Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

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WATER QUALITY

IN THE NORTH AND SOUTH BRANCHES OF THE CHICAGO RIVER,

CHICAGO RIVER, AND INSHORE AREA OF LAKE MICHIGAN

DURING NOVEMBER AND DECEMBER 1999

May 2000

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WATER QUALITY IN THE NORTH AND SOUTH BRANCHES OF THE CHICAGO RIVER, CHICAGO RIVER, AND INSHORE AREA OF LAKE MICHIGAN DURING NOVEMBER AND DECEMBER 1999

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DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

SUMMARY AND CONCLUSIONS

Early in November 1999, it was reported that there was a noticeable difference in the clarity of water between Lake Michigan and the Chicago River. The color of the water in the Chicago River appeared darker than in Lake Michigan. As a result of these observations, the Metropolitan Water Reclamation District of Greater Chicago conducted five water quality surveys during November and December 1999 in the North and South Branches of the Chicago River, the Chicago River, and Lake Michigan.

Based on the results from the five surveys, the following conclusions can be drawn as to water quality in the North Branch of the Chicago River, South Branch of the Chicago River, Chicago River, and Lake Michigan.

1. Water temperatures in the North Branch of the Chicago River were higher than temperatures measured in the Chicago River. Compared to the Chicago River, water temperatures in Lake Michigan were lower.
2. The concentration of dissolved oxygen was higher in the South Branch of the Chicago River compared to the North Branch. During four of the five surveys, the concentration of dissolved oxygen was lower at Clark Street

compared to monitoring locations upstream (eastward) in the Chicago River.

3. On December 7, 1999, the dissolved oxygen concentrations in the Chicago River between Clark Street and the Chicago River Lock were similar. This may have resulted because no water from the lake was coming into the river since the level of Lake Michigan was lower than the level of the Chicago River, and because of the residual effect of overflows from combined sewers and nonpoint runoff from a December 4 and 5 rainfall event.

4. Suspended solids and turbidity were higher in the North Branch of the Chicago River compared to constituent levels in the South Branch. Overall, suspended solids and turbidity levels decreased in the Chicago River from Clark Street to the Chicago River Lock.

5. The mean concentration of suspended solids and turbidity measured in Lake Michigan were substantially higher compared to the mean values measured in the Chicago River at the Chicago River Lock.

6. Low flows in the Chicago River may cause suspended solids to settle in the river.

7. Nutrient levels (ammonia nitrogen, nitrate nitrogen, and total phosphorus) in the North Branch of the Chicago River are slightly higher than nutrient levels in the South Branch. Compared to the North Branch, nutrient levels in the Chicago River were considerably lower. Nutrient concentrations decreased in the Chicago River from Clark Street to the Chicago River Lock.

8. Nutrient concentrations in the Chicago River are 10 to 100 times higher than nutrient concentrations in Lake Michigan.

9. It appears that during four of the five water quality surveys, water from Lake Michigan was entering the Chicago River and diluting the concentration of soluble chemical constituents in the Chicago River and the South Branch.

INTRODUCTION

The Chicago River extends from the junction of the North and South Branches of the Chicago River on the west to the Chicago River Lock on the east. Normal flow in the Chicago River is from east to west, resulting from water taken into the river from Lake Michigan. The flow in the Chicago River merges with the flow in the North Branch and continues southerly flowing into the South Branch. Since the water level in the Chicago River is maintained below the level of Lake Michigan by Federal regulation, gravity causes water to flow from the lake to the river through lock gates, sluice gates, and uncontrolled openings in walls separating the lake from the river. Flows through these three functional elements are referred to as lockage, discretionary diversion, and leakage, respectively.

These functional elements are derived from long-standing accounting procedures for the diversion of Lake Michigan waters through judicial decrees issued by the United States Supreme Court. The 1967 Decree allows the State of Illinois to allocate Lake Michigan diversion water to local governments for various purposes, primarily potable water supply. The Metropolitan Water Reclamation District of Greater Chicago

(District) has been allocated a specific amount of water for discretionary diversion. The water is used during warm weather periods to improve water quality in the Chicago inland waterway system. Warm temperatures adversely impact water quality. Hence, the additional high quality lake water available through discretionary diversion serves to improve these conditions. Discretionary diversion quantities are strictly controlled by adjusting sluice gate openings at the lakeward control structures.

