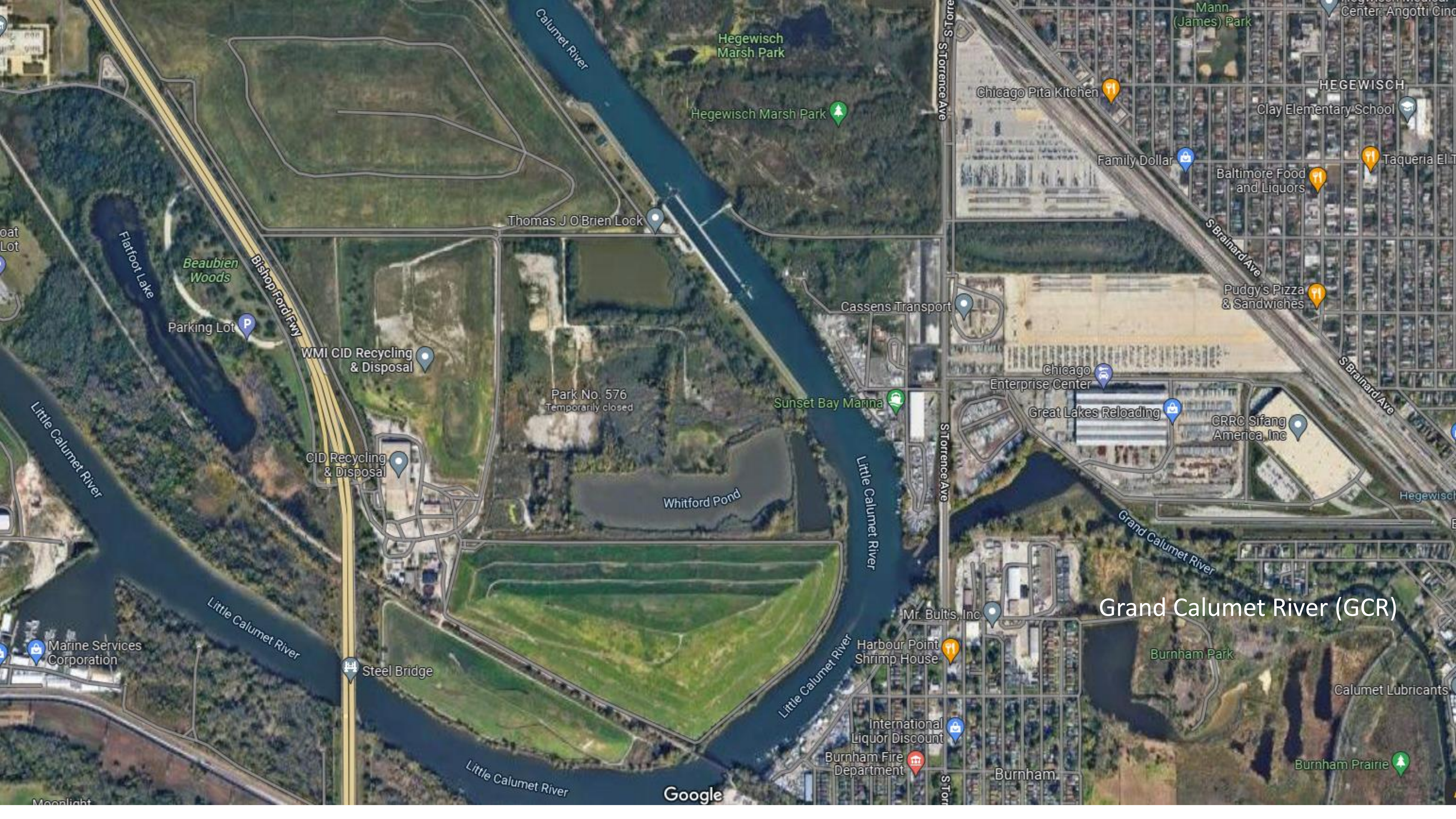
Calumet Waterway System




Grand Calumet River (GCR)
Calumet River
Hegewisch Marsh Park
Thomas J O'Brien Lock
Beaubien Woods
Flatfoot Lake
Bishop Ford Fwy
Parking Lot
WMI CID Recycling & Disposal
Park No. 576
Temporarily closed
CID Recycling & Disposal
Whitford Pond
Little Calumet River
Sunset Bay Marina
Cassens Transport
Chicago Enterprise Center
Great Lakes Reloading
CRRC Sifang America, Inc
Grand Calumet River
S Torrence Ave
S Brainard Ave
Chicago Pita Kitchen
Clay Elementary School
HEGEWISCH
Family Dollar
Baltimore Food and Liquors
Pudgy's Pizza & Sandwiches
Mann (James) Park
Mr. Bult's, Inc
Harbour Point Shrimp House
International Liquor Discount
Burnham Fire Department
Burnham
Burnham Park
Burnham Prairie
Calumet Lubricants
Marine Services Corporation
Steel Bridge
Google

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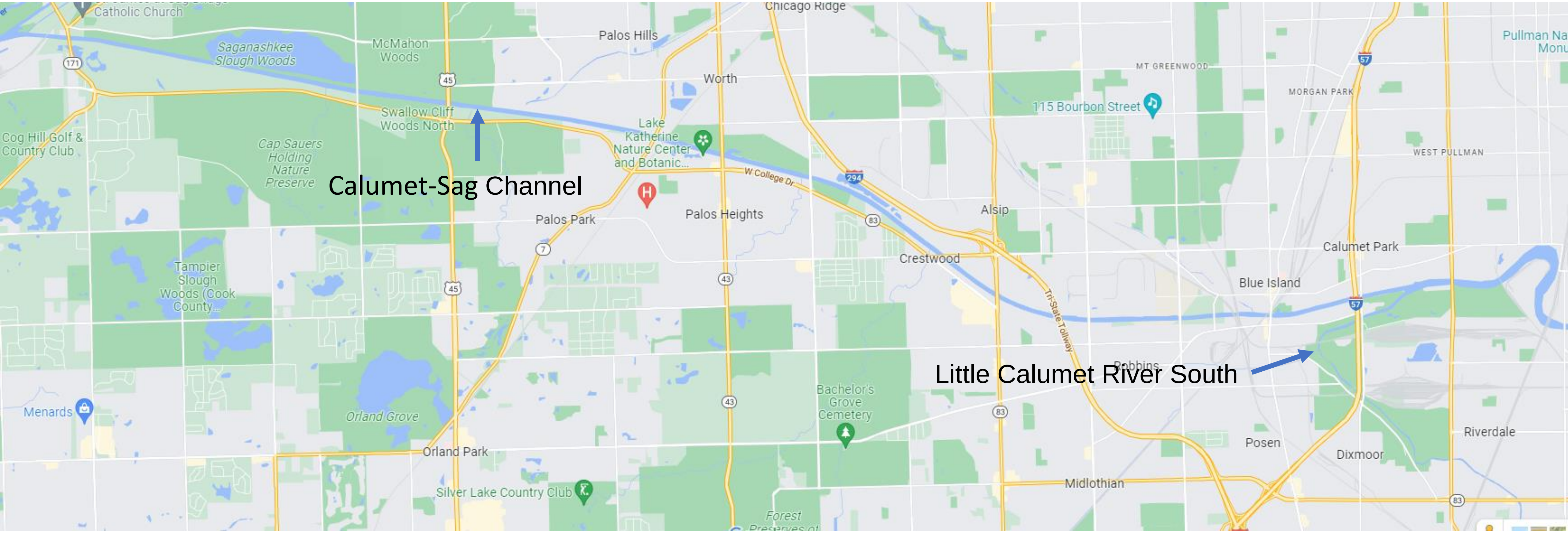
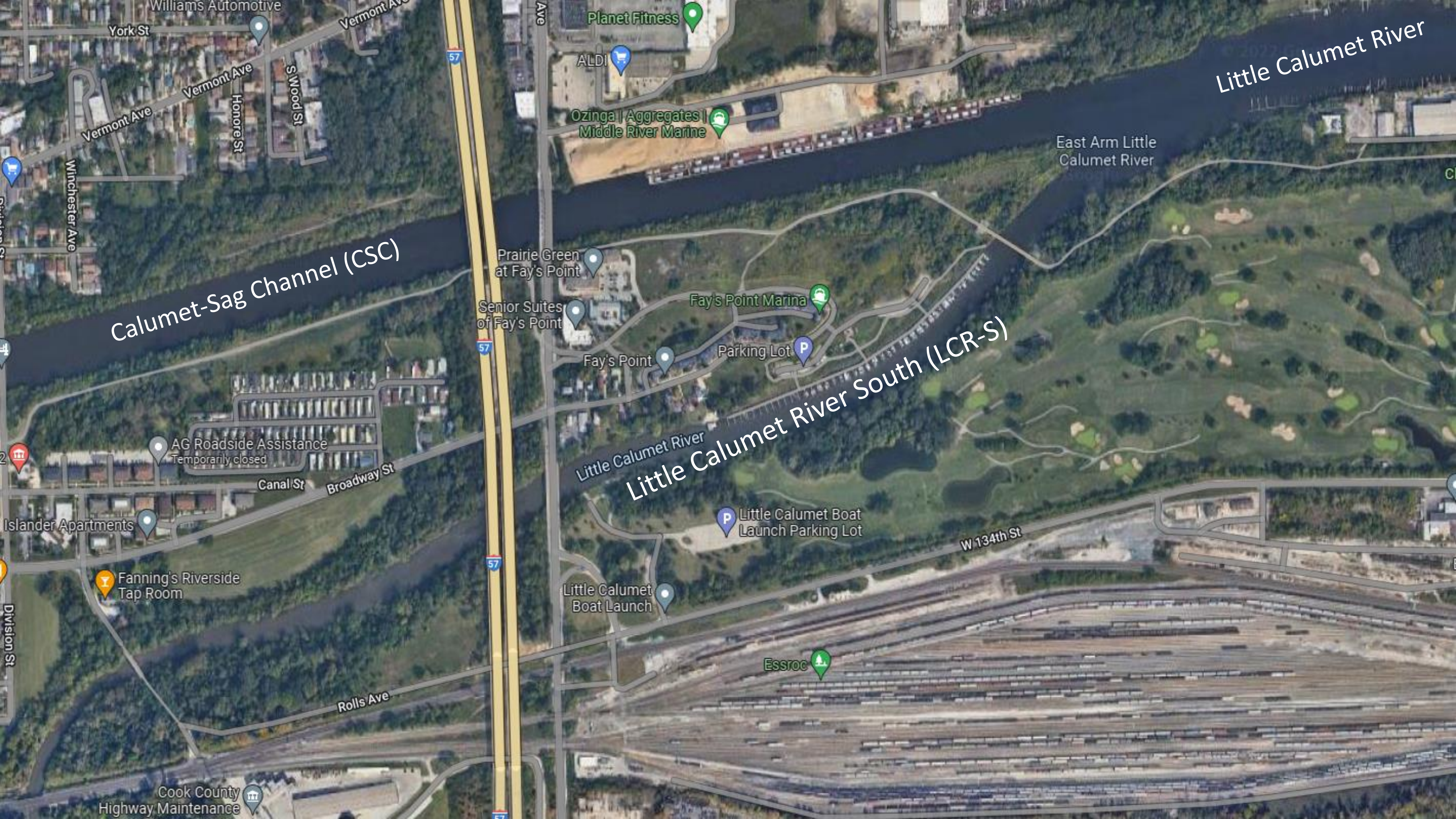
Calumet River System




Little Calumet River
Calumet-Sag Channel (CSC)
Little Calumet River South (LCR-S)
East Arm Little Calumet River
Williams Automotive
York St
Vermont Ave
S Wood St
Honore St
Winchester Ave
Planet Fitness
ALDI
Ozinga | Aggregates | Middle River Marine
Prairie Green at Fay's Point
Senior Suites of Fay's Point
Fay's Point Marina
Parking Lot
Fay's Point
AG Roadside Assistance
Temporarily closed
Canal St
Broadway St
Islander Apartments
Fanning's Riverside Tap Room
Little Calumet River
Little Calumet Boat Launch Parking Lot
W 134th St
Little Calumet Boat Launch
Essroc
Rolls Ave
Division St
Cook County Highway Maintenance
57

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Objectives

Objectives of the Thornton PCM Report

Conduct Ambient Water Quality Monitoring (AWQM), Continuous Dissolved Oxygen Monitoring (CDOM) and wet-weather water quality monitoring during 2017 and 2018 to document water quality under various weather conditions in the Calumet River System (CRS) following the completion of TCR.

The PCM report contains:

- CSO frequency, duration and volume data.
- WQ data generated between 1/1/2017 and 12/31/2018.
- Comparison of 2017-2018 post-construction data to applicable WQS for specified parameters.
- Comparison of AWQM 2017-2018 data to AWQM data prior to 1985 (Historic) and 2014-2015 (pre-construction).
- Comparison of 2014-2015 and 2017-2018 data from dry weather, wet weather without CSOs, and wet weather with CSOs.
- Comparison of 2017-2018 data from dry weather, wet weather without CSOs, and wet weather with CSOs.

Methodology

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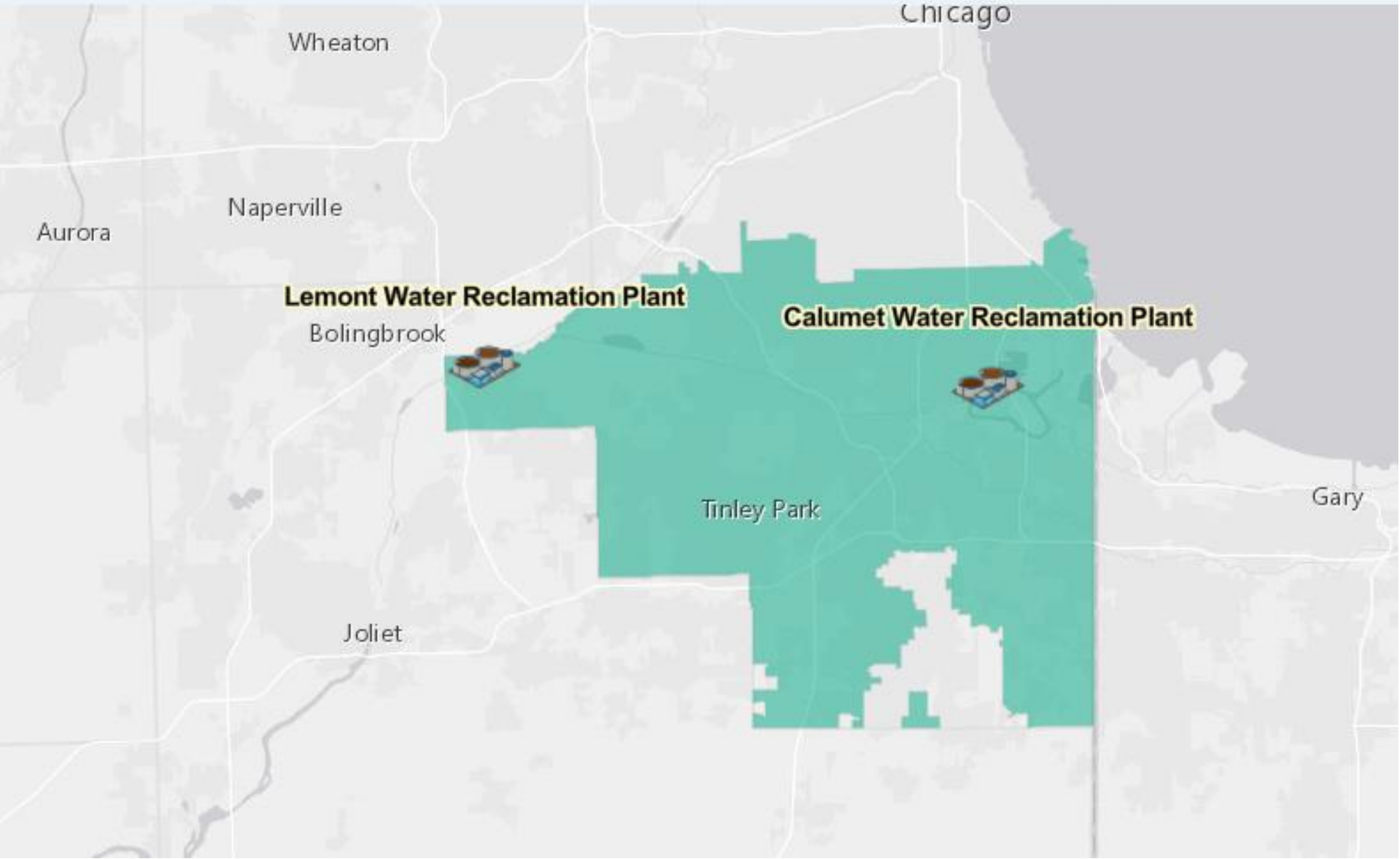
Methodology

