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Of Engineers
Chicago District

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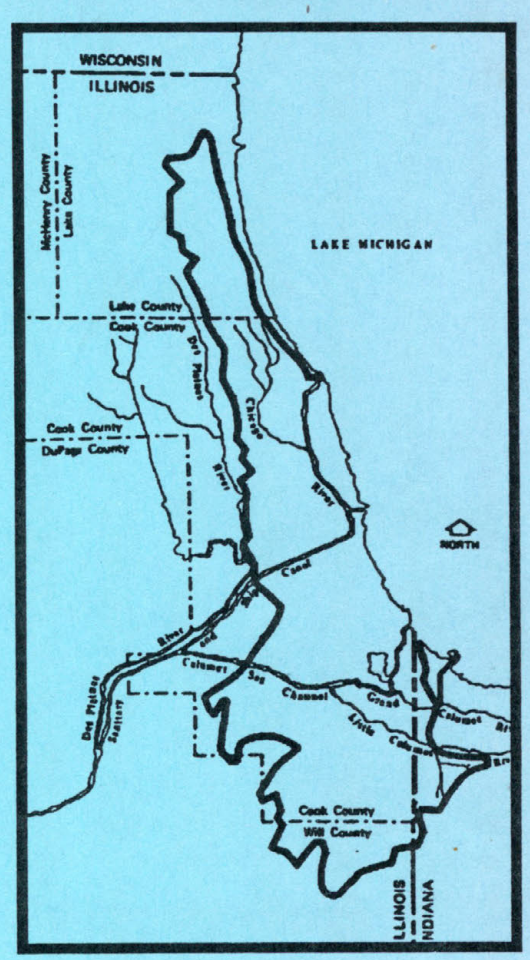
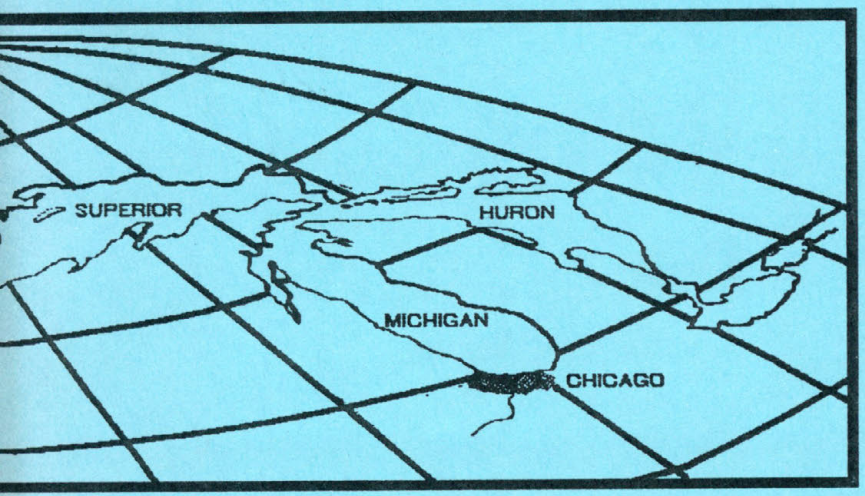
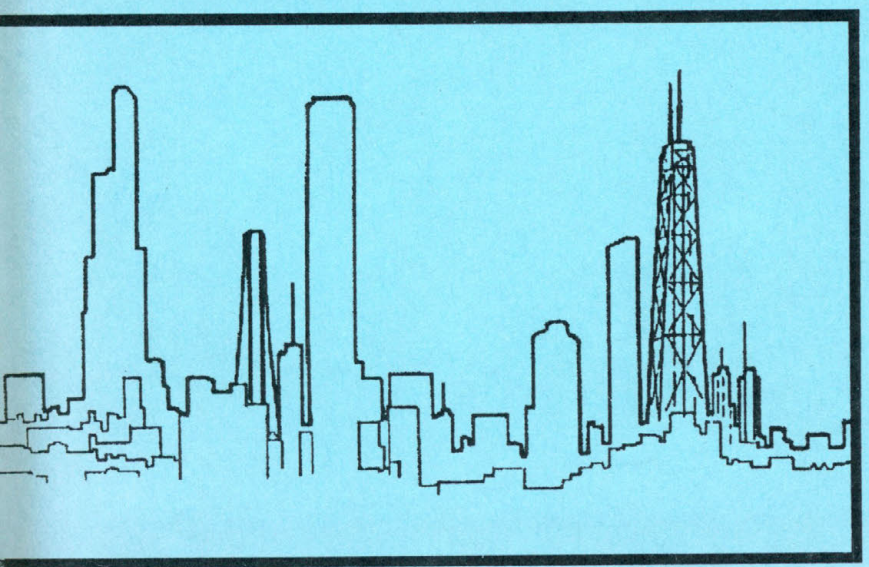
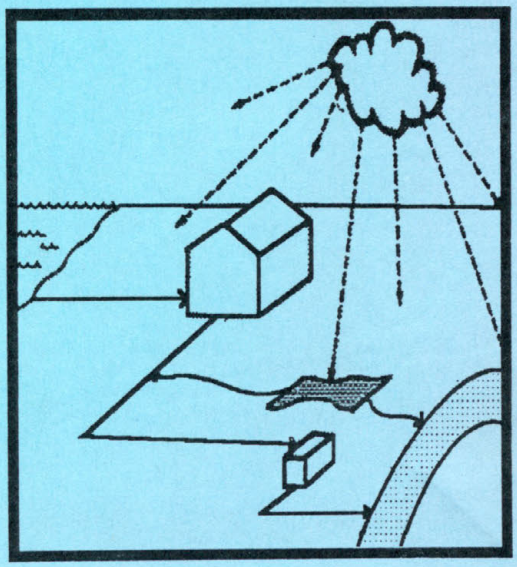
LAKE MICHIGAN DIVERSION ACCOUNTING ANNUAL REPORT WATER YEARS 1990-92









EXECUTIVE SUMMARY

This document is the Water Year's (WY's) 1990-1992 annual report of the Chicago District, U. S. Army Corps of Engineers activities in the monitoring and review of the accounting of Lake Michigan diversion flows through Chicago, Illinois as directed by 1980 amendment to the U. S. Supreme Court Decree. Additionally, this report serves to summarize the Corps' major accomplishment with respect to the mission as mandated by the Water Resources Development Act of 1986, PL99-662, Section 1142. This act gave the Corps complete responsibility for diversion accounting effective 1 October 1987. This report provides an overview and audit of flow measurements and accounting conducted by the Corps of Engineers from 1 October 1990 through 30 September 1992.

In the period of WY 1990 through WY 1992 the District has made many changes to improve the accuracy and efficiency of the diversion accounting, including:

The computer model used to simulate the watershed runoff has been updated to take into account the addition of Tunnel and Reservoir Plan and the canal system.

To evaluate the reported flows through and around the lakefront structures, flow velocities were measured downstream of each of the three structures, O'Brien Lock and Dam, Chicago Lock, and Wilmette Controlling Works.

The Illinois State Water Survey began collecting precipitation data from a 25 gage network in WY 1990. The new network extends through Cook County, IL on a six mile grid to cover the Des Plaines and diverted Lake Michigan watersheds within Cook County.

New regression equations were developed for the Romeoville AVM gage for calculating flows when the AVM is not operating. The USGS revised the regression equations and the updated flows have been included in the Accounting Reports for WY 1986 through WY 1989.

The USGS installed a gage on the west branch of the Grand Calumet River in Indiana near the Illinois border. Beginning with WY 1992, flows in the Grand Calumet River were measured.

The Third Technical Committee was under contract at the close of FY 1992. The Committee began its work in February 1993.

The Lake Michigan Diversion Accounting Reports for WY 1986, WY 1987, WY 1988, and WY 1989 have been completed. The State of Illinois exceeded the 3,200 cfs limit in all four years. The running average of the diversion for WY 1981 through WY 1989 is 3,443 cfs, or 243 cfs over the annual allocation. The cumulative deviation is now 2,189 cfs-years, with a maximum allowable cumulative deviation of 2,000 cfs-years.

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INTRODUCTION

The diversion of water from the Lake Michigan watershed is important to the Great Lake states and to the Canadian province of Ontario. The states and province that border the Great Lakes have concerns with diversions during periods of low lake levels and the long term effects of diversion. To insure these concerns are considered, the U.S. Army Corps of Engineers is responsible for the accounting of flow diverted from the Lake Michigan watershed.

The Water Year (WY) 1990-1992 Joint Annual Report on Lake Michigan Diversion Accounting presents Corps of Engineers activities in accounting for diversion from Lake Michigan by the State of Illinois. The accounting of the diversion is performed according to the guidelines established in the 1980 modified U.S. Supreme Court Decree concerning the diversion.

Presented in this report is the history of the diversion and its accounting, the certification of WY 1986, WY 1987, WY 1988, and WY 1989 diversion flows, a description of the sources of the diversion, a description of the accounting procedures, and a summary of all significant activities that occurred in WY 1990, WY 1991, and WY 1992.

AUTHORITY FOR REPORT

Under the provisions of the U.S. Supreme Court Decree in the Wisconsin, et al v. Illinois et al, 388 U.S. 426, 87 S.Ct. 1774 (1967) as modified 449 U.S. 48, 101 S. CT. 557 (1980), the Corps of Engineers monitors the measurement and computation Lake Michigan diversion by the State of Illinois. The terms of the modified decree require the Corps of Engineers to prepare an annual report on the accounting of the Lake Michigan water diverted by the State of Illinois and actions taken by the involved agencies.

HISTORY OF THE DIVERSION

Water was first diverted from Lake Michigan at Chicago into the Mississippi River Basin with the completion of the Illinois and Michigan (I & M) Canal in 1848. The Illinois and Michigan Canal was primarily for transportation and diverted up to 500 cubic feet per second (cfs).

Development of the Chicago sewer system led to severe sanitation problems in the Chicago River by the mid to late 1800's. The newly constructed sewers moved water and wastes into the Chicago River, which until 1900 drained to Lake Michigan. The water quality of Lake Michigan deteriorated and contaminated the city's primary water supply.

A second problem during this time was an increase in the overbank flooding within the city. The sewer system expanded as more roads and buildings were built. This construction increased the rate and volume of runoff and resulted in increased flooding.

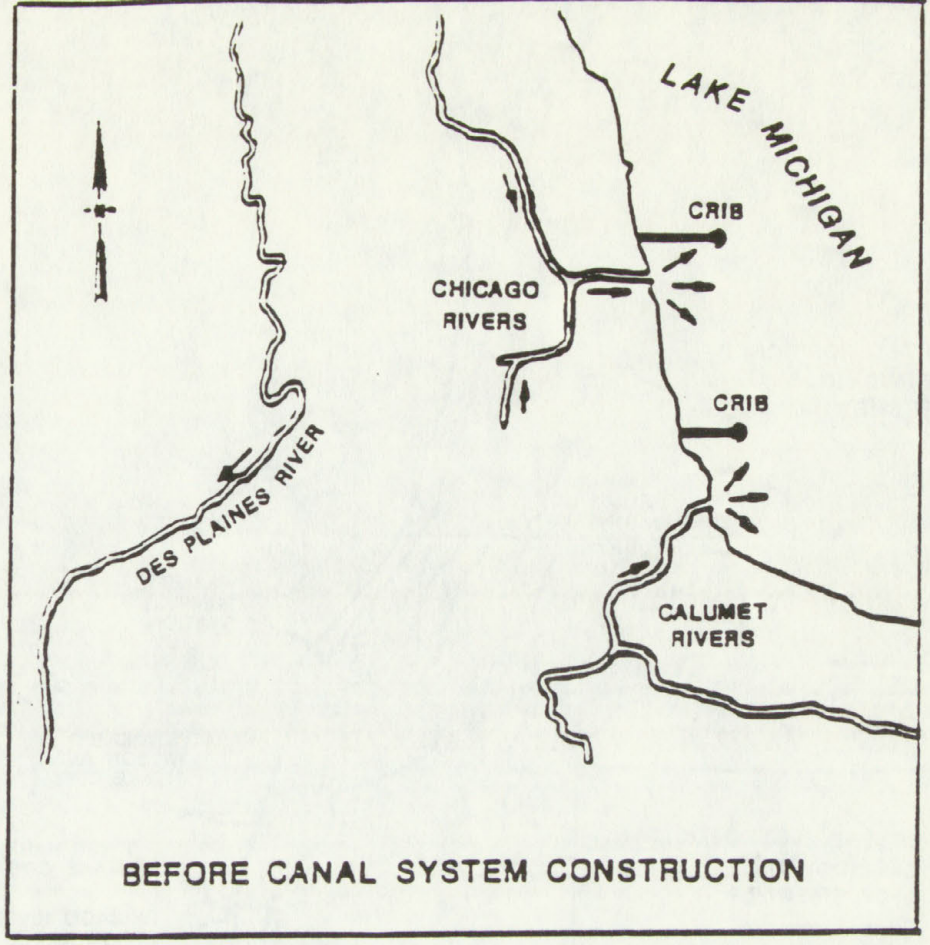
As a solution to the sanitation and flooding problems, the Chicago Sanitary and Ship Canal (CSSC) was built. The construction reversed the flow direction of the Chicago River (figure 1). The Chicago Sanitary And Ship Canal was completed in 1900 by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC, formerly the Metropolitan Sanitary District of Greater Chicago, MSDGC). The Sanitary and Ship Canal followed the course of the older I & M Canal. This canal is much larger than the I & M Canal and can handle the Chicago River flow as well as increased shipping. The Chicago River Controlling Works were constructed at the mouth of the Chicago River in the 1930s. The lock and sluice gates regulate the amount of Lake Michigan water allowed to pass into the river and restricts river flooding entering Lake Michigan.

Between 1907 and 1910, the MWRDGC constructed a second sanitary canal called the North Shore Canal. This canal extends from Lake Michigan at Wilmette south 6.14 miles to the North Branch of the Chicago River. The Wilmette Controlling Works regulate the amount of Lake Michigan flow allowed down the channel.

Construction of a third canal, the Calumet Sag Canal, was completed in 1922. The canal connects Lake Michigan, through the Grand Calumet River, to the Sanitary and Ship Canal. This canal carried sewage from South Chicago, Illinois and East Chicago, Indiana. The O'Brien Lock and Dam located on the Calumet River, regulates the flow of Lake Michigan waters down the canal. Figure 2 shows the affected watershed.

Upon completion of the Chicago Sanitary and Ship Canal in 1901, the Secretary of War issued a permit authorizing a diversion of 4,167 cfs. In 1908 and 1913, the United States brought actions to enjoin the MWRDGC from diverting more than the 4,167 cfs previously authorized in 1901. The two actions were consolidated and the Supreme Court entered a decree on 5 January 1925 allowing the Secretary of War to issue diversion permits. In March 1925, the permit issued limited diversion 8,500 cfs, about the average then being used.

In 1922, 1925, and 1926, several Great Lakes States filed similar original actions in the U.S. Supreme Court seeking to restrict the diversion at Chicago. A Special Master, appointed by the U.S. Supreme Court to hear the combined three suits, found the 1925 permit to be valid and recommended dismissal of the action. The U.S. Supreme Court, however, reversed the Special Master's finding. Subsequently, the Court instructed the Special Master to determine the steps necessary for Illinois and MWRDGC to reduce the diversion. Consequently, a 1930 decree reduced the allowable diversion (which did not include domestic pumpage) in three steps: to 6,500 cfs after 1 July 1930; to 5,000 cfs after 30 December 1935; and to 1,500 cfs after 31 December 1938.


LAKE MICHIGAN
CRIB
CHICAGO RIVERS
CRIB
DES PLAINES RIVER
CALUMET RIVERS
BEFORE CANAL SYSTEM CONSTRUCTION

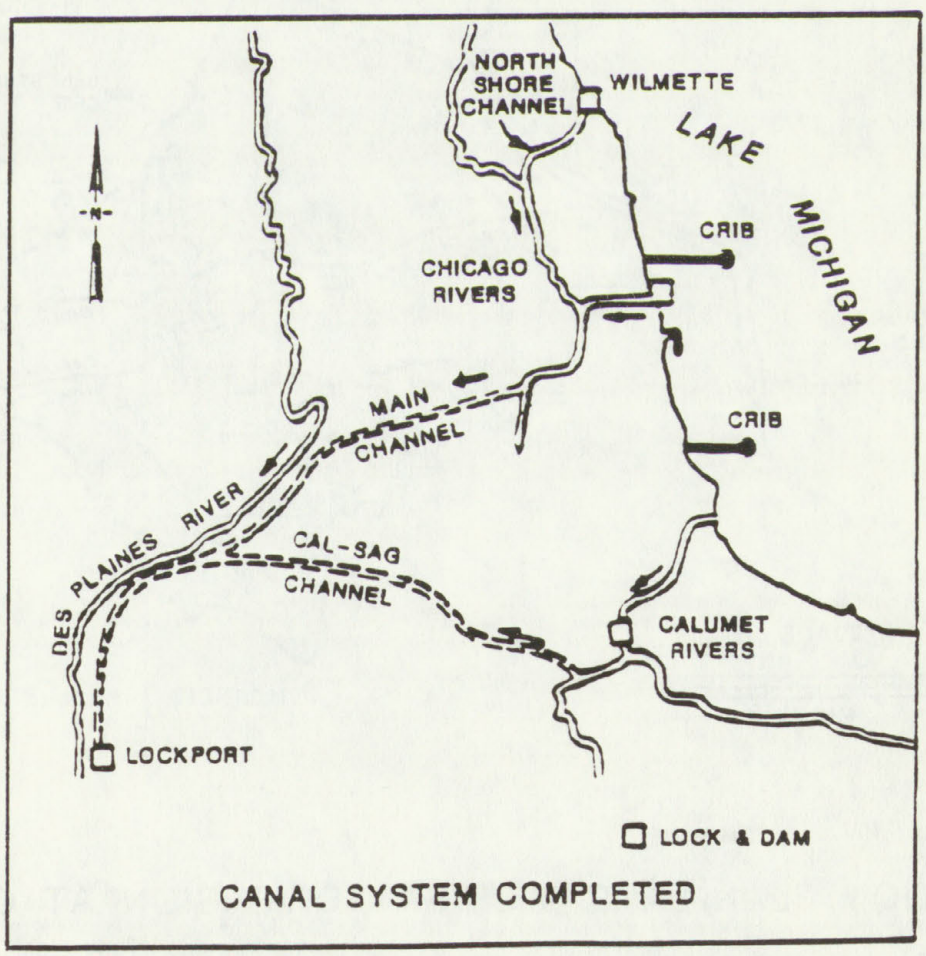
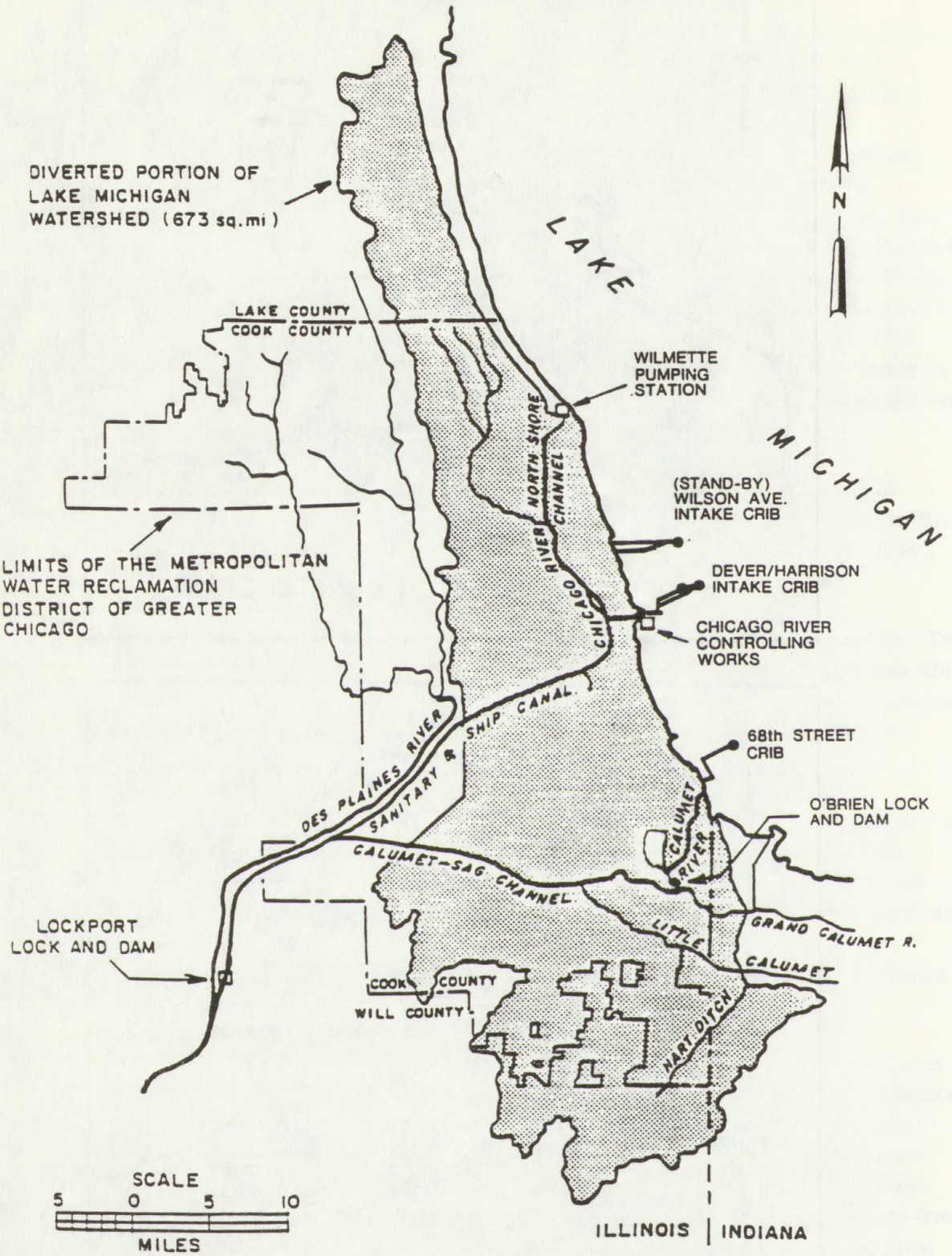

NORTH SHORE CHANNEL
WILMETTE
LAKE MICHIGAN
CRIB
CHICAGO RIVERS
MAIN CHANNEL
CRIB
DES PLAINES RIVER
CAL-SAG CHANNEL
CALUMET RIVERS
LOCKPORT
LOCK & DAM
CANAL SYSTEM COMPLETED

Figure 1



LOCATION PLAN-LAKE MICHIGAN DIVERSION AT CHICAGO

Figure 2

In 1967, an additional Supreme Court Decree limited the diversion of Lake Michigan water by the State of Illinois and its municipalities, including domestic pumpage, to a five year average of 3,200 cfs effective 1 March 1970. The 1967 Supreme Court Decree gave full responsibility to the State of Illinois for diversion measurements and computations. The role of the Corps of Engineers, as specified in the decree, was to be one of "general supervision and direction."

The 1967 decree was modified on 1 December 1980. This modified decree changed the beginning of the accounting year from 1 March to 1 October. The modified decree also extended the period for the running average diversion from five years to forty years beginning WY 1981.

The amended decree contains three provisions that affected the role of the Corps of Engineers in the diversion accounting program. First, although the State of Illinois was primarily responsible for measurement and computation of diversion flows, the decree allowed the Corps of Engineers to participate in the function, subject to agreement and cost sharing with the State of Illinois. Negotiations were held on cost sharing the computation of the diversion. No agreement was reached due to lack of funding. The measurement and computation of the diversion continued to be done by the Illinois Department of Transportation (IDOT) through its consultants, the Northeastern Illinois Planning Commission (NIPC), the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), and the United States Geological Survey (USGS).

Second, the supervisory role for the Corps of Engineers increased so the Corps of Engineers was responsible for auditing the computations and measurements performed by the State of Illinois.

Third, the modified decree states that the Chief of Engineers shall appoint a Three Member Technical Committee to determine the best current engineering practice and scientific knowledge for measuring the diversion and to make recommendations as appropriate. The decree states that "...the members should be selected on the basis of recognized experience and technical expertise in flow measurement or hydrology." A technical committee is to be reconvened at least once every five years. The first Technical Committee convened in June 1981 and completed its work in April 1982. The second Technical Committee convened in July 1986, and completed their final report in November 1987. The third Technical Committee convened in February 1993.

The Water Resources Development Act of 1986 gave the Corps of Engineers responsibility for the computation of diversion flows as formerly done by the State of Illinois. The Corps of Engineers' new mission became effective 1 October 1987.

SIGNIFICANT HYDROLOGIC EVENTS

In WY 1990, there were several significant hydrologic events. Unseasonably warm temperatures during the second week in March 1990 resulted in thunderstorms with rainfall averaging about 1.4 inches in northeast Illinois and northwest Indiana. The Fox and Des Plaines Rivers reached critical levels, but only the low lying, flood prone areas were affected. The Kankakee River in northwest Indiana reached near flood stage to 1.5 feet above flood stage. No significant flooding was reported near the Kankakee River.

During 9-11 May 1990, a 24 hour rain averaging about 3.4 inches caused flash flooding in some parts of northeast Illinois. This rain resulted in rises of about 1 to 1.5 feet above bankfull stages on Salt Creek, Des Plaines River and Du Page River. A 24 hour rain averaging about 1.7 inches caused flash flooding in some parts of northwest Indiana. This rain resulted in rises of 1 to 1.5 feet above bankfull stages on the Kankakee River and the Little Calumet River. Again, only the low lying flood prone areas were affected.

During the period 18-21 August 1990, a total of about 5.3 inches of rain fell at the National Weather Service O'Hare weather station. This rain event resulted in stages on Salt Creek at North Riverside about 3 feet over bankfull. The Des Plaines River at Riverside rose about 1.3 feet over bankfull. In northwest Indiana near the Illinois-Indiana border, a total of about 6.0 inches of rain fell at Hobart. The event caused stages above bankfull on the Kankakee River at Davis of 3.0 feet and at Shelby of 2.9 feet. No significant flood damages were reported from these storm events.

WY 1991 had two significant hydrologic events. On 27 November 1990, a 24 hour rain of 3.0 inches in northeastern Illinois and about 3.9 inches in the northwestern Indiana resulted in above bankfull conditions on the Des Plaines River, Salt Creek, and on the Kankakee and Calumet Rivers and their respective tributaries. New flood records reported were 5.2 feet above bankfull on the Little Calumet River at Munster, 2.7 feet above bankfull on Hart Ditch at Munster, and 5.4 feet above bankfull on the Little Calumet River at South Holland. The flooding in northwest Indiana forced the closure of the Calumet Highway and extensively damaged residences in northwestern Indiana near the Illinois border. Flood damages in northwest Indiana due to this extreme event were estimated at approximately $7.2 million.

The second event in WY 1991 occurred during 28-29 December 1990 when 3 to 4 inches of rain fell over an existing 2 to 6 inches of snowpack in the Kankakee River basin. The river stages on the Kankakee River rose above its banks by about 2.5 to 3.5 feet, causing extensive agricultural flooding. Some county roads and residences were affected by this flood.

The first event of WY 1992 happened on 24-26 November 1991. Roughly 2.5 inches of rain fell in northeastern Illinois causing bankfull conditions and sending the Salt Creek at North Riverside 1.65 feet above bankfull and 0.65 over flood stage.

On 13 April 1992, Chicago River water flowing through a punctured freight tunnel flooded much of downtown Chicago, including approximately 23 buildings and 40 miles of tunnel. The flooding also closed portions of the Chicago Transit Authority subway system and one underpass on the Kennedy Expressway. The Corps of Engineers was requested by Federal Emergency Management Agency (FEMA) to plug the leaks and dewater the tunnels. During the flood the Chicago River, under the direction of the Corps of Engineers, was drawn down to reduce the water pressure on the tunnel plugs. North Central Division has directed that the increase in diversion associated with this effort not be charged to the State of Illinois.

On 9 September 1992, a strong storm front passed through the southern part of the District. O'Hare Airport received 1.05 inches, South Bend, IN 2.3 inches, Midway Airport 2.9 inches, Romeoville, IL 3.54 inches, and Shorewood, IL 4.3 inches. Gages south of Chicago rose to bankfull with Davis on the Kankakee River and Munster on Hart Ditch both rising to flood stages.

OTHER SIGNIFICANT EVENTS

Several significant non-hydrologic events occurred during Fiscal Year (FY) 1990, FY 1991, and FY 1992. The most significant were upgrading the Acoustic Velocity Meter (AVM) gaging station at Romeoville, IL, installing a stream gage on the Grand Calumet River near the Illinois border, and installing a new 25 gage network of precipitation gages.

The Chicago River, under the direction of the Corps of Engineers, was drawn down in February 1987 for the removal of the 16th Street Swing Bridge, and in August-September 1988 for navigation repairs near Lockport.. North Central Division has directed that the increase in diversions associated with these efforts not be charged to the State of Illinois.

A separate, detailed chronology of significant non-hydrologic events is included in appendix A.

STATUS OF ACCOUNTING REPORTS

Lake Michigan diversion flow data is summarized in accounting reports prepared on an annual basis as flows are certified. Since implementation of the modified Supreme Court Decree of 1 December 1980 and before this report, the Corps of Engineers has certified diversion flows for the WY 1981 through WY 1985. The WY 1986, WY 1987, WY 1988, and WY 1989 Lake Michigan Diversion Accounting Reports are certified with this Joint Water Year 1990-1992 Annual Report. Table 1 shows the accounting year, the certified flows, the running average flows, and the cumulative deviation from the allowable diversion of 3,200 cfs.

Table 1 Status of the State of Illinois' Diversion
Under the 1980 Modified U.S. Supreme Court Decree

Accounting Year	Certified Flow (cfs)	Running Average (cfs)	Cumulative Deviation (cfs)
1981	3,106	3,106	94
1982	3,087	3,097	207
1983	3,613	3,269	-206
1984	3,432	3,310	-438
1985	3,472	3,342	-710
1986	3,751	3,410	-1,261
1987	3,774	3,462	-1,835
1988	3,376	3,451	-2,011
1989	3,378	3,443	-2,189

The running average diversion for the period WY 1981 through WY 1989 is 3,443 cfs, 243 cfs greater than the 3,200 cfs, 40 year average diversion specified by the modified decree. However, the running average is below the 40-year upper limit of 3,680 cfs, and the annual flows have not exceeded the two-year upper limit of 3,840 cfs. The cumulative deviation, the sum of the annual average flows over the allowed 3,200 cfs, is -2,189 cfs-years. The negative cumulative deviation indicates a flow debt against the 3,200 cfs average diversion with the maximum debt allowed of 2,000 cfs- years over the first 39 years of the 40 year averaging period.

The WY 1986 accounting was a joint project with NIPC (acting under contract to the Corps of Engineers) and the Corps of Engineers. The WY 1987, WY 1988, and WY 1989 accountings were completed by the Corps of Engineers.

Data collection and preparation for the WY 1987 accounting report was nearly completed in FY 1989. However, precipitation data was not available until July 1990. The WY 1988 accounting report was developed during the latter part of FY 1990 and the early part of FY 1991. The WY 1989 accounting report was developed during early FY 1991 and late FY 1992.

Data collection and preparation for the WY 1990 and WY 1991 accounting reports will be performed by the Corps. The Chicago District will complete these accounting reports. Data collection and preparation for these reports began in FY 1991. Certification is scheduled in FY 1994 for WY 1990 and WY 1991.

SOURCES OF DIVERSION

The Lake Michigan diversion consists of three primary components. These components are direct diversion through the three lakefront structures, domestic pumpage from Lake Michigan used for water supply and not returned to Lake Michigan, and stormwater runoff from the Lake Michigan watershed diverted from the lake.

Direct diversion locations are at the Chicago River Controlling Works (CRCW), the O'Brien Lock and Dam, and the Wilmette Controlling Works. These controlling structures are located downtown, at the south end, and at the north end of the Chicago area, respectively.

The direct diversion consists of four components; lockage, discretionary flow, navigation makeup flow, and leakage. The lockage component is the flow used in locking vessels to and from the lake. The purpose of the discretionary diversion was to dilute effluent from sewage discharges. When large storms are forecast, the canal is drawn down before the storm to prevent flooding. If the runoff is not enough to refill the canal, navigation makeup water is passed. The leakage component is water estimated to pass, in an uncontrolled way, through or around the lakefront structures.

Domestic pumpage from Lake Michigan is used for water supply and its effluent is discharged to various Water Reclamation Plants (WRP's). Currently, the WRP's that divert domestic pumpage from the lake either discharge to the canal system or to the Des Plaines River and its tributaries. In the future as more communities convert to Lake Michigan water supply, water supply effluent may also discharge to the Fox River. The Fox River is approximately 35 miles west of downtown Chicago.

Stormwater runoff that previously drained to Lake Michigan through the Chicago River and the Calumet River now drains to the Chicago Sanitary and Ship Canal (CSSC) and the Calumet Sag Channel, respectively. The Calumet Sag Channel drains to the CSSC to ultimately drain into the Illinois River and the Mississippi River. The drainage area of the diverted Lake Michigan watershed is approximately 673 square miles.

ACCOUNTING PROCEDURES

Diversion accounting uses both measured and estimated flows. A series of hydrologic and hydraulic computer models use various meteorological data to simulate flows not measured. These simulated flows as well as measured flows are used to compute the diversion. Along with the diversion calculation, a number of water budgets verify simulated flows and estimate of the reliability of the computed diversion.

DIVERSION COMPUTATION

An acoustic velocity meter (AVM) was installed and has been operating at Romeoville (five miles upstream of the Lockport Powerhouse and three miles upstream of the Lockport Controlling Works) since 12 June 1984. The AVM directly measures total flow through the canal above both the Powerhouse and the Controlling Works. The overwhelming majority of the Lake Michigan diversion and some non-Lake Michigan flows pass through the AVM. The diversion accounting procedure uses the flow measured at Romeoville and deducts flows not attributable to the diversion. Diversion flows which bypass Lockport are added to yield the net computed diversion of water from Lake Michigan. This procedure represents the accounting technique as required by the modified Supreme Court Decree.

During WY 1986, WY 1987, WY 1988, and WY 1989, the flow measured at Romeoville was roughly 110%, 107%, 105%, and 104%, respectively, of the average annual diversion and roughly 99%, 97%, 97%, and 97% of the diversion passed through the AVM.

Deductions from the Romeoville flow include runoff from 217 square miles of the Des Plaines River watershed discharged to the canal, groundwater supply effluent discharged to the canal, and Indiana water supply discharged to the canal through the Calumet River system and the Calumet Sag Channel (see figure 1 for locations). The NIPC computer models of the Des Plaines watershed area estimate the runoff deduction. The groundwater pumpage deductions are obtained directly from pumping records. The Indiana water supply is computed from pumping records and a calculation to determine the portion of the water supply draining west to the Calumet Sag Channel.

The additions for diversion flow that do not flow through Romeoville are primarily Lake Michigan water supply pumpage effluent treated and released to the Des Plaines River or its tributaries. This flow is obtained directly through pumping records of the communities involved and accounts for 1% to 3% of the diversion. As more communities convert to Lake Michigan water supply, the percentage will increase.

DIVERSION BUDGET CHECKS

Water budgets verify those flows not measured. Most of the budgets compare simulated flows to recorded flows and these comparisons indicate the accuracy of the diversion accounting. The four primary budgets are the budgets for the three major Water Reclamation Plants (WRP's) that serve the area involved in diversion accounting and the budget for the CSSC estimated at the lakefront. The remaining budgets estimate runoff from stream gaged areas in the Lake Michigan watershed or are budgets of non-simulated flows such as water supply pumpage. The budgets are discussed in more detail later in this report.

WY 1986, WY 1987, WY 1988, AND WY 1989 DIVERSION ACCOUNTING

New regression equations were developed for the Romeoville AVM gage for calculating flows when the AVM is inoperable. The USGS has reviewed the AVM flows for WY 1986 through WY 1992. The USGS revised the regression equations and the updated flows have been included in the Accounting Reports for WY 1986 through WY 1989.

In WY 1986 and WY 1987, the Tunnel and Reservoir Plan (TARP) began influencing diversion accounting. TARP is a comprehensive plan to eliminate sewer overflows to Chicago rivers and streams by diverting overflows into a system of tunnels and reservoirs. The overflows will be treated and released as treatment capacity allows. In WY 1986, Phase I of the Mainstream TARP tunnel was operational. In WY 1987, Phase I of the Calumet TARP tunnel became operational. TARP changes diversion accounting in that overflows are now from the treatment plants instead of the original overflow outlets.

The overall budget balance for the three largest WRP's had weighted average simulated to recorded ratios of 1.00 for WY 1986, 0.96 for WY 1987, 0.92 for WY 1988, and 1.01 for WY 1989. The ratios show that simulated flows are 100%, 96%, 92%, and 101% of the recorded flows at the WRP's for each year. As the ratio approaches 100%, the modeling better approximates the runoff in the Des Plaines watershed.

The budget balance for the canal system compares the recorded outflows to the simulated and measured inflows. The outflow was 117% of inflow for WY 1986, 116% for WY 1987, 115% for WY 1988, and 116% for WY 1989. Possible causes of the imbalance include under-reporting of lakefront flows, unreported discharges to the canal, low values for the simulated and measured inflows, and AVM measurements. The largest sources of error are due to leakages at the lakefront controlling works and the Chicago River Harbor Wall. The Harbor Wall was subject to overtopping before WY 1987 and is leaking. During WY 1987, the Harbor Wall was capped to eliminate overtopping. The difference between the outflow and the inflow dropped 41 cfs (6.8%) between WY 1986 and WY 1987 and dropped another 96 cfs (17%) between WY 1987 and WY 1988. From WY 1988 to WY 1989, the difference rose 10 cfs (2%). The decrease in the difference is most likely due to the capping in WY 1987, and lower lake levels in WY 1988, and reductions in diversion through the lakefront structures.

The Lake Michigan Diversion Accounting for WY 1986, WY 1987, WY 1988, and WY 1989 are discussed in detail in appendices B, C, D and E.

CLARIFICATION OF THE ACCOUNTING REPORT RESULTS

As shown in table 1, the State of Illinois exceeded the 3,200 cfs limit in the four water years accounted for in this report (WY's 1986-1989). This section provides a clarification as to the nature of the excesses. The diversion will be overviewed in terms of the sources of diversion and the accounting procedures. The overview is based on the flows listed in table 2, which consists of the 13 columns from the summary of diversion flow tables in the diversion accounting reports (appendices B, C, D and E) plus additional supporting data.

SOURCES

The section above, SOURCES OF DIVERSION, states that the diverted flow is the sum of direct diversions (lockages, discretionary, navigation makeup, and leakage), water supply and stormwater runoff. In accordance with the report of Albert Maris, Special Master for the 1966 and 1980 Supreme Court Decrees, the diversion equals the total flow leaving the watershed, consisting of 1,700 cfs of water supply plus 1,500 cfs of direct diversion and stormwater runoff.

a. Water Supply - Column 11 of table 2 shows the that average of the pumpage from Lake Michigan accountable to the state of Illinois for WY's 1986-1989 is 1807 cfs. This number is computed directly from the pumpage records of each user. However, this is not the water supply that is diverted from the Lake Michigan Watershed. To compute the diverted water supply, the water consumed in the system (i.e. leakages, evaporation, etc.) would have to be subtracted from the pumpage. Table 2 shows that, for a conservative estimate of 10% consumptive use, the net water supply diverted would be 1,626 cfs. As the pumpage records are generally accurate values, and the 10% consumptive use is conservative, it can be concluded that the State of Illinois' Water Supply pumpage is within the guidelines specified by Maris' Report. It should also be noted that the State of Illinois has developed an extensive unaccounted-for-flow program. Through this program the State has required end users of Lake Michigan water to effectively utilize their allocation by reducing leaks in their water supply systems. The State of Illinois' evaluation of their program has shown a major decrease in unaccounted-for-flows of from 10.4% in 1979 to 5.4% in 1991.

b. Runoff plus Direct Diversion - Columns 12 and 13 of table 2 give an average total of 1,310 cfs of runoff from the diverted watershed plus direct diversions accountable to the State of Illinois. Although this total is below the guidelines of 1,500 cfs, from Maris' Report, the total does not include the high leakages indicated by preliminary flow measurements (see the section LAKEFRONT FLOW MEASUREMENTS, and appendix F). Table 2 also lists the imbalances, which are defined as the difference between the accountable flows (column 10) and sum of the water supply, runoff and direct diversions (columns 11, 12 and 13). From the table, the average imbalance is 454 cfs, or 634 cfs if consumptive use is included.

Table 2 Water Year's 1986 - 1989
Average Diversion Flows (cfs)

Column	Description	WY 86	WY 87	WY 88	WY 89	Average
	Lockport Flows	3,725.0	3,780.5	3,101.7	3,334.0	3,485
1	AVM Record	4,113.1	4,028.0	3,536.5	3,515.2	3,798
2	Diversion Above Gage	0.3	1.5	0.6	1.3	1
3	Total Canal Flow	4,113.4	4,029.5	3,537.1	3,516.5	3,799
4	Groundwater	128.0	119.8	110.2	82.0	110
5	Indiana Pumpage	82.1	81.6	31.3	27.8	56
6	Des Plaines Runoff	179.9	146.4	105.8	134.9	142
7	Federal Facilities	2.0	4.2	23.1	2.0	8
8	Total Deductions	392.0	352.0	270.4	246.8	315
9	By-Passed Flows	29.7	96.0	108.9	108.2	86
10	Accountable Flows	3,751.1	3,773.5	3,375.6	3,377.9	3,570
	Standard Deviation	205.8	200.7	179.2	177.2	191
11	Illinois Pumpage	1,723.8	1,804.9	1,906.4	1,791.9	1,807
	% Consumptive Use	10.0	10.0	10.0	10.0	10
	Consumptive Use	172.4	180.5	190.6	179.2	181
	O'Hare Rainfall (inches)	40.2	39.5	27.6	39.2	36
12	Watershed Runoff	876.5	811.7	519.6	706.8	729
	Lockages	179.0	146.3	97.2	84.1	127
	Leakages	42.6	47.8	38.0	30.8	40
	Navigation Makeup	142.2	157.0	73.2	52.0	106
	Discretionary Flow	302.0	314.3	352.0	264.0	308
13	Direct Diversions	665.8	665.4	560.4	430.7	581
	Imbalance	485.0	491.5	389.2	448.5	454
	Standard Deviation	260.8	259.4	222.4	226.0	242
	Imbalance with Consumptive Use	657.4	672.0	579.8	627.7	634
	Standard Deviation	258.6	256.3	219.8	222.9	239

The majority of the imbalances are in all likelihood due to leakages through the lakefront structures. Therefore, it is highly likely that the WY's 1986-1989 yearly aggregate of the direct diversion plus stormwater runoff component has significantly exceeded the 1500 cfs estimate. It should be noted that the only component of direct diversion for which the State of Illinois has authority, the discretionary flows, has remained reasonable constant (except for the effects of the 1988-1989 drought) and will be significantly reduced by the year 2000 (from a limit of 320 cfs to 101 cfs - assuming TARP in place, sewage treatment plants upgraded and aeration facilities constructed). Finally, it is also noted that in spite of the drought, the average precipitation for the period (e.g. O'Hare Airport) was almost an inch above the long term average of 36.3 inches.

PROCEDURES

This section will highlight the impacts of the changes and upgrades in the accounting procedure has had on the computation of the Lake Michigan diversion. The accounting of the diversion consists of measuring the water that flows past Lockport, subtracting the deductions and adding back the by-passes.

a. The installation of the AVM has produced the single largest impact of any change in the accounting procedures. The AVM flow measurements, plus the use of the regression equations (that translate Lockport flows into AVM flows) for filling in missing records, have significantly increased the flow records, and therefore the flows accountable to the State of Illinois. Table 2 shows that the average difference between the Lockport flows and the AVM record is equal to 313 cfs, or a cumulative difference for WY's 1986-1989 of 1,252 cfs.

b. Revisions to the accounting procedures have also resulted in changes to the computations of deductions and by-passed flows. It is noted that these are small changes when compared to the impacts of the AVM versus Lockport measurements. The major changes have been in the modeling of the mainstream and the Calumet TARP systems, and the update to the Calumet SCALP (i.e., sewer routing) model. The major effect of these modeling efforts is to compute the deductible inflow and infiltration into the TARP tunnels. The total of this deduction is 60 cfs.

ERROR ANALYSIS

Although the charge from the Supreme Court Decree is to use "state-of-the-art" methods in measurements and hydraulic computations, there are always errors inherent in any technical analysis. A Monte Carlo simulation was run to evaluate the effects of errors on the development of the diversion accounting flows. The basis of the simulation was to first assign an error distribution to each of the measured or simulated flows. Then for a large number of trials a random error is associated with each flow and a net diversion is computed. This process then results in a distribution of errors for the net diversion.

Table 2 lists the standard deviations for accountable flows and imbalances computed using the Monte Carlo simulation. The standard deviation for the accountable flow in each year is 191 cfs, and for the imbalances it is about 242 cfs. The analysis shows that even though the accounting is being performed at a state-of-the-art level, the cumulative errors of all of the measurements and computations could significantly effect the net accounting of the total diversion by the State of Illinois.

ACCOMPLISHMENTS DURING FY 1990, FY 1991, AND FY 1992

In each accounting year, changes improve the accuracy and efficiency of the diversion accounting.

REVISION OF COMPUTER MODEL

The computer model has been updated to take into account the addition of TARP to the canal system. TARP is modeled using an extension of the UNET (Unsteady flow NETwork) model called TNET (Tunnel NETwork). TNET models the flow through the tunnel for conditions ranging from almost dry to flowing full to pressurized flow. The model also takes into account gate operations and pump cycling.

LAKEFRONT FLOW MEASUREMENTS

The accuracy of the canal balance budget, used to check the canal modeling, depends on the accuracy of the reported lakefront flows. While errors in the lakefront flows do not change the diversion accounting flows, errors reduce the accuracy and usefulness of the budget. To quantify errors in the reported flows through and around the lakefront structures a series of measurements have been taken at all three lakefront structures, the Chicago Lock, the O'Brien Lock and Dam and the Wilmette Controlling Works.

The first series of measurements were taken in WY 1990. Flow velocities were measured downstream of each of the three structures between 23 July and 27 July. Five flow measurements were taken at each site while the nearby structures maintained constant gate openings with all locks closed. Measured flows were compared to flows calculated using the MWRDGC methods. The measured flows were about twice the calculated flows. Given the limited nature of the study, in time and equipment, the results are only a guide to the possible errors in the present lakefront flow calculations. A copy of the flow study is provided as appendix F.

In WY 1993 a far more extensive series of measurements were undertaken. The USGS conducted a detailed program utilizing an Acoustic Doppler Current Profiler (ADCP) and dye tests. While the results of these measurements are still preliminary, the range of measured values are provided here to aid in the clarification of the accounting results.

Chicago Lock East and West Gates: The Chicago Lock has been in a state of disrepair for the last thirty-years. Prior to FY 1993, the last work performed was in 1963 on the southeast gate. Gate closure problems began occurring in 1991 on the southeast gate. Through several underwater investigations, it was discovered in mid-1992 that the east and west gates' rollers had significant wear. From May to October of 1993 necessary modifications to the gates' rollers were undertaken. Additionally, side seals were fastened and center seals were modified and adjustments were made to reduce leakage through the gates. A full dewatering of the gate blocks has been scheduled in the near future to address other deteriorated components at the Chicago lock.

Prior to the completion of repairs to the east gates, the USGS measurements showed a leakage in the range of 825-939 cfs (through the east gates when the west gates were open). Also, prior to the completion of repairs to the west gates, USGS measurements showed a leakage in the range of 106-200 cfs (through the west gates when the east gates were closed). Finally, USGS measurements on the Chicago River at Lake Shore Drive, for the period of April through October 1993, showed leakage in the range of 175-359 cfs. The measurements at Lake Shore Drive include leakage through the Lock and leakage along the Chicago Harbor walls.

O'Brien Lock and Dam: The USGS completed measurements at the Lock and Dam in September 1993. The average of discharges measured was 53 cfs.

Wilmette Pumping Station: Prior to the sealing of the pump bays at the Wilmette Controlling Works, the USGS measured a flow of 53 cfs in the North Shore Channel. After the bays were sealed in the summer, the velocities were below the ADCP limits and the flow probably less than 10 cfs.

It should again be noted that the ranges and average values of measurements given here are still preliminary and subject to revision. Additional measurements and evaluations are planned for WY 1994. Further, as these measurements were made in WY 1993, they may not represent the level of leakage occurring during WY's 1986-1989. Without further review of the how the lakefront structures have changed over time, it would be inappropriate to generalize these results.

PRECIPITATION DATA COLLECTION

The Illinois State Water Survey (under contract with the Corps of Engineers) began collecting precipitation data from a 25 gage network in WY 1990. The new network spreads through Cook County, IL on a six mile grid to cover the Des Plaines and diverted Lake Michigan watersheds within Cook County. The new network replaces a group of thirteen gages scattered across the county with operation spread among three agencies, National Weather Service, MWRDGC, and the City of Chicago. With operation of the network within one agency, data collection and reduction are consistent. The gage locations improved on the previous locations by placing the gages on the ground (instead of rooftops) with attention to security, and wind and rain shadows.

AVM GAGE REGRESSION EQUATIONS

New regression equations were developed for the Romeoville AVM gage for calculating flows when the AVM is down. The USGS has reviewed the AVM flows for WY 1986 through WY 1992. The USGS revised the regression equations and the updated flows have been included in the Accounting Reports for WY 1986 through WY 1989. A complete description of the review and the regression equations will be published by the USGS in late FY 1993 while a brief description has been included in Accounting Reports for WY 1986 through WY 1988.

Another update of the regression equations is underway to include the AVM's installed in the Lockport Powerhouse by the MWRDGC.

GRAND CALUMET GAGE

The USGS installed a gage on the west branch of the Grand Calumet River approximately 0.5 miles east of the Illinois border (Hohman Avenue in Hammond IN). Beginning with WY 1992, flows in the Grand Calumet River were measured rather than being based on regression equations using Lake Michigan levels.

SOFTWARE IMPROVEMENT

The Special Contributing Area Loading Program (SCALP) was updated by Chicago District personnel to store data in the Corps of Engineers Hydrologic Engineering Center's Data Storage System (HEC-DSS). SCALP is the program that, using runoff data, calculates the sewer flow volumes and destinations. Presently, SCALP uses the Time Series Storage (TSS) database, which is awkward and inefficient. The SCALP output data must be converted to DSS for use by the UNET and TNET flow models used in the Diversion Accounting. By converting SCALP to DSS, the data conversion process is simple and faster.

ACTIVITIES FOR FY 1993

ACCOUNTING REPORTS

The Accounting Report for WY 1989 was completed in FY 1993 and the Accounting Reports for WY 1990 and WY 1991 will be completed in FY 1994. The Accounting Reports for WY 1992 and WY 1993 will be completed in FY 1995. For WY 1993 and after, data collection and the Accounting Reports are expected to be completed in the second fiscal year following the end of the water year.

THIRD TECHNICAL COMMITTEE

The Third Technical Committee was under contract at the close of FY 1992. The Committee began its work in February 1993.

FLOW MEASUREMENTS

To improve the accuracy of the canal balance budget, used to check the canal modeling, additional flow measurements will be made at each of the three lakefront structures and at the Upper Des Plaines pumping station. The USGS will utilize a Doppler meter to accurately measure the flows. To develop rating tables, a series of measurements will be made throughout the year.

DIVERSION ACCOUNTING MANUAL

A manual will be written during FY 1993 to describe in detail the steps in the diversion accounting procedure. The manual will include any updates and modifications up to and including the WY 1990 Accounting Report.

SOFTWARE IMPROVEMENT

The conversion of the Hydrologic Simulation Program - FORTRAN (HSPF) from TSS to DSS is underway. HSPF uses hydrologic data, precipitation, wind speed, and so on, to calculate runoff. As with SCALP, the simulations and data conversions will be speeded up. The Corps of Engineers will be contracting with the USGS to convert HSPF.

SUMMARY AND CONCLUSIONS

SUMMARY

The Lake Michigan Diversion Accounting procedure continues to evolve with the inclusion of TARP in the modeling. A round of major improvements is underway for the WY 1990 report. Among the changes are inclusion of the more representative 25 rain gage network, and use of the more efficient DSS version of SCALP. A comprehensive manual will be written to include all the updates. The upcoming modification of HSPF will streamline the hydrology simulations and speed the completion of each subsequent report.

CONCLUSIONS

The Lake Michigan Diversion Accounting Reports for WY 1986, WY 1987, WY 1988, and WY 1989 have been completed as required by the Supreme Court Decree.

The State of Illinois exceeded the 3,200 cfs limit in all four years. The running average of the diversion for WY 1981 through WY 1989 is 3,443 cfs, or 243 cfs over the annual allocation. The cumulative deviation is now 2,189 cfs-years, with a maximum allowable cumulative deviation of 2,000 cfs-years.

APPENDIX A

SIGNIFICANT EVENTS (NON HYDROLOGIC)

04-Oct-89 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of August 1989. 3 offices on the mailing list.

20-Oct-89 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of September 1989.

30-Oct-89 Memorandum from NCC to NCD. Forwarded the Quarterly Status Report (QSR) and other documents for the Lake Michigan Diversion Accounting Program.

03-Nov-89 Letter from NCC to Northeastern Illinois Planning Commission. Forwarded to NIPC were data and materials needed for the preparation of WY86 Accounting Report and Reduction of WY87 Precipitation Data.

03-Nov-89 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of October 1989.

20-Nov-89 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of September 1989. 3 offices on the mailing list.

22-Nov-89 Letter from NCC to Illinois Department of Transportation. Forwarded revised scope of work by NCC which includes a suggested canal operation test. IDOT and MWRDGC are to review the scope of work for finalization by NCC.

06-Dec-89 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of November 1989.

12-Dec-89 Letter from NCC to IDOT. NCC reviewed the WY84 and WY85 LMDA reports developed by NIPC. Some of the simulation modeling parameters were questioned by the Second Technical Committee which warranted an evaluation by the Corps. Corps revisions are summarized in a combined WY84/WY85 LMDA report. WY84 and WY85 reports developed by IDOT were included as appendix to the Corps report. Forwarded draft of WY84/WY85 diversion accounting report developed by NCC to IDOT.

20-Dec-89 Memorandum from NCC to NCD. Forwarded a draft of the FY 89 Annual Report, the FY90 Diversion Accounting Budget, and the FY91-FY94 Projected Budgets.

03-Jan-90 Letter from NCC to Northeastern Illinois Planning Commission. NCC forwarded adjusted WY86 precipitation data by Illinois State Water Survey to Northeastern Illinois Planning Commission.

03-Jan-90 Letter from NCC to Northeastern Illinois Planning Commission. NCC forwarded a draft of the WY84/WY85 Accounting Report prepared by NCC to be used as a format for the WY86 Accounting Report being prepared by NIPC.

05-Jan-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of December 1989.

17-Jan-90 Memorandum from NCC-ED to NCC-OC. Wage rate determination for indefinite delivery contract extension with NIPC for hydrologic and hydraulic studies related to Lake Michigan Diversion Accounting.

19-Jan-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the months of October 1989 and November 1989. New format for the table. 4 offices on mailing list.

25-Jan-90 Memorandum from NCC-ED to NCR-CT. An extension of contract DACW23-89-D-0003 with Northeastern Illinois Planning Commission was requested.

07-Feb-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of January 1990.

13-Feb-90 Memorandum from NCC to NCD. Forwarded the FY89 Annual Report with a sample transmittal.

15-Feb-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of December 1989. 4 offices on the mailing list.

22-Feb-90 Letter from NCC to Northeastern Illinois Planning Commission. NCC forwarded WY87 revised Diversion Accounting Scope of Work.

02-Mar-90 Letter from NCC to NCE forwarding maps and pictures of three sites where flow measurements were to be taken. The three sites were Wilmette pumping station on the North Shore Channel, Chicago River Controlling Works and O'Brien Lock and Dam on the Calumet River. Based on the enclosed maps and pictures, a cost estimate for the flow measurements was to be determined. The feasibility of work being performed by NCE would be determined by the estimate they provided.

05-Mar-90 Letter from NCC to LTV Steel - Coke Plant. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Indiana Department of Environmental Management - Office of Water Management - Operations Branch. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Homewood Department of Public Works. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to the Town of Schererville. NCC requesting data for the completion of Lake Michigan Diversion Accounting for WY89 for the months of August and September 1989.

05-Mar-90 Letter from NCC to Calumet Flexicore Corp. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Underwriters Laboratories, Inc. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Illinois State Water Survey. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Texaco Refining and Marketing, Inc. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Republic Engineering Steel. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Illinois Department of Transportation. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to ACME Steel Company. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Indiana Department of Natural Resources. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Argonne National Laboratories. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Indiana Department of Environmental Management - Office of Water Management - Public Water Supply Section. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Whiting Filtration Plant. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to North Shore Sanitary District. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Stauffer Chemical. NCC requested data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

05-Mar-90 Letter from NCC to Village of Deerfield. NCC requesting data for the computation of Lake Michigan Diversion Accounting for WY88 and WY89.

07-Mar-90 Letter from NCC to Illinois Department of Transportation - Division of Water Resources. NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Assistant Attorney General - Department of Justice. NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Assistant Attorney General (Columbus, Ohio). NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Metropolitan Water Reclamation District of Greater Chicago. NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to New York Power Authority. NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Assistant Attorney General in Charge - Environmental Protection Division (Lansing, Michigan). NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Pennsylvania Department of Environmental Resources. NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Solicitor General of the U.S. Department of Justice. NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Assistant Attorney General - Department of Law - Environmental Protection Bureau. NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Assistant Attorney General - Natural Resources Division (St. Paul, Minnesota). NCC forwarded 1989 Annual Report on Lake Michigan Diversion.

07-Mar-90 Letter from NCC to Northeastern Planning Commission. NCC forwarded 1989 Annual Report on Lake Michigan Diversion

07-Mar-90 Memorandum from NCC for CE-CCK. Forwarded 1989 Annual Report on Lake Michigan Diversion.

08-Mar-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of February 1990.

16-Mar-90 Letter from NCC to MWRDGC. NCC requesting information on how MWRDGC calculates the flow transfer rate from the O'Hare and Salt Creek Basins to the Northside Basin.

20-Mar-90 Memorandum from NCC to NCR. Preparation of WY86 Accounting Report extended from 4/13/90 to 7/20/90.

20-Mar-90 Letter from NCC to The Hydrologic Engineering Center Research Branch. NCC reviewed a report entitled "Review of Acoustic Velocity Meter Regression Analysis" developed by HEC. There were comments on the report and an updated version required to reflect the comments.

20-Mar-90 Letter from NCC to Consumer Illinois Water Company. NCC requesting data for the computation of Lake Michigan Diversion for WY88 and WY89.

21-Mar-90 Letter from NCC to MWRDGC referring to a letter of 18 August 1988. Information was being requested on any upgrades or changes on the metering devices at the four water reclamation plants. The information would help in the comprehensive data quality assurance program for Lake Michigan Diversion Accounting.

21-Mar-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of January 1990. 4 offices on the mailing list.

22-Mar-90 Memorandum from NCC to NCR. Appointment of Authorized Representative of the Contracting Officer (T. Lormand) for Contract DACW23-89-D-0003 with the Northeastern Illinois Planning Commission.

26-Mar-90 Letter from NCC to Metropolitan Water Reclamation District of Greater Chicago. NCC requesting data for the computation of Lake Michigan Diversion for WY88 and WY89.

03-Apr-90 Letter from NCC to USGS. Letter is the same as 02 March 1990. The feasibility of work being performed by USGS would be determined by the cost estimate they provided.

05-Apr-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of March 1990.

10-Apr-90 Memorandum from NCC to NCD. Forwarded report prepared by NCC entitled "Implementation of the Water Control Master Plan" covering the period of May 1989 through May 1990.

11-Apr-90 Memorandum from NCC to NCR. Termination of current (T. Price) Authorized Representative of the Contracting Officer for contract DACW23-89-D-0003 with the Northeastern Illinois Planning Commission.

13-Apr-90 Letter from NCC to Thorn Creek Basin Sanitary District. NCC requesting data for the computation of Lake Michigan Diversion for WY88 and WY89.

23-Apr-90 Letter from NCC to MWRDGC. NCC requesting data for the computation of Lake Michigan Diversion for WY88 and WY89.

30-Apr-90 Letter from NCC to UNOCAL. NCC requesting data required for the computation of Lake Michigan Diversion for WY88 and WY89.

30-Apr-90 Letter from NCC to North Shore Sanitary District requesting data required for the computation of Lake Michigan Diversion for WY88 and WY89.

04-May-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of April 1990.

14-May-90 Letter from NCC to National Oceanic and Atmospheric Administration. NCC forwarded Tables of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the months of October 1989 through February 1, 1990. An explanation of the information provided was also included.

14-May-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of February 1990. 5 offices on the mailing list.

18-May-90 Memorandum from NCC to NCE regarding scheduling a series of flow measurements at the three Lake Michigan control structures. Measurements needed to assess the accuracy of the reported diversion flows.

24-May-90 Letter from NCC to NIPC. Forwarded scope of work to NIPC for a study of TARP contributing areas, the revision of the TARP Computer Program, and the development of TARP Models for WY86, WY87, and WY88.

25-May-90 Memorandum from NCC to NCE regarding scheduling a series of flow measurements at the three Lake Michigan control structures. Measurements needed to assess the accuracy of the reported diversion flows. NCE will conduct flow measurements. Navigation notices were issued to inform river traffic of the date and times of measurements.

25-May-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of March 1990. 5 offices on the mailing list.

05-Jun-90 Letter from NCC to Jardine Water Purification Plant. NCC requesting hourly precipitation data for Springfield Pumping Station, Mayfair Pumping Station, Roseland Pumping Station, and South Water Filtration Plant for 10/01/89 thru 4/30/90.

05-Jun-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of April 1990. 5 offices on the mailing list.

05-Jun-90 Letter from NCC to MWRDGC. NCC requesting precipitation charts from Calumet Treatment Works, Northside Treatment Works, Stickney Treatment Works, Glenview, and Water Reclamation District Office for 10/01/89 thru 4/30/90.

05-Jun-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of May 1990.

08-Jun-90 Memorandum INHOUSE Subject: Legal Review of Lake Michigan Diversion Navigation Makeup Component Review Scope of Work.

11-Jun-90 Memorandum from NCC to NCE. Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan diversion from the months of July 1989 through April 1990. NCE added to NCC mailing list.

12-Jun-90 Memorandum from NCC to NCD. NCC forwarded the revised scope of work for the proposed Lake Michigan Diversion Navigation Makeup Component Review. Once revised it will be transmitted to all interested parties.

12-Jun-90 Memorandum from NCD to NCC. Revised Lake Michigan Diversion Navigation Makeup Component Review Scope of Work. NCC directed to program full funding for the subject activity.

12-Jun-90 Letter from NCC to MWRDGC. NCC scheduled flow measurements at Wilmette Pumping Station, Chicago River Controlling Works, and O'Brien Lock and Dam for 7/23 thru 7/27/90. The purpose of flow measurements is to assess the accuracy of reported diversion flows.

12-Jun-90 Memorandum from NCC to NCD. Forwarded for approval to NCD was the Revised Lake Michigan Diversion Navigation Makeup Component Review Scope of Work.

14-Jun-90 Memorandum from NCC to NCD. Revised FY91 and FY92 Budgets for Water Control and Lake Michigan Diversion Accounting Activities.

20-Jun-90 Memorandum from NCC-ED to NCC-OC. A legal review of Lake Michigan Diversion Navigation Makeup Component Review Scope of Work.

26-Jun-90 Letter from NCC to NIPC. Forwarded revised Scope of Work. See Letter dated 24 May 1990.

03-Jul-90 Memorandum from NCC-OC to NCC-ED. Legal Review of LMDA Navigation Makeup Component Review Scope of Work. Outline potential liability aspects against the Federal Government.

05-Jul-90 Letter from NCC to Northeastern Illinois Planning Commission. NCC forwarded a revised scope of work entitled "Study of TARP Contributing Areas, The Revision of the TARP Computer Program, and the Development of the TARP Models for Water Years 86, 87, and 88". NCC also requested a fee proposal to perform the tasks in the scope of work.

06-Jul-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of June 1990.

07-Jul-90 Memorandum from NCC-ED to NCC-OC. Memo regarding the MWRDGC participation in Lake Michigan Diversion Navigation Component Review - Canal Operations Test. It would be necessary to assess liability for the MWRDGC participation in this project.

10-Jul-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of May 1990. 7 offices on the mailing list.

10-Jul-90 Semiannual Status Report for the Lake Michigan Diversion Accounting Program forwarded to NCD.

11-Jul-90 Memorandum from NCC to NCD. Forwarded the legal review of LMDA Navigation Makeup Component Review Scope of Work prepared by NCC-OC.

25-Jul-90 Letter from NCC to Water Department - City of Chicago Heights. NCC requesting data required for the computation of Lake Michigan Diversion for WY88 and WY89.

30-Jul-90 Letter from NCC to USGS forwarding comments on the draft report prepared by USGS entitled "Romeoville AVM Quality Assurance Plan".

02-Aug-90 Letter from NCC to MWRDGC. NCC completed flow measurements conducted from 7/23 thru 7/27/90 at the three Lake Michigan Control Structures. Copies of the upstream and downstream circular water elevation charts for each of the five days of measurement at the three sites were also requested by NCC. See letter dated 12 June 1990.

08-Aug-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of July 1990.

09-Aug-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of June 1990. 7 offices on the mailing list.

23-Aug-90 Letter from NCC to Chamline and Associates. NCC forwarded data requested for direct diversion flows for 1981 thru 1990 for Wilmette Controlling Works, Chicago River Controlling Works, and O'Brien Lock and Dam.

28-Aug-90 Letter from NCC to Illinois Department of Transportation (IDOT) giving notice of a training seminar on the use of hydraulic models of the Chicago Sanitary and Ship Canal and adjoining waterways, and the TARP tunnels. Seminar would be held 4-6 September 1990. The instructor was Robert L. Barkau. PhD., P.E.

28-Aug-90 Letter from NCC to MWRDGC giving notice of a training seminar on the use of hydraulic models of the Chicago Sanitary and Ship Canal and adjoining waterways, and the TARP tunnels. Seminar would be held 4-6 September 1990. The instructor was Robert L. Barkau. PhD., P.E.

30-Aug-90 Letter from NCC to MWRDGC. NCC requesting rating curves or tables and other necessary information from which sluice gate flows and leakages can be determined for 7/23 thru 7/27/90 for the three Lake Michigan Control Structures.

30-Aug-90 NCC forwarded Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of July 1990. 7 offices on the mailing list.

14-Sep-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of August 1990.

25-Sep-90 Memorandum from CECW to NCC. An update on the status of activities related to the life cycle replacement of water control computer systems.

02-Oct-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of September 1990.

05-Oct-90 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of August 1990. Seven offices on the mailing list.

16-Oct-90 Letter from Illinois Department of Transportation to NCC. IDOT requesting a status report on the condition of the Chicago River locks, including a new timetable for maintenance/rehabilitation of the facility.

25-Oct-90 Letter from NCC to ISWS. NCC forwarded precipitation gage data for Contract No. DACW23-90-C- 0051 with ISWS.

30-Oct-90 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of September 1990. Seven offices on the mailing list.

31-Oct-90 Letter from NCC to MWRDGC. NCC forwarded lockage data for the Chicago Lock for June 1988.

05-Nov-90 Letter from NCC to ISWS regarding contract extension for Reduction and Adjustment of WY88 and WY89 Precipitation data for Lake Michigan Diversion Accounting. NCC saw no need for contract extension since it was only a few days difference ISWS was asking for.

05-Nov-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of October 1990.

09-Nov-90 Letter from NCC to MWRDGC. NCC forwarded lockage data for the Chicago Lock for August 1987.

09-Nov-90 Letter from NCC to NIPC. NCC reviewed report entitled "Reduction of 1987 Water Year Precipitation Data for Lake Michigan Diversion Accounting" and the accompanying data. NCC was satisfied with the work prepared as part of contract DACW23-89-R-0014

19-Nov-90 Memorandum from NCD to NCC. Report entitled "Lake Michigan Diversion Accounting Program End of the Fiscal Year 6 month Status Report" needed more close detail of the manpower utilization breakdown.

19-Nov-90 Memorandum from NCC to NCD. Memo to transmit the semiannual status report for the Lake Michigan Diversion Accounting Program.

19-Nov-90 Memorandum from NCC-ED-HW to NCC-ED-HF. Memo concerning review of EDC Foundation draft FERC application.

21-Nov-90 Letter from NCC to IDOT. Response from NCC to the condition of the Chicago Harbor Lock.

21-Nov-90 Letter from NCC to Illinois Department of Transportation. See Letter dated 16 October 1990. Response to the condition of the Chicago Harbor Lock.

26-Nov-90 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of October 1990. Seven offices on the mailing list.

27-Nov-90 Letter from NCC to NIPC. NCC to negotiate second work order of the Indefinite Delivery Contract with NIPC. NCC forwarded a scope of work for development of a DSS-TSS Data Exchange Program and User's Manual.

04-Dec-90 Letter from NCD to IDOT. Letter from NCD stating that they are unable to fund the studies necessary to support the current scope of work within the next few years.(Study and analysis of Navigation Flows as Related to the LMDA Program at Chicago).

05-Dec-90 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of November 1990.

07-Dec-90 Letter from NCC to MWRDGC. NCC requesting information regarding the operation of Mainstream and Calumet TARP. An itemized listing of information required was enclosed.

12-Dec-90 Letter from NCC to Calumet Water Reclamation Plant. NCC requesting information for the development of simulation models for the Calumet TARP systems for WY87 and WY88.

08-Jan-91 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of December 1990.

08-Jan-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of November 1990. Seven offices on the mailing list.

08-Jan-91 Letter from Illinois Department of Transportation to NCD (copy furnished to NCC). IDOT continued the discussion concerning the status of diversion accounting and measurements, and the possibility of amending the U.S. Supreme Court

22-Jan-91 Letter from NCC to STS Consultants. NCC forwarded regression and AVM Flows for WY84 through WY89 and a copy of the Chicago Sanitary and Ship Canal at Romeoville Acoustic Velocity Meter Backup System Report.

29-Jan-91 Letter from NCC to MWRDGC. NCC forwarded the Chicago Sanitary and Ship Canal at Romeoville Acoustic Velocity Meter Backup Report, Review of "Acoustic Velocity Meter Regression Analysis" report, and the AVM Dial Up Procedures.

30-Jan-91 USGS forwarded plans to NCC for the construction of gages on the Grand Calumet River and on the Indiana Harbor Canal. A summary of costs for FY91 and FY92 was also enclosed.

31-Jan-91 Letter from NCD to Illinois Department of Transportation (copy furnished to NCC). Reply to letter dated 08 January 1991, concerning the status of the Lake Michigan Diversion Accounting and measurements at Chicago.

01-Feb-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of December 1990. Seven offices on the mailing list.

05-Feb-91 Memorandum from NCC to NCD. NCC forwarded Water Control's Data System Annual Report covering the Fiscal Year 1990.

07-Feb-91 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of January 1991.

22-Feb-91 Letter from NCC to Illinois Department of Transportation. NCC response on current condition at the Chicago Lock and implications for Lake Michigan Diversion.

26-Feb-91 Letter from NCD to Illinois Department of Transportation (copy furnished to NCC). Further reply to letter dated January 8, 1991. Concerning the status of the Lake Michigan Diversion accounting and measurements at Chicago.

04-Mar-91 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of February 1991.

11-Mar-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of January 1991. Seven offices on the mailing list.

12-Mar-91 Letting of a service contract to Ferranti O.R.E., Inc. to service the AVM station 05536995 Chicago Sanitary and Ship Canal at Romeoville, IL O.R.E. provided a scope of work.

22-Mar-91 Letter from NCC to Water Department - City of Chicago Heights. NCC requesting data for the computation of Illinois Lake Michigan Diversion for WY87 and WY90.

02-Apr-91 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of March 1991.

03-Apr-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of February 1991. Seven offices on the mailing list.

05-Apr-91 Letter from ISWS to NCC. ISWS forwarded items pertaining to the 1988 and 1989 Water Year data reduction/adjustment project.

12-Apr-91 Fax from Metropolitan Water Reclamation District of Greater Chicago to NCC. MWRDGC in the process of installing a cavitation monitoring system to improve the operation of the Lockport Powerhouse Facility.

24-Apr-91 Letter from NCC to USGS. NCC forwarded soundings of the Indiana Harbor Canal for August 1990.

26-Apr-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of March 1991. Seven offices on the mailing list.

28-May-91 Letter from ISWS to the Chicago Park District (Copy For: NCC). ISWS and USACE thanking the Chicago Park District for having continued access to the Lincoln Park Gun Club site where one of 25 rain gages in Cook County is located.