The District does not control lockage and leakage. Lockage is dependent upon the volume of navigation traffic through the Chicago River Lock and the difference in water level between the lake and the river. Leakage is due to the age of mechanical and structural elements separating the lake and river. The volume of leakage is dependent upon the difference in water level.

It should be noted that during warm weather, the normal westward flow of water in the Chicago River is relatively large in magnitude, resulting from navigation traffic and discretionary diversion. Conversely, during cold weather, the westward flow in the river is small by comparison because of the limited navigation and reduced or no discretionary diversion. Furthermore, a small difference in water level between

the lake and river can cause the flow rate in the Chicago River to approach minimal, even near-zero conditions.

During the months of June through October, the District takes discretionary diversion from Lake Michigan into the Chicago River through sluice gates located on the North and South Basin Walls at the Chicago River Controlling Works. Normally, no discretionary diversion is taken from the lake into the river during a seven-month period from November through May.

As a result of a 1996 Memorandum of Understanding (MOU) between the seven Great Lakes States and the United States Department of Justice, the United States Army Corps of Engineers (USACE) and the State of Illinois were committed to reduce uncontrolled water leakage into the Chicago River from Lake Michigan.

In late 1997, the USACE initiated repairs to the Chicago River Lock, including lock gate leakage reduction. Repairs to the east and west lock gates were completed in early 1999. In addition to repairing the lock gates, the State of Illinois agreed to build a cutoff wall across the Chicago Inner Harbor, eliminating the leakage through the U.S. Inner Breakwater. Construction of the wall began in 1999 and is scheduled for completion during 2000.

Early in November 1999, the Illinois Department of Natural Resources, Department of Water Resources, reported that there was a noticeable difference in the clarity of water between Lake Michigan and the Chicago River. The observation, that the color of the water in the river is darker than that of the lake, was confirmed by representatives of the District and other agencies. The common perception is that darker-appearing water is of poorer quality than lighter-appearing water.

As a result of these observations and the perception, the District conducted five water quality surveys in the North and South Branches of the Chicago River, the Chicago River, and the inshore area of Lake Michigan during November and December 1999. This report summarizes the results from the water quality surveys.