- CSO monitoring

Metropolitan Water Reclamation District of Greater Chicago

Calumet Area CSO Monitoring



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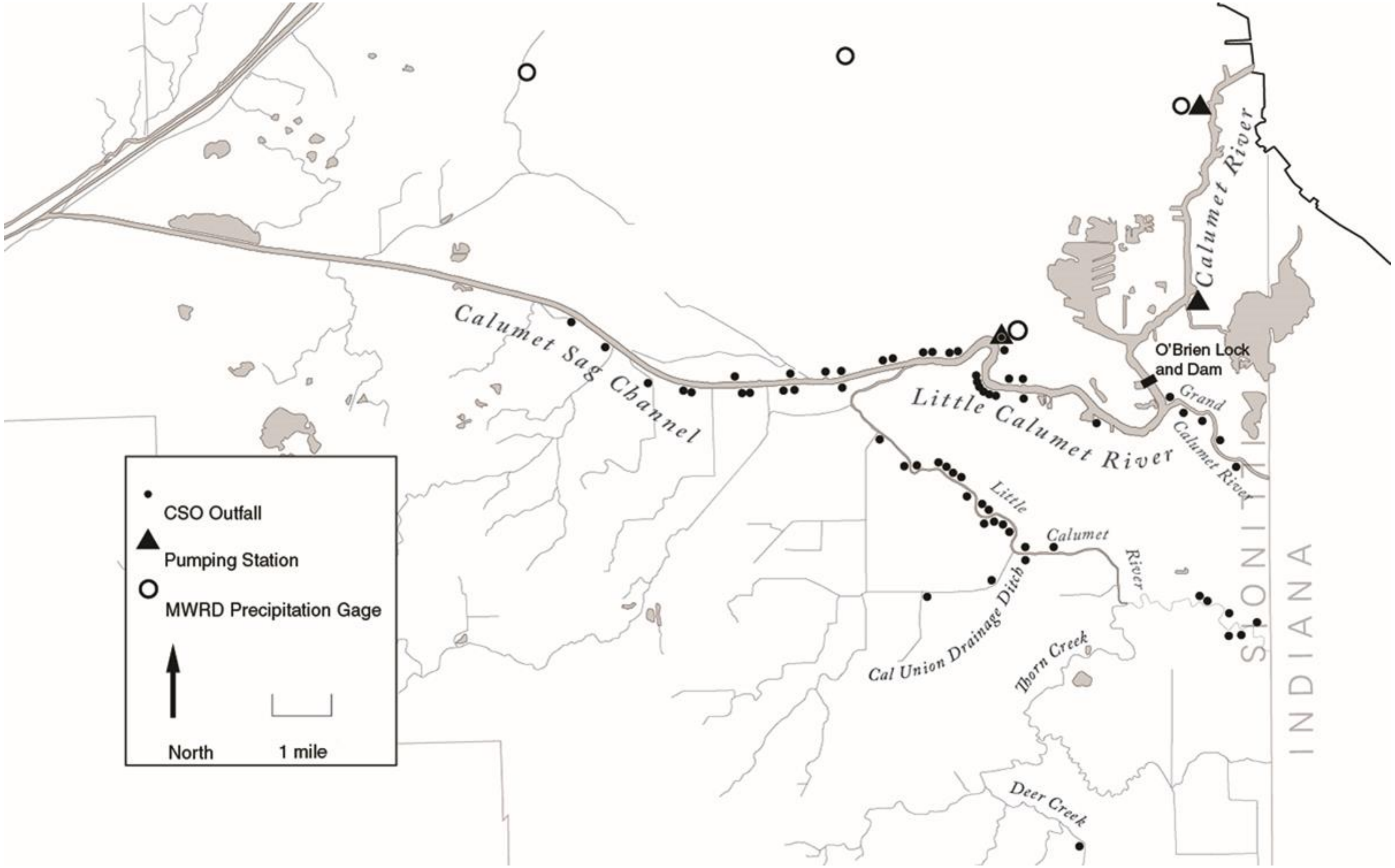
Calumet Waterways CSOs



CSOs

- Unmonitored outfalls were assumed to discharge when select monitored CSOs discharge because of similar invert elevations.
- Signals are transmitted to the Calumet WRP when the tide gate is open and assumed to be discharging. These signals are verified by WRP staff, and then volume estimates are performed via a conservative method which assumes that all rainfall that falls when a tide gate is open is being discharged to the waterway.
- These discharge volumes are then compared to two boundary conditions: (a) total area rainfall volume and (b) outfall pipe capacity. The minimum of these three values is used as the final discharge volume. Per the Calumet WRP NPDES permit, all individual CSO discharges resulting from the same storm shall be reported as one CSO event.

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Methodology

- AWQM Sampling

Ambient Water Quality Monitoring (AWQM)

Regulatory Requirements:

NPDES Permit Special Condition 5 (all permits): *The effluent, alone or in combination with other sources, shall not cause a violation of any applicable water quality standard outlined in 35 Ill. Adm. Code 302.*

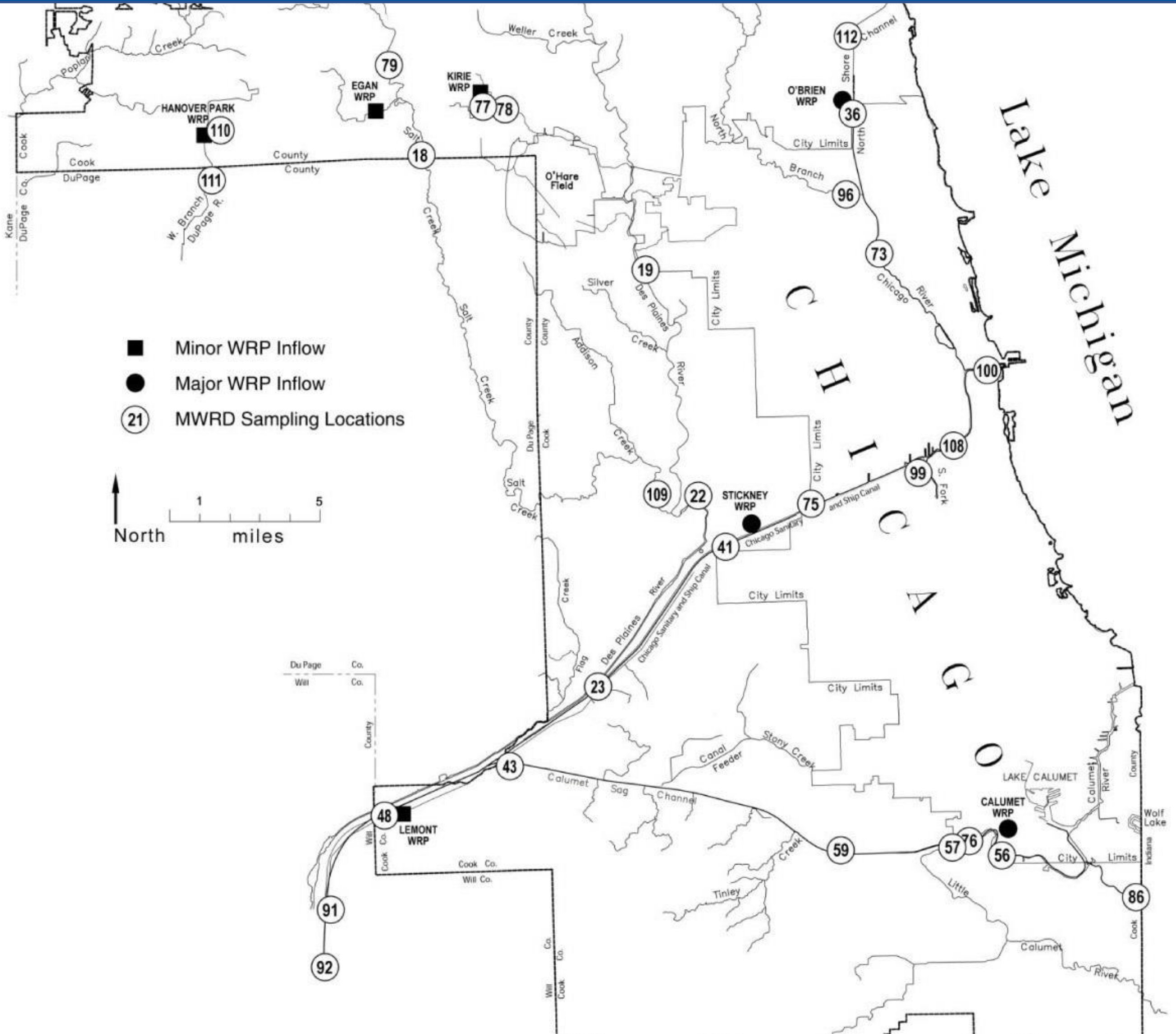
NPDES permits (various special condition numbers depending on the WRP) state in the paragraph entitled, “Compliance with Water Quality Standards” that …*discharges from the outfalls…shall not cause or contribute to violations of applicable water quality standards or cause or contribute to designated use impairment in the receiving waters.* MWRD *shall submit documentation of water quality data for the waterway systems within its jurisdiction…*

In general, there are applicable water quality standards for the parameters analyzed in the AWQM program.

Ambient Water Quality Monitoring (AWQM)

AWQM Locations

- **Des Plaines River System:**
  - Higgins Creek.
  - Salt Creek.
  - Weller Creek.
  - Des Plaines River.
  - West Branch DuPage River.
- **Chicago River System:**
  - North Branch Chicago River.
  - North Shore Channel.
  - Chicago River.
  - South Branch Chicago River.
  - South Fork South Branch Chicago River.
  - Chicago Sanitary and Ship Canal.
- **Calumet River System:**
  - Grand Calumet River.
  - Little Calumet River.
  - Calumet-Sag Channel.



Ambient Water Quality Monitoring (AWQM)

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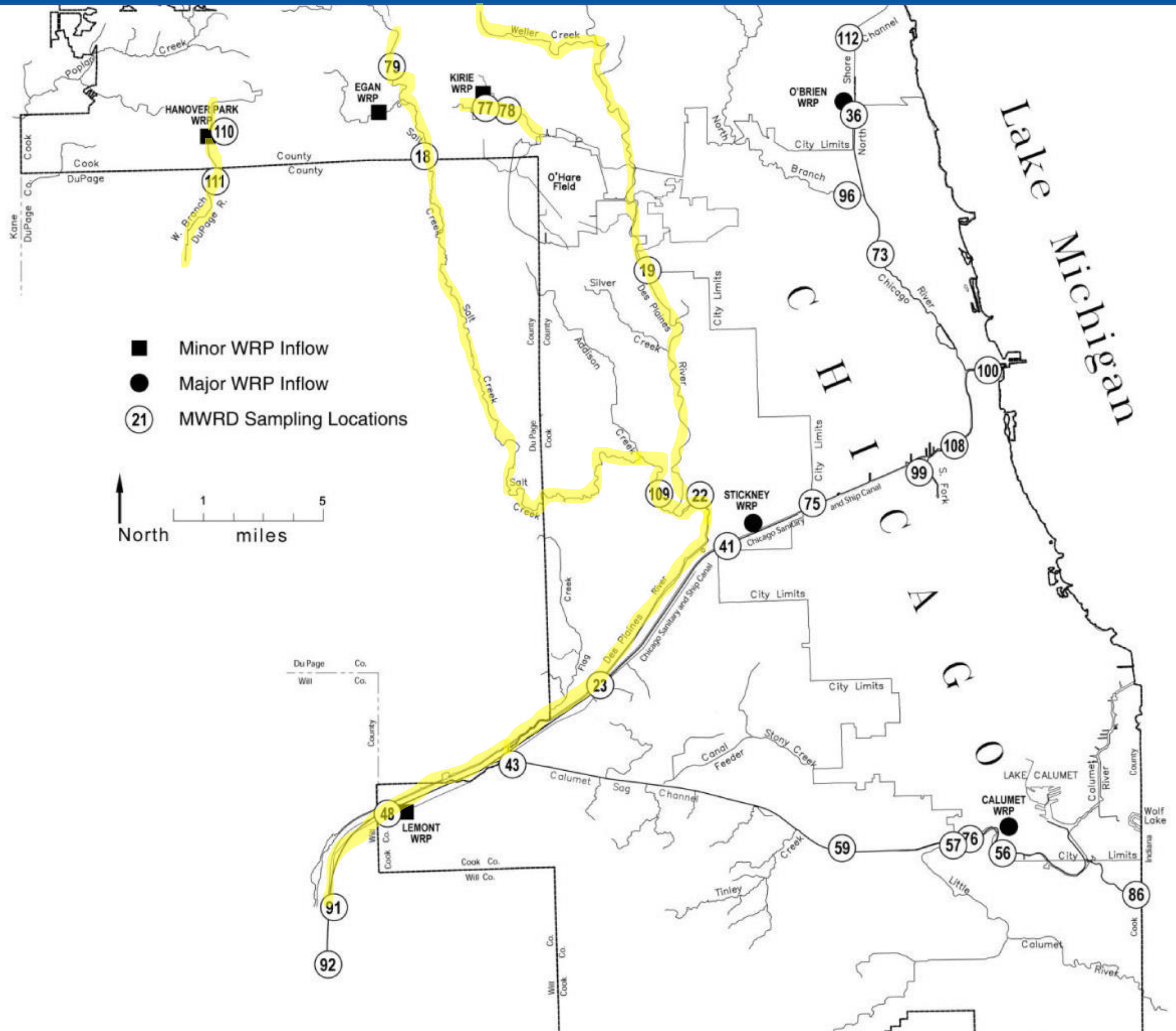

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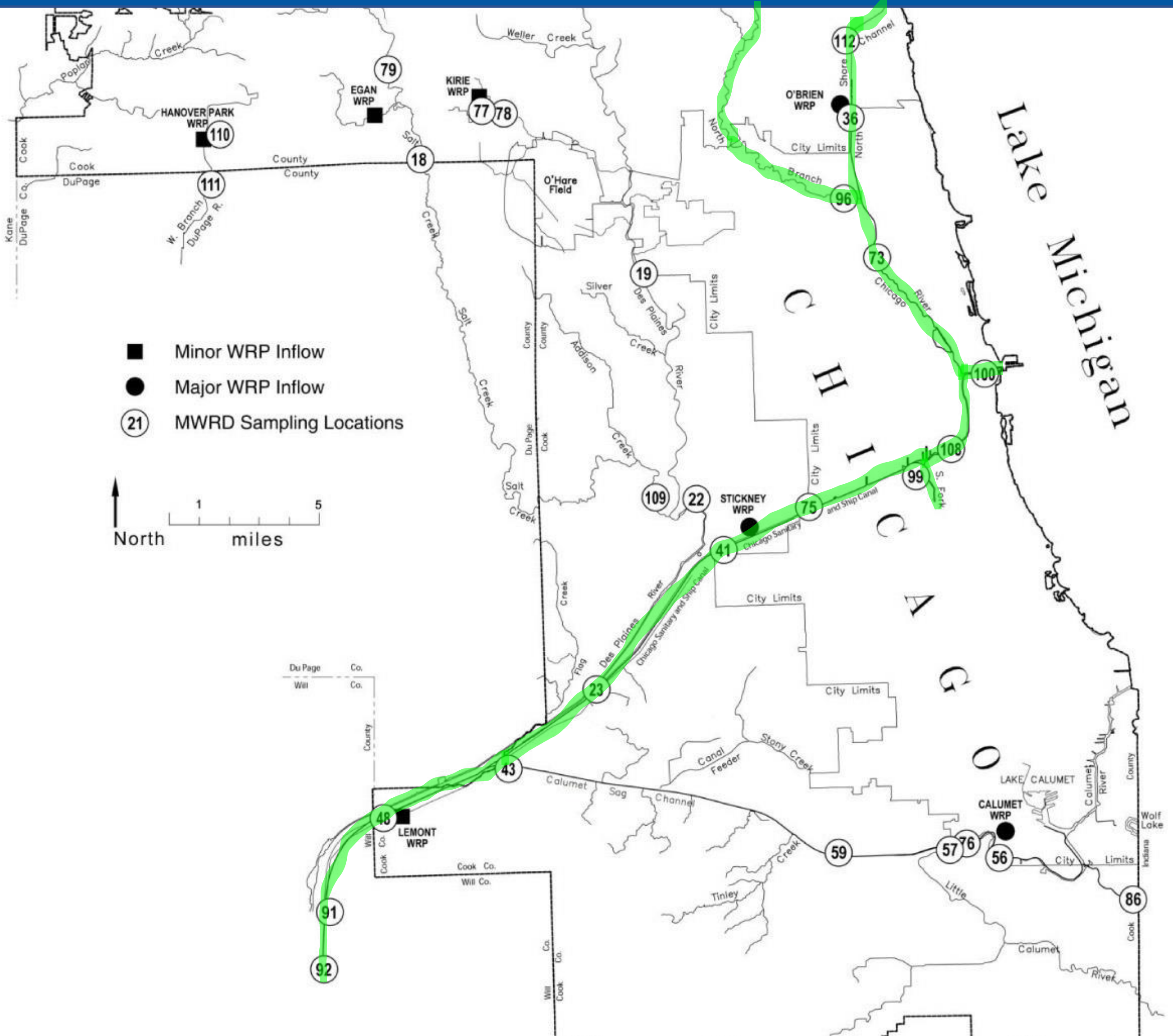