28-May-91 Letter from ISWS to NCC. ISWS requesting provisional AVM records for the Romeoville Station for WY90 and WY91.

10-Jun-91 Memorandum from NCC to NCD. NCC forwarded the WY86 Lake Michigan Diversion Accounting Report for review.

11-Jun-91 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of May 1991.

12-Jun-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of April 1991. Seven offices on the mailing list.

17-Jun-91 USGS prepared a price quote for the Watchdog Timer Board per NCC request. USGS also informed NCC about a Lightning Protection Package.

19-Jun-91 Memorandum from NCC to NCD. Completion dates for the six month FY91 Status Report and the Lake Michigan Diversion Accounting 1990 Annual Report.

20-Jun-91 Letter from Illinois Department of Transportation to Metropolitan Water Reclamation District of Greater Chicago (copy furnished to NCC). Letter concerning request made by the COE to drawdown the pool of the Chicago Sanitary and Ship Canal, above Lockport, IL.

26-Jun-91 Letter from NCC to Siemon, Larson and Purdy. NCC forwarded the 1989 Lake Michigan Diversion Accounting 1989 Annual Report and the Lake Michigan Diversion Accounting Manual of Procedures.

03-Jul-91 Memorandum from NCC to NCD. Submittal of the Annual Report for Water Control Data System.

09-Jul-91 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of June 1991.

11-Jul-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of May 1991. Seven offices on the mailing list.

11-Jul-91 USGS to purchase and install two Watchdog Timer Boards for the ORE model 7410 AVM at Romeoville, IL by NCC request.

08-Aug-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of June 1991. Seven offices on the mailing list.

09-Aug-91 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of July 1991.

14-Aug-91 Letter from NCC to MWRDGC. NCC forwarded one 30x42 inch copy of an AUTOCAD drawing showing diverted Lake Michigan Watershed, the Lower Des Plaines Watershed, special contributing areas, and a DOS backup of the AUTOCAD drawing.

5-Aug-91 Letter from, Illinois Department of Transportation to Metropolitan Water Reclamation District of Greater Chicago (copy furnished to NCC). IDOT forwarded a copy of a navigation notice to MWRDGC issued by COE announcing maintenance work on the Lockport Approach Dike.

21-Aug-91 Letter from NCC to Indiana Dept. of Environmental Management - Drinking Water Branch. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Homewood Dept. of Public Works. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Village of Deerfield. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Rhone-Poulenc Basic Chemical. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Consumer Illinois Water Company. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Indiana Dept. of Natural Resources. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Illinois Department of Transportation - Div. of Water Resources. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to ACME Steel Company. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Illinois Environmental Protection Agency - Div. of Water Pollution Control. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Republic Engineering Steel. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Jardine Water Purification Plant. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Texaco Refining and Marketing Inc. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Calumet Flexicore Corp. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Thorn Creek Basin Sanitary District. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Northshore Sanitary District - Clavey Road STP. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Argonne National Laboratories. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to LTV Steel. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to the Town of Scherville. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Uno-Ven Corporation. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Whiting Filtration Plant. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

21-Aug-91 Letter from NCC to Underwriters Laboratories Inc. NCC requesting data for the computation of Lake Michigan Diversion for WY90.

29-Aug-91 Letter from NCC to Indiana Department of Environmental Management. NCC requested data for the computation of Illinois Lake Michigan Diversion for WY90.

29-Aug-91 NCC forwarded the Table of Preliminary Lockport Flows as provided by MWRDGC and estimate of Lake Michigan Diversion for the month of July 1991. Seven offices on the mailing list.

23-Sep-91 Letter from NCC to MWRDGC. Monthly diversion lockage report for the month of August 1991.

24-Sep-91 Fax from NCD to NCC. Lake Michigan Diversion Master Plan 5 year plan. NCD wanted WY86 Accounting Report by the end of CY91. NCC forwarded a schedule of completion for other reports.

25-Sep-91 Memorandum from NCD to NCC. NCD forwarded a copy of updated information on NEXRAD.

02-Oct-91 Memo from CECW-EH-D Subject: Hydraulic and Hydrologic conference. April 27-28 1992. Hyatt Regency Hotel, Fort Worth, TX.

08-Oct-91 Memo for NCD from NCC. Subject: Review of ER 1110-2-240, Water Control Management.

11-Oct-91 Letter to State of New York - Dept. of Environmental Conservation. Providing comments on a letter concerning the proposed Lowell, Indiana diversion from Lake Michigan.

11-Oct-91 THRU 22-July-92 Forwarded Table of Preliminary Lockport Flows as provided by MWRDGC. Monthly for WY92. Sent to: Office of Oceanographic & Marine Assessment, Great Lakes Environmental Research LAB, Monroe Wastewater Treatment Plant, IDOT (LM Management Section), North Central Div., Detroit Dist., Rock Island Dist.

18-Oct-91 Letter to NCC from Northeastern Illinois Planning Commission. Forwarding completed tasks for the water year 1986 diversion accounting work order.

21-Oct-91 Memo for NCC from NCD Subject: Implementation of the North Central Division Water Control Master Plan.

22-Oct-91 THRU 10 Jun-92 Monthly Diversion Lockage Reports forwarded to MWRDGC for WY92.

25-Oct-91 Fax to NCR from NCC. Changes made to a Request for Proposal Plan.

29-Oct-91 Memo for NCD from NCC Subject: Review of AFOS Products.

29-Oct-91 Memo for NCD from NCC Subject: Status of Reservoir Regulation Manuals.

30-Oct 91 Memo for NCC from NCD Subject: O&M funding for CENCD-PE-ED-W.

31-Oct-91 Memo INHOUSE Subject: Cup McCook Reservoir PMP - Water Control Section

04-Nov-91 Memo INHOUSE Subject: Cup O'Hare Reservoir PMP - Engineering Design during construction (EDDC).

15-Nov-91 Memo for NCC from NCD Subject: Software Conversion for next Generation Water Control Data System computer.

15-Nov-91 Memo INHOUSE Subject: FY92 funding allocations for water control and Lake Michigan Diversion Accounting Projects.

18-Nov-91 Fax (Memo) from NCR to NCD Subject: Study of Stage and Discharge Frequencies on the Lower Ohio River.

18-Nov-91 Letter to NCC from National Oceanic and Atmospheric Administration, Informing of the New Address and telephone number for the National Weather Service Forecast Office.

27-Nov-91 Fax from USGS to NCC - copy of memo concerning re-establishment of small business set-aside.

27-Nov-91 Letter from USGS to NCC. Enclosed list of streamgaging stations that were funded by ISWS but no longer would be.

27-NOV-91 Memo from INHOUSE Subject: RFP DACW23-92-R-0003, Precipitation Network, U of I .

02-Dec-91 Letter to NCC from Northeastern Illinois Planning Commission. Request for payment of funds under work order 0001 Contract DACW23-89-D-0003, Diversion Accounting.

05-Dec-91 Letter from NCC to USGS requesting groundwater withdrawal information for all permitted users in IL.

09-Dec-91 Memo for NCR from NCC. Subject: Cost and Time Estimates for CENCC-ED-HW Coordination in the study of stage and discharge frequencies on the lower Ohio River.

18-Dec-91 Memo INHOUSE Subject: Technical and Price Analysis pending firm fixed price service contract DACW23-92-R-0003.

31-Dec-91 IDOT forwarded two copies of the report " River Stages in Illinois: Flood and Damage Data"

02-Jan-92 ISWS forwarded 20 copies of the final report detailing operations and data reduction for WY91. Also sent printout of data matrix for WY91 and 3 disks containing data in digital form.

16-Jan-92 Memo for Record Subject: Negotiation Objectives - RFP DACW23-92-R-0003, Pending Service Contract.

24-Jan-92 Memo for NCR from NCC Subject: ISWS, U of I, Precipitation Gage Network Operation and Maintenance Contract Award.

03-Feb-92 Memo for NCD from NCC Subject: Water Control Section Annual Report.

07-Feb-92 Memo for NCD From NCC Subject: Lake Michigan Diversion 5- year Master Plan.

07-Feb-92 Memo INHOUSE Subject: Functional and Organizational Allocation of funding by project for FY92. Request to formulate the FY93 FORCON and FY92 Operating Budget.

07-Feb-92 Memo for NCD from NCC Subject: Lake Michigan Diversion 5-year Master Plan.

10-Feb-92 Letter to U of I from NCC. Letter stating release of contract (see release of contract 11 Mar 92).

11-Feb-92 Letter from IDOT to NCC concerning Lake Michigan Diversion Accounting and Three Member Tech Committee.

13-Feb-92 USGS forwarded rating tables for surface water gaging stations.

13-Feb-92 Fax (Memo) to NCC from NCD Subject: Update on receipt and processing AFOS data from the NWS.

24-Feb-92 Memo from NCD to NCC Subject: Update on receipt and processing AFOS data from the NWS.

25-Feb-92 Memo for NCC from NCD Subject: Real-Time Water Control Hardware/Software Development.

26-Feb-92 Letter to NCC from U of I at Urbana-Champaign. Regarding Contract DACW23-92-C-0019.

27-Feb-92 USGS forwarded rating tables for surface-water gaging stations.

28-Feb-92 Letter from NCC to USGS requesting hourly flow and stage data from the Romeoville Acoustic Velocity Meter.

04-Mar-92 Fax to ISWS - Advanced copy of signed contract DACW23-92-C-0019.

11-Mar-92 Release of Contract - work completed for contract DACW23-89-0005.

13-Mar-92 Memo for NCC from NCD Subject: Lake Michigan Diversion 5-Year Master Plan.

13-Mar-92 Letter from USGS to NCC - Disk forwarded with 88-89 groundwater withdrawal data for requested townships.

26-Mar-92 Memo for NCD from NCC Subject: Water Control Master Plan Update.

30-Apr-92 Memo for NCC from NCD Subject: Submittal of Annual Report for Water Control Data System.

07-May-92 Memo INHOUSE Subject: Retention of USACE, Chicago District, Great Chicago Flood (GCF) of 1992 Records.

12-May-92 Fax from USGS to COE. Romeoville AVM Discharge Record Computation.

18-May-92 Memo for NCC from CECW-EH-W Subject: Schedule for revision of Water Control manuals.

01-Jun-92 Memo for NCC from NCD Subject: Schedule for revision of Water Control Manuals.

12-Jun-92 Letter from IDOT to NCC concerning Lockport Diversion Flows for April 1992. In connection with Chicago Flood.

15-Jun-92 Memo for NCC from CECW-EH-W Subject: Collection of project funds for operation of Hydrologic Programs.

23-Jun-92 Memo for NCC from NCD Subject: Update of the Hydrologic Information Officer (HIO) Notification list.

06-Jul-92 Memo for NCC from NCD Subject: Drought Contingency Plans (DCP) record of completion.

08-Jul-92 Memo for NCD from NCC Subject: Schedule for revision of Water Control Manuals. .

08-Jul-92 Memo for NCD from NCC Subject: Update of Hydrologic Information Officer (HIO) notification list.

14-Jul-92 Letter from USGS to NCC. List of stations that would be discontinued due to budget cuts in "92".

21-Jul-92 Memo for NCD from NCC Subject: Collection of project funds for operation of hydrologic programs.

22-Jul-92 Memo for NCC from NCD Subject: Status Report - HEC Support for Real Time Water Control Program.

24-Jul-92 Letter from IDOT to NCC. Concerning the extra diversion during the Chicago Flood and stating that the State of Illinois should not be charged for the extra diversion water under the U.S. Supreme Court Decree Diversion Limit. Request that tables be revised for April and May (Lockport Diversion Flows).

26-Aug-92 Memo for NCC from NCD Subject: Water Control Data System (WCDS) Software Development and Application.

02-Sep-92 Memo for NCC from NCD Subject: Review of the FY93 Cooperative Stream Gaging Program.

08-Sep-92 Memo for NCC from NCD Subject: Information for Corps Field Technical Advisory Group.

16-Sep-92 Memo for NCD from NCC Subject: Water Control Data System Software.

17-Sep-92 Memo for NCD from NCC Subject: USGS/Corps Cooperative Stream Gage Program, FY93.

28-Sep-92 Memo for NCD from NCC Subject: Lake Michigan Diversion Accounting Concerns.

APPENDIX B

LAKE MICHIGAN DIVERSION ACCOUNTING

WATER YEAR 1986 REPORT

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EXECUTIVE SUMMARY

In compliance with the modified 1980 U.S. modified U.S. Supreme Court decree, the WY86 diversion was computed using the best engineering technology available to date as applied to the diverted watersheds.

Given the complexity of the hydrologic cycle in the heavily urbanized Chicago metropolitan area, and given the number of human and other factors that cannot be adequately represented in numerical modeling procedures, the results of the simulations which compute diversion flows worked exceptionally well.

The WY86 diversion accountable to the State of Illinois is 3,751.1 cfs. This is 551.1 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average, rounded to the nearest cfs, beginning with WY81 is 3,410 cfs and the cumulative deviation from the 3,200 cfs average is -1,261 cfs-years. The negative cumulative deviation indicates a water allocation debt and the maximum allowable debt is 2,000 cfs-years.

INTRODUCTION

The diversion of water from the Lake Michigan watershed is of a major importance to the Great Lake states and to the Canadian province of Ontario. The states and province that border the Great Lakes have concerns with both diversions during periods of low lake levels as well as the long term effects of diversion. To insure that the concerns of these interested parties are considered, the U. S. Army Corps of Engineers has been given the responsibility for the accounting of flow that is diverted from the Lake Michigan watershed.

The Corps of Engineers, Chicago District, is responsible for monitoring the measurements and the computation of the diversion of Lake Michigan water by the State of Illinois. The computations for Water Year 1983 (WY83), WY84 and WY85 (1 October 1984 through 30 September 1985) were completed by the Northeastern Illinois Planning Commission (NIPC) for the Illinois Department of Transportation (IDOT). Prior to the WY83 report, the calculations were made by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) for IDOT. The Corps reviewed, modified, and updated the WY84 and WY85 diversion accounting completed by NIPC. The computations for WY86 were performed jointly by NIPC (under contract to the Corps of Engineers) and the Corps of Engineers. This report represents the final Lake Michigan diversion accounting for WY86.

AUTHORITY FOR REPORT

Under the provisions of the U.S. Supreme Court Decree in the Wisconsin, et al v. Illinois et al, 388 U.W. 426,87 S.Ct. 1774 (1967) as modified 449 U.S. 48, 101 S.Ct. 557 (1980), the Corps of Engineers is responsible for monitoring the measurement and computation of diversion of Lake Michigan water by the State of Illinois. The Water Resources Development Act of 1986 gave the Corps total responsibility for the computation of diversion flows as formerly done by the State of Illinois. The Corps' new mission became effective 1 October 1987.

HISTORY OF THE DIVERSION

Water has been diverted from Lake Michigan at Chicago into the Mississippi River Basin since the completion of the Illinois and Michigan Canal (I&M Canal) in 1848. At that time, diversion averaged about 500 cubic feet per second (cfs). The Illinois and Michigan Canal was built primarily to serve transportation needs. The canal provided a connecting watercourse between the Great Lakes and the Mississippi River system.

With the development of the Chicago metropolitan area, drainage and drainage improvements led to severe sanitation problems in the mid to late 1800's. The newly constructed sewers moved water and wastes into the Chicago River, which until 1900 drained to Lake Michigan. The water quality of Lake Michigan deteriorated and as such contaminated the city's primary water supply.

A second problem that occurred during this time period was an increase in the overbank flooding within the city. As more roads were built and buildings constructed the sewer system was correspondingly expanded. This increased the rate and volume of runoff and resulted in increased flooding.

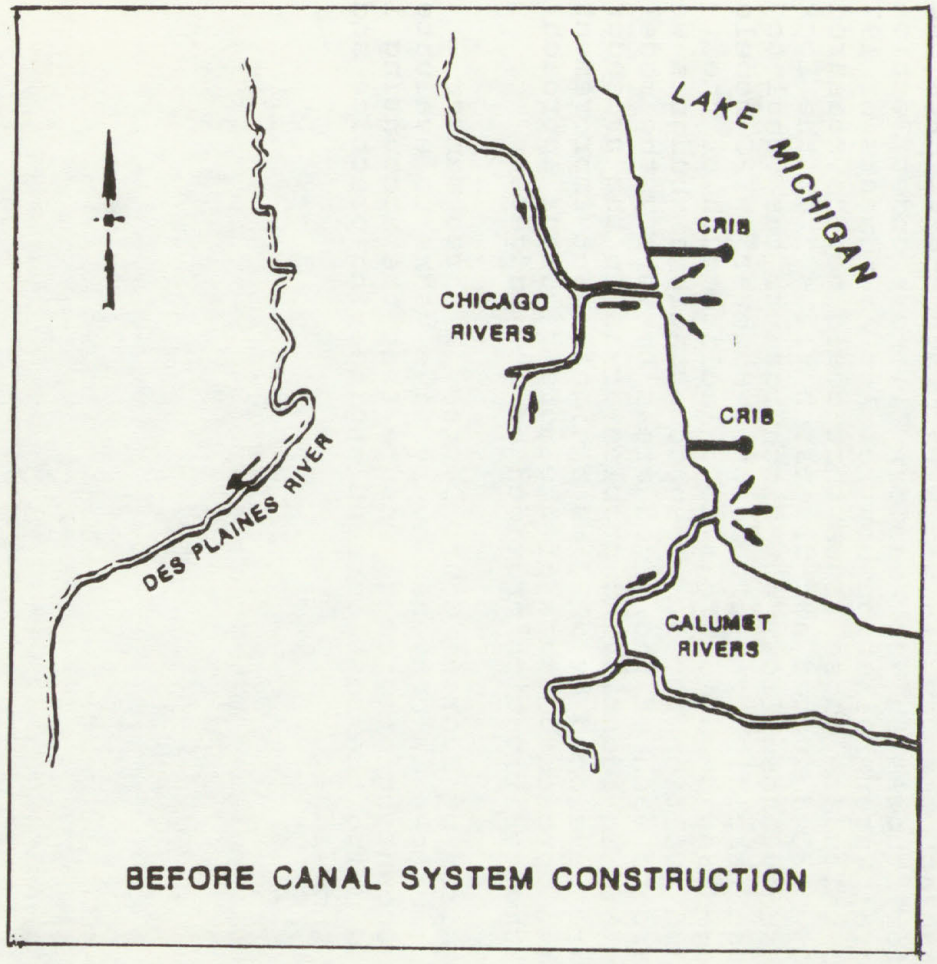
As a solution to the sanitation and flooding problems, construction of the Chicago Sanitary and Ship Canal (CSSC) was undertaken. This construction allowed the flow direction of the Chicago River to be reversed (Figure 1). Construction of the Chicago Sanitary and Ship Canal was completed in 1900 by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) (formerly Metropolitan Sanitary District of Greater Chicago, MSDGC). The Sanitary and Ship Canal followed the course of the older I and M Canal. This canal is much larger than the I and M canal and can handle the Chicago River flow as well as increased shipping. The Chicago River Controlling Works was constructed at the mouth of the Chicago River. The lock regulates the amount of Lake Michigan water allowed to pass into the river and restricts river flooding from entering Lake Michigan.

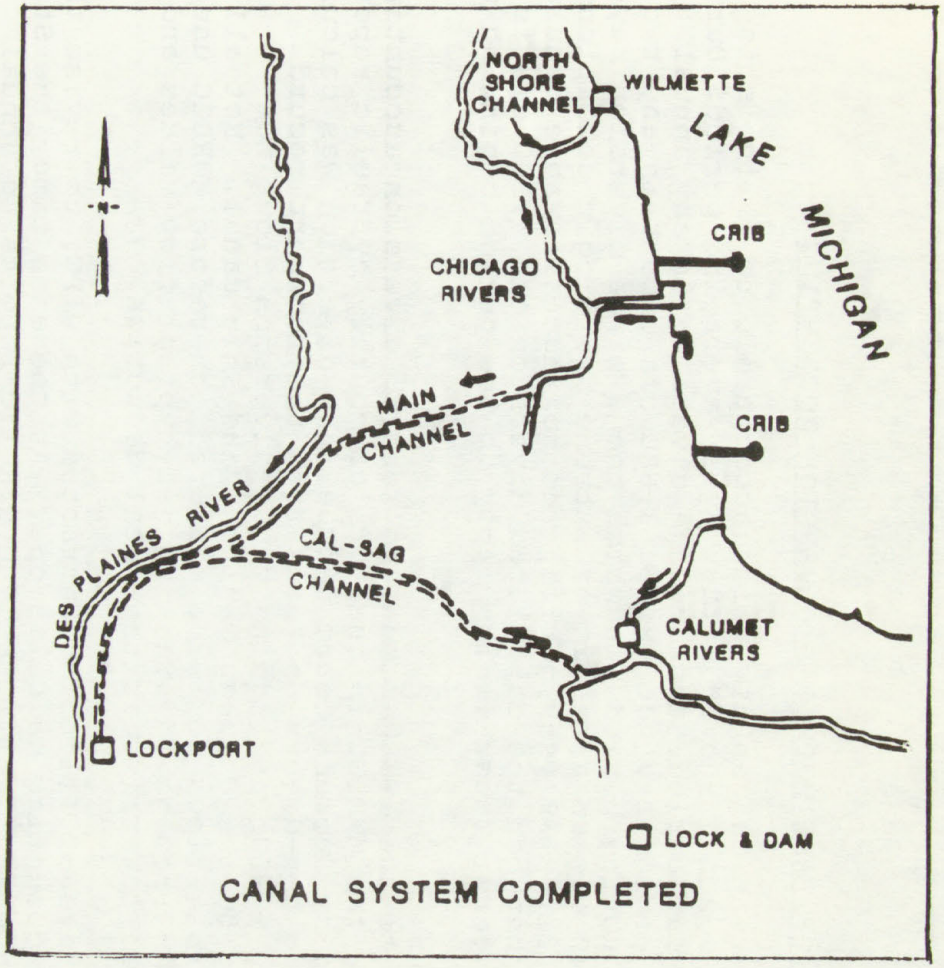
Between 1907 and 1910 the MWRDGC constructed a second sanitary canal called the North Shore Canal. It extended from Lake Michigan at Wilmette in a southerly direction 6.14 miles to the north branch of the Chicago River. The Wilmette Controlling Works regulate the amount of Lake Michigan flow allowed down the channel.

Construction of a third canal, the Calumet Sag Canal, was completed in 1922. The canal connects Lake Michigan through the Grand Calumet River, to the Sanitary and Ship Canal. This canal was constructed to carry sewage from South Chicago, Illinois and East Chicago, Indiana. The O'Brien Lock and Dam located on the Calumet River, regulates the flow of Lake Michigan waters down the canal.

Figure 1

Development of the Chicago Canal System





BACKGROUND OF LAKE MICHIGAN DIVERSION ACCOUNTING

The Lake Michigan diversion accountable to Illinois is limited to 3,200 cfs over a forty year averaging period. During the forty year period, the average diversion in any annual accounting period may not exceed 3,680 cfs except in any two annual accounting periods in which the average diversion may not exceed 3,840 cfs as a result of extreme hydrologic conditions. During the first 39 year period, the maximum allowable cumulative difference between the calculated diversion and 3,200 cfs is 2,000 cfs-years. These limits apply to the period beginning with WY81.

Prior to the 1983 accounting report, diversion accounting was done by the MWRDGC in the form of monthly hydraulic reports. As required by Supreme Court Decree, the diversion was calculated by deducting non-diversion flows from the Lockport record measured by MWRDGC and adding those diversion flows not discharging to the Chicago Sanitary and Ship canal. Not all of the deductible flows could be measured, therefore MWRDGC used flow records from gaged areas to get typical flow values and then extrapolated to arrive at the total deduction.

The State of Illinois contracted with NIPC, to revise the diversion accounting calculations. At the same time, the State of Illinois moved from monthly hydraulic reports to annual accounting reports. NIPC adapted computer models of the diverted Lake Michigan and the Des Plaines River watersheds, previously developed for studies in Northeastern Illinois under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500), to calculate those flows that could not be measured. Like MWRDGC, NIPC deducted non-diversion flows from the Lockport record and added those flows not discharged to the canal to calculate the Lake Michigan diversion. However, NIPC modeled both the gaged and ungaged areas to calculate much of the deduction and addition flows. Then computational budgets were developed around each of the gaged areas to verify the models. The budgets aid in identifying problem areas in the procedure. The procedure developed by NIPC is a significant improvement over the previous approach because of the more rigorous approach and because of the verification provided by the budgets.

As required by Supreme Court Decree, a three member technical committee is convened every five years to evaluate the diversion accounting program to ensure that the accounting is accomplished using the best current engineering practice and scientific knowledge.

The first technical committee was convened during the period that the diversion accounting was done by MWRDGC. The committee was primarily concerned with the rating of the various components at the Lockport facility, the primary diversion measurement location (Espey et al, 1981). In response to the Committee's concerns, the Corps' Waterways Experiment Station (WES) revised the ratings of the two sets of Lockport sluice gates (Hart and McGee, 1985).

In response to the Committee's concerns, the State of Illinois installed an acoustic velocity meter (AVM) at Romeoville five miles upstream of Lockport. The AVM is a highly accurate flow meter that proved to provide better flow measurements than the MWRDGC reported Lockport flows and the new Corps rating curves. The AVM became operational 12 June 1984. However, USGS did not publish the AVM flows until 1 October 1985. Because of significant equipment problems with the AVM, a replacement AVM was installed in November 1988.

To provide flows during periods of malfunction, various regression analyses were done to relate the MWRDGC reported Lockport flows to the AVM flows. Several sets of equations were proposed by the Corps of Engineers, the USGS, Harza Engineering Co., and the Second Technical Committee. The report, Chicago Sanitary and Ship Canal at Romeoville Acoustical Velocity Meter Backup System, was completed September 1989 (USACE, 1989). The regression equations that were ultimately used to estimate missing AVM flows from WY86 through WY91 were developed by the USGS in a report tentatively titled "Discharge and Regression Analyses for Acoustical Velocity Meter Data for the Chicago and Sanitary Ship Canal at Romeoville, Illinois." The final publication of this report is expected to be available in the spring of 1993.

The second and most recent technical committee reviewed the NIPC hydrologic and hydraulic computer models and agreed that the approach was consistent with what was required by the decree (Espey et al, 1987). However, the committee felt that some of the parameters used in the models were out of date and in need of revision. To address the committee's concerns, the Corps hired a consultant (C. B. Burke Engineering, Ltd.) in September of 1988 to review and update the modeling parameters. The final report concerning the updating of modeling parameters was submitted to the Corps in October 1990.

The Water Resources Development Act of 1986 gave the Corps of Engineers the full responsibility for computation of the Illinois Lake Michigan diversion as of 1 October 1987. When the Corps' new responsibility became effective, the WY84 diversion accounting report, developed by NIPC, had not been certified. As a result, the Corps was responsible for the WY84 and all subsequent reports.

NIPC completed the WY84 diversion accounting report in April of 1988. It was subsequently reviewed by the Corps. The Corps found the report to be adequate with two exceptions. First, the 1984 accounting was completed with the modeling parameters questioned by the second technical committee. Second, MWRDGC reported Lockport flows, adjusted using the WES rating curves, were used rather than AVM flows. The Corps, knowing that the modeling parameters required updating and that AVM flows for the period prior to installation could be calculated accurately using regression equations, refrained from certifying the WY84 report until these issues were resolved.

NIPC completed the WY85 diversion accounting report in December of 1988 and the report was reviewed by the Corps. Like the WY84 report, the WY85 accounting was done with the modeling parameters questioned by the second technical committee. Additionally, NIPC used the AVM flows published by the U.S. Geological Survey (USGS) in their WY85 Water Resources Data for Illinois report. Since the publication of the WY85 USGS report, more reliable equations have been developed for calculating flows when the AVM was malfunctioning.

Upon completion of the analysis of the modeling parameters by Christopher B. Burke Engineering, LTD, the WY84 and WY85 diversion flows were recalculated using the revised modeling parameters and the Romeoville AVM flows. The diversion flows were certified by the Corps of Engineer and transmitted to all interested parties in the Lake Michigan Diversion Accounting 1989 Annual Report (USACE, 1990).

The computation of the diversion from Lake Michigan by the State of Illinois for WY86 was undertaken as a joint effort between NIPC (under contract to the Corps of Engineers) and the Corps of Engineers. Significant revisions to the diversion accounting procedures were undertaken to account for changes in the diversion area attributable to TARP (Tunnel and Reservoir Plan). These revisions will be addressed latter in this report.

DIVERSION ACCOUNTING PROCEDURES

The diversion from Lake Michigan that is accountable to the State of Illinois is calculated by measuring the flow in the Chicago Sanitary and Ship Canal at Romeoville and deducting flows that do not constitute Lake Michigan diversion and are not accountable to the State of Illinois. Finally, additions are made to the Romeoville record for diversions that are not discharged to the canal. The deductions include groundwater water supply pumpage whose effluent is discharged to the canal, runoff from the Des Plaines River watershed that is discharged to the canal, Lake Michigan water supply pumpage from Indiana that is discharged to the canal, and water supply pumpage from Lake

Michigan used for Federal facilities that is discharged to the canal. The additions to the Romeoville record include flows diverted from the canal upstream of Romeoville, and Lake Michigan water supply whose effluent is not discharged to the canal. This procedure represents the accounting method required by the Supreme Court Decree.

The format of the diversion accounting tables have been revised for WY86 due to the streamlining of the computational process and to make the results easier to interpret. The diversion accounting results are presented as a series of columns that are listed in Table 1. Column 1 through Column 3 compute the total flow in the Sanitary and Ship Canal. Column 4 through Column 7 presents the deductions from the Canal system flows with the total deduction being presented in Column 8. Column 9 presents the additions to the Canal system record. Column 10 is the computed Lake Michigan diversion accountable to Illinois and is equal to the canal system flow minus the deductions plus the additions. Columns 11 through 13 are independent flow estimates for the three sources of diversion: water supply pumpage from Lake Michigan, runoff from the diverted Lake Michigan Watershed, and direct diversion through the lakefront structures. Column 11 through Column 13 are not used in the diversion calculation but are included as another estimate of the diversion for verification of the accounting flows in Column 10. The sum of Column 11 through Column 13 should theoretically equal the flow in Column 10.

In addition to the diversion calculations presented in the 13 columns, 13 computational budgets are prepared as input to the diversion calculation and to verify the estimated flows that cannot be measured. A summary of these budgets is presented in Table 2. Budgets 1 and 2 do not compare simulated to measured flows but are summations of critical water supply pumpage data. Budget 3 through Budget 6 partition stream gage records into runoff and sanitary/industrial discharge components to estimate a portion of the runoff from the diverted watershed that is used as input to Column 13, "Runoff from the Diverted Lake Michigan Watershed." Budget 7 through Budget 12 compare simulated to measured flows at MWRDGC facilities. These budgets are for verification of the diversion accounting procedures and give an indication of the accuracy of the diversion accounting. Budget 13 compares canal system inflows and outflows.

Table 1

Description of the Diversion Accounting Columns

Column No.	Description
1	Chicago Sanitary and Ship Canal (CSSC) at Romeoville AVM Gage Record
2	Diversion from the CSSC above the Romeoville AVM Gage
3	Total Flow Through the CSSC
4	Groundwater Pumpage Discharged into the CSSC and Adjoining Channels
5	Water Supply Pumpage from Indiana Reaching the CSSC
6	Runoff from the Des Plaines River Watershed which Reaches the CSSC
7	Lake Michigan Pumpage by Federal Facilities which Discharge to the CSSC and Adjoining Channels
8	Total Deduction from the CSSC Romeoville AVM Gage Record
9	Lake Michigan Pumpage Which is not Discharged into the CSSC
10	Total Diversion Accountable to the State of Illinois
11	Pumpage from Lake Michigan Which is Accountable to State of Illinois
12	Runoff from the Diverted Lake Michigan Watershed
13	Direct Diversions Through Lake Front Control Structures Which is Accountable to the State of Illinois

Table 2

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
1	Diverted Lake Michigan Pumpage	This budget sums Lake Michigan water diverted by the State of Illinois in the form of municipal and industrial water supply. The results of this budget are used in Column 11.
2	Groundwater Discharged to the CSSC	This budget sums groundwater pumpages that are discharged to the CSSC. The results of this budget are used in Column 4.
3	North Branch Chicago River at Niles, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 13 and Column 12.
4	Little Calumet River at the IL-IN State Line	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 13 and Column 12.
5	Thorn Creek at Thornton, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 13 and Column 12.
6	Little Calumet River at South Holland, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 13 and Column 12.
7	MWRDGC Northside Water Reclamation	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Northside Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Northside service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used on Budget 13 and Columns 6 and 12.

Table 2 (cont)

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
8	MWRDGC Upper Des Plaines Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Upper Des Plaines Pumping Station. This budget provides a calibration point to verify models of the Des Plaines River watershed
9	MWRDGC Mainstream TARP Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Mainstream TARP Pumping Station. The results of this simulation are used in Budgets 10 and 13 and Columns 6 and 12. The budget also provides internal verification of the accounting procedures.
10	MWRDGC Stickney Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Stickney Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Stickney service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 13 and Columns 6 and 12.
11	MWRDGC Calumet Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Calumet Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Calumet service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 13 and Columns 6 and 12.

Table 2 (cont)

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
12	MWRDGC Lemont Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Lemont Water Reclamation Facility. The simulations estimates the runoff from portions of the Des Plaines River watershed within the Lemont service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 13 and Column 6.
13	Chicago Canal System	This budget performs a water balance of the Chicago Canal System which includes the CSSC and adjoining channels. This budget provides a verification point for the accounting procedures.

REVISIONS TO THE LAKE MICHIGAN DIVERSION ACCOUNTING PROCEDURES

The primary revisions to the diversion accounting procedure included modeling of the mainstream TARP (Tunnel and Reservoir Plan) Pumping Station and the revision of the regression equations that estimate daily AVM discharge at Romeoville on the Sanitary and Ship Canal during periods when the AVM is not operational. Additionally, several minor revisions were incorporated in the budget and column computations to streamline the diversion computations. These minor revisions do not significantly affect the computed diversion.

One revision to the diversion accounting procedures that affects the computed diversion is the inclusion of modeling of the Mainstream TARP Pumping Station. TARP is a comprehensive flood control and pollution control plan to alleviate the adverse effects of overflows on the waterways and Lake Michigan in the Chicago area. TARP is designed to capture sewage that would be conveyed into streams with runoff in the form of combined sewer overflows from the 375 square miles of combined sewer area within the MWRDGC service basin. The introduction of the Mainstream portion of the TARP system affects the methods employed to compute Illinois' diversion from Lake Michigan. Combined sewer overflows which prior to TARP discharged into a specific waterway, may now be discharged into a different waterway via the TARP Tunnels. In 1986, only Phase 1 of Mainstream TARP was in operation. A more detailed discussion of the Mainstream TARP modeling is presented in the section titled "Budget 9: Mainstream TARP" later in this report.

The second significant change to the diversion accounting procedure included the use of revised regression equations to estimate AVM discharge on days that the AVM is not operational. Development of these equations is discussed further in the section titled "Column 1: Chicago Sanitary and Ship Canal (CSSC) at Romeoville, USGS AVM Gage Record" presented later in this report.

ACCOUNTING RESULTS

The WY86 diversion accounting monthly summary of flows is presented in Table 3. Table 3 shows the total WY86 Lake Michigan diversion accountable to the State of Illinois is 3,751.1 cfs (Column 10). This is 551.1 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average, rounded to the nearest cfs, (Table 4) beginning with WY81 is 3,410 cfs. The cumulative deviation from the 3,200 cfs average is -1,261 cfs-years. The negative cumulative deviation indicates a water allocation debt and the maximum allowable debt is 2,000 cfs-years. Tabular data on daily diversion flows in presented in Appendix A.

Table 3

Lake Michigan Diversion Accounting – WY 1986

Summary of Diversion Flows (cfs)

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13
OCT 85	4318.5	0.3	4318.8	123.4	74.5	181.4	1.6	381.0	28.4	3966.2	1573.1	717.9	895.1
NOV 85	5244.1	0.3	5244.4	152.7	70.0	506.9	1.8	731.3	30.2	4543.3	1533.4	2395.7	296.9
DEC 85	3347.0	0.2	3347.2	116.7	76.4	200.7	1.7	395.4	26.3	2978.1	1563.2	829.1	161.4
JAN 86	2647.5	0.3	2647.8	114.2	75.4	114.4	2.4	306.4	27.0	2368.4	1584.9	376.4	140.9
FEB 86	3622.8	0.3	3623.1	136.9	77.5	246.0	2.4	462.8	28.5	3188.8	1586.8	1075.3	160.2
MAR 86	3482.9	0.2	3483.2	127.9	74.9	216.2	2.2	421.3	28.4	3090.3	1596.2	952.9	157.2
APR 86	3098.4	0.3	3098.7	112.7	79.1	72.0	2.0	265.8	28.3	2861.2	1646.6	341.3	355.9
MAY 86	3773.2	0.4	3773.6	121.8	82.8	117.1	1.9	323.6	30.2	3480.2	1723.8	754.9	468.1
JUN 86	4570.6	0.5	4571.0	132.9	89.6	121.7	2.0	346.3	31.2	4255.9	1858.2	899.7	803.6
JUL 86	5425.8	0.6	5426.4	128.0	98.3	163.2	2.3	391.8	33.4	5068.0	2142.4	838.9	1572.0
AUG 86	4650.4	0.6	4651.0	120.3	98.5	40.4	2.0	261.1	32.3	4422.2	2037.7	277.4	1599.1
SEP 86	5181.1	0.5	5181.6	150.2	87.5	191.3	1.8	430.8	32.2	4782.9	1825.2	1118.4	1334.0
WY 86	4113.1	0.4	4113.4	128.0	82.1	179.9	2.0	392.0	29.7	3751.1	1723.8	876.5	665.8

COMPUTATIONS:

1. COLUMN 3 EQUALS THE SUM OF COLUMN 1 AND COLUMN 2.
2. COLUMN 8 EQUALS THE SUM OF COLUMN 4 THROUGH COLUMN 7.
3. COLUMN 10 EQUALS COLUMN 3 MINUS COLUMN 8 PLUS COLUMN 9.

DEDUCTIONS FROM THE ROMEOVILLE GAGE RECORD

ADDITIONS TO THE ROMEOVILLE GAGE RECORD

NOTES:

1. ALL VALUES ARE ROUNDED TO THE NEAREST TENTH.
2. MATHEMATICAL COMPUTATIONS BETWEEN COLUMNS UTILIZE UNROUNDED VALUES.
3. AVERAGE VALUES FOR WY86 WERE COMPUTED USING DAILY VALUES.

Table 4

Status of the State of Illinois' Diversion from Lake Michigan Under the 1980 Modified U.S. Supreme Court Decree

Accounting Year	Certified Flow, cfs	Running Average, cfs	Cumulative Deviation, cfs
1981	3,106	3,106	+ 94
1982	3,087	3,097	+ 207
1983	3,613	3,269	- 206
1984	3,432	3,309	- 438
1985	3,472	3,342	- 710
1986	3,751	3,410	- 1,261

DISCUSSIONS OF RESULTS

The following is a discussion of the column functions and computational budgets. The discussion of the column functions describes the purpose of each column as well as some observations on the WY86 values in the columns. The discussion of the computational budgets presents the purpose of each budget and the results of the budget flow balances. The results of the computational budgets are used in the diversion calculations with seven budgets are used to verify the diversion simulation models. The columns are discussed first followed by the discussion of the budgets.

COLUMNS

The columns display the components of the diversion calculation and include the Romeoville flow as well as the various deductions and additions to the Romeoville record. The final three columns display the three diversion components (Lake Michigan pumpage accountable to Illinois, runoff from the diverted watershed, and direct diversion through the lakefront control structures) and the sum of the three columns should theoretically equal the Romeoville based diversion calculation. A comparison of the sum of these three columns to the calculated diversion is presented in the discussion of Column 11 through Column 13.

COLUMN 1: CHICAGO SANITARY AND SHIP CANAL (CSSC) AT ROMEOVILLE, USGS AVM GAGE RECORD

The discharge at Romeoville for WY86 is 4,113.1 cfs. The AVM was inoperable during WY86, therefore the flow at this accounting site was calculated from the regression equations. It was determined previously that the regression equations using MWRDGC reported Lockport flows more accurately estimates the flow in the canal at Romeoville than the MWRDGC Lockport flows alone (USACE, 1989).

The regression equations used to estimate AVM discharge during periods when the AVM was inoperable were revised by the USGS during a study performed for the Corps in December 1992. The study was performed in order to incorporate AVM discharge flow revisions into the regression equations as well as to statistically compare the performance of the two different AVMs, the Sarasota AVM (12 June 1984 - 3 November 1988) and the ORE AVM that became operable on 17 November 1988. Modifications to the AVM flow record were the result of corrections to the cross sectional area that were determined by measurement of the channel cross section at Romeoville in 1991. The period of record used in developing the revised regression equations was from WY86 through WY91. The equations were used to estimate daily-mean discharge at the AVM for the 545 days when the AVM was not operational from WY86 through WY91. It was determined that a single set of regression equations were valid for the entire period since it was statistically shown that the two different AVMs performed similarly. The complete development of the final regression equations can be found in the USGS report tentatively titled "Discharge and Regression Analyses for Acoustical Velocity Meter Data for the Chicago Sanitary and Ship Canal at Romeoville, Illinois." The final publication of this report should be available in the spring of 1993. The final regression equations developed in that report are as follows:

When flows at Lockport are through the turbines only,

$$(1)\quad Q_{AVM} = (1.1270 \times Q_{TLL}) + 75.48$$

When flows at Lockport are through the turbines and powerhouse sluice gates with sluice gate flow less than 5000 cfs,

$$(2)\quad Q_{AVM} = (1.1270 \times Q_{TLL}) + (0.6842 \times Q_{PHSG}) + 219.7$$

When flows at Lockport are through the turbines, powerhouse sluice gates, and controlling works or when flow through the powerhouse sluice gates is greater than 5000 cfs.

$$(3)\quad Q_{AVM} = (1.1270 \times Q_{TLL}) + (0.4361 \times Q_{PHSG}) + (0.3228 \times Q_{CW}) + 1086$$

Where: Q_{AVM} = Estimated AVM discharge.
Q_{TLL} = MWRDGC reported flow through the Lockport turbines and locks plus leakage.
Q_{PHSG}= MWRDGC reported flow through the Lockport powerhouse sluice gates.
Q_{CW} = MWRDGC reported flow through the Lockport controlling works.

COLUMN 2: DIVERSIONS FROM THE CSSC ABOVE THE GAGE

Argonne Laboratories was the only diversion from the Chicago Sanitary and Ship Canal water upstream of the Romeoville gage in WY86. The average withdrawal for WY86 is 0.4 cfs.

COLUMN 3: TOTAL FLOW THROUGH THE CSSC

Column 3 is the sum of Column 1 and Column 2 and represents the total flow entering the canal system. The average canal flow is 4,113.5 cfs for WY86.

COLUMN 4: GROUNDWATER DISCHARGED TO THE CSSC AND ADJOINING CHANNELS

Column 4 is the effluent whose source is groundwater water supply pumpage by communities, industrial users, and other private users as reported by the Illinois State Water Survey (ISWS). It also includes the groundwater seepage into the TARP system that is discharged to the canal. This quantity is determined by summing all reported groundwater sources in the area tributary to the canal and the estimated groundwater seepage into the Mainstream TARP system (Budget 9). This total is then adjusted by subtracting the groundwater normally tributary to the canal that is contained in the combined sewer overflows that discharge to the Des Plaines River and other watercourses not tributary to the CSSC. This method prevents double accounting of the combined sewer overflow portion of the groundwater supply pumpage.

Using ISWS groundwater records, groundwater pumpages were assumed to reach the CSSC and adjoining channels if they were located in the diverted Lake Michigan watershed in Illinois or if they were located within MWRDGC service boundaries in which their effluent was discharged into the CSSC and adjoining channels. Groundwater seepage into the Mainstream TARP system was determined through simulation and is discussed further in Budget 9. The groundwater constituent of combined sewer overflows is determined entirely thorough simulation.

Groundwater pumpage from the Lake Michigan watershed whose effluent is discharged to the canal is a deduction except to the extent that the groundwater sources are recharged by Lake Michigan. Current piezometric levels indicate that groundwater is discharging to the lake. Therefore, groundwater pumpage from within the Lake Michigan Watershed and reaching the canal continues to be a deduction. Research literature will be reviewed periodically to verify this assumption.

Column 4 represents a deduction from the Romeoville record and averaged 128.0 cfs for WY86. Groundwater pumpage tributary to the canal is composed of 39.8 cfs of groundwater pumpage from the Lake Michigan watershed, 35.9 cfs of groundwater pumpage from outside of the Lake Michigan watershed, and 52.5 cfs of groundwater seepage into the TARP system. The total of these three components is 128.2 cfs. However, the deduction from the Romeoville gage record is 128.0 cfs since 0.2 cfs of the groundwater supply pumpage was determined, through simulation, to be discharged to the Des Plaines River and other watercourses not tributary to the CSSC in the form of combined sewer overflows.

COLUMN 5: WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CHICAGO SANITARY AND SHIP CANAL

Column 5 represents the computation of Indiana water supply reaching the canal through the Grand Calumet and the Little Calumet Rivers. In the case of the Little Calumet River, a drainage divide exists east of the confluence with Hart Ditch. Therefore, flows from Hart Ditch, including virtually all dry weather flows, normally flow westward into Illinois. Under high flow conditions, the drainage divide may shift westward and a portion of the Hart Ditch flows may be diverted eastward to Burns Ditch and ultimately to Lake Michigan. However, it is believed that the occurrence in the shift in the drainage divide is infrequent and the flow that is diverted eastward is insignificant. Therefore, it is assumed that all effluent discharged into Hart Ditch and the Little Calumet River west of the divide flow westward. For WY86, total flow in the Little Calumet River was 58.1 cfs, with 4.6 cfs of that flow being determined to be water supply.

The Grand Calumet River has a summit. On one side of the summit, the flow is toward Lake Michigan. On the other side of the side of the summit, the flow is toward the Calumet Sag Channel. However, the location of the summit is variable and highly influenced by Lake Michigan levels (USGS, 1984). Thus the calculation of this deduction from the Romeoville record is influenced by Lake Michigan levels. In the absence of a stream gaging station on the Grand Calumet River to measure westward flow into Illinois, flow is computed based on a statistical relationship of which the principle variable is lake levels.

Flow in the Grand Calumet River is estimated to be in excess of 90% sanitary effluent. Therefore, it is assumed that The portion of this flow that is attributable to domestic water supply is equal to the sum of the daily water supply for East Chicago, Hammond, and Whiting unless this sum is greater than the flow in the Grand Calumet River. In the case that the combine water supply for these communities is in excess of the flow in the Grand Calumet River, it is assumed that the flow consists entirely of effluent that originates from water supply.

The total Grand Calumet flow reaching Illinois in WY86 was computed as 166.9 cfs. It was determined that 77.5 cfs of that flow was water supply pumpage. Therefore, the total WY86 Indiana water supply deduction, including the flow from the Little Calumet and Grand Calumet Rivers is 82.1 cfs.

COLUMN 6: RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CHICAGO SANITARY AND SHIP CANAL

The WY86 average discharge of Des Plaines River watershed runoff reaching the canal (Column 6) is 179.9. The infiltration and inflow discharged to the water reclamation plants is 105.5 cfs, the infiltration and inflow reaching the canal through combined sewer overflows is 10.2 cfs, and the runoff from the Lower Des Plaines and Summit Conduit areas is 64.2 cfs. The deduction is largely determined by simulation but it is also influenced by the O'Hare basin flow transfer. O'Hare Basin flow transfer will be discussed in more detail later in the report.

COLUMN 7: LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES WHICH DISCHARGE TO THE CSSC

Column 7 represents Lake Michigan diversions for Federal use, not chargeable to State of Illinois, and is typically comprised of water supply used by federal facilities. Column 7 represents a deduction from the Romeoville record and the amount of the WY86 deduction is 2.0 cfs.

COLUMN 8: TOTAL DEDUCTIONS FROM THE CSSC ROMEOVILLE GAGE RECORD

Column 8 is the sum of Columns 4, 5, 6, and 7 and represents the total deduction from the Romeoville record. The total deduction for WY86 is 392.0 cfs.

COLUMN 9: LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL

This Column represents water supply pumpage from Lake Michigan that is not discharged to the canal. The water supply pumpage not discharged to the canal is composed of two components:

(1) Water supply used by communities serviced by water reclamation facilities that do not discharge to the CSSC (27.9 cfs)

(2) The sanitary portion of combined sewer overflows that do not discharge to the CSSC that is attributable to Lake Michigan domestic water supply (1.8 cfs).

The communities that make up the flow in the first component are suburbs whose treated effluent is discharged to the Des Plaines River and other watercourses not tributary to the CSSC. These communities include Elk Grove Village, Hoffman Estates, Mount Prospect, Schaumburg, Hanover Park, Rolling Meadows, Streamwood, Arlington Heights, Buffalo Grove, Palatine, Wheeling, Lincolnshire, Riverwoods, Libertyville, Illinois Beach State Park, Winthrop Harbor, Zion, Waukegan, 76 percent of North Chicago, and 38.2 percent of Des Plaines. It should be noted that the Lake Michigan water supply component of the O'Hare flow transfer is subtracted from the total Lake Michigan water supply of the above communities since (1) the O'Hare flow transfer is treated at the Northside WRP that discharges sanitary effluent that is tributary to the canal and (2) the entire Lake Michigan component of the O'Hare flow transfer is from communities contained in the above list. The flow for these communities are measured while the flow of the second component is derived from simulation. Column 9 represents an addition to the Romeoville record and the total WY86 addition is 29.7 cfs.

COLUMN 10: TOTAL DIVERSION

Column 10 is equivalent to Column 3 with the deduction of Column 8 and the addition of Column 9. The total diversion for WY86 is 3,751.1 cfs. This amount is 551.1 cfs greater than Illinois's long term diversion allocation of 3,200 cfs. The 40 year running average diversion, beginning with WY81, is 3,410 cfs and the cumulative deviation from the 3,200 cfs allocation is -1,261 cfs. The negative deviation indicates that the cumulative diversion is greater than an average of 3,200 cfs for the period.

COLUMN 11 THROUGH COLUMN 13: LAKE MICHIGAN DIVERSION COMPONENTS

Column 11 through Column 13 represent the three Lake Michigan diversion components (Lake Michigan pumpage accountable to Illinois, runoff from the diverted Lake Michigan watershed, and direct diversion through the lakefront structures). The sum of the columns (3,266.1 cfs) should theoretically equal the total diversion as shown in Column 10 (3,751.1 cfs) with one exception. The Romeoville record receives effluent that is assumed to contain only 90% of the water supply pumpage while Column 11, Lake Michigan pumpage accountable to Illinois, does not account for consumptive use. This is based on a consumptive loss (water supply pumpage that is consumed or lost prior to reaching the water reclamation facilities) estimate of 10% of the water supply pumpage (International Great Lake Diversion Consumptive Use Study Board, 1981).

Because the diversion estimate from Columns 11 - 13 is based on simulation, suspect ratings of the lakefront structures, and simple flow separation techniques, the estimate is not expected to be as accurate as the AVM based calculations. However, a difference between estimates of 485.0 cfs or 12.9% is a marginal balance. The difference between these two methods of estimating the diversion is greater than should be expected. This discrepancy becomes even greater when consumptive use is accounted for in Column 11. The discrepancy in these two estimates is related to the balance in Budget 13, discussed in a subsequent section, and potential sources of the discrepancy are addressed in that budget discussion.

Using the quantities derived from these three columns, approximately 52.8% of the WY86 Illinois diversion is attributable to pumpage from Lake Michigan for domestic water supply. Runoff from the diverted Lake Michigan Watershed accounted for 26.8% of the diversion and direct diversion through the lakefront structures accounted for 20.4% of the diversion. A more detailed breakdown of these percentages is shown in Table 5 and Figure 2.

Table 5

Breakdown of the Diversion by the State of Illinois
Based on Columns 11 Through 13

Category	Flow	Percentage
Lake Michigan Pumpage by the State of Illinois	1,723.8 cfs	52.8 %
Runoff from the Diverted Lake Michigan Watershed	876.5 cfs	26.8 %
Direct Diversions		
Lockages	179.0 cfs	5.5 %
Leakages	42.6 cfs	1.3 %
Navigation Makeup Flow	142.2 cfs	4.4 %
Discretionary Flow	302.0 cfs	9.2 %

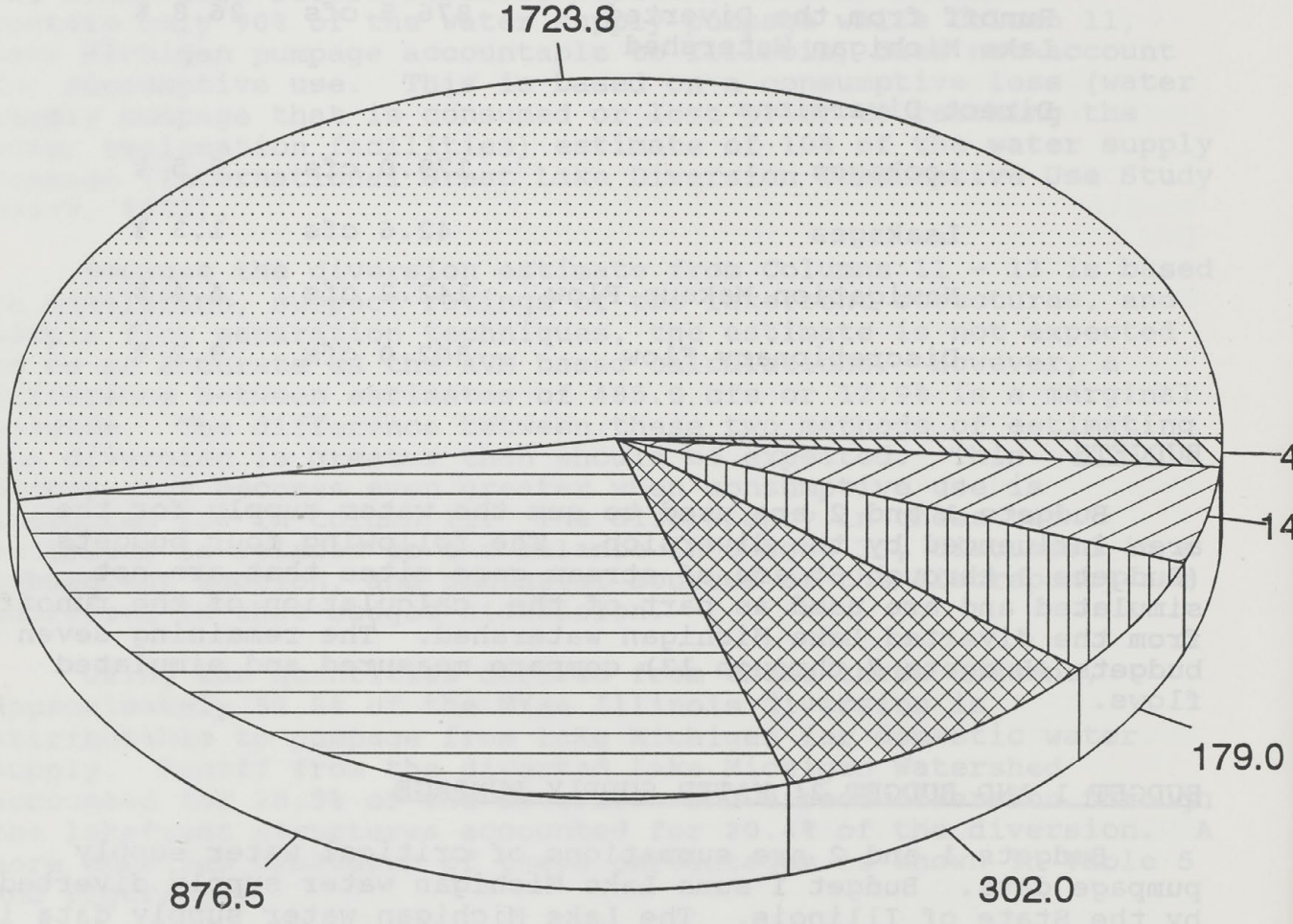
BUDGETS

Budgets 1 and 2 are used to sum the water supply for the area influenced by the diversion. The following four budgets (Budgets 3 through 6) are of stream gage sites that are not simulated and are used as part of the calculation of the runoff from the diverted Lake Michigan watershed. The remaining seven budgets (Budgets 7 through 13) compare measured and simulated flows.

BUDGET 1 AND BUDGET 2: WATER SUPPLY PUMPAGE

Budgets 1 and 2 are summations of critical water supply pumpage data. Budget 1 sums Lake Michigan water supply diverted by the State of Illinois. The Lake Michigan water supply data is supplied by the state as daily values for primary users and monthly data for secondary users. Budget 2 sums groundwater pumpages in the Lake Michigan and Des Plaines River watersheds that are diverted to the Chicago Sanitary and Ship Canal. Groundwater pumpage data is received as a total annual withdrawal based on calendar years.

Figure 2
Component Breakdown of Illinois' Diversion
Based on Columns 11 through 13



DIVERSION COMPONENTS			
WATER SUPPLY	52.8 %	RUNOFF	26.8 %
DISCRETIONARY	9.2 %	LOCKAGES	5.5 %
NAV MAKEUP	4.4 %	LEAKAGES	1.3 %

BUDGET 1: DIVERTED LAKE MICHIGAN WATER SUPPLY

Budget 1 represents the summation of Lake Michigan pumpage accountable to the State of Illinois. For WY86, the average annual Lake Michigan pumpage accountable to Illinois is 1,723.8 cfs.

BUDGET 2: GROUNDWATER DIVERTED TO THE CHICAGO SANITARY AND SHIP CANAL

Budget 2 is groundwater water supply pumpage by communities, industrial users, and other private users, as reported by the Illinois State Water Survey (ISWS), whose effluent is discharged to the canal. This quantity is determined by summing all reported groundwater sources in the area tributary to the canal less groundwater not discharged to the canal in the form of combined sewer overflows.

Using ISWS groundwater records, groundwater pumpages were assumed to reach the CSSC and adjoining channels if they were located in the diverted Lake Michigan watershed in Illinois or if they were located within MWRDGC service boundaries in which their effluent was discharged into the CSSC and adjoining channels.

The total groundwater pumpage by communities, industrial users, and other private users whose sanitary effluent is tributary to the canal is 75.7 cfs for WY86. It was determined through simulation that 0.2 cfs of this flow never reached the canal. Instead it was discharged to the Des Plaines River or other watercourses not tributary to the canal in the form of combined sewer overflows. The total groundwater pumpage reaching the canal represents an increase of 1.3 cfs from WY85 to WY86.

BUDGETS 3 THROUGH BUDGET 6: STREAM GAGING STATIONS

Budgets 3 through 6 are used to make estimates of runoff from portions of the diverted Lake Michigan watershed. Sanitary and other point source flows are subtracted from the stream gaging record to develop the runoff estimates. The runoff estimates are used in Column 12. The flow at the stream gaging sites is also part of Budget 13, the canal system budget. Table 6 presents the estimated runoff from these budgets. It should be noted that Budgets 4 through 6 are a composite calculation of the runoff above the Little Calumet River at South Holland gage.

Table 6

Stream Gage Flow Separation

Budget	Location	Flow cfs	Sanitary cfs	Runoff cfs
3	North Branch Chicago River at Niles, IL	153.9	21.1	132.8
4	Little Calumet River at IL-IN State Line	58.1	3.6	54.5
5	Thorn Creek at Thornton, IL	91.7	17.7	74.0
6	Little Calumet River at South Holland, IL	167.2	19.5	147.7

BUDGETS 7 THROUGH BUDGET 12: MWRDGC WATER RECLAMATION FACILITIES

The budgets for the water reclamation plants compare the simulated flows to the measured inflows at the MWRDGC facilities and perform verifications of the diversion accounting program. The simulated flows were developed from an estimated sanitary flow with a daily, weekly, and monthly flow variation and from precipitation-based runoff simulations. The estimated sanitary flow input to the simulation model is based on the population estimates for each plant's service basin. Per capita sanitary flows are determined based on the service basin's water supply minus an assumed 10 percent consumptive loss. Simulated flows were compared with recorded inflows at each facility to assess the accuracy of the simulations.

The discussion of the budgets will concentrate on the results of each simulation, with the exception of Budget 9, as the development of these models have been discussed in previous reports. The discussion of Budget 9 will go in-depth into the development of the Mainstream TARP model that was incorporated into the Lake Michigan diversion accounting program for WY86. A summary of the simulation results is presented in Table 7.

TABLE 7

WY 1986 SUMMARY OF SIMULATION STATISTICS

Budget No.->	7	8	9	10	11	12	13
Description	Northside WRP (1)	Upper Des Plaines Pump Station (1)	Mainstream TARP Pump Station (2)	Stickney WRP (1)	Calumet WRP (1)	Lemont WRP (1)	Chicago Canal System Balance (1)
Mean Recorded Flow, cfs	451.2	83.1	110.5	1138.5	381.9	1.9	3467.8
Max. Recorded Flow, cfs	690.0	148.9	300.9	2277.2	461.0	3.0	11482.0
Min. Recorded Flow, cfs	310.8	36.5	18.3	719.4	210.4	1.2	1911.8
Mean Simulated Flow, cfs	429.0	70.8	84.5	1225.2	322.0	2.0	4115.9
Max. Simulated Flow, cfs	657.8	181.4	224.0	2569.7	660.0	5.4	10919.0
Min. Simulated Flow, cfs	312.9	43.0	42.7	847.1	211.0	1.3	1870.7
Mean S/R	0.95	0.85	0.77	1.08	0.84	1.05	1.19
Max. S/R	1.42	2.61	4.69	1.79	1.73	2.44	1.98
Min. S/R	0.63	0.38	0.29	0.64	0.58	0.56	0.57
Correlation	0.78	0.27	0.48	0.79	0.47	0.64	0.91

(1) Based on daily values.

(2) Based on weekly values.

BUDGET 7: NORTHSIDE WATER RECLAMATION FACILITY

Budget 7 analyzes the water balance at the MWRDGC Northside Water Reclamation Facility (Figure 3). Overall, the balance for WY86 of the inflow to the Northside facility is very good. The simulated to recorded flow ratio (S/R) for the Northside is 0.95, indicating that the simulated inflow volume is extremely close to the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.78, indicating that the model predicted the inflow hydrograph to the Northside facility satisfactorily.

BUDGET 8: UPPER DES PLAINES PUMP STATION

Budget 8 analyzes the water balance at Upper Des Plaines Pump Station (UDPPS) (Figure 4). The pump station budget is used to verify simulated flows. However it has no direct impact on the diversion calculation.

The balance at UDPPS for WY86 is poor. The simulated to recorded flow ratio (S/R) for the UDPPS is 0.85, indicating that the simulated inflow volume to UDPPS is close to the recorded inflow volume. However, the coefficient of correlation (R) simulated to recorded flow is 0.24, indicating the time series trends in the simulated inflow did not compare well with the time series trends of recorded inflow. The source of this discrepancy is unknown.

Based on this result and the plot of simulated and recorded inflow it appears that the recorded flow does not accurately reflect hydrologic conditions of the pump station service area. This may be due to problems with the flow measurement at the pump station. First, recorded flow data was only available for 227 days in WY86. This is attributable to meter malfunctions, problems with the recording charts, which made data reduction undoable, and various other reasons. In view of this significant quantity of missing data (38 % missing data), the quantitative analyses of the simulation are of limited value. Second, the accuracy of the flow meters at the pump station is questionable and unmetered bypass flows are a frequent occurrence. Therefore, total flow may not be measured in storm events and the recycling of flow is possible. Further investigation of the accuracy of flow measurement at the pump station is required to verify of the simulation procedures.

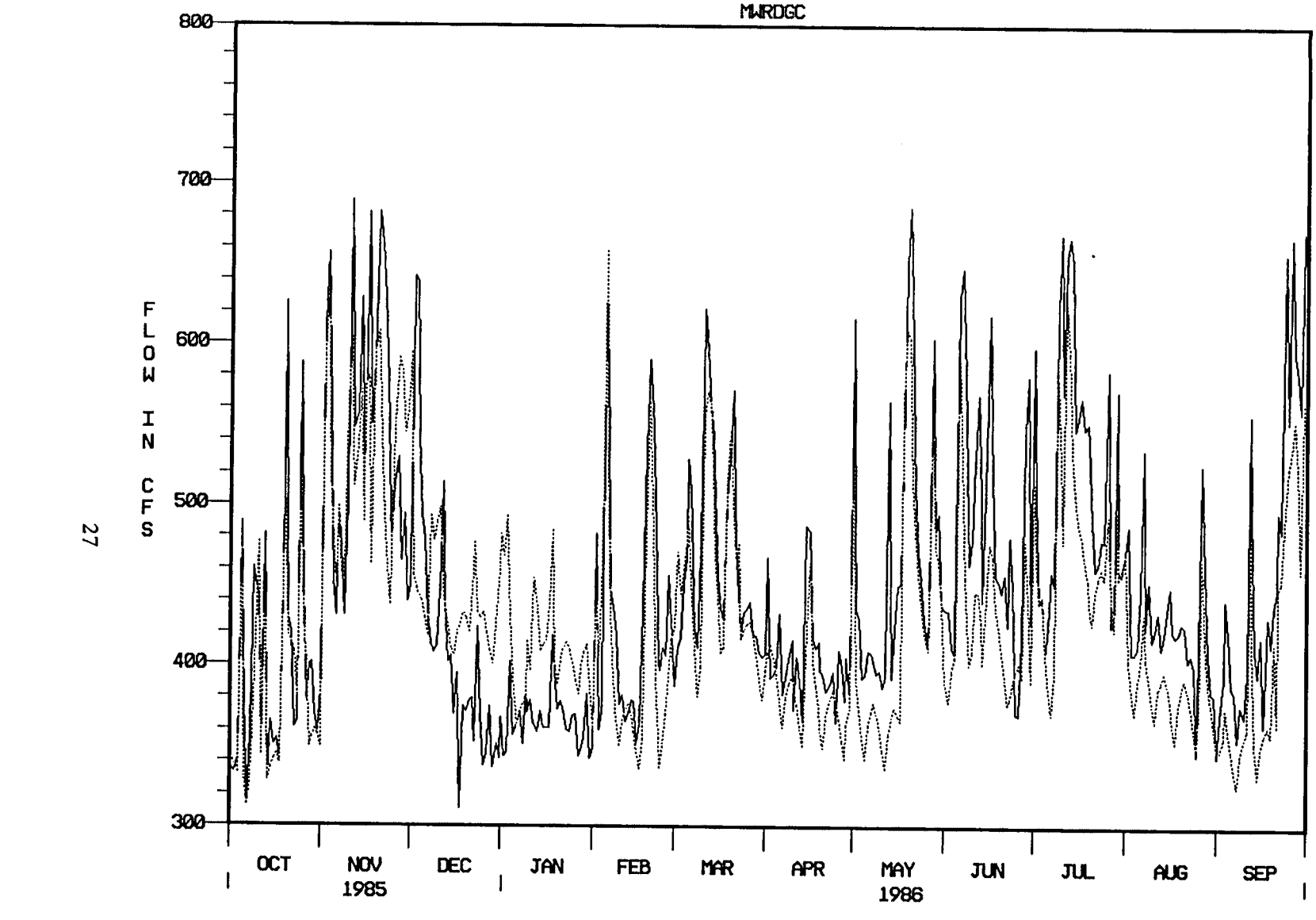


Figure 3

Budget 7 - Simulation of MWRDGC Northside Water Reclamation Facility

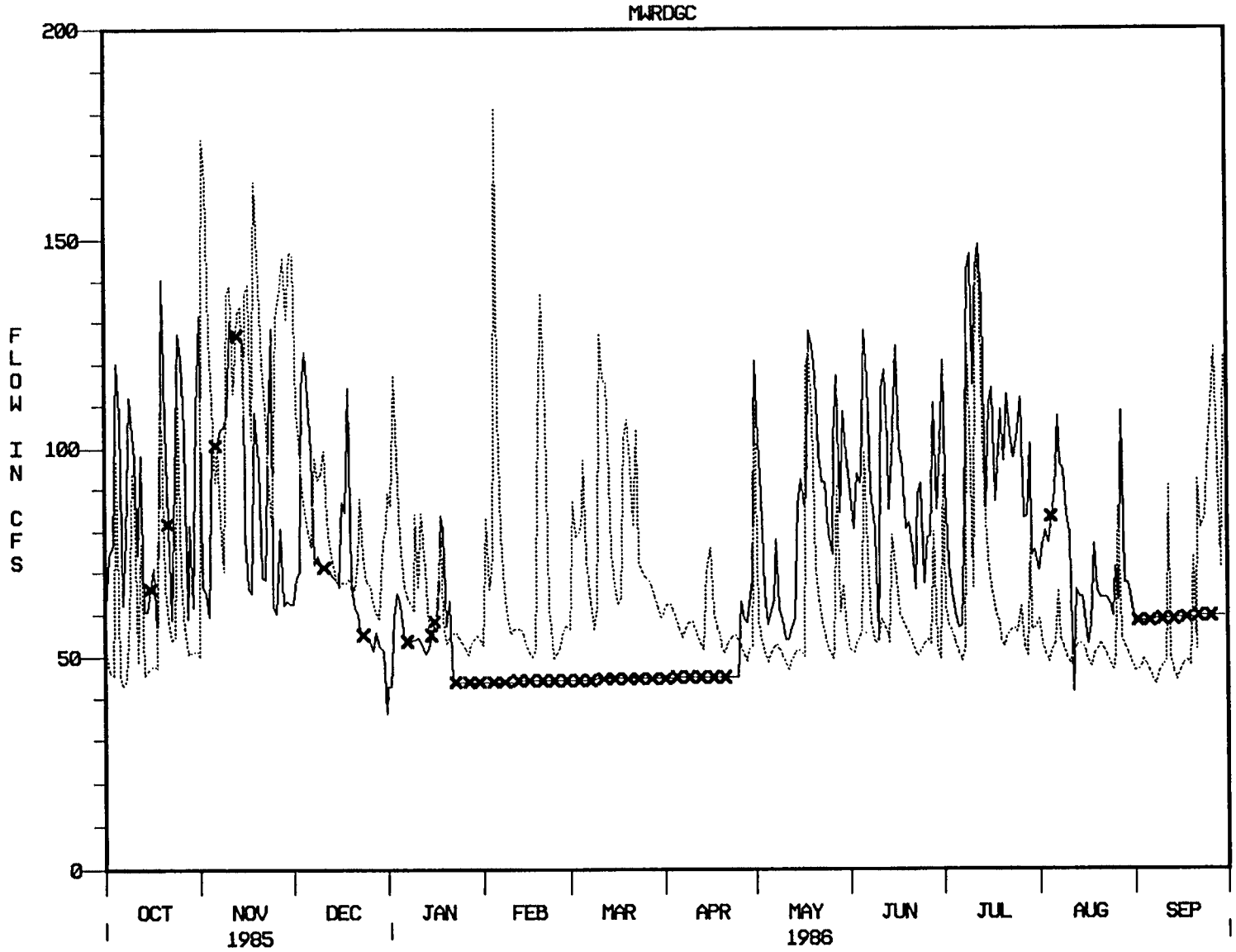


Figure 4

Budget 8 - Simulation of the MWRDGC Upper Des Plaines Pump Station

BUDGET 9: MAINSTREAM TARP

Budget 9 analyzes the water budget at the MWRDGC Mainstream TARP Pumping Station. The results of Budget 9 are used as input to Budget 10 in addition to providing a verification point for simulated flows.

The operation of the Mainstream TARP Pumping Station to Stickney was initiated in May, 1985. Removal of most of the bulkheads on the collector system was accomplished by October 1985 (Neubauer, 1990). Therefore, it was impractical to model Mainstream TARP prior to October 1985 due to the dynamics of the system as additional segments of Mainstream TARP were coming online when the bulkheads were removed.

Mainstream TARP extends from Wilmette, Illinois to McCook Illinois (Figure 5). It consists of large tunnels constructed 200 to 300 ft. below the North Shore Channel, the North and South Branches of the Chicago River, the Sanitary and Ship Canal with branches under the Chicago River and South Fork of the Chicago River. Additional branches extend west of Summit Conduit (Tunnel 13A).