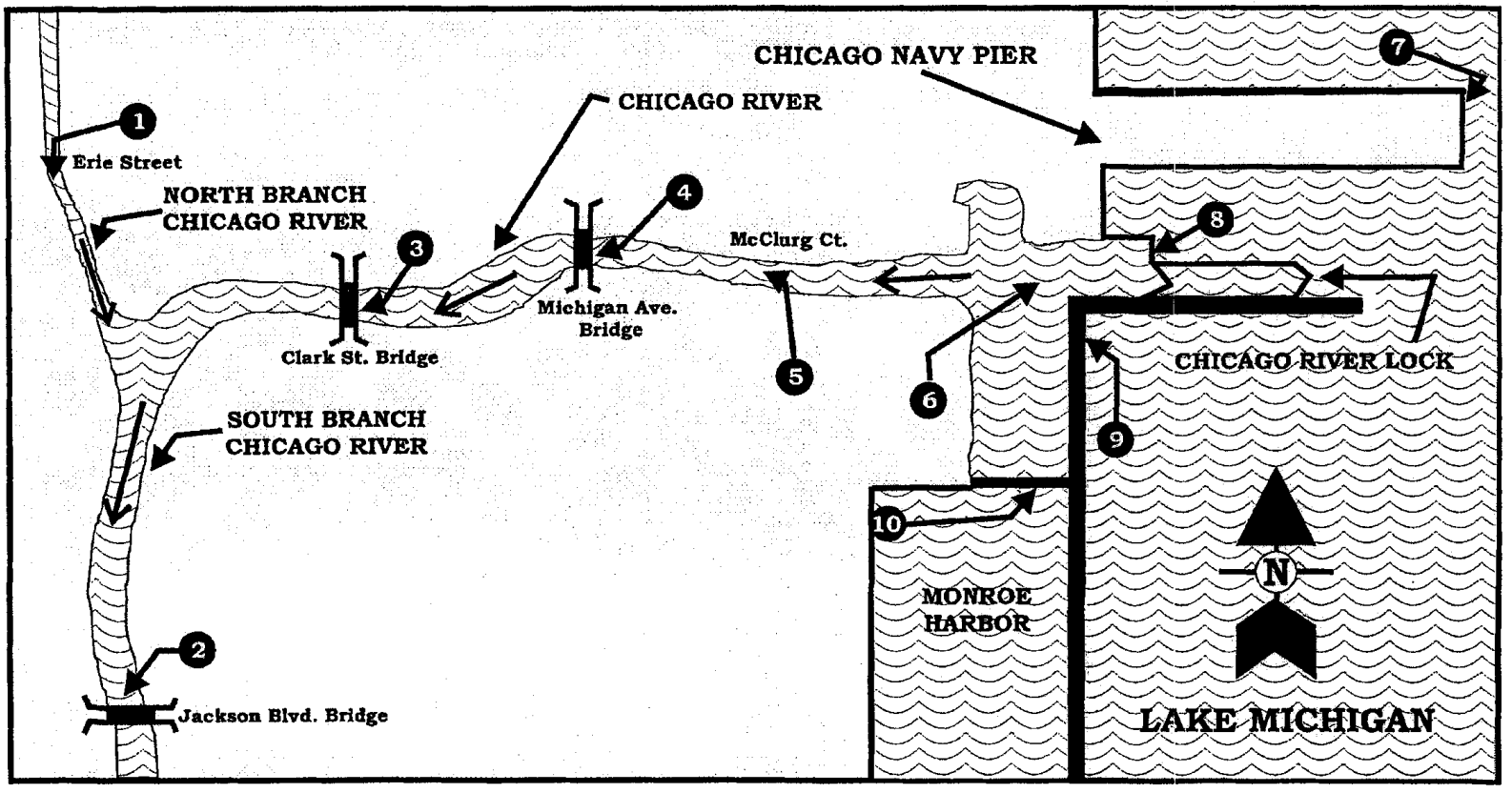
SAMPLING LOCATIONS

The ten sampling locations selected for the water quality surveys are shown in Figure 1. One station was located on the North Branch of the Chicago River, one station on the South Branch of the Chicago River, four stations on the Chicago River, and four stations in Lake Michigan. Table 1 describes the ten sampling locations.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 1

SAMPLING STATIONS 1-10 (NUMBERED CIRCLES) IN THE NORTH AND SOUTH BRANCHES OF THE CHICAGO RIVER, CHICAGO RIVER, AND LAKE MICHIGAN



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 1

DESCRIPTION OF TEN SAMPLING STATIONS IN THE NORTH BRANCH OF THE CHICAGO RIVER, SOUTH BRANCH OF THE CHICAGO RIVER, CHICAGO RIVER, AND LAKE MICHIGAN

Station Number	Station Location	Description of Sampling Station
1	Erie Street	North Branch Chicago River; 100 feet upstream from Erie Street in the center of the river.
2	Jackson Boulevard	South Branch Chicago River; 100 feet upstream from Jackson Boulevard Bridge in the center of the river.
3	Clark Street	Chicago River; 100 feet upstream from Clark Street Bridge in the center of the river.
4	Michigan Avenue	Chicago River; 100 feet upstream from Michigan Avenue Bridge in the center of the river.
5	McClurg Court	Chicago River; center of river across from Centennial Fountain.
6	Chicago River Lock	Chicago River; 400 feet downstream from Chicago River Lock in the center of the river.
7	Navy Pier	Lake Michigan; East end of Chicago Navy Pier.
8	North Sluice Gates	Lake Michigan; Lake side of north sluice gates.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 1 (Continued)

DESCRIPTION OF TEN SAMPLING STATIONS IN THE NORTH BRANCH OF THE CHICAGO RIVER, SOUTH BRANCH OF THE CHICAGO RIVER, CHICAGO RIVER, AND LAKE MICHIGAN

Station Number	Station Location	Description of Sampling Station
9	Chicago Marine Police	Lake Michigan; East of Chicago Marine Police Station.
10	South Sluice Gates	Lake Michigan; Lake side of south sluice gates in Monroe Harbor.

MATERIALS AND METHODS

Surface water samples for chemical analyses were collected using a four-gallon stainless steel bucket. Samples from all ten stations were collected on November 23, November 30, December 7, December 14, and December 21, 1999. No water samples were collected at Navy Pier on November 23. All samples were transported to the Dr. Cecil Lue-Hing Research and Development Complex in iced insulated chests within four hours of collection for analysis.