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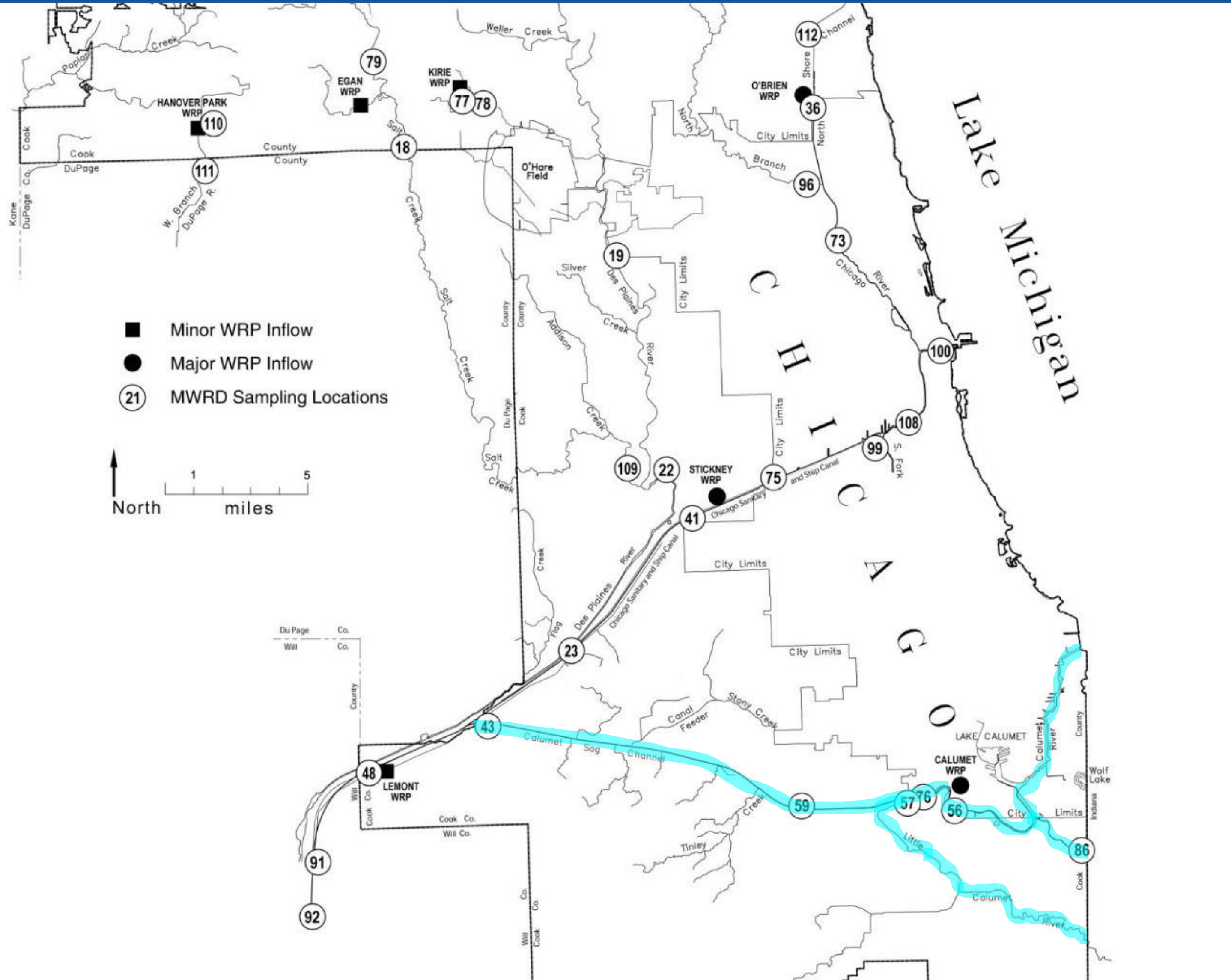

Ambient Water Quality Monitoring Locations Assessed in the CRS

Location	Waterway	Station Number	Designated Use Category	Latitude	Longitude
130th St.	Calumet River	WW_55	CAWS A/Non-Contact	41° 39' 33.48"	-87° 34' 21.66"
Burnham Ave.	Grand Calumet River	WW_86	CAWS A[1]/Incidental Contact	41° 37' 52.75"	-87° 32' 20.76"
Indiana Ave.	Little Calumet River	WW_56	CAWS A/Primary Contact	41° 39' 01.19"	-87° 37' 01.64"
Halsted St.	Little Calumet River	WW_76	CAWS A/Primary Contact	41° 39' 27.05"	-87° 38' 28.13"
Wentworth Ave.	Little Calumet River South	WW_52	General Use	41° 35' 06.34"	-87° 31' 46.89"
Ashland Ave.	Little Calumet River South	WW_57	General Use	41° 39' 06.04"	-87° 39' 38.13"
170th St.	Thorn Creek	WW_97	General Use	41° 35' 11.90"	-87° 34' 32.96"
Cicero Ave.	Calumet-Sag Channel	WW_59	CAWS A/Primary Contact	41° 39' 19.23"	-87° 44' 17.67"
Route 83	Calumet-Sag Channel	WW_43	CAWS A/Primary Contact	41° 41' 46.82"	-87° 56' 10.71"

[1]Chicago Area Waterway System Aquatic Life Use A.

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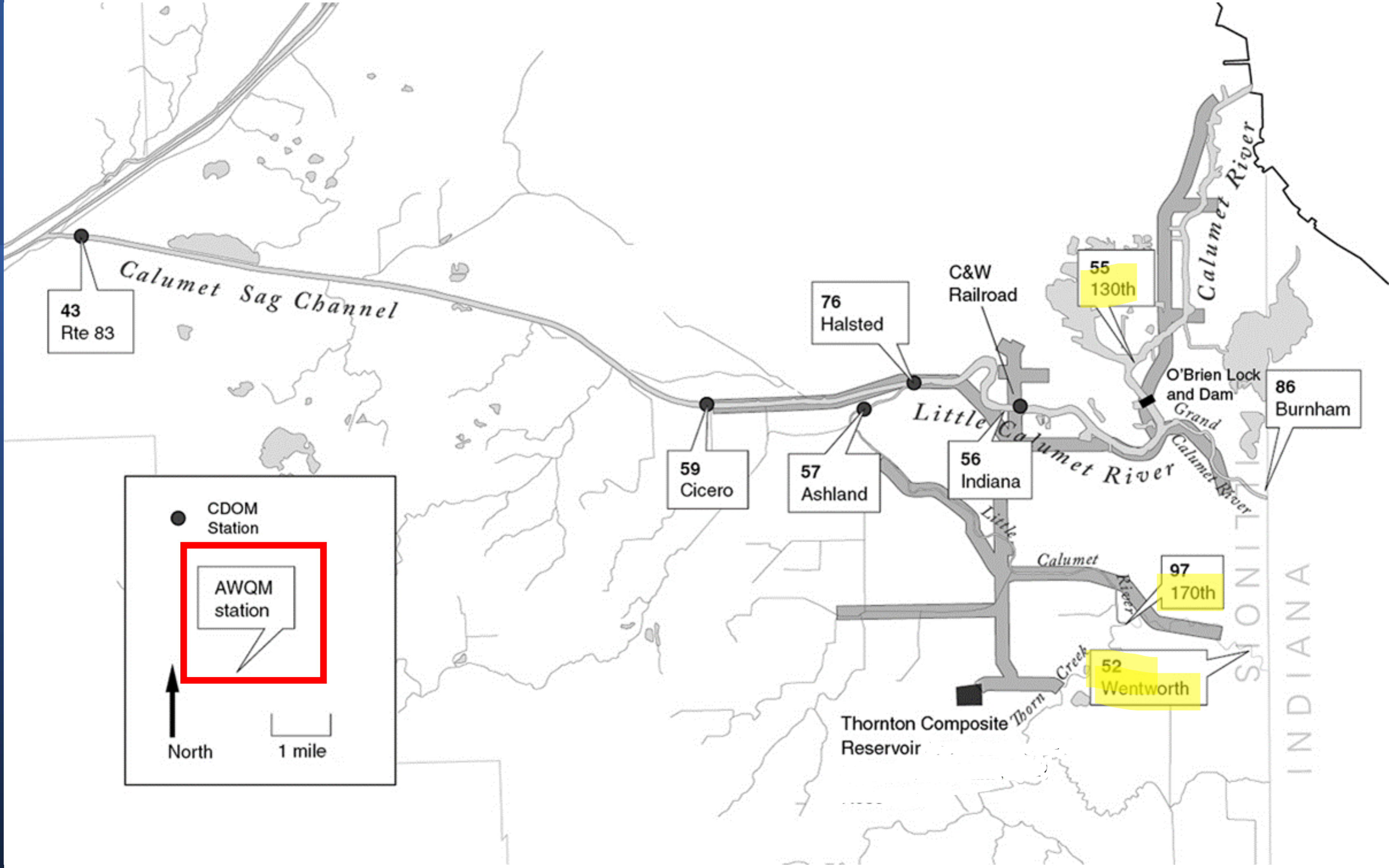
Metropolitan Water Reclamation District of Greater Chicago

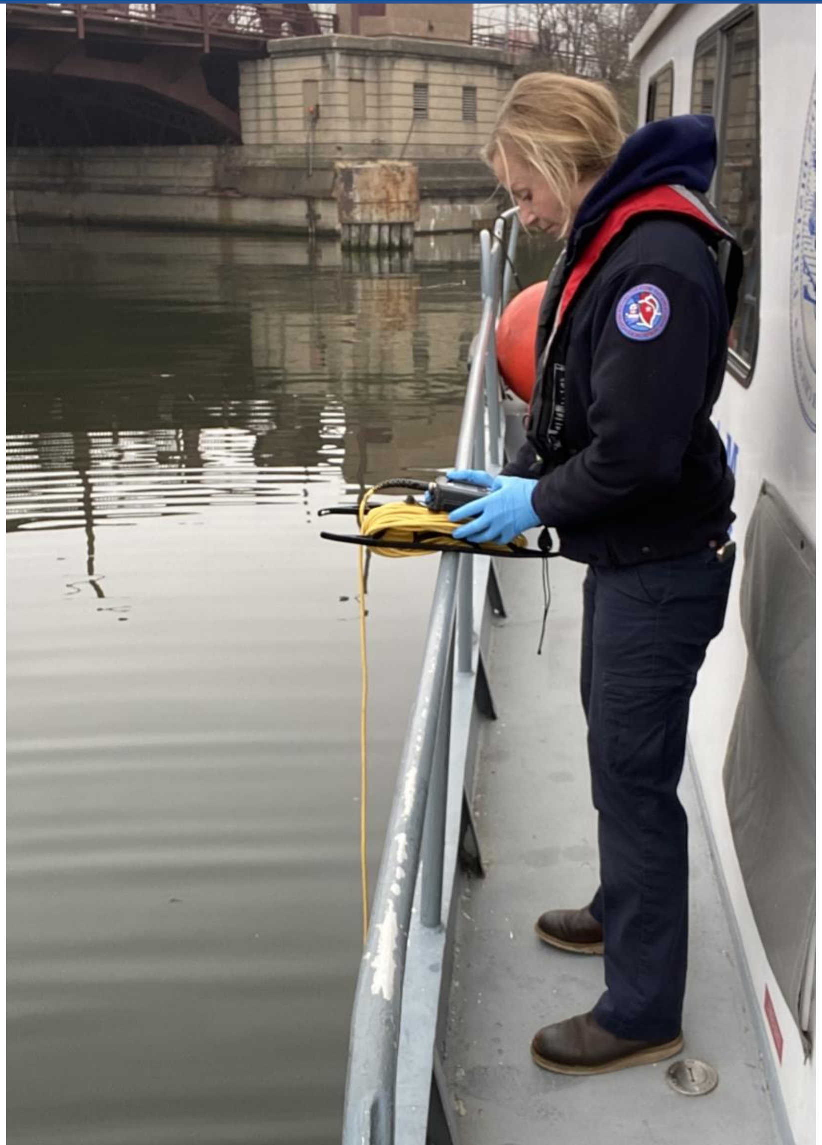
Calumet Waterway System



Ambient Water Quality Monitoring (AWQM)

Sampling Methods

- Aliquots containers are prepared with individual labels sample preservatives
- **Field measurements are taken (DO, temp, pH)**
- Samples collected from stainless steel pail by PCTs
- Bac'T sampling procedure (special sampling can)
- LLHg sampling (clean hands/dirty hands)
- Ice samples, deliver to lab in timely manner to remain within sample holding times



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Ambient Water Quality Monitoring (AWQM)

AWQM Analyses

- Dissolved oxygen*
- Temperature*
- pH*
- Ammonia nitrogen
- Ammonia nitrogen, un-ionized
- Nitrate and nitrite nitrogen
- Kjeldahl nitrogen
- Phosphorus, total
- Sulfate
- Total dissolved solids
- Suspended solids
- Volatile suspended solids
- Alkalinity
- Chloride
- Fluoride
- Organic carbon, total
- Phenol
- Cyanide, total
- Cyanide, chlorine amenable
- Chromium, hexavalent
- Metals, total and dissolved
- Mercury, Low Level
- Fecal coliform
- n Hexane extractable materials
- Chlorophyll a
- Benzene, ethyl benzene, toluene, xylenes
- Organic priority pollutants

Continuous Dissolved Oxygen Monitoring (CDOM)

GIS Maps & Data

Discover and Interact with MWRD Geographic Data

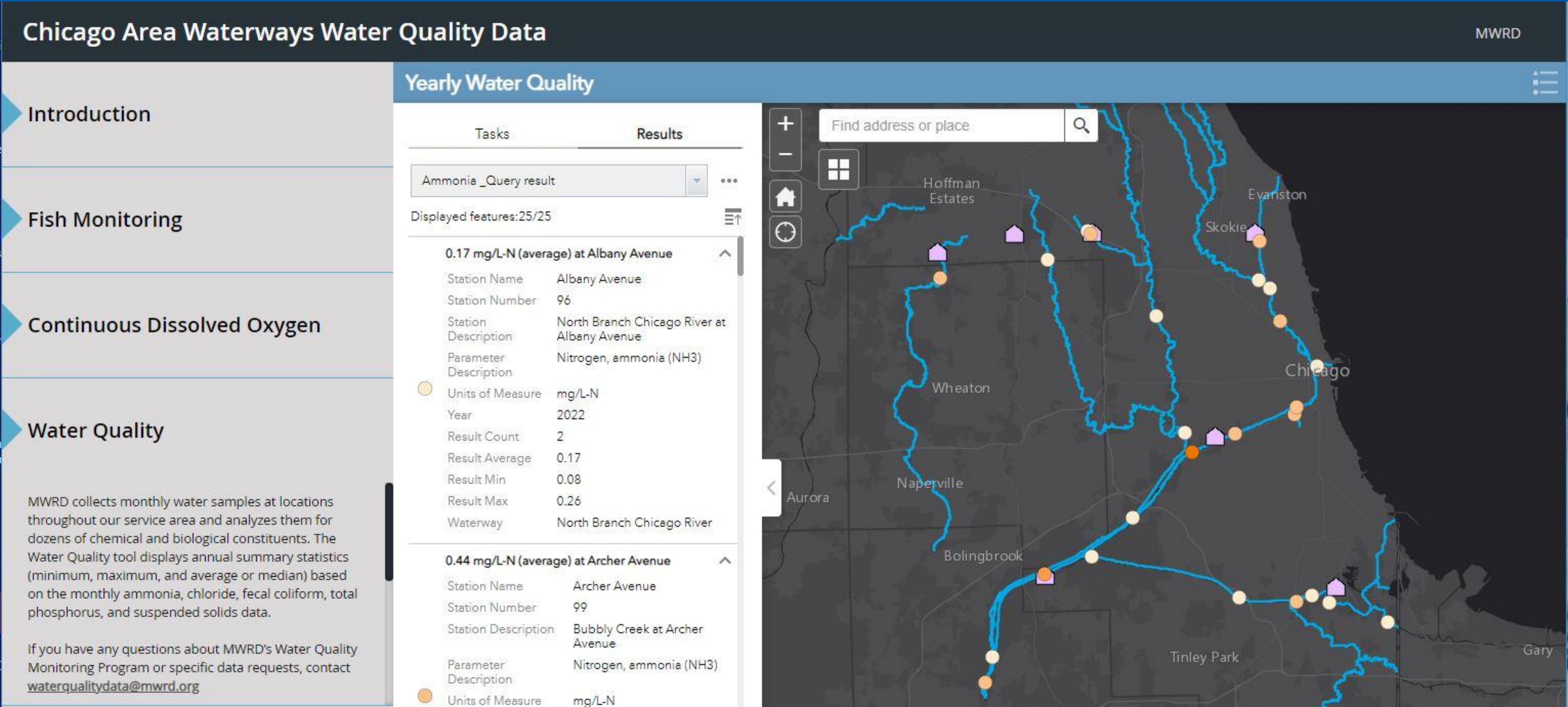
Chicago Area Waterways Water Quality Data

Water quality data including fish populations, dissolved oxygen and water chemistry are available here.

Details | View

https://mwrd.org/chicago-area-waterways-water-quality-monitoring.
https://gispub.mwrd.org/awqa/

Ambient Water Quality Monitoring (AWQM)



Metropolitan Water Reclamation District of Greater Chicago

Methodology

- Wet- and Dry-Weather Sampling

Wet- and Dry- Weather Monitoring

- In addition to the routine monthly monitoring in the AWQM Program, water quality monitoring was conducted during various wet- and dry-weather conditions at each of the nine sampling locations in the CRS.
- Definitions of conditions were from the limited-use analysis done during the Chicago Area Waterway System (CAWS) Use Attainability Analysis (UAA).
  1. Dry weather (<0.1 inch precipitation). Dry weather was defined by antecedent dry conditions for two days following a 0.25–0.49 inch event, four days following a 0.50–0.99 inch event, and six days following a >1.0 inch event
  2. Wet weather without CSOs (>0.5 inch precipitation). Water sampling occurred within 12 hours of the end of the rain event.
  3. Wet weather with CSOs, including 125th Street Pump Station, if discharging. Water sampling occurred within 12 hours of the end of the rain event.
- Average rainfall from the four District rain gauges in the Calumet area were used to determine if conditions were met.

Wet- and Dry- Weather Monitoring (Continued)

- In order to assess effects of CSOs on the CRS after the TCR was online, the following constituents were analyzed:
  - Dissolved Oxygen (DO)
  - Total Ammonia Nitrogen (TAN)
  - Total Suspended Solids (TSS)
  - Total Dissolved Solids (TDS)
  - Five-day Biochemical Oxygen Demand (BOD5)
  - Fecal Coliform (FC)
- Applicable WQS were also used for evaluation.