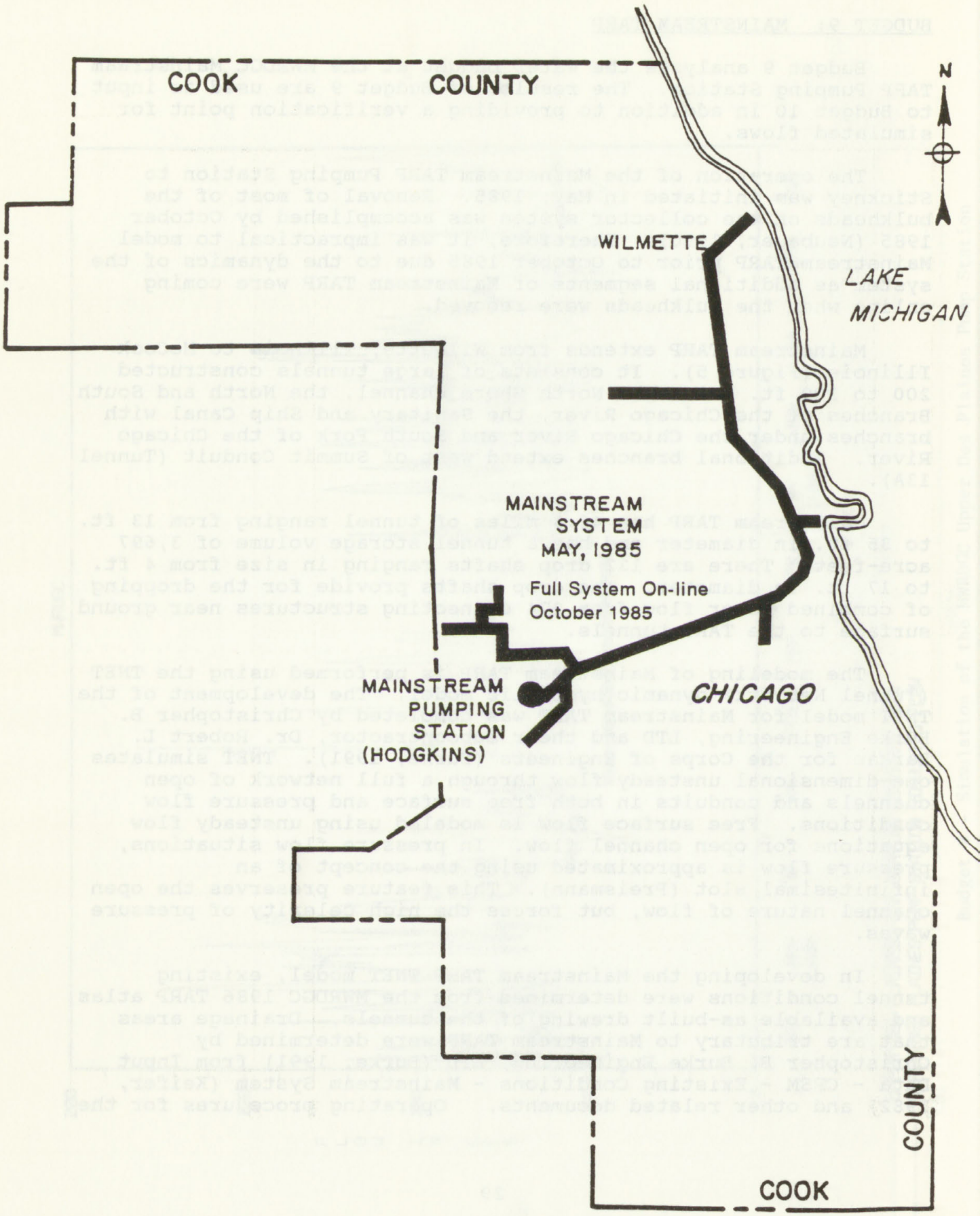
Mainstream TARP has 40.3 miles of tunnel ranging from 13 ft. to 35 ft. in diameter and has a tunnel storage volume of 3,697 acre-feet. There are 132 drop shafts ranging in size from 4 ft. to 17 ft. in diameter. The drop shafts provide for the dropping of combined sewer flow from 274 connecting structures near ground surface to the TARP tunnels.

The modeling of Mainstream TARP is performed using the TNET (Tunnel Network) dynamic hydraulic model. The development of the TNET model for Mainstream TARP was completed by Christopher B. Burke Engineering, LTD and their subcontractor, Dr. Robert L. Barkau for the Corps of Engineers (Burke, 1991). TNET simulates one-dimensional unsteady flow through a full network of open channels and conduits in both free surface and pressure flow conditions. Free surface flow is modeled using unsteady flow equations for open channel flow. In pressure flow situations, pressure flow is approximated using the concept of an infinitesimal slot (Preismann). This feature preserves the open channel nature of flow, but forces the high celerity of pressure waves.

In developing the Mainstream TARP TNET model, existing tunnel conditions were determined from the MWRDGC 1986 TARP atlas and available as-built drawing of the tunnels. Drainage areas that are tributary to Mainstream TARP were determined by Christopher B. Burke Engineering, LTD (Burke, 1991) from Input Data - CRSM - Existing Conditions - Mainstream System (Keifer, 1982) and other related documents. Operating procedures for the

Figure 5

Map of Mainstream TARP



Mainstream TARP were obtained from MWRDGC for Water Year 1986. These operating directives, for the December 10, 1985 through September 10, 1987, included guidelines for the operation of gated drop shafts, instructions for TARP pumping, and instructions for emergency conditions. Pumping capacity for both the Stickney Water Reclamation Facility and the Mainstream Pumping Station were obtained from MWRDGC as well (MWRDGC, 1990).

The operational data and pumping capacities obtained from MWRDGC were incorporated into the Mainstream TARP TNET model. Operational rules for gated drop shafts were incorporated in the form of a tunnel stage-percent drop shaft capacity rating curves referenced from index drop shafts. The curves were based on MWRDGC procedures regarding gate closures based on water surface elevation in the Mainstream TARP tunnels. A smooth curve over 4 ft. of elevation was used to prevent "slamming shut" of the gates. This unrealistic condition would cause severe wave oscillation in the tunnels and instability the numerical computations. The lower end of this curve, or the point at which gate closure begins, was derived from MWRDGC operational data.

Pumping from the Mainstream Pumping to the Stickney Water Reclamation Facility is determined based on the minimum of (1) available capacity at the Stickney Water Reclamation Facility and (2) pumping capacity at the Mainstream Pumping Station. Available capacity was determined as the difference between treatment capacity and simulated inflow from interceptor sewers.

Treatment capacity of the Stickney Water Reclamation Facility is variable. Normal pumping/secondary treatment capacity is about 2,227 cfs. Under high flow conditions, maximum pumping/ primary treatment capacity is about 2,738 cfs with flows exceeding secondary treatment capacity being bypassed to the Chicago Sanitary and Ship Canal. This is also contingent on the number of treatment batteries that are operational at any given time.

In the development of the Mainstream TARP TNET model, it is necessary to distinguish between conditions that would require only normal treatment capacity and those requiring maximum capacity. It was assumed that conditions requiring maximum treatment capacity would only occur in extreme hydrologic events. Therefore, an extreme hydrologic event was defined as occurring when the total combined sewer overflows into the Mainstream TARP system exceed 5,000 cfs. This became the change point between normal and maximum treatment capacities. When the composite combined sewer overflow routed to Mainstream TARP exceeds 5,000 cfs, then maximum treatment capacity conditions are applied.

Another factor in the development of the Mainstream TARP TNET model is the simulation of dry weather flow. Dry weather flow can consist of groundwater seepage and/or discharge from sewered areas that directly connect to Mainstream TARP. Through written and telephonic correspondence with MWRDGC, it was determined that flow to Mainstream TARP is derived strictly from interceptor relief points that are not open during dry weather (Sobanski, 1991). Also, MWRDGC reports that leakage into the sewer/TARP system for the Stickney Water Reclamation Facility is estimated to be between 0.75 and 1.0 MGD (1.2 to 1.5 cfs), which is an insignificant volume when compared with pumpage volume at the Mainstream Pumping Station for WY86. Therefore it was assumed that dry weather flow consisted entirely of groundwater seepage.

Design seepage in the tunnel is 0.05 million gallons per day per mile. Mainstream TARP has 40.3 miles of tunnel, giving a total design seepage of approximately 3.1 cfs. The Mainstream TARP TNET model was tested using a uniform distribution of flow within each reach of the tunnel network that resulted in the design groundwater seepage rate of 3.1 cfs. It was observed that the total simulated volume was significantly less than the recorded Mainstream Pumping Station discharge volume.

In MWRDGC correspondence dated 27 December 1990, MWRDGC reports that during dry weather conditions, dewatering Mainstream TARP requires approximately 100 million gallons of pumpage every three days. This translates into an average uniform inflow of approximately 51 cfs. The Mainstream TARP TNET model was tested using a uniform distribution of flow within each reach of the tunnel network that resulted in a groundwater seepage rate of 51.4 cfs. This resulted in a significant improvement of the water balance in the Mainstream TARP water balance.

Although effort was made to incorporate Mainstream TARP operating procedures into the TNET model, it was not feasible to incorporate all features of the operating procedures. First, operating procedures are divided into four categories, dry weather, "typical" precipitation event, "extreme" precipitation, and emergency operations. Dry weather operations tend to focus operating Mainstream TARP in the most economical fashion. Therefore, dry weather groundwater flows are allowed to accumulate, and are then pumped at night once there has been sufficient accumulation. Per MWRDGC correspondence, dry weather flows are normally pumped every three days and are pumped at night when costs for electrical service are reduced and normally requires the use of a high head pump for 10 hrs.

The Mainstream TNET model was developed to simulate MWRDGC procedures for pumping of dry weather flows. However, there are two major short comings of the model in simulating pumpage of dry weather flows. First the model cannot determine the optimum pumping time, therefore pumping can be initiated at any time if pumping is needed as indicated at the pump sense point. The pump sense point activates/deactivates the pumping algorithm of the model based on water surface elevation in the tunnel. Second, the TNET model cannot simulate the designated operation of a high head pump, but rather simulates based on available pumping capacity. Nevertheless, the TNET model did simulate dry weather operations of Mainstream TARP reasonable well. Based on a random sample of dry weather events, the average periodicity of pumping was 2.88 days, the average pumpage volume was 81.08 MGAL, and the average pumping time was 6 hrs.

A second limitation of the Mainstream TARP TNET model is the inability to "forecast" precipitation events. MWRDGC operational procedures call for the dewatering of the tunnel system of accumulated dry weather flow prior to a precipitation event to maximize storage of combined sewer overflows. The incorporation of a pseudo-forecast routine into the model would be helpful. However, the development of a pseudo-forecast algorithm into the model is logically complex and would require considerable effort and was therefore considered to be unfeasible at this time.

A third limitation of the Mainstream TARP model is the ability to change gated drop shaft operating procedures given the severity of the forecasted precipitation event. This again is attributable to the inability of the Mainstream TARP TNET model to "forecast" precipitation events. Therefore, gated drop shaft operating procedures for both "typical" and "extreme" precipitation events were evaluated to determine similarities in the procedures and to reduce the operating procedures to a single set of gate operating curves that would best encompass both conditions.

A fourth limitation is the limited number of sense points in the model, and the inability of the model to simulate gate closure based on an average water surface elevation within a tunnel reach. Incorporating a procedure based on improved sense point modeling would be more reflective of MWRDGC operating procedures and would provide for a better simulation.

In analyzing the balance at the Mainstream Pumping Station, weekly flows were used instead of daily flows. Days with no pumpage occur frequently. Therefore, it is not possible to compute a S/R ratio for these days.

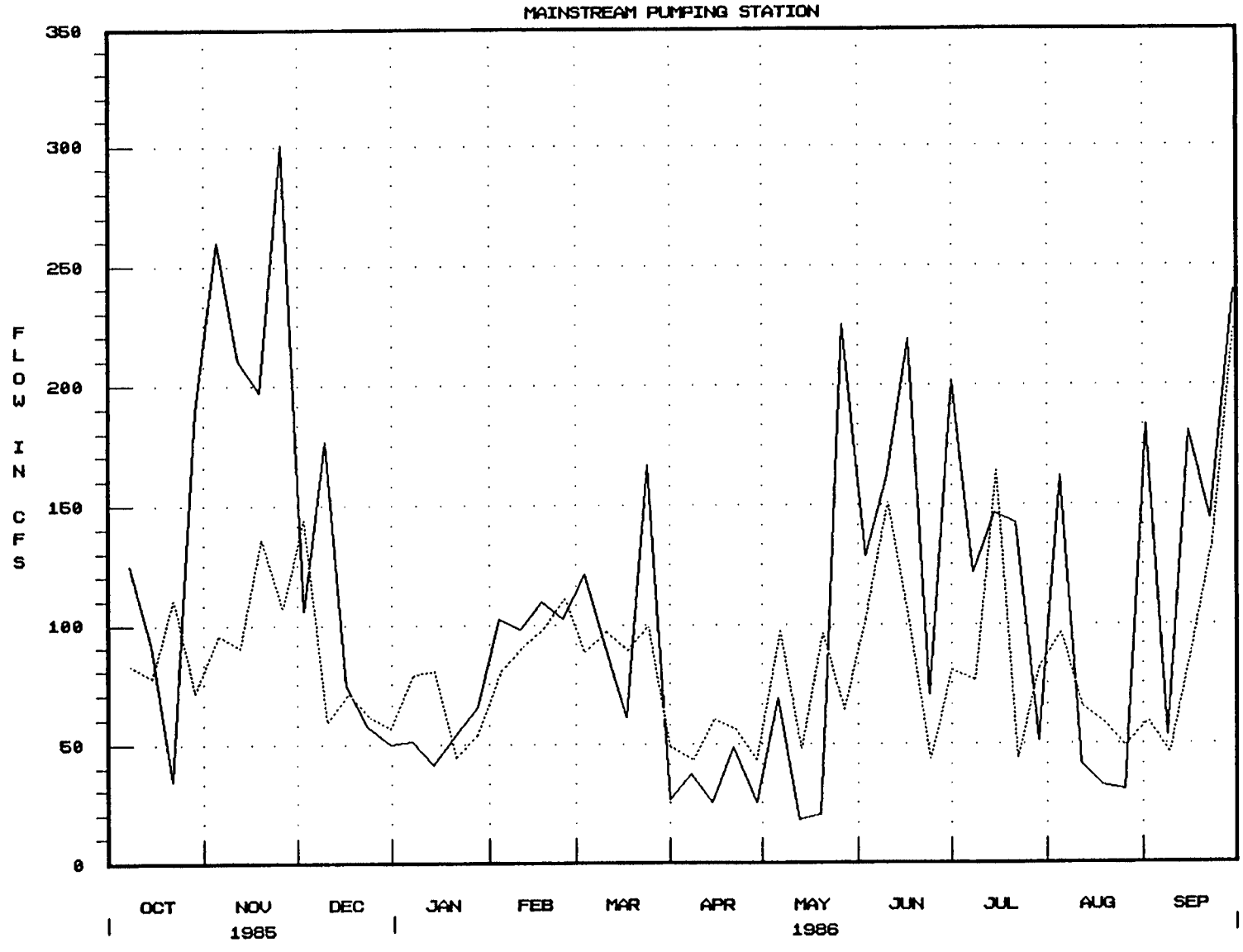
The balance for WY86 of the inflow to the Mainstream Pumping Station is fair. The simulated to recorded flow ratio (S/R) for the Mainstream Pumping Station is 0.77, indicating that the simulated inflow volume is less than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.48. This seems to indicate that the model does not satisfactorily predict the inflow hydrograph to the Mainstream Pumping Station.

Visually analyzing the plot of the simulated versus recorded flow at the pump station (Figure 6), it appears that the model responds similarly to recorded pumpage record. However, the model tends to have lower peak flows and a shorter duration hydrograph. Both of these factors result in the simulated pumpage volume being less than the recorded pumpage volume.

In summary, it appears that the simulation of the Mainstream TARP system is reasonable. However, there is concern regarding the consistent underestimation of pumpage volume and the difference in simulated pumpage and recorded pumpage time series. A review of MWRDGC information regarding Mainstream TARP indicates that bypass flows are discharged to TARP, when available, via drop shaft 11 (DSN 11). Further coordination with MWRDGC established that this is a frequent occurrence. This may account for the simulation of a pumpage volume that is less than the recorded pumpage volume. Records concerning the dates and pumpages back to TARP were not maintained for WY86. Therefore, data necessary to evaluate the impact of pumping back into TARP is not available. Therefore, it was decided that the model would not be adjusted, that may improve the simulation, to prevent double accounting of flows. This will be investigated further in the future to assess the affects of return flow to TARP on the Mainstream TARP TNET simulation results.

BUDGET 10: STICKNEY WATER RECLAMATION FACILITY

Budget 10 analyzes the water balance at the MWRDGC Stickney Water Reclamation Facility (Figure 7). This budget has undergone significant revision to include the modeling of Mainstream TARP (Budget 9). Simulated Mainstream TARP pumpages from Budget 9 were combined with simulated interceptor inflow to Stickney Water Reclamation Facility to derive the total simulated inflow to the Stickney Facility. Total simulated inflow was compared with recorded inflow to assess the accuracy of the simulation.


MAINSTREAM PUMPING STATION
FLOW IN CFS
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300
250
200
150
100
50
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OCT
NOV
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FLOW TO STICKNEY OBSERVED FLOW
FLOW TO STICKNEY SIMULATED FLOW

Figure 6

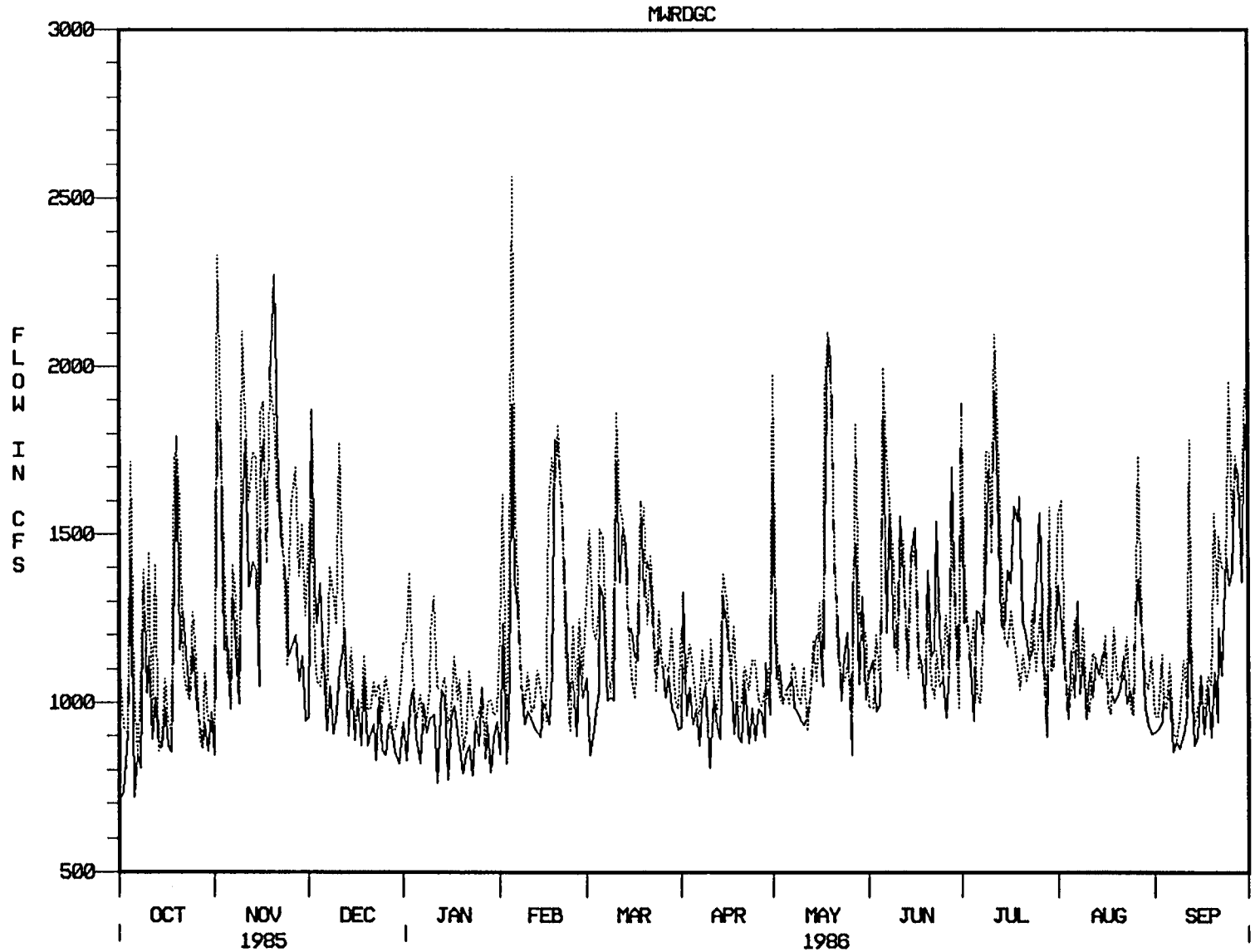


Figure 7

Budget 10 - Simulation of the MWRDGC Stickney Water Reclamation Facility

Overall, the balance for WY86 of the inflow to the Stickney facility is exceptionally good. The simulated to recorded flow ratio (S/R) for the Stickney is 1.08, indicating that the simulated inflow volume is slightly higher to the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.79, indicating that the model predicted the inflow hydrograph to the Stickney facility exceptionally well.

BUDGET 11: CALUMET WATER RECLAMATION FACILITY

Budget 11 analyzes the water balance at the MWRDGC Calumet Water Reclamation Facility (Figure 8). The annual simulated to recorded flow ratio for Calumet Water (S/R=0.84) is fair, but the daily S/R shows a high degree of variability (Range, S/R=0.58 to 1.73). The coefficient of correlation of simulated inflow to recorded inflow (R) is 0.47. Both the high variability in S/R and the poor correlation seem to indicate that the simulation does not provide a satisfactory representation of the hydrology and/or hydraulics of the Calumet service basin.

The hydraulic response to storm events at the Calumet facility was compared to that of the Northside and the Stickney facilities. Base flow at Calumet is about 320 to 360 cfs while peak storm flows in response to inflow-infiltration are on the order of 420 to 460 cfs. At Northside and Stickney, peak flows can be twice as high or greater relative to base flow. Therefore, it appears that the model is simulating proper hydraulic response, but the treatment facility cannot accommodate the storm inflow. This will be investigated at a later date.

BUDGET 12: LEMONT WATER RECLAMATION FACILITY

Budget 12 analyzes the water balance at the MWRDGC Lemont Water Reclamation Facility (Figure 9). Overall, the balance for WY86 of the inflow to the Lemont facility is good. The simulated to recorded flow ratio (S/R) for the Lemont is 1.05, indicating that the simulated inflow volume was extremely close to the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.64, indicating that the model predicted the inflow hydrograph to the Lemont facility reasonably well.

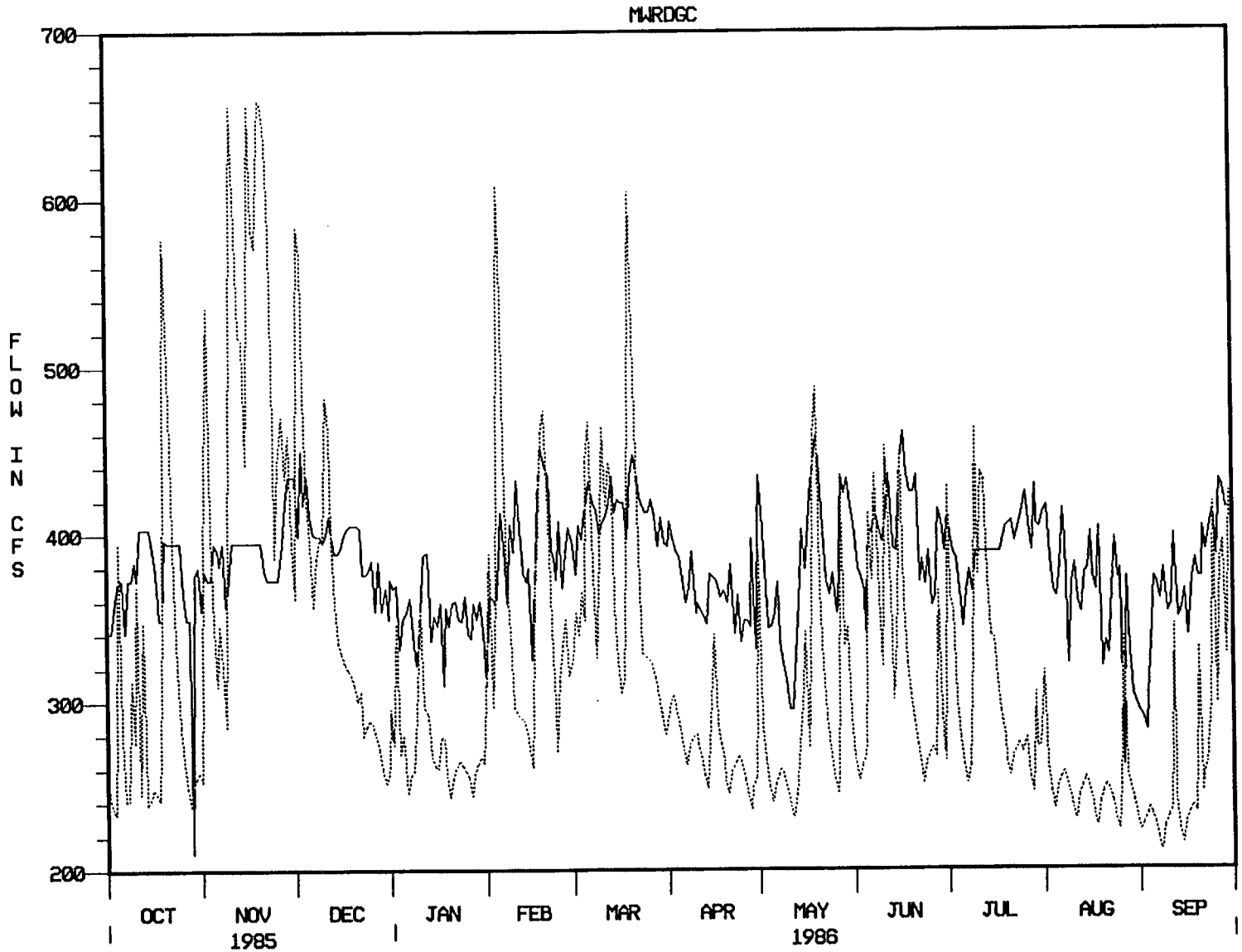


Figure 8

Budget 11 - Simulation of the MWRDGC Calumet Water Reclamation Facility

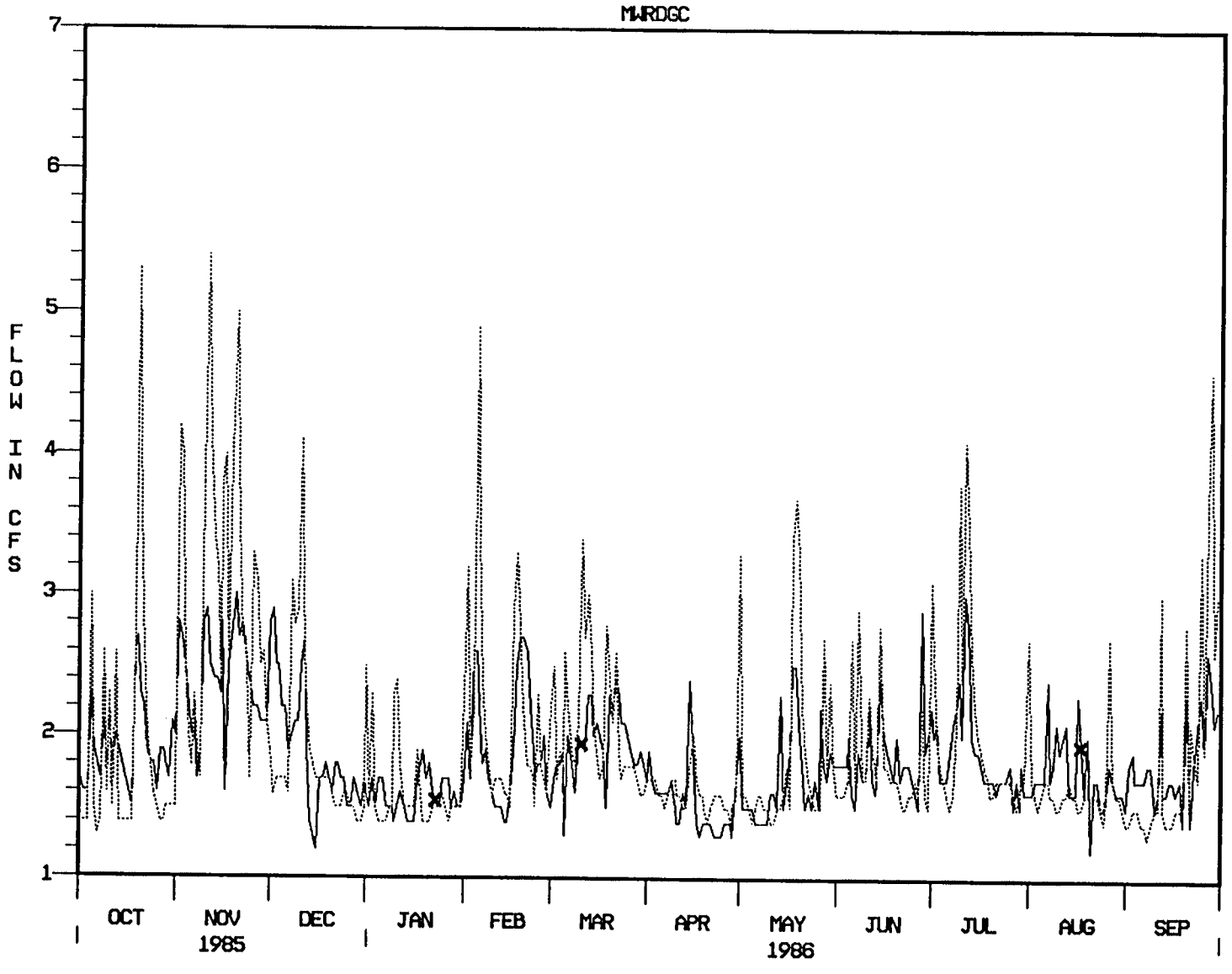


Figure 9

Budget 12 - Simulation of the MWRDGC Lemont Water Reclamation Facility

BUDGET 13: CHICAGO CANAL SYSTEM BALANCE

Budget 13 compares the inflows and outflows to the canal system (Figure 10). The inflow components include direct diversions through the lakefront structures, stormwater runoff discharged to the canal system, and domestic water supply whose effluent discharges to the canal system. The outflows from the canal system include the discharge at Lockport, backflows through the lakefront structures, and withdrawals upstream of Lockport by Argonne National labs. The individual components are presented in Table 8 for WY86.

Overall, the balance for WY86 of the inflow to the canal system to the outflows from the canal system is marginal. The S/R (outflow/inflow) for the canal system is 1.19, indicating that the inflow to the canal system is considerably less than the outflow from the canal system. The coefficient of correlation (R) of inflow to outflow is 0.91, indicating that the time series trends of inflow to outflow are well correlated. Therefore, based on the fact that the inflow is well correlated with the outflow, it appears that there is a moderately variable to constant underreported or unreported inflow.

In this balance the measured/simulated inflows are 648.1 cfs (15.7%) less than the measured/simulated outflows. In the Lake Michigan Diversion Accounting 1989 Report (USACE, 1990), it was reported that the Chicago Harbor wall was in poor condition and was not repaired until WY87. Therefore, some of the discrepancy in this budget may be due to this. Data necessary to perform this analysis is not available.

Other possible sources of the canal flow imbalance may include underreporting of the lakefront flows through the sluice gates and locks and unaccounted for flow sources. The underreporting of the lakefront flows could be the result of both inaccurate rating curves for the lakefront control structures and leakage through those structures. Flow meter measurements at the lakefront direct diversion points were done to assess if leakage is significant. This study (USACE, 1990) showed that, given the accuracy limits of the Price AA current meter, lakefront flows are underreported, but the magnitude of underreporting could not be determined. Unaccounted flows could include unreported discharges to the canal.

TABLE 8

BREAKDOWN OF FLOW COMPONENTS IN BUDGET 13 FOR WY 1986

INFLOWS (cfs)	
Lake Controlling Structures (measured)	
- Wilmette Controlling Works	41.0
- Chicago River Controlling Works	291.7
- O'Brien Lock and Dam	333.0
Streamflows (measured)	
- North Branch Chicago River at Niles	153.9
- Little Calumet River at South Holland	167.2
Streamflow (estimated)	
- Grand Calumet River at Holman Ave.	166.9
MWRDGC Water Reclamation Facilities	
- Northside	451.2
- Stickney	1138.5
- Calumet	381.9
- Lemont	1.9
Other Point Sources (measured)	6.4
Summit Conduit (simulated)	11.5
Combined Sewer Overflows	199.0
Direct Runoff to CSSC (simulated)	123.7
TOTAL INFLOWS (cfs)	3467.8

OUTFLOWS (cfs)	
Cal-Sag Flow Transferred to Calumet WRP as Steel Mill Blow-down	2.4
Lake Front Backflows	0.0
Argonne Laboratory	0.4
USGS AVM Record	4113.1
TOTAL OUTFLOWS (cfs)	4115.9

DIFFERENCE (cfs)	-648.1

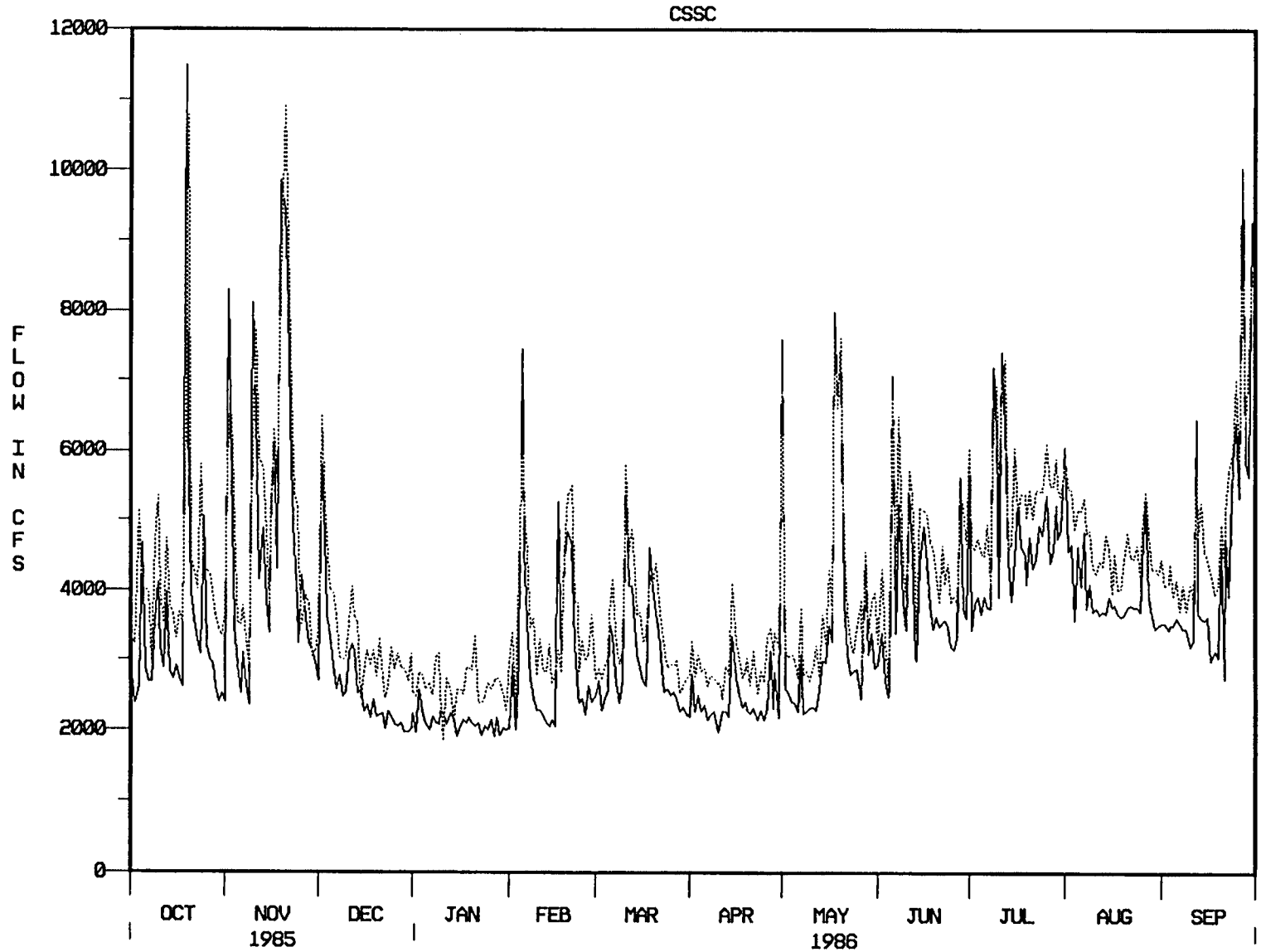


Figure 10

Budget 13 - Canal System Balance

AREAS FOR IMPROVEMENT IN THE DIVERSION ACCOUNTING PROCEDURES

As a result of reviewing and calculating the WY86 diversion accounting, and referencing the results of the WY84 and WY85 diversion accounting, a number of areas of potential improvement have become evident. The following paragraphs discuss those areas where improvement is needed.

O'HARE AND EGAN BASIN TRANSFER

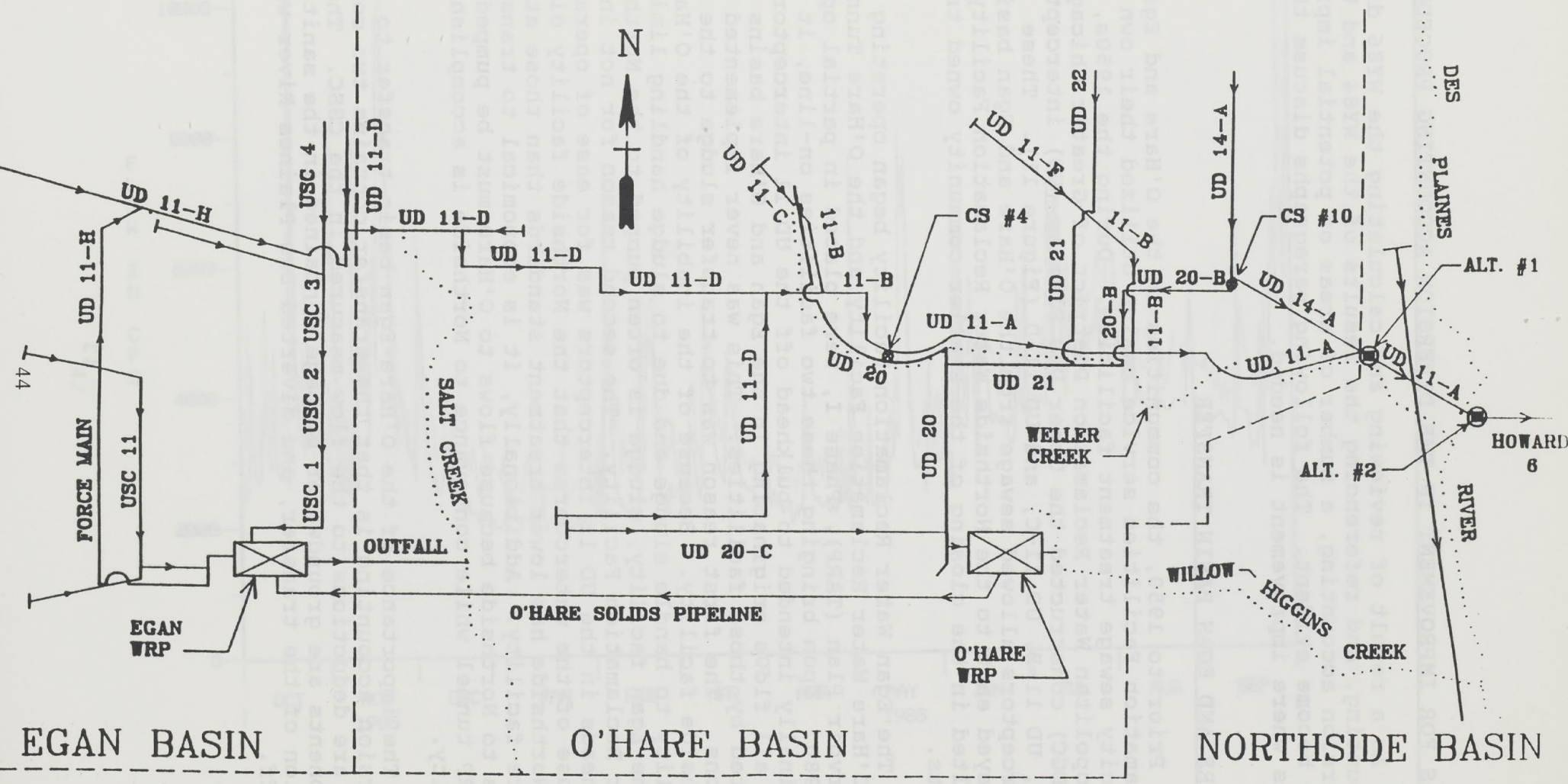
Prior to 1950, the communities in the O'Hare and Egan Water Reclamation Facilities service basins utilized their own small capacity sewage treatment facilities. During the 1950s, the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) constructed the Upper Des Plaines (UD) interceptors UD 11-A, UD 11-B, UD 11-C, and UD 11-D (Figure 11). These interceptors allowed sewage from the O'Hare and Egan basins to be conveyed east to the Northside Water Reclamation Facility. This resulted in the closing of the smaller community owned treatment plants.

The Egan Water Reclamation Facility began operating in 1975. The O'Hare Water Reclamation Facility and the O'Hare Tunnel and Reservoir Plan (TARP), Phase I, were placed in partial operation in 1980. Upon bringing these two facilities on-line, it was originally intended to bulkhead off the UD 11 interceptors so that all flows originating in the Egan and O'Hare basins would be treated by those facilities. This was never implemented for two reasons. The first reason was to transfer sludge to the Northside facility. Because of the inability of the O'Hare facility to handle sludge and due to sludge handling limitations at the Egan facility, sludge is often pumped to the Northside Water Reclamation Facility. The second reason for not installing bulkheads in the UD 11 interceptors was for ease of operation. Because of the watercourse that the Northside facility discharges to, Northside has lower treatment standards than those at the O'Hare facility. Additionally, it is economical to transfer flows to Northside because flows to O'Hare must be pumped out of a TARP tunnel while conveyance to Northside is accomplished by gravity.

The importance of the O'Hare-Egan basin transfer to diversion accounting is that the transfer contains two components that are deductions to the flow measured in the CSSC. These components are groundwater pumpage contained in the sanitary portion of the transfer, and diverted Des Plaines River watershed runoff.

Figure 11

O'Hare and Egan Basin Transfer Schematic



MWRD INTERCEPTOR

MWRD TARP TUNNEL

APPROXIMATE SERVICE BASIN BOUNDARY

APPROXIMATE STREAM/RIVER COURSE

CS #4 MWRD CONTROL STRUCTURE

NOTES:
- DRAWING IS NOT TO SCALE.
- BASIN BOUNDARIES, STREAM/RIVER COURSES, AND SEWER NETWORKS MAY BE SIMPLIFIED IN SOME AREAS.

The water supply in the diverted area was entirely from groundwater sources during WY84. Therefore, the total basin transfer was a deduction from the Romeoville record for that year. The extent of the O'Hare service area being diverted is not known and the diverted flow is not measured. Thus an estimate of the annual basin transfer was provided by MWRDGC. At the current time, the amount of the transfer is only estimated.

In WY85, a portion of the diverted service area converted from groundwater supply sources to Lake Michigan water, thus, the full basin transfer was no longer a deduction. A determination of the deduction required not only an estimate of the amount transferred but also an estimate of the sanitary effluent portion of the transfer. It also required an estimate of the Lake Michigan water portion of the effluent.

In WY86, more of the diverted service area converted from groundwater supply sources to Lake Michigan water. Again, the computational procedures previously developed were used. Although they are an approximation, they are the best and only technique available at this time.

For future accounting, simply measuring the basin transfer will not provide any information on the component makeup of the transfer. Thus, a review of the complex hydraulics and hydrology is necessary to determine the best procedure for estimating these flows. Several alternatives, including flow measurement and modeling are under consideration at this time.

GRAND CALUMET RIVER

The flow in the Grand Calumet River drains both to the Lake Michigan via Indiana Harbor and to the Calumet Sag Channel. When lake levels are high a larger portion of the flow drains to the Calumet Sag Channel. The Grand Calumet River flow calculation is based on a regression equation relating Lake Michigan stages and measured flows in Hart Ditch to the Grand Calumet River flow. A number of current meter measurements were made on the Grand Calumet by MWRDGC and other agencies. NIPC used these current meter observations to develop this regression equation. Review of the regression equations showed that it did not accurately determine flow when compared with the latest available flow measurements. Further review of the regression data showed that the data displayed a time dependent component, violating the assumptions of linear regression analysis.

The majority of the flow in the Grand Calumet River, draining to Illinois, is water supply effluent. The level of Lake Michigan influences the portion of the effluent that drains to Illinois and the portion that drains back to the lake. The water supply deduction is equal to the total water supply pumpage discharged to the river if the pumpage rate is less than the calculated river flow. The deduction is equal to the river flow if the pumpage rate is greater than the river flow.

This procedure is the only method currently available to calculate the Indiana deduction. A stream gage is being installed in the West Branch of the Grand Calumet River to measure flow into Illinois. This should increase the accuracy of this computation significantly. This stream gage will be operational in WY92. The same computational procedure for separating stream flow into sanitary and runoff will be used with the Grand Calumet stream gage record.

MWRDGC CALUMET WATER RECLAMATION FACILITY

The MWRDGC Calumet Water Reclamation Facility balance was discussed in a previous section where it was noted that although the annual S/R ratio was reasonable, the simulated inflows exhibited poor correlation to the recorded inflows. While the simulated inflow fluctuations at the Calumet plant are similar to those at the other MWRDGC facilities, the recorded Calumet flow fluctuations are much less than at the others. The problem may be related to flow measurement at the plant. Personnel at MWRDGC need to be consulted on this issue to determine the source of the problem. In addition, a portion of the Calumet WRP service area in the vicinity of the Calumet River needs to be investigated to correct errors regarding the presence of combined versus separate sewers.

MWRDGC UPPER DES PLAINES PUMP STATION

A review of the Upper Des Plaines pump station and its flow record indicates that the flow at the pump station is suspect and subject to operator error. Better flow measurement is needed at the pump station. With better flow measurement, this will become the most important balances for calibrating and verifying the simulation models of the Des Plaines watershed. In the diversion calculation, the primary use of the models is to calculate the deduction for runoff from the Des Plaines watershed discharged to the canal. All of the runoff draining to the pump station is from the Des Plaines watershed, is deductible, and is from somewhat similar land cover as the remaining deductible Des

Plaines watershed. Thus, the characteristics of the Upper Des Plaines watershed may be the gaged area that is the most representative of the total deductible Des Plaines watershed. Installation of better flow measurement equipment at the pump station is being investigated.

CANAL SYSTEM BALANCE

As discussed previously, the canal system balance indicated that the total inflows were 15.7% less than the outflows. A portion of the imbalance may be the result of overtopping and leakage through the Chicago Harbor wall. The wall was repaired at the beginning of WY87 and the diversion accounting for that time should provide valuable insight on the magnitude of the overtopping and leakage. Flow meter measurements at the lakefront direct diversion points were done to assess if leakage is still significant. This study (USACE, 1990) showed that, given the accuracy limits of the Price AA current meter in extremely low velocity profiles, the lakefront flows are underreported. However, sound conclusions cannot be drawn regarding the magnitude of the underreporting.

In addition to the problems previously noted, there may be unreported discharges to the CSSC and adjoining waterways that affect the canal system balance. Reconnaissance missions should be made to determine if there are any unreported discharges that are being made directly to the canal system.

PRECIPITATION DATA

The runoff simulation models used to accomplish the diversion accounting are driven by precipitation and other meteorologic data. In performing the WY83 diversion accounting, NIPC discovered problems with the precipitation data related to shielding of the rain gages by buildings and other obstructions. To address this problem, the Illinois State Water Survey (ISWS) was contracted to assess the problem and adjust the precipitation data. The ISWS has also adjusted the WY84 though WY89 data used for Lake Michigan diversion accounting. To resolve the problem, a precipitation gage network of 25 gages was installed by the ISWS under contract with the Corps. However, no data will be available from the network until WY90. Prior to WY90, the precipitation data will be adjusted as in the past.

TUNNEL AND RESERVOIR PLAN

The model developed for the Mainstream Pumping Station for WY86 performed acceptably for WY86, but there are several areas in which the model can be improved. First, modeling of dry weather flow can be improved to more accurately simulate MWRDGC operational procedures. Second, the incorporation of a pseudo-forecasting algorithm would allow the model to simulate MWRDGC dewatering procedures prior to a storm. Third, dynamic constituent (I-I versus sanitary versus groundwater) tracking can be incorporated to allow more accurate determination of the deductible components of TARP flow. Fourth, the inclusion of an algorithm to operate gaged dropshafts based on average water surface elevation in a tunnel reach would provide better simulation of gage operations.

SUMMARY

In compliance with the modified 1980 U.S. modified U.S. Supreme Court decree, the WY86 diversion was computed using the best engineering technology available to date as applied to the diverted watersheds. In the development of WY86 Lake Michigan diversion accounting, a new model, TNET, was incorporated into the computations to model the hydrologic condition of the diverted area that is affected by Mainstream TARP.

Overall, the simulations that comprise a significant portion of the diversion accounting computations worked well. The two most significant budgets to the diversion accounting computations, Budget 7, Northside Water Reclamation Facility, and Budget 10, Stickney Water Reclamation Facility, performed exceptional well. These two budgets combined compute the majority of the deductible Des Plaines River watershed runoff. Both of these budgets have simulated to recorded ratios between 0.90 and 1.10 and correlations greater than 0.75. Given the complexity of the hydrologic cycle in the heavily urbanized Chicago metropolitan area, and given the number of human and other factors that cannot be adequately represented in numerical modeling procedures, the results of these two budgets are outstanding. Other simulation budgets have performed reasonably well, but there is room for improvement. Areas of improvement previously outlined will be considered in order to improve the accuracy of the diversion computation.

The WY86 diversion, rounded to the nearest cfs, accountable to the State of Illinois is 3,751 cfs. This is 551 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average beginning with WY81 is 3,410 cfs and the cumulative deviation from the 3,200 cfs average is -1,261 cfs-years. The negative cumulative deviation indicates a water allocation debt and the maximum allowable debt is 2,000 cfs-years.

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Lake Michigan Diversion Accounting

Water Year 1986 Report

Appendix A

Summary of Daily Diversion Flows

COLUMN COMPUTATIONS

1. COLUMN 3 EQUALS THE SUM OF COLUMN 1 AND COLUMN 2.
2. COLUMN 8 EQUALS THE SUM OF COLUMNS 4 THROUGH COLUMN 7.
3. COLUMN 10 EQUALS COLUMN 3 LESS COLUMN 8 WITH THE ADDITION OF COLUMN 9.

NOTES

1. ALL VALUES ARE ROUNDED TO THE NEAREST TENTH.
2. MATHEMATICAL COMPUTATIONS BETWEEN COLUMNS UTILIZE UNROUNDED VALUES.
3. AVERAGE VALUES FOR WY87 WERE COMPUTED USING DAILY VALUES.

LEGEND

DEDUCTIONS FROM THE ROMEOVILLE GAGE RECORD

ADDITIONS TO THE ROMEOVILLE GAGE RECORD

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Oct-85	3330	0.3	3330.2	175.7	74.5	50.4	1.6	302.2	28.0	3056.0	1613.8	164.9	1181.8
02-Oct-85	3231	0.8	3231.8	75.7	74.5	24.4	1.6	176.2	28.7	3084.3	1610.2	48.9	787.6
03-Oct-85	5133	0.2	5133.2	75.7	74.5	24.0	1.6	175.9	31.3	4988.7	1615.6	65.6	809.2
04-Oct-85	4020	0.4	4020.4	154.9	74.5	382.1	1.6	613.2	30.6	3443.6	1586.2	1988.0	568.7
05-Oct-85	4031	0.2	4031.2	164.8	74.5	78.9	1.6	319.9	25.2	3736.5	1543.6	460.2	893.4
06-Oct-85	3982	0.2	3982.2	75.7	74.5	49.3	1.6	201.2	25.9	3806.9	1510.0	183.7	876.5
07-Oct-85	2988	0.5	2988.5	163.2	74.5	43.5	1.6	282.9	26.3	2734.0	1587.4	175.0	882.0
08-Oct-85	4715	0.3	4715.3	142.2	74.5	198.6	1.6	416.9	31.4	4329.8	1595.6	651.1	943.0
09-Oct-85	5371	0.4	5371.4	128.8	74.5	136.0	1.6	341.0	30.8	5061.2	1581.5	495.6	1795.3
10-Oct-85	3977	0.3	3977.3	190.0	74.5	196.4	1.6	462.6	30.4	3545.1	1580.1	891.5	706.5
11-Oct-85	3570	0.8	3570.8	75.7	74.5	57.7	1.6	209.6	28.1	3389.3	1568.0	240.4	893.8
12-Oct-85	4767	0.1	4767.1	176.6	74.5	208.8	1.6	461.6	29.4	4330.9	1530.5	897.5	1466.1
13-Oct-85	3806	0.3	3806.3	75.7	74.5	62.1	1.6	214.0	27.5	3619.8	1523.2	231.8	886.3
14-Oct-85	3667	0.4	3667.4	75.7	74.5	47.0	1.6	198.8	27.6	3496.1	1592.1	197.2	788.5
15-Oct-85	3296	0.3	3296.3	170.6	74.5	46.7	1.6	293.4	29.1	3031.0	1591.1	214.2	884.3
16-Oct-85	3714	0.4	3714.4	75.7	74.5	36.1	1.6	188.0	27.9	3554.3	1596.9	128.3	881.5
17-Oct-85	3561	0.3	3561.2	75.7	74.5	34.1	1.6	185.9	27.9	3402.6	1588.2	117.3	830.5
18-Oct-85	6586	0.3	6586.3	173.2	74.5	1311.7	1.6	1561.1	38.6	5063.9	1583.8	5888.1	517.0
19-Oct-85	10801	0.2	10801.0	119.9	74.5	911.1	1.6	1107.2	27.8	9721.8	1578.3	2982.7	578.8
20-Oct-85	4484	0.2	4484.2	316.6	74.5	460.9	1.6	855.7	23.7	3652.3	1491.2	1445.8	792.0
21-Oct-85	4289	0.2	4289.2	75.7	74.5	290.1	1.6	442.0	29.8	3874.1	1570.0	825.9	796.3
22-Oct-85	4006	0.2	4006.2	75.7	74.5	185.2	1.6	337.0	27.1	3696.3	1584.2	524.8	877.5
23-Oct-85	5828	0.4	5828.4	75.7	74.5	123.8	1.6	275.6	27.7	5580.5	1599.3	361.5	933.4
24-Oct-85	4226	0.4	4226.4	169.9	74.5	169.8	1.6	415.9	30.7	3841.2	1585.9	1132.2	2012.6
25-Oct-85	4297	0.0	4297.0	182.2	74.5	105.3	1.6	363.6	27.9	3961.3	1575.3	501.3	922.6
26-Oct-85	4210	0.4	4210.4	75.7	74.5	79.9	1.6	231.7	27.2	4005.9	1549.5	302.4	967.1
27-Oct-85	3878	0.2	3878.2	75.7	74.5	70.0	1.6	221.9	23.4	3679.7	1554.7	255.8	980.6
28-Oct-85	3657	0.4	3657.4	184.6	74.5	71.5	1.6	332.2	27.7	3352.9	1574.0	273.3	762.5
29-Oct-85	3462	1.0	3463.0	75.7	74.5	60.2	1.6	212.0	28.2	3279.2	1582.0	194.9	507.9
30-Oct-85	3343	0.2	3343.2	75.7	74.5	54.5	1.6	206.4	28.2	3163.0	1572.9	207.9	507.2
31-Oct-85	3647	0.3	3647.3	75.7	74.5	52.5	1.6	204.4	28.5	3471.4	1550.6	208.5	518.3
OCT 85	4318.5	0.3	4318.8	123.4	74.5	181.4	1.6	381.0	29.4	3966.2	1573.1	717.9	895.1

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Nov-85	6527	0.3	6527.3	183.5	70.0	866.9	1.8	1122.1	48.4	5453.6	1565.1	4876.8	813.8
02-Nov-85	6522	0.3	6522.2	201.3	70.0	683.9	1.8	957.0	32.8	5598.1	1518.0	2959.6	585.5
03-Nov-85	4896	0.6	4896.6	253.6	70.0	414.8	1.8	740.2	24.8	4181.1	1500.4	1522.0	195.8
04-Nov-85	3561	0.2	3561.2	75.6	70.0	272.9	1.8	420.3	26.1	3167.1	1566.6	876.3	145.3
05-Nov-85	3512	0.3	3512.3	75.7	70.0	184.4	1.8	331.8	25.2	3205.7	1554.4	616.0	144.3
06-Nov-85	3804	0.1	3804.1	117.6	70.0	265.4	1.8	454.8	31.3	3380.7	1568.5	1024.9	169.5
07-Nov-85	3322	0.4	3322.4	223.6	70.0	206.0	1.8	501.3	26.8	2847.9	1572.9	638.8	140.8
08-Nov-85	2949	0.5	2949.5	75.6	70.0	145.9	1.8	293.3	27.1	2683.3	1552.4	497.1	164.3
09-Nov-85	6126	0.1	6126.1	85.8	70.0	1138.5	1.8	1296.0	39.9	4870.0	1497.5	4551.6	526.8
10-Nov-85	7714	1.2	7715.2	101.9	70.0	970.6	1.8	1144.3	27.7	6598.6	1477.6	3667.7	263.5
11-Nov-85	5915	0.1	5915.1	236.8	70.0	587.3	1.8	895.8	29.1	5048.4	1552.0	2135.8	141.0
12-Nov-85	5736	0.3	5736.3	223.9	70.0	539.2	1.8	834.9	32.6	4934.0	1507.8	2062.9	965.3
13-Nov-85	4838	0.2	4838.2	239.1	70.0	493.6	1.8	804.4	29.5	4063.3	1545.5	1774.8	178.3
14-Nov-85	3827	0.3	3827.3	75.6	70.0	329.5	1.8	476.9	29.2	3379.6	1541.0	1122.3	515.5
15-Nov-85	5188	0.3	5188.3	89.6	70.0	604.9	1.8	766.2	34.3	4456.3	1559.5	2359.7	253.3
16-Nov-85	6308	0.1	6308.1	163.0	70.0	681.6	1.8	916.3	29.5	5420.3	1519.4	3617.2	157.5
17-Nov-85	5528	0.2	5528.2	243.5	70.0	414.6	1.8	729.8	29.3	4824.7	1503.0	2187.2	169.5
18-Nov-85	8401	0.3	8401.3	80.9	70.0	1071.8	1.8	1224.4	39.6	7216.5	1556.2	5392.0	978.8
19-Nov-85	10916	0.3	10916.0	90.7	70.0	873.8	1.8	1036.2	30.4	9910.4	1577.0	5714.8	582.8
20-Nov-85	8970	0.2	8970.2	160.1	70.0	611.7	1.8	843.5	29.1	8155.8	1557.9	5114.2	521.5
21-Nov-85	6805	0.2	6805.2	246.6	70.0	456.4	1.8	774.8	27.8	6058.1	1560.7	3629.7	113.5
22-Nov-85	5404	0.2	5404.2	137.2	70.0	391.0	1.8	600.0	29.4	4833.5	1547.7	2529.1	148.8
23-Nov-85	5180	0.2	5180.2	75.6	70.0	270.4	1.8	417.8	25.6	4788.0	1517.4	1803.5	130.5
24-Nov-85	4460	0.2	4460.1	191.7	70.0	261.5	1.8	525.0	27.1	3962.3	1477.3	1553.9	94.0
25-Nov-85	3521	0.2	3521.1	87.8	70.0	594.5	1.8	754.0	34.7	2801.9	1551.9	2272.2	131.3
26-Nov-85	3943	0.4	3943.4	228.1	70.0	496.5	1.8	796.4	31.7	3178.7	1549.5	1787.4	142.3
27-Nov-85	3791	0.3	3791.3	86.5	70.0	362.3	1.8	520.6	32.5	3303.2	1548.1	1548.7	150.8
28-Nov-85	3061	0.2	3061.2	222.5	70.0	370.1	1.8	664.4	25.8	2422.6	1494.0	1394.9	124.3
29-Nov-85	3145	0.2	3145.2	75.2	70.0	330.3	1.8	477.2	31.0	2699.0	1481.0	1398.2	139.0
30-Nov-85	3453	0.2	3453.2	232.4	70.0	316.1	1.8	620.2	22.9	2855.9	1480.8	1241.2	118.0
NOV 85	5244.1	0.3	5244.4	152.7	70.0	506.9	1.8	731.3	30.2	4543.3	1533.4	2395.7	296.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Dec-85	6511	0.2	6511.2	198.1	76.4	298.1	1.7	574.2	24.2	5961.2	1475.9	2975.1	400.3
02-Dec-85	5199	0.3	5199.3	109.3	76.4	238.7	1.7	426.0	27.6	4800.9	1556.2	2588.4	122.6
03-Dec-85	4707	0.3	4707.3	75.7	76.4	194.9	1.7	348.7	26.4	4385.0	1549.7	1589.3	132.5
04-Dec-85	4022	0.2	4022.2	75.7	76.4	173.8	1.7	327.5	27.5	3722.1	1578.5	1116.7	132.2
05-Dec-85	3988	0.3	3988.3	176.3	76.4	169.2	1.7	423.6	27.1	3591.8	1560.8	979.9	132.9
06-Dec-85	3651	0.3	3651.3	75.7	76.4	156.1	1.7	309.8	28.1	3367.6	1564.6	806.3	171.5
07-Dec-85	3051	0.2	3051.2	138.9	76.4	372.3	1.7	589.2	27.6	2489.6	1513.1	1179.3	118.5
08-Dec-85	2999	0.2	2999.2	169.9	76.4	370.9	1.7	618.8	24.5	2404.9	1519.6	986.3	110.6
09-Dec-85	3055	0.4	3055.4	75.5	76.4	346.5	1.7	500.1	26.7	2583.9	1566.7	944.6	130.8
10-Dec-85	3562	0.2	3562.2	153.1	76.4	500.3	1.7	731.4	30.9	2861.7	1568.5	1552.5	143.2
11-Dec-85	4072	0.2	4072.1	190.0	76.4	334.9	1.7	603.0	26.0	3495.1	1554.2	1359.3	124.3
12-Dec-85	3627	0.4	3627.4	75.7	76.4	258.3	1.7	412.0	26.2	3241.6	1531.2	1072.0	124.1
13-Dec-85	3527	0.0	3527.0	75.7	76.4	214.0	1.7	367.8	26.8	3186.0	1556.3	810.3	120.1
14-Dec-85	2462	0.2	2462.2	190.2	76.4	203.3	1.7	471.6	24.1	2014.7	1539.1	718.0	139.2
15-Dec-85	2821	0.2	2821.2	75.7	76.4	174.9	1.7	328.6	24.4	2516.9	1547.7	595.5	109.7
16-Dec-85	3131	0.3	3131.2	75.7	76.4	161.3	1.7	315.0	27.7	2843.9	1575.0	496.5	132.4
17-Dec-85	2942	0.3	2942.2	75.7	76.4	150.5	1.7	304.2	27.7	2665.8	1594.5	453.7	194.2
18-Dec-85	3161	0.3	3161.3	158.5	76.4	149.3	1.7	385.9	29.2	2801.6	1587.0	460.1	201.9
19-Dec-85	2758	0.3	2758.3	75.7	76.4	137.4	1.7	291.2	27.7	2494.9	1607.6	395.5	204.4
20-Dec-85	3303	0.2	3303.2	94.0	76.4	132.7	1.7	304.8	25.5	3023.9	1581.2	405.2	178.6
21-Dec-85	2732	0.2	2732.2	140.9	76.4	144.7	1.7	363.6	26.4	2394.9	1567.9	482.3	178.6
22-Dec-85	2460	0.2	2460.2	111.7	76.4	160.7	1.7	350.5	24.9	2134.6	1544.0	519.7	130.2
23-Dec-85	2639	0.3	2639.3	138.3	76.4	134.4	1.7	350.7	27.0	2315.5	1592.4	406.4	121.2
24-Dec-85	3190	0.2	3190.2	75.7	76.4	117.5	1.7	271.2	25.9	2944.9	1615.8	397.8	187.6
25-Dec-85	2877	0.2	2877.2	138.3	76.4	116.1	1.7	332.4	23.2	2568.0	1513.3	362.3	190.9
26-Dec-85	3110	0.3	3110.2	116.4	76.4	107.3	1.7	301.7	23.5	2832.1	1576.4	275.5	180.0
27-Dec-85	2908	0.2	2908.2	75.7	76.4	99.4	1.7	253.2	26.9	2681.9	1613.1	272.9	158.4
28-Dec-85	2908	0.2	2908.2	95.5	76.4	98.2	1.7	271.8	24.9	2660.4	1574.4	245.4	210.9
29-Dec-85	2715	0.2	2715.2	144.8	76.4	122.8	1.7	345.7	26.7	2396.2	1545.4	349.7	187.4
30-Dec-85	3124	0.6	3124.6	127.6	76.4	137.9	1.7	343.5	25.9	2807.1	1588.7	387.6	177.4
31-Dec-85	2545	0.1	2545.1	117.4	76.4	244.7	1.7	440.2	26.9	2131.8	1601.2	516.8	156.4
DEC 85	3347.0	0.2	3347.2	116.7	76.4	200.7	1.7	395.4	26.3	2978.1	1563.2	829.1	161.4

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jan-86	2477	0.3	2477.3	181.4	77.0	133.3	2.4	394.1	25.5	2108.7	1535.0	348.0	163.8
02-Jan-86	2823	0.3	2823.3	116.8	77.0	297.8	2.4	494.0	29.9	2359.2	1519.8	922.3	169.5
03-Jan-86	2813	0.3	2813.2	134.7	77.0	141.8	2.4	355.9	27.3	2484.7	1592.1	404.1	144.5
04-Jan-86	2609	0.2	2609.2	75.7	77.0	109.3	2.4	264.4	23.1	2367.9	1559.1	376.8	135.6
05-Jan-86	2665	0.4	2665.4	166.5	77.0	98.4	2.4	344.2	24.6	2345.8	1551.0	289.7	177.2
06-Jan-86	2492	0.3	2492.3	75.7	77.0	83.3	2.4	238.4	27.4	2281.4	1609.5	230.2	192.2
07-Jan-86	3033	0.2	3033.2	75.7	77.0	77.3	2.4	232.3	28.0	2828.9	1612.3	215.8	210.2
08-Jan-86	3122	0.2	3122.2	125.8	50.8	76.5	2.4	255.5	27.8	2694.6	1642.9	227.0	183.0
09-Jan-86	2505	0.3	2505.2	117.0	54.5	242.6	2.4	416.5	30.3	2119.0	1619.8	565.2	131.6
10-Jan-86	1868	0.2	1868.2	190.2	77.0	228.6	2.4	498.1	29.4	1398.5	1600.3	589.6	121.2
11-Jan-86	2735	0.2	2735.2	75.4	77.0	177.3	2.4	332.0	29.9	2430.1	1579.8	606.3	126.4
12-Jan-86	2577	0.2	2577.2	123.1	77.0	122.1	2.4	324.6	26.9	2279.5	1564.5	483.4	154.0
13-Jan-86	2145	0.2	2145.2	169.5	77.0	87.4	2.4	336.2	26.1	1835.1	1586.2	335.8	148.8
14-Jan-86	2580	0.2	2580.2	75.7	77.0	69.4	2.4	224.4	27.6	2383.6	1621.1	272.8	141.3
15-Jan-86	2596	0.2	2596.2	93.9	77.0	63.9	2.4	237.2	27.2	2386.3	1588.6	227.8	148.7
16-Jan-86	2504	0.2	2504.2	140.9	77.0	130.2	2.4	350.4	28.6	2182.4	1606.0	392.8	142.6
17-Jan-86	2903	0.4	2903.4	75.6	77.0	134.1	2.4	289.1	27.5	2641.8	1603.7	499.1	90.9
18-Jan-86	2902	0.4	2902.4	183.4	77.0	96.2	2.4	358.9	25.0	2568.5	1567.2	514.3	99.4
19-Jan-86	2846	0.2	2846.1	75.7	77.0	80.0	2.4	235.1	25.2	2636.3	1526.2	491.3	101.0
20-Jan-86	3357	0.2	3357.2	75.7	77.0	76.7	2.4	231.7	29.4	3151.9	1591.8	376.0	89.2
21-Jan-86	2394	0.3	2394.2	171.0	77.0	82.2	2.4	332.5	27.6	2089.3	1592.7	385.5	132.9
22-Jan-86	2392	0.3	2392.3	75.7	77.0	76.3	2.4	231.3	27.8	2188.8	1587.3	325.3	95.7
23-Jan-86	2475	0.4	2475.4	75.7	77.0	77.0	2.4	232.0	27.0	2270.4	1596.2	276.0	113.5
24-Jan-86	2666	0.3	2666.3	94.1	77.0	92.4	2.4	265.8	26.7	2427.2	1573.4	288.6	108.7
25-Jan-86	2565	0.1	2565.1	142.5	77.0	97.0	2.4	318.9	24.7	2271.0	1566.8	300.5	107.0
26-Jan-86	2726	0.2	2726.2	75.7	77.0	84.8	2.4	239.8	23.6	2510.0	1512.4	283.8	99.0
27-Jan-86	2755	0.3	2755.3	129.0	77.0	86.7	2.4	295.0	27.1	2487.4	1592.3	306.8	237.1
28-Jan-86	2718	0.3	2718.3	118.2	77.0	85.1	2.4	282.6	27.9	2463.6	1614.5	238.0	180.7
29-Jan-86	2559	0.5	2559.5	75.7	77.0	81.7	2.4	236.7	28.0	2350.7	1606.3	228.9	132.2
30-Jan-86	2293	0.2	2293.2	94.1	77.0	82.3	2.4	255.8	27.5	2064.9	1617.2	205.6	145.9
31-Jan-86	2978	0.2	2978.2	141.4	77.0	173.3	2.4	394.1	27.9	2612.0	1594.6	460.8	143.9
JAN 86	2647.5	0.3	2647.8	114.2	75.4	114.4	2.4	306.4	27.0	2368.4	1584.9	376.4	140.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Feb-86	3405	0.2	3405.2	207.0	77.5	401.1	2.4	688.0	27.4	2744.6	1557.0	1069.8	98.0
02-Feb-86	2461	0.3	2461.3	75.6	77.5	175.8	2.4	331.4	23.2	2153.1	1546.5	429.3	106.4
03-Feb-86	4242	0.3	4242.3	166.3	77.5	209.3	2.4	455.6	29.5	3816.2	1603.1	795.3	766.5
04-Feb-86	6220	0.3	6220.3	124.4	77.5	892.3	2.4	1096.5	46.1	5169.9	1603.6	4766.7	644.8
05-Feb-86	5195	0.9	5195.9	212.2	77.5	495.1	2.4	787.2	30.0	4438.7	1606.6	2597.4	112.5
06-Feb-86	4520	0.3	4520.3	180.2	77.5	323.8	2.4	583.9	29.7	3965.1	1601.9	1448.8	151.8
07-Feb-86	3462	0.3	3462.3	75.7	77.5	219.8	2.4	375.3	28.2	3115.6	1593.8	811.3	120.9
08-Feb-86	3603	0.2	3603.2	75.7	77.5	167.6	2.4	323.1	24.7	3304.8	1561.0	594.2	124.7
09-Feb-86	2815	0.2	2815.2	175.3	77.5	145.2	2.4	400.5	25.6	2440.3	1551.8	483.5	91.9
10-Feb-86	3327	0.3	3327.3	75.7	77.5	121.3	2.4	276.9	27.4	3077.8	1606.9	361.1	115.7
11-Feb-86	2848	0.3	2848.3	75.7	77.5	110.3	2.4	265.8	27.7	2610.3	1613.3	318.1	135.1
12-Feb-86	2830	0.3	2830.3	136.2	77.5	106.7	2.4	322.8	27.0	2534.5	1611.3	290.0	133.4
13-Feb-86	3265	0.4	3265.4	115.3	77.5	99.6	2.4	294.7	28.6	2997.2	1615.4	229.2	128.5
14-Feb-86	2657	0.5	2657.5	75.7	77.5	92.3	2.4	247.9	27.1	2436.7	1589.3	211.1	127.0
15-Feb-86	2776	0.1	2776.1	94.9	77.5	89.6	2.4	264.5	25.6	2537.3	1571.9	203.9	137.9
16-Feb-86	3166	0.1	3166.1	146.2	77.5	976.5	2.4	1202.6	29.3	1992.8	1523.4	2337.8	91.4
17-Feb-86	2849	0.3	2849.3	311.8	77.5	286.9	2.4	678.5	28.0	2196.9	1611.9	1118.0	95.4
18-Feb-86	4585	0.3	4585.2	75.0	77.5	336.4	2.4	491.3	35.6	4129.6	1595.2	2050.6	106.0
19-Feb-86	5394	0.3	5394.3	266.4	77.5	330.9	2.4	677.2	37.2	4754.4	1608.2	2651.5	106.4
20-Feb-86	5506	0.2	5506.2	197.4	77.5	227.7	2.4	505.0	33.1	5034.3	1598.1	2504.3	110.5
21-Feb-86	3855	0.2	3855.2	151.8	77.5	148.9	2.4	380.6	25.7	3500.3	1572.9	1050.2	136.7
22-Feb-86	3838	0.2	3838.2	75.7	77.5	121.1	2.4	276.7	25.2	3586.8	1597.4	569.4	125.4
23-Feb-86	2830	0.1	2830.1	75.7	77.5	106.3	2.4	261.9	23.2	2591.4	1538.7	431.8	87.7
24-Feb-86	3276	0.3	3276.2	164.1	77.5	178.5	2.4	422.4	27.4	2881.3	1592.2	544.0	97.1
25-Feb-86	3006	0.2	3006.2	75.7	77.5	118.3	2.4	273.9	26.3	2758.6	1593.2	415.2	127.7
26-Feb-86	3096	0.2	3096.2	195.8	77.5	111.4	2.4	387.1	27.4	2736.5	1571.9	588.3	137.4
27-Feb-86	3671	0.2	3671.2	75.6	77.5	96.7	2.4	252.2	28.6	3445.7	1601.4	564.7	122.8
28-Feb-86	2740	0.3	2740.3	157.6	77.5	197.7	2.4	435.2	29.3	2334.5	1591.2	674.6	146.0
FEB 86	3622.8	0.3	3623.1	136.9	77.5	246.0	2.4	462.8	28.6	3188.8	1586.8	1075.3	160.2