The water samples were analyzed for suspended solids, turbidity, total ammonia nitrogen, nitrate nitrogen, and total phosphorus. Samples for dissolved oxygen were fixed in the field and returned to the laboratory for titration. Water temperature was measured in the field.

RESULTS AND DISCUSSION

Water Quantity

In 1996, the United States Geological Survey (USGS) installed a three-path acoustic velocity meter (AVM) at Columbus Drive on the Chicago River. As a result of the individual path velocities, the USGS generally observed a normal distribution of velocity in the vertical profile. However, during the period of November through March in 1998-1999 and in 1999-2000, low discharge conditions in the Chicago River resulted in the USGS recording occasional bidirectional flows. In March 1999, the USGS measured water temperature at several locations in the study area, and found significant temperature variations in the vertical profile. It was initially suspected that thermal stratification caused the bidirectional flows.

It may also be possible that the interaction between flows in the North Branch, the South Branch, and in the Chicago River in the vicinity of Wolf Point is producing density currents in the Chicago River. Density currents can result from thermal stratification and from differences in the concentration of water quality constituents. These currents would have had a stronger impact during November and December

1999 due to the following activities and conditions: (1) curtailment of diversion in November 1999; (2) reduced leakage through the lock gates and harbor walls resulting from extremely low water levels in Lake Michigan; and (3) the completion of lock gate repairs.

Water level records from the District's Maintenance and Operations (M&O) Department indicate that on the five days when water quality samples were collected, the difference between the water level in the lake and in the river varied from the lake being 0.90 feet higher than the river (Table 2, shown as + in the difference column) to the river being 0.05 feet higher than the lake (Table 2, shown as -).

Also, rainfall records indicate that during mid-November through late-December 1999, the only significant rainfall that would have contributed additional flows and possible combined sewer overflows (CSOs) in the North Branch and the Chicago River occurred on December 4 and 5, 1999. Approximately 1.2 inches of precipitation was recorded in the north and central regions of the District's service area. Furthermore, the M&O Department reported that on December 5, 1999, the Tunnel and Reservoir Plan Mainstream System tunnels were at 90 percent capacity.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 2

AVERAGE WATER LEVELS RECORDED IN LAKE MICHIGAN AND THE CHICAGO RIVER DURING NOVEMBER 23 AND 30, AND DECEMBER 7, 14, AND 21, 1999

Date	Lake Michigan (feet) CCD	Chicago River (feet) CCD	Difference
11/23/99	-1.40	-1.80	+0.40
11/30/99	-1.33	-1.89	+0.56
12/07/99	-1.76	-1.71	-0.05
12/14/99	-0.96	-1.86	+0.90
12/21/99	-1.81	-1.92	+0.11

CCD = Chicago City Datum.

Water Quality

During June through October, when water from Lake Michigan is diverted into the Chicago River, the direction of flow in the river is from east to west away from the lake. The presumption is that during the period of no discretionary diversion (November through May), the water in the Chicago River continues to flow slowly towards the junction of the North and South Branches of the Chicago River due to occasional opening of the locks for navigation and due to leakage. During the two-month study period, no discretionary water was diverted from Lake Michigan into the Chicago River through the sluice gates.

The concentrations of seven constituents measured in water samples collected from ten sampling stations during November and December 1999 are presented in Tables 3 through 7.

WATER TEMPERATURE

Water temperature varied from 8.3 to 17.0ºC in the North and South Branches of the Chicago River, from 6.4 to 15.0ºC in the Chicago River, and from 2.0 to 8.0ºC in Lake Michigan.

Water temperatures in the North Branch were higher than temperatures measured in the Chicago River. Compared to the Chicago River, water temperatures in Lake Michigan were lower.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

WATER QUALITY AT TEN STATIONS IN THE NORTH BRANCH OF THE CHICAGO RIVER, SOUTH BRANCH OF THE CHICAGO RIVER, CHICAGO RIVER, AND INSHORE AREA OF LAKE MICHIGAN
NOVEMBER 23, 1999