Metropolitan Water Reclamation District of Greater Chicago

Methodology

- Statistical Analysis of AWQM Data

Statistical Analysis of AWQM Data

- Water quality data from AWQM and wet- and dry-weather sampling were analyzed for equality of means and standard deviations, using parametric ANOVA.
- The following comparisons were made with the ANOVA:
  - AWQM data from 2017 – 2018 (Post-Construction) vs 1974 – 1985 (Historic pre-TARP) vs 2014 – 2015 (Pre-construction/before TCR).
  - AWQM data collected during 2017 – 2018 and 2014 – 2015, during dry weather, wet weather without CSOs, and wet weather with CSOs.
- Whenever results were reported as less than the Reporting Limit the Reporting limit was used as the concentration of that sample.
- Normality was tested using the Kolomogorov and Smirnov method for sample sizes greater than 10 but less than 30.
- Equality of variances was tested using various methods (F-tests, Bartlett, Cochran, Levene, or Levene-Forsythe), and determination of which method was used was dependent on the number of levels of comparison, sample sizes, and fulfillment of normality assumptions. The test method with the highest resulting p value was reported.

Statistical Analysis (Continued)

- ANOVA was done using actual data and natural logarithm (log)-transformed ($y = \ln(x)$) data (Fecal Coliform). The results from the log-transformed data are presented in this report for comparison between the historic, pre-, and post-construction periods because the data were log-normal distributed.
- Uniformly minimum variance unbiased estimator (UMVUE) was used for calculating population means, because UMVUE variances are lower than other mean estimators.
- UMVUE was also used to compare monthly AWQM data and data from wet weather with CSOs, wet weather without CSOs, and dry weather during pre- and post-construction monitoring periods.
- Data were not used in the ANOVA if variances were less than or equal to 0. This happened when the sample size was one, or all the data values were the same. As a result, some levels were not included in the ANOVA. Data levels were ranked using Tukey's multiple range test, and populations with the same letter are considered not statistically significantly different.

Metropolitan Water Reclamation District of Greater Chicago

Methodology

- Continuous Dissolved Oxygen Monitoring

Continuous Dissolved Oxygen Monitoring (CDOM)

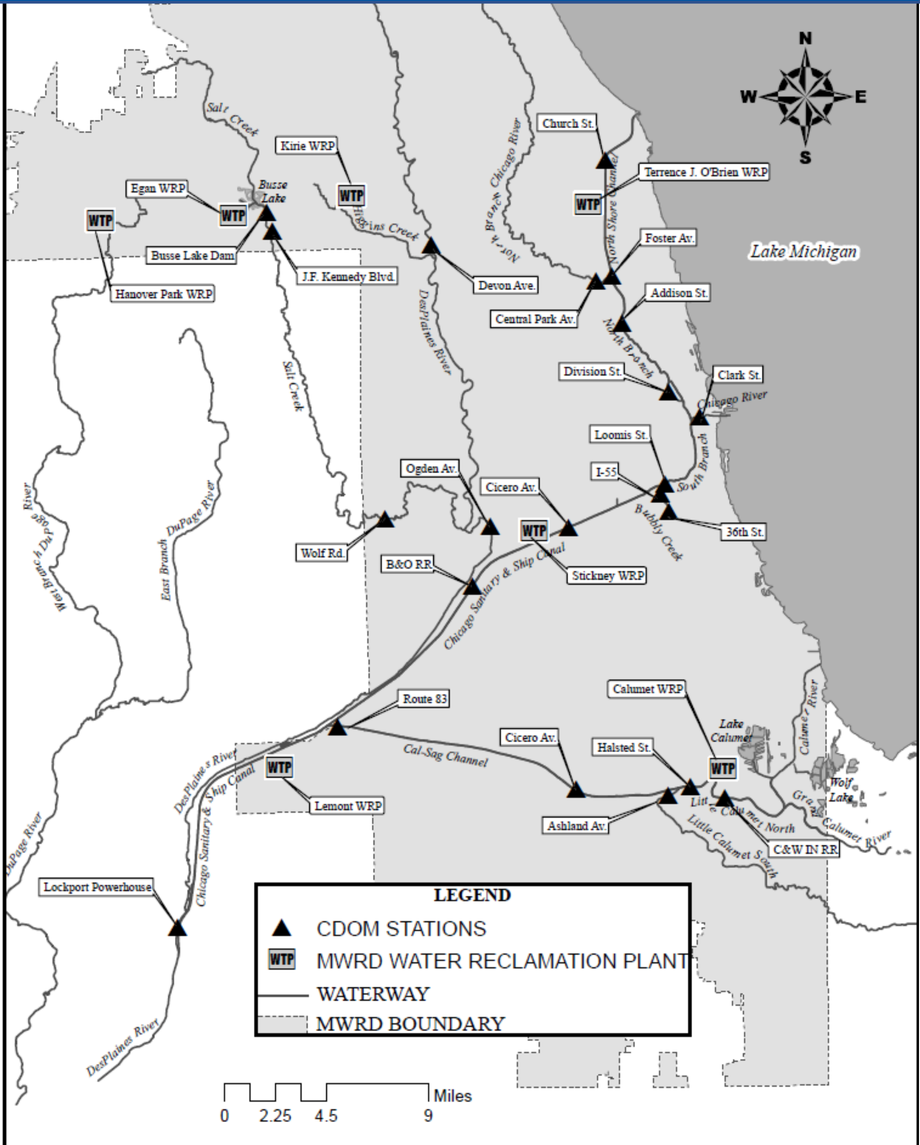
Hourly Dissolved Oxygen, Specific Conductivity, Temperature Readings

3 parameters
24 hours/day
365 days/year
20 sites *(10 telemetry)*

525,600 data points/Year

Continuous Dissolved Oxygen Monitoring (CDOM)

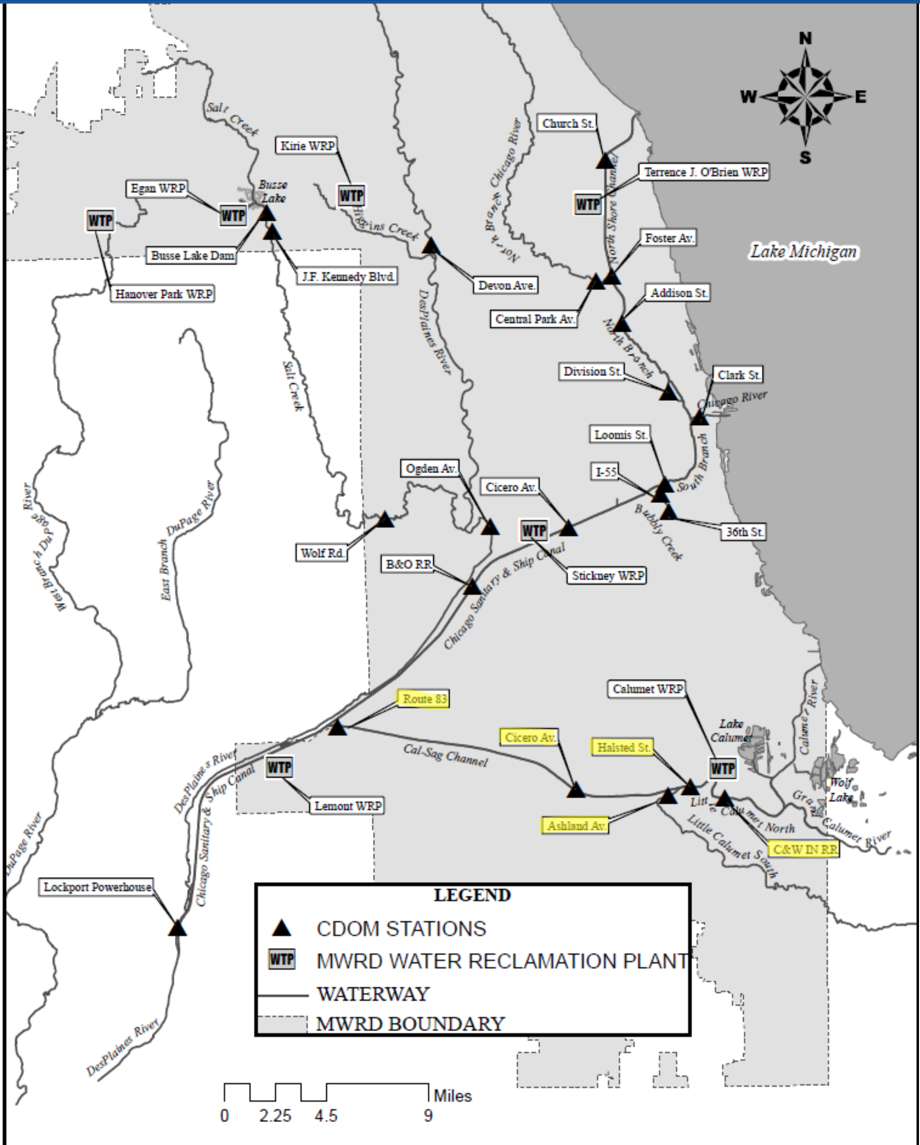
- CDOM locations are located throughout the District service area.
- Locations have been chosen using criteria including:
  - Upstream and downstream of water reclamation plants
  - On tributaries upstream of the Chicago Area Waterway System (CAWS)
  - Covering IEPA waterway segment IDs in the Chicago Area Waterway System



Continuous Dissolved Oxygen Monitoring Locations in the Calumet River System

Location	Waterway	Designated Use Category	Latitude	Longitude
C&W Indiana Railroad	Little Calumet River	CAWS A[1]/Primary Contact	41° 39' 01.07"	-87° 36' 42.75"
Halsted Street	Little Calumet River	CAWS A/Primary Contact	41° 39' 25.95"	-87° 38' 27.86"
Ashland Avenue	Little Calumet River, South	General Use	41° 39' 06.64"	-87° 39' 37.27"
Cicero Avenue	Calumet-Sag Channel	CAWS A/Primary Contact	41° 39' 20.70"	-87° 44' 18.78"
Route 83	Calumet-Sag Channel	CAWS A/Primary Contact	41° 41' 46.68"	-87° 56' 29.29"

[1]Chicago Area Waterway System Aquatic Life Use A.



Continuous Dissolved Oxygen Monitoring (CDOM)

Continuous Dissolved Oxygen Monitoring (CDOM)

Continuous Dissolved Oxygen Monitoring (CDOM)

GIS Maps & Data

Discover and Interact with MWRD Geographic Data

Chicago Area Waterways Water Quality Data

Water quality data including fish populations, dissolved oxygen and water chemistry are available here.

Details View

Chicago Area Waterways Water Quality Data

MWRD

- Introduction
- Fish Monitoring
- Continuous Dissolved Oxygen
- Water Quality
- Additional Resources

Metropolitan Water Reclamation District of Greater Chicago

Chicago Area Waterways Water Quality Data

The Metropolitan Water Reclamation District of Greater Chicago monitors water quality in Chicago area rivers and streams. Water quality data including fish populations, dissolved oxygen and water chemistry are available here. For more information about MWRD's monitoring programs please visit our MWRD Water Quality Monitoring website.

If you have any questions about MWRD's waterway monitoring programs or specific data requests, contact waterqualitydata@mwrd.org.

https://gispub.mwrd.org/awqa/

Continuous Dissolved Oxygen Monitoring (CDOM)

GIS Maps & Data

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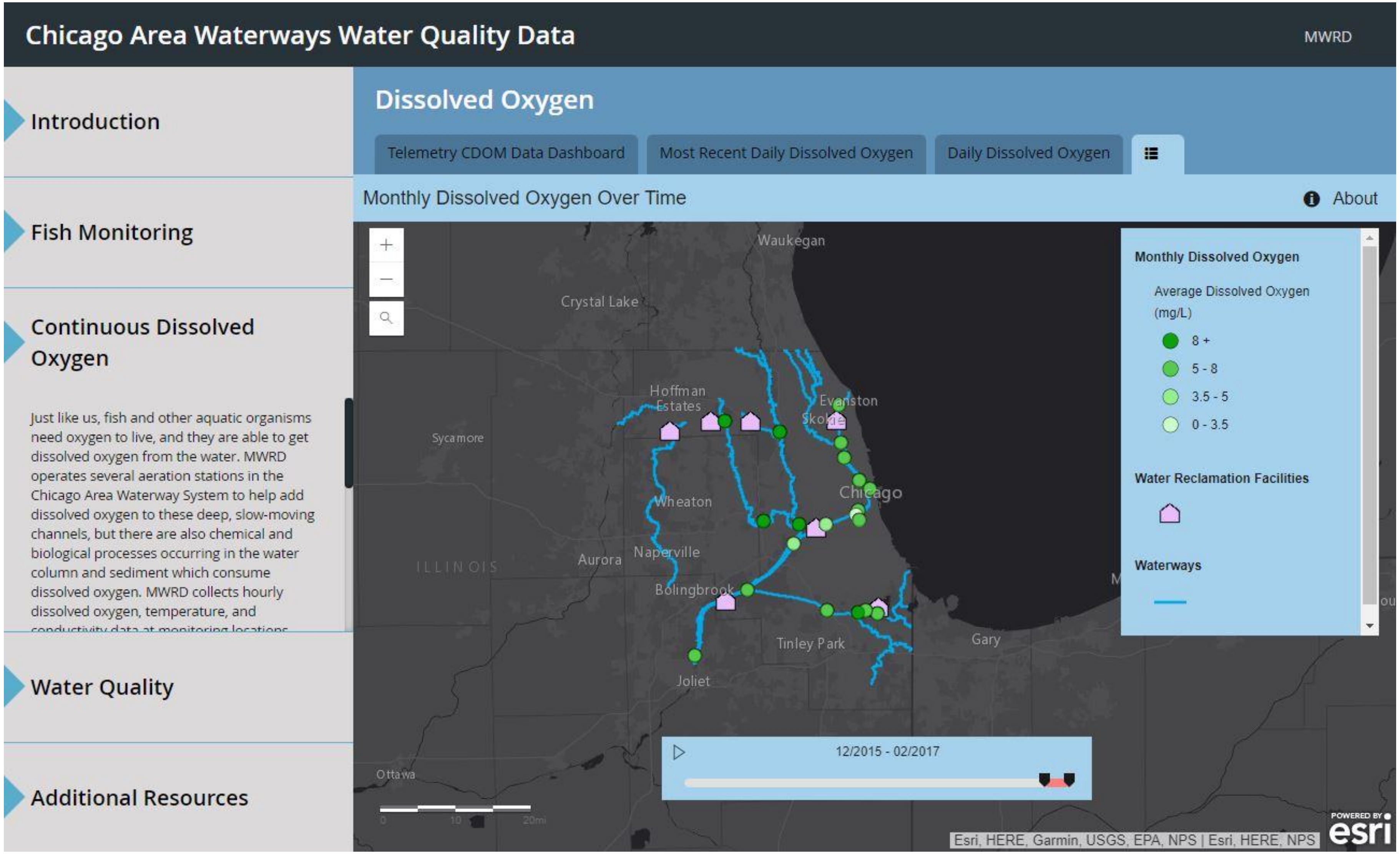

Metropolitan Water Reclamation District of Greater Chicago

Results

- CSO Monitoring

Date, Location, Time, Duration, and estimated Volume of CSOs that occurred post-Construction of TCR (2017–2018)

Date of CSO	CSO Location	CSO Start Time	CSO Stop Time	CSO Duration	Estimated Volume (gallons)
02/28/2017	C-1	8:30 pm	9:04 pm	34 minutes	89,570
	CDS-45	6:42 pm	7:46 pm	1 hour 4 minutes	865,656
	CDS-45	8:12 pm	11:59 pm	3 hours 47 minutes	3,070,374
03/30/2017	CDS-45	2:21 am	4:00 am	1 hour, 39 minutes	1,501,182
	CDS-18*	11:26 am	11:43 am	17 minutes	485,983

*Unable to verify if discharge actually occurred at this location, as it may have ended before it could be investigated.