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Mar-86	2879	0.1	2879.1	160.0	74.9	278.6	2.2	515.8	29.3	2392.7	1560.4	1211.6	116.0
02-Mar-86	2731	0.0	2731.0	153.7	74.9	161.0	2.2	391.8	26.4	2365.6	1538.6	672.5	106.5
03-Mar-86	2931	0.5	2931.4	90.4	74.9	157.0	2.2	324.6	29.0	2635.8	1622.4	702.9	109.7
04-Mar-86	3035	0.1	3035.1	150.6	74.9	145.8	2.2	373.5	29.2	2690.8	1613.5	699.3	116.7
05-Mar-86	3664	0.5	3664.4	97.9	74.9	294.8	2.2	469.8	32.4	3227.0	1614.7	1445.3	120.5
06-Mar-86	4180	0.0	4180.0	253.9	74.9	258.6	2.2	589.7	27.6	3617.9	1610.2	1217.6	117.0
07-Mar-86	3229	0.5	3229.5	75.7	74.9	168.0	2.2	320.8	27.0	2935.7	1632.3	719.2	148.0
08-Mar-86	2948	0.0	2948.0	75.7	74.9	129.6	2.2	282.4	24.7	2690.3	1574.2	447.5	100.9
09-Mar-86	3172	0.1	3172.1	158.0	74.9	186.1	2.2	421.3	29.0	2776.9	1554.9	855.3	97.2
10-Mar-86	5795	0.4	5795.4	137.8	74.9	552.7	2.2	767.6	36.8	5064.6	1616.0	2917.6	469.8
11-Mar-86	4569	0.0	4569.0	218.9	74.9	386.7	2.2	682.8	29.8	3915.0	1603.0	1933.5	121.7
12-Mar-86	4889	0.4	4889.4	114.9	74.9	374.4	2.2	566.5	30.4	4353.3	1607.1	1572.3	355.0
13-Mar-86	4222	0.0	4222.0	106.5	74.9	307.9	2.2	491.6	27.6	3758.0	1606.9	1227.0	122.2
14-Mar-86	3649	0.6	3649.6	141.5	74.9	214.5	2.2	433.1	27.8	3244.3	1602.5	938.8	130.8
15-Mar-86	3713	0.0	3713.0	75.7	74.9	165.2	2.2	318.0	26.4	3421.5	1572.1	746.7	100.6
16-Mar-86	3280	0.0	3280.0	75.7	74.9	142.7	2.2	295.5	25.7	3010.2	1551.4	623.5	86.2
17-Mar-86	3380	0.5	3380.4	180.2	74.9	138.0	2.2	395.4	27.8	3012.9	1606.6	591.9	121.6
18-Mar-86	4224	0.0	4224.0	92.9	74.9	363.2	2.2	533.3	23.3	3724.0	1603.8	1687.4	620.8
19-Mar-86	4137	0.5	4137.5	216.9	74.9	358.2	2.2	652.3	30.0	3515.2	1590.6	2012.7	176.0
20-Mar-86	4417	0.0	4417.0	75.6	74.9	257.6	2.2	410.4	30.3	4037.0	1596.3	1396.4	104.2
21-Mar-86	3848	0.4	3848.4	153.5	74.9	330.6	2.2	561.2	27.5	3314.7	1592.2	1200.3	106.5
22-Mar-86	3430	0.0	3430.0	147.5	74.9	225.8	2.2	450.5	30.5	3010.0	1574.5	932.5	89.5
23-Mar-86	3197	0.2	3197.2	75.7	74.9	157.3	2.2	310.1	26.2	2913.3	1546.4	589.0	122.3
24-Mar-86	2895	0.4	2895.4	195.9	74.9	147.4	2.2	420.4	28.4	2503.4	1607.8	559.8	94.4
25-Mar-86	2957	0.3	2957.3	75.6	74.9	129.5	2.2	282.3	29.4	2704.4	1619.4	434.0	96.5
26-Mar-86	2919	0.4	2919.4	75.6	74.9	122.5	2.2	275.3	29.8	2672.9	1610.8	414.7	264.4
27-Mar-86	2991	0.2	2991.2	75.6	74.9	117.2	2.2	270.0	28.0	2749.1	1627.1	397.4	105.7
28-Mar-86	2538	0.4	2538.4	176.2	74.9	119.0	2.2	372.3	27.5	2193.6	1593.6	393.8	109.2
29-Mar-86	2634	0.3	2634.3	75.7	74.9	107.2	2.2	260.1	26.2	2400.4	1626.1	330.2	177.8
30-Mar-86	2736	0.4	2736.4	75.7	74.9	101.9	2.2	254.8	24.6	2506.3	1547.9	320.6	140.5
31-Mar-86	2782	0.3	2782.3	186.1	74.9	103.9	2.2	367.2	26.1	2441.2	1657.4	348.8	124.5
MAR 86	3482.9	0.2	3483.2	127.9	74.9	216.2	2.2	421.3	29.4	3090.3	1596.2	952.9	157.2

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Apr-86	3274	0.2	3274.2	75.6	79.1	92.0	2.0	248.8	29.8	3054.3	1619.6	325.1	225.8
02-Apr-86	2771	0.5	2771.5	75.6	79.1	87.9	2.0	244.7	29.3	2556.2	1629.4	334.8	143.0
03-Apr-86	3089	0.2	3089.2	140.2	79.1	87.9	2.0	309.1	27.5	2807.5	1601.6	345.4	296.4
04-Apr-86	2856	0.5	2856.5	112.7	79.1	82.1	2.0	275.9	28.0	2608.6	1622.6	333.7	174.5
05-Apr-86	2895	0.3	2895.2	75.7	79.1	75.7	2.0	232.4	27.3	2690.1	1593.4	300.7	197.7
06-Apr-86	2627	0.3	2627.3	75.7	79.1	69.5	2.0	226.2	23.3	2424.4	1582.1	269.1	190.0
07-Apr-86	2785	0.3	2785.3	159.3	79.1	71.5	2.0	311.9	28.8	2502.2	1658.6	268.7	136.8
08-Apr-86	2748	0.3	2748.3	75.7	79.1	62.7	2.0	219.5	26.8	2557.6	1638.7	224.1	134.5
09-Apr-86	2658	0.2	2658.2	75.6	79.1	59.9	2.0	216.7	26.7	2470.2	1614.7	220.3	113.0
10-Apr-86	2695	0.3	2695.3	159.3	79.1	62.8	2.0	303.1	29.1	2421.3	1620.6	246.9	141.8
11-Apr-86	2458	0.3	2458.3	75.7	79.1	54.6	2.0	211.4	28.1	2275.1	1661.3	186.5	208.1
12-Apr-86	2928	0.3	2928.3	75.7	79.1	52.2	2.0	209.0	29.0	2748.3	1581.0	216.2	269.4
13-Apr-86	2813	0.2	2813.2	168.4	79.1	56.4	2.0	305.9	28.5	2533.9	1566.5	262.1	252.5
14-Apr-86	4111	0.2	4111.2	160.2	79.1	107.8	2.0	349.1	30.1	3792.2	1609.6	629.8	726.7
15-Apr-86	3252	0.4	3252.4	110.4	79.1	126.9	2.0	318.4	30.0	2963.9	1608.8	685.2	166.2
16-Apr-86	3030	0.2	3030.2	75.6	79.1	60.5	2.0	217.2	27.9	2840.9	1617.1	324.5	201.1
17-Apr-86	2750	0.3	2750.3	184.2	79.1	60.0	2.0	325.4	28.8	2453.7	1641.8	332.8	266.4
18-Apr-86	2900	0.3	2900.3	75.7	79.1	49.3	2.0	206.1	28.5	2722.7	1648.7	254.1	229.8
19-Apr-86	3055	0.2	3055.2	75.7	79.1	46.6	2.0	203.4	29.6	2878.4	1616.1	236.1	259.5
20-Apr-86	2652	0.3	2652.3	111.4	79.1	46.7	2.0	239.3	25.0	2438.0	1526.8	212.5	276.1
21-Apr-86	3136	0.3	3136.3	139.0	79.1	47.0	2.0	267.1	27.9	2897.2	1585.9	224.7	185.6
22-Apr-86	2537	0.3	2537.3	75.7	79.1	41.4	2.0	198.2	27.6	2366.7	1609.9	235.1	194.0
23-Apr-86	2866	0.2	2866.2	118.7	79.1	42.6	2.0	242.5	26.8	2652.6	1681.0	228.3	207.3
24-Apr-86	2706	0.4	2706.4	134.8	79.1	41.7	2.0	257.6	29.1	2477.9	1721.1	192.2	258.8
25-Apr-86	3322	0.3	3322.3	75.7	79.1	35.8	2.0	192.6	28.5	3158.3	1768.2	160.7	271.3
26-Apr-86	3459	0.4	3459.4	93.6	79.1	35.4	2.0	210.3	26.8	3275.9	1847.8	201.9	1060.7
27-Apr-86	3101	0.3	3101.3	141.0	79.1	36.8	2.0	258.9	28.8	2869.2	1776.2	224.4	348.4
28-Apr-86	3396	0.5	3396.5	75.7	79.1	31.3	2.0	188.0	27.1	3235.6	1702.1	179.6	609.6
29-Apr-86	3215	0.4	3215.4	133.6	79.1	33.9	2.0	248.6	29.9	2995.6	1776.6	192.5	184.8
30-Apr-86	6867	0.4	6867.4	253.5	79.1	401.0	2.0	735.7	36.7	6168.5	1670.6	2191.1	2744.5
APR 86	3098.4	0.3	3098.7	112.7	79.1	72.0	2.0	265.8	29.3	2861.2	1646.6	341.3	355.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-May-86	3127	0.4	3127.4	175.8	82.8	66.9	1.9	327.3	29.1	2829.1	1668.1	448.7	172.6
02-May-86	3034	0.3	3034.3	75.7	82.8	44.7	1.9	205.1	28.6	2857.9	1655.8	250.3	225.4
03-May-86	3084	0.1	3084.1	93.7	82.8	37.8	1.9	216.2	28.7	2894.6	1654.0	207.0	303.1
04-May-86	2998	0.2	2998.2	140.9	82.8	36.0	1.9	261.6	27.9	2764.5	1677.0	182.9	296.2
05-May-86	2754	0.3	2754.3	75.7	82.8	28.5	1.9	188.8	30.0	2595.6	1827.6	138.1	166.0
06-May-86	3751	0.4	3751.4	133.8	82.8	30.2	1.9	248.6	31.1	3533.8	1850.9	192.3	917.1
07-May-86	2781	0.5	2781.5	114.2	82.8	27.5	1.9	226.3	31.1	2586.2	1836.0	191.5	183.6
08-May-86	2857	0.4	2857.4	75.7	82.8	23.6	1.9	184.0	30.2	2703.7	1807.0	186.2	223.4
09-May-86	2726	0.5	2726.4	75.7	82.8	22.4	1.9	182.8	29.7	2573.4	1830.5	170.7	303.2
10-May-86	2879	0.3	2879.2	168.5	82.8	27.5	1.9	280.8	29.4	2627.9	1862.2	200.7	370.5
11-May-86	3222	0.6	3222.6	75.7	82.8	20.8	1.9	181.2	29.7	3068.2	1739.0	149.2	296.5
12-May-86	2778	0.4	2778.4	93.1	82.8	21.6	1.9	199.3	31.6	2610.7	1706.6	160.5	356.1
13-May-86	3676	0.4	3676.4	159.8	82.8	29.5	1.9	273.9	31.2	3433.6	1781.9	324.0	667.0
14-May-86	3265	0.3	3265.3	75.7	82.8	23.1	1.9	183.5	30.3	3112.2	1691.3	339.0	489.2
15-May-86	4320	0.5	4320.5	136.4	82.8	52.6	1.9	273.6	31.8	4078.7	1696.6	662.3	507.9
16-May-86	3691	0.4	3691.4	130.3	82.8	32.2	1.9	247.2	31.2	3475.5	1704.9	459.2	777.8
17-May-86	7631	0.6	7631.6	83.1	82.8	574.1	1.9	741.9	41.9	6931.6	1657.0	3870.0	1911.0
18-May-86	6616	0.3	6616.3	193.7	82.8	514.6	1.9	793.0	32.5	5855.8	1573.3	2904.7	1366.6
19-May-86	7624	0.3	7624.3	166.5	82.8	567.5	1.9	818.7	34.4	6840.0	1623.2	3525.1	1008.6
20-May-86	4612	0.3	4612.3	239.1	82.8	222.5	1.9	546.3	29.2	4095.2	1590.0	1364.2	196.6
21-May-86	3714	0.3	3714.3	75.6	82.8	129.0	1.9	289.4	29.4	3454.4	1684.7	735.8	238.3
22-May-86	3290	0.7	3290.7	75.6	82.8	87.6	1.9	247.9	30.1	3072.9	1679.8	539.3	366.3
23-May-86	3117	0.4	3117.4	92.2	82.8	67.5	1.9	244.4	28.7	2901.7	1717.7	443.9	371.1
24-May-86	3484	0.3	3484.3	159.8	82.8	60.8	1.9	305.3	27.3	3206.3	1733.6	416.3	370.3
25-May-86	3866	0.4	3866.4	75.7	82.8	49.2	1.9	209.6	26.4	3683.3	1660.9	340.3	378.0
26-May-86	2998	0.2	2998.2	90.2	82.8	47.0	1.9	221.9	28.9	2803.2	1574.5	337.3	311.8
27-May-86	4583	0.3	4583.3	231.6	82.8	311.5	1.9	627.8	32.6	3988.1	1661.5	1674.0	378.3
28-May-86	3419	0.4	3419.4	167.8	82.8	116.3	1.9	368.8	29.4	3080.0	1712.8	920.6	242.1
29-May-86	3838	0.5	3838.5	75.5	82.8	180.0	1.9	340.3	32.0	3530.3	1701.2	832.7	305.9
30-May-86	3979	0.5	3979.5	174.3	82.8	105.7	1.9	364.8	29.4	3644.1	1834.4	613.5	365.3
31-May-86	3256	0.5	3256.5	75.7	82.8	72.8	1.9	233.1	30.3	3053.8	2044.4	423.0	446.1
MAY 86	3773.2	0.4	3773.6	121.8	82.8	117.1	1.9	323.6	30.2	3480.2	1723.8	754.9	468.1

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jun-86	4332	0.3	4332.3	75.7	89.6	61.6	2.0	228.9	29.2	4132.6	1810.6	363.4	917.8
02-Jun-86	3286	0.3	3286.3	172.5	89.6	59.6	2.0	323.8	29.8	2992.3	1780.9	350.8	479.2
03-Jun-86	2671	0.4	2671.4	75.6	89.6	48.1	2.0	215.4	30.6	2486.9	1872.8	248.1	288.7
04-Jun-86	3454	0.3	3454.3	75.6	89.6	44.5	2.0	211.8	31.2	3273.8	1858.7	262.0	296.1
05-Jun-86	6772	0.5	6772.5	180.5	89.6	368.5	2.0	640.7	38.0	6169.8	1716.3	3087.2	1088.1
06-Jun-86	4379	0.3	4379.3	370.4	89.6	126.9	2.0	588.9	30.1	3820.4	1700.9	1216.1	228.7
07-Jun-86	6496	0.4	6496.4	126.6	89.6	279.1	2.0	497.3	30.8	6029.9	1696.4	2024.1	745.6
08-Jun-86	4315	0.3	4315.3	277.9	89.6	137.3	2.0	506.8	27.4	3835.9	1689.8	1275.5	630.2
09-Jun-86	3940	0.4	3940.4	75.6	89.6	85.3	2.0	252.5	29.2	3717.2	1793.9	765.0	547.4
10-Jun-86	5717	0.7	5717.7	97.5	89.6	193.9	2.0	383.0	31.9	5366.7	1780.1	1417.4	1505.7
11-Jun-86	5386	0.4	5386.4	269.8	89.6	132.6	2.0	494.0	30.7	4923.1	1839.4	1033.2	1235.2
12-Jun-86	4103	0.4	4103.4	75.6	89.6	83.1	2.0	250.4	31.4	3884.4	1734.6	638.7	227.3
13-Jun-86	3394	0.4	3394.4	75.6	89.6	61.7	2.0	229.0	30.0	3195.4	1753.2	426.0	484.0
14-Jun-86	5201	0.2	5201.2	109.3	89.6	251.9	2.0	452.8	33.0	4781.4	1653.1	1409.3	791.2
15-Jun-86	5157	0.3	5157.3	263.8	89.6	211.9	2.0	567.3	25.9	4616.0	1618.2	2046.7	639.0
16-Jun-86	5112	0.7	5112.7	75.6	89.6	118.6	2.0	285.8	29.8	4856.6	1825.0	1245.3	1017.0
17-Jun-86	4714	0.6	4714.6	75.6	89.6	84.3	2.0	251.6	29.6	4492.6	1790.7	686.3	1023.9
18-Jun-86	4588	0.5	4588.5	75.6	89.6	64.6	2.0	231.9	30.2	4386.9	1831.6	460.2	1010.9
19-Jun-86	4219	0.9	4219.9	172.7	89.6	59.1	2.0	323.5	32.9	3929.3	2099.2	412.9	842.4
20-Jun-86	3845	0.7	3845.7	75.7	89.6	47.1	2.0	214.3	32.5	3663.8	2024.1	329.8	954.9
21-Jun-86	4672	0.6	4672.6	75.7	89.6	43.3	2.0	210.6	31.8	4493.8	2267.7	287.5	1123.6
22-Jun-86	4136	0.3	4136.3	163.5	89.6	58.9	2.0	314.1	31.2	3853.4	2073.4	368.1	694.5
23-Jun-86	4408	0.8	4408.8	75.7	89.6	40.3	2.0	207.6	30.5	4231.6	2133.2	253.0	1057.1
24-Jun-86	3834	0.3	3834.3	75.6	89.6	38.0	2.0	205.3	30.1	3659.2	1832.2	256.8	963.9
25-Jun-86	3936	0.3	3936.3	179.4	89.6	43.2	2.0	314.2	30.1	3652.2	1919.1	274.4	1062.2
26-Jun-86	3820	0.6	3820.6	75.6	89.6	35.0	2.0	202.2	32.0	3650.3	2263.0	210.7	1029.9
27-Jun-86	5318	0.7	5318.7	123.9	89.6	233.0	2.0	448.5	39.5	4909.7	1954.9	1813.1	1332.5
28-Jun-86	5199	0.5	5199.5	197.0	89.6	82.0	2.0	370.6	28.9	4857.7	1863.7	984.1	466.9
29-Jun-86	4677	0.7	4677.7	75.7	89.6	56.3	2.0	223.6	29.6	4483.7	1825.8	473.4	1061.1
30-Jun-86	6036	0.3	6036.3	148.8	89.6	502.7	2.0	743.0	38.9	5330.1	1742.8	2370.5	364.2
JUN 86	4570.6	0.5	4571.0	132.9	89.6	121.7	2.0	346.3	31.2	4255.9	1858.2	899.7	803.6

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jul-86	4685	0.4	4685.4	210.7	98.3	187.8	2.3	499.1	29.0	4214.3	1732.8	739.6	609.0
02-Jul-86	4602	0.5	4602.5	75.5	98.3	129.1	2.3	305.3	31.2	4328.4	1776.5	542.8	1117.3
03-Jul-86	4766	0.5	4766.5	75.6	98.3	81.1	2.3	257.4	30.0	4539.1	1833.1	377.0	1444.7
04-Jul-86	4561	0.5	4561.5	176.4	98.3	65.3	2.3	342.3	28.4	4247.6	1917.4	320.6	1476.7
05-Jul-86	4512	0.6	4512.6	75.7	98.3	47.3	2.3	223.6	29.1	4318.1	2264.7	237.1	1440.7
06-Jul-86	4966	0.7	4966.7	75.7	98.3	40.8	2.3	217.1	31.2	4780.8	2347.0	232.7	1215.1
07-Jul-86	4110	0.7	4110.7	171.6	98.3	44.6	2.3	316.9	32.2	3826.0	1995.8	310.3	1292.6
08-Jul-86	6485	0.6	6485.6	184.3	98.3	529.3	2.3	814.3	40.9	5712.2	1936.7	2761.8	1528.2
09-Jul-86	6947	0.4	6947.4	191.3	98.3	442.2	2.3	734.0	35.6	6248.9	1860.9	2501.1	602.0
10-Jul-86	5497	0.4	5497.4	196.3	98.3	208.6	2.3	505.5	32.3	5024.3	1810.9	1178.2	371.8
11-Jul-86	6916	0.7	6916.7	145.1	98.3	723.7	2.3	969.5	43.1	5990.3	1815.6	3197.6	1317.0
12-Jul-86	7323	0.5	7323.5	244.8	98.3	539.5	2.3	885.0	35.5	6473.9	1807.3	2157.7	1696.5
13-Jul-86	4588	0.6	4588.6	201.5	98.3	337.2	2.3	639.3	30.5	3979.8	1816.8	1444.1	820.9
14-Jul-86	4698	0.5	4698.5	75.6	98.3	206.4	2.3	382.6	31.4	4347.3	1906.8	745.4	931.1
15-Jul-86	6044	0.9	6044.9	75.6	98.3	145.4	2.3	321.7	31.3	5754.6	2124.5	727.2	1362.2
16-Jul-86	5147	0.5	5147.5	144.7	98.3	108.5	2.3	353.9	31.9	4825.6	2580.0	781.3	2099.9
17-Jul-86	5404	1.2	5405.2	109.1	98.3	85.7	2.3	295.5	35.2	5144.9	2806.9	606.0	1409.1
18-Jul-86	5392	0.9	5392.9	75.6	98.3	72.0	2.3	248.3	33.3	5177.9	2620.4	449.3	1428.1
19-Jul-86	5071	0.8	5071.8	75.7	98.3	65.3	2.3	241.6	35.1	4865.3	2687.2	401.3	980.7
20-Jul-86	5448	0.5	5448.5	163.0	98.3	66.9	2.3	330.5	32.0	5150.0	2244.3	436.2	2066.7
21-Jul-86	5039	0.9	5039.9	75.6	98.3	57.9	2.3	234.2	32.6	4838.3	2200.8	346.1	1757.9
22-Jul-86	5454	0.5	5454.5	75.6	98.3	55.3	2.3	231.5	34.3	5257.3	2255.0	288.6	2040.5
23-Jul-86	5454	0.6	5454.6	172.4	98.3	59.2	2.3	332.2	34.4	5156.8	2416.0	310.4	2452.3
24-Jul-86	5412	0.7	5412.7	75.6	98.3	50.7	2.3	227.0	36.4	5222.2	2491.9	242.9	2164.5
25-Jul-86	6099	0.9	6099.9	148.9	98.3	69.6	2.3	319.1	36.8	5817.6	2107.9	564.5	2237.6
26-Jul-86	5509	0.4	5509.4	106.5	98.3	51.9	2.3	259.1	31.9	5282.2	2039.7	339.6	1931.3
27-Jul-86	5500	0.9	5500.9	75.7	98.3	46.7	2.3	222.9	30.2	5308.1	2164.5	241.2	2428.3
28-Jul-86	5917	0.7	5917.7	225.8	98.3	115.7	2.3	442.1	35.1	5510.8	2129.1	1019.4	1943.3
29-Jul-86	5486	0.7	5486.7	75.6	98.3	48.5	2.3	224.8	34.0	5296.0	2160.3	318.9	2288.3
30-Jul-86	5340	0.2	5340.2	75.6	98.3	44.8	2.3	221.0	32.9	5152.1	2158.3	251.7	2437.5
31-Jul-86	5828	0.6	5828.6	116.2	98.3	332.5	2.3	549.3	37.3	5316.7	2203.8	1934.2	1841.7
JUL 86	5425.8	0.6	5426.4	128.0	98.3	163.2	2.3	391.8	33.4	5068.0	2142.4	838.9	1572.0

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Aug-86	5468	0.8	5468.8	392.4	98.5	91.1	2.0	584.0	34.4	4919.2	2091.3	397.3	1997.7
02-Aug-86	5478	0.6	5478.6	134.2	98.5	58.1	2.0	292.8	32.8	5218.5	2054.9	241.8	2343.9
03-Aug-86	4898	0.5	4898.5	75.7	98.5	45.7	2.0	221.8	31.7	4708.4	2007.0	201.7	1424.3
04-Aug-86	5170	0.5	5170.5	75.6	98.5	40.7	2.0	216.8	33.1	4986.8	2179.1	177.8	2333.4
05-Aug-86	5129	0.8	5129.8	181.6	98.5	44.6	2.0	326.7	34.3	4837.4	2143.1	226.1	1865.5
06-Aug-86	5323	0.8	5323.8	75.6	98.5	50.2	2.0	226.2	37.9	5135.4	1918.0	374.0	2053.1
07-Aug-86	4831	0.7	4831.7	75.6	98.5	35.5	2.0	211.7	27.0	4647.1	1912.3	324.0	1397.0
08-Aug-86	4878	0.6	4878.6	185.4	98.5	41.4	2.0	327.3	32.1	4583.4	2029.5	315.1	1697.4
09-Aug-86	4342	0.4	4342.4	75.7	98.5	32.7	2.0	208.8	30.1	4163.7	2065.8	229.2	1518.1
10-Aug-86	4242	0.7	4242.7	75.7	98.5	31.5	2.0	207.6	28.6	4063.7	1836.5	244.1	1363.5
11-Aug-86	4440	0.4	4440.4	143.7	98.5	34.1	2.0	278.3	30.6	4192.7	2019.9	245.1	1414.5
12-Aug-86	4354	0.5	4354.5	113.4	98.5	28.6	2.0	242.5	32.5	4144.5	2086.0	204.2	1411.3
13-Aug-86	4810	0.4	4810.4	75.6	98.5	25.3	2.0	201.4	32.0	4641.0	2150.5	168.2	1397.2
14-Aug-86	4604	1.1	4605.1	75.6	98.5	24.7	2.0	200.8	32.7	4437.0	1999.2	145.9	1588.7
15-Aug-86	3990	0.7	3990.7	174.1	98.5	30.7	2.0	305.3	32.0	3717.4	2016.2	206.9	1352.5
16-Aug-86	4530	0.5	4530.5	75.7	98.5	23.7	2.0	199.8	29.9	4360.5	2055.7	164.8	1542.1
17-Aug-86	4021	1.0	4022.0	75.7	98.5	22.9	2.0	199.1	29.6	3851.5	1998.4	179.5	1412.0
18-Aug-86	4035	0.5	4035.5	195.0	98.5	30.0	2.0	325.4	31.2	3741.3	2173.4	240.0	1393.8
19-Aug-86	4481	0.6	4481.6	75.6	98.5	21.4	2.0	197.5	34.4	4318.4	2157.2	174.2	1479.6
20-Aug-86	4832	0.7	4832.7	75.6	98.5	20.6	2.0	196.8	33.4	4669.4	2279.6	152.6	1565.3
21-Aug-86	4497	0.7	4497.7	75.6	98.5	20.0	2.0	196.1	35.1	4336.6	2201.4	169.2	1525.0
22-Aug-86	4463	0.7	4463.7	174.7	98.5	26.0	2.0	301.2	34.6	4197.1	2270.5	204.5	1597.9
23-Aug-86	4669	0.7	4669.7	75.7	98.5	19.1	2.0	195.3	32.0	4506.5	2158.2	153.8	1542.1
24-Aug-86	4218	0.4	4218.4	75.7	98.5	18.7	2.0	194.9	33.1	4056.7	2074.7	129.4	1624.2
25-Aug-86	4847	0.8	4847.8	188.7	98.5	25.8	2.0	314.9	33.5	4566.4	2119.8	204.3	2010.4
26-Aug-86	5411	0.7	5411.7	169.4	98.5	280.7	2.0	550.6	42.0	4903.2	1971.0	1936.9	1416.7
27-Aug-86	4828	0.5	4828.5	152.2	98.5	37.4	2.0	290.1	33.3	4571.7	1833.6	489.9	1237.5
28-Aug-86	4326	0.4	4326.4	75.6	98.5	24.2	2.0	200.3	31.5	4157.7	1833.1	233.4	1478.4
29-Aug-86	4340	0.4	4340.4	75.7	98.5	21.5	2.0	197.7	30.7	4173.4	1791.0	165.7	1445.4
30-Aug-86	4234	0.4	4234.4	162.7	98.5	25.6	2.0	288.7	29.5	3975.1	1872.7	175.3	1540.3
31-Aug-86	4472	0.3	4472.3	75.7	98.5	18.7	2.0	194.9	29.5	4305.9	1868.5	125.2	1603.4
AUG 86	4650.4	0.6	4651.0	120.3	98.5	40.4	2.0	261.1	32.3	4422.2	2037.7	277.4	1599.1

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1986	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Sep-86	4072	0.3	4072.3	75.7	87.5	18.7	1.8	183.6	28.8	3917.5	1963.4	128.1	1589.6
02-Sep-86	4135	0.5	4135.5	173.8	87.5	24.6	1.8	287.7	32.5	3880.3	2094.5	186.5	1483.9
03-Sep-86	4387	0.4	4387.4	75.7	87.5	19.5	1.8	184.4	32.3	4235.2	1963.8	174.3	1376.1
04-Sep-86	3942	0.5	3942.5	75.7	87.5	17.8	1.8	182.8	32.8	3792.5	1962.0	145.2	1381.7
05-Sep-86	4176	0.4	4176.4	176.4	87.5	24.0	1.8	289.7	31.7	3918.3	1957.3	177.0	1462.8
06-Sep-86	3698	0.3	3698.3	75.7	87.5	17.2	1.8	182.2	30.0	3546.1	1815.4	136.2	1549.4
07-Sep-86	4109	0.3	4109.3	75.7	87.5	17.2	1.8	182.1	29.9	3957.0	1778.8	133.7	1514.2
08-Sep-86	3703	0.4	3703.4	75.7	87.5	17.1	1.8	182.0	31.1	3552.4	1904.4	213.1	1431.0
09-Sep-86	4101	0.5	4101.5	166.1	87.5	23.0	1.8	278.3	32.4	3855.5	1882.7	154.1	1290.2
10-Sep-86	3876	0.7	3876.7	75.7	87.5	17.0	1.8	181.9	32.1	3727.0	1941.7	97.5	1302.5
11-Sep-86	5676	0.6	5676.6	160.9	87.5	424.9	1.8	675.1	40.5	5042.0	1857.9	3267.3	896.0
12-Sep-86	4767	0.5	4767.5	182.7	87.5	61.9	1.8	334.0	31.3	4464.8	1788.0	585.4	1084.3
13-Sep-86	5281	0.3	5281.3	75.7	87.5	32.3	1.8	197.2	29.1	5112.2	1744.1	227.2	1535.2
14-Sep-86	4579	0.3	4579.3	131.1	87.5	28.0	1.8	248.3	29.0	4360.0	1691.1	223.6	1512.4
15-Sep-86	4445	0.5	4445.5	119.1	87.5	24.5	1.8	232.9	29.0	4241.6	1797.7	229.2	1366.0
16-Sep-86	4262	0.2	4262.2	75.7	87.5	20.0	1.8	185.0	29.8	4107.1	1784.3	186.1	1026.0
17-Sep-86	3958	0.3	3958.3	122.6	87.5	22.2	1.8	234.0	30.2	3754.5	1774.3	177.6	944.0
18-Sep-86	4080	0.5	4080.4	115.8	87.5	21.4	1.8	226.4	28.9	3882.9	1748.8	197.0	968.4
19-Sep-86	4940	0.3	4940.3	118.7	87.5	230.0	1.8	438.0	35.1	4537.4	1772.6	1346.3	1305.4
20-Sep-86	4385	0.5	4385.5	254.7	87.5	76.5	1.8	420.5	28.9	3991.9	1713.0	551.2	363.5
21-Sep-86	5147	0.4	5147.4	214.8	87.5	213.8	1.8	517.8	32.9	4662.4	1673.8	1369.0	1547.3
22-Sep-86	5728	0.9	5728.9	203.0	87.5	142.2	1.8	434.5	34.3	5328.7	1852.2	1300.9	794.4
23-Sep-86	5977	0.7	5977.7	202.9	87.5	122.3	1.8	414.5	29.4	5592.6	1783.4	1251.1	2293.5
24-Sep-86	7018	0.6	7018.6	158.9	87.5	396.5	1.8	644.7	40.2	6414.1	1779.5	2571.1	1675.8
25-Sep-86	5819	1.0	5820.0	287.7	87.5	206.2	1.8	583.1	30.8	5267.6	1868.1	1429.5	1649.0
26-Sep-86	8826	0.3	8826.3	81.4	87.5	1565.5	1.8	1736.2	40.6	7130.8	1814.8	4910.1	745.6
27-Sep-86	6427	0.7	6427.7	232.5	87.5	536.3	1.8	858.0	29.3	5598.0	1770.8	1951.5	1368.2
28-Sep-86	7270	0.5	7270.5	357.7	87.5	328.9	1.8	775.9	29.4	6523.1	1720.2	1657.2	1818.7
29-Sep-86	8586	0.8	8586.8	174.8	87.5	478.9	1.8	743.0	40.8	7884.6	1790.3	4458.9	1759.1
30-Sep-86	8063	0.3	8063.3	190.6	87.5	610.9	1.8	890.8	37.3	7209.7	1767.7	4115.2	985.8
SEP 86	5181.1	0.5	5181.6	150.2	87.5	191.3	1.8	430.8	32.2	4782.9	1825.2	1118.4	1334.0

APPENDIX C

LAKE MICHIGAN DIVERSION ACCOUNTING

WATER YEAR 1987 REPORT

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EXECUTIVE SUMMARY

In compliance with the modified 1980 U.S. modified U.S. Supreme Court decree, the WY87 diversion was computed using the best engineering technology available to date as applied to the diverted watersheds.

Given the complexity of the hydrologic cycle in the heavily urbanized Chicago metropolitan area, and given the number of human and other factors that cannot be adequately represented in numerical modeling procedures, the results of the simulations which compute diversion flows worked exceptionally well.

The WY87 diversion accountable to the State of Illinois is 3,773.5 cfs. This is 573.5 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average, rounded to the nearest cfs, beginning with WY81 is 3,462 cfs and the cumulative deviation from the 3,200 cfs average is -1,835 cfs-years. The negative cumulative deviation indicates a water allocation debt and the maximum allowable debt is 2,000 cfs-years.

INTRODUCTION

The diversion of water from the Lake Michigan watershed is of a major importance to the Great Lake states and to the Canadian province of Ontario. The states and province that border the Great Lakes have concerns with both diversions during periods of low lake levels as well as the long term effects of diversion. To insure that the concerns of these interested parties are considered, the U. S. Army Corps of Engineers has been given the responsibility for the accounting of flow that is diverted from the Lake Michigan watershed.

The Corps of Engineers, Chicago District, is responsible for monitoring the measurements and the computation of the diversion of Lake Michigan water by the State of Illinois. The computations for Water Year 1983 (WY83), WY84 and WY85 (1 October 1984 through 30 September 1985) were completed by the Northeastern Illinois Planning Commission (NIPC) for the Illinois Department of Transportation (IDOT). Prior to the WY83 report, the calculations were made by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) for IDOT. The Corps reviewed, modified, and updated the WY84 and WY85 diversion accounting completed by NIPC. The computations for WY86 were performed jointly by NIPC (under contract to the Corps of Engineers) and the Corps of Engineers. The computations for WY87 were performed solely by the Corps of Engineers. This report represents the final Lake Michigan diversion accounting for WY87.

AUTHORITY FOR REPORT

Under the provisions of the U.S. Supreme Court Decree in the Wisconsin, et al v. Illinois et al, 388 U.W. 426,87 S.Ct. 1774 (1967) as modified 449 U.S. 48, 101 S.Ct. 557 (1980), the Corps of Engineers is responsible for monitoring the measurement and computation of diversion of Lake Michigan water by the State of Illinois. The Water Resources Development Act of 1986 gave the Corps total responsibility for the computation of diversion flows as formerly done by the State of Illinois. The Corps' new mission became effective 1 October 1987.

HISTORY OF THE DIVERSION

Water has been diverted from Lake Michigan at Chicago into the Mississippi River Basin since the completion of the Illinois and Michigan Canal in 1848. At that time, diversion averaged about 500 cubic feet per second (cfs). The Illinois and Michigan Canal was built primarily to serve transportation needs. The canal provided a connecting watercourse between the Great Lakes and the Mississippi River system.

With the development of the Chicago metropolitan area, drainage and drainage improvements led to severe sanitation problems in the mid to late 1800's. The newly constructed sewers moved water and wastes into the Chicago River, which until 1900 drained to Lake Michigan. The water quality of Lake Michigan deteriorated and as such contaminated the city's primary water supply.

A second problem that occurred during this time period was an increase in the overbank flooding within the city. As more roads were built and buildings constructed the sewer system was correspondingly expanded. This increased the rate and volume of runoff and resulted in increased flooding.

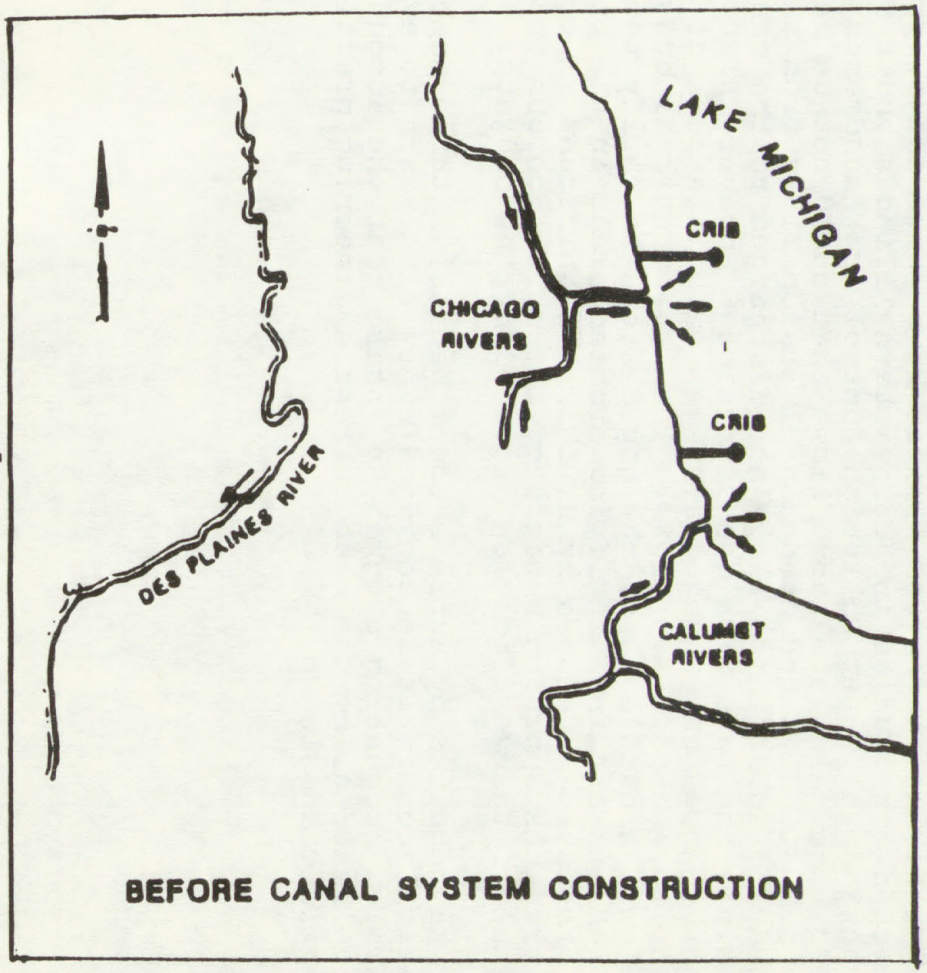
As a solution to the sanitation and flooding problems construction of the Chicago Sanitary and Ship Canal (CSSC) was undertaken. This construction allowed the flow direction of the Chicago River to be reversed (Figure 1). Construction of the Chicago Sanitary and Ship Canal was completed in 1900 by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) (formerly Metropolitan Sanitary District of Greater Chicago, MSDGC). The Sanitary and Ship Canal followed the course of the older I and M Canal. This canal is much larger than the I and M canal and can handle the Chicago River flow as well as increased shipping. The Chicago River Controlling Works was constructed at the mouth of the Chicago River. The lock regulates the amount of Lake Michigan water allowed to pass into the river and restricts river flooding from entering Lake Michigan.

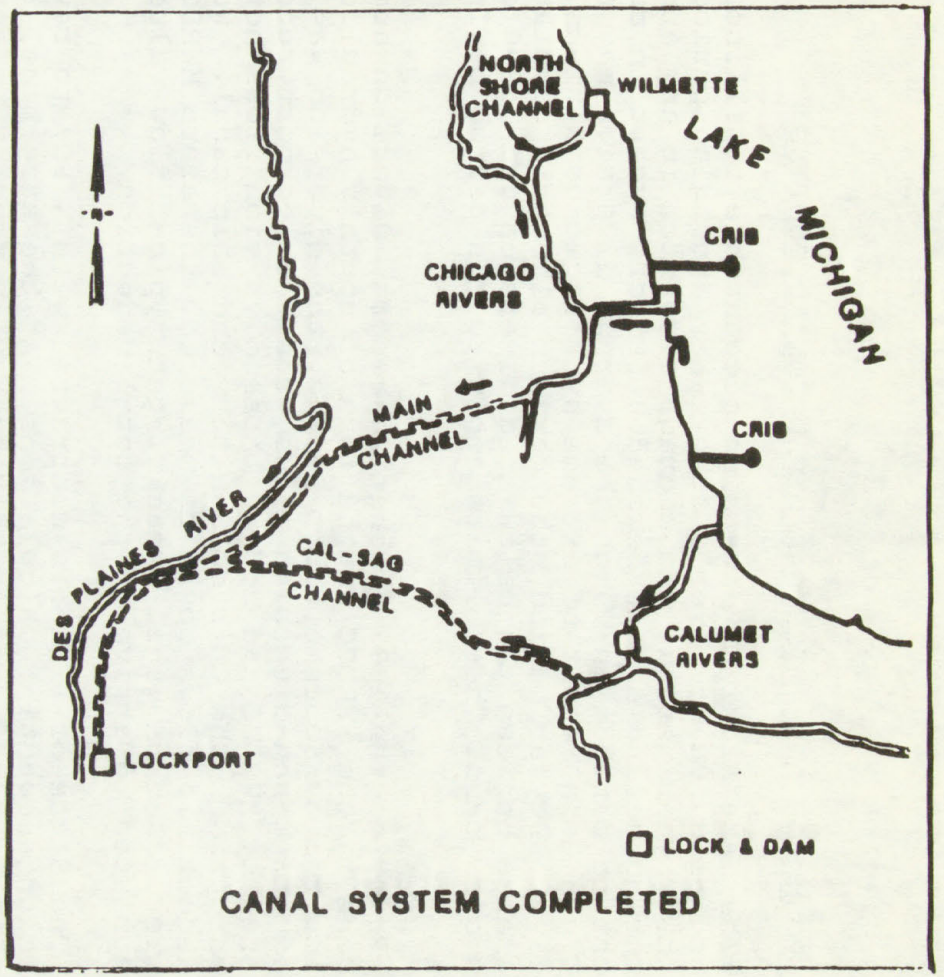
Between 1907 and 1910 the MWRDGC constructed a second sanitary canal called the North Shore Canal. It extended from Lake Michigan at Wilmette in a southerly direction 6.14 miles to the north branch of the Chicago River. The Wilmette Controlling Works regulate the amount of Lake Michigan flow allowed down the channel.

Construction of a third canal, the Calumet Sag Canal, was completed in 1922. The canal connects Lake Michigan through the Grand Calumet River, to the Sanitary and Ship Canal. This canal was constructed to carry sewage from South Chicago, Illinois and East Chicago, Indiana. The O'Brien Lock and Dam located on the Calumet River, regulates the flow of Lake Michigan waters down the canal.

Figure 1

Development of the Chicago Canal System





BACKGROUND OF LAKE MICHIGAN DIVERSION ACCOUNTING

The Lake Michigan diversion accountable to Illinois is limited to 3,200 cfs over a forty year averaging period. During the forty year period, the average diversion in any annual accounting period may not exceed 3,680 cfs except in any two accounting periods in which the average diversion may not exceed 3,840 cfs as a result of extreme hydrologic conditions. During the first 39 year period, the maximum allowable cumulative difference between the calculated diversion and 3,200 cfs is 2,000 cfs-years. These limits apply to the period beginning with WY81.

Prior to the 1983 accounting report, diversion accounting was done by the MWRDGC in the form of monthly hydraulic reports. As required by Supreme Court Decree, the diversion was calculated by deducting non-diversion flows from the Lockport record measured by MWRDGC and adding those diversion flows not discharging to the Chicago Sanitary and Ship canal. Not all of the deductible flows could be measured, therefore MWRDGC used flow records from gaged areas to get typical flow values and then extrapolated to arrive at the total deduction.

The State of Illinois contracted with NIPC, to revise the diversion accounting calculations. At the same time, the State of Illinois moved from monthly hydraulic reports to annual accounting reports. NIPC adapted computer models of the diverted Lake Michigan and the Des Plaines River watersheds, previously developed for studies in Northeastern Illinois under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500), to calculate those flows that could not be measured. Like MWRDGC, NIPC deducted non-diversion flows from the Lockport record and added those flows not discharged to the canal to calculate the Lake Michigan diversion. However, NIPC modeled both the gaged and ungaged areas to calculate much of the deduction and addition flows. Then computational budgets were developed around each of the gaged areas to verify the models. The budgets aid in identifying problem areas in the procedure. The procedure developed by NIPC is a significant improvement over the previous approach because of the more rigorous approach and because of the verification provided by the budgets.

As required by Supreme Court Decree, a three member technical committee is convened every five years to evaluate the diversion accounting program to ensure that the accounting is accomplished using the best current engineering practice and scientific knowledge.

The first technical committee was convened during the period that the diversion accounting was done by MWRDGC. The committee was primarily concerned with the rating of the various components at the Lockport facility, the primary diversion measurement location (Espey et al, 1981). In response to the Committee's concerns, the Corps' Waterways Experiment Station (WES) revised the ratings of the two sets of Lockport sluice gates (Hart and McGee, 1985).

In response to the Committee's concerns, the State of Illinois installed an acoustic velocity meter (AVM) at Romeoville five miles upstream of Lockport. The AVM is a highly accurate flow meter that proved to provide better flow measurements than the MWRDGC reported Lockport flows and the new Corps rating curves. The AVM became operational 12 June 1984. However, USGS did not publish the AVM flows until 1 October 1985. Because of significant equipment problems with the AVM, a replacement AVM was installed in November 1988.

To provide flows during periods of malfunction, various regression analyses were done to relate the MWRDGC reported Lockport flows to the AVM flows. Several sets of equations were proposed by the Corps of Engineers, the USGS, Harza Engineering Co., and the Second Technical Committee. The report, Chicago Sanitary and Ship Canal at Romeoville Acoustical Velocity Meter Backup System, was completed September 1989 (USACE, 1989). The regression equations that were ultimately used to estimate missing AVM flows from WY86 through WY91 were developed by the USGS in a report tentatively titled "Discharge and Regression Analyses for Acoustical Velocity Meter Data for the Chicago and Sanitary Ship Canal at Romeoville, Illinois." The final publication of this report is expected to be available in the spring of 1993.

The second and most recent technical committee reviewed the NIPC hydrologic and hydraulic computer models and agreed that the approach was consistent with what was required by the decree (Espey et al, 1987). However, the committee felt that some of the parameters used in the models were out of date and in need of revision. To address the committee's concerns, the Corps hired a consultant (C. B. Burke Engineering, Ltd.) in September of 1988 to review and update the modeling parameters. The final report concerning the updating of modeling parameters was submitted to the Corps in October 1990.

The Water Resources Development Act of 1986 gave the Corps of Engineers the full responsibility for computation of the Illinois Lake Michigan diversion as of 1 October 1987. When the Corps' new responsibility became effective, the WY84 diversion accounting report, developed by NIPC, had not been certified. As a result, the Corps was responsible for the WY84 and all subsequent reports.

NIPC completed the WY84 diversion accounting report in April of 1988. It was subsequently reviewed by the Corps. The Corps found the report to be adequate with two exceptions. First, the 1984 accounting was completed with the modeling parameters questioned by the second technical committee. Second, MWRDGC reported Lockport flows, adjusted using the WES rating curves, were used instead of AVM flows. The Corps, knowing that the modeling parameters required updating and that AVM flows for the period prior to installation could be calculated accurately using regression equations, refrained from certifying the WY84 report until these issues were resolved.

NIPC completed the WY85 diversion accounting report in December of 1988 and the report was reviewed by the Corps. Like the WY84 report, the WY85 accounting was done with the modeling parameters questioned by the second technical committee. Additionally, NIPC used the AVM flows published by the U.S. Geological Survey (USGS) in their WY85 Water Resources Data for Illinois report. Since the publication of the WY85 USGS report, more reliable equations have been developed for calculating flows when the AVM was malfunctioning.

Upon completion of the analysis of the modeling parameters by Christopher B. Burke Engineering, LTD, the WY84 and WY85 diversion flows were recalculated using the revised modeling parameters and the Romeoville AVM flows. The diversion flows were certified by the Corps of Engineers and transmitted to all interested parties in the Lake Michigan Diversion Accounting 1989 Annual Report (USACE, 1990).

The computation of Illinois' diversion from Lake Michigan for WY86 was undertaken as a joint effort between NIPC (under contract to the Corps of Engineers) and the Corps of Engineers. The computation of Illinois' diversion from Lake Michigan for WY87 was performed solely by the Corps of Engineers. Significant revisions to the diversion accounting procedures were undertaken to account for the impact of Calumet TARP (Tunnel and Reservoir Plan). These revisions as well as other minor revisions will be addressed latter in this report.

DIVERSION ACCOUNTING PROCEDURES

The Lake Michigan diversion accountable to the State of Illinois is calculated by measuring the flow in the Chicago Sanitary and Ship Canal at Romeoville and deducting flows that do not constitute Lake Michigan diversion and are not accountable to the State of Illinois. Finally, additions are made to the Romeoville record for diversions that are not discharged to the canal. The deductions include groundwater water supply pumpage whose effluent is discharged to the canal, runoff from the Des

Plaines River watershed that is discharged to the canal, Lake Michigan water supply pumpage from Indiana that is discharged to the canal, and water supply pumpage from Lake Michigan used for Federal facilities that is discharged to the canal. The additions to the Romeoville record include flows diverted from the canal upstream of Romeoville, and Lake Michigan water supply whose effluent is not discharged to the canal. This procedure represents the accounting method required by the Supreme Court Decree.

The diversion accounting results are presented as a series of columns that are listed in Table 1. Column 1 through Column 3 compute the total flow in the Sanitary and Ship Canal. Column 4 through Column 7 presents the deductions from the Canal system flows with the total deduction being presented in Column 8. Column 9 presents the additions to the Canal system record. Column 10 is the computed Lake Michigan diversion accountable to Illinois and is equal to the canal system flow minus the deductions plus the additions. Columns 11 through 13 are independent flow estimates for the three sources of diversion: water supply pumpage from Lake Michigan, runoff from the diverted Lake Michigan Watershed, and direct diversion through the lakefront structures. Column 11 through Column 13 are not used in the diversion calculation but are included as another estimate of the diversion for verification of the accounting flows in Column 10. The sum of Column 11 through Column 13 should theoretically equal the flow in Column 10.

In addition to the diversion calculations presented in the 13 columns, 14 computational budgets are prepared as input to the diversion calculation and to verify the estimated flows that cannot be measured. A summary of these budgets is presented in Table 2. Budgets 1 and 2 do not compare simulated to measured flows but are summations of critical water supply pumpage data. Budget 3 through Budget 6 partition stream gage records into runoff and sanitary/industrial discharge components to estimate a portion of the runoff from the diverted watershed that is used as input to Column 13, "Runoff from the Diverted Lake Michigan Watershed." Budget 7 through Budget 13 compare simulated to measured flows at MWRDGC facilities. These budgets are for verification of the diversion accounting procedures and give an indication of the accuracy of the diversion accounting. Budget 14 compares canal system inflows and outflows.

Table 1

Description of the Diversion Accounting Columns

Column No.	Description
1	Chicago Sanitary and Ship Canal (CSSC) at Romeoville AVM Gage Record
2	Diversion from the CSSC above the Romeoville AVM Gage
3	Total Flow Through the CSSC
4	Groundwater Pumpage Discharged into the CSSC and Adjoining Channels
5	Water Supply Pumpage from Indiana Reaching the CSSC
6	Runoff from the Des Plaines River Watershed which Reaches the CSSC
7	Lake Michigan Pumpage by Federal Facilities which Discharge to the CSSC and Adjoining Channels
8	Total Deduction from the CSSC Romeoville AVM Gage Record
9	Lake Michigan Pumpage Which is not Discharged into the CSSC
10	Total Diversion Accountable to the State of Illinois
11	Pumpage from Lake Michigan Which is Accountable to State of Illinois
12	Runoff from the Diverted Lake Michigan Watershed
13	Direct Diversions Through Lake Front Control Structures Which is Accountable to the State of Illinois

Table 2

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
1	Diverted Lake Michigan Pumpage	This budget sums Lake Michigan water diverted by the State of Illinois in the form of municipal and industrial water supply. The results of this budget are used in Column 11.
2	Groundwater Discharged to the CSSC	This budget sums groundwater pumpages that are discharged to the CSSC. The results of this budget are used in Column 4.
3	North Branch Chicago River at Niles, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
4	Little Calumet River at the IL-IN State Line	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
5	Thorn Creek at Thornton, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
6	Little Calumet River at South Holland, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
7	MWRDGC Northside Water Reclamation	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Northside Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Northside service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used on Budget 14 and Columns 6 and 12.

Table 2 (cont)

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
8	MWRDGC Upper Des Plaines Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Upper Des Plaines Pumping Station. This budget provides a calibration point to verify models of the Des Plaines River watershed
9	MWRDGC Mainstream TARP Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Mainstream TARP Pumping Station. The results of this simulation are used in Budgets 10 and 14 and Columns 6 and 12. The budget also provides internal verification of the accounting procedures.
10	MWRDGC Stickney Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Stickney Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Stickney service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Columns 6 and 12.
11	MWRDGC Calumet TARP Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Calumet TARP Pumping Station. The results of this simulation are used in Budgets 12 and 14 and Columns 6 and 12. The budget also provides internal verification of the accounting procedures.

Table 2 (cont)

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
12	MWRDGC Calumet Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Calumet Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Calumet service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Columns 6 and 12.
13	MWRDGC Lemont Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Lemont Water Reclamation Facility. The simulations estimates the runoff from portions of the Des Plaines River watershed within the Lemont service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Column 6.
14	Chicago Canal System	This budget performs a water balance of the Chicago Canal System which includes the CSSC and adjoining channels. This budget provides a verification point for the accounting procedures.

REVISIONS TO THE LAKE MICHIGAN DIVERSION ACCOUNTING PROCEDURES

Several minor revisions were incorporated in the budget and column computations to streamline the diversion computations. These minor revisions do not significantly change the computed diversion.

The most significant revision to the diversion accounting procedures for WY87 that affects the computed diversion is the inclusion of modeling of the Calumet TARP (Tunnel and Reservoir Plan) Pumping Station. TARP is a comprehensive flood control and pollution control plan to alleviate the adverse effects of overflows on the waterways and Lake Michigan in the Chicago area. TARP is designed to capture sewage that would be conveyed into streams with runoff in the form of combined sewer overflows from the 375 square miles of combined sewer area within the MWRDGC service basin. The introduction of the Calumet portion of the TARP system affects the methods employed to compute Illinois' diversion from Lake Michigan. Combined sewer overflows, which prior to TARP, discharged into a specific waterway, may now be discharged into a different waterway via the TARP Tunnels. In 1987, only a portion of Phase 1 of Calumet TARP was in operation.

ACCOUNTING RESULTS

The WY87 diversion accounting monthly summary is presented in Table 4. Table 3 shows the total WY87 Lake Michigan diversion accountable to the State of Illinois is 3,773.5 cfs (Column 10). This is 573.5 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average (Table 3), rounded to the nearest cfs, beginning with WY81 is 3,462 cfs and the cumulative deviation from the 3,200 cfs average is -1,835 cfs-years. The negative cumulative deviation indicates a water allocation debt and the maximum allowable debt is 2,000 cfs-years. Tabular data on daily diversion flows in presented in Appendix A.

Table 3

Status of the State of Illinois' Diversion from Lake Michigan Under the 1980 Modified U.S. Supreme Court Decree

Accounting Year	Certified Flow, cfs	Running Average, cfs	Cumulative Deviation, cfs
1981	3,106	3,106	+ 94
1982	3,087	3,097	+ 207
1983	3,613	3,269	- 206
1984	3,432	3,309	- 438
1985	3,472	3,342	- 710
1986	3,751	3,410	- 1,261
1987	3,774	3,462	- 1,835

Table 4

Lake Michigan Diversion Accounting – WY 1987

Summary of Diversion Flows (cfs)

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13
OCT 86	5244.1	1.7	5245.8	126.0	80.0	238.3	2.4	446.6	82.8	4882.1	1686.5	1388.3	943.8
NOV 86	3320.7	2.3	3322.9	111.9	77.7	138.2	2.2	330.0	82.8	3075.3	1653.7	746.2	209.3
DEC 86	2991.6	1.0	2992.6	107.7	77.3	161.4	2.3	348.7	81.9	2725.8	1625.9	631.1	150.1
JAN 87	2675.2	0.4	2675.6	125.8	78.0	154.0	1.7	359.5	86.4	2402.5	1632.0	574.9	123.9
FEB 87	2745.4	2.2	2747.6	94.0	77.6	96.7	27.1	295.4	84.4	2536.5	1639.8	445.8	110.5
MAR 87	3156.0	2.1	3158.1	108.3	76.6	116.0	1.9	302.8	84.1	2939.4	1640.9	520.3	283.3
APR 87	3553.1	0.5	3553.6	111.9	78.9	110.0	1.8	302.6	87.1	3338.0	1667.6	761.1	292.3
MAY 87	4142.5	2.5	4145.0	119.3	87.5	86.1	1.9	294.9	88.0	3948.0	1822.6	748.9	575.5
JUN 87	4198.5	1.0	4199.4	134.4	96.9	95.7	2.3	329.2	129.3	3999.6	2144.3	742.6	769.7
JUL 87	4426.2	0.8	4427.0	119.4	92.4	56.1	2.0	269.9	128.6	4285.7	2243.7	409.3	1287.9
AUG 87	6830.2	1.4	6831.5	168.0	87.3	399.5	2.1	656.9	108.7	6283.4	2042.0	2342.9	1175.9
SEP 87	4893.7	2.5	4896.2	106.6	69.6	93.3	2.0	271.5	97.9	4722.6	1849.3	378.4	1996.5
WY 87	4028.0	1.5	4029.5	119.8	81.6	146.4	4.2	352.0	96.0	3773.5	1804.9	811.7	665.4

COMPUTATIONS:

1. COLUMN 3 EQUALS THE SUM OF COLUMN 1 AND COLUMN 2.
2. COLUMN 8 EQUALS THE SUM OF COLUMN 4 THROUGH COLUMN 7.
3. COLUMN 10 EQUALS COLUMN 3 MINUS COLUMN 8 PLUS COLUMN 9.

DEDUCTIONS FROM THE ROMEOVILLE GAGE RECORD

ADDITIONS TO THE ROMEOVILLE GAGE RECORD

NOTES:

1. ALL VALUES ARE ROUNDED TO THE NEAREST TENTH.
2. MATHEMATICAL COMPUTATIONS BETWEEN COLUMNS UTILIZE UNROUNDED VALUES.
3. AVERAGE VALUES FOR WY87 WERE COMPUTED USING DAILY VALUES.

DISCUSSIONS OF RESULTS

The following is a discussion of the column functions and computational budgets. The discussion of the column functions describes the purpose of each column as well as some observations on the WY87 values in the columns. The discussion of the computational budgets presents the purpose of each budget and the results of the budget flow balances. The results of the computational budgets are used in the diversion calculations with seven budgets are used to verify the diversion simulation models. The columns are discussed first followed by the discussion of the budgets.

COLUMNS

The columns display the components of the diversion calculation and include the Romeoville flow as well as the various deductions and additions to the Romeoville record. The final three columns display the three diversion components (Lake Michigan pumpage accountable to Illinois, runoff from the diverted watershed, and direct diversion through the lakefront control structures) and the sum of the three columns should theoretically equal the Romeoville based diversion calculation. A comparison of the sum of these three columns to the calculated diversion is presented in the discussion of Column 11 through Column 13.

COLUMN 1: CHICAGO SANITARY AND SHIP CANAL (CSSC) AT ROMEOVILLE, USGS AVM GAGE RECORD

The discharge at Romeoville for WY87 is 4,028.0 cfs. For days when the AVM was inoperable, the flow at the Romeoville site was calculated from regression equations. It was determined previously that the regression equations using MWRDGC reported Lockport flows more accurately estimates the flow in the canal at Romeoville than the MWRDGC Lockport flows alone (USACE, 1989).

COLUMN 2: DIVERSIONS FROM THE CSSC ABOVE THE GAGE

Argonne Laboratories and Uno-ven Corporation (net, withdrawal- discharge) were the only diversions from the Chicago Sanitary and Ship Canal upstream of the Romeoville gage in WY87. The average withdrawal upstream of the AVM for WY87 is 1.5 cfs.

COLUMN 3: TOTAL FLOW THROUGH THE CSSC

Column 3 is the sum of Column 1 and Column 2 and represents the total flow entering the canal system. The average canal flow is 4,029.5 cfs for WY87.

COLUMN 4: GROUNDWATER DISCHARGED TO THE CSSC AND ADJOINING CHANNELS

Column 4 is the effluent whose source is groundwater water supply pumpage by communities, industrial users, and other private users as reported by the Illinois State Water Survey (ISWS). It also includes the groundwater seepage into the TARP system that is discharged to the canal. This quantity is determined by summing all reported groundwater pumpages tributary to the canal along with the estimated groundwater seepage into the Mainstream TARP (Budget 9) and Calumet TARP (Budget 11) systems. This total is then adjusted by subtracting the groundwater normally tributary to the canal that is contained in the combined sewer overflows that discharge to the Des Plaines River and other watercourses not tributary to the CSSC. This method prevents double accounting of the combined sewer overflow portion of the groundwater supply pumpage.

Using ISWS groundwater records, groundwater pumpages were assumed to reach the CSSC and adjoining channels if they were located in the diverted Lake Michigan watershed in Illinois or if they were located within MWRDGC service boundaries. Groundwater seepage into the Mainstream TARP and Calumet TARP systems was determined through simulation and is discussed further in Budgets 9 and 11. The groundwater constituent of combined sewer overflows is determined entirely thorough simulation.

Groundwater pumpage from the Lake Michigan watershed whose effluent is discharged to the canal is a deduction except to the extent that the groundwater sources are recharged by Lake Michigan. Current piezometric levels indicate that groundwater is discharging to the lake. Therefore, groundwater pumpage from within the Lake Michigan Watershed and reaching the canal continues to be a deduction. Research literature will be reviewed periodically to verify this assumption.

Column 4 represents a deduction from the Romeoville record and averaged 119.8 cfs for WY87. Groundwater pumpage tributary to the canal is composed of 21.7 cfs of groundwater pumpage from the Lake Michigan watershed, 30.2 cfs of groundwater pumpage from outside of the Lake Michigan watershed, 50.7 cfs of groundwater seepage into the Mainstream TARP system, and 17.3 cfs of

groundwater seepage into the Calumet TARP system. The total of these components is 119.9 cfs. However, the deduction from the Romeoville gage record is 119.8 cfs since 0.1 cfs of this groundwater supply pumpage was determined, through simulation, to be discharged to the Des Plaines River and other watercourses not tributary to the CSSC in the form of combined sewer overflows.

COLUMN 5: WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CHICAGO SANITARY AND SHIP CANAL

Column 5 represents the computation of Indiana water supply reaching the canal through the Grand Calumet and the Little Calumet Rivers. In the case of the Little Calumet River, a drainage divide exists east of the confluence with Hart Ditch. Therefore, flows from Hart Ditch, including virtually all dry weather flows, normally flow westward into Illinois. Under high flow conditions, the drainage divide may shift westward and a portion of the Hart Ditch flows may be diverted eastward to Burns Ditch and ultimately to Lake Michigan. However, it is accepted that the occurrence in the shift in the drainage divide is infrequent and the flow that is diverted eastward is insignificant. Therefore, it is assumed that all effluent discharged into Hart Ditch and the Little Calumet River west of the divide flow westward. For WY87, total flow in the Little Calumet River was 65.3 cfs, with 4.4 cfs of that flow being determined to be Indiana water supply.

The Grand Calumet River has a summit. On one side of the summit, the flow is toward Lake Michigan. On the other side of the side of the summit, the flow is toward the Calumet Sag Channel. However, the location of the summit is variable and highly influenced by Lake Michigan levels (USGS, 1984). Thus the calculation of this deduction from the Romeoville record is influenced by Lake Michigan levels. In the absence of a stream gaging station on the Grand Calumet River to measure westward flow into Illinois, flow is computed based on a statistical relationship of which the principal variable is lake levels.

Flow in the Grand Calumet River is estimated to be in excess of 90% sanitary effluent. Therefore, it is assumed that the portion of this flow that is attributable to domestic water supply is equal to the sum of the daily water supply for East Chicago, Hammond, and Whiting unless this sum is greater than the flow in the Grand Calumet River. In the case that the combine water supply for these communities is in excess of the flow in the Grand Calumet River, it is assumed that the flow consists entirely of effluent that originates from water supply.

The total Grand Calumet flow reaching Illinois in WY87 was computed as 129.3 cfs. It was determined that 77.2 cfs of that flow was water supply pumpage. Therefore, the total WY87 Indiana water supply deduction, including the flow from the Little Calumet and Grand Calumet Rivers is 81.6 cfs.

COLUMN 6: RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CHICAGO SANITARY AND SHIP CANAL

The WY87 average discharge of Des Plaines River watershed runoff reaching the canal (Column 6) is 146.4. The infiltration and inflow discharged to the water reclamation plants is 88.2 cfs, the infiltration and inflow reaching the canal through combined sewer overflows is 10.5 cfs, and the runoff from the Lower Des Plaines and Summit Conduit areas is 47.7 cfs. The deduction is largely determined by simulation but it is also influenced by the O'Hare basin flow transfer which contributed 10.0 cfs of the 88.2 cfs runoff to the water reclamation facilities during WY87. O'Hare Basin flow transfer will be discussed in more detail later in the report.

COLUMN 7: LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES WHICH DISCHARGE TO THE CSSC

Column 7 represents Lake Michigan diversions for Federal use, not chargeable to State of Illinois, and is typically comprised of water supply used by federal facilities. Column 7 represents a deduction from the Romeoville record and the amount of the WY87 deduction is 4.2 cfs.

COLUMN 8: TOTAL DEDUCTIONS FROM THE CSSC ROMEOVILLE GAGE RECORD

Column 8 is the sum of Columns 4, 5, 6, and 7 and represents the total deduction from the Romeoville record. The total deduction for WY87 is 352.0 cfs.

COLUMN 9: LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL

This column represents water supply pumpage from Lake Michigan that is not discharged to the canal. The water supply pumpage not discharged to the canal is composed of two components:

(1) Lake Michigan water supply used by communities serviced by water reclamation facilities that do not discharge to the CSSC (94.6 cfs). This is an increase of 66.7 cfs from WY86.

(2) The sanitary portion of combined sewer overflows that do not discharge to the CSSC that is attributable to Lake Michigan domestic water supply (1.4 cfs).

The communities that make up the flow in the first component are suburbs whose treated effluent is discharged to the Des Plaines River and other watercourses not tributary to the CSSC. These communities include Elk Grove Village, Hoffman Estates, Mount Prospect, Schaumburg, Hanover Park, Rolling Meadows, Streamwood, Arlington Heights, Buffalo Grove, Palatine, Wheeling, Lincolnshire, Riverwoods, Libertyville, Illinois Beach State Park, Winthrop Harbor, Zion, Waukegan, 76 percent of North Chicago, and 38.2 percent of Des Plaines. It should be noted that the Lake Michigan water supply component of the O'Hare flow transfer is subtracted from the total Lake Michigan water supply of the above communities since (1) the O'Hare flow transfer is treated at the Northside WRP that discharges sanitary effluent that is tributary to the CSSC and (2) the entire Lake Michigan water supply component of the O'Hare flow transfer is from communities contained in the above list. The Lake Michigan water supply for these communities is measured while the sanitary portion of the CSO's is derived through simulation. Column 9 represents an addition to the Romeoville record and the total WY87 addition is 96.0 cfs.

COLUMN 10: TOTAL DIVERSION

Column 10 is equivalent to Column 3 with the deduction of Column 8 and the addition of Column 9. The total diversion for WY87 is 3,773.5 cfs. This amount is 573.5 cfs greater than Illinois's long term diversion allocation of 3,200 cfs. The 40-year running average diversion, beginning with WY81, is 3,462 cfs and the cumulative deviation from the 3,200 cfs allocation is -1,835 cfs. The negative deviation indicates that the cumulative diversion is greater than an average of 3,200 cfs for the period.

COLUMN 11 THROUGH COLUMN 13: LAKE MICHIGAN DIVERSION COMPONENTS

Column 11 through Column 13 represent the three Lake Michigan diversion components: Lake Michigan pumpage accountable to Illinois (1804.9 cfs), runoff from the diverted Lake Michigan watershed (811.7 cfs), and direct diversion through the lakefront structures (665.4 cfs). The sum of the columns (3,282.0 cfs) should theoretically equal the total diversion as shown in Column 10 (3,773.5 cfs) with one exception. The Romeoville record receives effluent that is assumed to contain only 90% of the water supply pumpage while Column 11, Lake Michigan water supply pumpage accountable to Illinois, does not account for consumptive use. This is based on a consumptive loss (water supply pumpage that is consumed or lost prior to reaching the water reclamation facilities) estimate of 10% of the water supply pumpage (International Great Lake Diversion Consumptive Use Study Board, 1981).

Because the diversion estimate from Columns 11 - 13 is based on simulation, suspect ratings of the lakefront structures, and simple flow separation techniques, the estimate is not expected to be as accurate as the AVM based calculations. However a difference between estimates of 491.5 cfs or 13% is only a marginal balance and is much greater than should be expected. This discrepancy becomes even greater when consumptive use is accounted for in Column 11. The discrepancy in these two estimates is related to the balance in Budget 14, discussed in a subsequent section, and potential sources of the discrepancy are addressed in that budget discussion.