Location	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Suspended Solids (mg/L)	Turbidity (NTU)	Total Ammonia Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Phosphorus (mg/L)
			North Branch of the Chicago River				
Erie Street	17.0	6.6	17	10	1.75	6.46	1.98
			South Branch of the Chicago River				
Jackson Boulevard	17.0	7.2	13	11	0.91	6.11	1.66
			Chicago River				
Clark Street	15.0	5.5	7	6	0.89	6.12	1.67
Michigan Avenue	15.0	6.7	3	5	0.62	5.37	1.38
McClurg Court	15.0	7.4	3	5	0.50	4.28	1.03
Chicago River Lock	15.0	8.8	4	6	0.29	2.44	0.50
			Lake Michigan				
Navy Pier	ND	ND	ND	ND	ND	ND	ND
North Sluice Gates	8.0	10.0	4	7	0.06	0.28	0.10
Chicago Marine Police	8.0	8.8	47	24	0.08	0.30	0.42
South Sluice Gates	8.0	10.2	12	8	0.07	0.32	<0.01

ND = No data.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

WATER QUALITY AT TEN STATIONS IN THE NORTH BRANCH OF THE CHICAGO RIVER, SOUTH BRANCH OF THE CHICAGO RIVER, CHICAGO RIVER, AND INSHORE AREA OF LAKE MICHIGAN
NOVEMBER 30, 1999

Location	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Suspended Solids (mg/L)	Turbidity (NTU)	Total Ammonia Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Phosphorus (mg/L)
			North Branch of the Chicago River				
Erie Street	17.0	6.7	21	15	1.25	8.83	1.71
			South Branch of the Chicago River				
Jackson Boulevard	15.0	6.9	13	10	1.55	7.42	1.60
			Chicago River				
Clark Street	15.0	6.1	4	6	0.90	5.33	1.12
Michigan Avenue	15.0	7.0	3	5	0.72	4.23	0.94
McClurg Court	15.0	7.0	2	6	0.69	4.21	0.90
Chicago River Lock	15.0	8.1	2	5	0.62	3.96	0.90
			Lake Michigan				
Navy Pier	6.0	10.5	7	8	0.04	0.13	<0.01
North Sluice Gates	6.0	9.2	1	4	0.04	0.13	0.02
Chicago Marine Police	6.0	10.8	11	7	0.04	0.15	<0.01
South Sluice Gates	6.0	10.2	2	5	0.04	0.15	<0.01

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

WATER QUALITY AT TEN STATIONS IN THE NORTH BRANCH OF THE CHICAGO RIVER, SOUTH BRANCH OF THE CHICAGO RIVER, CHICAGO RIVER, AND INSHORE AREA OF LAKE MICHIGAN
DECEMBER 7, 1999

Location	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Suspended Solids (mg/L)	Turbidity (NTU)	Total Ammonia Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Phosphorus (mg/L)
			North Branch of the Chicago River				
Erie Street	10.8	7.7	19	17	0.23	2.94	0.21
			South Branch of the Chicago River				
Jackson Boulevard	8.9	7.9	15	14	0.20	3.11	0.37
			Chicago River				
Clark Street	8.2	7.0	8	9	0.52	3.00	0.56
Michigan Avenue	7.5	6.4	5	7	0.75	3.31	0.67
McClurg Court	7.0	6.9	4	6	0.72	3.43	0.82
Chicago River Lock	8.5	7.3	4	6	0.71	3.43	0.85
			Lake Michigan				
Navy Pier	4.0	10.5	19	17	0.02	0.25	0.05
North Sluice Gates	4.0	10.8	11	11	0.02	0.25	0.03
Chicago Marine Police	4.0	9.8	31	22	0.02	0.26	0.05
South Sluice Gates	4.0	11.5	13	11	0.01	0.26	0.05

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6

WATER QUALITY AT TEN STATIONS IN THE NORTH BRANCH OF THE CHICAGO RIVER, SOUTH BRANCH OF THE CHICAGO RIVER, CHICAGO RIVER, AND INSHORE AREA OF LAKE MICHIGAN
DECEMBER 14, 1999