Thornton Reservoir Service Area CSOs and Precipitation

Totals 2010 - 2020

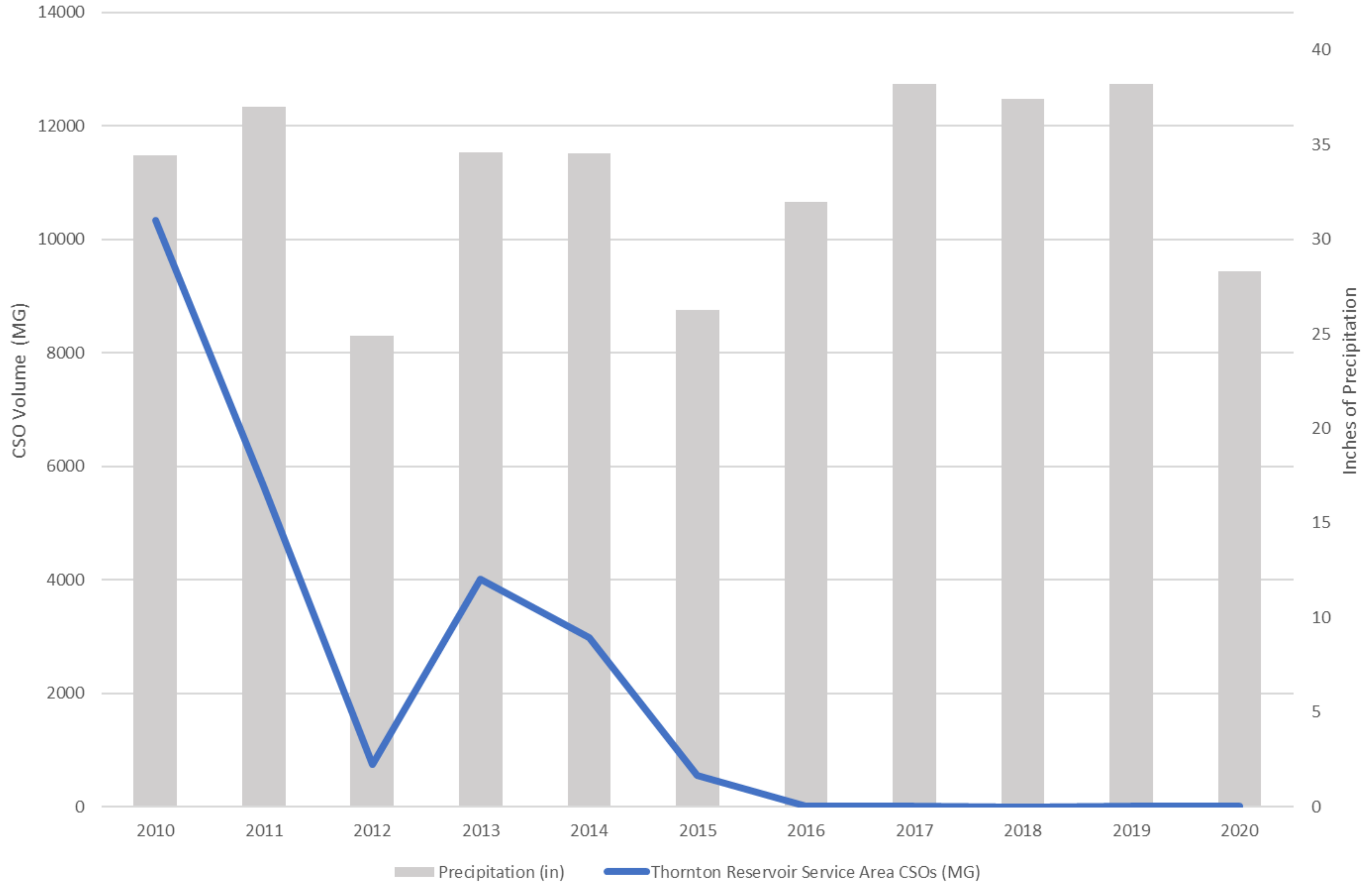

Chart provided by Ed Staudacher

CSO Monitoring Results

- The 125th Street Pumping Station never discharged during the post-construction monitoring period.
  - Update: 125th Street Pumping Station has STILL not been active since 6/16/15
- The largest single rain event during the post-construction monitoring period was 4.34 inches (October 14-15, 2017) and no CSOs occurred.
  - Update: That amount has not been surpassed since then but 2019 was the third wettest year in Chicago history, and May 2018 (8.21”), 2019 (8.25”), and 2020 (8.3”) are the three wettest Mays on record.
- Update: Since TCR went online it had captured over 47 BG of CSO by the end of 2021.

Metropolitan Water Reclamation District of Greater Chicago

Results

- Water Quality Monitoring

Summary of Monthly CRS AWQM Data
Pre- and Post-Construction of TCR

		WW_55		WW_56		WW_76		WW_57		WW_52	
		130th St. – Calumet River		Indiana Ave. – LCR		Halsted St. – LCR		Ashland Ave. – LCR-S		Wentworth Ave. – LCR-S	
Parameter		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
TAN	Minimum	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.10
(mg/L)	Maximum	0.61	0.50	0.87	0.61	1.66	1.03	0.48	0.51	0.93	0.50
	Mean	0.17	0.23	0.24	0.30	0.57	0.34	0.23	0.29	0.29	0.32
	Std. Dev.	0.13	0.17	0.19	0.19	0.48	0.21	0.10	0.17	0.17	0.15
TSS	Minimum	<4	<4	4	5	4	<4	7	6	6	6
(mg/L)	Maximum	9	7	80	31	33	17	206	135	226	192
	Mean	5	4	20	11	13	8	51	32	46	44
	Std. Dev.	1.4	0.8	17.2	5.9	9.0	3.3	55.1	37.3	49.3	43.9
TDS	Minimum	230	182	260	268	412	340	264	434	222	156
(ppm)	Maximum	436	448	700	560	896	736	1,570	1,234	986	822
	Mean	298	315	440	430	606	536	941	735	603	617
	Std. Dev.	63	88	137	85	157	99	350	258	219	181
BOD_5	Minimum	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
(mg/L)	Maximum	<2	8	3	3	8	4	9	9	14	8
	Mean	2	3	2	2	3	2	3	3	4	3
	Std. Dev.	0.0	1.5	0.4	0.4	1.9	0.7	1.8	1.7	2.6	1.7

Summary of Monthly CRS AWQM Data
Pre- and Post-Construction of TCR (Continued)

		WW_55		WW_56		WW_76		WW_57		WW_52	
		130th St. – Calumet River		Indiana Ave. – LCR		Halsted St. – LCR		Ashland Ave. – LCR-S		Wentworth Ave. – LCR-S	
Parameter		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
DO	Minimum	6.0	6.8	6.1	4.6	4.7	6.2	4.3	3.9	3.7	2.4
(mg/L)	Maximum	12.0	11.9	14.3	12.2	11.8	11.9	11.5	13.9	12.4	12.6
	Mean	8.8	9.2	9.4	9.4	7.7	8.2	7.4	8.6	6.9	7.5
	Std. Dev.	1.6	1.8	2.1	1.8	1.5	1.2	2.5	2.3	2.6	2.9
FC	Minimum	9	9	9	9	50	<10	60	30	300	210
(CFU/100 mL)	Maximum	1,500	30	5,700	170	39,000	2,900	20,000	9,500	100,000	64,000
	Geo. Mean	20	12	37	19	1,811	114	740	275	2,201	1,156
	Std. Dev.	353	6	1,356	41	10,257	676	4,266	2,315	27,036	13,440

Summary of Monthly CRS AWQM Data
Pre- and Post-Construction of TCR (Continued)

		WW_59		WW_43		WW_86		WW_97	
		Cicero Ave. – CSC		Route 83 – CSC		Burnham Ave. – GCR		170th St. – Thorn Cr.	
Parameter		Pre	Post	Pre	Post	Pre	Post	Pre	Post
TAN	Minimum	0.20	0.15	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
(mg/L)	Maximum	1.69	1.02	1.04	5.66	4.19	0.93	1.16	0.80
	Mean	0.55	0.38	0.50	0.60	1.10	0.30	0.26	0.29
	Std. Dev.	0.38	0.20	0.26	1.12	1.24	0.22	0.27	0.22
TSS	Minimum	5	6	5	7	<4	4	6	7
(mg/L)	Maximum	111	43	62	39	38	19	181	194
	Mean	26	17	19	17	12	10	40	39
	Std. Dev.	22.3	9.4	12.7	8.2	8.7	4.0	45.3	50.6
TDS	Minimum	308	376	308	404	298	330	456	338
(ppm)	Maximum	892	688	956	846	834	736	1,964	2,780
	Mean	623	569	640	581	664	528	1,289	1,309
	Std. Dev.	161	84	175	106	133	114	525	585
BOD_5	Minimum	<2	<2	<2	<2	<2	<2	<2	<2
(mg/L)	Maximum	6	21	3	3	16	4	9	11
	Mean	3	3	2	2	4	2	3	3
	Std. Dev.	1.0	4.1	0.4	0.5	3.7	0.5	2.0	2.3

Summary of Monthly CRS AWQM Data
Pre- and Post-Construction of TCR (Continued)

		WW_59		WW_43		WW_86		WW_97	
		Cicero Ave. – CSC		Route 83 – CSC		Burnham Ave. – GCR		170th St. – Thorn Cr.	
Parameter		Pre	Post	Pre	Post	Pre	Post	Pre	Post
DO	Minimum	4.4	5.5	3.8	4.7	1.3	4.7	2.4	4.6
(mg/L)	Maximum	9.1	10.3	10.1	10.1	13.5	9.7	12.1	11.7
	Mean	6.8	7.8	6.7	7.7	5.7	7.6	7.7	8.7
	Std. Dev.	1.4	1.3	1.6	1.4	3.0	1.4	2.6	2.0
FC	Minimum	20	9	<10	9	20	40	80	80
(CFU/100 mL)	Maximum	53,000	860	12,000	2,000	570,000	20,000	84,000	55,000
	Geo. Mean	925	80	174	49	965	457	1,305	721
	Std. Dev.	11,359	270	2,602	445	129,934	4,204	19,147	12,338

Metropolitan Water Reclamation District of Greater Chicago

Results

- Water Quality Monitoring
  - Statistical Analysis

Statistical Analysis of AWQM Data

- Statistically significant differences were mainly observed between the historic sampling period and the pre- and post-construction sampling periods.
- Mean concentrations from the pre- and post-construction monitoring periods were not statistically different for most parameters.
- Means and Standard Deviations were calculated using a Uniformly Minimum Variance Unbiased Estimator.
- Means were determined to be significantly different if $p \leq 0.05$.
- Rank based on Tukey’s multiple range test and populations with the same letters are not significantly different.

Statistical Comparison of Total Suspended Solids Data from Monthly CRS AWQM

Location	Sampling Period	N	Mean	Standard Deviation	p	Rank
WW_43	1974–1984	144	40.5	34.3	0.000	a
	2014–2015	22	19.1	12.3		b
	2017–2018	23	16.6	8.0		b
WW_52	1974–1984	114	55.2	55.8	0.427	a
	2014–2015	20	44.1	37.9		a
	2017–2018	22	43.0	40.7		a
WW_55	1974–1984	121	19.1	9.7	0.000	a
	2014–2015	19	4.7	1.1		b
	2017–2018	20	4.3	0.7		b
WW_56	1974–1984	108	27.6	14.2	0.000	a
	2014–2015	19	19.7	14.1		b
	2017–2018	23	11.1	5.2		c
WW_57	1974–1984	112	48.3	65.2	0.296	a
	2014–2015	21	48.7	51.2		a
	2017–2018	23	29.8	29.2		a
WW_59	1974–1984	128	39.8	28.6	0.000	a
	2014–2015	21	25.3	16.7		b
	2017–2018	23	16.5	8.9		b
WW_76	1974–1984	113	25.8	15.9	0.000	a
	2014–2015	22	12.5	8.4		b
	2017–2018	23	8.0	3.3		b
WW_86	2014–2015	21	11.5	7.5	0.788	a
	2017–2018	23	10.0	4.3		a
WW_97	2017–2018	20	39.8	49.7	0.820	a
	2014–2015	22	35.0	40.6		a

Statistical Comparison of Total Dissolved Solids Data from Monthly CRS AWQM

Location	Sampling Period	N	Mean	Standard Deviation	p	Rank
WW_43	1974–1984	144	603	176	0.600	a
	2014–2015	22	641	192		a
	2017–2018	23	581	107		a
WW_52	1974–1984	115	642	246	0.746	a
	2014–2015	17	609	270		a
	2017–2018	22	626	257		a
W_55	1974–1984	121	387	168	0.060	a
	2014–2015	16	298	60		a
	2017–2018	20	315	91		a
WW_56	1974–1984	108	443	166	0.978	a
	2014–2015	19	441	142		a
	2017–2018	23	430	89		a
WW_57	1974–1984	112	830	361	0.221	a
	2014–2015	21	955	457		a
	2017–2018	23	734	251		a
WW_59	1974–1984	128	609	167	0.679	a
	2014–2015	21	625	179		a
	2017–2018	23	570	91		a
WW_76	1974–1984	113	599	214	0.503	a
	2014–2015	22	606	156		a
	2017–2018	23	536	103		a
WW_86	2014–2015	21	666	161	0.002	a
	2017–2018	23	528	118		b
WW_97	2017–2018	17	1,308	679	0.998	a
	2014–2015	22	1,333	751		a

Statistical Comparison of Fecal Coliform Data from Monthly CRS AWQM

Location	Sampling Period	N	Geometric Mean	Standard Deviation	p	Rank
WW_43	1974–1984	137	36,959	241,712	0.000	a
	2014–2015	22	818	2,511		b
	2017–2018	23	186	498		b
WW_52	1974–1984	111	152,757	707,068	0.000	a
	2014–2015	20	7,190	16,862		b
	2017–2018	22	2,376	3,778		b
WW_55	1974–1984	120	318	991	0.000	a
	2014–2015	19	53	102		b
	2017–2018	20	12	4		b
WW_56	1974–1984	107	5,441	18,264	0.000	a
	2014–2015	19	199	635		b
	2017–2018	23	27	28		b
WW_57	1974–1984	111	29,374	152,970	0.000	a
	2014–2015	21	1,617	2,722		b
	2017–2018	23	1,062	2,892		b
WW_59	1974–1984	125	75,410	356,414	0.000	a
	2014–2015	21	4,007	11,549		b
	2017–2018	23	227	488		c
WW_76	1974–1984	108	360,525	8,805,664	0.000	a
	2014–2015	22	7,369	20,593		b
	2017–2018	23	321	683		c
WW_86	2014–2015	21	17,897	112,094	0.267	a
	2017–2018	23	1,760	4,775		a
WW_97	2014–2015	20	4,368	10,425	0.254	a
	2017–2018	22	2,589	6,629		a

Metropolitan Water Reclamation District of Greater Chicago

Results

- Wet- and Dry-Weather Sampling
  - Statistical Analysis

Analysis of Wet- and Dry-Weather Monitoring Data

- A total of 37 sampling events (20 pre- and 17 post-construction) met the criteria for dry-weather conditions, 14 events (six pre- and eight post-construction) met the criteria for wet weather without CSOs, and six events (four pre- and two post-construction) met the criteria for wet weather with CSOs.
- However, the 125th Street Pump Station was not active prior to the two wet-weather sampling events when CSOs occurred in February and March 2017.
- The 125th Street Pump Station did not discharge during the post-construction monitoring period.
- Methods of statistical analysis were the same as with routine AWQM data (ANOVA).
- Category 1 is dry-weather.
- Category 2 is wet-weather without CSOs.
- Category 3 is wet-weather with CSOs.
- NA = Less than three data points were available, so no standard deviation was calculated.
- NC = Not calculated because the variance was zero or there was only one value for one of the levels.

Comparison of Wet- and Dry-Weather Monitoring Total Ammonia Nitrogen Data

		Event	WW_86 Burnham Ave. – GCR		
Parameter		Type	1	2	3
TAN	Minimum	Pre	<0.10	0.15	0.77
(mg/L)		Post	<0.10	<0.10	0.33
	Maximum	Pre	4.19	1.44	1.88
		Post	0.93	0.89	0.97
	Mean	Pre	1.03	0.74	1.19
		Post	0.34	0.28	0.65
	Std. Dev.	Pre	1.30	0.57	0.49
		Post	0.23	0.28	NA
	p value		0.03	0.11	0.26

Comparison of Wet- and Dry-Weather Monitoring Total Suspended Solids Data

		Event	WW_56 Indiana Ave. – LCR			WW_76 Halsted St. – LCR		
Parameter		Type	1	2	3	1	2	3
TSS	Minimum	Pre	8	4	12	4	5	8
(mg/L)		Post	5	7	11	<4	<4	6
	Maximum	Pre	80	26	14	33	23	16
		Post	31	30	13	17	10	9
	Mean	Pre	23	16	13	14	11	12
		Post	12	11	12	8	7	8
	Std. Dev.	Pre	18.2	8.3	0.8	9.0	6.6	3.4
		Post	6.8	7.6	NA	3.8	2.1	NA
	p value		0.03	0.27	0.31	0.01	0.21	0.17

Comparison of Wet- and Dry-Weather Monitoring Total Dissolved Solids Data

		Event	WW_43 Route 83. – CSC			WW_86 Burnham Ave. – GCR			WW_57 Ashland Ave. – LCR-S		
Parameter		Type	1	2	3	1	2	3	1	2	3
TDS	Minimum	Pre	380	424	280	548	482	250	422	644	210
(mg/L)		Post	404	316	328	374	330	240	454	306	240
	Maximum	Pre	956	762	402	940	732	402	1,570	1,222	448
		Post	846	584	404	736	614	260	1,234	840	262
	Mean	Pre	643	588	323	731	639	316	1,054	826	295
		Post	586	449	366	537	445	250	787	479	251
	Std. Dev.	Pre	177	126	69	109	112	78	276	232	133
		Post	115	83	NA	112	91	NA	275	177	NA
	p value		0.26	0.03	0.51	0.00	0.01	0.87	0.01	0.01	0.68

Comparison of Wet- and Dry-Weather Monitoring Dissolved Oxygen Data

		Event	WW_55 130th St. – Cal. River			WW_56 Indiana Ave. – LCR			WW_76 Halsted St. – LCR		
Parameter		Type	1	2	3	1	2	3	1	2	3
DO	Minimum	Pre	7.3	7.6	6.5	6.1	7.7	5.5	2.9	4.7	3.4
(mg/L)		Post	6.8	7.2	9.1	4.6	7.0	9.9	6.9	6.2	7.0
	Maximum	Pre	11.2	12.0	7.6	12.2	12.7	8.6	11.8	9.3	7.0
		Post	11.9	12.2	11.3	12.2	14.5	10.5	11.9	9.3	8.5
	Mean	Pre	8.9	9.4	7.0	9.3	10.0	7.0	7.5	6.7	4.7
		Post	9.4	8.7	10.2	9.6	9.2	10.2	8.5	7.4	7.8
	Std. Dev.	Pre	1.3	1.9	0.5	1.5	2.1	1.3	1.9	1.9	1.60
		Post	1.9	1.9	NA	1.9	2.6	NA	1.1	1.2	NA
	p value		0.38	0.49	0.01	0.65	0.57	0.03	0.04	0.39	0.07

Comparison of Wet- and Dry-Weather Monitoring Dissolved Oxygen Data (Continued)