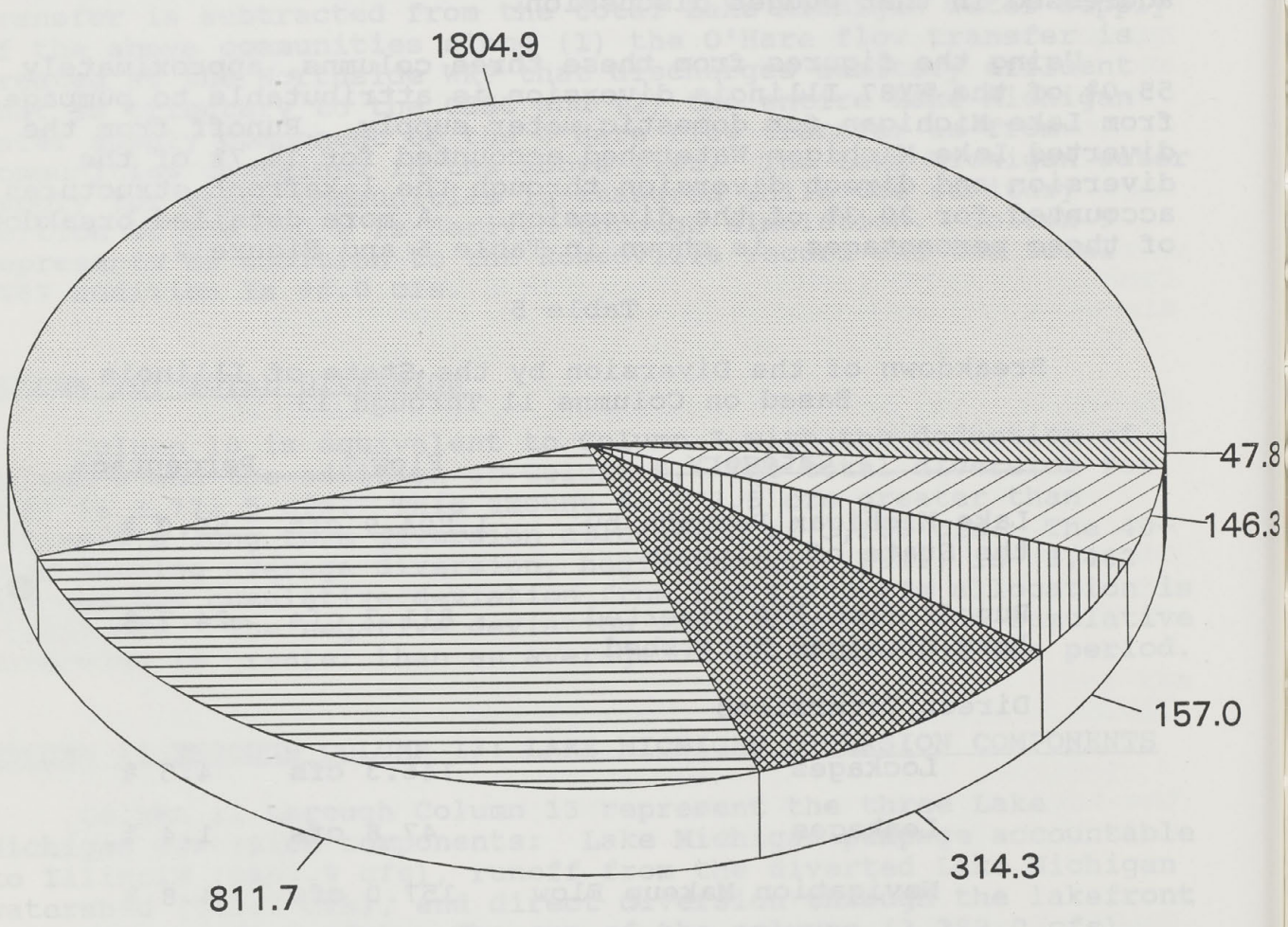
Using the figures from these three columns, approximately 55.0% of the WY87 Illinois diversion is attributable to pumpage from Lake Michigan for domestic water supply. Runoff from the diverted Lake Michigan Watershed accounted for 24.7% of the diversion and direct diversion through the lakefront structures accounted for 20.3% of the diversion. A more detailed breakdown of these percentages is shown in Table 5 and Figure 2.

Table 5

Breakdown of the Diversion by the State of Illinois
Based on Columns 11 Through 13

Category	Flow	Percentage
Lake Michigan Pumpage by the State of Illinois	1,804.9 cfs	55.0 %
Runoff from the Diverted Lake Michigan Watershed	811.7 cfs	24.7 %
Direct Diversions		
Lockages	146.3 cfs	4.5 %
Leakages	47.8 cfs	1.4 %
Navigation Makeup Flow	157.0 cfs	4.8 %
Discretionary Flow (adjusted for backflows)	314.3 cfs	9.6 %

Figure 2
Component Breakdown of Illinois' Diversion
Based on Columns 11 through 13



BUDGETS

The first two budgets are used to sum the water supply for the area influenced by the diversion. The following four budgets are of stream gage sites that are not simulated and are used as part of the calculation of the runoff from the diverted Lake Michigan watershed. The remaining seven budgets compare measured and simulated flows.

BUDGET 1 AND BUDGET 2: WATER SUPPLY PUMPAGE

Budgets 1 and 2 are summations of critical water supply pumpage data. Budget 1 sums Lake Michigan water supply diverted by the State of Illinois. The Lake Michigan water supply data is supplied by the state as daily values for primary users and monthly data for secondary users. Budget 2 sums groundwater pumpages in the Lake Michigan and Des Plaines River watersheds that are diverted to the Chicago Sanitary and Ship Canal. Groundwater pumpage data is recorded as a total annual withdrawal based on calendar years.

BUDGET 1: DIVERTED LAKE MICHIGAN WATER SUPPLY

Budget 1 represents the summation of Lake Michigan pumpage accountable to the State of Illinois. For WY87, the average annual Lake Michigan pumpage accountable to Illinois is 1,804.9 cfs.

BUDGET 2: GROUNDWATER DIVERTED TO THE CHICAGO SANITARY AND SHIP CANAL

Budget 2 is groundwater water supply pumpage by communities, industrial users, and other private users, as reported, by the Illinois State Water Survey (ISWS) whose effluent is discharged to the canal. This quantity is determined by summing all reported groundwater sources in the area tributary to the canal less groundwater not discharged to the canal in the form of combined sewer overflows.

Using ISWS groundwater records, groundwater pumpages were assumed to reach the CSSC and adjoining channels if they were located in the diverted Lake Michigan watershed in Illinois or if they were located within MWRDGC service boundaries in which their effluent was discharged into the CSSC and adjoining channels.

The total groundwater pumpage by communities, industrial users, and other private users whose sanitary effluent is tributary to the canal is 51.9 cfs for WY87. It was determined through simulation that 0.2 cfs of this flow never reached the canal. Instead it was discharged to the Des Plaines River or other watercourses not tributary to the canal in the form of combined sewer overflows. The total groundwater pumpage reaching the canal represents a decrease of 23.8 cfs from WY86 to WY87.

BUDGETS 3 THROUGH BUDGET 6: STREAM GAGING STATIONS

The stream gage budgets are used to make estimates of runoff from portions of the diverted Lake Michigan watershed. Sanitary and other point source flows are subtracted from the stream gaging record to develop the runoff estimates. The runoff estimates are used in Column 12. The flow at the stream gaging sites is also part of Budget 14, the canal system budget. Table 6 presents the estimated runoff from these budgets. It should be noted that Budgets 4 through 6 are a composite calculation of the runoff above the Little Calumet River at South Holland gage.

Table 6

Stream Gage Flow Separation

Budget	Location	Flow cfs	Sanitary cfs	Runoff cfs
3	North Branch Chicago River at Niles, IL	123.0	19.1	103.9
4	Little Calumet River at IL-IN State Line	65.3	3.6	61.7
5	Thorn Creek at Thornton, IL	107.9	16.6	91.3
6	Little Calumet River at South Holland, IL	188.4	19.4	169.0

BUDGETS 7 THROUGH BUDGET 13: MWRDGC WATER RECLAMATION FACILITIES

The budgets for the water reclamation plants compare the simulated flows to the measured inflows at the MWRDGC facilities and perform verifications of the diversion accounting program. The simulated flows were developed from an estimated sanitary flow with a daily, weekly, and monthly flow variation and from precipitation-based runoff simulations. The estimated sanitary flow input to the simulation model is based on the population estimates for each plant's service basin. Per capita sanitary flows are determined based on the service basin's water supply minus an assumed 10 percent consumptive loss. Simulated flows were compared with recorded inflows at each facility to assess the accuracy of the simulations.

The discussion of the budgets will concentrate on the results of each simulation, with the exception of Budget 11, as the development of these models have been discussed in previous reports. The discussion of Budget 11 will go in-depth into the development of the Calumet TARP model that was incorporated into the Lake Michigan diversion accounting program for WY87. A summary of the simulation results is presented in Table 7.

BUDGET 7: NORTHSIDE WATER RECLAMATION FACILITY

Budget 7 analyzes the water balance at the MWRDGC Northside Water Reclamation Facility (Figure 3). Overall, the balance for WY87 of the inflow to the Northside facility is good. The simulated to recorded flow ratio (S/R) for the Northside WRP is 0.95, indicating that the simulated inflow volume is extremely close to the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.69, indicating that the model predicted the inflow hydrograph to the Northside facility well.

BUDGET 8: UPPER DES PLAINES PUMP STATION

Budget 8 analyzes the water balance at Upper Des Plaines Pump Station (UDPPS) (Figure 4). The pump station budget is used to verify simulated flows. However it has no direct impact on the diversion calculation.

TABLE 7

WY 1987 SUMMARY OF SIMULATION STATISTICS

Budget No.->	7	8	9	10	11	12	13	14
Description	Northside WRP (1)	Upper Des Plaines Pump Station (1)	Mainstream TARP Pump Station (2)	Stickney WRP (1)	Calumet TARP Pump Station (2)	Calumet WRP (1)	Lemont WRP (1)	Chicago Canal System Balance (1)
Mean Recorded Flow, cfs	442.8	81.1	102.4	1203.8	39.4	361.4	2.2	3478.9
Max. Recorded Flow, cfs	667.1	152.9	542.3	2250.1	115.8	453.4	9.5	21867.0
Min. Recorded Flow, cfs	346.0	47.9	16.8	735.1	7.3	290.9	1.5	1832.8
Mean Simulated Flow, cfs	419.4	66.6	89.4	1193.3	43.6	311.9	1.9	4047.1
Max. Simulated Flow, cfs	707.1	233.5	410.2	3074.4	83.6	718.1	5.4	15849.0
Min. Simulated Flow, cfs	325.8	45.3	37.2	857.9	26.7	226.2	1.3	2186.8
Mean S/R	0.95	0.84	0.87	0.99	1.11	0.86	0.86	1.16
Max. S/R	1.37	3.06	6.47	1.72	5.64	1.89	1.70	1.95
Min. S/R	0.66	0.43	0.40	0.64	0.33	0.59	0.51	0.70
Correlation	0.69	0.59	0.80	0.76	0.53	0.42	0.73	0.90

(1) Based on daily values.

(2) Based on weekly values.

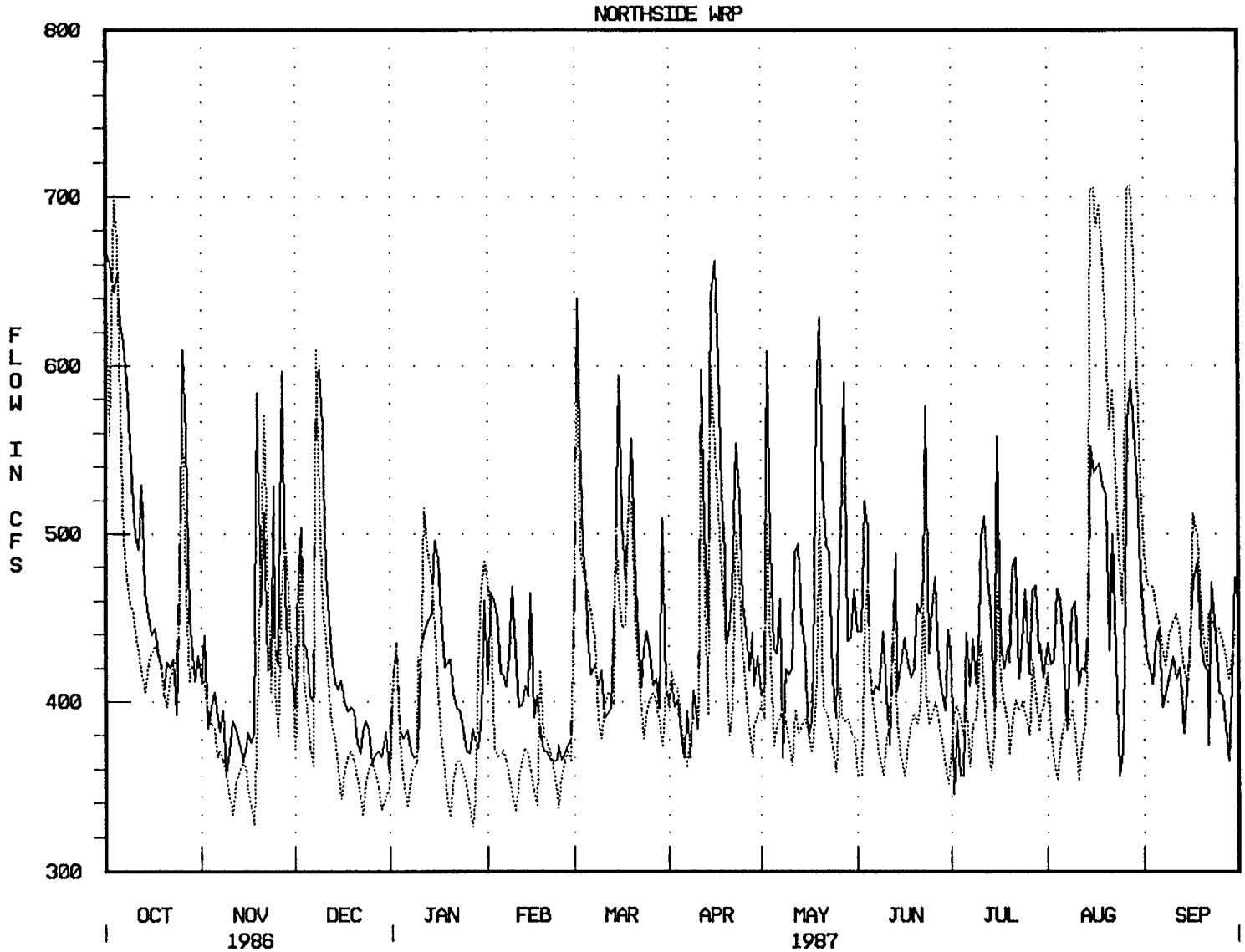


Figure 3

TOTAL PLANT FLOW OBSERVED FLOW
TOTAL PLANT FLOW SIMULATED FLOW

Budget 7 - Simulation of the MWRDGC Northside Water Reclamation Facility

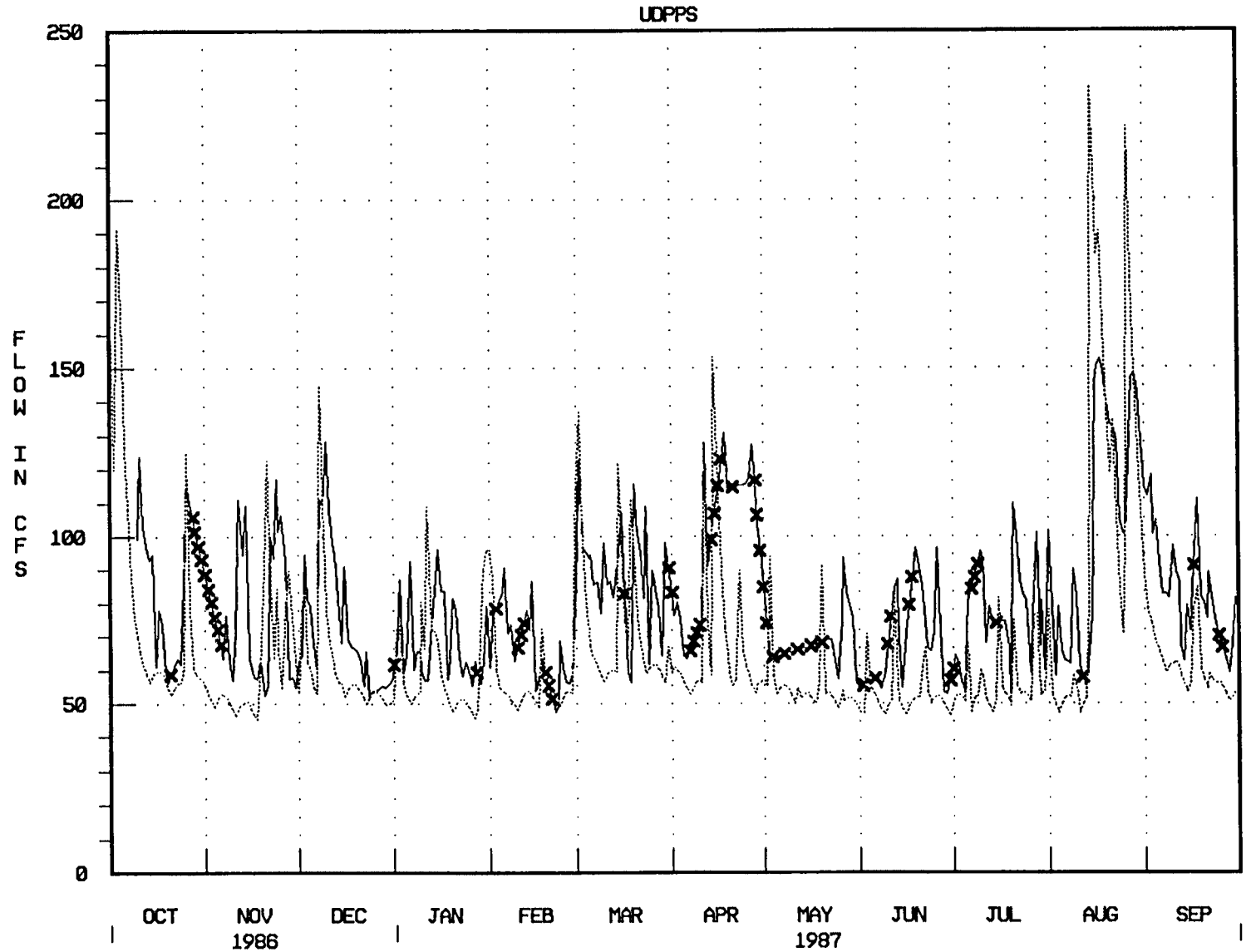


Figure 4

TOTAL PLANT FLOW OBSERVED FLOW
TOTAL PLANT FLOW SIMULATED FLOW

Budget 8 - Simulation of the MWRDGC Upper Des Plaines Pump Station

The balance at UDPPS for WY87 was fair. The simulated to recorded flow ratio (S/R) for the UDPPS is 0.84, indicating that the simulated inflow volume to UDPPS is close to the recorded inflow volume. However, the daily S/R ratio shows a high degree of variability which ranges from 0.43 to 3.06. The coefficient of correlation (R) of simulated to recorded flow is 0.59. This indicates that the time series trends in the simulated inflow compared marginally with the time series trends of recorded inflow. Nevertheless, this is a significant improvement over WY86 coefficient correlation (R) of 0.24.

While the statistical results for WY87 at the Upper Des Plaines Pump Station are much improved, this does not lead to the conclusion that flow measurement alternatives should not be investigated. This site has continued to experience its share of problems. During WY87, 90 days of records were unavailable due to meter malfunctions, problems with the recording charts that made data transformation undoable, and various other reasons. In view of the significant quantity of missing data (25 % missing data), the quantitative analyses of the simulation are of limited value. Second, the accuracy of the flow meters at the pump station is questionable and unmetered bypass flows are a frequent occurrence. Therefore, total flow may not be measured in storm events and the recycling of flow is possible. Further investigation of the accuracy of flow measurement at the pump station is required to verify and calibrate the simulation models that compute the deductible runoff from the Des Plaines watershed contained in Column 6.

BUDGET 9: MAINSTREAM TARP

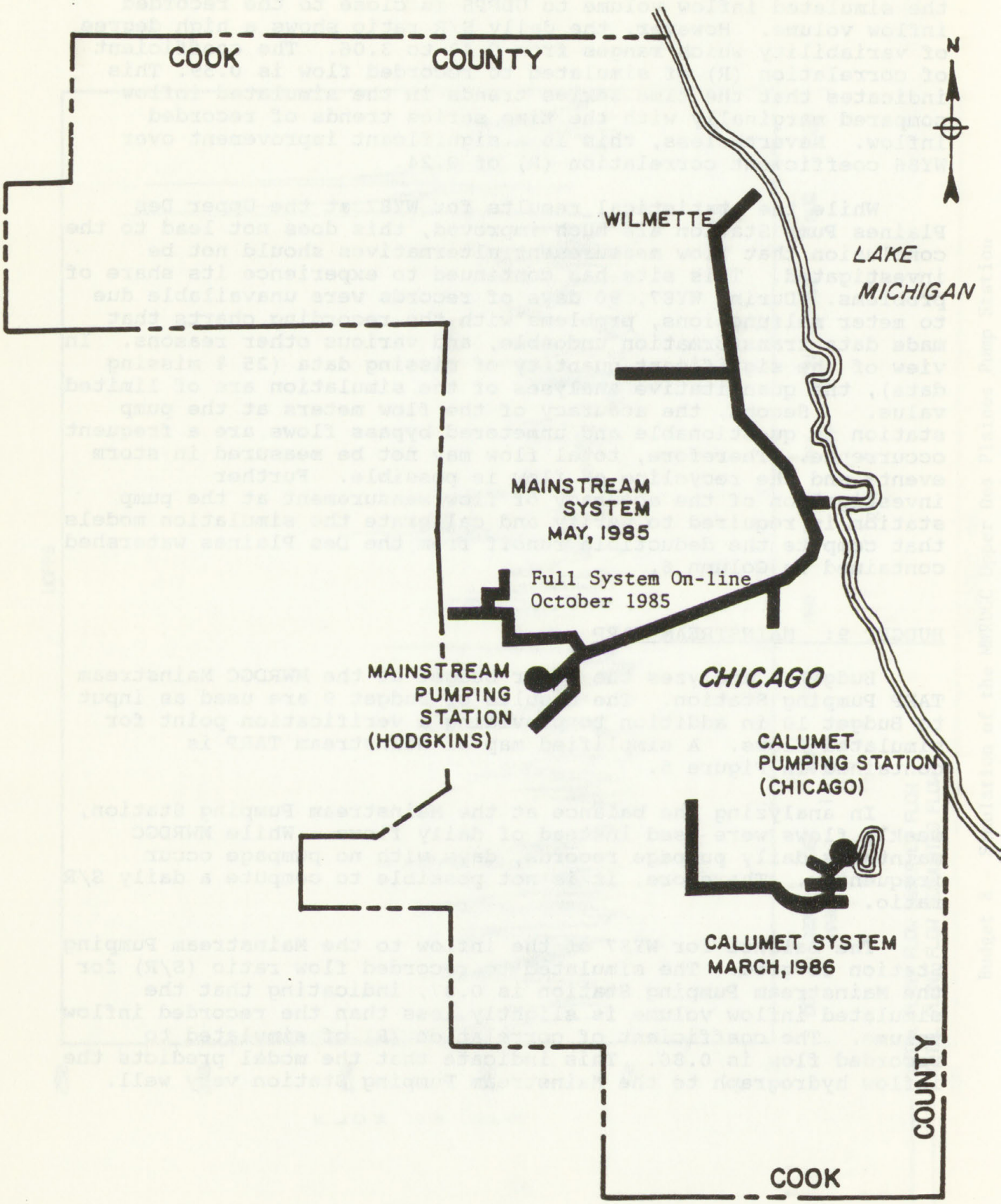
Budget 9 analyzes the water budget at the MWRDGC Mainstream TARP Pumping Station. The results of Budget 9 are used as input to Budget 10 in addition to providing a verification point for simulated flows. A simplified map of Mainstream TARP is contained in Figure 5.

In analyzing the balance at the Mainstream Pumping Station, weekly flows were used instead of daily flows. While MWRDGC maintains daily pumpage records, days with no pumpage occur frequently. Therefore, it is not possible to compute a daily S/R ratio.

The balance for WY87 of the inflow to the Mainstream Pumping Station is good. The simulated to recorded flow ratio (S/R) for the Mainstream Pumping Station is 0.87, indicating that the simulated inflow volume is slightly less than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.80. This indicate that the model predicts the inflow hydrograph to the Mainstream Pumping Station very well.

Figure 5

Map of Mainstream and Calumet TARP



From a review of the plot of the simulated versus recorded flow at the pump station (Figure 6), it appears that the model responds similarly to recorded pumpage record. However, the model tends to have slightly lower peak flows. This results in the simulated pumpage volume being less than the recorded pumpage volume. The one exception is during the cold months, ie. January and February, when the simulated pumpage exceeds the recorded pumpage.

In summary, it appears that the simulation of the Mainstream TARP system is reasonable. However, there is concern regarding the consistent underestimation of pumpage volume and the difference in simulated (hourly) pumpage and recorded (daily) pumpage time series. A review of MWRDGC information regarding Mainstream TARP indicates that bypass flows are discharged to TARP, when available, via drop shaft 11 (DSN 11). Further coordination with MWRDGC established that this is a frequent occurrence. This may account for the simulation of a pumpage volume that is less than the recorded pumpage volume. Records concerning the dates and pumpages back to TARP were not maintained for WY87. Therefore, data necessary to evaluate the impact of pumping back into TARP is not available. Therefore, it was decided that the model would not be adjusted so as to avoid double accounting of flows. This will be investigated further in the future to assess the affects of return flow to TARP on the Mainstream TARP TNET simulation results.

BUDGET 10: STICKNEY WATER RECLAMATION FACILITY

Budget 10 analyzes the water balance at the MWRDGC Stickney Water Reclamation Facility (Figure 7). In the computation of this Budget, simulated Mainstream TARP pumpages from Budget 9 were combined with simulated interceptor inflow to Stickney Water Reclamation Facility to derive the total simulated inflow to the Stickney Facility. Total simulated inflow was compared with recorded inflow to assess the accuracy of the simulation.

Overall, the balance for WY87 of the inflow to the Stickney facility is exceptionally good. The simulated to recorded flow ratio (S/R) for the Stickney is 0.99, indicating that the simulated inflow volume is extremely close to the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.76, indicating that the model predicted the inflow hydrograph to the Stickney facility exceptionally well.

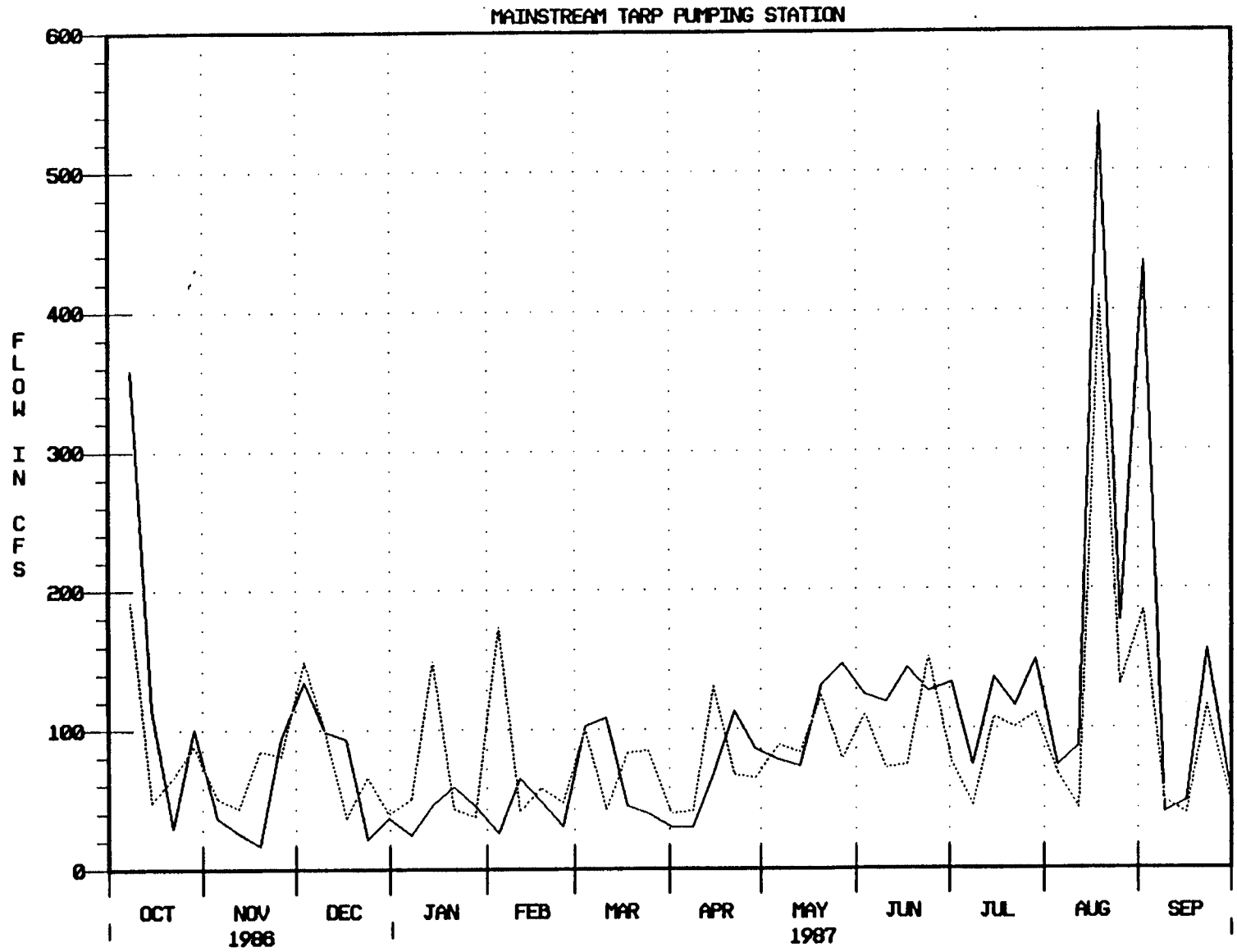


Figure 6

OBSERVED FLOW TO STICKNEY WRP
SIMULATED FLOW TO STICKNEY WRP

Budget 9 - Simulation of the MWRDGC Mainstream Pumping Station.

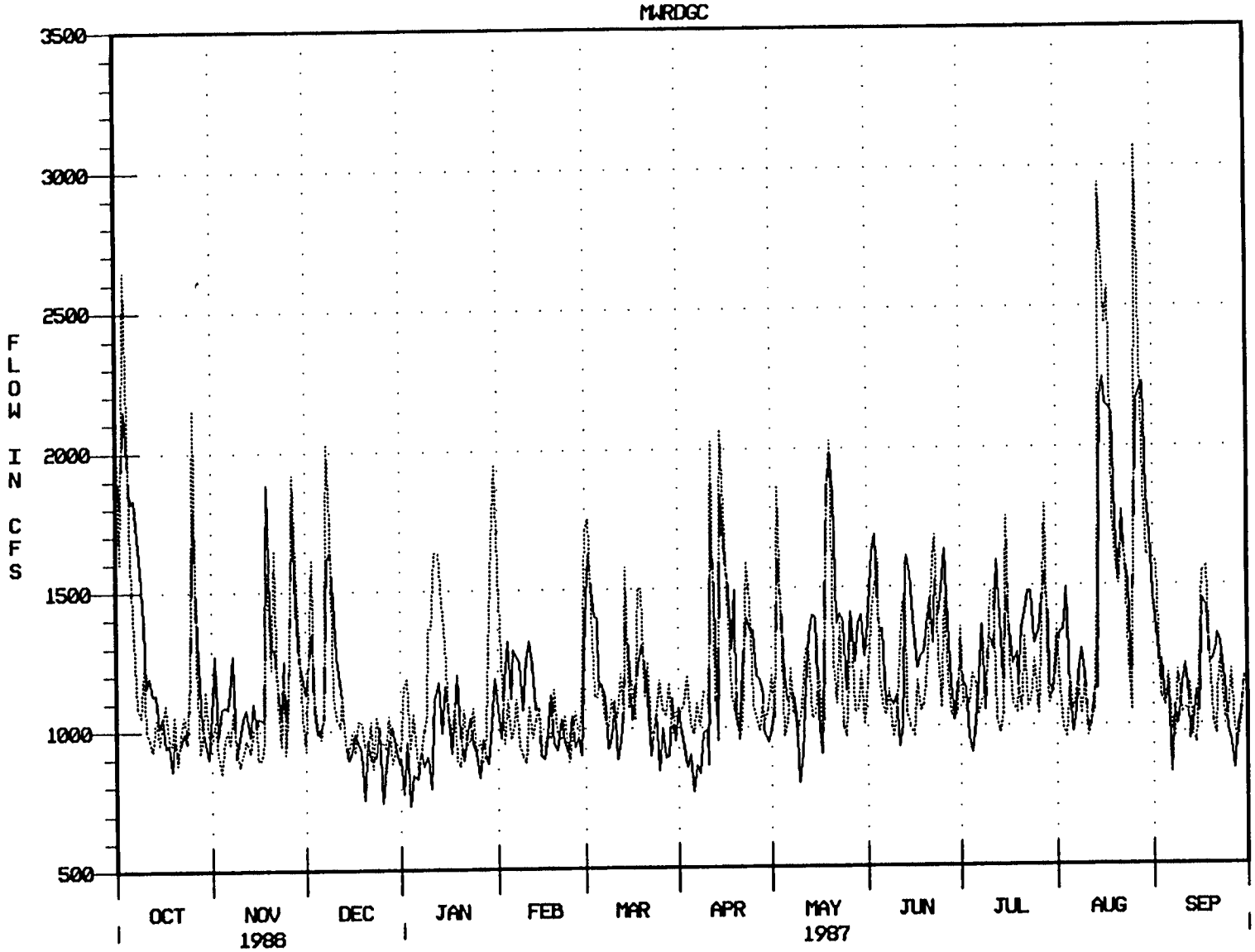


Figure 7

STICKNEY WRP OBSERVED FLOW
STICKNEY WRP SIMULATED FLOW

Budget 10 - Simulation of the MWRDGC Stickney Water Reclamation Facility.

BUDGET 11: CALUMET TARP

Budget 11 analyzes the water budget at the MWRDGC Calumet TARP Pumping Station. The results of Budget 11 are used as input to Budget 12 in addition to providing a verification point for simulated flows.

The operation of the Calumet TARP Pumping Station to Calumet WRP was initiated in March, 1986. However, TARP flows were not recorded until October 1986. Additionally, operational procedures were being modified as additional segments of the system became operational. Therefore, it was impractical to model Calumet TARP prior to WY87 due to the dynamics of the system as additional segments of Calumet TARP came online as well as the fact that pumping records were not available to calibrate the model.

Calumet TARP (Figure 5) for WY87 consists of large tunnels constructed 225 to 325 feet below the Cal-Sag Channel as well as four low-level interceptor relief tunnels (18-E Extension A, Cal-Sag Relief Tunnel, Tunnel 19R-1, and Tunnel 20R-2) constructed 150 to 225 feet below the Cal-Sag Channel and its tributaries.

For WY87, Calumet TARP contains 9.2 miles of primary tunnel ranging from 9 ft. to 21 ft. in diameter and 15.9 miles of low-level interceptors ranging from 8.5 ft. to 17 ft. in diameter. The total tunnel storage volume is 509 acre-feet. There are 25 drop shafts ranging in size from 6 ft. to 15 ft. in diameter. There are also 21 access manholes containing ungated drop pipes. These access manholes range from 6.6 ft. to 7 ft. in diameter. The drop shafts provide for the dropping of combined sewer flow to the TARP tunnels from connecting structures near the ground surface. The access manholes with drop pipes provide relief to overtaxed separate sewers by dropping overflows into TARP via the ungated and uncontrolled drop pipes.

The modeling of Calumet TARP is performed using the TNET (Tunnel Network) dynamic hydraulic model. TNET simulates one-dimensional unsteady flow through a full network of open channels and conduits in both free surface and pressure flow conditions. Free surface flow is modeled using unsteady flow equations for open channel flow. In pressure flow situations, pressure flow is approximated using the concept of an infinitesimal slot (Preismann). This feature preserves the open channel nature of flow, but forces the high celerity of pressure waves.

In developing the Calumet TARP TNET model, existing tunnel conditions were determined from the MWRDGC 1986 TARP atlas and available as-built drawings of the tunnels. Drainage areas that are tributary to Calumet TARP were determined by Christopher B. Burke Engineering, LTD (Burke, 1991) and the Corps of Engineers from the Preliminary Design report for the Calumet System of the Tunnel and Reservoir Plan (Keifer, 1976) and other related documents. Operating procedures for the Calumet TARP were obtained from MWRDGC for Water Year 1987. These operating procedures included guidelines for the operation of gated drop shafts under dry weather, wet weather, and emergency conditions. Pumping capacity for both the Calumet Water Reclamation Facility and the Calumet Pumping Station were obtained from MWRDGC as well (MWRDGC, 1990).

The operational data and pumping capacities obtained from MWRDGC were incorporated into the Calumet TARP TNET model. Operational rules for gated drop shafts were incorporated in the form of a tunnel stage-percent drop shaft capacity rating curves referenced from one index drop shaft. Only one index drop shaft was used since the information on gate closures provided by the MWRDGC did not differentiate between the closure sequences for different segments of Calumet TARP. The curves were based on MWRDGC procedures regarding the relation of water surface elevation to gate closures in the Calumet TARP tunnels. A smooth curve over 2 ft. of elevation was used to prevent "slamming shut" of the gates. This unrealistic condition would cause severe wave oscillation in the tunnels and instability the numerical computations. The lower end of this curve, or the point at which gate closure begins, was derived from MWRDGC operational data.

Pumping from the Calumet Pumping to the Calumet Water Reclamation Facility is determined based on the minimum of (1) available capacity at the Calumet Water Reclamation Facility and (2) pumping capacity at the Calumet Pumping Station. Available capacity was determined as the difference between treatment capacity and simulated inflow from interceptor sewers.

Treatment capacity of the Calumet Water Reclamation Facility is variable. Normal pumping/secondary treatment capacity is about 354 cfs. Under high flow conditions, maximum pumping/ primary treatment capacity is about 450 cfs with flows exceeding secondary treatment capacity being bypassed to the Little Calumet River. This is also contingent on the number of treatment batteries that are operational at any given time.

In the development of the Calumet TARP TNET model, it is necessary to distinguish between conditions that would require only normal treatment capacity and those requiring maximum capacity. It was assumed that conditions requiring maximum treatment capacity would only occur in extreme hydrologic events. Therefore, an extreme hydrologic event was defined as occurring when the total combined sewer overflows into the Calumet TARP system exceed 30 cfs. This became the change point between normal and maximum treatment capacities. When the composite combined sewer overflow routed to Calumet TARP exceeds 30 cfs, then maximum treatment capacity conditions are applied.

Another factor in the development of the Calumet TARP TNET model is the simulation of dry weather flow. Dry weather flow can consist of groundwater seepage and/or discharge from sewered areas that directly connect to Mainstream TARP. Through the Preliminary Design report for the Calumet System of the Tunnel and Reservoir Plan (Keifer, 1976) and through construction drawings, it was determined that two low level interceptor relief tunnels, the Cal-Sag tunnel and tunnel 19R-1, receive a significant amount of dry weather sanitary flow from separately sewered areas. Since leakage is considered to be small, it was assumed that dry weather flow consisted entirely of groundwater seepage and sanitary flows from some separately sewered areas collected by the Cal-Sag and 19R-1 low-level interceptor relief tunnels.

Design seepage in the tunnel is 0.05 million gallons per day per mile. Calumet TARP has 25.1 miles of tunnel, giving a total design seepage of approximately 1.9 cfs. The Calumet TARP TNET model was tested using a uniform distribution of flow within each reach of the tunnel network that resulted in a total groundwater seepage of 1.9 cfs. It was observed that the total simulated volume was significantly less than the recorded Calumet Pumping Station discharge volume. Therefore, 3 separate dry weather periods during WY87 were used to calibrate the groundwater seepage rate so that the total simulated pumpage volume at the Calumet Pump Station was almost the same as the recorded pumpage volume. Using this calibration technique, it was determined that the total groundwater seepage be set at approximately 17.0 cfs. The Calumet TARP TNET model was then tested using a uniform distribution of flow within each reach of the tunnel network that resulted in a groundwater seepage rate of 17.0 cfs. This resulted in a significant improvement of the water balance at the Calumet TARP Pumping Station.

Although effort was made to incorporate Calumet TARP operating procedures into the TNET model, it was not feasible to incorporate all features of the operating procedures. First, operating procedures for Calumet TARP are divided into three categories, dry weather, wet weather, and emergency operations. Dry weather operations tend to focus operating Calumet TARP in the most economical fashion. Therefore, dry weather groundwater flows are allowed to accumulate, and are then pumped at night once there has been sufficient accumulation. Per MWRDGC correspondence, dry weather flows are normally pumped at night when costs for electrical service are reduced and normally requires the use of a high head pump.

The Calumet TNET model was developed to simulate MWRDGC procedures for pumping of dry weather flows. However, there are two major short comings of the model in simulating pumpage of dry weather flows. First the model cannot determine the optimum pumping time, therefore pumping can be initiated at any time if pumping is needed as indicated at the pump sense point. The pump sense point activates/deactivates the pumping algorithm of the model based on water surface elevation in the tunnel. Second, the TNET model cannot simulate the designated operation of a high head pump, but simulates based on available pumping capacity. Nevertheless, the TNET model did simulate dry weather operations of Calumet TARP reasonable well.

A second limitation of the Calumet TARP TNET model is the inability to "forecast" precipitation events. MWRDGC operational procedures call for the dewatering of the tunnel system of accumulated dry weather flow prior to a precipitation event to maximize storage of combined sewer overflows. The incorporation of a pseudo-forecast routine into the model would be helpful. However, the development of a pseudo-forecast algorithm into the model is logically complex and would require considerable effort and was therefore considered to be unfeasible at this time.

A third limitation is the limited number of sense points in the model, and the inability of the model to simulate gate closure based on an average water surface elevation within a tunnel reach. Incorporating a procedure based on improved sense point modeling would be more reflective of MWRDGC operating procedures and would provide for a better simulation.

In analyzing the balance at the Calumet Pumping Station, weekly flows were used instead of daily flows. While the MWRDGC maintain daily pumpage records, days with no pumpage occur frequently. Therefore, it is not possible to compute a daily S/R ratio.

The balance for WY87 of the inflow to the Calumet Pumping Station is fair. The simulated to recorded flow ratio (S/R) for the Mainstream Pumping Station is 1.11, indicating that the simulated inflow volume is only slightly larger than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.53. This indicates that there is similarity in the trends between the simulated and observed inflow, but there is room for improvement in the model's ability to predict the inflow hydrograph to the Calumet Pumping Station record.

From a review of the plot of the simulated versus recorded flow at the pump station (Figure 8), it appears that the model responds similarly to recorded pumpage record. However, the model tends to have a smaller range of flows, ie. recorded peak flows have lower simulated flows while recorded low flows have higher simulated flows. The one exception is during the cold months, ie. January and February, when the simulated pumpage exceeds the recorded pumpage.

In summary, it appears that the simulation of the Calumet TARP system is fair. However, there is concern regarding the difference in simulated pumpage and recorded pumpage time series. Unfortunately, the inability of the Calumet Water Reclamation Facility simulation (Budget 12) to adequately simulate plant inflows has an adverse effect on the results of this budget, and until simulated interceptor flows improve this budget will not result in a good simulation.

BUDGET 12: CALUMET WATER RECLAMATION FACILITY

Budget 12 analyzes the water balance at the MWRDGC Calumet Water Reclamation Facility (Figure 9). The annual simulated to recorded flow ratio (S/R) for Calumet Water is good (0.86), but the daily S/R shows a high degree of variability (0.59 to 1.89). The coefficient of correlation of simulated inflow to recorded inflow (R) is 0.42. Both the high variability in S/R and the poor correlation seem to indicate that the simulation does not provide a satisfactory representation of the hydrology and/or hydraulics of the Calumet service basin.

The hydraulic response to storm events at the Calumet facility was compared to that of the Northside and the Stickney facilities. Base flow at Calumet is about 320 to 360 cfs while peak storm flows in response to inflow-infiltration are on the order of 400 to 440 cfs. At Northside and Stickney, peak flows can be twice as high or greater relative to base flow. Therefore, it appears that the model is simulating proper hydraulic response, but the treatment facility cannot accommodate the storm inflow. This will be investigated at a later date.

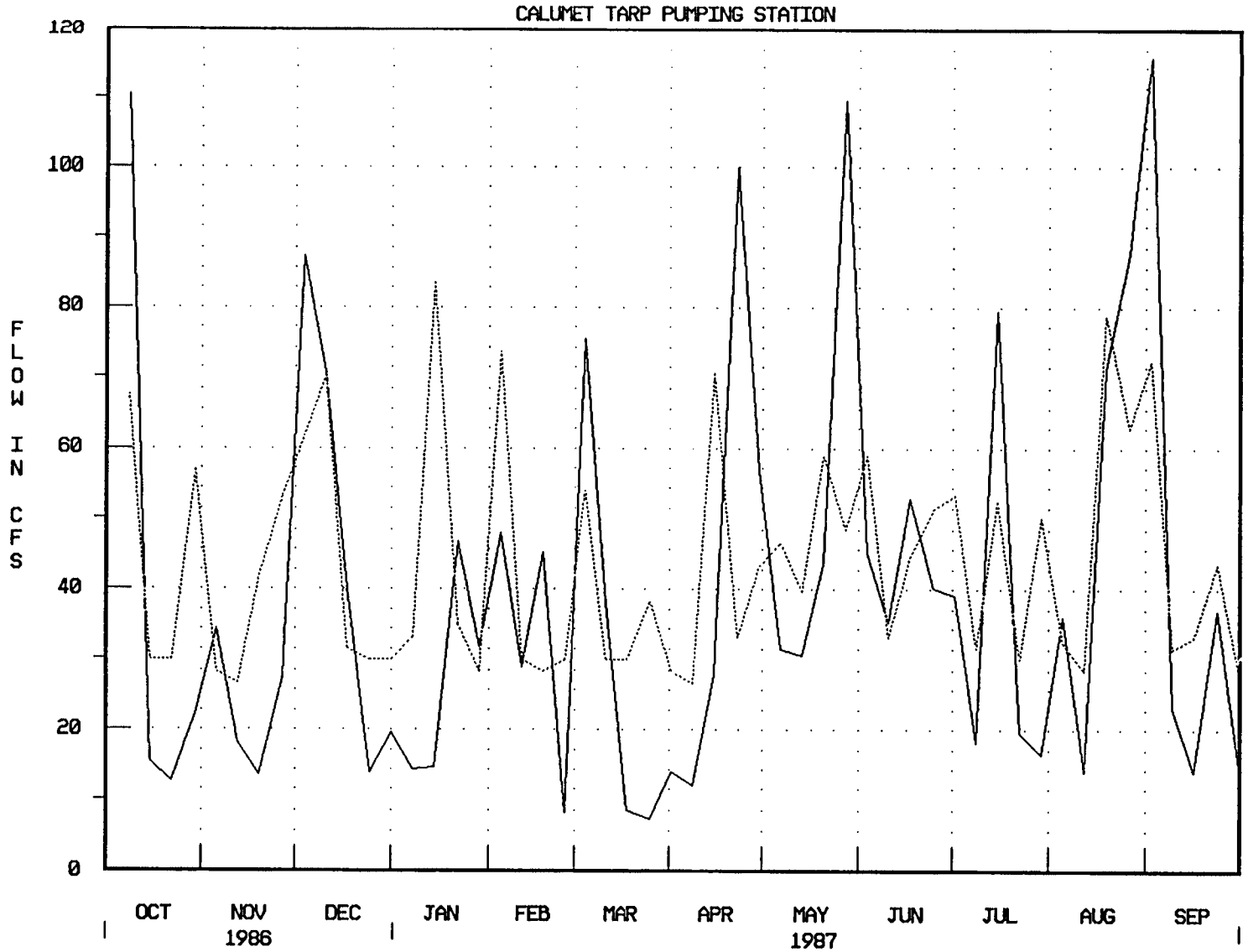


Figure 8

OBSERVED FLOW TO CALUMET WRP AND LITTLE CALUMET RIVER
SIMULATED FLOW TO CALUMET WRP AND LITTLE CALUMET RIVER

Budget 11 - Simulation of the MWRDGC Calumet Pumping Station

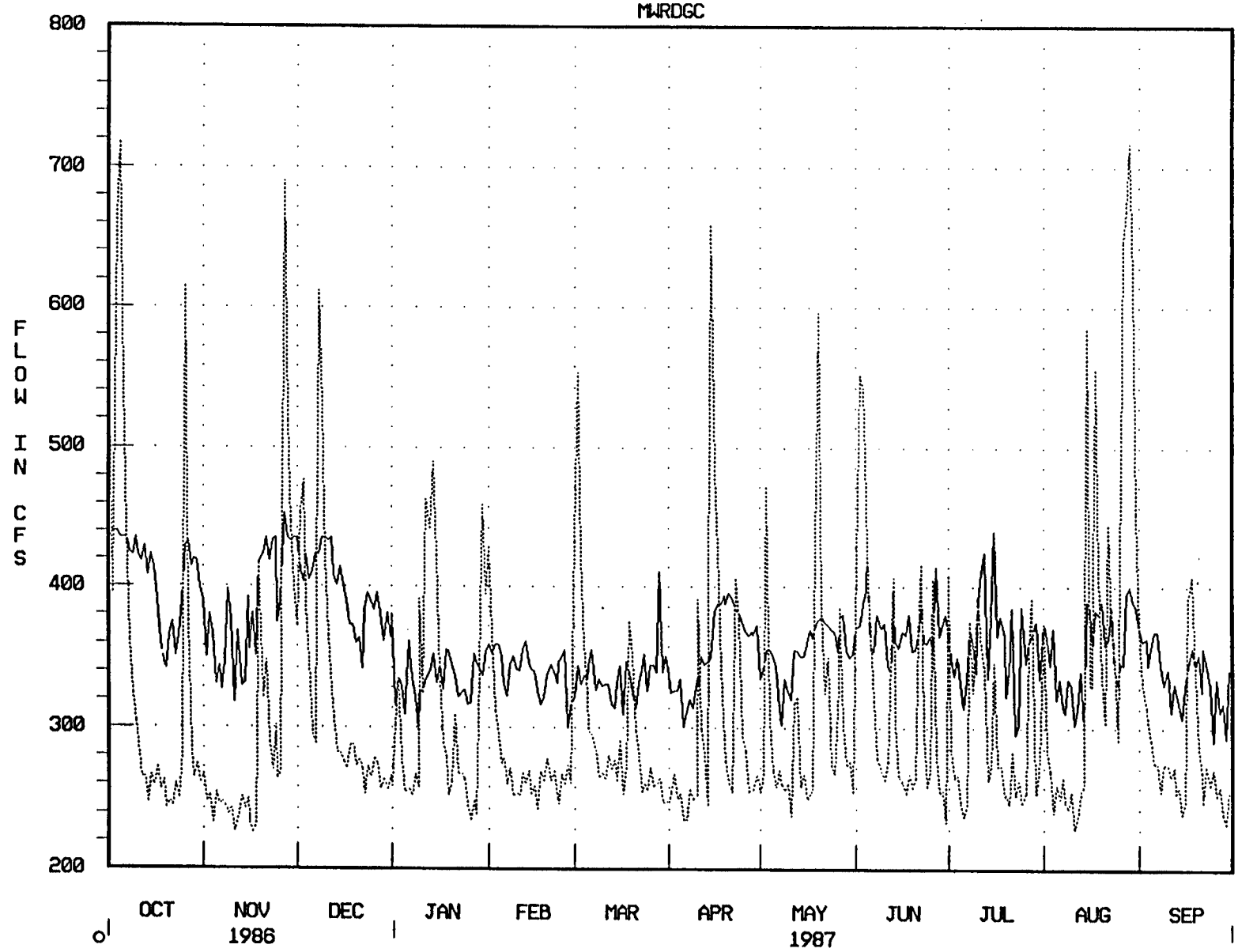


Figure 9

CALUMET WRP OBSERVED FLOW
CALUMET WRP SIMULATED FLOW
Budget 12 - Simulation of the MWRDGC Calumet Water Reclamation Facility.

BUDGET 13: LEMONT WATER RECLAMATION FACILITY

Budget 13 analyzes the water balance at the MWRDGC Lemont Water Reclamation Facility (Figure 10). Overall, the balance for WY87 of the inflow to the Lemont facility is good. The simulated to recorded flow ratio (S/R) for the Lemont is 0.86, indicating that the simulated inflow volume was slightly less than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.73, indicating that the model predicted the inflow hydrograph to the Lemont facility well.

BUDGET 14: CHICAGO CANAL SYSTEM BALANCE

Budget 14 compares the inflows and outflows to the canal system (Figure 11). The inflow components include direct diversions through the lakefront structures, stormwater runoff discharged to the canal system, and domestic water supply whose effluent discharges to the canal system. The outflows from the canal system include the discharge at Lockport, backflows through the lakefront structures, and withdrawals upstream of Lockport by Argonne National labs and Uno-ven corporation. The individual components are presented in Table 8 for WY87.

Overall, the balance for WY87 of the inflow to the canal system to the outflows from the canal system is fair. The S/R (outflow/inflow) for the canal system is 1.16, indicating that the inflow to the canal system is considerably less than the outflow from the canal system. The coefficient of correlation (R) of inflow to outflow is 0.90, indicating that the time series trends of inflow to outflow are well correlated. Therefore, based on the fact that the inflow is well correlated with the outflow, it appears that there is a moderately variable to constant underreported or unreported inflow.

In this balance the measured/simulated inflows are 566.0 cfs (14%) less than the measured/simulated outflows. In the Lake Michigan Diversion Accounting 1989 Report (USACE, 1990), it was reported that the Chicago Harbor wall was in poor condition and was not repaired until WY87. Therefore, discrepancies in this budget should be reduced for WY87. The difference between inflows and outflows has dropped 41.0 cfs (7%) from WY86 to WY87. This may be attributable to the repair of the Chicago Harbor wall.

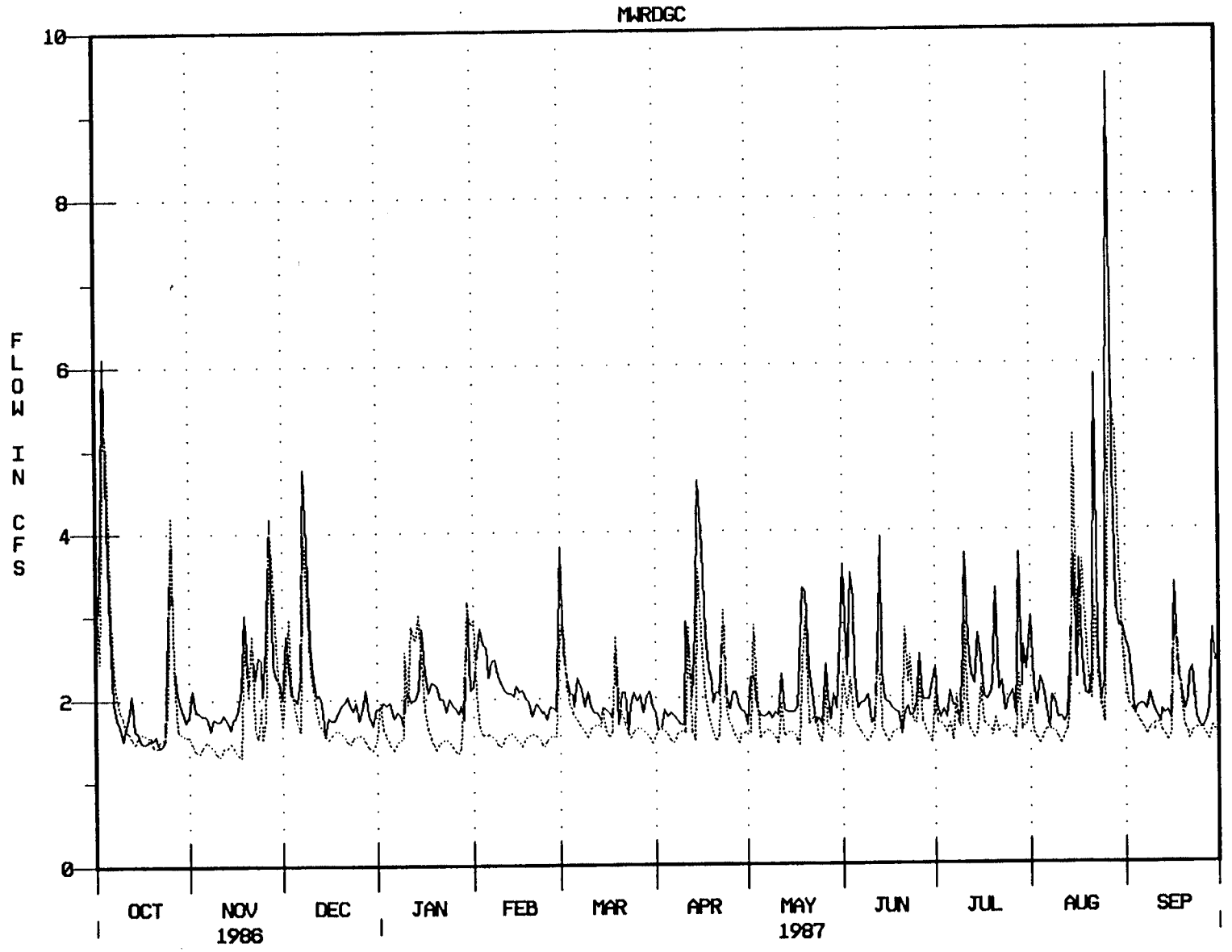


Figure 10

LEMONT WRP OBSERVED FLOW
LEMONT WRP SIMULATED FLOW

Budget 13 - Simulation of the MWRDGC Lemont Water Reclamation Facility.

TABLE 8

SUMMARY OF FLOW COMPONENTS FOR
CANAL SYSTEM BALANCE – WY 1987

INFLOWS (cfs)	
Lake Controlling Structures (measured)	
– Wilmette Controlling Works	32.2
– Chicago River Controlling Works	350.6
– O'Brien Lock and Dam	290.9
Streamflows (measured)	
– North Branch Chicago River at Niles	123.0
– Little Calumet River at South Holland	188.4
Streamflow (estimated)	
– Grand Calumet River at Holman Ave.	129.3
MWRDGC Water Reclamation Facilities	
– Northside	442.8
– Stickney	1203.8
– Calumet	361.4
– Calumet TARP Pumpage to River	29.0
– Lemont	2.2
Other Point Sources (measured)	7.9
Summit Conduit (simulated)	9.5
Combined Sewer Overflows	191.0
Direct Runoff to CSSC (simulated)	119.1
TOTAL INFLOWS (cfs)	3481.1

OUTFLOWS (cfs)	
Cal–Sag Flow Transferred to Calumet WRP as Steel Mill Blow–down	3.5
Lake Front Backflows	8.4
Argonne Laboratory	0.5
Uno–ven Corporation	6.7
USGS AVM Record	4028.0
TOTAL OUTFLOWS (cfs)	4047.1

DIFFERENCE (cfs)	–566.0

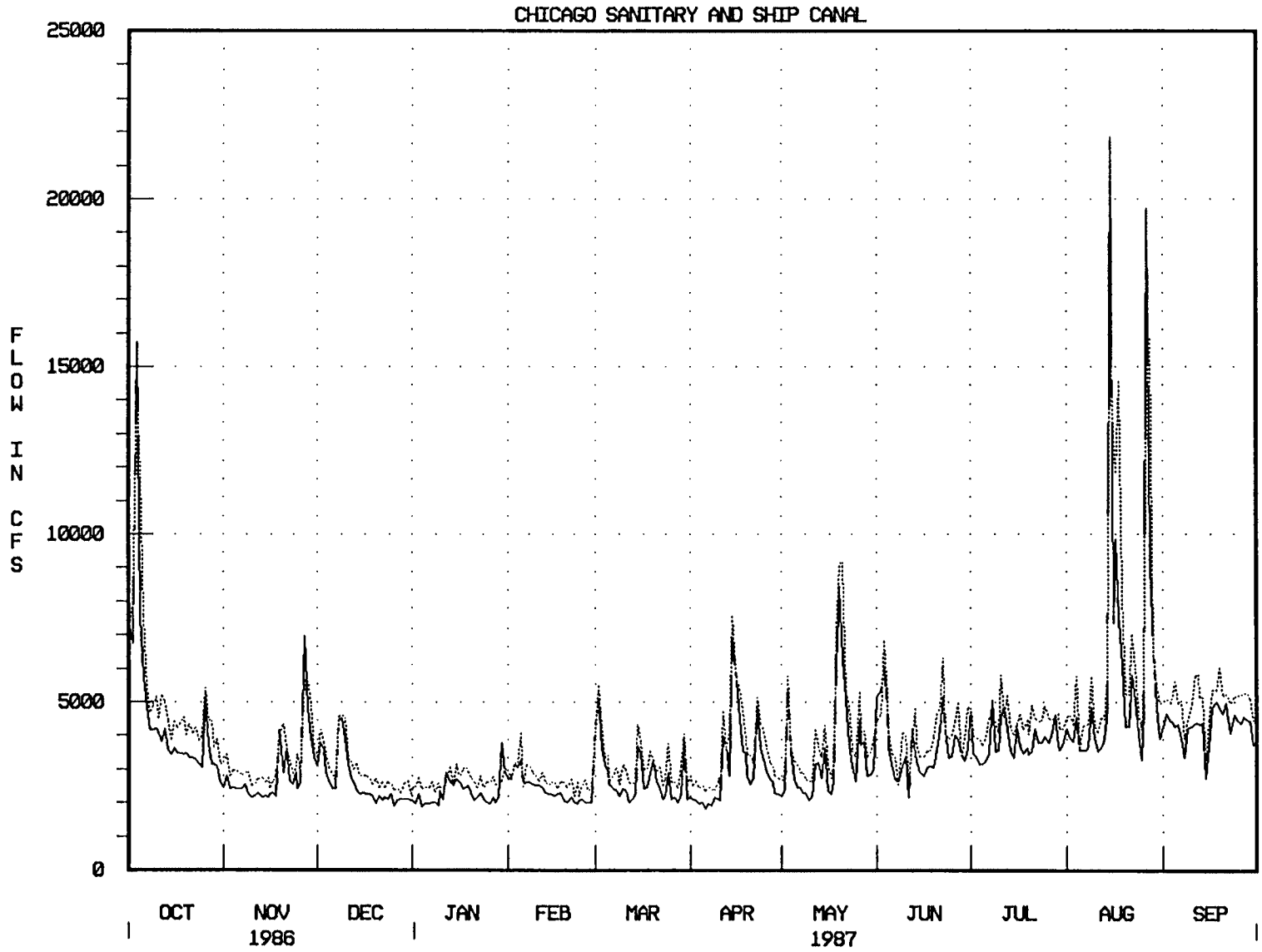


Figure 11

Budget 14 - Canal System Balance

Still, there remains a significant quantity of unaccounted flows in the water budget. Other possible sources of the canal flow imbalance may include underreporting of the lakefront flows through the sluice gates and locks and unaccounted for flow sources. The underreporting of the lakefront flows could be the result of both inaccurate rating curves for the lakefront control structures and leakage through those structures. Flow meter measurements at the lakefront direct diversion points were done to assess if leakage is significant. This study (USACE, 1990) showed that, given the accuracy limits of the Price AA current meter, lakefront flows are underreported, but the magnitude of underreporting could not be determined. Unaccounted flows could include unreported discharges to the canal.

AREAS FOR IMPROVEMENT IN THE DIVERSION ACCOUNTING PROCEDURES

As a result of reviewing and calculating the WY87 diversion accounting, and referencing the results of the WY84, WY85, and WY86 diversion accounting, a number of areas of potential improvement have become evident. The following paragraphs discuss those areas where improvement is needed.

O'HARE AND EGAN BASIN TRANSFER

A portion of the flows originating in the O'Hare and Egan Water Reclamation Plants' (WRP) service basins are transferred east to the Northside WRP. The extent of the O'Hare service area being diverted is not known and the diverted flow is not measured. Thus an estimate of the annual basin transfer is provided by MWRDGC. The total O'Hare-Egan flow transfer for WY87 was estimated by the MWRDGC to be 30.9 cfs (20 MGD).

This transfer is significant to diversion accounting because the O'Hare and Egan facilities discharge outside of the CSSC while the Northside facility discharges flows that reach the CSSC. Therefore, this transfer contains two components that are deductions to the flow measured in the CSSC. The two deductible components are groundwater pumpage contained in the sanitary portion of the transfer, and diverted Des Plaines River watershed runoff. These two deductible components are contained in Columns 4 and 6, respectively.

To determine the two deductible components requires an estimate of the sanitary and runoff portions of the flow transfer. Presently the sanitary and runoff portions of the flow transfer are estimated using the same constituent (sanitary, inflow, and infiltration) proportions simulated for the Upper Des Plaines Pump Station by SCALP. Additionally, estimates must be made of the groundwater and Lake Michigan water components contained in the sanitary portion of the transfer. For WY87 it was estimated that the water supply for the O'Hare and Egan

service basins was composed of 13.9 percent groundwater (2.9 cfs) and 86.1 percent Lake Michigan Water (18.0 cfs). The diverted Des Plaines River watershed runoff was estimated at 10.0 cfs.

For future accounting, simply measuring the basin transfer will not provide any information on the component makeup of the transfer. Thus, a review of the complex hydraulics and hydrology is necessary to determine the best procedure for estimating these flows. Several alternatives, including flow measurement and modeling are under consideration at this time. A more detailed discussion of the O'Hare and Egan basin transfer can be found in the Lake Michigan Diversion Accounting WY86 Report (USACE, 1991).

GRAND CALUMET RIVER

The flow in the Grand Calumet River drains both to the Lake Michigan via Indiana Harbor and to the Calumet Sag Channel that is tributary to the CSSC. When lake levels are high a larger portion of the flow drains to the Calumet Sag Channel. The Grand Calumet River flow calculation is currently based on a regression equation relating Lake Michigan stages and measured flows in Hart Ditch to the Grand Calumet River flow. Through current meter measurements by MWRDGC and other agencies, it was determined that the accuracy of the regression equation is questionable.

The Grand Calumet River flow to Illinois is important to diversion accounting because the majority of the flow in the Grand Calumet River is water supply effluent. This is a deduction to the AVM gage record and is contained in Column 5, Water Supply Pumpage from Indiana Reaching the CSSC. The Indiana water supply deduction is equal to the total water supply pumpage discharged to the Grand Calumet River if the pumpage rate is less than the calculated river flow. The deduction is equal to the river flow if the pumpage rate is greater than the river flow since under these conditions it is assumed that the river flow is composed entirely of sanitary effluent.

This procedure is the only method currently available to calculate the Indiana deduction. A stream gage has been installed in the West Branch of the Grand Calumet River to measure flow into Illinois. This should increase the accuracy of this computation significantly. The same computational procedure for separating stream flow into sanitary and runoff will be used with the Grand Calumet stream gage record.

MWRDGC CALUMET WATER RECLAMATION FACILITY

The MWRDGC Calumet Water Reclamation Plant (WRP) balance was discussed in a previous section where it was noted that although the annual S/R ratio was reasonable, the simulated inflows exhibited poor correlation to the recorded inflows. For WY87 the Corps of Engineers attempted to improve the SCALP (Special Contributing Area Loading Program) hydraulic simulation model so as to better reflect more recent hydraulic conditions of the Calumet service basin. However, the response of the revised simulation model for WY87 did not result in an improved response. Review of recent sewer studies and field evaluation of the sewer system may be required to develop a model that would more accurately represent the hydraulic response of the Calumet WRP service basin. One other possible explanation of the poor simulated to recorded correlation that should not be overlooked is inaccurate flow measurement at the plant. Personnel at MWRDGC need to be consulted on this issue to determine if current flow measurement techniques need to be improved. In addition, a portion of the Calumet WRP service area in the vicinity of the Calumet River needs to be investigated to correct errors regarding the presence of combined versus separate sewers.

MWRDGC UPPER DES PLAINES PUMP STATION

A review of the Upper Des Plaines pump station and its flow record indicates that the flow at the pump station is suspect and subject to operator error. Better flow measurement is needed at the pump station. With better flow measurement, this will become the most important balances for calibrating and verifying the simulation models of the Des Plaines watershed. In the diversion calculation, the primary use of the models is to calculate the deduction for runoff from the Des Plaines watershed discharged to the canal. All of the runoff draining to the pump station is from the Des Plaines watershed, is deductible, and is from somewhat similar land cover as the remaining deductible Des Plaines watershed. Thus, the characteristics of the Upper Des Plaines watershed may be the gaged area that is the most representative of the total deductible Des Plaines watershed. Installation of better flow measurement equipment at the pump station is being investigated.

CANAL SYSTEM BALANCE

As discussed previously, the canal system balance indicated that the total inflows were 14% less than the outflows. The discrepancy in this water balance dropped 41.0 cfs from WY86 to WY87. This may be attributable to the repair of the Chicago Harbor wall in WY87.

Flow meter measurements at the lakefront direct diversion points were done to assess if leakage is still significant. This study (USACE, 1990) showed that, given the accuracy limits of the Price AA current meter in extremely low velocity profiles, the lakefront flows are underreported. However, sound conclusions cannot be drawn regarding the magnitude of the underreporting.

In addition to the problems previously noted, there may be unreported discharges to the CSSC and adjoining waterways that affect the canal system balance. Reconnaissance missions should be made to determine if there are any unreported discharges that are being made directly to the canal system.

PRECIPITATION DATA

The runoff simulation models used to accomplish the diversion accounting are driven by precipitation and other meteorologic data. In performing the WY83 diversion accounting, NIPC discovered problems with the precipitation data related to shielding of the rain gages by buildings and other obstructions. To address this problem, the Illinois State Water Survey (ISWS) was contracted to assess the problem and adjust the precipitation data. The ISWS has also adjusted the WY84 though WY89 data used for Lake Michigan diversion accounting. To resolve the problem, a precipitation gage network of 25 gages was installed by the ISWS under contract with the Corps. However, no data will be available from the network until WY90. Prior to WY90, the precipitation data will be adjusted as in the past.

TUNNEL AND RESERVOIR PLAN

The model developed for the Mainstream Pumping Station performed acceptably for WY87 while the Model developed for the Calumet Pumping Station performed only marginally. There are several areas in which the models can be improved. First, modeling of dry weather flow can be improved to more accurately simulate MWRDGC operational procedures. Second, the incorporation of a pseudo-forecasting algorithm would allow the model to simulate MWRDGC dewatering procedures prior to a storm.

Third, dynamic constituent (I-I versus sanitary versus groundwater) tracking can be incorporated to allow more accurate determination of the deductible components of TARP flow. Fourth, the inclusion of an algorithm to operate gaged dropshafts based on average water surface elevation in a tunnel reach would provide better simulation of gage operations.

SUMMARY

In compliance with the modified 1980 U.S. modified U.S. Supreme Court decree, the WY87 diversion was computed using the best engineering technology available to date as applied to the diverted watersheds. In the development of WY87 Lake Michigan diversion accounting, a Calumet TARP model, was incorporated into the computations to model the Calumet TARP system.

Overall, the simulations that comprise a significant portion of the diversion accounting computations worked well. The two most significant budgets to the diversion accounting computations, Budget 7, Northside Water Reclamation Facility, and Budget 10, Stickney Water Reclamation Facility, performed exceptional well. These two budgets combined compute the majority of the deductible Des Plaines River watershed runoff. These budgets have simulated to recorded ratios of 0.95 and 0.99 and correlations of 0.69 and 0.76. Given the complexity of the hydrologic cycle in the heavily urbanized Chicago metropolitan area, and given the number of human and other factors that cannot be adequately represented in numerical modeling procedures, the results of these two budgets are excellent. Other simulation budgets have performed well, but there is room for improvement. Areas of improvement previously outlined will be considered in order to improve the accuracy of the diversion computation.

The WY87 diversion accountable to the State of Illinois is 3,773.5 cfs. This is 573.5 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average, rounded to the nearest cfs, beginning with WY81 is 3,462 cfs and the cumulative deviation from the 3,200 cfs average is -1,835 cfs-years. The negative cumulative deviation indicates a water allocation debt and the maximum allowable debt is 2,000 cfs-years.

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Lake Michigan Diversion Accounting

Water Year 1987 Report

Appendix A

Summary of Daily Diversion Flows

COLUMN COMPUTATIONS

1. COLUMN 3 EQUALS THE SUM OF COLUMN 1 AND COLUMN 2.
2. COLUMN 8 EQUALS THE SUM OF COLUMNS 4 THROUGH COLUMN 7.
3. COLUMN 10 EQUALS COLUMN 3 LESS COLUMN 8 WITH THE ADDITION OF COLUMN 9.