Location	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Suspended Solids (mg/L)	Turbidity (NTU)	Total Ammonia Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Phosphorus (mg/L)
			North Branch of the Chicago River				
Erie Street	11.0	5.6	28	18	1.67	7.19	1.49
			South Branch of the Chicago River				
Jackson Boulevard	9.8	5.7	12	11	0.91	6.49	1.38
			Chicago River				
Clark Street	8.4	6.9	5	6	0.63	3.97	0.75
Michigan Avenue	7.6	8.2	5	5	0.44	2.85	0.56
McClurg Court	6.8	9.0	4	7	0.37	2.21	0.42
Chicago River Lock	6.4	9.1	3	7	0.34	2.01	0.36
			Lake Michigan				
Navy Pier	5.0	11.1	44	27	0.04	0.24	0.21
North Sluice Gates	5.0	8.2	31	25	0.04	0.25	0.35
Chicago Marine Police	5.0	11.5	51	19	0.08	0.25	0.17
South Sluice Gates	5.0	11.2	20	15	0.14	0.27	0.18

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

WATER QUALITY AT TEN STATIONS IN THE NORTH BRANCH OF THE CHICAGO RIVER, SOUTH BRANCH OF THE CHICAGO RIVER, CHICAGO RIVER, AND INSHORE AREA OF LAKE MICHIGAN
DECEMBER 21, 1999

Location	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Suspended Solids (mg/L)	Turbidity (NTU)	Total Ammonia Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Phosphorus (mg/L)
			North Branch of the Chicago River				
Erie Street	ND	7.1	14	8	2.69	4.89	2.73
			South Branch of the Chicago River				
Jackson Boulevard	8.3	7.9	10	9	0.94	4.79	1.80
			Chicago River				
Clark Street	8.1	8.8	2	5	0.39	2.69	0.62
Michigan Avenue	8.5	10.0	2	6	0.23	1.83	0.47
McClurg Court	ND	10.8	4	7	0.19	1.43	0.34
Chicago River Lock	ND	11.0	4	8	0.16	1.14	0.20
			Lake Michigan				
Navy Pier	2.0	11.0	5	7	0.05	0.24	0.25
North Sluice Gates	2.0	12.2	3	6	0.11	0.82	0.32
Chicago Marine Police	2.0	10.2	2	4	0.08	0.25	0.32
South Sluice Gates	2.0	12.8	4	7	0.07	0.26	0.10

ND = No data.

DISSOLVED OXYGEN

Dissolved oxygen in the North and South Branches of the Chicago River ranged from 5.6 to 7.9 mg/L, from 5.5 to 11.0 mg/L in the Chicago River, and from 8.0 to 12.8 mg/L in Lake Michigan.

The concentration of dissolved oxygen was higher in the South Branch compared to the North Branch. During four of the five water quality surveys, the concentration of dissolved oxygen was lower at Clark Street compared to stations upstream (eastward) in the Chicago River. However, on December 7, 1999, the dissolved oxygen concentration at the four monitoring locations in the Chicago River was similar. This may have resulted because the level of Lake Michigan was lower than the Chicago River, and because of the residual effect of overflows from combined sewers and nonpoint runoff from the December 4 and 5, 1999 rainfall event.

SUSPENDED SOLIDS

Suspended solids varied from 13 to 28 mg/L in the North and South Branches of the Chicago River, from 2 to 8 mg/L in the Chicago River, and from 1-51 mg/L in Lake Michigan. Turbidity followed the same pattern as suspended solids.

Suspended solids and turbidity were higher in the North Branch compared to constituent levels in the South Branch and

in the Chicago River. Overall, suspended solids and turbidity levels decreased in the Chicago River from Clark Street to the Chicago River Lock.

The mean concentration of suspended solids and turbidity measured at the four stations in Lake Michigan (17 mg/L and 12 NTU, respectively) were substantially higher compared to the mean values measured in the Chicago River at the Chicago River Lock (3 mg/L and 6 NTU, respectively). Low flows in the Chicago River may cause suspended solids in the water column to settle.

NUTRIENTS

Ammonia nitrogen, nitrate nitrogen, and total phosphorus all show similar trends. Nutrient levels in the North Branch are slightly higher than nutrient levels in the South Branch. Compared to the North Branch, nutrient levels in the Chicago River were considerably lower. Nutrient concentrations decrease in the Chicago River from Clark Street to the Chicago River Lock.

Nutrient concentrations in the Chicago River are 10 to 100 times higher than nutrient concentrations in Lake Michigan. Total ammonia nitrogen and total phosphorus levels in

the Chicago River exceeded the Lake Michigan open water nutrient standards of 0.02 and 0.007 mg/L, respectively.