		Event	WW_43 Route 83 – CSC			WW_86 Burnham Ave. – GCR		
Parameter		Type	1	2	3	1	2	3
DO	Minimum	Pre	4.1	4.2	5.0	1.9	0.0	0.0
(mg/L)		Post	6.2	5.7	8.5	5.4	6.1	5.5
	Maximum	Pre	9.0	10.1	6.2	13.5	6.2	1.6
		Post	10.1	8.9	9.5	9.7	9.4	5.8
	Mean	Pre	6.6	6.1	5.7	6.0	4.5	0.9
		Post	8.1	7.0	9.0	7.8	7.1	5.7
	Std. Dev.	Pre	1.3	2.3	0.5	2.9	2.3	0.7
		Post	1.1	1.3	NA	1.3	1.0	NA
	p value		0.00	0.37	0.00	0.03	0.03	0.00

Comparison of Wet- and Dry-Weather Monitoring Dissolved Oxygen Data (Continued)

		Event	WW_57 Ashland Ave. – LCR-S			WW_52 Wentworth Ave. – LCR-S			WW_76 Cicero Ave. – CSC		
Parameter		Type	1	2	3	1	2	3	1	2	3
DO	Minimum	Pre	4.7	4.7	4.1	4.6	4.6	5.0	4.4	5.2	4.5
(mg/L)		Post	3.9	6.1	7.5	3.2	4.8	8.1	6.2	5.6	8.4
	Maximum	Pre	11.5	9.0	5.2	12.4	9.9	5.3	9.1	10.0	5.3
		Post	13.5	10.0	8.1	12.6	10.7	8.8	10.3	9.4	8.9
	Mean	Pre	7.4	6.7	4.9	7.1	6.7	5.1	6.8	6.9	5.0
		Post	9.1	7.5	7.8	7.9	7.4	8.5	8.2	7.3	8.7
	Std. Dev.	Pre	2.5	1.8	0.5	2.5	2.2	0.2	1.3	1.9	0.4
		Post	2.3	1.5	NA	3.1	1.9	NA	1.1	1.5	NA
	p value		0.05	0.38	0.00	0.37	0.52	0.01	0.00	0.68	0.00

Comparison of Wet- and Dry-Weather Monitoring Fecal Coliform Data

		Event	WW_55 130th St. – Cal. River			WW_56 Indiana Ave. – LCR-S			WW_76 Halsted St. – LCR		
Parameter		Type	1	2	3	1	2	3	1	2	3
FC	Minimum	Pre	9	9	90	9	<10	310	50	2,000	34,000
(CFU/ 100 mL)		Post	9	9	<10	9	<10	<10	<10	30	60
	Maximum	Pre	110	1,500	500	2,100	90	8,000	83,000	24,000	100,000
		Post	20	91	20	170	530	50	2,900	5,100	70
	Geometric Mean	Pre	13	45	181	35	34	2,148	1,562	7,378	73,811
		Post	11	23	14	16	86	22	120	266	65
	Std. Dev.	Pre	25	600	191	671	31	4,167	20,087	7,756	31,117
		Post	4	27	NA	39	179	NA	773	1,730	NA
	p value		0.35	0.44	0.02	0.13	0.18	0.02	0.00	0.00	0.00

Comparison of Wet- and Dry-Weather Monitoring Fecal Coliform Data (Continued)

		Event	WW_43 Route 83 – CSC			WW_57 Ashland Ave. – LCR			WW_59 Cicero. – CSC		
Parameter		Type	1	2	3	1	2	3	1	2	3
FC	Minimum	Pre	<10	210	3,700	60	600	7,000	20	210	20,000
(CFU/ 100 mL)		Post	9	90	1,400	30	5,200	4,900	9	190	2,000
	Maximum	Pre	2,600	2,000	68,000	20,000	6,900	44,000	7,700	4,700	900,000
		Post	780	5,900	1,600	2,700	13,000	7,700	860	5,800	4,800
	Geometric Mean	Pre	74	518	22,169	498	2,246	19,710	540	1,868	128,969
		Post	35	2,260	1,497	165	7,540	6,142	68	1,699	3,098
	Std. Dev.	Pre	586	664	28,651	4,614	2,208	17,378	2,431	1,570	426,334
		Post	249	1,846	NA	655	2,634	NA	285	1,852	NA
	p value		0.14	0.04	0.05	0.02	0.01	0.15	0.00	0.88	0.07

Summary of Wet- and Dry-Weather Data Analysis

- Comparison between the pre- and post-construction wet-weather events with CSOs is somewhat skewed because the criteria for wet weather events with CSOs during the pre-construction monitoring period required the activation of the 125th Street Pump Station.
- Since that did not happen, the two CSO events that occurred in the LCR-S were sampled as wet-weather events with CSOs.
- Rainfall amounts for wet-weather sampling events without CSOs during the post-construction monitoring period were higher than those in the pre-construction monitoring period (1.25 and 0.7 inches on average, respectively).
  - This difference could have contributed to the increase in geometric mean FC concentrations at those locations.
- In addition, the two CSO events during the post-construction monitoring period occurred within 30 days of each other in February and March, when temperatures are fairly low yielding higher DO concentrations.
  - In contrast, most of the pre-construction wet-weather sampling events took place during spring and summer with higher water temperatures resulting in lower DO concentrations before rain events even occurred.

Summary of Wet- and Dry-Weather Data Analysis (Continued)

- Mean DO concentrations were significantly higher during the post-construction monitoring period at all sampling locations but 170th, with most of the increases observed during dry weather and wet weather with CSOs.
- Significant improvements in DO concentrations during post construction dry-weather conditions are likely a result of improvements in the District's operation of Sidestream Elevated Pool Aeration (SEPA) stations and Lake Michigan discretionary diversion.
- Significant improvements in DO concentrations during wet-weather events with CSOs in the post-construction monitoring period are likely due to the capture of CSOs by the TCR.
- Post-construction mean TDS concentrations were not significantly different during events with CSOs at any CRS locations.
- Mean BOD5 concentrations were lower during the post-construction period but, there were no statistically significant differences at any of the sampling locations or event types.

Metropolitan Water Reclamation District of Greater Chicago

Results

- Compliance with WQS During Post-Construction Monitoring

Compliance with WQS During Post-Construction Monitoring

- All the CRS reaches monitored were 100 percent compliant with acute and chronic TAN WQS for CAWS A and General Use Waters. There was also 100 percent compliance with TAN WQS in all CRS reaches during the pre-construction monitoring period.
- The FC concentrations were below 400 CFU/100 mL one hundred percent of the time at Indiana (WW_56) and Halsted (WW_76) for all three types of sampling events during recreational months.
- The FC concentrations at Cicero (WW_59) and Route 83 (WW_43) were below 400 CFU/100 mL one hundred percent of the time during recreational months under dry-weather conditions.
- However, at most stations, FC was above 400 CFU/100 mL most or all of the time during wet weather, irrespective of whether there were CSOs.

Fecal Coliform Pre- and Post-Construction Compliance

Station ID	Dry-Weather Geometric Mean	Wet-Weather Without CSOs Geometric Mean	Wet-Weather With CSOs Geometric Mean	Dry-Weather Percentage Below 400 CFU/100 mL	Wet-Weather Without CSOs Percentage Below 400 CFU/100 mL	Wet-Weather With CSOs Percentage Below 400 CFU/100 mL
WW_55[4]	12	31	14	NA	NA	NA
WW_86[4]	180	2,270	50,160	NA	NA	NA
WW_56[5]	12	66	22	100	100	100
WW_76[5]	47	175	65	100	100	100
WW_52[6]	853	6,509	9,249	22.2	16.7	0.0
WW_97[6]	530	7,489	7,099	62.5	0.0	0.0
WW_57[6]	75	7,652	6,142	87.5	0.0	0.0
WW_59[5]	29	1,425	3,098	100	14.3	0.0
WW_43[5]	14	2,036	1,497	100	14.3	0.0

Results

- Continuous Dissolved Oxygen Monitoring Compliance

CDOM Pre- and Post-Construction Comparisons

- AWQM DO versus CDOM
  - AWQM is just a snapshot, while CDOM is like the Jelly of the Month Club because it just keeps giving the whole year long.
- The two wet-weather events that resulted in CSOs in February and March 2017 did not cause DO concentrations to drop below any of the applicable DO WQS within seven days of the CSO occurrence at any CDOM location.
- All CDOM locations had relatively higher mean DO concentrations during 2017–2018.
- SEPA Station 4 was out of service from May 30, 2018, to July 20, 2018, due to electrical issues. Compliance with DO standards at Route 83 would most likely have been higher during 2017–2018 if SEPA Station 4 had been operational during that time.

CDOM Pre- and Post-Construction Data Comparisons

		Little Calumet River		Little Calumet River South	Calumet-Sag Channel	
Parameter	Period	C&W Indiana Railroad	Halsted Street	Ashland Avenue	Cicero Avenue	Route 83
Number of Observations	Pre	13,103	13,577	15,843	14,814	16,628
	Post	17,013	16,509	16,056	16,513	16,989
Minimum DO	Pre	0.2	0.4	0.2	0.2	0.4
	Post	1.3	0.2	1.2	1.4	0.4
Maximum DO	Pre	19.8	22.2	23.2	12.9	14.0
	Post	21.8	5.1	24.0	17.1	15.4
Mean DO	Pre	8.9	6.9	8.6	6.8	6.8
	Post	9.6	8.0	8.9	7.8	7.7
Standard Deviation (mg/L)	Pre	2.7	1.9	3.4	2.0	2.1
	Post	2.5	1.8	3.0	1.9	2.1
Percentage Above DO Standard	Pre	95.2	92.0	94.5	89.0	83.1
	Post	96.5	94.6	94.0	92.8	91.1

Recent Water Quality Trends

Additional Statistical Analysis

- Compiled data into two groups, Pre-TCR (2011–2015), and Post-TCR (2017–2021).
- Compared TDS, TSS, FC, and DO data from routine monthly AWQM sampling.
- Data for locations WW_55, WW_52, and WW_97 were not analyzed, because they were deactivated after 2018.
- BOD_5 was not analyzed, because routine AWQM samples are not analyzed for that parameter, and it was reported as > 2 mg/L very frequently in post-construction monitoring anyway.
- TAN was not analyzed, because concentrations were below detection (<0.3 or <0.5 mg/L) most of the time at sampling locations within the Calumet River System in Post-TCR samples.
- Data were tested for normality, using Shapiro-Wilk tests and analyzed with Wilcoxon Rank Sum Tests.
- Used the Wilcoxon Rank Sum to test for significance.
    - Tests if data values in one group are frequently higher than those in the other group (Helsel et al, 2020).
- AWQM data in the PCM report were analyzed for equality of **MEANS that were calculated via UMVUE**, **using parametric ANOVA.**

Mean Concentrations Pre-TCR (2011-2015) and Post-TCR (2017-2021)

	WW_43		WW_56		WW_57		WW_59		WW_76		WW_86	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
TSS (mg/L)	18	19	16	10	44	36	23	19	12	7	13	10
TDS (mg/L)	627	578	449	418	889	779	644	569	605	531	640	523
DO (mg/L)	6.4	8.1	8.4	9.8	7.3	7.9	6.6	8.0	7.2	8.4	4.9	7.6
FC* (CFU/100ml)	166	72	66	25	784	601	1,466	159	1,456	114	1,152	451

Median Concentrations Pre-TCR (2011-2015) and Post-TCR (2017-2021)

	WW_43		WW_56		WW_57		WW_59		WW_76		WW_86	
	Rt. 83 CSC		Indiana Ave. LCR		Ashland Ave. LCR-S		Cicero Ave. CSC		Halsted St. LCR		Burnham Ave. GCR	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
DO (mg/L)	6.7	7.9	8.3	9.6	7.3	7.9	6.6	8.0	7.2	8.4	4.9	7.6
p value	0.000		0.002		0.272		0.000		0.000		0.000	
TDS (mg/L)	602	561	426	411	889	779	644	569	605	531	640	523
p value	0.133		0.759		0.082		0.035		0.020		0.000	
TSS (mg/L)	15	14	12	9	44	36	23	19	12	7	13	10
p value	0.863		0.000		0.483		0.010		0.002		0.107	
FC (CFU/100ml)	140	40	66	25	784	601	1,466	159	1,456	114	1,152	451
p value	0.020		0.011		0.425		0.000		0.000		0.351	

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Significant Difference in Means Between Pre (2014-2015) and Post (2017-2018)

Parameter	WW_43	WW_56	WW_57	WW_59	WW_76	WW_86
DO	No	No	No	No	No	Yes
TDS	No	No	No	No	No	Yes
TSS	No	Yes	No	No	No	No
FC	Yes	No	No	Yes	Yes	No

Significant Difference in Pre-TCR (2011-2015) and Post-TCR (2017-2021)

Parameter	WW_43	WW_56	WW_57	WW_59	WW_76	WW_86
DO	Yes	Yes	No	Yes	Yes	Yes
TDS	No	No	No	Yes	Yes	Yes
TSS	No	Yes	No	Yes	Yes	No
FC	Yes	Yes	No	Yes	Yes	No

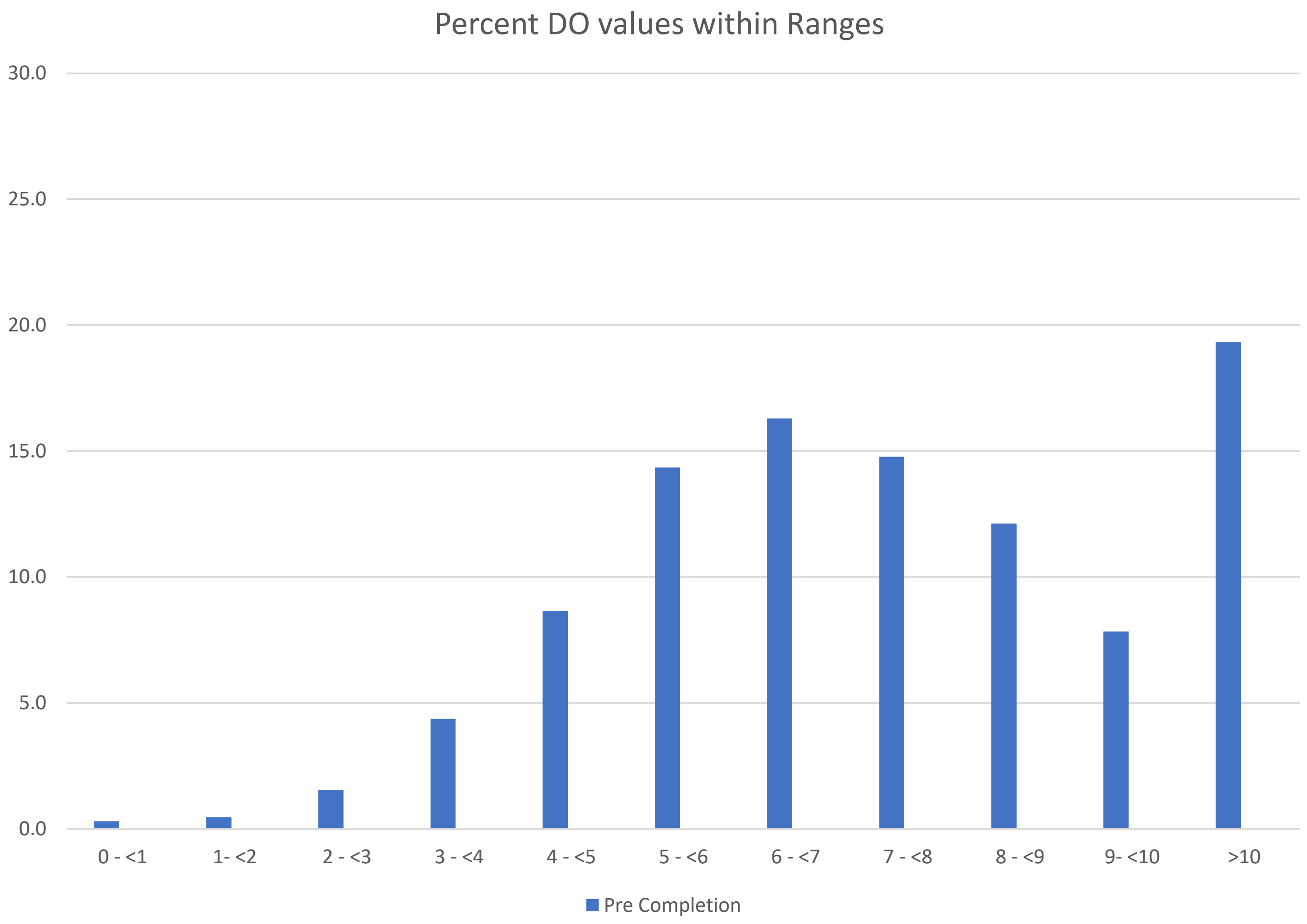
Additional CDOM Data Comparisons

- Expanded Pre- and Post-construction data ranges the same as we did for AWQM data.
- Looked at seasonal shifts in data.