NOTES

1. ALL VALUES ARE ROUNDED TO THE NEAREST TENTH.
2. MATHEMATICAL COMPUTATIONS BETWEEN COLUMNS UTILIZE UNROUNDED VALUES.
3. AVERAGE VALUES FOR WY87 WERE COMPUTED USING DAILY VALUES.

LEGEND

DEDUCTIONS FROM THE ROMEOVILLE GAGE RECORD

ADDITIONS TO THE ROMEOVILLE GAGE RECORD

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Oct-86	7329	1.7	7330.7	250.7	79.9	549.1	2.4	882.1	90.4	6538.9	1740.0	3644.9	1321.8
02-Oct-86	7946	1.7	7947.7	269.3	80.0	322.8	2.3	674.4	83.5	7356.7	1742.3	2322.2	1916.4
03-Oct-86	14079	1.7	14081.0	208.4	79.9	1763.0	2.4	2053.6	97.0	12124.0	1687.3	10724.0	838.0
04-Oct-86	11810	1.7	11812.0	268.0	79.9	796.6	2.3	1146.8	85.8	10750.0	1615.6	5068.4	261.0
05-Oct-86	7556	1.7	7557.7	215.9	79.7	507.0	2.4	804.9	81.6	6834.4	1594.2	2831.2	385.9
06-Oct-86	5418	1.7	5419.7	174.1	79.9	350.9	2.4	607.2	82.3	4894.7	1714.6	1777.5	516.1
07-Oct-86	4733	1.7	4734.7	65.7	80.0	230.4	2.4	378.5	81.8	4437.9	1723.7	1239.0	382.5
08-Oct-86	4897	1.7	4898.7	65.7	79.9	167.1	2.3	315.0	83.4	4667.0	1738.5	923.9	739.9
09-Oct-86	5150	1.7	5151.7	170.7	80.0	138.0	2.3	391.1	81.2	4841.8	1716.3	877.0	1138.6
10-Oct-86	4512	1.7	4513.7	65.7	80.0	116.5	2.4	264.6	83.2	4332.3	1702.0	727.2	1315.1
11-Oct-86	5203	1.7	5204.7	61.1	79.9	105.6	2.3	248.9	79.0	5034.8	1662.9	647.8	1133.1
12-Oct-86	4997	1.7	4998.7	65.7	79.9	100.1	2.4	248.0	79.0	4829.6	1628.9	578.3	1577.1
13-Oct-86	4404	1.7	4405.7	147.0	79.9	98.1	2.3	327.2	82.8	4161.3	1705.6	579.2	1103.6
14-Oct-86	3899	1.7	3900.7	65.7	79.9	92.5	2.3	240.4	82.2	3742.5	1688.0	490.5	1092.2
15-Oct-86	4416	1.7	4417.7	92.0	80.0	90.2	2.4	264.6	83.2	4236.2	1698.2	502.2	1276.4
16-Oct-86	4250	1.7	4251.7	122.3	79.9	89.5	2.3	294.1	81.7	4039.3	1702.1	502.8	1270.9
17-Oct-86	4430	1.7	4431.7	61.1	80.0	84.2	2.4	227.7	82.5	4266.5	1633.6	488.9	1262.6
18-Oct-86	4588	1.7	4589.7	65.7	79.9	82.6	2.4	230.6	78.9	4438.0	1590.5	454.4	1367.3
19-Oct-86	4045	1.7	4046.7	143.1	79.9	82.1	2.6	307.7	81.3	3820.3	1630.3	478.4	1344.3
20-Oct-86	4353	1.7	4354.7	65.7	79.9	77.4	2.5	225.5	80.4	4209.6	1704.7	399.2	1223.1
21-Oct-86	4061	1.7	4062.7	94.0	79.9	75.1	2.6	251.5	83.4	3894.6	1748.5	416.4	1221.3
22-Oct-86	4299	1.7	4300.7	124.7	80.0	74.1	2.5	281.3	83.1	4102.4	1756.3	417.6	1151.2
23-Oct-86	3845	1.7	3846.7	61.1	79.9	68.7	2.6	212.3	81.4	3715.7	1725.3	388.7	1043.9
24-Oct-86	4074	1.7	4075.7	93.7	79.8	126.1	2.5	302.1	83.9	3857.5	1700.4	681.7	523.8
25-Oct-86	5443	1.7	5444.7	325.6	79.7	475.3	2.4	883.0	84.9	4646.6	1637.4	2104.9	1054.5
26-Oct-86	4473	1.7	4474.7	147.5	79.9	244.4	2.4	474.2	82.0	4082.5	1677.7	1149.5	425.0
27-Oct-86	4473	1.7	4474.7	65.7	80.5	134.9	2.5	283.6	80.1	4271.2	1671.4	687.8	449.4
28-Oct-86	3624	1.7	3625.7	61.1	80.6	102.9	2.4	247.0	83.7	3462.4	1716.2	519.5	656.8
29-Oct-86	3897	1.7	3898.7	161.0	80.0	90.8	2.4	334.2	80.7	3645.2	1690.8	570.4	601.7
30-Oct-86	3172	1.7	3173.7	61.1	80.1	77.5	2.4	221.0	82.6	3035.2	1692.6	450.8	448.9
31-Oct-86	3192	1.7	3193.7	65.7	80.0	72.6	2.4	220.7	81.6	3054.6	1647.0	393.5	216.4
OCT 86	5244.1	1.7	5245.8	126.0	80.0	238.3	2.4	446.6	82.8	4882.1	1686.5	1388.3	943.8

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Nov-86	3466	2.3	3468.2	124.3	77.2	70.2	2.2	273.8	79.1	3273.5	1624.3	464.7	328.0
02-Nov-86	2810	2.3	2812.2	84.7	77.1	66.7	2.3	230.8	80.3	2661.8	1595.1	419.3	267.1
03-Nov-86	2982	2.3	2984.2	61.1	77.3	63.0	2.3	203.8	83.5	2864.0	1679.4	355.2	217.0
04-Nov-86	2960	2.3	2962.2	99.6	77.4	63.2	2.3	242.5	80.7	2800.4	1659.8	395.4	189.5
05-Nov-86	2890	2.3	2892.2	100.3	77.3	60.9	2.3	240.7	83.6	2735.1	1665.3	354.1	201.2
06-Nov-86	2809	2.3	2811.2	61.1	77.2	57.9	2.3	198.5	82.4	2695.2	1674.6	299.8	201.5
07-Nov-86	2896	2.3	2898.2	136.3	77.3	59.1	2.3	274.9	80.8	2703.9	1671.1	352.8	187.2
08-Nov-86	2973	2.3	2975.2	79.8	77.3	55.6	2.3	214.9	82.9	2843.3	1642.1	284.2	279.0
09-Nov-86	2498	2.3	2500.2	65.8	77.3	54.4	2.3	199.6	75.8	2376.5	1579.4	243.2	152.0
10-Nov-86	2569	2.3	2571.2	98.2	77.4	53.6	2.2	231.4	82.5	2422.3	1679.1	267.1	169.7
11-Nov-86	2700	2.3	2702.2	102.6	77.6	52.5	2.3	234.9	79.5	2546.8	1671.7	300.3	169.7
12-Nov-86	2743	2.3	2745.2	65.7	77.4	50.5	2.3	196.0	82.2	2631.5	1651.6	262.4	167.3
13-Nov-86	2605	2.3	2607.2	93.6	77.4	49.7	2.3	223.0	83.7	2468.0	1682.9	246.9	124.0
14-Nov-86	2774	2.3	2776.2	125.8	77.3	50.3	2.3	255.7	81.1	2601.7	1665.3	205.4	141.6
15-Nov-86	2460	2.3	2462.2	61.1	77.4	46.2	2.2	186.9	80.7	2356.0	1636.1	194.5	190.4
16-Nov-86	2651	2.3	2653.2	79.8	77.3	45.7	2.3	205.0	79.6	2527.9	1615.6	242.6	200.0
17-Nov-86	2818	2.3	2820.2	130.7	77.5	46.9	2.3	257.4	83.7	2646.5	1671.2	272.8	165.4
18-Nov-86	4049	2.3	4051.2	205.1	77.4	270.7	2.3	555.5	85.0	3580.8	1662.0	1232.9	150.3
19-Nov-86	4357	2.3	4359.2	126.5	77.4	179.7	2.2	385.9	82.7	4056.1	1663.1	789.7	183.7
20-Nov-86	3640	2.3	3642.2	196.8	77.4	313.4	2.3	589.9	85.9	3138.3	1660.3	1221.7	742.9
21-Nov-86	3275	2.3	3277.2	100.0	77.4	151.8	2.3	331.4	83.8	3029.6	1659.3	706.8	148.0
22-Nov-86	2876	2.3	2878.2	65.7	77.5	98.6	2.2	244.1	79.5	2713.7	1646.4	470.3	155.5
23-Nov-86	3043	2.3	3045.2	138.3	77.4	171.7	2.2	389.7	81.5	2737.1	1592.1	918.8	136.4
24-Nov-86	3429	2.3	3431.2	65.7	77.4	105.2	2.3	250.6	82.1	3262.8	1651.3	542.4	136.8
25-Nov-86	2942	2.3	2944.2	149.5	77.4	101.1	2.3	330.2	81.6	2695.9	1665.5	512.7	147.9
26-Nov-86	5653	2.3	5655.2	213.2	77.4	711.3	2.2	1004.1	85.7	4736.8	1652.9	3612.6	325.0
27-Nov-86	5642	2.3	5644.2	232.2	77.3	423.0	2.2	734.7	81.9	4991.4	1598.0	2791.0	89.0
28-Nov-86	4940	2.3	4942.2	163.1	77.3	304.3	2.2	546.9	79.6	4475.0	1571.5	1845.1	96.0
29-Nov-86	3656	2.3	3658.2	85.5	77.3	204.0	2.2	369.0	79.2	3368.5	1578.7	1161.0	114.2
30-Nov-86	3375	2.3	3377.2	70.6	77.3	154.6	2.2	304.7	79.0	3151.6	1559.7	1001.4	147.5
NOV 86	3282.7	2.3	3284.9	112.8	77.4	137.9	2.3	330.2	81.7	3036.4	1640.8	732.2	197.5

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Dec-86	4219	1.0	4220.0	106.9	77.4	299.9	2.2	486.3	84.1	3817.9	1654.4	1477.4	411.9
02-Dec-86	3800	1.0	3801.0	272.6	77.2	389.4	2.3	741.4	82.3	3141.9	1659.2	1534.0	292.9
03-Dec-86	3424	1.0	3425.0	97.9	77.4	248.2	2.2	425.7	82.6	3082.0	1654.6	882.3	109.3
04-Dec-86	3046	1.0	3047.0	70.3	77.4	170.0	2.2	320.0	80.8	2807.9	1646.2	615.6	129.7
05-Dec-86	2866	1.0	2867.0	61.1	77.3	125.4	2.3	266.2	82.7	2683.5	1638.3	456.8	138.6
06-Dec-86	2656	1.0	2657.0	149.4	77.4	109.4	2.3	338.4	81.5	2400.2	1618.9	467.9	118.0
07-Dec-86	4587	1.0	4588.0	198.4	77.2	601.6	2.2	879.5	89.8	3798.4	1574.8	2266.7	433.1
08-Dec-86	4614	1.0	4615.0	315.3	77.4	520.5	2.3	915.4	85.2	3784.8	1649.5	2049.4	330.8
09-Dec-86	4588	1.0	4589.0	84.7	77.4	308.1	2.3	472.5	82.3	4198.8	1639.1	1332.2	150.8
10-Dec-86	3304	1.0	3305.0	70.3	77.3	217.5	2.2	367.4	82.6	3020.2	1651.7	877.0	100.2
11-Dec-86	3260	1.0	3261.0	65.7	77.5	161.8	2.3	307.3	83.1	3036.8	1644.4	550.7	105.8
12-Dec-86	2998	1.0	2999.0	146.1	77.4	136.9	2.2	362.6	83.4	2719.8	1651.3	541.5	128.0
13-Dec-86	3130	1.0	3131.0	61.1	77.4	118.5	2.3	259.3	81.1	2952.8	1615.1	438.7	142.7
14-Dec-86	2795	1.0	2796.0	65.7	77.2	117.1	2.2	262.3	82.1	2615.8	1625.1	374.5	105.8
15-Dec-86	2795	1.0	2796.0	132.4	77.5	106.4	2.2	318.5	83.6	2561.1	1686.6	421.7	135.9
16-Dec-86	2792	1.0	2793.0	61.1	77.4	99.7	2.3	240.5	82.5	2635.0	1673.8	377.1	107.0
17-Dec-86	2699	1.0	2700.0	112.2	77.2	99.5	2.2	291.1	80.9	2489.7	1665.5	399.2	131.7
18-Dec-86	2497	1.0	2498.0	103.3	77.4	96.9	2.3	279.8	83.5	2301.7	1641.6	388.1	132.4
19-Dec-86	2782	1.0	2783.0	61.1	77.4	92.6	2.2	233.4	80.2	2629.9	1656.6	335.5	115.9
20-Dec-86	2476	1.0	2477.0	65.7	77.4	91.5	2.2	236.8	80.1	2320.3	1628.3	369.4	127.0
21-Dec-86	2616	1.0	2617.0	149.3	77.2	92.4	2.3	321.2	81.0	2376.8	1572.9	395.1	111.3
22-Dec-86	2456	1.0	2457.0	61.1	77.2	86.6	2.3	227.3	80.4	2310.1	1653.4	265.3	104.5
23-Dec-86	2634	1.0	2635.0	143.4	77.4	88.3	2.5	311.5	83.2	2406.7	1639.1	336.2	112.9
24-Dec-86	2580	1.0	2581.0	79.9	77.3	83.4	2.4	243.1	79.6	2417.6	1623.9	333.4	113.0
25-Dec-86	2387	1.0	2388.0	65.7	77.2	81.6	2.3	226.9	79.6	2240.8	1531.5	303.7	104.0
26-Dec-86	2437	1.0	2438.0	65.7	77.4	79.7	2.3	225.1	78.2	2291.0	1552.5	293.6	110.0
27-Dec-86	2330	1.0	2331.0	143.4	77.2	80.0	2.3	302.9	79.1	2107.3	1549.6	326.9	103.4
28-Dec-86	2580	1.0	2581.0	65.7	77.1	76.7	2.3	221.8	79.1	2438.3	1537.5	250.2	104.2
29-Dec-86	2650	1.0	2651.0	115.0	77.2	78.7	2.6	273.5	80.2	2457.7	1616.2	341.6	122.7
30-Dec-86	2264	1.0	2265.0	85.8	77.4	74.2	2.2	239.5	82.3	2107.8	1624.0	316.5	108.4
31-Dec-86	2477	1.0	2478.0	61.1	77.4	70.7	2.3	211.4	81.9	2348.4	1625.8	244.9	111.6
DEC 86	2991.6	1.0	2992.6	107.7	77.3	161.4	2.3	348.7	81.9	2725.8	1625.9	631.1	150.1

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jan-87	2457	0.4	2457.4	87.6	78.0	139.9	1.7	307.2	84.1	2234.2	1527.8	516.4	91.0
02-Jan-87	2756	0.4	2756.4	157.9	78.0	126.5	1.8	364.3	83.7	2475.8	1574.1	556.5	119.9
03-Jan-87	2401	0.4	2401.4	65.7	77.9	90.3	1.7	235.6	89.4	2249.2	1575.1	325.4	112.9
04-Jan-87	2467	0.4	2467.4	155.8	77.9	81.5	1.7	316.9	83.9	2234.4	1575.4	350.6	99.6
05-Jan-87	2461	0.4	2461.4	65.8	78.0	72.4	1.7	217.9	85.2	2328.8	1645.5	256.2	126.6
06-Jan-87	2636	0.4	2636.4	61.1	78.3	67.5	1.7	208.5	87.0	2514.9	1645.0	244.7	112.9
07-Jan-87	2308	0.4	2308.4	98.2	77.9	66.7	1.7	244.5	84.7	2148.6	1652.2	280.9	127.0
08-Jan-87	2586	0.4	2586.4	120.0	77.9	64.7	1.8	264.4	86.1	2408.1	1634.5	255.8	94.8
09-Jan-87	2440	0.4	2440.4	123.9	77.9	263.7	1.7	467.2	89.5	2062.7	1630.6	807.6	135.1
10-Jan-87	2445	0.4	2445.4	210.1	77.9	182.7	1.7	472.4	85.7	2058.6	1583.9	668.4	124.0
11-Jan-87	2674	0.4	2674.4	129.0	77.9	387.3	1.7	595.8	90.3	2168.9	1588.6	1435.6	123.0
12-Jan-87	3044	0.4	3044.4	277.5	77.9	341.6	1.7	698.7	87.9	2433.6	1626.6	1047.2	128.4
13-Jan-87	2532	0.4	2532.4	158.3	77.9	364.1	1.7	602.0	89.1	2019.5	1661.1	1085.8	115.5
14-Jan-87	3141	0.4	3141.4	138.0	78.0	257.4	1.8	475.1	85.6	2751.9	1635.1	903.1	108.5
15-Jan-87	2788	0.4	2788.4	65.7	78.0	154.9	1.7	300.4	86.6	2574.6	1638.9	616.1	117.2
16-Jan-87	3023	0.4	3023.4	61.1	78.0	102.1	1.7	242.9	85.8	2866.2	1636.7	473.6	102.5
17-Jan-87	3032	0.4	3032.4	149.4	78.0	85.3	1.7	314.4	85.0	2803.0	1603.6	456.1	120.5
18-Jan-87	2951	0.4	2951.4	61.1	78.0	71.0	1.6	211.8	83.4	2822.9	1583.5	339.0	133.6
19-Jan-87	2754	0.4	2754.4	65.7	78.0	66.5	1.7	212.0	86.4	2628.7	1638.0	352.3	111.0
20-Jan-87	2609	0.4	2609.4	156.7	78.3	67.4	1.6	304.1	86.7	2392.0	1655.1	394.6	123.9
21-Jan-87	2398	0.4	2398.4	65.7	78.1	60.6	1.7	206.1	86.2	2278.5	1652.3	228.5	131.1
22-Jan-87	2805	0.4	2805.4	61.1	78.1	57.0	1.7	198.0	85.8	2693.2	1648.8	307.5	138.8
23-Jan-87	2465	0.4	2465.4	146.2	78.2	58.2	1.7	284.4	85.9	2266.9	1654.9	300.4	172.0
24-Jan-87	2597	0.4	2597.4	61.1	78.1	52.6	1.7	193.5	84.2	2488.1	1660.7	204.9	157.3
25-Jan-87	2618	0.4	2618.4	113.1	78.0	52.5	1.7	245.3	83.8	2456.9	1629.2	234.4	141.0
26-Jan-87	2816	0.4	2816.4	85.6	78.2	49.9	1.7	215.4	87.6	2688.6	1691.7	227.3	134.3
27-Jan-87	2570	0.4	2570.4	61.1	78.2	46.7	1.7	187.6	84.7	2467.4	1669.4	164.9	139.2
28-Jan-87	2493	0.4	2493.4	172.7	78.2	148.9	1.7	401.6	88.4	2180.3	1677.5	607.8	151.9
29-Jan-87	2663	0.4	2663.4	170.2	78.2	535.0	1.7	785.0	93.0	1971.3	1679.1	1780.4	101.8
30-Jan-87	2979	0.4	2979.4	388.1	78.3	299.5	1.7	767.6	91.3	2303.0	1671.4	1251.3	134.6
31-Jan-87	3023	0.4	3023.4	166.6	78.2	358.0	1.7	604.5	89.7	2507.6	1646.0	1148.2	111.2
JAN 87	2675.2	0.4	2675.6	125.8	78.0	154.0	1.7	359.5	86.4	2402.5	1632.0	574.9	123.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Feb-87	2724	2.4	2726.4	141.5	77.5	260.6	1.7	481.3	83.6	2328.7	1616.2	1087.6	125.2
02-Feb-87	3189	2.4	3191.4	85.7	77.5	215.7	1.7	360.6	85.6	2916.4	1696.5	982.0	89.3
03-Feb-87	3216	2.4	3218.4	155.8	77.5	131.4	1.8	366.5	84.1	2935.9	1668.5	770.3	114.9
04-Feb-87	4061	2.4	4063.4	61.1	77.6	79.6	785.6	1004.0	85.7	3145.0	1679.8	493.2	97.1
05-Feb-87	2474	2.4	2476.4	85.7	77.7	69.0	1.7	214.1	82.6	2345.0	1651.0	411.1	109.8
06-Feb-87	3127	2.4	3129.4	144.8	77.6	81.0	1.6	305.1	85.5	2909.8	1653.3	443.2	110.3
07-Feb-87	3120	2.4	3122.4	85.7	77.7	69.4	1.7	214.6	81.7	2989.4	1632.3	363.8	102.7
08-Feb-87	2686	2.4	2688.4	61.1	77.7	67.3	1.7	207.8	83.9	2764.4	1582.9	542.3	117.0
09-Feb-87	2845	2.4	2847.4	85.7	77.6	67.2	1.8	212.3	83.6	2718.7	1665.7	354.4	115.7
10-Feb-87	2624	2.4	2626.4	143.8	77.8	69.4	1.7	292.6	85.8	2419.8	1655.6	370.7	97.0
11-Feb-87	2946	2.4	2948.4	85.7	77.8	67.7	1.7	212.9	83.2	2818.7	1659.1	316.4	122.3
12-Feb-87	2597	2.4	2599.4	91.6	77.8	68.5	1.7	239.6	84.0	2443.8	1660.8	339.4	96.0
13-Feb-87	2526	2.4	2528.4	123.1	77.9	70.7	1.6	273.3	84.6	2339.7	1640.2	330.0	127.7
14-Feb-87	2628	2.4	2630.4	61.1	77.8	68.1	1.7	208.7	83.3	2505.0	1601.4	361.2	130.6
15-Feb-87	2615	2.4	2617.4	83.4	77.6	69.6	1.7	232.4	82.9	2467.9	1573.0	338.8	107.0
16-Feb-87	2440	2.4	2442.4	123.3	77.6	70.0	1.7	272.6	84.7	2254.4	1676.2	351.1	101.0
17-Feb-87	2632	2.4	2634.4	85.7	77.9	93.9	1.7	239.1	86.6	2481.8	1657.4	391.2	113.4
18-Feb-87	2670	2.4	2672.4	159.9	77.8	77.8	1.7	317.2	83.6	2438.8	1665.4	335.8	118.0
19-Feb-87	2407	2.4	2409.4	85.7	77.8	70.8	1.7	216.0	85.1	2278.5	1668.7	251.4	88.0
20-Feb-87	2719	2.4	2721.4	61.1	77.7	67.9	1.6	208.4	84.3	2597.3	1649.4	244.2	138.5
21-Feb-87	2215	2.4	2217.4	127.0	77.6	69.6	1.7	275.9	85.9	2027.2	1622.7	282.4	98.0
22-Feb-87	2608	2.4	2610.4	79.7	77.5	66.4	1.6	225.1	82.0	2467.3	1593.2	246.3	88.0
23-Feb-87	2175	2.4	2177.4	61.1	77.6	64.9	1.6	205.3	86.6	2058.9	1673.8	241.6	132.0
24-Feb-87	2520	2.4	2522.4	82.8	77.6	65.6	1.7	227.7	83.5	2378.2	1655.5	252.7	98.0
25-Feb-87	2729	2.4	2731.4	120.1	77.6	65.6	1.9	265.2	86.5	2552.6	1650.0	271.9	98.8
26-Feb-87	2377	2.4	2379.4	85.7	77.6	63.6	2.0	208.8	85.2	2255.8	1653.2	234.5	114.4
27-Feb-87	2477	2.4	2479.4	120.3	77.5	64.1	1.9	263.8	85.3	2300.8	1643.7	274.1	120.4
28-Feb-87	4065	2.4	4067.4	118.7	77.6	473.7	1.8	671.8	93.6	3489.2	1609.7	2031.6	118.0
FEB 87	2771.9	2.4	2774.3	94.5	77.7	98.9	29.7	300.8	84.6	2558.2	1644.8	461.2	110.3

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Mar-87	5502	2.1	5504.1	258.0	76.6	444.9	2.0	781.5	84.2	4806.8	1578.7	2109.5	955.0
02-Mar-87	4273	2.1	4275.1	226.6	76.7	287.5	1.9	592.8	83.0	3765.3	1657.9	1359.4	91.0
03-Mar-87	3357	2.1	3359.1	65.7	76.7	184.2	2.0	328.6	86.3	3116.8	1664.8	834.2	90.8
04-Mar-87	3464	2.1	3466.1	65.7	76.6	133.5	2.0	277.8	82.6	3270.8	1648.7	622.0	113.8
05-Mar-87	2678	2.1	2680.1	97.3	76.6	108.3	2.0	284.2	85.6	2481.4	1646.7	539.4	109.8
06-Mar-87	2749	2.1	2751.1	116.7	76.7	96.1	1.9	291.3	83.9	2543.6	1647.9	461.1	117.8
07-Mar-87	3077	2.1	3079.1	65.7	76.9	86.4	1.9	230.8	84.5	2932.7	1635.3	353.9	135.5
08-Mar-87	2577	2.1	2579.1	61.1	76.5	80.1	2.0	219.7	81.0	2440.4	1604.4	346.7	186.3
09-Mar-87	3160	2.1	3162.1	148.8	76.5	80.1	1.9	307.2	85.0	2939.8	1627.9	479.3	104.3
10-Mar-87	3025	2.1	3027.1	61.1	76.7	73.3	2.1	213.1	83.4	2897.3	1655.1	319.3	99.0
11-Mar-87	2604	2.1	2606.1	65.7	76.6	70.6	2.0	215.0	85.9	2477.0	1661.0	272.9	105.3
12-Mar-87	2552	2.1	2554.1	136.2	76.6	68.4	2.0	283.2	83.7	2354.5	1662.2	297.1	160.5
13-Mar-87	2629	2.1	2631.1	65.7	76.6	64.8	1.9	209.1	84.3	2506.3	1652.7	251.2	109.3
14-Mar-87	4358	2.1	4360.1	217.1	76.6	193.8	1.9	489.3	89.3	3960.0	1614.2	821.3	1046.5
15-Mar-87	3771	2.1	3773.1	65.7	76.6	129.0	1.9	273.2	82.4	3582.3	1584.5	508.4	842.0
16-Mar-87	2990	2.1	2992.1	163.8	76.5	101.2	2.0	343.4	84.1	2732.7	1656.5	498.3	155.3
17-Mar-87	2994	2.1	2996.1	65.7	76.6	83.6	1.9	227.8	83.9	2852.2	1684.8	388.4	108.3
18-Mar-87	3548	2.1	3550.1	90.6	76.6	266.9	1.9	435.9	90.3	3204.4	1645.0	1071.4	107.0
19-Mar-87	3262	2.1	3264.1	208.3	76.5	188.7	1.8	475.3	84.8	2873.6	1667.0	882.7	481.3
20-Mar-87	2965	2.1	2967.1	65.7	76.5	123.3	1.9	267.3	82.6	2782.4	1671.3	490.4	124.5
21-Mar-87	3074	2.1	3076.1	167.0	76.6	100.2	1.8	345.7	81.7	2812.1	1615.7	454.5	123.8
22-Mar-87	2500	2.1	2502.1	61.1	76.6	79.3	1.8	218.9	82.2	2365.5	1608.4	329.0	121.0
23-Mar-87	2727	2.1	2729.1	65.7	76.9	70.6	1.8	215.1	83.1	2597.1	1678.9	298.6	124.8
24-Mar-87	3800	2.1	3802.1	76.2	76.7	64.8	1.9	219.7	83.0	3665.4	1667.5	286.8	766.8
25-Mar-87	2607	2.1	2609.1	139.3	76.5	64.1	1.8	281.7	84.5	2411.9	1643.2	303.8	197.0
26-Mar-87	2643	2.1	2645.1	61.1	76.6	58.0	1.8	197.6	84.2	2531.7	1658.9	226.7	118.5
27-Mar-87	2425	2.1	2427.1	61.1	76.6	55.9	1.9	195.5	84.4	2316.0	1642.2	225.0	94.0
28-Mar-87	3101	2.1	3103.1	145.5	76.5	57.8	1.8	281.5	83.3	2904.9	1616.5	280.6	276.3
29-Mar-87	4078	2.1	4080.1	61.1	78.4	52.5	1.8	191.9	81.5	3969.7	1573.0	257.4	1485.2
30-Mar-87	2520	2.1	2522.1	110.8	76.5	72.2	1.9	261.3	83.7	2344.4	1634.9	327.1	124.8
31-Mar-87	2825	2.1	2827.1	98.3	76.5	54.7	1.8	231.3	85.2	2681.0	1662.9	234.0	108.3
MAR 87	3156.0	2.1	3158.1	108.3	76.6	116.0	1.9	302.8	84.1	2939.4	1640.9	520.3	283.3

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Apr-87	2536	0.5	2536.5	61.1	78.8	53.7	1.8	195.4	84.6	2426.0	1656.8	218.5	106.6
02-Apr-87	2643	0.5	2643.5	79.9	78.8	50.4	1.8	210.8	85.2	2517.9	1635.2	263.2	100.0
03-Apr-87	2394	0.5	2394.5	133.9	78.9	51.2	1.8	265.8	85.5	2214.2	1632.8	251.1	134.1
04-Apr-87	2512	0.5	2512.5	65.7	78.8	46.4	1.9	192.8	84.6	2404.2	1614.2	212.0	121.4
05-Apr-87	2371	0.5	2371.5	61.1	78.8	44.3	1.8	185.9	84.7	2270.3	1534.8	212.6	97.4
06-Apr-87	2464	0.5	2464.5	141.2	78.9	45.6	1.8	267.5	85.5	2282.5	1656.1	236.4	124.1
07-Apr-87	2417	0.5	2417.5	65.7	78.9	41.8	1.8	188.2	87.9	2317.2	1666.0	166.9	188.2
08-Apr-87	2372	0.5	2372.5	112.9	78.9	41.3	1.8	234.9	84.6	2222.4	1686.8	192.8	204.0
09-Apr-87	2768	0.5	2768.5	95.6	78.9	39.2	1.8	215.6	86.8	2641.7	1705.3	159.7	162.4
10-Apr-87	2402	0.5	2402.5	93.7	78.9	42.1	1.8	216.4	87.6	2273.6	1717.6	276.9	170.1
11-Apr-87	4697	0.5	4697.5	262.1	78.9	328.9	1.8	671.6	92.9	4118.8	1621.2	1499.5	522.0
12-Apr-87	3636	0.5	3636.5	65.7	78.9	109.3	1.8	255.7	84.7	3465.5	1598.9	697.0	703.6
13-Apr-87	4112	0.5	4112.5	152.9	78.9	68.9	1.8	302.5	87.3	3897.3	1672.6	444.2	619.2
14-Apr-87	7556	0.5	7556.5	172.4	78.9	605.5	1.8	858.6	99.4	6796.3	1665.1	3544.5	722.0
15-Apr-87	5640	0.5	5640.5	250.1	78.9	320.5	1.8	651.2	88.8	5078.0	1646.8	3016.9	245.2
16-Apr-87	5428	0.5	5428.5	176.3	78.8	210.0	1.8	466.9	85.6	5047.2	1646.3	2002.8	147.0
17-Apr-87	4778	0.5	4778.5	65.7	78.9	131.7	1.8	278.0	87.7	4588.2	1654.1	1201.7	224.4
18-Apr-87	3878	0.5	3878.5	61.1	78.9	94.3	1.8	236.1	84.7	3727.1	1656.7	868.7	281.0
19-Apr-87	3460	0.5	3460.5	158.8	78.8	79.0	1.8	318.4	86.8	3228.9	1595.5	692.0	296.5
20-Apr-87	3434	0.5	3434.5	65.7	79.1	64.5	1.8	211.2	85.7	3309.1	1760.8	498.4	216.9
21-Apr-87	3217	0.5	3217.5	61.1	78.8	56.6	1.8	198.3	88.2	3107.5	1706.8	469.4	185.4
22-Apr-87	5141	0.5	5141.5	100.2	78.9	251.8	1.8	432.7	90.6	4799.4	1648.0	1350.8	1448.5
23-Apr-87	4394	0.5	4394.5	246.1	78.8	128.0	1.8	454.7	85.0	4024.8	1658.9	1324.0	198.8
24-Apr-87	4148	0.5	4148.5	61.1	78.9	86.3	1.9	228.1	86.5	4006.9	1681.5	838.9	184.5
25-Apr-87	3627	0.5	3627.5	65.7	78.9	67.7	1.8	214.1	85.8	3499.2	1663.6	551.1	292.9
26-Apr-87	3200	0.5	3200.5	61.1	78.8	56.5	1.8	198.2	85.1	3087.4	1649.4	428.9	288.9
27-Apr-87	3094	0.5	3094.5	145.1	78.8	53.8	1.9	279.6	86.0	2903.0	1730.4	390.4	242.9
28-Apr-87	2867	0.5	2867.5	61.1	78.9	45.9	1.8	187.7	86.0	2765.9	1732.7	270.5	163.1
29-Apr-87	2767	0.5	2767.5	80.5	78.9	43.9	1.9	205.2	86.5	2650.8	1811.9	270.3	188.7
30-Apr-87	2640	0.5	2640.5	134.3	78.9	42.5	1.7	257.4	86.5	2469.6	1722.5	280.1	187.8
APR 87	3553.1	0.5	3553.6	111.9	78.9	110.0	1.8	302.6	87.1	3338.0	1667.6	761.1	292.3

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-May-87	2790	2.5	2792.5	65.7	87.8	38.8	2.0	194.2	97.0	2695.3	1739.0	206.3	206.0
02-May-87	5803	2.5	5805.5	244.6	87.7	274.7	1.9	608.9	100.9	5297.5	1626.4	1594.6	1646.0
03-May-87	3623	2.5	3625.5	190.4	87.7	141.3	1.9	421.3	94.9	3299.1	1582.1	838.3	589.0
04-May-87	3268	2.5	3270.5	65.7	87.7	63.3	1.9	218.6	95.0	3146.9	1669.0	465.9	204.0
05-May-87	3166	2.5	3168.5	61.1	87.7	50.1	1.9	200.8	96.9	3064.6	1712.9	322.1	213.0
06-May-87	2927	2.5	2929.5	161.7	87.7	47.5	1.8	298.7	96.3	2727.1	1773.5	326.9	227.0
07-May-87	2882	2.5	2884.5	61.1	87.7	38.9	1.9	189.6	99.7	2791.6	1725.3	229.8	212.0
08-May-87	2710	2.5	2712.5	61.1	87.7	35.9	1.9	186.7	97.8	2623.6	1805.8	200.7	234.0
09-May-87	2682	2.5	2684.5	65.7	79.8	33.9	1.9	181.3	98.0	2599.1	1901.1	170.4	285.0
10-May-87	2594	2.5	2596.5	150.3	87.6	33.9	1.9	273.7	97.3	2420.1	1836.5	232.3	291.0
11-May-87	4172	2.5	4174.5	88.2	87.9	147.3	2.0	325.4	101.7	3950.8	1924.6	996.6	186.0
12-May-87	3679	2.5	3681.5	219.3	87.7	50.0	1.9	358.9	96.9	3419.5	1751.4	584.6	337.0
13-May-87	3366	2.5	3368.5	61.1	87.7	33.5	1.9	184.2	97.8	3282.1	1801.9	221.9	255.0
14-May-87	4314	2.5	4316.5	65.7	87.8	30.6	1.9	186.0	96.8	4227.3	1815.5	173.1	1196.0
15-May-87	3158	2.5	3160.5	162.0	87.7	30.9	2.1	282.7	95.8	2973.6	1821.6	236.5	295.0
16-May-87	2732	2.5	2734.5	65.7	87.8	25.9	1.9	181.4	98.8	2651.7	1959.2	146.2	343.0
17-May-87	3083	2.5	3085.5	65.7	87.7	32.2	2.0	187.6	97.9	2995.8	1961.7	265.1	295.0
18-May-87	7108	2.5	7110.5	251.6	87.7	178.6	2.0	519.8	102.3	6692.9	1826.7	1575.4	1792.0
19-May-87	9110	2.5	9112.5	251.4	87.8	522.4	2.0	863.6	105.4	8352.4	1782.4	4869.9	403.0
20-May-87	9164	2.5	9166.5	159.9	87.7	93.3	2.1	343.0	97.2	8920.7	1752.9	2250.9	1219.0
21-May-87	5322	2.5	5324.5	65.7	88.0	68.0	2.1	223.8	97.1	5197.8	1900.6	1198.5	1335.0
22-May-87	4924	2.5	4926.5	183.3	87.9	76.5	1.8	349.4	99.0	4676.0	1770.2	941.9	612.0
23-May-87	3583	2.5	3585.5	61.1	87.8	39.2	1.9	190.0	94.3	3489.8	1637.3	510.7	290.0
24-May-87	3359	2.5	3361.5	65.7	87.4	34.6	1.9	189.6	92.6	3264.5	1584.7	389.0	272.0
25-May-87	5317	2.5	5319.5	133.4	87.6	160.8	1.8	383.5	95.8	5031.7	1623.7	932.7	1355.0
26-May-87	4074	2.5	4076.5	237.9	87.8	83.0	2.1	410.8	98.0	3763.8	1842.5	806.8	674.0
27-May-87	4198	2.5	4200.5	65.7	88.2	51.2	1.9	206.9	100.3	4093.9	2036.2	416.8	1131.0
28-May-87	3378	2.5	3380.5	61.1	88.2	38.9	1.9	190.1	99.1	3289.5	2074.4	298.4	254.0
29-May-87	3514	2.5	3516.5	159.3	88.1	36.5	2.1	286.1	101.8	3332.3	2170.5	293.5	359.0
30-May-87	3955	2.5	3957.5	61.1	88.1	30.4	2.1	181.7	93.9	3875.7	2049.9	354.5	564.0
31-May-87	4461	2.5	4463.5	86.1	88.0	147.7	2.0	323.7	101.3	4241.1	2039.9	1165.2	566.0
MAY 87	4142.5	2.5	4145.0	119.3	87.5	86.1	1.9	294.9	98.0	3948.0	1822.6	748.9	575.5

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jun-87	4670	1.0	4671.0	241.2	96.6	179.1	2.3	519.2	126.6	4280.4	2009.5	2709.0	366.0
02-Jun-87	6819	1.0	6820.0	127.6	96.6	296.7	2.2	522.9	131.3	6428.4	1879.1	3237.5	388.0
03-Jun-87	5164	1.0	5165.0	334.6	96.6	151.7	2.1	584.9	125.1	4705.2	1833.2	2391.9	471.0
04-Jun-87	4108	1.0	4109.0	101.7	96.5	96.8	2.2	299.2	126.6	3936.5	1866.9	1275.9	235.0
05-Jun-87	3514	1.0	3515.0	65.7	96.6	63.6	2.2	228.1	124.4	3411.3	1942.9	739.1	283.0
06-Jun-87	3416	1.0	3417.0	65.7	96.8	47.2	2.1	211.8	125.4	3330.6	2095.3	493.6	311.0
07-Jun-87	2584	1.0	2585.0	140.0	96.6	40.2	2.3	279.1	125.0	2430.9	2183.6	403.4	275.0
08-Jun-87	4107	1.0	4108.0	65.7	96.9	32.9	2.4	197.9	127.6	4037.6	2109.6	280.6	868.0
09-Jun-87	4042	1.0	4043.0	61.1	96.4	29.0	2.3	188.8	126.6	3980.8	1919.6	255.1	1131.0
10-Jun-87	2653	1.0	2654.0	170.1	96.7	31.5	2.2	300.6	128.6	2482.2	1966.6	257.7	220.0
11-Jun-87	3787	1.0	3788.0	77.8	96.6	360.1	2.2	536.7	134.8	3386.2	1956.2	1777.0	215.0
12-Jun-87	4798	1.0	4799.0	268.9	96.9	97.5	2.3	465.6	127.0	4460.5	2020.8	780.6	244.0
13-Jun-87	3786	1.0	3787.0	65.7	96.9	52.5	2.3	217.4	131.2	3700.8	2206.7	288.5	391.0
14-Jun-87	3390	1.0	3391.0	61.1	96.7	37.6	2.4	197.9	126.9	3322.0	2616.0	202.0	327.0
15-Jun-87	3374	1.0	3375.0	65.7	97.0	30.8	2.5	195.9	133.5	3312.6	2403.2	175.3	430.0
16-Jun-87	3547	1.0	3548.0	140.7	97.0	26.3	2.5	268.5	134.7	3414.3	2410.8	195.7	797.0
17-Jun-87	3538	1.0	3539.0	65.7	97.0	23.5	2.6	188.8	135.2	3485.4	2616.4	141.6	790.0
18-Jun-87	4003	1.0	4004.0	61.1	97.1	20.8	2.5	181.5	133.1	3955.6	2852.4	127.2	777.0
19-Jun-87	4611	1.0	4612.0	142.5	97.3	23.0	2.5	265.2	134.6	4481.3	2623.0	168.4	1196.0
20-Jun-87	4879	1.0	4880.0	167.5	97.1	299.0	2.4	566.1	132.3	4446.3	2194.4	754.6	1127.0
21-Jun-87	6343	1.0	6344.0	173.9	96.7	232.0	2.3	504.9	131.6	5970.7	1933.3	1973.8	1358.0
22-Jun-87	4153	1.0	4154.0	325.6	96.8	188.2	2.2	612.8	126.5	3669.7	1939.7	853.2	1079.0
23-Jun-87	3907	1.0	3908.0	172.6	96.9	64.1	2.2	335.8	129.2	3701.4	2120.9	284.7	824.0
24-Jun-87	4022	1.0	4023.0	65.7	97.2	41.4	2.2	206.5	131.0	3947.5	2419.8	156.2	824.0
25-Jun-87	4406	1.0	4407.0	177.5	97.0	131.4	2.1	408.1	129.5	4128.4	2102.4	740.5	473.0
26-Jun-87	4985	1.0	4986.0	116.6	97.1	48.9	2.2	264.8	126.1	4849.3	2014.2	343.4	1211.0
27-Jun-87	3384	1.0	3385.0	61.2	96.9	33.2	2.1	193.3	124.6	3316.3	2010.7	149.6	1274.0
28-Jun-87	3882	1.0	3883.0	81.6	96.9	27.4	2.2	208.2	127.5	3802.3	2069.9	116.6	1226.0
29-Jun-87	4848	1.0	4849.0	119.3	96.9	24.3	2.3	242.8	127.0	4733.2	2064.4	197.1	1432.0
30-Jun-87	4846	1.0	4847.0	194.4	96.9	131.7	2.2	425.1	128.2	4550.1	1915.9	649.7	2102.0
JUN 87	4185.5	1.0	4186.5	132.6	96.8	95.5	2.3	327.3	129.3	3988.6	2143.2	737.3	754.8

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jul-87	4021	0.8	4021.8	65.7	97.4	38.2	2.2	203.4	126.5	3944.8	1934.4	259.2	1267.0
02-Jul-87	3953	0.8	3953.8	61.1	97.6	28.6	2.1	189.4	129.4	3893.8	2111.3	163.9	1251.0
03-Jul-87	3873	0.8	3873.8	65.7	97.4	24.8	2.1	190.0	129.4	3813.2	2279.4	123.7	1236.0
04-Jul-87	3724	0.8	3724.8	139.5	97.4	24.1	2.1	263.1	129.4	3591.1	2155.2	152.7	1318.0
05-Jul-87	3999	0.8	3999.8	127.1	97.4	55.1	1.9	281.5	125.6	3843.9	1876.7	240.5	1237.0
06-Jul-87	4595	0.8	4595.8	102.5	97.5	23.3	2.1	225.3	126.5	4496.9	2047.8	154.1	1315.0
07-Jul-87	4573	0.8	4573.8	70.4	97.5	91.0	2.0	260.8	126.0	4441.0	2166.3	1277.8	1575.0
08-Jul-87	4435	0.8	4435.8	79.7	97.6	50.8	2.2	230.3	126.1	4333.6	2344.6	539.6	1113.0
09-Jul-87	4066	0.8	4066.8	150.4	94.5	50.9	2.2	298.0	129.9	3898.7	2388.9	574.8	888.0
10-Jul-87	5856	0.8	5856.8	105.1	94.6	218.4	2.2	420.3	132.6	5569.3	2185.1	1305.4	925.0
11-Jul-87	4551	0.8	4551.8	309.9	92.6	80.0	2.1	484.5	127.8	4195.0	2202.6	1054.7	1559.0
12-Jul-87	5193	0.8	5193.8	75.1	93.4	49.5	1.9	219.9	126.8	5102.8	2165.3	475.9	1114.0
13-Jul-87	4250	0.8	4250.8	61.1	97.3	35.0	2.1	195.4	127.2	4182.5	1968.0	230.2	1065.0
14-Jul-87	4045	0.8	4045.8	65.7	97.2	29.5	2.0	194.3	125.4	3976.9	1877.8	175.5	1148.0
15-Jul-87	4318	0.8	4318.8	263.7	97.1	152.1	2.0	514.8	131.5	3935.4	1832.8	1129.5	1023.0
16-Jul-87	4675	0.8	4675.8	130.7	97.3	38.3	1.9	268.3	124.8	4532.3	1914.0	293.0	1208.0
17-Jul-87	4194	0.8	4194.8	65.7	81.9	29.7	2.0	179.3	127.0	4142.5	2175.5	160.4	1249.0
18-Jul-87	4485	0.8	4485.8	61.1	81.8	24.8	2.0	169.8	129.0	4442.0	2318.1	118.2	1376.0
19-Jul-87	4037	0.8	4037.8	145.9	85.6	26.1	2.2	259.8	129.8	3906.8	2527.7	150.6	1365.0
20-Jul-87	4935	0.8	4935.8	60.8	86.4	75.1	2.5	224.8	134.5	4845.5	2708.4	295.0	1080.0
21-Jul-87	4537	0.8	4537.8	213.2	85.6	39.0	2.1	340.0	130.7	4328.5	2521.9	297.3	1687.0
22-Jul-87	4431	0.8	4431.8	61.1	88.7	21.2	1.7	172.7	129.9	4388.0	2625.2	103.4	1395.0
23-Jul-87	4448	0.8	4448.8	65.7	78.0	19.9	1.8	165.3	129.4	4412.9	2731.4	94.4	1378.0
24-Jul-87	4892	0.8	4892.8	157.4	78.0	21.1	1.8	258.2	131.1	4765.7	2676.8	135.5	1674.0
25-Jul-87	4501	0.8	4501.8	65.7	91.8	17.4	1.8	176.7	128.6	4453.7	2579.2	70.5	1511.0
26-Jul-87	4457	0.8	4457.8	152.5	97.5	61.2	1.8	313.0	129.3	4274.1	2639.9	749.3	1129.0
27-Jul-87	4513	0.8	4513.8	324.0	94.0	239.5	1.8	659.2	130.0	3984.5	1944.6	1099.9	1283.0
28-Jul-87	4679	0.8	4679.8	116.3	89.5	29.3	2.0	237.0	127.1	4569.9	1995.7	169.9	1257.0
29-Jul-87	4209	0.8	4209.8	61.1	89.5	22.6	1.9	175.0	125.3	4160.1	2150.2	87.4	1426.0
30-Jul-87	4181	0.8	4181.8	91.4	94.3	20.9	1.8	208.3	128.7	4102.1	2333.2	105.0	1656.0
31-Jul-87	4586	0.8	4586.8	186.3	97.8	101.8	2.4	388.3	129.9	4328.3	2176.4	901.6	1216.0
JUL 87	4426.2	0.8	4427.0	119.4	92.4	56.1	2.0	269.9	128.6	4265.7	2243.7	409.3	1287.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Aug-87	4600	1.4	4601.4	114.7	92.7	37.0	1.9	246.3	104.7	4459.8	2326.8	466.0	1300.0
02-Aug-87	4314	1.4	4315.4	65.7	88.3	28.7	2.0	182.7	105.3	4238.0	2487.5	188.2	1424.0
03-Aug-87	5819	1.4	5820.4	61.1	83.4	21.0	2.0	167.5	108.8	5761.6	2528.2	120.1	2010.0
04-Aug-87	3650	1.4	3651.4	143.1	94.3	21.6	2.1	261.0	107.2	3497.6	2243.3	150.7	1463.0
05-Aug-87	4276	1.4	4277.4	61.1	94.5	16.3	2.2	174.1	107.1	4210.4	2211.4	82.0	1652.0
06-Aug-87	4329	1.4	4330.4	92.0	89.4	17.2	2.1	200.8	106.3	4237.9	2336.9	76.6	1664.0
07-Aug-87	4323	1.4	4324.4	114.0	84.0	16.8	2.5	217.3	108.4	4215.5	2464.7	87.5	1610.0
08-Aug-87	5735	1.4	5736.4	61.1	87.1	25.9	2.3	176.3	105.4	5665.4	2001.1	100.2	2620.0
09-Aug-87	4263	1.4	4264.4	158.5	94.2	27.3	2.2	282.2	101.3	4083.5	1852.0	221.5	1701.0
10-Aug-87	4120	1.4	4121.4	61.1	94.3	14.7	2.0	172.1	104.3	4053.5	2059.5	86.0	1622.0
11-Aug-87	4596	1.4	4597.4	61.1	95.0	14.2	2.3	172.6	104.2	4529.0	2221.1	56.9	1707.0
12-Aug-87	4457	1.4	4458.4	65.7	94.8	14.6	2.0	177.1	105.6	4386.9	2332.8	52.3	1831.0
13-Aug-87	5070	1.4	5071.4	154.0	92.1	206.5	2.0	454.6	113.0	4729.8	2260.0	1332.4	877.1
14-Aug-87	14623	1.4	14624.0	204.5	94.3	1700.4	2.0	2001.2	140.1	12763.0	1974.9	18060.0	86.1
15-Aug-87	12917	1.4	12918.0	560.1	84.1	532.1	2.0	1178.2	118.1	11858.0	2012.4	3831.5	1176.0
16-Aug-87	11869	1.4	11890.0	492.8	87.4	727.1	2.4	1309.6	114.1	10695.0	1953.2	4913.9	1975.0
17-Aug-87	14567	1.4	14568.0	527.1	94.4	635.6	2.0	1259.0	114.3	13424.0	2023.6	4726.7	152.0
18-Aug-87	8201	1.4	8202.4	113.2	83.0	466.0	2.0	664.2	110.0	7648.2	1949.0	2419.0	1169.0
19-Aug-87	5274	1.4	5275.4	185.5	87.4	290.0	2.0	564.8	105.6	4816.2	1943.4	1349.9	523.0
20-Aug-87	5207	1.4	5208.4	189.9	83.2	192.7	2.0	467.8	104.8	4845.5	2002.4	904.2	1215.0
21-Aug-87	7034	1.4	7035.4	124.3	74.9	452.1	2.0	653.3	110.4	6492.5	1935.3	1890.5	1457.0
22-Aug-87	6030	1.4	6031.4	252.6	94.2	274.5	2.0	623.3	102.1	5510.2	1858.3	1604.9	1133.0
23-Aug-87	4667	1.4	4668.4	131.4	86.3	178.5	2.2	398.4	101.4	4371.4	1759.8	782.5	1228.0
24-Aug-87	4184	1.4	4185.4	65.7	81.9	120.6	2.2	270.5	101.4	4016.3	1878.7	480.1	1029.0
25-Aug-87	5679	1.4	5680.4	149.1	73.4	287.0	2.2	511.7	108.4	5275.1	1822.9	1072.5	1575.0
26-Aug-87	14266	1.4	14267.0	104.0	93.7	2808.9	2.1	3008.7	136.6	11415.0	1806.6	12911.0	342.0
27-Aug-87	15838	1.4	15839.0	83.1	94.4	1288.8	2.0	1468.2	110.5	14482.0	1821.2	6345.8	80.0
28-Aug-87	6348	1.4	6349.4	113.9	94.2	819.1	2.0	1029.2	105.9	5426.0	1821.7	3584.5	194.0
29-Aug-87	5441	1.4	5442.4	162.1	75.7	533.6	2.0	773.3	101.5	4770.5	1788.1	2139.4	229.0
30-Aug-87	4989	1.4	4990.4	229.0	62.9	367.4	2.2	661.5	102.0	4430.8	1771.6	1466.8	222.0
31-Aug-87	5011	1.4	5012.4	306.0	76.5	252.0	2.1	636.6	102.0	4477.7	1854.9	1125.6	1187.0
AUG 87	6830.2	1.4	6831.5	168.0	87.3	399.5	2.1	656.9	108.7	6283.4	2042.0	2342.9	1175.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1987	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Sep-87	5096	2.5	5098.5	330.6	64.9	186.8	2.0	584.3	99.0	4613.2	1891.8	930.5	1880.0
02-Sep-87	4980	2.5	4982.5	65.9	86.0	142.1	2.1	296.1	97.3	4783.7	1877.3	593.4	1972.0
03-Sep-87	5081	2.5	5083.5	65.7	78.2	122.5	2.0	268.4	97.2	4912.3	1885.6	459.2	2039.0
04-Sep-87	5660	2.5	5662.5	65.7	70.0	110.4	2.0	248.2	99.7	5514.0	1984.3	387.5	2053.0
05-Sep-87	4965	2.5	4967.5	149.7	67.7	104.5	2.0	323.8	97.0	4740.7	1985.7	391.0	2096.0
06-Sep-87	5048	2.5	5050.5	65.7	67.6	95.7	2.0	231.1	99.1	4918.5	1909.8	307.1	2092.0
07-Sep-87	3912	2.5	3914.5	61.1	75.7	90.0	1.9	228.7	98.7	3782.5	1809.7	278.1	1243.0
08-Sep-87	4441	2.5	4443.5	170.8	73.4	90.6	2.0	336.8	100.0	4206.7	1879.1	336.4	2215.0
09-Sep-87	4978	2.5	4980.5	65.7	69.7	82.9	1.9	220.2	98.6	4858.9	1920.1	262.6	2134.0
10-Sep-87	5045	2.5	5047.5	61.1	71.1	78.4	2.0	212.6	99.3	4934.3	1933.2	236.4	1443.7
11-Sep-87	5076	2.5	5078.5	65.7	71.8	75.7	2.0	215.2	99.8	4962.1	1986.4	224.1	1581.7
12-Sep-87	5153	2.5	5155.5	140.2	65.8	74.5	1.9	282.5	98.5	4971.5	1904.7	279.5	2431.0
13-Sep-87	5145	2.5	5147.5	65.7	62.7	69.6	1.9	199.9	97.4	5045.1	1816.4	235.8	2452.0
14-Sep-87	3130	2.5	3132.5	61.1	58.5	66.0	2.0	187.7	98.1	3043.0	1936.4	199.6	750.0
15-Sep-87	4457	2.5	4459.5	139.9	59.9	86.3	1.9	268.0	99.4	4290.9	1889.1	326.1	1686.0
16-Sep-87	5375	2.5	5377.5	158.1	63.9	262.0	1.9	486.0	103.2	4994.7	1862.0	896.8	2047.0
17-Sep-87	5378	2.5	5380.5	226.3	76.6	199.9	1.9	504.7	101.6	4977.4	1833.7	940.4	2159.0
18-Sep-87	6056	2.5	6058.5	136.8	86.0	120.9	2.0	345.7	99.0	5811.9	1809.1	619.1	2342.0
19-Sep-87	5162	2.5	5164.5	65.7	68.7	84.8	1.9	221.0	97.7	5041.2	1745.4	332.0	2351.0
20-Sep-87	5279	2.5	5281.5	65.7	70.6	73.9	1.9	212.2	95.2	5164.7	1665.6	274.5	2651.0
21-Sep-87	5150	2.5	5152.5	145.4	85.9	80.6	2.0	313.9	99.5	4938.2	1765.1	412.4	2356.0
22-Sep-87	4954	2.5	4956.5	165.4	85.8	73.9	2.0	327.0	98.8	4728.3	1778.8	463.3	1640.1
23-Sep-87	5142	2.5	5144.5	61.1	64.0	60.6	1.9	187.7	96.4	5053.3	1801.8	276.8	2371.1
24-Sep-87	5219	2.5	5221.5	65.7	65.9	58.5	1.9	212.0	96.0	5107.5	1803.2	234.7	2540.0
25-Sep-87	5187	2.5	5189.5	165.7	60.8	59.0	2.0	287.4	96.7	4998.9	1838.6	276.9	2499.0
26-Sep-87	5243	2.5	5245.5	65.7	54.7	53.7	1.9	176.0	96.1	5167.6	1832.9	202.1	2820.0
27-Sep-87	5247	2.5	5249.5	61.1	61.2	50.6	1.9	174.8	96.7	5171.4	1828.7	187.2	2601.0
28-Sep-87	5133	2.5	5135.5	79.8	50.7	74.0	2.0	206.4	99.3	5028.4	1895.6	269.3	2492.0
29-Sep-87	4459	2.5	4461.5	140.4	55.9	63.4	2.0	261.7	98.6	4298.5	1839.6	314.8	1542.0
30-Sep-87	3363	2.5	3365.5	61.1	65.4	47.6	2.0	176.1	98.1	3287.6	1771.6	189.1	1196.0
SEP 87	4950.5	2.5	4953.0	108.0	69.3	94.0	2.0	273.2	99.4	4778.2	1856.0	377.9	2055.9

APPENDIX D

LAKE MICHIGAN DIVERSION ACCOUNTING

WATER YEAR 1988 REPORT

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EXECUTIVE SUMMARY

In compliance with the modified 1980 U.S. Supreme Court decree (hereinafter the Decree), the WY88 diversion was computed using the best engineering technology available to date as applied to the diverted watersheds.

Given the complexity of the hydrologic cycle in the heavily urbanized Chicago metropolitan area, and given the number of human and other factors that cannot be adequately represented in numerical modeling procedures, the results of the simulations which compute diversion flows worked exceptionally well.

The WY88 diversion accountable to the State of Illinois is 3,375.6 cfs. This is 175.6 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average, rounded to the nearest cfs, beginning with WY81 is 3,451 cfs and the cumulative deviation from the 3,200 cfs average is -2,011 cfs-years. The negative cumulative deviation indicates a water allocation debt and the maximum allowable deficit is 2,000 cfs-years.

INTRODUCTION

The diversion of water from the Lake Michigan watershed is of major importance to the Great Lake states and to the Canadian province of Ontario. The states and province that border the Great Lakes have concerns with both diversions during periods of low lake levels as well as the long term effects of diversion. To insure that the concerns of these interested parties are considered, the U. S. Army Corps of Engineers has been given the responsibility for the accounting of flow that is diverted from the Lake Michigan watershed.

The Corps of Engineers, Chicago District, is responsible for monitoring the measurements and the computation of the diversion of Lake Michigan water by the State of Illinois. The computations for Water Year 1983 (WY83), WY84 and WY85 (1 October 1984 through 30 September 1985) were completed by the Northeastern Illinois Planning Commission (NIPC) for the Illinois Department of Transportation (IDOT). Prior to the WY83 report, the calculations were made by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) for IDOT. The Corps reviewed, modified, and updated the WY84 and WY85 diversion accounting completed by NIPC. The computations for WY86 were performed jointly by NIPC (under contract to the Corps of Engineers) and the Corps of Engineers. Beginning in WY87 the computations were performed solely by the Corps of Engineers. This report represents the final Lake Michigan diversion accounting for WY88.

AUTHORITY FOR REPORT

Under the provisions of the U.S. Supreme Court Decree in the Wisconsin, et al v. Illinois et al, 388 U.S. 426,87 S.Ct. 1774 (1967) as modified 449 U.S. 48, 101 S.Ct. 557 (1980), the Corps of Engineers is responsible for monitoring the measurement and computation of diversion of Lake Michigan water by the State of Illinois. The Water Resources Development Act of 1986 (Section 1142 of PL 99-662) gave the Corps total responsibility for the computation of diversion flows as formerly done by the State of Illinois. The Corps' new mission became effective 1 October 1987.

HISTORY OF THE DIVERSION

Water has been diverted from Lake Michigan at Chicago into the Mississippi River Basin since the completion of the Illinois and Michigan Canal in 1848. At that time, diversion averaged about 500 cubic feet per second (cfs). The Illinois and Michigan Canal was built primarily to serve transportation needs. The canal provided a connecting watercourse between the Great Lakes and the Mississippi River system.

With the development of the Chicago metropolitan area, drainage and drainage improvements led to severe sanitation problems in the mid to late 1800's. The newly constructed sewers moved water and wastes into the Chicago River, which until 1900 drained to Lake Michigan. The water quality of Lake Michigan deteriorated and contaminated the city's primary water supply.

A second problem that occurred during this time period was an increase in the overbank flooding within the city. As more roads were built and buildings constructed the sewer system was correspondingly expanded. This increased the rate and volume of runoff and resulted in increased flooding.

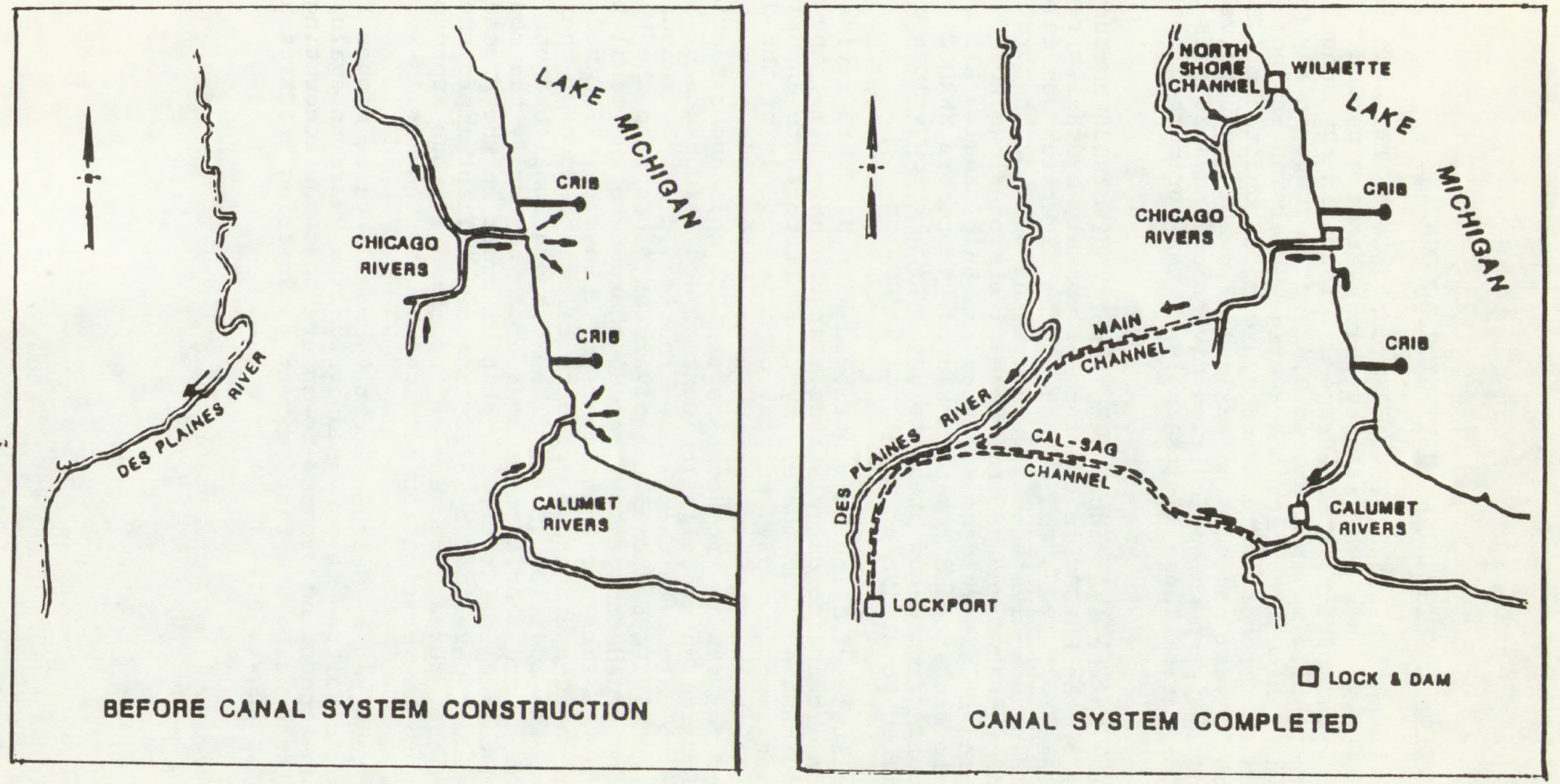
As a solution to the sanitation and flooding problems construction of the Chicago Sanitary and Ship Canal (CSSC) was undertaken. This construction allowed the flow direction of the Chicago River to be reversed (Figure 1). Construction of the Chicago Sanitary and Ship Canal was completed in 1900 by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) (formerly Metropolitan Sanitary District of Greater Chicago, MSDGC). The Sanitary and Ship Canal followed the course of the older I and M Canal. This canal is much larger than the I and M canal and can handle the Chicago River flow as well as increased shipping. The Chicago River Controlling Works was constructed at the mouth of the Chicago River. The lock regulates the amount of Lake Michigan water allowed to pass into the river and restricts river flooding from entering Lake Michigan.

Between 1907 and 1910 the MWRDGC constructed a second sanitary canal called the North Shore Canal. It extended from Lake Michigan at Wilmette in a southerly direction 6.14 miles to the north branch of the Chicago River. The Wilmette Controlling Works regulates the amount of Lake Michigan flow allowed down the channel.

Construction of a third canal, the Calumet Sag Canal, was completed in 1922. The canal connects Lake Michigan through the Grand Calumet River, to the Sanitary and Ship Canal. This canal was constructed to carry sewage from South Chicago, Illinois and East Chicago, Indiana. The O'Brien Lock and Dam located on the Calumet River, regulates the flow of Lake Michigan waters down the canal.

Figure 1

Development of the Chicago Canal System



BACKGROUND OF LAKE MICHIGAN DIVERSION ACCOUNTING

The Lake Michigan diversion accountable to Illinois is limited to 3,200 cfs over a forty year averaging period. During the forty year period, the average diversion in any annual accounting period may not exceed 3,680 cfs except in any two accounting periods in which the average diversion may not exceed 3,840 cfs as a result of extreme hydrologic conditions. During the first 39 year period, the maximum allowable cumulative difference between the calculated diversion and 3,200 cfs is 2,000 cfs-years. These limits apply to the period beginning with WY81.

Prior to the 1983 accounting report, diversion accounting was done by the MWRDGC in the form of monthly hydraulic reports. As required by Supreme Court Decree, the diversion was calculated by deducting non-diversion flows from the Lockport record measured by MWRDGC and adding those diversion flows not discharging to the Chicago Sanitary and Ship canal. All of the deductible flows could not be measured, therefore MWRDGC used flow records from gaged areas to get typical flow values and then extrapolated to arrive at the total deduction.

The State of Illinois contracted with NIPC, to revise the diversion accounting calculations. At the same time, the State of Illinois moved from monthly hydraulic reports to annual accounting reports. NIPC adapted computer models of the diverted Lake Michigan and the Des Plaines River watersheds, previously developed for studies in Northeastern Illinois under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500), to calculate those flows that could not be measured. Like MWRDGC, NIPC deducted non-diversion flows from the Lockport record and added those flows not discharged to the canal to calculate the Lake Michigan diversion. However, NIPC modeled both the gaged and ungaged areas to calculate much of the deduction and addition flows. Then computational budgets were developed around each of the gaged areas to verify the models. The budgets aid in identifying problem areas in the procedure. The procedure developed by NIPC is a significant improvement over the previous approach because of the more rigorous approach and because of the verification provided by the budgets.

As required by Supreme Court Decree, a three member technical committee is convened every five years to evaluate the diversion accounting program to ensure that the accounting is accomplished using the best current engineering practice and scientific knowledge.

The first technical committee was convened during the period that the diversion accounting was done by MWRDGC. The committee was primarily concerned with the rating of the various components at the Lockport facility, the primary diversion measurement location (Espey et al, 1981). In response to the Committee's concerns, the Corps' Waterways Experiment Station (WES) revised the ratings of the two sets of Lockport sluice gates (Hart and McGee, 1985).

In response to the Committee's concerns, the State of Illinois installed an acoustic velocity meter (AVM) at Romeoville five miles upstream of Lockport. The AVM is a highly accurate flow meter that proved to provide better flow measurements than the MWRDGC reported Lockport flows and the new Corps rating curves. The AVM became operational 12 June 1984. However, USGS did not publish the AVM flows until 1 October 1985. Because of significant equipment problems with the AVM, a replacement AVM was installed in November 1988.

To provide flows during periods of malfunction, various regression analyses were done to relate the MWRDGC reported Lockport flows to the AVM flows. Several sets of equations were proposed by the Corps of Engineers, the USGS, Harza Engineering Co., and the Second Technical Committee. The report, Chicago Sanitary and Ship Canal at Romeoville Acoustical Velocity Meter Backup System, was completed September 1989 (USACE, 1989). The regression equations that were ultimately used to estimate missing AVM flows from WY86 through WY91 were developed by the USGS in a report tentatively titled "Discharge and Regression Analyses for Acoustical Velocity Meter Data for the Chicago and Sanitary Ship Canal at Romeoville, Illinois." The final publication of this report is expected to be available in the spring of 1993.

The second and most recent technical committee reviewed the NIPC hydrologic and hydraulic computer models and agreed that the approach was consistent with what was required by the decree (Espey et al, 1987). However, the committee felt that some of the parameters used in the models were out of date and in need of revision. To address the committee's concerns, the Corps hired a consultant (C. B. Burke Engineering, Ltd.) in September of 1988 to review and update the modeling parameters. The final report concerning the updating of modeling parameters was submitted to the Corps in October 1990.

The Water Resources Development Act of 1986 gave the Corps of Engineers the full responsibility for computation of the Illinois Lake Michigan diversion as of 1 October 1987. When the Corps' new responsibility became effective, the WY84 diversion accounting report, developed by NIPC, had not been certified. As a result, the Corps was responsible for the WY84 and all subsequent reports.

NIPC completed the WY84 diversion accounting report in April of 1988. It was subsequently reviewed by the Corps. The Corps found the report to be adequate with two exceptions. First, the 1984 accounting was completed with the modeling parameters questioned by the second technical committee. Second, MWRDGC reported Lockport flows, adjusted using the WES rating curves, were used rather than AVM flows. The Corps, knowing that the modeling parameters required updating and that AVM flows for the period prior to installation could be calculated accurately using regression equations, refrained from certifying the WY84 report until these issues were resolved.

NIPC completed the WY85 diversion accounting report in December of 1988 and the report was reviewed by the Corps. Like the WY84 report, the WY85 accounting was done with the modeling parameters questioned by the second technical committee. Additionally, NIPC used the AVM flows published by the U.S. Geological Survey (USGS) in their WY85 Water Resources Data for Illinois report. Since the publication of the WY85 USGS report, more reliable equations have been developed for calculating flows when the AVM was malfunctioning. These equations are periodically reviewed and updated as necessary.

Upon completion of the analysis of the modeling parameters by Christopher B. Burke Engineering, LTD, the WY84 and WY85 diversion flows were recalculated using the revised modeling parameters and the Romeoville AVM flows. The diversion flows were certified by the Corps of Engineers and transmitted to all interested parties in the Lake Michigan Diversion Accounting 1989 Annual Report (USACE, 1990).

The computation of Illinois' diversion from Lake Michigan for WY86 was undertaken as a joint effort between NIPC (under contract to the Corps of Engineers) and the Corps of Engineers. The computation of Illinois' diversion from Lake Michigan for WY87 and WY88 were performed solely by the Corps of Engineers.

DIVERSION ACCOUNTING PROCEDURES

The Lake Michigan diversion accountable to the State of Illinois is calculated by measuring the flow in the Chicago Sanitary and Ship Canal at Romeoville and deducting flows that do not constitute Lake Michigan diversion and are not accountable to the State of Illinois. Finally, additions are made to the Romeoville record for diversions that are not discharged to the canal. The deductions include groundwater water supply pumpage whose effluent is discharged to the canal, runoff from the Des

Plaines River watershed that is discharged to the canal, Lake Michigan water supply pumpage from Indiana that is discharged to the canal, and water supply pumpage from Lake Michigan used for Federal facilities that is discharged to the canal. The additions to the Romeoville record include flows diverted from the canal upstream of Romeoville, and Lake Michigan water supply whose effluent is not discharged to the canal. This procedure represents the accounting method required by the Supreme Court Decree.

The diversion accounting results are presented as a series of columns that are listed in Table 1. Column 1 through Column 3 compute the total flow in the Sanitary and Ship Canal. Column 4 through Column 7 presents the deductions from the Canal system flows with the total deduction being presented in Column 8. Column 9 presents the additions to the Canal system record. Column 10 is the computed Lake Michigan diversion accountable to Illinois and is equal to the canal system flow minus the deductions plus the additions. Columns 11 through 13 are independent flow estimates for the three sources of diversion: water supply pumpage from Lake Michigan, runoff from the diverted Lake Michigan Watershed, and direct diversion through the lakefront structures. Column 11 through Column 13 are not used in the diversion calculation but are included as another estimate of the diversion for verification of the accounting flows in Column 10. The sum of Column 11 through Column 13 should theoretically equal the flow in Column 10.

In addition to the diversion calculations presented in the 13 columns, 14 computational budgets are prepared as input to the diversion calculation and to verify the estimated flows that cannot be measured. A summary of these budgets is presented in Table 2. Budgets 1 and 2 do not compare simulated to measured flows but are summations of critical water supply pumpage data. Budget 3 through Budget 6 partition stream gage records into runoff and sanitary/industrial discharge components to estimate a portion of the runoff from the diverted watershed that is used as input to Column 12, "Runoff from the Diverted Lake Michigan Watershed." Budget 7 through Budget 13 compare simulated to measured flows at MWRDGC facilities. These budgets are for verification of the diversion accounting procedures and give an indication of the accuracy of the diversion accounting. Budget 14 compares canal system inflows and outflows.

Table 1

Description of the Diversion Accounting Columns

Column No.	Description
1	Chicago Sanitary and Ship Canal (CSSC) at Romeoville AVM Gage Record
2	Diversion from the CSSC above the Romeoville AVM Gage
3	Total Flow Through the CSSC
4	Groundwater Pumpage Discharged into the CSSC and Adjoining Channels
5	Water Supply Pumpage from Indiana Reaching the CSSC
6	Runoff from the Des Plaines River Watershed which Reaches the CSSC
7	Lake Michigan Pumpage by Federal Facilities which Discharge to the CSSC and Adjoining Channels
8	Total Deduction from the CSSC Romeoville AVM Gage Record
9	Lake Michigan Pumpage Which is not Discharged into the CSSC
10	Total Diversion Accountable to the State of Illinois
11	Pumpage from Lake Michigan Which is Accountable to State of Illinois
12	Runoff from the Diverted Lake Michigan Watershed
13	Direct Diversions Through Lake Front Control Structures Which is Accountable to the State of Illinois

Table 2

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
1	Diverted Lake Michigan Pumpage	This budget sums Lake Michigan water diverted by the State of Illinois in the form of municipal and industrial water supply. The results of this budget are used in Column 11.
2	Groundwater Discharged to the CSSC	This budget sums groundwater pumpages that are discharged to the CSSC. The results of this budget are used in Column 4.
3	North Branch Chicago River at Niles, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
4	Little Calumet River at the IL-IN State Line	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
5	Thorn Creek at Thornton, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
6	Little Calumet River at South Holland, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
7	MWRDGC Northside Water Reclamation	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Northside Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Northside service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used on Budget 14 and Columns 6 and 12.

Table 2 (cont)

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
8	MWRDGC Upper Des Plaines Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Upper Des Plaines Pumping Station. This budget provides a calibration point to verify models of the Des Plaines River watershed
9	MWRDGC Mainstream TARP Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Mainstream TARP Pumping Station. The results of this simulation are used in Budgets 10 and 14 and Columns 6 and 12. The budget also provides internal verification of the accounting procedures.
10	MWRDGC Stickney Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Stickney Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Stickney service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Columns 6 and 12.
11	MWRDGC Calumet TARP Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Calumet TARP Pumping Station. The results of this simulation are used in Budgets 12 and 14 and Columns 6 and 12. The budget also provides internal verification of the accounting procedures.

Table 2 (cont)

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
12	MWRDGC Calumet Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Calumet Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Calumet service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Columns 6 and 12.
13	MWRDGC Lemont Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Lemont Water Reclamation Facility. The simulations estimates the runoff from portions of the Des Plaines River watershed within the Lemont service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Column 6.
14	Chicago Canal System	This budget performs a water balance of the Chicago Canal System which includes the CSSC and adjoining channels. This budget provides a verification point for the accounting procedures.

REVISIONS TO THE LAKE MICHIGAN DIVERSION ACCOUNTING PROCEDURES

There were no major revisions to the WY88 diversion accounting procedure.

ACCOUNTING RESULTS

The WY88 diversion accounting monthly summary is presented in Table 4. Table 4 shows the total WY88 Lake Michigan diversion accountable to the State of Illinois is 3,375.6 cfs (Column 10). This is 175.6 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average (Table 3), rounded to the nearest cfs, beginning with WY81 is 3,451 cfs and the cumulative deviation from the 3,200 cfs average is -2,011 cfs-years. The negative cumulative deviation indicates a water allocation deficit and the maximum allowable deficit is 2,000 cfs-years. Tabular data on daily diversion flows is presented in Appendix A.

Table 3

Status of the State of Illinois' Diversion from Lake Michigan Under the 1980 Modified U.S. Supreme Court Decree

Accounting Year	Certified Flow, cfs	Running Average, cfs	Cumulative Deviation, cfs
1981	3,106	3,106	+ 94
1982	3,087	3,097	+ 207
1983	3,613	3,269	- 206
1984	3,432	3,309	- 438
1985	3,472	3,342	- 710
1986	3,751	3,410	- 1,261
1987	3,774	3,462	- 1,835
1988	3,376	3,451	- 2,011

Table 4

Lake Michigan Diversion Accounting – WY 1988

Summary of Diversion Flows (cfs)

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13
OCT 87	3137.1	0.3	3137.4	91.1	38.7	40.8	1.9	172.5	82.7	3057.6	1733.3	171.4	780.5
NOV 87	2808.3	0.3	2808.6	108.7	33.0	69.2	1.8	212.6	84.1	2680.1	1667.1	341.7	266.9
DEC 87	3991.0	0.7	3991.7	162.3	32.4	285.2	1.9	481.8	83.7	3593.7	1638.3	1382.9	88.7
JAN 88	3438.3	0.9	3439.2	122.0	27.9	233.9	2.3	386.1	90.5	3143.5	1729.1	999.5	118.9
FEB 88	3127.8	0.3	3128.1	120.7	30.1	169.4	1.9	322.0	85.3	2891.4	1701.3	724.9	83.5
MAR 88	3081.7	0.4	3082.1	106.3	27.2	143.5	1.8	278.8	82.4	2885.6	1677.5	610.4	130.3
APR 88	3530.9	0.4	3531.3	102.0	31.8	145.0	1.6	280.4	94.1	3345.0	1673.5	792.5	178.0
MAY 88	2802.0	0.4	2802.4	95.9	33.8	39.1	1.9	170.7	115.9	2747.7	1918.5	235.4	247.7
JUN 88	3368.3	0.9	3369.2	89.5	32.5	21.1	2.1	145.3	169.3	3393.2	2421.4	127.4	801.9
JUL 88	4015.6	0.8	4016.3	115.1	30.2	50.9	1.9	198.1	160.1	3978.3	2422.9	316.3	1039.3
AUG 88	4558.2	0.9	4559.1	107.2	29.2	42.5	16.4	195.3	135.5	4499.3	2341.2	331.2	1323.6
SEP 88	4556.5	0.5	4557.0	101.0	28.5	27.6	245.9	403.0	112.2	4266.2	1941.9	195.3	1659.6
WY 88	3536.5	0.6	3537.1	110.2	31.3	105.8	23.1	270.4	108.9	3375.6	1906.4	519.6	560.4

COMPUTATIONS:

1. COLUMN 3 EQUALS THE SUM OF COLUMN 1 AND COLUMN 2.
2. COLUMN 8 EQUALS THE SUM OF COLUMN 4 THROUGH COLUMN 7.
3. COLUMN 10 EQUALS COLUMN 3 MINUS COLUMN 8 PLUS COLUMN 9.

DEDUCTIONS FROM THE ROMEOVILLE GAGE RECORD

ADDITIONS TO THE ROMEOVILLE GAGE RECORD

NOTES:

1. ALL VALUES ARE ROUNDED TO THE NEAREST TENTH.
2. MATHEMATICAL COMPUTATIONS BETWEEN COLUMNS UTILIZE UNROUNDED VALUES.
3. AVERAGE VALUES FOR WY88 WERE COMPUTED USING DAILY VALUES.

DISCUSSIONS OF RESULTS

The following is a discussion of the column functions and computational budgets. The discussion of the column functions describes the purpose of each column as well as some observations on the WY88 values in the columns. The discussion of the computational budgets presents the purpose of each budget and the results of the budget flow balances. The results of the computational budgets are used in the diversion calculations where seven budgets are used to verify the diversion simulation models. The columns are discussed first followed by the discussion of the budgets.

COLUMNS

The columns display the components of the diversion calculation and include the Romeoville flow as well as the various deductions and additions to the Romeoville record. The final three columns display the three diversion components (Lake Michigan pumpage accountable to Illinois, runoff from the diverted watershed, and direct diversion through the lakefront control structures) and the sum of the three columns should theoretically equal the Romeoville based diversion calculation. A comparison of the sum of these three columns to the calculated diversion is presented in the discussion of Column 11 through Column 13.

COLUMN 1: CHICAGO SANITARY AND SHIP CANAL (CSSC) AT ROMEOVILLE, USGS AVM GAGE RECORD

The discharge at Romeoville for WY88 is 3,536.5 cfs. For days when the AVM was inoperable, the flow at the Romeoville site was calculated from regression equations.

COLUMN 2: DIVERSIONS FROM THE CSSC ABOVE THE GAGE

Argonne Laboratories and Uno-ven Corporation were the only diversions from the Chicago Sanitary and Ship Canal upstream of the Romeoville gage in WY88. The average withdrawal upstream of the AVM for WY88 is 0.6 cfs.

COLUMN 3: TOTAL FLOW THROUGH THE CSSC

Column 3 is the sum of Column 1 and Column 2 and represents the total flow entering the canal system. The average canal flow is 3,537.1 cfs for WY88.

COLUMN 4: GROUNDWATER DISCHARGED TO THE CSSC AND ADJOINING CHANNELS

Column 4 is groundwater water supply pumpage by communities, industrial users, and other private users as reported by the Illinois State Water Survey (ISWS) whose effluent is discharged to the CSSC. It also includes the groundwater seepage into the TARP system that is discharged to the canal. This quantity is determined by summing all reported groundwater pumpages tributary to the canal along with the estimated groundwater seepage into the Mainstream TARP (Budget 9) and Calumet TARP (Budget 11) systems. This total is then adjusted by subtracting the groundwater normally tributary to the canal that is contained in the combined sewer overflows that discharge to the Des Plaines River and other watercourses not tributary to the CSSC. This method prevents double accounting of the combined sewer overflow portion of the groundwater supply pumpage.

Using ISWS groundwater records, groundwater pumpages were assumed to reach the CSSC and adjoining channels if they were located in the diverted Lake Michigan watershed in Illinois or if they were located within MWRDGC service boundaries in which their effluent was discharged into the CSSC and adjoining channels. Groundwater seepage into the Mainstream TARP and Calumet TARP systems was determined through simulation and is discussed in Budgets 9 and 11. The groundwater constituent of combined sewer overflows is determined entirely thorough simulation.

Groundwater pumpage from the Lake Michigan watershed whose effluent is discharged to the canal is a deduction except to the extent that the groundwater sources are recharged by Lake Michigan. Current piezometric levels indicate that groundwater is discharging to the lake. Therefore, groundwater pumpage from within the Lake Michigan Watershed that reaches the canal continues to be a deduction. Research literature will be reviewed periodically to verify this assumption.

Column 4 represents a deduction from the Romeoville record and averaged 110.2 cfs for WY88. Groundwater pumpage tributary to the canal is composed of 23.1 cfs of groundwater pumpage from the Lake Michigan watershed, 18.6 cfs of groundwater pumpage from outside of the Lake Michigan watershed, 51.7 cfs of groundwater seepage into the Mainstream TARP system, and 17.0 cfs of groundwater seepage into the Calumet TARP system. The total of these components is 110.4 cfs. However, the deduction from the Romeoville gage record is 110.2 cfs since 0.2 cfs of this groundwater supply pumpage was determined, through simulation, to be discharged to the Des Plaines River and other watercourses not tributary to the CSSC in the form of combined sewer overflows. The groundwater deduction has decreased 9.6 cfs from WY87.

COLUMN 5: WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CHICAGO SANITARY AND SHIP CANAL

Column 5 represents the computation of Indiana water supply reaching the canal through the Grand Calumet and the Little Calumet Rivers. In the case of the Little Calumet River, a drainage divide exists east of the confluence with Hart Ditch. Therefore, flows from Hart Ditch, including virtually all dry weather flows, normally flow westward into Illinois. Under high flow conditions, the drainage divide may shift westward and a portion of the Hart Ditch flows may be diverted eastward to Burns Ditch and ultimately to Lake Michigan. However, it is believed that the occurrence in the shift in the drainage divide is infrequent and the flow that is diverted eastward is insignificant. Therefore, it is assumed that all effluent discharged into Hart Ditch and the Little Calumet River west of the divide flow westward. For WY88, total flow in the Little Calumet River was 53.9 cfs, with 5.2 cfs of that flow being determined to be Indiana water supply.

The Grand Calumet River has a summit. On one side of the summit, the flow is toward Lake Michigan. On the other side of the side of the summit, the flow is toward the Calumet Sag Channel. However, the location of the summit is variable and highly influenced by Lake Michigan levels (USGS, 1984). Thus the calculation of this deduction from the Romeoville record is influenced by Lake Michigan levels. In the absence of a stream gaging station on the Grand Calumet River to measure westward flow into Illinois, flow is computed based on a statistical relationship of which the principal variable is lake levels.

Flow in the Grand Calumet River is estimated to be in excess of 90% sanitary effluent. Therefore, it is assumed that the portion of this flow that is attributable to domestic water supply is equal to the sum of the daily water supply for East Chicago, Hammond, and Whiting unless this sum is greater than the flow in the Grand Calumet River. In the case that the combined water supply for these communities is in excess of the flow in the Grand Calumet River, it is assumed that the flow consists entirely of effluent that originates from water supply.

The total Grand Calumet flow reaching Illinois in WY88 was computed as 26.7 cfs. It was determined that 26.1 cfs of that flow was water supply pumpage. Therefore, the total WY88 Indiana water supply deduction, including the flow from the Little Calumet and Grand Calumet Rivers is 31.3 cfs. This is significantly less than the Indiana water supply deduction for WY87 of 81.6 cfs. This is due to significantly lower Lake Michigan levels during WY88 that resulted in lower estimated

Grand Calumet flows. Total Grand Calumet flow dropped from 129.3 cfs in WY87 down to 26.7 cfs in WY88 while the deductible water supply in the Grand Calumet River dropped from 77.2 cfs to 26.1 cfs.

COLUMN 6: RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CHICAGO SANITARY AND SHIP CANAL

The WY88 average discharge of Des Plaines River watershed runoff reaching the canal (Column 6) is 105.8. The infiltration and inflow discharged to the water reclamation plants is 65.2 cfs, the infiltration and inflow reaching the canal through combined sewer overflows is 5.8 cfs, and the runoff from the Lower Des Plaines and Summit Conduit areas is 34.8 cfs. The deduction is largely determined by simulation but it is also influenced by the O'Hare basin flow transfer that contributed 8.0 cfs of the 65.2 cfs runoff to the water reclamation facilities during WY88. The deductible Des Plaines River watershed dropped 17.0 cfs from WY87 to WY88.

COLUMN 7: LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES WHICH DISCHARGE TO THE CSSC

Column 7 represents Lake Michigan diversions for Federal use, not chargeable to the State of Illinois, and is typically comprised of water supply used by federal facilities. In WY88, there were drawdowns of the CSSC for Corps of Engineers maintenance work. The drawdowns occurred on 27 August 1988, 20-24 September 1988, and 26-28 September 1988. The drawdowns accounted for a total of 21.1 cfs average flow over WY88. This flow is included with the Lake Michigan water usage by federal facilities to developing this column total. Column 7 represents a deduction from the Romeoville record and the total amount of the WY88 deduction is 23.1 cfs.

COLUMN 8: TOTAL DEDUCTIONS FROM THE CSSC ROMEOVILLE GAGE RECORD

Column 8 is the sum of Columns 4, 5, 6, and 7 and represents the total deduction from the Romeoville record. The total deduction for WY88 is 270.4 cfs.

COLUMN 9: LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL

This column represents water supply pumpage from Lake Michigan that is not discharged to the canal. The water supply pumpage not discharged to the canal is composed of two components:

(1) Lake Michigan water supply used by communities serviced by water reclamation facilities that do not discharge to the CSSC (107.8 cfs). This is an increase of 13.2 cfs from WY87.

(2) The sanitary portion of combined sewer overflows attributable to Lake Michigan domestic water supply that does not discharge to the CSSC (1.1 cfs).

The communities that make up the flow in the first component are suburbs whose treated effluent is discharged to the Des Plaines River and other watercourses not tributary to the CSSC. These communities include Elk Grove Village, Hoffman Estates, Mount Prospect, Schaumburg, Hanover Park, Rolling Meadows, Streamwood, Arlington Heights, Buffalo Grove, Palatine, Wheeling, Lincolnshire, Riverwoods, Libertyville, Illinois Beach State Park, Winthrop Harbor, Zion, Waukegan, 76 percent of North Chicago, and 38.2 percent of Des Plaines. It should also be noted that the Lake Michigan water supply component of the O'Hare flow transfer is subtracted from the total Lake Michigan water supply of the above communities since (1) the O'Hare flow transfer is treated at the Northside WRP which discharges sanitary effluent that is tributary to the CSSC and (2) the entire Lake Michigan water supply component of the O'Hare flow transfer is from communities contained in the above list. The Lake Michigan water supply for these communities is measured while the sanitary portion of the CSO's is derived through simulation. Column 9 represents an addition to the Romeoville record and the total WY88 addition is 108.9 cfs. This is an increase of 12.9 cfs from WY87 to WY88.

COLUMN 10: TOTAL DIVERSION

Column 10 is equivalent to Column 3 with the deduction of Column 8 and the addition of Column 9. The total diversion for WY88 is 3,375.6 cfs. This amount is 175.6 cfs greater than Illinois's long term diversion allocation of 3,200 cfs. The 40-year running average diversion, rounded to the nearest cfs, beginning with WY81, is 3,451 cfs and the cumulative deviation from the 3,200 cfs allocation is -2,011 cfs. The negative deviation indicates that the cumulative diversion is greater than an average of 3,200 cfs for the period.

COLUMN 11 THROUGH COLUMN 13: LAKE MICHIGAN DIVERSION COMPONENTS

Column 11 through Column 13 represent the three Lake Michigan diversion components: Lake Michigan pumpage accountable to Illinois (1906.4 cfs), runoff from the diverted Lake Michigan watershed (519.6 cfs), and direct diversion through the lakefront structures (560.4 cfs). The sum of the columns (2,986.4 cfs) should theoretically equal the total diversion as shown in Column 10 (3,375.6 cfs) with one exception. The Romeoville record receives effluent that is assumed to contain only 90% of the water supply pumpage while Column 11, Lake Michigan water supply pumpage accountable to Illinois, does not account for consumptive use. This is based on a consumptive loss (water supply pumpage that is consumed or lost prior to reaching the water reclamation facilities) estimate of 10% of the water supply pumpage (International Great Lake Diversion Consumptive Use Study Board, 1981).

Because the diversion estimate from Columns 11 - 13 is based on simulation, suspect ratings of the lakefront structures, and simple flow separation techniques, the estimate is not expected to be as accurate as the AVM based calculations. However a difference between estimates of 389.2 cfs or 11.5% is a fair balance. But, this discrepancy becomes even greater when consumptive use is accounted for in Column 11. The discrepancy in these two estimates is related to the canal system balance in Budget 14, discussed in a subsequent section, and potential sources of the discrepancy are addressed in that budget discussion.

Using the figures from these three columns, 63.8% of the WY88 Illinois diversion is attributable to pumpage from Lake Michigan for domestic water supply. Runoff from the diverted Lake Michigan Watershed accounted for 17.4% of the diversion, and direct diversion through the lakefront structures accounted for 18.8% of the diversion. Water supply from Lake Michigan accounted for a higher percentage of the diversion than in recent years. Water supply from Lake Michigan was at its highest level since the diversion has been computed. There are two primary reasons for this. First, more communities are converting from groundwater to Lake Michigan water as their primary source of water. Secondly, WY88 was a dry year. In WY 1988, 27.6 inches of precipitation was reported at O'Hare Airport. The annual average at O'Hare Airport from 1951 to 1980 was 33.3 inches. This is significant since water supply pumpage rises during periods of low precipitation, especially during the summer months due to increased lawn watering, etc. A more detailed breakdown of these percentages is shown in Table 5 and Figure 2.

Table 5

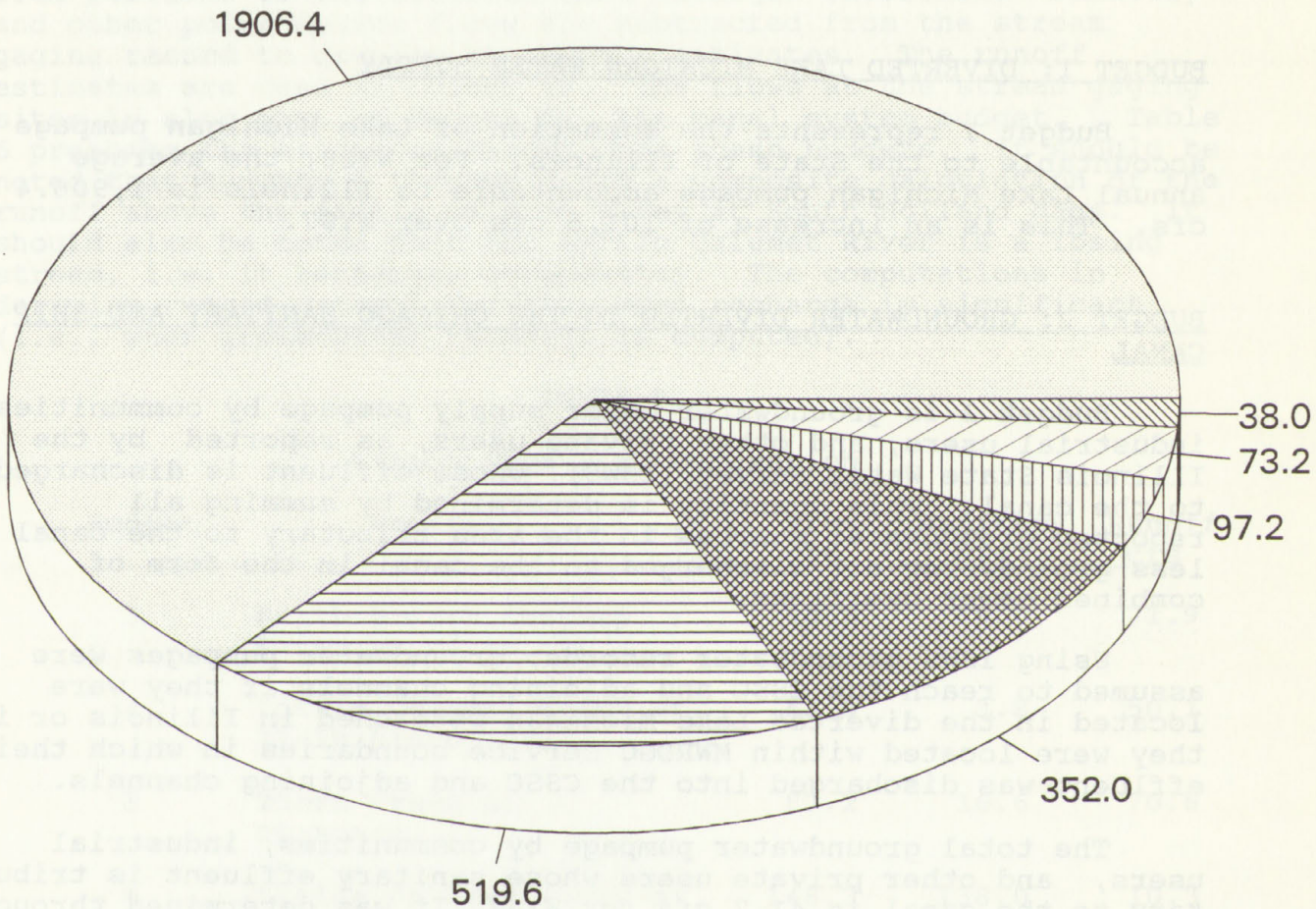
Breakdown of the Diversion by the State of Illinois
Based on Columns 11 Through 13

Category	Flow	Percentage
Lake Michigan Pumpage by the State of Illinois	1,906.4 cfs	63.8 %
Runoff from the Diverted Lake Michigan Watershed	519.6 cfs	17.4 %
Direct Diversions		
Lockages	97.2 cfs	3.3 %
Leakages	38.0 cfs	1.3 %
Navigation Makeup Flow	73.2 cfs	2.4 %
Discretionary Flow	352.0 cfs	11.8 %

BUDGETS

The first two budgets are used to sum the water supply for the area influenced by the diversion. The following four budgets are of stream gage sites that are not simulated and are used as part of the calculation of the runoff from the diverted Lake Michigan watershed. The remaining seven budgets compare measured and simulated flows.

Figure 2
Component Breakdown of Illinois' Diversion
Based on Columns 11 through 13



DIVERSION COMPONENTS

WATER SUPPLY 63.8 %	RUNOFF 17.4 %
DISCRETIONARY 11.8 %	LOCKAGES 3.3 %
NAV MAKEUP 2.4 %	LEAKAGES 1.3 %

BUDGET 1 AND BUDGET 2: WATER SUPPLY PUMPAGE

Budgets 1 and 2 are summations of critical water supply pumpage data. Budget 1 sums Lake Michigan water supply diverted by the State of Illinois. The Lake Michigan water supply data is supplied by the state as daily values for primary users and monthly data for secondary users. Budget 2 sums groundwater pumpages in the Lake Michigan and Des Plaines River watersheds that are diverted to the Chicago Sanitary and Ship Canal. Groundwater pumpage data is recorded as a total annual withdrawal based on calendar years.

BUDGET 1: DIVERTED LAKE MICHIGAN WATER SUPPLY

Budget 1 represents the summation of Lake Michigan pumpage accountable to the State of Illinois. For WY88, the average annual Lake Michigan pumpage accountable to Illinois is 1,906.4 cfs. This is an increase of 101.5 cfs over WY87.

BUDGET 2: GROUNDWATER DIVERTED TO THE CHICAGO SANITARY AND SHIP CANAL

Budget 2 is groundwater water supply pumpage by communities, industrial users, and other private users, as reported by the Illinois State Water Survey (ISWS), whose effluent is discharged to the canal. This quantity is determined by summing all reported groundwater sources in the area tributary to the canal less groundwater not discharged to the canal in the form of combined sewer overflows.

Using ISWS groundwater records, groundwater pumpages were assumed to reach the CSSC and adjoining channels if they were located in the diverted Lake Michigan watershed in Illinois or if they were located within MWRDGC service boundaries in which their effluent was discharged into the CSSC and adjoining channels.

The total groundwater pumpage by communities, industrial users, and other private users whose sanitary effluent is tributary to the canal is 41.7 cfs for WY88. It was determined through simulation that 0.1 cfs of this flow never reached the canal. Instead it was discharged to the Des Plaines River or other watercourses not tributary to the canal in the form of combined sewer overflows. The total groundwater pumpage reaching the canal represents a decrease of 10.2 cfs from WY87 to WY88.

In addition to groundwater supply pumpage there was also a significant amount of groundwater infiltration into the two TARP systems that ultimately reached the canal. Mainstream TARP and Calumet TARP accounted for 51.7 cfs and 17.0 cfs, respectively, of groundwater discharged to the canal during WY88. These values are essentially the same as for WY87.

BUDGETS 3 THROUGH BUDGET 6: STREAM GAGING STATIONS

The stream gage budgets are used to make estimates of runoff from portions of the diverted Lake Michigan watershed. Sanitary and other point source flows are subtracted from the stream gaging record to develop the runoff estimates. The runoff estimates are used in Column 12. The flows at the stream gaging sites is also part of Budget 14, the canal system budget. Table 6 presents the estimated runoff from these budgets. It should be noted that Budgets 4 through 6 are a composite calculation of the runoff above the Little Calumet River at South Holland gage. It should also be noted that the Little Calumet River is a losing stream, i.e. it recharges groundwater. The computations in deriving runoff account for this when recharge is significant (i.e., when groundwater recharge is computed).

Table 6

Stream Gage Flow Separation

Budget	Location	Flow cfs	Sanitary cfs	Runoff cfs
3	North Branch Chicago River at Niles, IL	90.9	19.0	71.9
4	Little Calumet River at IL-IN State Line	53.9	3.8	50.1
5	Thorn Creek at Thornton, IL	87.2	16.6	70.6
6	Little Calumet River at South Holland, IL_1	148.3	138.0	10.3

1 Incremental Runoff

BUDGETS 7 THROUGH BUDGET 13: MWRDGC WATER RECLAMATION FACILITIES

The budgets for the water reclamation plants compare the simulated flows to the measured inflows at the MWRDGC facilities and perform verifications of the diversion accounting program. The simulated flows were developed from an estimated sanitary flow with a daily, weekly, and monthly flow variation and from precipitation-based runoff simulations. The estimated sanitary flow input to the simulation model is based on the population estimates for each plant's service basin. Per capita sanitary flows are determined based on the service basin's water supply minus an assumed 10 percent consumptive loss. Simulated flows were compared with recorded inflows at each facility to assess the accuracy of the simulations.

The discussion of the budgets will concentrate on the results of each simulation as the development of these models have been discussed in previous reports. A summary of the simulation results is presented in Table 7.

BUDGET 7: NORTHSIDE WATER RECLAMATION FACILITY

Budget 7 analyzes the water balance at the MWRDGC Northside Water Reclamation Facility (Figure 3). In reviewing the recorded inflow record at the MWRDGC Northside facility, it was observed that there were several occurrences of extremely low flow which appeared to be unreasonable. The minimum flow in the recorded inflow was 48.4 cfs. This value appears very unreasonable, given that the normal dry weather flow is 360 to 400 cfs. Other values appeared equally unreasonable. Therefore, a data smoothing procedure was employed to smooth outliers in the data. The unadjusted and adjusted (smoothed) inflows are presented in Figure 3.

The balance for WY88 of the inflow to the Northside facility is good. The simulated to adjusted recorded inflow ratio (S/R) for the Northside WRP is 0.97, indicating that the simulated inflow volume is extremely close to the adjusted observed inflow volume. The coefficient of correlation (R) of simulated to adjusted observed flow is 0.62, indicating that the model predicted the inflow hydrograph to the Northside facility with a fair amount of accuracy.

BUDGET 8: UPPER DES PLAINES PUMP STATION

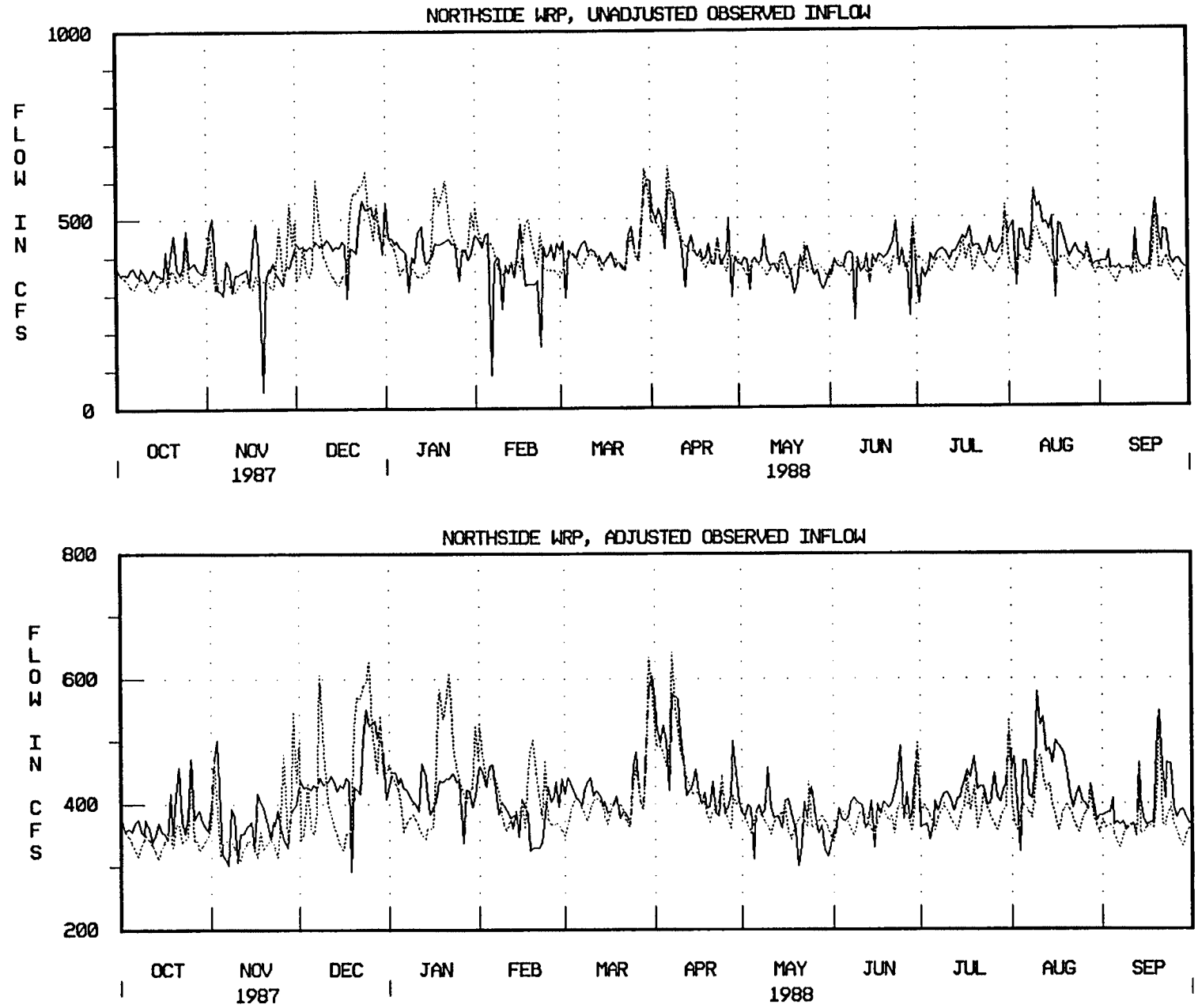
Budget 8 analyzes the water balance at Upper Des Plaines Pump Station (UDPPS) (Figure 4). The pump station budget is used to verify simulated flows. However it has no direct impact on the diversion calculation.

TABLE 7

WY 1988 SUMMARY OF SIMULATION STATISTICS

Budget No.->	7	8	9	10	11	12	13	14
Description	Northside WRP (1)(4)	Upper Des Plaines Pump Station (1),(3)	Mainstream TARP Pump Station (2)	Stickney WRP (1)	Calumet TARP Pump Station (2)	Calumet WRP (1)	Lemont WRP (1)	Chicago Canal System Balance (1)
Mean Recorded Flow, cfs	411.2	81.1	92.5	1244.1	32.2	360.5	2.2	3075.1
Max. Recorded Flow, cfs	607.4	146.2	238.8	2214.5	162.7	532.3	7.4	6882.8
Min. Recorded Flow, cfs	294.2	24.1	18.1	849.6	3.3	270.8	1.0	1779.4
Mean Simulated Flow, cfs	397.0	58.7	84.1	1151.7	40.6	288.6	1.8	3544.9
Max. Simulated Flow, cfs	642.7	160.5	232.2	2417.9	126.6	678.8	5.3	8481.1
Min. Simulated Flow, cfs	310.4	42.0	37.6	820.9	26.7	209.5	1.2	1951.2
Mean S/R	0.97	0.72	0.91	0.93	1.26	0.80	0.82	1.15
Max. S/R	1.52	3.73	2.73	1.38	8.60	1.71	1.53	1.44
Min. S/R	0.73	0.39	0.22	0.55	0.32	0.49	0.41	0.77
Correlation	0.62	0.47	0.51	0.70	0.61	0.52	0.75	0.95

(1) Based on daily values.
(2) Based on weekly values.
(3) Does not include days with missing records.
(4) Recorded flows were corrected for outliers.


NORTHSIDE WRP, UNADJUSTED OBSERVED INFLOW
FLOW IN CFS
1000
500
0
OCT
NOV
1987
DEC
JAN
FEB
MAR
APR
MAY
1988
JUN
JUL
AUG
SEP
NORTHSIDE WRP, ADJUSTED OBSERVED INFLOW
FLOW IN CFS
800
600
400
200
OCT
NOV
1987
DEC
JAN
FEB
MAR
APR
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1988
JUN
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SEP
NORTHSIDE WRP OBSERVED FLOW
NORTHSIDE WRP SIMULATED FLOW

Figure 3

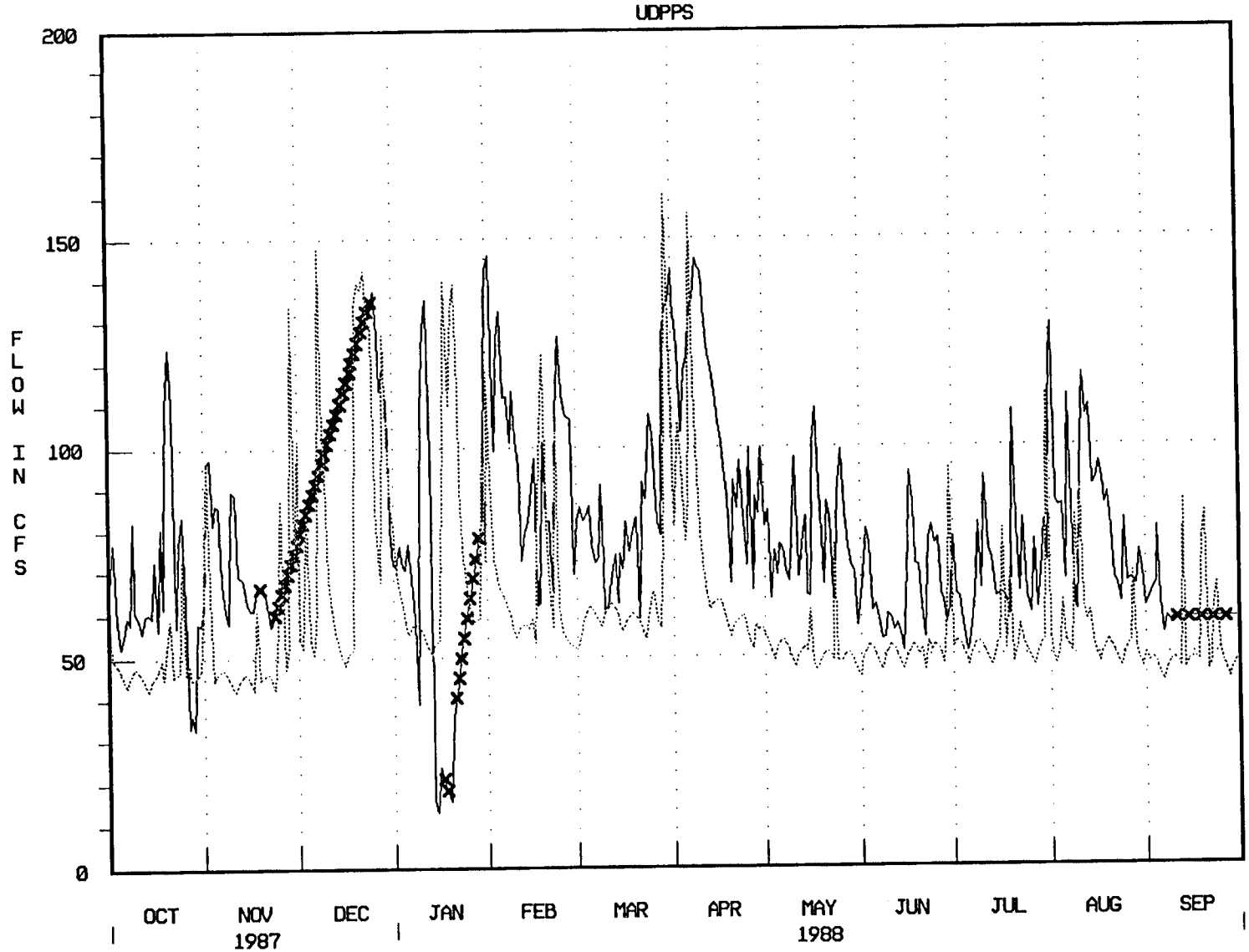


Figure 4

Budget 8 - Simulation of the MWRDGC Upper Des Plaines Pump Station

The balance at UDPPS for WY88 was fair. The simulated to recorded flow ratio (S/R) for the UDPPS is 0.72, indicating that the simulated inflow volume to UDPPS is somewhat less than the recorded inflow volume. However, the daily S/R ratio shows a high degree of variability, indicating that the trends within the recorded and simulated inflow may not correspond very well. The coefficient of correlation (R) of simulated to recorded flow is 0.47, indicating the time series trends in the simulated inflow compared marginally with the time series trends of recorded inflow.

While the statistical results for WY87 and WY88 at the Upper Des Plaines Pump Station are much improved over WY86, this does not lead to the conclusion that flow measurement alternatives should not be investigated. This site has continued to experience its share of problems. During WY88, 68 days of records were unavailable that were attributable to meter malfunctions, problems with the recording charts which made data transformation undoable, and various other reasons. In view of the significant quantity of missing data (19 % missing data), the quantitative analyses of the simulation are of limited value. Second, the accuracy of the flow meters at the pump station is questionable and unmetered bypass flows are a frequent occurrence. Therefore, total flow may not be measured in storm events and the recycling of flow is possible. Further investigation of the accuracy of flow measurement at the pump station is required to verify and calibrate the simulation models that compute the deductible runoff from the Des Plaines watershed contained in Column 6.

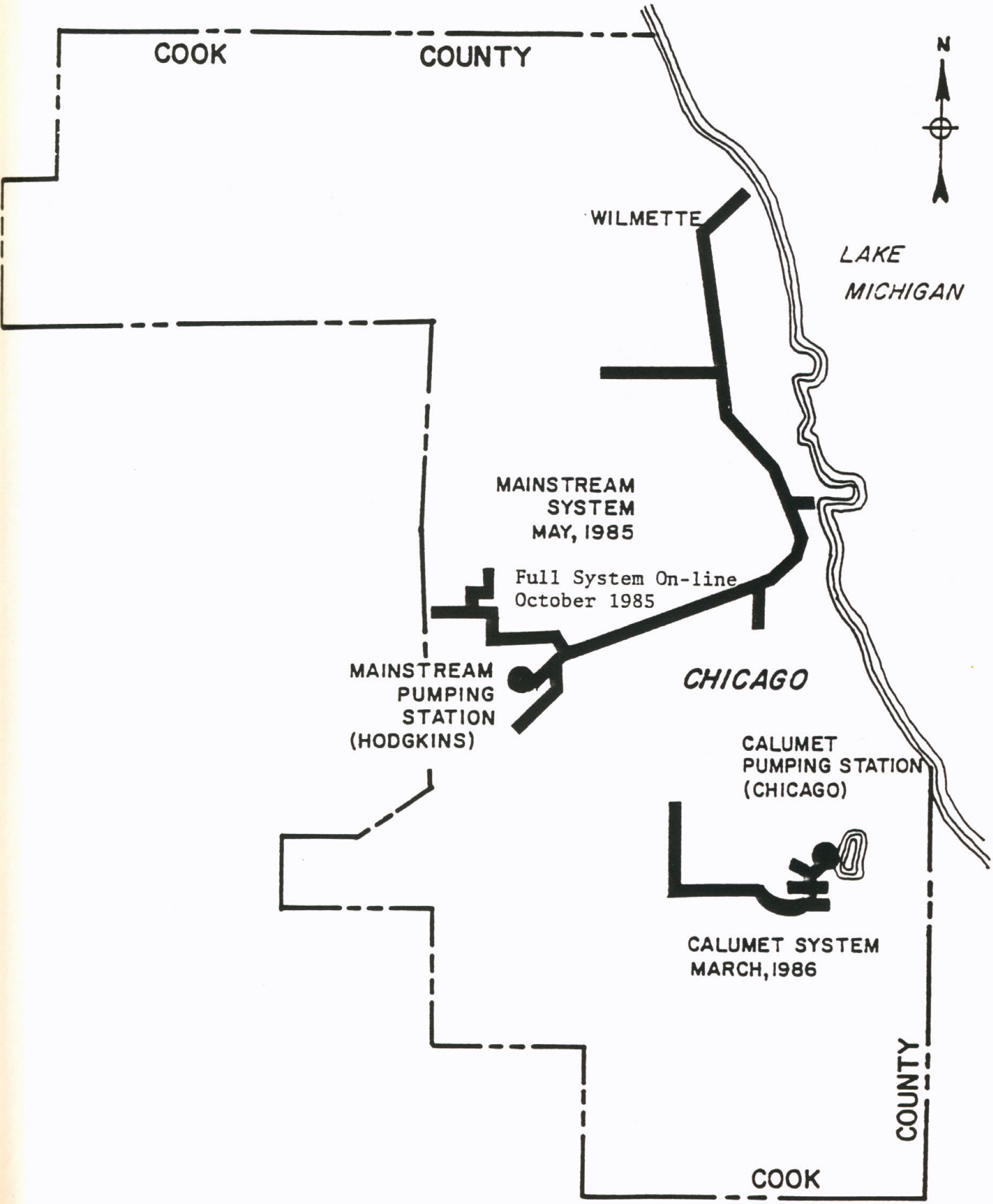
BUDGET 9: MAINSTREAM TARP PUMPING STATION

Budget 9 analyzes the water budget at the MWRDGC Mainstream TARP Pumping Station. The results of Budget 9 are used as input to Budget 10 in addition to providing a verification point for simulated flows. The modeling of Mainstream TARP is performed using the Tunnel Network (TNET) dynamic hydraulic model. A simplified map of Mainstream TARP is contained in Figure 5. A more in-depth description of Mainstream TARP and the simulation model is contained in the Water Year 1986 report (USACE, 1991).

In analyzing the balance at the Mainstream TARP Pumping Station, weekly flows were used rather than daily flows. While MWRDGC maintains daily pumpage records, days with no pumpage occur frequently. Therefore, it is not possible to compute a daily S/R ratio.

Figure 5

Map of Mainstream and Calumet TARP



The balance for WY88 of the inflow to the Mainstream Pumping Station is fair. The simulated to recorded flow ratio (S/R) for the Mainstream Pumping Station is 0.91, indicating that the simulated inflow volume is slightly less than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.51, indicating that the model prediction of trends in the inflow at the pump station was fair.

From a review of the plot of the simulated versus recorded flow at the pump station (Figure 6), it appears that the model responds similarly to recorded pumpage record. However, the model tends to have slightly lower peak flows. This results in the simulated pumpage volume being less than the recorded pumpage volume.

In summary, it appears that the simulation of the Mainstream TARP system is reasonable. However, there is concern regarding the underestimation of pumpage volume and the difference in simulated and recorded pumpage time series. A review of MWRDGC information regarding Mainstream TARP indicates that bypass flows are discharged to TARP, when available, via drop shaft 11 (DSN 11). Coordination with MWRDGC established that this is a frequent occurrence. This may account for the simulation of a pumpage volume that is less than the recorded pumpage volume. Records concerning the dates and pumpages back to TARP were not maintained for WY88. Therefore, data necessary to evaluate the impact of pumping back into TARP is not available. Therefore, it was decided that the model would not be adjusted so as to avoid double accounting of flows.

BUDGET 10: STICKNEY WATER RECLAMATION FACILITY

Budget 10 analyzes the water balance at the MWRDGC Stickney Water Reclamation Facility (Figure 7). Simulated Mainstream TARP pumpages from Budget 9 are combined with simulated interceptor inflow to Stickney Water Reclamation Facility to derive the total simulated inflow to the Stickney Facility. Total simulated inflow is compared with recorded inflow to assess the accuracy of the simulation.

Overall, the balance for WY88 of the inflow to the Stickney facility is good. The simulated to recorded flow ratio (S/R) for the Stickney is 0.93, indicating that the simulated inflow volume is very close to the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.70, indicating that the model predicted the inflow hydrograph to the Stickney facility reasonably well.

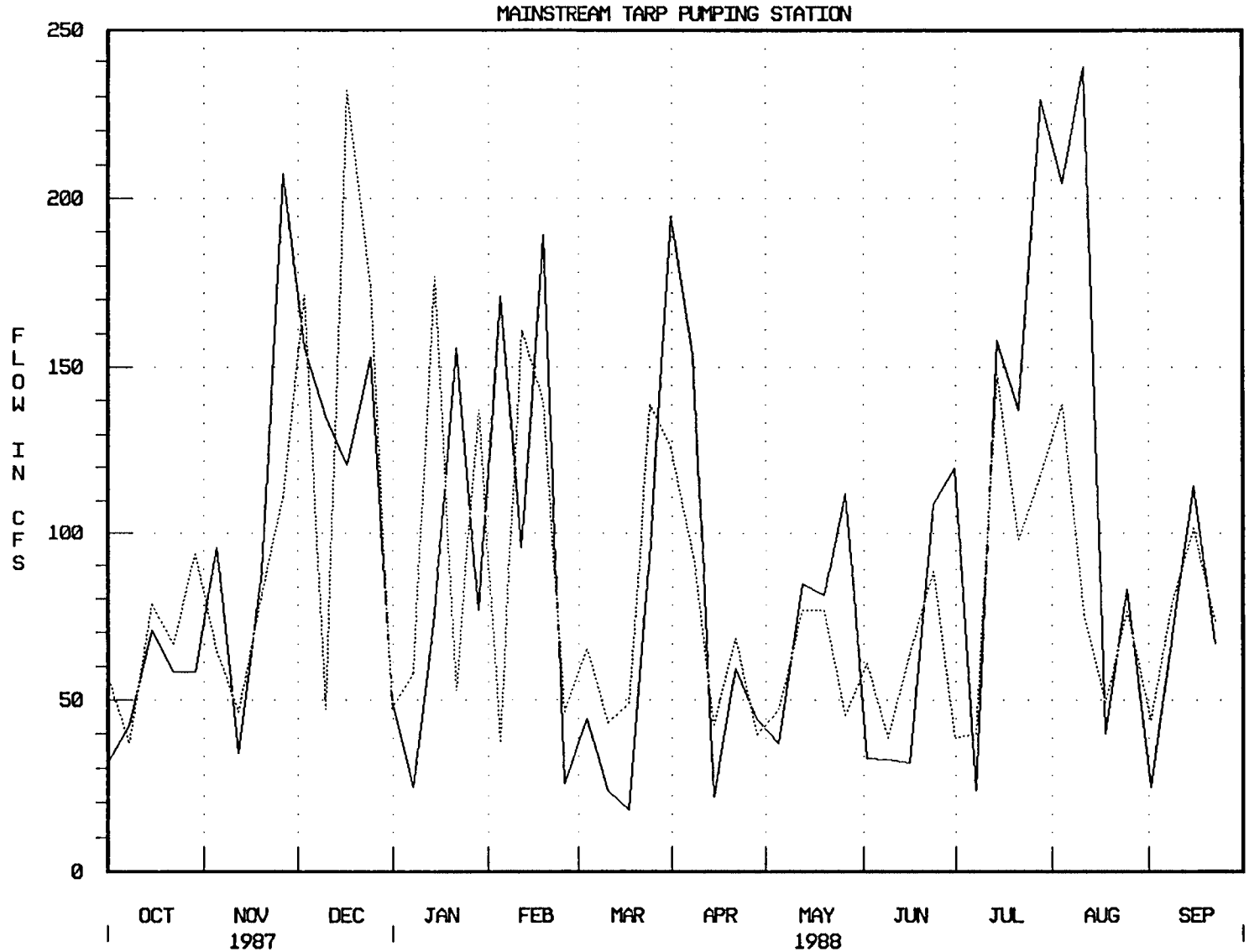
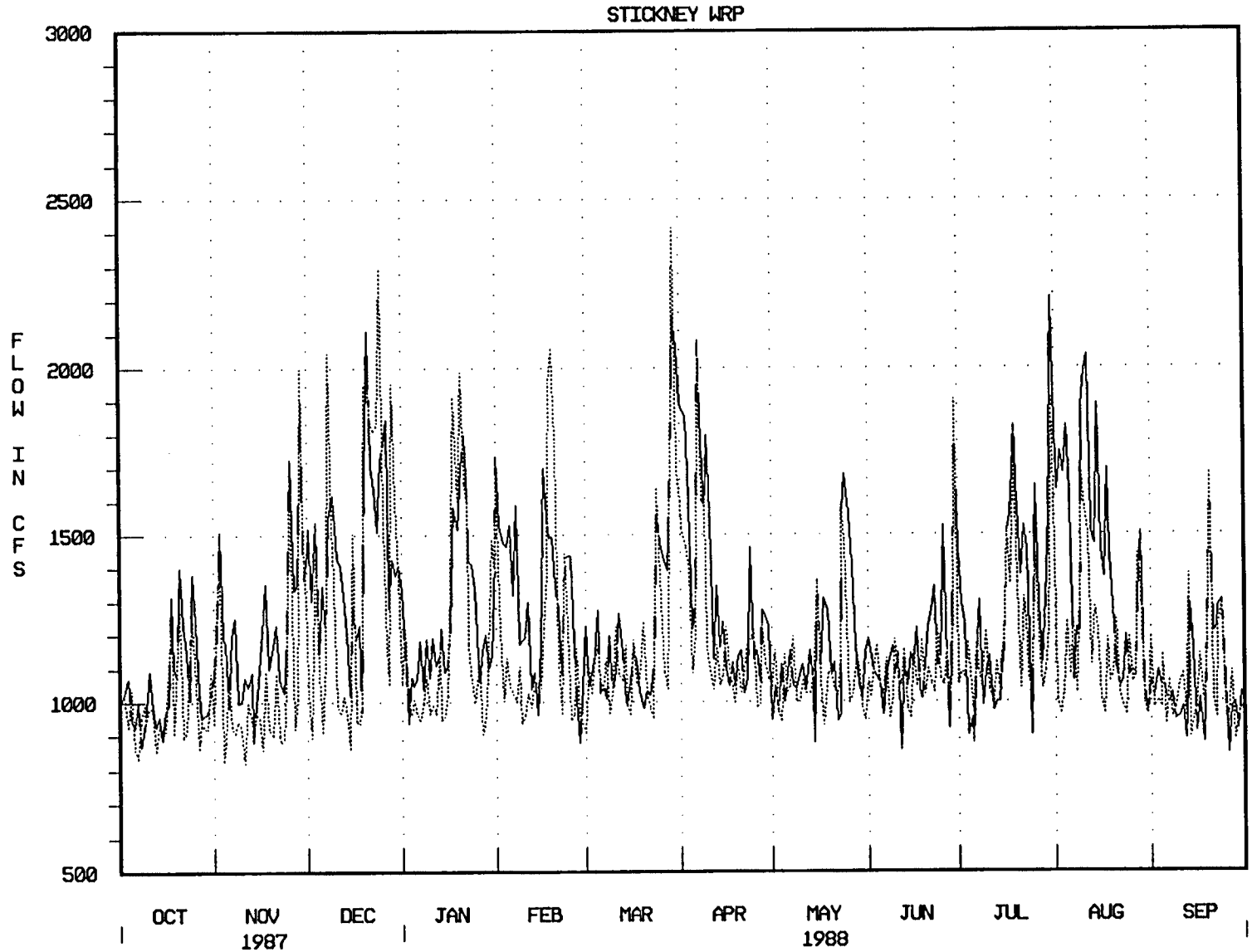


Figure 6

Budget 9 - Simulation of the MWRDGC Mainstream Pumping Station



OBSERVED FLOW
SIMULATED FLOW

Figure 7

Budget 10 - Simulation of the MWRDGC Stickney Water Reclamation Facility

BUDGET 11: CALUMET TARP PUMPING STATION

Budget 11 analyzes the water budget at the MWRDGC Calumet TARP Pumping Station (Figure 8). The results of Budget 11 are used as input to Budget 12 in addition to providing a verification point for simulated flows. The modeling of Calumet TARP is performed using the Tunnel Network (TNET) dynamic hydraulic model. A simplified map of Calumet TARP is contained in Figure 5. A more in-depth description of Calumet TARP and the simulation model is contained in the Water Year 1987 report (USACE, 1992).

In analyzing the balance at the Calumet TARP Pumping Station, weekly flows were used instead of daily flows. While MWRDGC maintain daily pumpage records, days with no pumpage occur frequently. Therefore, it is not possible to compute a daily S/R ratio.

The balance for WY88 of the inflow to the Calumet Pumping Station is fair. The simulated to recorded flow ratio (S/R) for the Calumet TARP Pumping Station is 1.26 indicating that the simulated inflow volume is significantly larger than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.61, indicating that there was a reasonable agreement between the trends in the simulated and observed inflow.

BUDGET 12: CALUMET WATER RECLAMATION FACILITY

Budget 12 analyzes the water balance at the MWRDGC Calumet Water Reclamation Facility (Figure 9). Simulated Calumet TARP pumpages from Budget 11 are combined with simulated interceptor inflows to the Calumet Water Reclamation Facility to derive the total simulated inflow to the Calumet Facility. Total simulated inflow is compared with recorded inflow to assess the accuracy of the simulation.

The annual simulated to recorded flow ratio (S/R) for the Calumet Water Reclamation Facility is good (0.80), but the daily S/R shows a high degree of variability, indicating that the trends in the simulated and recorded inflow may not be in agreement. The coefficient of correlation of simulated inflow to recorded inflow (R) is 0.52. This is an improvement over WY87 which showed a coefficient of correlation of 0.42. Both the high variability in S/R and the low correlation seem to indicate that there is room for improvement in the simulation of the Calumet service basin.

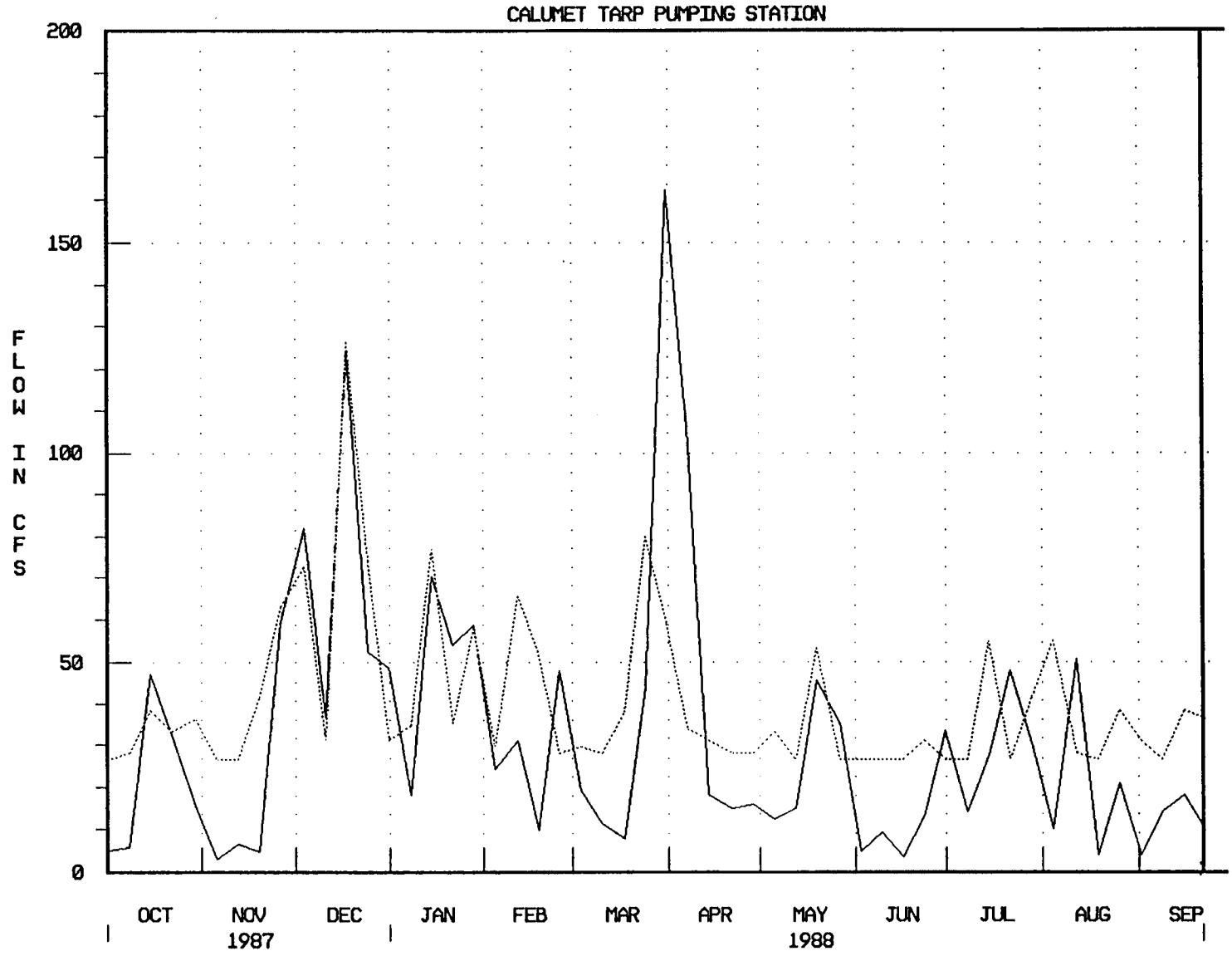


Figure 8

Budget 11 - Simulation of the MWRDGC Calumet Pumping Station

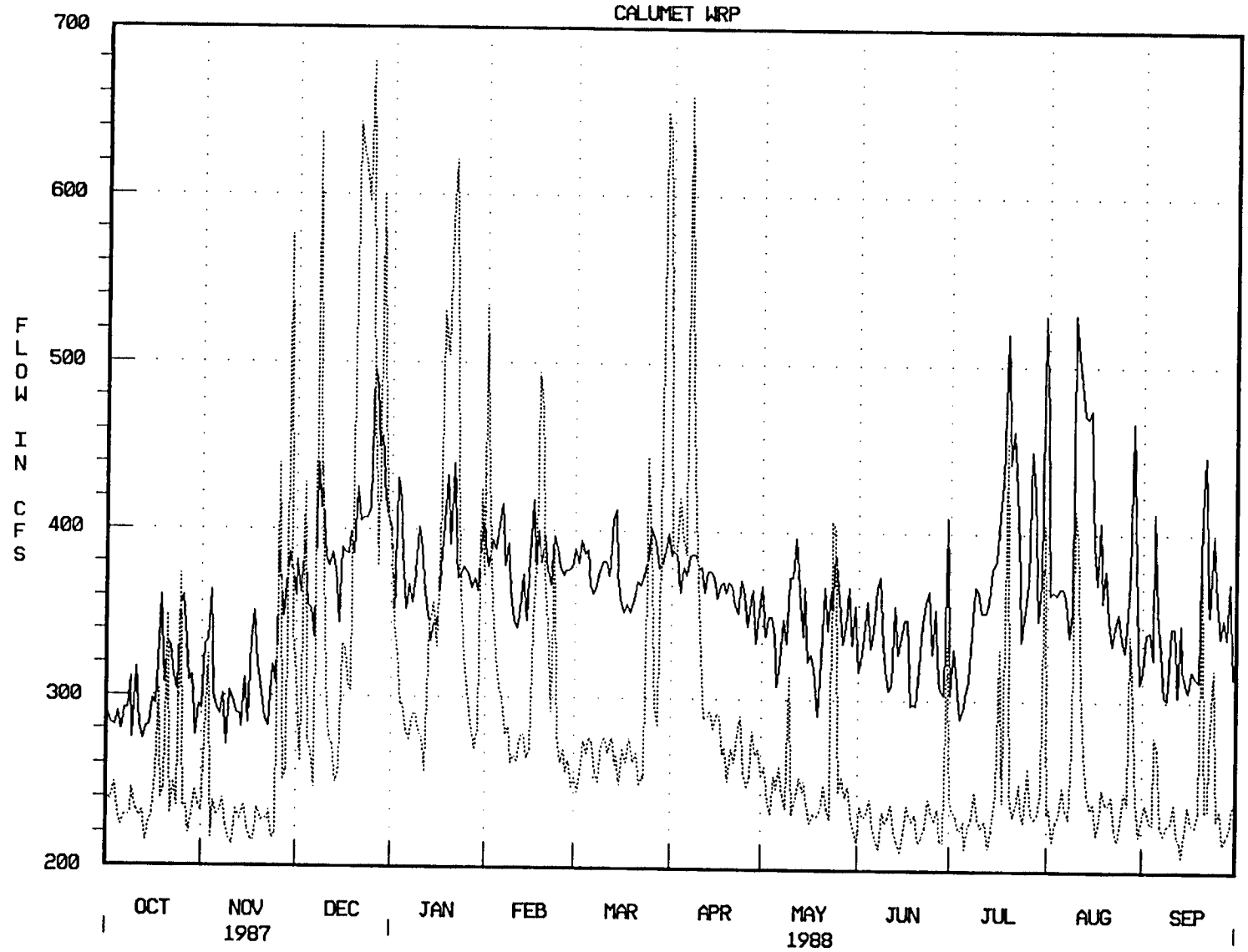


Figure 9

Budget 12 - Simulation of the MWRDGC Calumet Water Reclamation Facility

The hydraulic response to storm events at the Calumet facility was compared to that of the Northside and the Stickney facilities. Base flow at Calumet is about 320 to 360 cfs while peak storm flows in response to inflow-infiltration are on the order of 420 to 460 cfs. At Northside and Stickney, peak flows can be twice as high or greater relative to base flow. Therefore, it appears that the model is simulating proper hydraulic response, but the treatment facility cannot accommodate the storm inflow. This will be investigated at a later date.

BUDGET 13: LEMONT WATER RECLAMATION FACILITY

Budget 13 analyzes the water balance at the MWRDGC Lemont Water Reclamation Facility (Figure 10). Overall, the balance for WY88 of the inflow to the Lemont facility is good. The simulated to recorded flow ratio (S/R) for the Lemont is 0.82, indicating that the simulated inflow volume was somewhat less than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.75, indicating that the model predicted the inflow hydrograph to the Lemont facility well.

BUDGET 14: CHICAGO CANAL SYSTEM BALANCE

Budget 14 compares the inflows and outflows to the canal system (Figure 11). The inflow components include direct diversions through the lakefront structures, stormwater runoff discharged to the canal system, and domestic water supply whose effluent discharges to the canal system. The outflows from the canal system include the discharge at Lockport, backflows through the lakefront structures, and withdrawals upstream of Lockport by Argonne National labs and Uno-ven corporation. The individual components are presented in Table 8 for WY88.

Overall, the balance for WY88 of the inflow to the canal system to the outflows from the canal system is fair. The S/R (outflow/inflow) for the canal system is 1.15, indicating that the inflow to the canal system is less than the outflow from the canal system. The average measured/simulated inflow was 3075.1 cfs while the average measured/simulated outflow was 3544.9 cfs. This is a difference of 469.8 cfs (13.3%) for WY88 as compared to 566.0 cfs (14.0%) for the previous water year, WY87.

The coefficient of correlation (R) of inflow to outflow is 0.95, indicating that the time series trends of inflow to outflow are very well correlated. Therefore, based on the fact that the inflow is well correlated with the outflow, it appears that there is a moderately variable to constant underreported or unreported inflow.

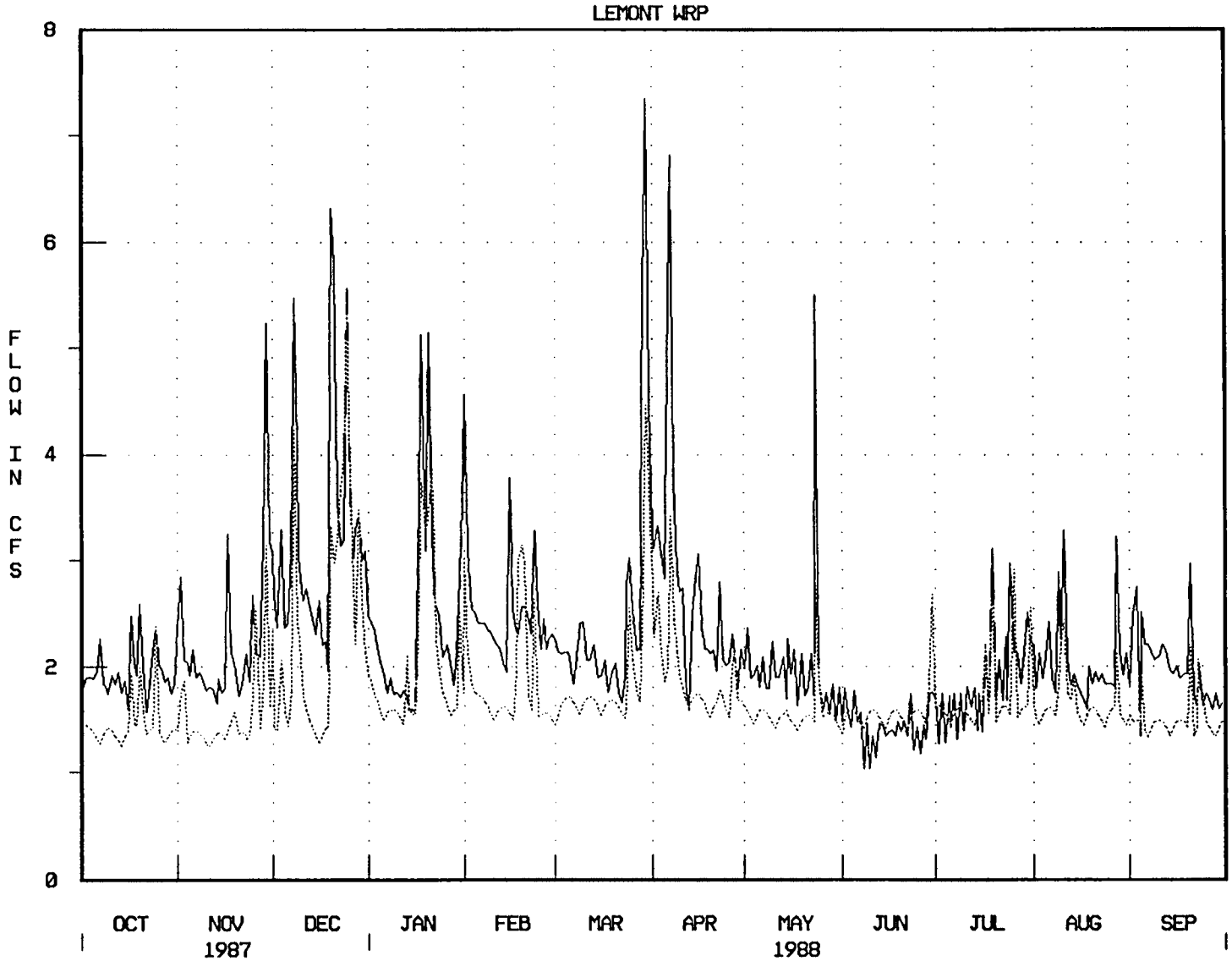


Figure 10

Budget 13 - Simulation of the MWRDGC Lemont Water Reclamation Facility

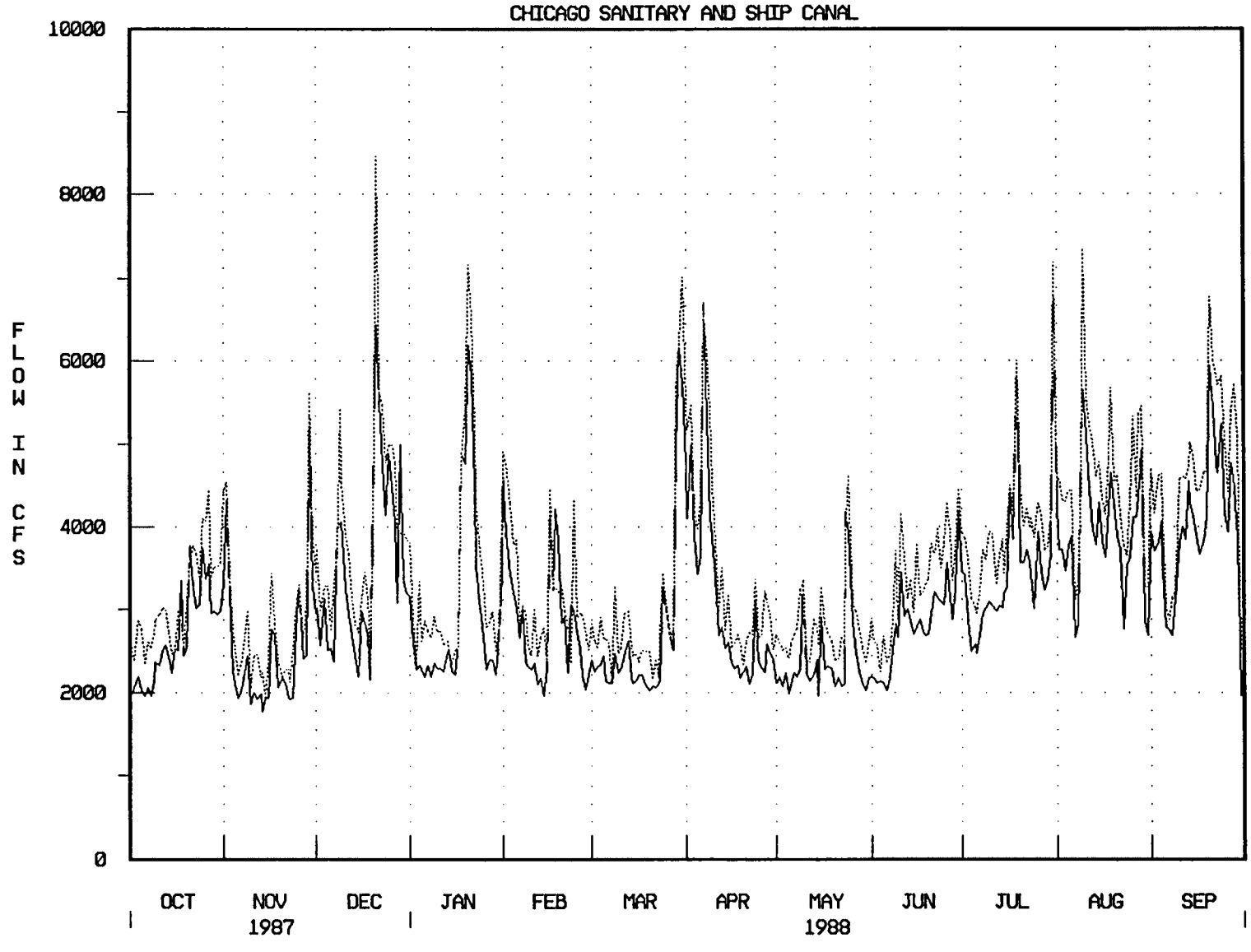


Figure 11

CANAL SYSTEM INFLOWS
CANAL SYSTEM OUTFLOWS

Budget 14 - Canal System Balance

TABLE 8

SUMMARY OF FLOW COMPONENTS FOR
CANAL SYSTEM BALANCE - WY1988

INFLOWS (cfs)	
Lake Controlling Structures (measured)	
- Wilmette Controlling Works	26.5
- Chicago River Controlling Works	288.9
- O'Brien Lock and Dam	244.9
Streamflows (measured)	
- North Branch Chicago River at Niles	90.9
- Little Calumet River at South Holland	148.3
Streamflow (estimated)	
- Grand Calumet River at Holman Ave.	26.7
MWRDGC Water Reclamation Facilities	
- Northside	411.2
- Stickney	1244.1
- Calumet	360.5
- Calumet TARP Pumpage to River	17.2
- Lemont	2.2
Other Point Sources (measured)	28.7
Summit Conduit (simulated)	8.3
Combined Sewer Overflows	91.7
Direct Runoff to CSSC (simulated)	85.0
TOTAL INFLOWS (cfs)	3075.1

OUTFLOWS (cfs)	
Cal-Sag Flow Transferred to Calumet WRP as Steel Mill Blow-down	1.9
Lake Front Backflows	0.0
Argonne Laboratory	0.5
Uno-ven Corporation	6.0
USGS AVM Record	3536.5
TOTAL OUTFLOWS (cfs)	3544.9

DIFFERENCE (cfs)	-469.8

Possible sources of the canal flow imbalance may include underreporting of the lakefront flows through the sluice gates and locks and unaccounted for flow sources. The underreporting of the lakefront flows could be the result of both inaccurate rating curves for the lakefront control structures and leakage through those structures. Flow meter measurements at the lakefront direct diversion points were done to assess if leakage is significant. This study (USACE, 1990) showed that, given the accuracy limits of the Price AA current meter, lakefront flows are underreported, but the magnitude of underreporting could not be determined. Unaccounted flows could also include unreported discharges to the canal.