Dissolved Oxygen

Sites include:

- C&W Indiana Railroad
- Halsted Street
- Ashland Avenue
- Route 83

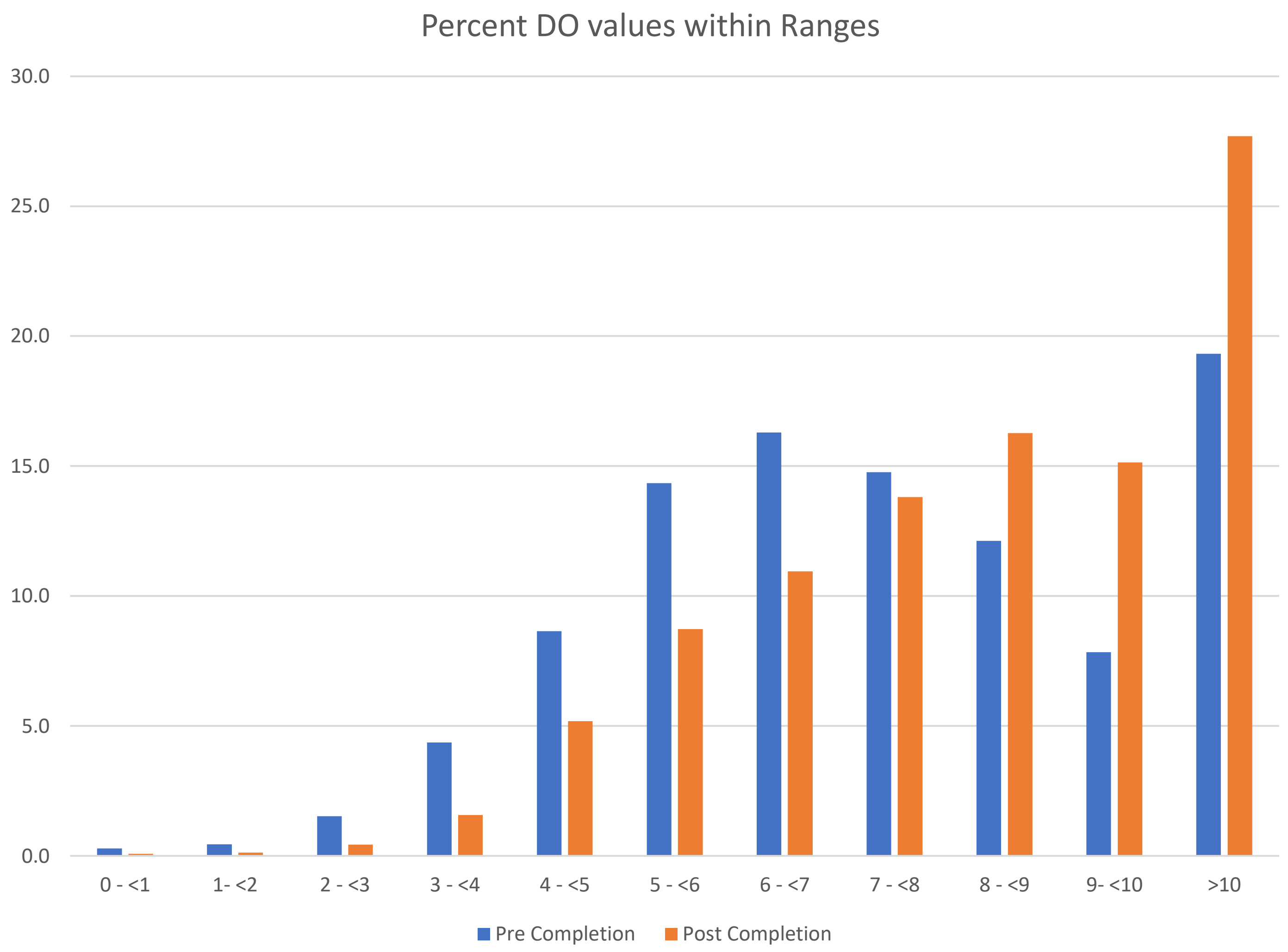


Dissolved Oxygen

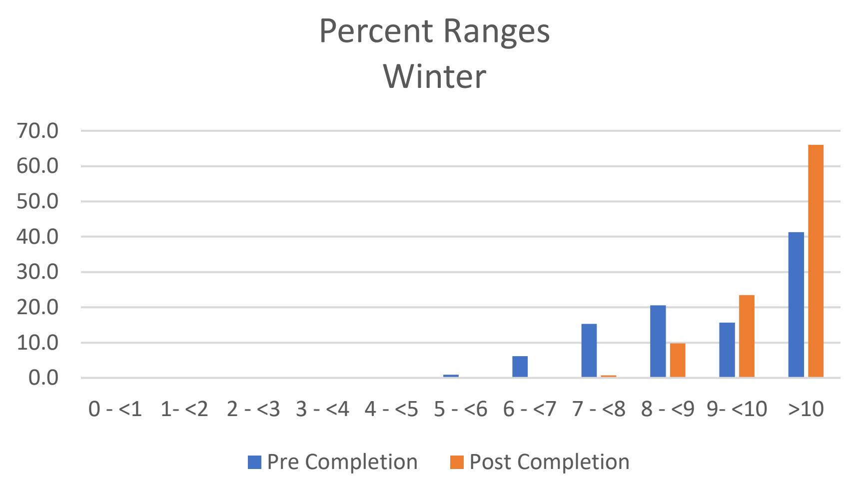
DO has shifted higher since the completion of TCR

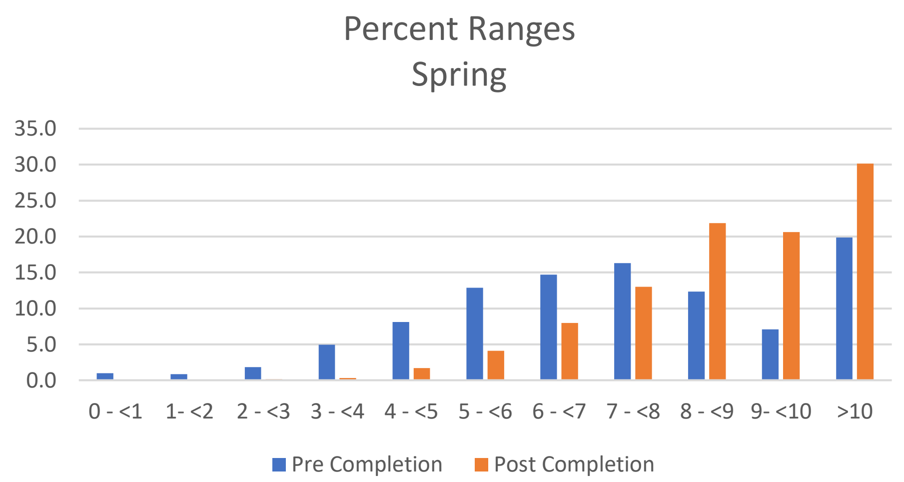
	Pre Completion	
	# in range	% in range
0 - <1	433	0.3
1- <2	669	0.5
2 - <3	2270	1.5
3 - <4	6457	4.4
4 - <5	12789	8.6
5 - <6	21214	14.3
6 - <7	24095	16.3
7 - <8	21837	14.8
8 - <9	17929	12.1
9- <10	11586	7.8
>10	28575	19.3
total =	147854	100
Min	0.15	
Max	23.18	
Mean	7.612206501	

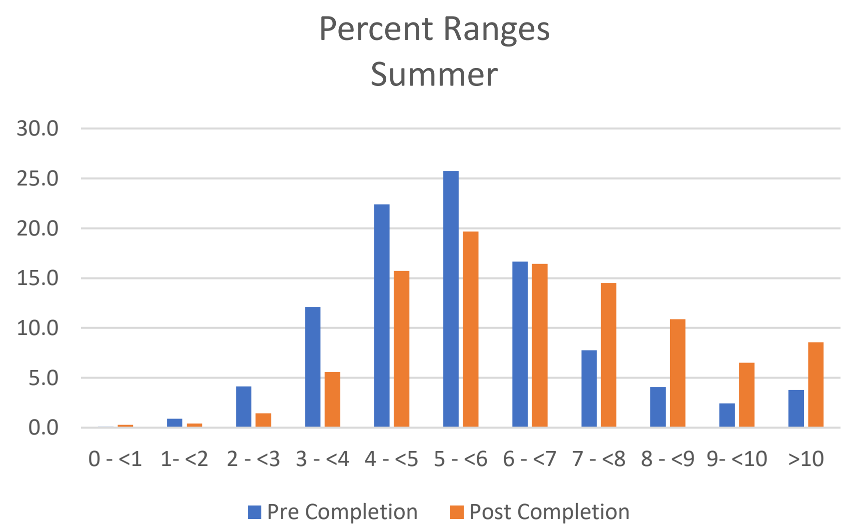
	Post Completion	
	# in range	% in range
0 - <1	133	0.1
1- <2	217	0.1
2 - <3	730	0.4
3 - <4	2634	1.6
4 - <5	8687	5.2
5 - <6	14606	8.7
6 - <7	18336	11.0
7 - <8	23119	13.8
8 - <9	27234	16.3
9- <10	25360	15.1
>10	46374	27.7
total =	167430	100
Min	0.04	
Max	23.99	
Mean	8.586487535	

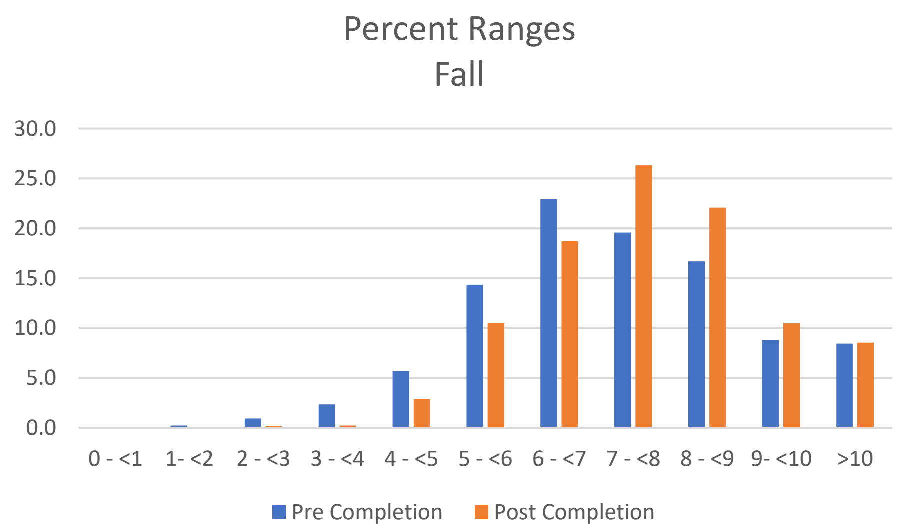


Dissolved Oxygen









Metropolitan Water Reclamation District of Greater Chicago

Other WQ Studies

Water Resources Research

RESEARCH ARTICLE
10.1029/2020WR028422

Key Points:
- Decreasing trends in nutrients, suspended solids, and fecal coliform were demonstrated in Chicago area waterways
- Increasing trends were observed for dissolved oxygen, chloride, and temperature in Chicago area waterways
- Investment in wastewater treatment, tunnel, and reservoir infrastructure improved water quality in Chicago area waterways

Long-Term Trends Show Improvements in Water Quality in the Chicago Metropolitan Region With Investment in Wastewater Infrastructure, Deep Tunnels, and Reservoirs

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[1]Monitoring and Research Department, Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL, USA

Abstract The ecological degradation of streams draining urban land, known as the urban stream syndrome, is characterized by elevated nutrients and contaminants, increased hydrologic flashiness, and altered biotic assemblages. This study demonstrated an improvement in chemical characteristics by evaluating water quality trends from 1975 to 2012 and from 2013 to 2018 in the Chicago, Calumet, and Des Plaines River Systems in Cook County, Illinois. Data from 41 monitoring locations were compiled

Highlights from Pluth et al.

- Seasonal Kendall test and Wilcoxon Rank-Sum tests.

- The largest WQ trends were observed in the Calumet River System

- Largest decreasing trend in concentrations of TOC were in the LCR, Thorn Creek and CSC(from 1974-2012) but no trend from 2013-2018

- Largest decrease in Total Kjeldahl Nitrogen (Organically bound nitrogen) concentrations observed at WW_76 from 1974-2012.
  - Annual median TKN was 11mg/L in 1975 and in 2012 it was <1 mg/L.

- Ammonium nitrogen decreased the most in the CSC and LCR (1975-2012).

- Decreasing trends in phosphorus at WW_52, 55, 57 and Thorn Creek.

- Decreasing trends in TSS and FC at all sampling locations. Largest decreases in FC in the LCR and CSC.

- Increasing trend in DO in the CSC and LCR, with CSC having the largest increase (up to 38%).

Science of the Total Environment 824 (2022) 153776

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Decreases in wastewater pollutants increased fish diversity of Chicago's waterways

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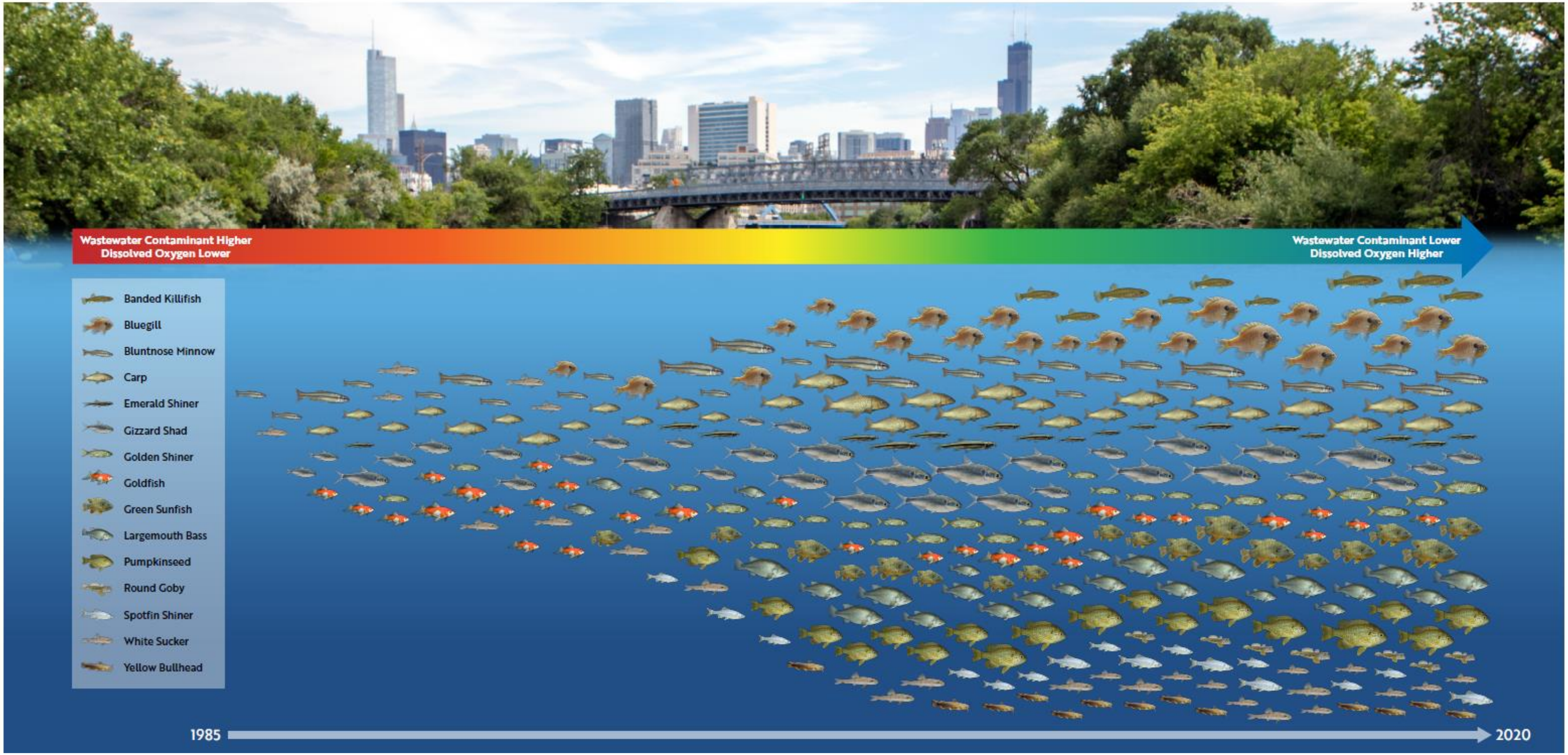
[b] Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL, USA

Decreases in wastewater pollutants increased fish diversity of Chicago's waterways



Urban Ecosystems
https://doi.org/10.1007/s11252-020-01020-3

Chicago's fish assemblage over ~30 years – more fish and more native species

Austin Happel[1] · Dustin Gallagher[2]

Highlights from Happel and Gallagher

- Multivariate modelling and visualization techniques used to assess and describe compositional changes in the fish assemblage of Chicago's waterways.

- There were gradual enhancements in fish assemblages characterized by more fish and more native species.

- For the 1985-2000 period native species richness was significantly higher in the Calumet River than other CAWS waterways.
- For the 2001-2018 period native species richness were the highest in the Calumet River and Little Calumet River when compared to the other CAWS waterways.


MODEL No. 118
A|24
IN-SIGHT
HONDA

Metropolitan Water Reclamation District of Greater Chicago

Acknowledgements

- For the PCM Report
  - We would like to thank **Dr. Heng Zhang**, Dr. Albert Cox, Dr. Zainul Abedin, Jennifer Wasik, all of the Pollution Control Technicians, and Patrol Boat Captains that collected all of the water samples, Ed Staudacher, Margaret Conway, Laura Franklin, and all of the Aquatic Ecology Technicians that assisted with water sampling, and all the District chemists and lab technicians that processed and analyzed water samples.

- Additionally
  - Tom Minarik, Thais Pluth, Dominic Brose, Dr. Sam Dennison, Dr. Austin Happel, and Justin Vick for always being bothered by people who confuse him for me.

REPORT NO. 22-13
"POST-CONSTRUCTION MONITORING REPORT FOR THE CALUMET TUNNEL AND RESERVOIR PLAN SYSTEM " is available for your reading pleasure at MWRD.org.

Metropolitan Water Reclamation District of Greater Chicago

QUESTIONS?

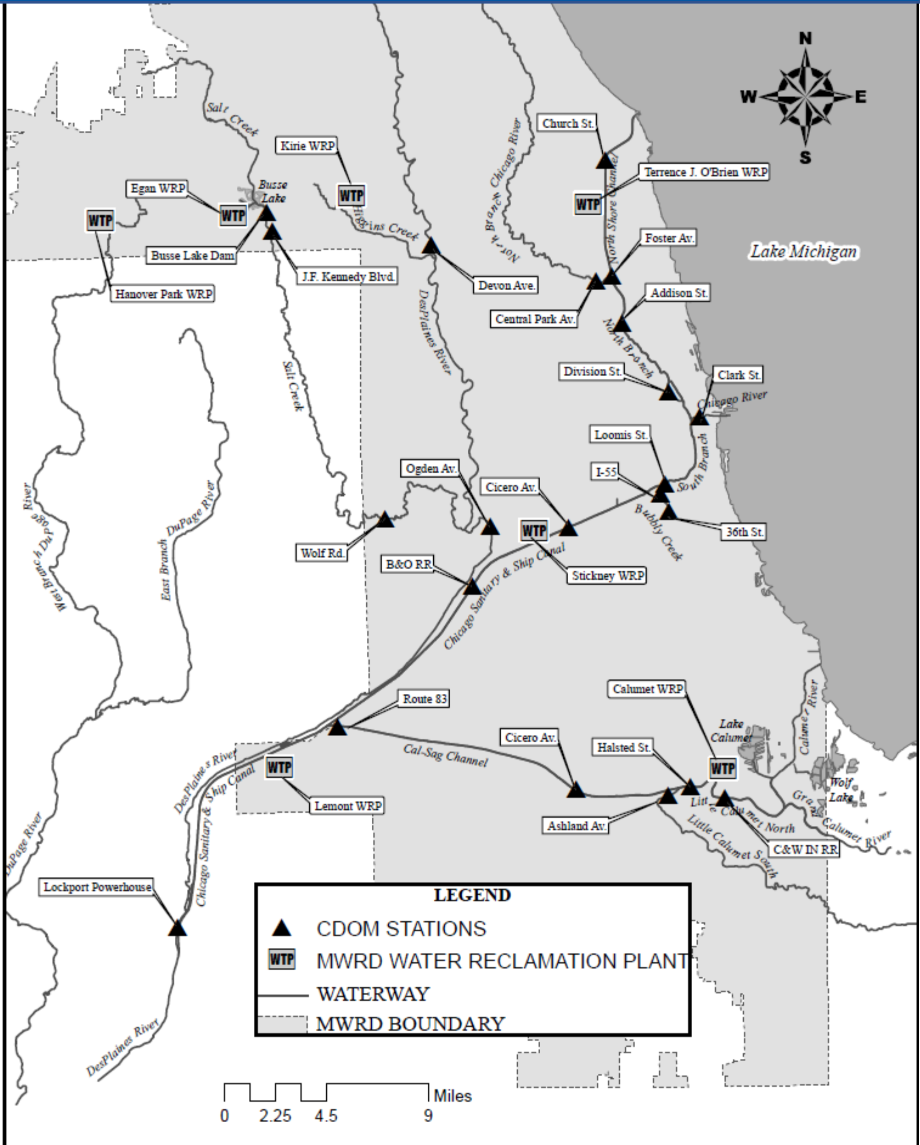
Who did it best?

Applicable Water Quality Standards Used for Evaluation

Water Quality Constituent	Applicable Water Quality Standards (Title 35Illinois Administrative Code Subtitle C, Chapter 1, Section Number)
Dissolved Oxygen	During March through July, DO shall not be less than 5.0 mg/L at any time; during August through February, it shall not be less than 3.5 mg/L at any time (302.206; 302.405).
Total Ammonia Nitrogen	Not to exceed 15 mg/L; pH- and temperature-based acute and chronic standards (302.212 and 302.412)
Total Suspended Solids	No Applicable water quality standard
Total Dissolved Solids	No Applicable water quality standard
Fecal Coliform	During May through October: Geometric mean of five samples within 30 days not to exceed 200 CFU/100 mL; no more than 10% of samples shall exceed 400 CFU/100 mL during any 30-day period (302.209).
Five-day Biochemical Oxygen Demand	No Applicable water quality standard

Continuous Dissolved Oxygen Monitoring (CDOM)

- The IPCB has assigned water uses for water bodies within the state of Illinois.
  - The Chicago River, Salt Creek, Des Plaines River, and the shallow portion of the LCR are designated as General Use Waters.
    - 5.5mg/L Aug.-Feb.
    - 6.0mg/L Mar.-Jul.
  - The NSC, NBCR, SBCR, Grand Calumet River, the deep-draft portion of the LCR, and the CSC are designated as CAWS Aquatic Life Use A Waters.
    - 4.0mg/L Aug.-Feb.
    - 5.0mg/L Mar.-Jul.
  - The CSSC is designated as CAWS and Brandon Pool Aquatic Life Use B Waters.
    - 4.0mg/L



Metropolitan Water Reclamation District of Greater Chicago

TCR (Continued)

- At the bottom of the reservoir is an impermeable layer of shale existing approximately 500 feet below ground that prevent water from escaping at through the bottom.
- To keep water from escaping through the sides, a double-row grout curtain was installed around the outside perimeter of the hole.
- TCR is the LARGEST CSO FACILITY IN THE WORLD!
- The District received the American Public Works Association award for “Project of the Year” on March 18, 2016 for TCR.
- TCR has virtually eliminated CSOs in the CRS.

Additional Statistical Analysis (Continued)

- This additional statistical analysis is **NOT** the same as what was done in the PCM Report.
- AWQM data in the PCM report were analyzed for equality of **MEANS** and standard deviations, using parametric ANOVA.
- Normality was tested using the Kolomogorov and Smirnov method for sample sizes greater than 10 but less than 30.

- Uniformly minimum variance unbiased estimator (UMVUE) for population means were also utilized when log-transformed data were compared because UMVUE variances are lower than other mean estimators.

Mean Concentrations in 1974-1984 (Historic), 2014-2015 (Pre), and 2017-2018 (Post) at CRS Monitoring Locations

	WW_43			WW_59			WW_57		
	Route 83 – CSC			Cicero Ave. – CSC			Ashland Ave. – LCR-S		
	Historic	Pre	Post	Historic	Pre	Post	Historic	Pre	Post
TSS (mg/L)	41	19	17	40	25	17	48	49	30
TDS (mg/L)	603	641	581	609	625	570	830	955	734
DO (mg/L)	3.3	6.7	7.7	4.0	6.8	7.8	5.5	7.4	8.6
FC* (CFU/100ml)	36,959	818	186	75,410	4,007	227	29,374	1,617	1,062

Mean Concentrations in 1974-1984 (Historic), 2014-2015 (Pre), and 2017-2018 (Post) (Continued)

	WW_56			WW_76			WW_86	
	Indiana Ave. – LCR			Halsted S. – LCR			Burnham Ave. – GCR	
	Historic	Pre	Post	Historic	Pre	Post	Pre	Post
TSS (mg/L)	28	20	11	26	13	8	12	10
TDS (mg/L)	443	441	430	599	606	536	666	528
DO (mg/L)	6.1	9.4	9.4	4.9	7.7	8.2	5.8	7.6
FC* (CFU/100ml)	5,441	199	27	306,525	7,369	321	17,897	1,760

Metropolitan Water Reclamation District of Greater Chicago

Improvements in Water Quality (Pre-construction)

Metropolitan Water Reclamation District of Greater Chicago

Improvements to Water Quality

- Formation of the Metropolitan Sanitary District of Greater Chicago (AKA MWRDGC, MWRD, and the District) in 1889.
  - Reversed the flow of the Chicago River in 1900.
  - Cal-Sag Channel was created in 1922.
  - Calumet Water Reclamation Plant built in1922.
- Federal Water Pollution Control Act in 1948.
  - Basis of the CWA.
- Sewage and Waste Control Ordinance in 1969.
  - Legal framework to abate pollution by regulating and controlling sewage and industrial wastes discharged to the District.
- The Clean Water Act in1972.
  - Regulated discharges of pollutants.
  - National Pollutant Discharge Elimination System (NPDES).
- Federal General Pretreatment Requirements were approved(40 CFR 403) – 1978.
  - Regulate effluents of indirect industrial users to POTWs.

Improvements to WQ (Continued)

- MWRD Board of Commissioners adopted the User Charge Ordinance in1979.

- Expansion of secondary treatment at the Calumet WRP in 1985.

- MWRD built 5 Sidestream elevated pool aeration (SEPA) stations.
  - Calumet River (#1), Little Calumet River (#2), Calumet-Sag Channel (#s 3,4, & 5).
  - All 5 Online by 1994.
  - Operated between March and November.

- The Metropolitan Water Reclamation District of Greater Chicago (District) entered into a Consent Decree on January 6, 2014 with USEPA and Illinois EPA.
  - Required amounts of Green Infrastructure (GI).
  - Enforceable schedule for construction of TARP.
  - Debris removal
    - 2 skimmer boats
    - 50’ barge and 36’ debris boat
  - Reporting

Improvements to Water Quality (Continued)

- GI projects
    - Space to Grow
    - Various GI projects with numerous villages, townships, and communities.
    - Rain barrel program
- Disinfection at Calumet WRP started in 2016.
    - Chlorination/dechlorination
    - Between March and November
- Improved operations at O'Brien Lock and Dam (Discretionary Diversion) and the SEPA stations from the use of supplementary real-time dissolved oxygen (DO) monitoring data in the Calumet River System (CRS) 2017.
- Phosphorus removal is on the way at Calumet WRP in 2024.

Statistical Comparison of Total Ammonia Nitrogen Data from Monthly CRS AWQM

Location	Sampling Period	N	Mean	Standard Deviation	p	Rank
WW_43	1974–1984	142	6.37	4.00	0.000	a
	2014–2015	22	0.51	0.33		b
	2017–2018	23	0.50	0.51		b
WW_52	1974–1984	114	2.84	2.74	0.000	a
	2014–2015	20	0.28	0.14		b
	2017–2018	22	0.32	0.19		b
WW_55	1974–1984	121	0.79	0.93	0.000	a
	2014–2015	19	0.16	0.09		b
	2017–2018	20	0.22	0.17		b
WW_56	1974–1984	108	2.62	2.61	0.000	a
	2014–2015	19	0.23	0.17		b
	2017–2018	23	0.31	0.24		b
WW_57	1974–1984	112	2.68	3.18	0.000	a
	2014–2015	21	0.23	0.11		b
	2017–2018	23	0.29	0.20		b
WW_59	1974–1984	128	7.47	4.20	0.000	a
	2014–2015	21	0.54	0.31		b
	2017–2018	23	0.38	0.20		b
WW_76	1974–1984	113	9.04	5.82	0.000	a
	2014–2015	22	0.56	0.49		b
	2017–2018	23	0.34	0.22		b
WW_86	2014–2015	21	1.11	1.58	0.003	a
	2017–2018	23	0.30	0.24		b
WW_97	2017–2018	22	0.29	0.26	0.536	a
	2014–2015	20	0.24	0.19		a

Statistical Comparison of Five-Day Biochemical Oxygen Demand Data from Monthly CRS AWQM

Location	Sampling Period	N	Mean	Standard Deviation	p	Rank
WW_43	1974–1984	144	5.68	3.30	0.000	a
	2014–2015	20	2.25	0.41		b
	2017–2018	20	2.30	0.44		b
WW_52	1974–1984	115	10.34	5.48	0.000	a
	2014–2015	20	3.49	1.73		b
	2017–2018	20	3.11	1.45		b
WW_55	1974–1984	120	3.65	2.32	0.001	a
	2017–2018	18	2.43	0.95		ab
WW_56	1974–1984	105	5.23	3.00	0.000	a
	2014–2015	17	2.17	0.35		b
	2017–2018	21	2.24	0.40		b
WW_57	1974–1984	112	7.11	4.16	0.000	a
	2014–2015	19	2.99	1.35		b
	2017–2018	21	2.84	1.24		b
WW_59	1974–1984	127	7.14	3.67	0.000	a
	2014–2015	19	2.50	0.79		b
	2017–2018	21	2.75	1.52		b
WW_76	1974–1984	113	8.42	4.74	0.000	a
	2014–2015	18	2.99	1.39		b
	2017–2018	21	2.33	0.56		b
WW_86	2014–2015	20	3.73	2.48	0.011	a
	2017–2018	20	2.14	0.38		b
WW_97	2014–2015	20	3.24	1.57	0.451	a
	2017–2018	19	2.89	1.41		a

Statistical Comparison of Dissolved Oxygen Data from Monthly CRS AWQM

Location	Sampling Period	N	Mean	Standard Deviation	p	Rank
WW_43	1974–1984	135	3.31	2.77	0.000	b
	2014–2015	22	6.67	1.69		a
	2017–2018	23	7.71	1.47		a
WW_52	1974–1984	111	4.84	4.33	0.000	b
	2014–2015	20	6.89	2.61		a
	2017–2018	22	7.61	3.53		a
WW_55	1974–1984	121	8.72	2.50	0.431	a
	2014–2015	19	8.83	1.59		a
	2017–2018	20	9.23	1.76		a
WW_56	1974–1984	108	6.05	2.83	0.000	b
	2014–2015	19	9.44	2.16		a
	2017–2018	23	9.38	2.04		a
WW_57	1974–1984	110	5.49	3.62	0.000	b
	2014–2015	21	7.35	2.46		a
	2017–2018	23	8.61	2.60		a
WW_59	1974–1984	125	4.00	4.53	0.000	b
	2014–2015	21	6.83	1.43		a
	2017–2018	23	7.85	1.32		a
WW_76	1974–1984	108	4.92	3.90	0.000	b
	2014–2015	22	7.68	1.50		a
	2017–2018	23	8.17	1.19		a
WW_86	2014–2015	21	5.77	3.62	0.003	b
	2017–2018	23	7.56	1.46		a
WW_97	2017–2018	20	7.79	3.12	0.141	a
	2014–2015	22	8.66	2.13		a

Metropolitan Water Reclamation District of Greater Chicago

Conclusions

Conclusions of the TCR PCM Report

- The 125th Street Pumping Station never discharged during the post-construction monitoring period.
  - Update: 125th Street Pumping Station has **STILL not been active since 6/16/15!**
- The largest single rain event during the post-construction monitoring period was 4.34 inches and no CSOs occurred.
  - Update: That amount has not been surpassed since then but 2019 was the third wettest year on record in Chicago, and May 2018 (8.21”), 2019 (8.25”), and 2020 (8.3”) are the three wettest Mays on record.
- The total estimated volume of CSOs during the post-construction monitoring period (2017-2018) (6.0 million gallons [MG]) was 99.8 percent lower than the pre-construction monitoring period (3.5 BG).
  - Update: TCR had captured over 47 BG as of then end of 2021 and there have been ZERO CSO events in the CRS Since 2021.
- After the two post-construction (2017-2018) CSO events, TAN and DO complied with the corresponding WQS at all monitoring locations.
  - FC concentrations were less than 400 CFU/100 mL at Halsted Street in the LCR (WW_76) and Indiana Avenue in the LCR (WW_56), but exceeded 400 CFU/100 mL at the other CRS monitoring locations, both upstream and downstream of CSO discharges.

Conclusions of the TCR PCM Report (Continued)

- Exceedances of 400 CFU/100 mL were also typical during wet-weather events without CSOs, suggesting nonpoint source contributions.

- During the post-construction monitoring period, water quality at the sampling locations directly downstream of CSO discharges was similar to water quality observed during wet-weather events without CSOs.

- During the post-construction monitoring period, water quality during wet- (with and without CSOs) and dry-weather conditions was generally similar with the following exceptions:
  a) Geometric mean FC concentrations during wet weather were higher in eight out of nine locations sampled.
  b) Mean total suspended solids (TSS) concentrations during wet weather were higher in five out of nine locations sampled and mean total dissolved solids (TDS) concentrations were lower during wet weather in seven out of nine locations sampled.

Conclusions of the TCR PCM Report (Continued)

- Mean TAN, BOD5, FC, and TSS concentrations from monthly AWQM sampling were significantly lower during the post-construction monitoring period compared to historic concentrations for all the locations that were monitored during all three monitoring periods.

- The DO concentrations at the AWQM locations increased significantly in the CRS during both the pre- and post-construction monitoring periods compared to the historic period.
  - Most of the significant DO increases between the pre- and post-construction monitoring periods were observed during sampling events in dry and wet weather with CSOs.

- Overall compliance with DO WQS increased at most continuous DO monitoring (CDOM) locations between pre- and post-construction monitoring periods and was greater than 90 percent at all locations during the post-construction monitoring period.

- Mean TSS concentrations in the pre- and post-monitoring periods were not significantly different at any CRS locations during wet-weather events with or without CSOs.

Conclusions of the TCR PCM Report (Continued)

- Mean Total Ammonia Nitrogen (TAN), five-day biochemical oxygen demand (BOD5), Fecal Coliform (FC), and Total Suspended Solids (TSS) concentrations from monthly AWQM sampling were significantly lower during the post-construction monitoring period compared to historic concentrations for all the locations that were monitored during all three monitoring periods.
  - Update: This is still the case, however TAN and BOD5 are now mainly below detection limits so statistical analysis is not applicable for most locations.
- The DO concentrations at the AWQM locations increased significantly in the CRS during both the pre- and post-construction monitoring periods compared to the historic period. Most of the significant DO increases between the pre- and post-construction monitoring periods were observed during sampling events in dry and wet weather with CSOs.
- Overall compliance with DO WQS increased at most continuous DO monitoring (CDOM) locations between pre- and post-construction monitoring periods and was greater than 90 percent at all locations during the post-construction monitoring period.
- Mean TSS concentrations in the pre- and post-monitoring periods were not significantly different at any CRS locations during wet-weather events with or without CSOs.