AREAS FOR IMPROVEMENT IN THE DIVERSION ACCOUNTING PROCEDURES

As a result of reviewing and calculating the WY88 diversion accounting, and referencing the results of the WY84 through WY87 diversion accounting, a number of areas of potential improvement have become evident. The following paragraphs discuss those areas where improvement is needed.

O'HARE AND EGAN BASIN TRANSFER

A portion of the flows originating in the O'Hare and Egan Water Reclamation Plants' (WRP) service basins are transferred east to the Northside WRP. The extent of the O'Hare service area being diverted is not known and the diverted flow is not measured. Thus an estimate of the annual basin transfer is provided by MWRDGC. The total O'Hare-Egan flow transfer for WY88 was estimated by the MWRDGC to be 31.0 cfs (20 MGD).

This transfer is significant to diversion accounting in light of the fact that the O'Hare and Egan facilities discharge outside of the CSSC while the Northside facility discharges flows that reach the CSSC. Therefore, this transfer contains two components that are deductions to the flow measured in the CSSC. The two deductible components are groundwater pumpage contained in the sanitary portion of the transfer, and diverted Des Plaines River watershed runoff. These two deductible components are contained in Columns 4 and 6, respectively.

To determine the two deductible components requires an estimate of the sanitary and runoff portions of the flow transfer. Presently the sanitary and runoff portions of the flow transfer are estimated using the same constituent (sanitary, inflow, and infiltration) proportions simulated for the Upper Des Plaines Pump Station by SCALP (Special Contributing Area Program). Additionally, estimates must be made of the groundwater and Lake Michigan water components contained in the sanitary portion of the transfer. For WY88 it was estimated that

the water supply for the O'Hare and Egan service basins was composed of 7.9 percent groundwater (1.8 cfs) and 92.1 percent Lake Michigan Water (20.2 cfs). The diverted Des Plaines River watershed runoff was estimated at 8.0 cfs.

For future accounting, simply measuring the basin transfer will not provide any information on the component makeup of the transfer. Thus, a review of the complex hydraulics and hydrology is necessary to determine the best procedure for estimating these flows. Several alternatives, including flow measurement and modeling are under consideration at this time. A more detailed discussion of the O'Hare and Egan basin transfer can be found in the Lake Michigan Diversion Accounting WY86 Report (USACE, 1991).

GRAND CALUMET RIVER

The flow in the Grand Calumet River drains both to the Lake Michigan via Indiana Harbor and to the Calumet Sag Channel which is tributary to the CSSC. When lake levels are high a larger portion of the flow drains to the Calumet Sag Channel. The Grand Calumet River flow calculation is currently based on a regression equation relating Lake Michigan stages and measured flows in Hart Ditch to the Grand Calumet River flow. Through current meter measurements by MWRDGC and other agencies it was determined that the accuracy of these regression equations are in question.

The Grand Calumet River flow to Illinois is important to diversion accounting because the majority of the flow in the Grand Calumet River is water supply effluent. This is a deduction to the AVM gage record and is contained in Column 5, Water Supply Pumpage from Indiana Reaching the CSSC. The Indiana water supply deduction is equal to the total water supply pumpage discharged to the Grand Calumet River if the pumpage rate is less than the calculated river flow. The deduction is equal to the river flow if the pumpage rate is greater than the river flow since under these conditions it is assumed that the river flow is composed entirely of sanitary effluent.

This procedure is the only method currently available to calculate the Indiana deduction. A stream gage has been installed in the West Branch of the Grand Calumet River to measure flow into Illinois. This should increase the accuracy of this computation significantly. The same computational procedure for separating stream flow into sanitary and runoff will be used with the Grand Calumet stream gage record.

MWRDGC CALUMET WATER RECLAMATION FACILITY

The MWRDGC Calumet Water Reclamation Plant (WRP) balance was discussed in a previous section where it was noted that although the annual S/R ratio was reasonable, the simulated inflows exhibited only a marginal correlation to the recorded inflows. For WY87, the Corps of Engineers attempted to improve the SCALP (Special Contributing Area Loading Program) hydraulic simulation model so as to better reflect more recent hydraulic conditions of the Calumet service basin. However, the response of the revised simulation model for WY87 did not result in an improved response. The response for WY88 did however show an improved correlation as it rose from 0.42 for WY87 to 0.52 for WY88. This may have been the result of WY88 being a dry year. As was discussed previously, problems arise with the model during storm events since the Calumet Facility's maximum capacity is only slightly larger than the base flow of the Calumet service basin. The Calumet facility will be increasing its capacity soon, and these changes will be incorporated into the model when they become active.

Review of recent sewer studies and field evaluation of the sewer system may be required to develop a model that would more accurately represent the hydraulic response of the Calumet WRP service basin. One other possible explanation of the poor simulated to recorded correlation that should not be overlooked is inaccurate flow measurement at the plant. Personnel at MWRDGC need to be consulted on this issue to determine if current flow measurement techniques need to be improved. In addition, a portion of the Calumet WRP service area in the vicinity of the Calumet River needs to be investigated to correct errors regarding the presence of combined versus separate sewers.

MWRDGC UPPER DES PLAINES PUMP STATION

A review of the Upper Des Plaines pump station and its flow record indicates that the flow at the pump station is suspect and subject to operator error. Better flow measurement is needed at the pump station. With better flow measurement, this will become the most important balances for calibrating and verifying the simulation models of the Des Plaines watershed. In the diversion calculation, the primary use of the models is to calculate the deduction for runoff from the Des Plaines watershed discharged to the canal. Runoff from the Des Plaines watershed is deductible. The Upper Des Plaines Pump Station is the only point at which a model of inflow-infiltration can be calibrated and extrapolated to the remaining Des Plaines River watershed. Installation of better flow measurement equipment at the pump station would facilitate model calibration.

CANAL SYSTEM BALANCE

As discussed previously, the canal system balance indicated that the total inflows were 13.3% less than the outflows. Flow meter measurements at the lakefront direct diversion points were conducted in July 1990 to assess if leakage is still significant. This study (USACE, 1990) showed that, given the accuracy limits of the Price AA current meter in extremely low velocity profiles, the lakefront flows are underreported. However, sound conclusions cannot be drawn regarding the magnitude of the underreporting.

In addition to the problems previously noted, there may be unreported discharges to the CSSC and adjoining waterways that affect the canal system balance. Reconnaissance missions should be made to determine if there are any unreported discharges that are being made directly to the canal system.

PRECIPITATION DATA

The runoff simulation models used to accomplish the diversion accounting are driven by precipitation and other meteorologic data. In performing the WY83 diversion accounting, NIPC discovered problems with the precipitation data related to shielding of the rain gages by buildings and other obstructions. To address this problem, the Illinois State Water Survey (ISWS) was contracted to assess the problem and adjust the precipitation data. The ISWS has also adjusted the WY84 though WY89 data used for Lake Michigan diversion accounting. To resolve the problem, a precipitation gage network of 25 gages was installed by the ISWS under contract with the Corps. However, no data will be available from the network until WY90. Prior to WY90, the precipitation data will be adjusted as in the past.

TUNNEL AND RESERVOIR PLAN

There are several areas where the TARP models can be improved. First, modeling of dry weather flow can be improved to more accurately simulate MWRDGC operational procedures. Second, the incorporation of a pseudo-forecasting algorithm would allow the model to simulate MWRDGC dewatering procedures prior to a storm. Third, dynamic constituent (I-I versus sanitary versus groundwater) tracking can be incorporated to allow more accurate determination of the deductible components of TARP flow. Fourth, the inclusion of an algorithm to operate gaged dropshafts based on average water surface elevation in a tunnel reach would provide better simulation of gage operations.

SUMMARY

In compliance with the modified 1980 U.S. Supreme Court decree, the WY88 diversion was computed using the best engineering technology available to date as applied to the diverted watersheds.

Overall, the simulations that comprise a significant portion of the diversion accounting computations worked well. The two most significant budgets to the diversion accounting computations, Budget 7, Northside Water Reclamation Facility, and Budget 10, Stickney Water Reclamation Facility, performed well. Together, Budgets 7 and 10 compute the majority of the deductible Des Plaines River watershed runoff. These budgets have simulated to recorded ratios of 0.97 and 0.93 and correlations of 0.62 and 0.70, respectively. Given the complexity of the hydrologic cycle in the heavily urbanized Chicago metropolitan area, and given the number of human and other factors that cannot be adequately represented in numerical modeling procedures, the results of these two budgets are very good. Other simulation budgets have performed reasonably well, but there is room for improvement. Areas of improvement previously outlined will be considered in order to improve the accuracy of the diversion computation.

The WY88 diversion accountable to the State of Illinois is 3,375.6 cfs. This is 175.6 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average beginning with WY81 and rounded to the nearest cfs is 3,451 cfs, and the cumulative deviation from the 3,200 cfs average is -2,011 cfs-years. The negative cumulative deviation indicates a water allocation deficit and the maximum allowable deficit is 2,000 cfs-years.

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Lake Michigan Diversion Accounting

Water Year 1988 Report

Appendix A

Summary of Daily Diversion Flows

COLUMN COMPUTATIONS

1. COLUMN 3 EQUALS THE SUM OF COLUMN 1 AND COLUMN 2.
2. COLUMN 8 EQUALS THE SUM OF COLUMNS 4 THROUGH COLUMN 7.
3. COLUMN 10 EQUALS COLUMN 3 LESS COLUMN 8 WITH THE ADDITION OF COLUMN 9.

NOTES

1. ALL VALUES ARE ROUNDED TO THE NEAREST TENTH.
2. MATHEMATICAL COMPUTATIONS BETWEEN COLUMNS UTILIZE UNROUNDED VALUES.
3. AVERAGE VALUES FOR WY87 WERE COMPUTED USING DAILY VALUES.

LEGEND

DEDUCTIONS FROM THE ROMEOVILLE GAGE RECORD

ADDITIONS TO THE ROMEOVILLE GAGE RECORD

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Oct-87	2583	0.3	2583.3	87.5	29.1	47.6	1.9	166.1	92.2	2509.4	1775.5	145.3	141.0
02-Oct-87	2387	0.3	2387.3	93.7	80.3	34.2	1.9	210.1	92.5	2269.7	1732.6	129.5	195.0
03-Oct-87	2882	0.3	2882.3	56.4	68.7	32.1	1.8	158.9	90.8	2814.2	1727.3	95.5	298.0
04-Oct-87	2761	0.3	2761.3	137.9	31.1	32.9	2.0	203.8	90.1	2647.6	1704.0	132.6	290.0
05-Oct-87	2355	0.3	2355.3	51.5	31.1	28.6	2.0	113.1	93.7	2336.0	1792.0	77.9	252.0
06-Oct-87	2605	0.3	2605.3	56.4	54.9	27.9	1.8	141.0	93.3	2557.7	1761.0	74.8	249.0
07-Oct-87	2543	0.3	2543.3	89.2	80.3	27.8	2.0	199.3	91.5	2435.5	1752.1	89.9	275.0
08-Oct-87	2711	0.3	2711.3	95.1	44.8	27.3	1.8	169.0	94.0	2636.4	1771.0	85.5	428.0
09-Oct-87	2890	0.3	2890.3	56.3	28.6	25.5	1.9	112.3	90.9	2868.9	1756.4	85.2	647.0
10-Oct-87	2939	0.3	2939.3	87.6	47.3	25.4	1.8	162.0	93.7	2871.0	1713.7	119.6	394.0
11-Oct-87	3023	0.3	3023.3	94.8	49.8	25.3	1.8	171.6	90.0	2941.8	1672.4	123.7	729.0
12-Oct-87	3004	0.3	3004.3	56.4	33.1	24.1	1.9	115.4	93.0	2981.9	1781.8	82.3	877.0
13-Oct-87	2730	0.3	2730.3	111.3	27.3	24.7	1.9	165.2	93.7	2658.8	1798.2	101.4	710.0
14-Oct-87	2465	0.3	2465.3	73.8	27.3	22.6	2.0	125.7	93.8	2433.4	1791.7	81.4	594.0
15-Oct-87	2515	0.3	2515.3	51.5	34.1	21.0	1.9	108.5	95.7	2502.6	1801.4	64.9	770.0
16-Oct-87	2980	0.3	2980.3	69.8	32.6	96.1	1.9	200.4	93.1	2873.1	1785.8	232.5	687.0
17-Oct-87	2803	0.3	2803.3	193.0	30.3	44.4	1.6	269.2	92.3	2626.4	1685.5	382.9	1056.0
18-Oct-87	2559	0.3	2559.3	56.3	27.3	30.7	1.9	116.3	90.2	2533.2	1659.7	123.5	465.0
19-Oct-87	3109	0.3	3109.3	72.6	40.6	123.7	1.8	238.7	95.2	2965.8	1720.0	405.5	476.0
20-Oct-87	3583	0.3	3583.3	248.8	37.0	85.7	1.8	373.3	94.6	3304.7	1739.0	580.3	1237.0
21-Oct-87	3786	0.3	3786.3	51.5	36.7	28.0	1.9	118.2	93.2	3761.4	1722.1	123.7	1177.0
22-Oct-87	3664	0.3	3664.3	56.3	27.3	24.8	1.9	110.4	92.1	3646.1	1727.8	92.2	1079.0
23-Oct-87	3390	0.3	3390.3	162.4	41.2	26.2	2.0	231.8	93.4	3251.9	1719.4	132.5	1231.0
24-Oct-87	4099	0.3	4099.3	70.9	41.7	163.3	2.1	278.0	93.1	3914.4	1672.1	692.9	1138.0
25-Oct-87	4067	0.3	4067.3	146.5	30.4	34.2	2.0	213.0	92.7	3947.0	1721.7	211.1	1184.0
26-Oct-87	4433	0.3	4433.3	56.3	27.3	32.6	2.1	118.3	91.3	4406.3	1709.2	135.4	1650.0
27-Oct-87	3387	0.3	3387.3	111.2	30.9	30.5	2.0	174.5	93.2	3306.0	1731.8	177.7	1132.0
28-Oct-87	3521	0.3	3521.3	73.8	30.2	24.8	2.0	130.8	91.5	3482.0	1700.1	136.2	1148.0
29-Oct-87	3505	0.3	3505.3	56.3	33.4	23.3	1.9	114.9	93.9	3483.9	1706.7	108.0	1164.0
30-Oct-87	3565	0.3	3565.3	147.3	28.6	25.1	2.0	203.0	91.3	3453.6	1714.6	143.6	1148.0
31-Oct-87	4405	0.3	4405.3	51.3	36.7	44.2	2.0	134.1	93.0	4364.2	1686.2	145.5	1374.0
OCT 87	3137.1	0.3	3137.4	91.1	38.7	40.8	1.9	172.5	92.7	3057.6	1733.3	171.4	790.5

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Nov-87	4544	0.3	4544.3	186.4	43.5	140.3	1.9	352.1	84.3	4276.5	1640.7	579.9	2016.0
02-Nov-87	3401	0.3	3401.3	278.5	37.2	123.2	1.8	440.7	87.1	3047.8	1713.8	630.9	465.0
03-Nov-87	2731	0.3	2731.3	51.5	27.1	31.6	1.8	111.9	85.0	2704.3	1737.9	152.4	116.0
04-Nov-87	2535	0.3	2535.3	56.4	26.3	27.3	1.8	111.7	84.9	2508.5	1729.6	128.6	128.0
05-Nov-87	2226	0.3	2226.3	151.3	25.8	27.1	1.8	206.0	83.4	2103.7	1719.0	151.5	189.0
06-Nov-87	2368	0.3	2368.3	51.5	27.1	22.3	1.8	102.6	84.4	2350.2	1700.0	90.1	104.0
07-Nov-87	2678	0.3	2678.3	56.3	27.1	21.8	1.7	107.0	83.8	2655.1	1668.4	87.6	147.0
08-Nov-87	2984	0.3	2984.3	90.0	33.1	21.7	1.7	146.5	82.5	2920.2	1652.7	99.9	664.0
09-Nov-87	2063	0.3	2063.3	96.7	42.3	21.3	1.8	162.2	82.7	1983.8	1694.0	102.0	102.0
10-Nov-87	2441	0.3	2441.3	51.5	48.9	19.5	1.7	121.6	83.8	2403.5	1696.4	76.2	120.0
11-Nov-87	2469	0.3	2469.3	129.2	27.1	22.1	1.8	180.1	81.9	2371.0	1686.8	109.4	106.0
12-Nov-87	2170	0.3	2170.3	72.9	27.1	19.5	1.8	121.3	84.3	2133.3	1686.9	77.1	115.0
13-Nov-87	2242	0.3	2242.3	51.4	27.1	18.4	1.8	98.7	84.4	2227.9	1658.1	62.3	119.0
14-Nov-87	1943	0.3	1943.3	93.7	28.8	19.8	1.7	144.0	84.1	1883.5	1662.2	79.6	144.0
15-Nov-87	2384	0.3	2384.3	95.6	31.9	19.0	1.8	148.2	81.7	2317.7	1625.1	75.2	126.0
16-Nov-87	3458	0.3	3458.3	51.5	31.5	31.7	1.8	116.5	84.4	3426.3	1682.4	70.3	679.0
17-Nov-87	2828	0.3	2828.3	171.1	27.1	63.3	1.8	263.3	84.5	2649.5	1684.2	295.2	399.0
18-Nov-87	2386	0.3	2386.3	56.3	27.1	42.2	1.8	127.4	84.9	2343.7	1669.4	124.1	89.0
19-Nov-87	2201	0.3	2201.3	51.5	27.1	19.6	1.8	99.9	83.2	2184.6	1666.7	70.8	208.0
20-Nov-87	2281	0.3	2281.3	151.8	28.8	21.7	1.8	204.1	82.8	2160.0	1675.9	115.0	138.0
21-Nov-87	2290	0.3	2290.3	51.5	27.1	17.7	1.8	98.1	83.1	2275.3	1651.1	57.5	90.0
22-Nov-87	2124	0.3	2124.3	56.4	27.1	17.8	1.9	103.2	80.8	2101.9	1621.8	60.2	97.0
23-Nov-87	2512	0.3	2512.3	72.3	27.1	25.2	1.8	126.3	85.5	2471.4	1698.2	80.9	86.0
24-Nov-87	3016	0.3	3016.3	123.5	27.1	85.7	1.8	238.1	85.9	2864.1	1691.1	348.4	737.0
25-Nov-87	3315	0.3	3315.3	252.3	55.0	208.1	1.9	517.3	85.6	2883.6	1657.4	1229.6	198.0
26-Nov-87	2664	0.3	2664.3	56.3	44.1	35.8	1.8	138.1	82.4	2608.5	1619.8	246.9	83.0
27-Nov-87	3066	0.3	3066.3	51.4	38.6	76.5	1.9	168.3	83.2	2981.2	1598.3	290.7	88.0
28-Nov-87	5612	0.3	5612.3	250.9	48.0	504.5	1.8	805.3	90.1	4897.1	1596.9	2614.9	186.0
29-Nov-87	3871	0.3	3871.3	314.8	35.8	143.6	1.9	496.1	83.6	3458.8	1571.6	1130.7	177.0
30-Nov-87	3445	0.3	3445.3	56.1	36.7	226.8	1.9	321.4	85.5	3209.4	1657.9	1013.9	91.0
NOV 87	2808.3	0.3	2808.6	108.7	33.0	69.2	1.8	212.6	84.1	2680.1	1667.1	341.7	266.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Dec-87	3734	0.7	3734.7	156.0	45.7	94.6	1.9	298.2	83.5	3520.1	1648.6	655.4	96.0
02-Dec-87	2973	0.7	2973.7	56.4	27.0	62.6	1.8	147.8	82.3	2908.3	1654.2	406.1	89.0
03-Dec-87	3270	0.7	3270.7	217.3	30.0	185.3	2.0	434.5	84.3	2920.5	1649.0	1025.5	104.0
04-Dec-87	3295	0.7	3295.7	132.8	36.9	81.8	1.9	253.4	80.6	3122.9	1672.4	553.5	93.0
05-Dec-87	2747	0.7	2747.7	56.4	27.0	51.0	1.8	136.2	80.2	2691.7	1615.6	323.9	72.0
06-Dec-87	3313	0.7	3313.7	138.3	27.0	101.4	1.9	268.6	81.1	3126.3	1603.3	420.7	101.0
07-Dec-87	3679	0.7	3679.7	218.2	27.0	584.0	1.9	831.0	92.0	2940.7	1624.6	2318.1	103.0
08-Dec-87	5415	0.7	5415.7	274.1	27.0	329.6	1.8	632.5	88.5	4869.8	1686.9	1986.1	78.0
09-Dec-87	4522	0.7	4522.7	220.1	27.0	309.1	1.9	558.1	83.6	4048.3	1659.2	1764.0	87.0
10-Dec-87	3878	0.7	3878.7	56.3	27.0	148.6	1.9	233.8	82.7	3727.7	1660.8	896.0	80.0
11-Dec-87	3667	0.7	3667.7	51.5	27.0	97.6	1.9	177.9	80.8	3570.7	1651.2	607.9	82.0
12-Dec-87	3120	0.7	3120.7	109.0	27.0	74.8	1.9	212.6	80.5	2988.6	1628.9	507.1	79.0
13-Dec-87	2830	0.7	2830.7	94.4	27.0	61.7	1.9	185.0	79.6	2725.4	1597.5	381.3	76.0
14-Dec-87	2716	0.7	2716.7	56.4	27.0	54.7	1.9	139.9	82.1	2658.9	1651.5	310.9	79.0
15-Dec-87	3124	0.7	3124.7	165.1	70.2	64.5	1.9	301.6	80.6	2903.7	1658.6	1179.9	98.0
16-Dec-87	3472	0.7	3472.7	56.3	52.2	61.3	1.8	171.5	82.1	3383.3	1665.2	794.3	87.0
17-Dec-87	3133	0.7	3133.7	56.3	27.0	55.0	1.9	140.3	81.5	3074.9	1657.5	554.3	96.0
18-Dec-87	2572	0.7	2572.7	92.1	27.0	54.0	1.9	174.9	82.6	2480.4	1658.7	457.7	77.0
19-Dec-87	3705	0.7	3705.7	155.1	27.0	497.1	1.9	681.1	93.4	3118.1	1631.6	2187.6	68.0
20-Dec-87	8471	0.7	8471.7	310.4	27.0	524.5	1.8	863.7	87.0	7695.0	1618.5	3857.2	70.0
21-Dec-87	5631	0.7	5631.7	348.1	27.0	564.3	1.9	941.3	86.5	4777.0	1657.1	3522.9	51.0
22-Dec-87	5466	0.7	5466.7	284.7	27.0	589.0	2.0	902.7	88.6	4652.7	1658.5	2693.9	72.0
23-Dec-87	4755	0.7	4755.7	260.9	27.0	591.7	2.0	881.6	89.2	3962.4	1657.9	2161.7	86.0
24-Dec-87	4984	0.7	4984.7	370.2	33.7	930.5	1.9	1336.3	89.6	3737.1	1628.0	2711.8	302.0
25-Dec-87	4995	0.7	4995.7	209.7	39.3	557.4	1.8	808.2	81.3	4268.8	1560.9	1951.4	67.0
26-Dec-87	4768	0.7	4768.7	60.2	27.0	387.5	1.8	476.5	78.0	4370.2	1584.3	1331.6	64.0
27-Dec-87	3982	0.7	3982.7	61.3	27.0	275.5	1.8	365.6	76.8	3695.9	1577.9	946.2	70.0
28-Dec-87	3923	0.7	3923.7	139.8	54.9	591.6	1.9	788.2	90.9	3226.5	1648.6	2994.4	90.0
29-Dec-87	3919	0.7	3919.7	327.4	48.0	384.0	2.1	761.6	82.2	3240.4	1649.3	1383.4	85.0
30-Dec-87	3839	0.7	3839.7	234.7	27.0	270.6	2.1	534.3	80.7	3386.1	1623.4	1057.5	79.0
31-Dec-87	3824	0.7	3824.7	61.0	27.0	206.2	2.0	296.2	84.0	3612.6	1646.9	927.5	70.0
DEC 87	3991.0	0.7	3991.7	162.3	32.4	285.2	1.9	481.8	83.7	3593.7	1638.3	1382.9	88.7

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jan-88	2877	0.9	2877.9	166.1	27.1	163.8	2.1	359.0	85.3	2604.1	1586.7	711.8	75.0
02-Jan-88	2353	0.9	2353.9	56.3	27.1	138.2	2.1	223.8	86.6	2216.7	1613.2	519.4	72.0
03-Jan-88	3360	0.9	3360.9	51.4	27.1	124.2	2.1	204.9	90.0	3246.0	1688.4	432.5	74.0
04-Jan-88	2602	0.9	2602.9	109.2	27.1	118.2	2.2	256.7	89.7	2435.8	1712.8	425.8	83.0
05-Jan-88	2864	0.9	2864.9	99.1	27.1	109.9	2.5	238.6	89.7	2715.9	1756.3	346.4	83.0
06-Jan-88	2754	0.9	2754.9	51.4	27.1	102.1	2.4	183.1	92.8	2664.1	1782.9	288.8	109.0
07-Jan-88	2665	0.9	2665.9	74.1	27.1	98.4	2.2	201.8	90.1	2554.1	1769.4	285.5	130.0
08-Jan-88	2929	0.9	2929.9	118.6	27.1	96.0	2.3	244.0	90.2	2776.1	1773.2	313.0	129.0
09-Jan-88	2728	0.9	2728.9	51.4	27.1	89.7	2.3	170.6	89.2	2647.5	1727.3	279.5	152.0
10-Jan-88	2746	0.9	2746.9	92.3	27.1	86.3	2.3	208.0	89.1	2627.9	1700.0	259.7	100.0
11-Jan-88	2570	0.9	2570.9	94.1	27.1	82.1	2.3	205.7	90.9	2456.1	1767.3	249.9	96.0
12-Jan-88	2630	0.9	2630.9	157.1	27.1	235.9	2.3	422.4	92.0	2300.5	1789.9	592.7	92.0
13-Jan-88	2513	0.9	2513.9	56.4	27.1	121.5	2.3	207.2	91.3	2397.9	1787.7	467.3	124.0
14-Jan-88	2362	0.9	2362.9	61.3	27.1	96.5	2.3	187.2	89.4	2265.0	1758.5	375.8	111.0
15-Jan-88	2514	0.9	2514.9	90.6	27.1	87.6	2.3	207.7	90.1	2397.3	1761.8	353.8	68.0
16-Jan-88	2544	0.9	2544.9	197.1	27.1	240.6	2.4	467.2	90.2	2167.9	1733.3	815.6	63.0
17-Jan-88	4819	0.9	4819.9	134.7	27.1	688.4	2.3	852.5	99.5	4066.9	1704.8	2857.3	64.0
18-Jan-88	5403	0.9	5403.9	259.6	27.1	553.2	2.3	842.2	91.4	4653.0	1796.0	2620.9	75.0
19-Jan-88	7173	0.9	7173.9	234.0	32.8	718.8	2.3	987.8	99.3	6285.4	1778.3	3391.2	691.0
20-Jan-88	6519	0.9	6519.9	190.7	34.5	693.1	2.3	920.5	93.5	5692.9	1749.1	3474.1	181.0
21-Jan-88	5208	0.9	5208.9	277.1	31.4	459.9	2.3	770.7	90.7	4528.9	1742.6	2362.6	71.0
22-Jan-88	4290	0.9	4290.9	73.6	27.1	298.3	2.3	401.3	90.3	3979.9	1734.5	1400.6	69.0
23-Jan-88	3808	0.9	3808.9	56.3	27.1	208.0	2.2	293.7	87.1	3602.3	1692.9	907.2	64.0
24-Jan-88	3461	0.9	3461.9	56.3	27.1	162.7	2.2	248.4	87.5	3301.0	1668.8	674.7	80.0
25-Jan-88	2787	0.9	2787.9	159.5	27.1	140.5	2.3	329.4	89.3	2547.8	1730.5	579.1	84.0
26-Jan-88	2853	0.9	2853.9	56.4	35.0	120.3	2.3	213.9	87.7	2727.7	1747.2	428.4	110.0
27-Jan-88	2977	0.9	2977.9	51.5	27.1	108.8	2.3	189.7	89.0	2877.1	1725.7	376.6	90.0
28-Jan-88	2492	0.9	2492.9	166.8	27.1	105.3	2.3	301.4	88.1	2279.5	1739.4	398.9	83.0
29-Jan-88	2787	0.9	2787.9	135.2	27.1	300.2	2.3	464.8	95.3	2418.4	1703.0	1095.9	75.0
30-Jan-88	4086	0.9	4086.9	231.8	27.1	245.3	2.2	506.4	87.4	3667.9	1719.5	1321.8	69.0
31-Jan-88	4914	0.9	4914.9	173.6	27.1	456.2	2.3	659.3	92.7	4348.3	1662.2	2376.9	258.0
JAN 88	3439.3	0.9	3439.2	122.0	27.9	233.9	2.3	386.1	90.8	3143.5	1729.1	999.5	116.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Feb-88	4772	0.3	4772.3	144.8	32.1	289.2	1.9	468.0	85.9	4390.2	1717.9	1797.6	72.0
02-Feb-88	4284	0.3	4284.3	56.4	33.9	199.7	1.9	291.8	82.7	4075.2	1716.3	1107.9	93.0
03-Feb-88	3794	0.3	3794.3	128.8	27.4	157.7	1.9	315.7	83.6	3562.2	1714.4	824.8	79.0
04-Feb-88	3841	0.3	3841.3	74.6	27.4	132.3	1.9	236.2	85.1	3690.2	1712.0	606.1	101.0
05-Feb-88	2822	0.3	2822.3	56.3	27.4	118.5	1.9	204.2	85.1	2703.3	1709.2	484.5	96.0
06-Feb-88	3035	0.3	3035.3	51.4	80.4	110.1	1.9	243.8	82.2	2873.7	1713.4	606.3	86.0
07-Feb-88	2952	0.3	2952.3	140.2	27.4	108.0	2.0	277.5	83.0	2757.8	1676.4	378.1	80.0
08-Feb-88	2592	0.3	2592.3	51.5	27.4	99.9	1.9	180.7	85.4	2497.1	1730.3	305.3	93.0
09-Feb-88	2444	0.3	2444.3	93.9	27.4	97.2	1.9	220.4	83.5	2307.4	1720.9	295.1	91.0
10-Feb-88	2996	0.3	2996.3	93.9	27.4	93.0	1.9	216.2	84.7	2864.8	1699.8	279.1	82.0
11-Feb-88	2452	0.3	2452.3	56.3	39.5	89.1	1.9	186.9	84.1	2349.5	1685.7	246.5	108.0
12-Feb-88	2670	0.3	2670.3	103.4	27.4	98.2	1.9	220.9	85.2	2534.5	1727.1	265.5	95.0
13-Feb-88	2795	0.3	2795.3	91.0	27.4	85.3	1.9	205.7	82.8	2672.4	1683.9	253.4	74.0
14-Feb-88	2387	0.3	2387.3	74.1	27.4	91.1	1.9	194.5	85.6	2278.3	1650.2	377.4	64.0
15-Feb-88	4458	0.3	4458.3	149.6	27.4	187.7	1.9	366.6	84.9	4176.6	1727.8	1484.3	99.0
16-Feb-88	3265	0.3	3265.3	204.1	27.4	198.1	1.9	431.4	90.6	2924.4	1696.2	1258.4	73.0
17-Feb-88	3250	0.3	3250.3	317.0	27.4	594.5	1.9	940.8	84.3	2403.8	1709.5	2159.5	83.0
18-Feb-88	3212	0.3	3212.3	346.3	27.4	639.6	1.9	1015.3	93.8	2290.8	1720.7	1929.3	72.0
19-Feb-88	3290	0.3	3290.3	316.7	27.4	295.3	1.9	641.3	85.8	2734.7	1693.8	1150.8	90.0
20-Feb-88	2980	0.3	2980.3	56.2	28.1	204.9	1.9	291.0	82.7	2772.0	1677.7	942.9	73.0
21-Feb-88	2839	0.3	2839.3	56.4	27.4	94.7	1.9	180.4	82.7	2741.6	1658.1	435.2	70.0
22-Feb-88	2369	0.3	2369.3	160.6	27.4	410.8	1.9	600.7	92.2	1860.8	1724.2	1143.5	54.0
23-Feb-88	4309	0.3	4309.3	240.7	27.4	124.5	1.9	394.5	84.3	3999.1	1724.4	726.5	153.0
24-Feb-88	2907	0.3	2907.3	51.4	27.4	81.3	1.9	162.1	85.9	2831.2	1699.9	442.8	71.0
25-Feb-88	2957	0.3	2957.3	56.4	27.4	68.8	1.9	154.5	83.2	2886.1	1709.7	324.1	79.0
26-Feb-88	2941	0.3	2941.3	163.3	27.4	65.6	1.9	258.2	85.2	2768.3	1707.6	327.8	73.0
27-Feb-88	2750	0.3	2750.3	56.3	27.4	61.3	1.9	147.0	83.4	2686.7	1656.4	298.4	82.0
28-Feb-88	2504	0.3	2504.3	51.5	27.4	61.4	1.9	142.1	81.4	2443.6	1662.7	274.7	61.0
29-Feb-88	2839	0.3	2839.3	56.4	27.4	63.7	1.9	149.3	85.4	2775.3	1712.7	285.7	74.0
FEB 88	3127.8	0.3	3128.1	120.7	30.1	169.4	1.9	322.0	85.3	2891.4	1701.3	724.9	83.5

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Mar-88	2617	0.4	2617.4	142.1	27.2	69.0	1.8	240.1	82.5	2459.7	1712.1	340.8	74.0
02-Mar-88	2538	0.4	2538.4	51.4	27.2	69.3	1.8	149.8	80.8	2469.4	1725.9	326.1	78.0
03-Mar-88	2917	0.4	2917.4	98.5	27.2	74.2	1.8	201.7	83.6	2799.3	1694.1	343.2	71.0
04-Mar-88	2663	0.4	2663.4	107.9	27.2	76.5	1.8	213.5	82.7	2532.6	1709.6	317.2	79.0
05-Mar-88	2650	0.4	2650.4	56.3	27.2	77.1	1.8	162.5	79.4	2567.3	1670.9	267.6	65.0
06-Mar-88	2605	0.4	2605.4	56.3	27.2	78.4	1.8	163.8	82.7	2524.3	1640.2	256.0	62.0
07-Mar-88	2151	0.4	2151.4	133.4	27.2	81.2	1.8	243.7	81.3	1989.0	1704.4	293.4	73.0
08-Mar-88	3278	0.4	3278.4	51.4	27.2	78.6	1.8	159.1	83.4	3202.6	1702.1	268.6	197.0
09-Mar-88	2474	0.4	2474.4	56.3	27.2	78.9	1.8	164.3	81.4	2391.5	1689.4	320.6	70.0
10-Mar-88	2528	0.4	2528.4	156.3	27.2	81.7	1.8	267.0	82.7	2344.0	1708.0	372.2	90.0
11-Mar-88	2941	0.4	2941.4	51.4	27.2	77.2	1.8	157.7	81.0	2864.7	1703.0	302.2	84.0
12-Mar-88	2987	0.4	2987.4	56.3	27.2	76.7	1.7	162.0	80.8	2906.2	1641.3	296.1	358.0
13-Mar-88	2549	0.4	2549.4	136.5	27.3	77.8	1.9	243.5	78.9	2384.7	1618.6	328.1	86.0
14-Mar-88	2451	0.4	2451.4	56.3	27.2	74.3	1.8	159.7	83.2	2374.8	1691.0	275.6	78.0
15-Mar-88	2472	0.4	2472.4	51.4	27.2	72.2	1.8	152.7	80.4	2400.0	1675.5	255.4	74.0
16-Mar-88	2371	0.4	2371.4	157.9	27.2	74.5	1.8	261.5	82.7	2192.6	1672.2	294.0	82.0
17-Mar-88	2518	0.4	2518.4	51.4	27.2	69.3	1.8	149.8	80.2	2448.8	1680.2	221.3	88.0
18-Mar-88	2487	0.4	2487.4	56.3	27.2	68.6	1.9	154.1	81.6	2414.9	1679.1	222.3	81.0
19-Mar-88	2486	0.4	2486.4	163.5	27.2	70.5	1.8	263.0	80.0	2303.4	1657.0	268.0	72.0
20-Mar-88	2176	0.4	2176.4	56.3	27.2	66.6	1.8	152.0	81.6	2106.0	1625.9	206.7	70.0
21-Mar-88	2385	0.4	2385.4	51.4	27.2	64.5	1.8	145.0	80.8	2321.2	1692.5	197.0	73.0
22-Mar-88	2206	0.4	2206.4	56.4	27.2	63.7	1.8	149.1	81.5	2138.8	1692.2	193.0	77.0
23-Mar-88	2699	0.4	2699.4	150.7	27.2	64.9	1.8	244.7	82.3	2536.9	1694.1	236.7	95.0
24-Mar-88	3436	0.4	3436.4	199.4	27.2	268.1	1.8	496.6	83.6	3023.4	1713.2	1043.9	102.0
25-Mar-88	3075	0.4	3075.4	141.0	27.2	162.1	1.8	332.1	83.5	2826.7	1677.8	768.8	145.0
26-Mar-88	2694	0.4	2694.4	51.4	27.2	100.4	1.8	180.9	79.4	2592.9	1652.7	387.6	70.0
27-Mar-88	2772	0.4	2772.4	56.3	27.2	81.0	1.8	166.4	80.5	2686.4	1618.7	296.3	66.0
28-Mar-88	5697	0.4	5697.4	225.2	27.2	357.4	1.8	611.7	87.8	5173.4	1658.1	1467.9	1113.0
29-Mar-88	6242	0.4	6242.4	241.0	27.2	823.1	1.8	1093.2	93.3	5242.4	1659.9	3585.8	231.0
30-Mar-88	7017	0.4	7017.4	139.0	27.2	593.6	1.8	761.6	85.2	6341.0	1680.4	3012.1	62.0
31-Mar-88	5450	0.4	5450.4	236.0	27.2	375.6	1.8	640.7	84.5	4894.2	1661.7	1958.6	74.0
MAR 88	3081.7	0.4	3082.1	106.3	27.2	143.5	1.8	278.8	82.4	2885.6	1677.5	610.4	130.3

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Apr-88	5155	0.4	5155.4	236.6	27.4	243.2	1.6	509.0	91.8	4738.2	1628.6	1186.4	88.0
02-Apr-88	5476	0.4	5476.4	94.3	27.4	283.1	1.6	406.4	98.7	5166.7	1620.2	1275.7	1175.0
03-Apr-88	4177	0.4	4177.4	175.3	27.4	231.5	1.6	435.7	89.8	3831.4	1520.4	1335.3	160.0
04-Apr-88	3980	0.4	3980.4	56.4	27.4	188.4	1.5	273.6	94.6	3801.3	1675.9	1356.1	107.0
05-Apr-88	4311	0.4	4311.4	63.4	27.4	221.2	1.6	313.6	98.6	4096.6	1722.3	1561.6	117.0
06-Apr-88	6542	0.4	6542.4	150.1	77.4	680.8	1.6	910.0	101.9	5734.3	1654.2	3936.9	88.0
07-Apr-88	6054	0.4	6054.4	219.2	27.4	365.8	1.6	613.9	96.6	5537.0	1680.2	2815.4	67.0
08-Apr-88	5416	0.4	5416.4	276.7	32.1	245.2	1.6	555.7	95.1	4955.6	1692.8	1676.2	117.0
09-Apr-88	4517	0.4	4517.4	61.2	27.4	173.3	1.6	263.5	95.2	4349.1	1675.0	1055.7	168.0
10-Apr-88	3810	0.4	3810.4	56.3	39.7	138.2	1.6	235.9	94.1	3668.6	1626.1	776.5	139.0
11-Apr-88	2986	0.4	2986.4	51.4	41.9	118.5	1.6	213.5	93.2	2866.1	1671.6	630.7	91.0
12-Apr-88	3509	0.4	3509.4	164.1	32.6	110.8	1.6	309.1	94.7	3294.9	1692.7	594.7	101.0
13-Apr-88	2745	0.4	2745.4	56.3	27.4	98.9	1.6	184.3	94.1	2655.2	1703.8	448.2	132.0
14-Apr-88	3179	0.4	3179.4	51.4	27.4	92.1	1.6	172.5	93.1	3100.0	1669.0	396.1	116.0
15-Apr-88	2550	0.4	2550.4	135.9	27.4	90.3	1.6	255.2	93.4	2388.6	1670.2	386.4	142.0
16-Apr-88	2592	0.4	2592.4	73.0	27.4	83.6	1.6	185.6	92.3	2499.1	1686.1	313.3	166.0
17-Apr-88	2706	0.4	2706.4	51.4	27.4	77.8	1.6	158.2	91.9	2640.0	1660.9	277.2	154.0
18-Apr-88	2604	0.4	2604.4	56.3	27.4	73.6	1.6	159.0	94.1	2539.5	1695.2	251.7	113.0
19-Apr-88	2326	0.4	2326.4	140.6	27.4	70.7	1.6	240.3	94.0	2180.0	1720.9	276.2	104.0
20-Apr-88	2615	0.4	2615.4	56.3	27.4	63.2	1.6	148.5	95.0	2561.8	1697.1	224.6	124.0
21-Apr-88	2733	0.4	2733.4	81.2	27.4	60.9	1.6	171.1	91.2	2653.5	1681.9	225.8	112.0
22-Apr-88	2695	0.4	2695.4	113.5	32.7	66.1	1.6	213.9	95.2	2576.7	1670.9	245.8	179.0
23-Apr-88	3383	0.4	3383.4	56.3	41.8	81.3	1.6	181.1	92.1	3294.4	1638.6	539.6	425.0
24-Apr-88	2665	0.4	2665.4	166.7	26.4	60.7	1.6	255.4	91.4	2501.4	1625.3	354.2	192.0
25-Apr-88	2688	0.4	2688.4	51.4	27.4	53.0	1.6	133.5	95.1	2650.0	1711.8	246.1	133.0
26-Apr-88	3242	0.4	3242.4	56.3	31.5	86.5	1.6	175.9	92.3	3158.7	1710.3	260.3	138.0
27-Apr-88	3105	0.4	3105.4	110.3	43.1	123.3	1.6	278.3	94.5	2921.6	1679.7	434.8	108.0
28-Apr-88	2959	0.4	2959.4	88.8	35.5	64.6	1.6	190.5	94.0	2862.9	1679.8	288.0	149.0
29-Apr-88	2508	0.4	2508.4	56.3	27.4	54.8	1.6	140.1	95.6	2463.9	1717.7	217.1	166.0
30-Apr-88	2698	0.4	2698.4	51.4	27.3	48.2	1.6	128.6	91.8	2661.6	1727.2	188.7	208.0
APR 88	3530.9	0.4	3531.3	102.0	31.8	145.0	1.6	280.4	94.1	3345.0	1673.5	792.5	176.0

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-May-88	2603	0.4	2603.4	143.5	33.1	47.3	1.9	225.7	112.6	2490.3	1714.9	223.3	215.0
02-May-88	2515	0.4	2515.4	51.4	34.1	40.6	1.9	128.0	113.7	2501.1	1823.8	157.1	164.0
03-May-88	2558	0.4	2558.4	51.5	37.9	37.9	1.9	129.1	114.8	2544.0	1849.1	145.9	191.0
04-May-88	2409	0.4	2409.4	141.7	34.0	38.6	1.9	216.2	114.9	2308.1	1824.9	182.1	152.0
05-May-88	2598	0.4	2598.4	51.4	30.8	32.9	1.9	117.0	115.5	2596.9	1862.2	129.8	182.0
06-May-88	2710	0.4	2710.4	56.3	29.2	31.2	1.9	118.7	115.9	2707.7	1910.9	128.7	186.0
07-May-88	2766	0.4	2766.4	152.9	34.9	32.0	1.9	221.8	113.5	2658.1	1686.7	167.4	237.0
08-May-88	3232	0.4	3232.4	51.4	29.0	27.0	1.9	109.4	112.0	3235.0	1779.4	119.8	370.0
09-May-88	3336	0.4	3336.4	71.1	29.0	29.9	1.9	131.9	113.5	3318.0	1728.6	285.0	1162.0
10-May-88	2402	0.4	2402.4	133.8	30.3	29.8	1.9	195.8	114.0	2320.6	1723.3	211.8	130.0
11-May-88	2352	0.4	2352.4	71.6	29.0	26.0	1.9	128.5	113.2	2337.1	1797.0	144.4	142.0
12-May-88	2883	0.4	2883.4	56.3	29.0	24.3	1.9	111.5	114.4	2886.3	1803.1	126.7	154.0
13-May-88	2792	0.4	2792.4	81.9	30.2	23.3	1.9	137.2	114.4	2769.6	1809.9	138.7	450.0
14-May-88	2589	0.4	2589.4	116.0	29.1	23.1	1.9	170.1	112.1	2531.4	1900.2	154.1	174.0
15-May-88	3248	0.4	3248.4	127.6	29.2	58.6	1.9	217.3	117.4	3148.6	1753.3	488.1	563.0
16-May-88	2829	0.4	2829.4	114.6	41.1	21.4	1.9	179.0	113.7	2764.1	1715.0	172.7	216.0
17-May-88	2731	0.4	2731.4	56.3	42.3	18.9	1.9	119.4	115.1	2727.1	1785.8	117.8	129.0
18-May-88	2600	0.4	2600.4	112.8	37.6	19.0	1.9	171.3	114.4	2543.5	1875.2	139.1	207.0
19-May-88	2398	0.4	2398.4	91.1	36.6	16.9	1.9	146.5	116.2	2368.1	1971.0	121.0	207.0
20-May-88	2402	0.4	2402.4	56.3	34.9	15.0	1.9	108.0	114.4	2408.8	2028.2	118.7	193.0
21-May-88	2673	0.4	2673.4	51.4	34.8	13.4	1.9	101.6	116.5	2688.3	2075.9	96.9	232.0
22-May-88	2578	0.4	2578.4	141.3	40.5	15.6	1.9	199.3	117.5	2496.6	1986.7	135.3	241.0
23-May-88	3905	0.4	3905.4	143.9	47.2	335.4	1.9	528.4	120.7	3497.7	1761.1	1436.3	223.0
24-May-88	4600	0.4	4600.4	277.5	58.1	124.9	1.9	462.4	116.3	4254.3	1752.9	1278.4	154.0
25-May-88	3038	0.4	3038.4	51.4	33.0	28.6	1.9	114.9	114.5	3038.0	1802.5	258.8	162.0
26-May-88	2982	0.4	2982.4	56.3	29.0	22.4	1.9	109.7	117.6	2990.4	1991.4	146.4	139.0
27-May-88	2757	0.4	2757.4	95.5	29.0	19.4	1.9	145.8	120.3	2731.9	2146.1	127.9	201.0
28-May-88	2530	0.4	2530.4	116.4	27.7	17.9	1.9	163.9	117.9	2484.5	2221.4	120.5	224.0
29-May-88	2378	0.4	2378.4	51.4	30.2	13.5	1.9	97.0	119.4	2400.8	2285.5	75.3	225.0
30-May-88	2561	0.4	2561.4	51.4	29.0	12.1	1.9	94.5	121.8	2588.8	2401.4	53.9	231.0
31-May-88	2907	0.4	2907.4	145.6	29.0	14.2	1.9	190.7	124.9	2841.6	2505.3	94.6	222.0
MAY 88	2802.0	0.4	2802.4	95.9	33.8	39.1	1.9	170.7	115.9	2747.7	1918.5	235.4	247.7

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jun-88	2614	0.9	2614.9	56.3	30.3	10.8	2.2	99.6	166.6	2683.9	2549.7	61.3	229.0
02-Jun-88	2583	0.9	2583.9	81.5	44.6	10.8	2.1	139.1	167.9	2612.7	2225.1	73.1	167.0
03-Jun-88	2238	0.9	2238.9	109.5	37.1	11.6	2.1	160.3	163.9	2242.5	2108.0	80.7	198.0
04-Jun-88	2689	0.9	2689.9	56.3	30.3	10.1	2.1	98.8	168.2	2757.2	2276.6	54.7	236.0
05-Jun-88	2376	0.9	2376.9	51.4	30.3	9.5	2.1	93.3	166.6	2450.2	2494.5	46.3	217.0
06-Jun-88	2469	0.9	2469.9	141.9	30.3	12.3	2.1	186.6	171.7	2455.0	2606.3	88.1	202.0
07-Jun-88	2869	0.9	2869.9	51.4	28.6	9.3	2.1	91.4	173.8	2952.3	2682.3	48.8	477.0
08-Jun-88	3725	0.9	3725.9	56.3	58.3	9.8	2.1	126.5	168.4	3767.8	2297.0	51.5	766.0
09-Jun-88	2884	0.9	2884.9	136.2	45.1	11.9	2.1	195.4	165.7	2855.2	2054.9	92.1	734.0
10-Jun-88	4166	0.9	4166.9	51.4	29.6	9.1	2.1	92.2	168.2	4240.9	2182.9	44.9	1493.0
11-Jun-88	3654	0.9	3654.9	56.3	30.3	9.6	2.1	98.4	168.5	3725.0	2417.5	47.3	1280.0
12-Jun-88	3148	0.9	3148.9	133.2	30.3	11.7	2.1	177.4	169.6	3141.3	2521.3	86.1	1044.0
13-Jun-88	3361	0.9	3361.9	51.4	30.3	9.1	2.1	92.9	170.8	3439.8	2609.1	45.0	975.0
14-Jun-88	2965	0.9	2965.9	51.4	30.3	9.1	2.1	92.9	174.7	3047.6	2756.2	50.1	787.0
15-Jun-88	3790	0.9	3790.9	136.4	30.3	11.9	2.1	180.7	170.8	3781.0	2661.1	92.7	809.0
16-Jun-88	3177	0.9	3177.9	56.3	30.3	9.6	2.1	98.4	173.1	3252.6	2545.7	53.3	807.0
17-Jun-88	3206	0.9	3206.9	66.8	30.5	9.6	2.1	108.9	172.2	3270.2	2471.6	58.5	856.0
18-Jun-88	3296	0.9	3296.9	131.1	30.3	11.7	2.1	175.1	167.4	3289.1	2535.4	86.0	863.0
19-Jun-88	3381	0.9	3381.9	56.3	30.3	9.6	2.1	98.4	170.1	3453.6	2534.6	45.4	787.0
20-Jun-88	3809	0.9	3809.9	101.7	30.3	25.1	2.1	159.1	172.9	3823.6	2604.4	172.2	854.0
21-Jun-88	3666	0.9	3666.9	115.4	30.3	13.7	2.2	161.5	173.5	3678.9	2645.9	325.5	826.0
22-Jun-88	3989	0.9	3989.9	51.4	30.3	16.3	2.1	100.1	174.3	4064.1	2600.9	192.0	769.0
23-Jun-88	3491	0.9	3491.9	164.0	35.4	15.6	2.1	217.1	168.6	3443.4	2254.4	329.4	790.0
24-Jun-88	3815	0.9	3815.9	51.4	30.3	9.4	2.1	93.2	168.0	3890.6	2348.3	53.3	1089.0
25-Jun-88	4272	0.9	4272.9	51.4	30.3	9.3	2.1	93.1	169.5	4349.3	2739.9	35.4	1163.0
26-Jun-88	3947	0.9	3947.9	138.1	28.9	12.4	2.1	181.6	165.7	3932.0	2301.1	70.3	1242.0
27-Jun-88	3340	0.9	3340.9	70.0	30.3	9.7	2.1	112.2	170.0	3398.7	2344.5	29.9	1182.0
28-Jun-88	3767	0.9	3767.9	51.3	30.3	79.2	2.1	162.8	171.0	3776.0	2315.5	213.9	1121.0
29-Jun-88	4447	0.9	4447.9	303.4	30.5	233.0	2.1	569.0	169.2	4048.0	1965.5	1071.7	940.0
30-Jun-88	3916	0.9	3916.9	56.3	31.7	13.0	2.1	103.2	160.9	3974.5	1991.1	122.1	1155.0
JUN 88	3368.3	0.9	3369.2	89.5	32.5	21.1	2.1	145.3	169.3	3393.2	2421.4	127.4	801.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jul-88	3873	0.8	3873.7	51.4	30.2	11.1	1.9	94.7	155.5	3934.5	2177.6	62.9	1304.0
02-Jul-88	3609	0.8	3609.7	51.4	30.2	10.4	1.9	93.9	154.8	3670.7	2210.4	46.3	841.0
03-Jul-88	3145	0.8	3145.7	136.2	30.2	12.4	1.9	180.6	156.2	3121.3	2237.7	77.6	850.0
04-Jul-88	3008	0.8	3008.7	56.3	30.2	9.7	1.9	98.2	155.2	3065.7	2300.6	30.6	866.0
05-Jul-88	2961	0.8	2961.7	51.4	30.2	9.1	1.9	92.6	160.4	3029.5	2559.9	26.8	789.0
06-Jul-88	3227	0.8	3227.7	134.9	30.2	11.8	1.9	178.9	161.8	3210.7	2816.1	70.7	749.0
07-Jul-88	3723	0.8	3723.7	51.4	30.2	9.1	1.9	92.6	154.8	3796.0	2839.5	28.6	820.0
08-Jul-88	3586	0.8	3586.7	56.3	30.2	9.6	1.9	98.1	152.9	3651.6	2842.1	34.0	1148.0
09-Jul-88	3944	0.8	3944.7	134.0	30.2	11.8	1.9	177.9	152.9	3929.8	2876.1	74.2	1125.0
10-Jul-88	3927	0.8	3927.7	51.4	30.2	9.1	1.9	92.6	159.5	3994.6	2467.6	31.6	1034.0
11-Jul-88	3320	0.8	3320.7	56.3	30.2	9.6	1.9	98.1	160.7	3383.4	2473.3	37.2	1164.0
12-Jul-88	3668	0.8	3668.7	142.9	30.2	12.1	1.9	187.1	159.6	3642.2	2597.5	83.3	1170.0
13-Jul-88	3871	0.8	3871.7	51.4	30.2	9.1	1.9	92.6	161.6	3940.7	2662.1	33.6	1125.0
14-Jul-88	3430	0.8	3430.7	80.6	30.2	10.0	1.9	122.8	154.2	3472.2	2824.0	46.9	1232.0
15-Jul-88	3991	0.8	3991.7	113.2	30.2	11.5	1.9	156.8	156.1	4001.0	2960.3	60.6	1184.0
16-Jul-88	4515	0.8	4515.7	113.3	30.2	137.6	1.9	283.0	156.8	4399.6	2630.6	1404.9	939.0
17-Jul-88	4206	0.8	4206.7	246.1	30.2	18.6	1.9	296.8	158.1	4068.0	2131.0	275.3	1169.0
18-Jul-88	6021	0.8	6021.7	198.3	30.2	369.4	1.9	599.8	165.2	5587.2	2063.6	2115.5	453.0
19-Jul-88	4495	0.8	4495.7	286.6	30.2	25.0	1.9	343.7	159.0	4311.0	2062.8	358.7	827.0
20-Jul-88	4005	0.8	4005.7	51.4	30.2	13.2	1.9	96.8	155.6	4064.6	2125.5	99.1	1162.0
21-Jul-88	4220	0.8	4220.7	138.4	30.2	25.0	1.9	195.5	157.8	4183.0	2113.2	359.2	1101.0
22-Jul-88	4003	0.8	4003.7	112.7	30.2	14.1	1.9	158.9	157.1	4001.9	2151.2	113.6	1195.0
23-Jul-88	4102	0.8	4102.7	51.4	30.2	10.5	1.9	94.0	153.2	4161.9	2283.6	48.5	1268.0
24-Jul-88	3857	0.8	3857.7	51.4	30.2	9.8	1.9	93.3	159.7	3925.2	2280.3	37.5	1232.0
25-Jul-88	4296	0.8	4296.7	205.0	30.2	310.5	1.9	547.7	158.6	3907.7	2135.0	535.9	876.0
26-Jul-88	4141	0.8	4141.7	186.2	30.2	26.6	2.1	245.1	155.6	4052.3	2156.1	109.4	1193.0
27-Jul-88	3732	0.8	3732.7	51.4	30.2	15.5	1.9	99.0	156.2	3789.9	2379.7	30.1	1191.0
28-Jul-88	3746	0.8	3746.7	66.8	30.2	12.7	1.9	111.6	160.6	3795.8	2656.7	32.8	1171.0
29-Jul-88	4099	0.8	4099.7	134.0	30.2	13.6	1.9	179.7	152.0	4082.0	2690.9	65.6	1180.0
30-Jul-88	7206	0.8	7206.7	177.0	30.2	383.1	1.9	592.1	170.5	6785.1	2289.1	3197.3	576.0
31-Jul-88	4556	0.8	4556.7	279.9	30.2	35.5	1.9	347.5	159.1	4368.3	2116.9	277.1	1284.0
JUL 88	4015.6	0.8	4016.3	115.1	30.2	50.9	1.9	198.1	160.1	3978.3	2422.9	316.3	1039.3

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Aug-88	4578	0.9	4578.9	56.3	29.2	19.1	2.5	107.2	138.4	4608.2	2719.7	70.9	1138.0
02-Aug-88	4323	0.9	4323.9	51.4	29.2	13.7	2.5	96.8	141.2	4368.3	2960.4	42.4	1107.0
03-Aug-88	4300	0.9	4300.9	51.4	29.2	11.3	2.5	94.4	142.0	4348.5	3001.0	36.3	996.0
04-Aug-88	4433	0.9	4433.9	153.1	29.2	25.9	2.5	210.8	140.9	4364.1	2818.2	119.9	992.0
05-Aug-88	4448	0.9	4448.9	56.3	29.2	10.6	2.5	98.6	141.5	4491.7	2579.2	38.4	1319.0
06-Aug-88	3118	0.9	3118.9	162.7	29.2	13.2	2.5	207.6	137.2	3048.5	2573.1	82.2	734.0
07-Aug-88	3331	0.9	3331.9	51.4	29.2	9.3	2.5	92.4	139.7	3378.3	2586.4	25.6	760.0
08-Aug-88	4567	0.9	4567.9	62.8	29.2	239.7	2.5	334.2	144.0	4377.7	2527.9	1945.5	1014.0
09-Aug-88	7334	0.9	7334.9	358.9	29.2	157.8	2.5	548.4	138.9	6925.4	2175.1	2062.3	557.0
10-Aug-88	5563	0.9	5563.9	155.9	29.2	284.7	2.5	472.3	140.5	5232.1	2039.3	1750.8	318.0
11-Aug-88	5213	0.9	5213.9	294.1	29.2	74.0	2.5	399.8	134.4	4948.5	2220.1	1014.2	551.0
12-Aug-88	5028	0.9	5028.9	56.3	29.2	35.1	2.5	123.1	134.8	5040.6	2386.8	260.5	1224.0
13-Aug-88	4599	0.9	4599.9	89.5	29.2	59.1	2.5	180.4	139.9	4553.5	2300.8	399.3	1100.0
14-Aug-88	4783	0.9	4783.9	151.5	29.2	24.2	2.5	207.3	132.9	4709.5	2244.5	224.0	1255.0
15-Aug-88	4336	0.9	4336.9	56.3	29.2	17.6	2.5	105.6	135.5	4366.8	2376.1	104.6	1336.0
16-Aug-88	4135	0.9	4135.9	51.4	29.2	13.7	2.5	96.9	135.0	4174.1	2719.7	71.2	1272.0
17-Aug-88	4825	0.9	4825.9	150.2	29.2	15.3	2.5	197.2	137.6	4766.4	2877.7	107.3	1516.0
18-Aug-88	5684	0.9	5684.9	56.3	29.2	12.0	2.5	100.0	139.0	5722.9	2439.9	67.3	2252.0
19-Aug-88	4552	0.9	4552.9	51.4	29.2	11.0	2.5	94.2	133.0	4591.7	2014.2	123.0	1977.0
20-Aug-88	4608	0.9	4608.9	162.3	29.2	14.1	2.5	208.1	130.2	4531.1	2114.2	117.7	1886.0
21-Aug-88	4133	0.9	4133.9	56.3	29.2	10.7	2.5	98.7	129.7	4163.9	2102.8	51.1	1848.0
22-Aug-88	3760	0.9	3760.9	51.4	29.2	10.0	2.5	93.1	131.2	3799.1	2095.4	38.8	840.0
23-Aug-88	3645	0.9	3645.9	51.4	29.2	9.9	433.5	524.1	132.0	3253.8	2088.9	49.4	1007.0
24-Aug-88	4287	0.9	4287.9	153.2	29.2	13.1	2.5	198.0	132.4	4222.4	2230.7	90.6	1712.0
25-Aug-88	5328	0.9	5328.9	56.3	29.2	10.2	2.5	98.3	132.2	5362.9	2230.0	33.8	2197.0
26-Aug-88	4366	0.9	4366.9	51.4	29.2	9.6	2.5	92.7	134.9	4409.2	2210.5	29.3	2187.0
27-Aug-88	5361	0.9	5361.9	112.7	29.2	125.5	2.5	269.9	139.6	5225.6	1947.5	595.1	1888.0
28-Aug-88	5448	0.9	5448.9	250.0	29.2	28.2	2.5	309.8	129.6	5268.7	1806.1	492.0	2136.0
29-Aug-88	3275	0.9	3275.9	56.3	29.2	12.8	2.5	100.9	132.2	3307.3	2012.5	81.1	921.0
30-Aug-88	3258	0.9	3258.9	51.4	29.2	11.2	2.5	94.3	132.2	3296.8	2025.2	51.4	922.0
31-Aug-88	4684	0.9	4684.9	153.2	29.2	13.7	2.5	198.6	134.6	4620.9	2132.2	90.0	2071.0
AUG 88	4558.2	0.9	4559.1	107.2	29.2	42.5	16.4	195.3	135.9	4499.3	2341.2	331.2	1323.6

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1988	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Sep-88	4165	0.5	4165.5	56.3	28.5	10.6	2.8	98.2	117.5	4184.8	2200.6	36.7	1870.0
02-Sep-88	4614	0.5	4614.5	51.4	28.5	9.9	2.9	92.7	115.9	4637.7	2178.5	31.3	1883.0
03-Sep-88	4654	0.5	4654.5	51.4	28.5	9.8	2.8	92.5	115.2	4677.2	2016.0	43.7	2166.0
04-Sep-88	4099	0.5	4099.5	143.4	28.5	50.0	2.7	224.7	110.5	3985.3	1776.1	194.6	1368.0
05-Sep-88	3050	0.5	3050.5	66.3	28.5	13.4	2.7	110.9	109.6	3049.3	1765.5	111.0	912.0
06-Sep-88	2871	0.5	2871.5	159.4	28.5	14.2	2.9	205.0	110.0	2776.4	1912.1	100.3	951.0
07-Sep-88	3132	0.5	3132.5	51.5	28.5	9.8	2.8	92.5	110.3	3150.3	1975.8	33.7	882.0
08-Sep-88	3234	0.5	3234.5	51.4	28.5	9.5	2.9	92.4	113.6	3255.7	2072.1	30.5	1434.0
09-Sep-88	4568	0.5	4568.5	84.0	28.5	10.5	2.8	125.7	112.4	4555.0	2111.6	41.0	2036.0
10-Sep-88	4603	0.5	4603.5	118.6	28.5	11.9	2.9	161.9	112.7	4554.2	2189.7	59.9	2205.0
11-Sep-88	4563	0.5	4563.5	51.5	28.5	9.2	2.9	92.1	112.7	4584.1	2144.3	21.2	2213.0
12-Sep-88	4723	0.5	4723.5	293.6	28.5	74.2	2.8	399.1	118.6	4442.9	2066.9	1090.6	1714.0
13-Sep-88	5015	0.5	5015.5	51.5	28.5	16.4	2.9	99.2	113.4	5029.6	1915.1	152.3	2067.0
14-Sep-88	4869	0.5	4869.5	51.4	28.5	11.1	2.8	93.8	111.5	4887.1	2011.0	55.5	2181.0
15-Sep-88	4429	0.5	4429.5	56.3	28.5	10.7	2.8	98.3	113.2	4444.4	1955.8	36.4	2206.0
16-Sep-88	4440	0.5	4440.5	139.7	28.5	12.5	2.8	183.5	111.8	4368.8	1912.7	74.9	1879.0
17-Sep-88	4666	0.5	4666.5	51.4	28.5	9.3	2.8	92.0	112.4	4686.8	2075.7	16.7	2191.0
18-Sep-88	4643	0.5	4643.5	174.3	28.5	52.9	2.8	258.4	117.6	4502.6	1928.8	555.6	1631.0
19-Sep-88	6793	0.5	6793.5	249.5	28.5	178.8	2.8	459.6	116.4	6450.3	1833.6	1305.9	2464.0
20-Sep-88	6008	0.5	6008.5	118.2	28.5	25.9	912.8	1085.5	110.8	5033.9	1807.3	392.9	2028.0
21-Sep-88	5810	0.5	5810.5	56.3	28.5	14.5	536.8	636.2	110.4	5284.7	1790.1	114.5	2037.0
22-Sep-88	5712	0.5	5712.5	129.8	28.5	113.9	476.8	749.1	112.1	5075.6	1814.0	414.8	1677.0
23-Sep-88	5810	0.5	5810.5	210.9	28.5	56.8	1073.8	1372.0	110.4	4549.0	1824.0	365.2	1726.0
24-Sep-88	5051	0.5	5051.5	51.4	28.5	15.2	23.8	119.0	109.4	5042.0	1805.1	91.0	2196.0
25-Sep-88	4422	0.5	4422.5	56.3	28.5	13.5	2.8	101.1	107.5	4428.9	1753.8	67.2	2259.0
26-Sep-88	5386	0.5	5386.5	158.9	28.5	15.0	826.8	1029.2	109.5	4466.7	1892.7	103.0	2129.0
27-Sep-88	5702	0.5	5702.5	51.5	28.5	13.2	1560.8	1653.9	111.4	4160.0	1907.0	102.5	1059.0
28-Sep-88	5078	0.5	5078.5	51.4	28.5	10.5	1902.7	1993.2	110.1	3195.3	1836.9	99.4	150.0
29-Sep-88	2486	0.5	2486.5	56.3	28.5	10.8	2.8	98.5	110.2	2498.2	1873.9	44.5	149.0
30-Sep-88	2099	0.5	2099.5	136.2	28.5	12.9	2.8	180.4	110.0	2029.1	1911.1	71.1	124.0
SEP 88	4556.5	0.5	4557.0	101.0	28.5	27.6	245.9	403.0	112.2	4266.2	1941.9	195.3	1659.6

APPENDIX E

LAKE MICHIGAN DIVERSION ACCOUNTING

WATER YEAR 1989 REPORT

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EXECUTIVE SUMMARY

In compliance with the modified 1980 U.S. Supreme Court decree (hereinafter the Decree), the WY89 diversion was computed using the best engineering technology available to date as applied to the diverted watersheds.

Given the complexity of the hydrologic cycle in the heavily urbanized Chicago metropolitan area, and given the number of human and other factors that cannot be adequately represented in numerical modeling procedures, the results of the simulations which compute diversion flows worked exceptionally well.

The WY89 diversion accountable to the State of Illinois is 3,377.9 cfs. This is 177.9 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average, rounded to the nearest cfs, beginning with WY81 is 3,443 cfs and the cumulative deviation from the 3,200 cfs average is -2,189 cfs-years. The negative cumulative deviation indicates a water allocation deficit and the maximum allowable debt is 2,000 cfs-years.

INTRODUCTION

The diversion of water from the Lake Michigan watershed is of major importance to the Great Lake states and to the Canadian province of Ontario. The states and province that border the Great Lakes have concerns with both diversions during periods of low lake levels as well as the long term effects of diversion. To insure that the concerns of these interested parties are considered, the U. S. Army Corps of Engineers has been given the responsibility for the accounting of flow that is diverted from the Lake Michigan watershed.

The Corps of Engineers, Chicago District, is responsible for monitoring the measurements and the computation of the diversion of Lake Michigan water by the State of Illinois. The computations for Water Year 1983 (WY83), WY84 and WY85 (1 October 1984 through 30 September 1985) were completed by the Northeastern Illinois Planning Commission (NIPC) for the Illinois Department of Transportation (IDOT). Prior to the WY83 report, the calculations were made by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) for IDOT. The Corps reviewed, modified, and updated the WY84 and WY85 diversion accounting completed by NIPC. The computations for WY86 were performed jointly by NIPC (under contract to the Corps of Engineers) and the Corps of Engineers. Beginning in WY87 the computations were performed solely by the Corps of Engineers. This report represents the final Lake Michigan diversion accounting for WY89.

AUTHORITY FOR REPORT

Under the provisions of the U.S. Supreme Court Decree in the Wisconsin, et al v. Illinois et al, 388 U.S. 426,87 S.Ct. 1774 (1967) as modified 449 U.S. 48, 101 S.Ct. 557 (1980), the Corps of Engineers is responsible for monitoring the measurement and computation of diversion of Lake Michigan water by the State of Illinois. The Water Resources Development Act of 1986 (Section 1142 of PL 99-662) gave the Corps total responsibility for the computation of diversion flows as formerly done by the State of Illinois. The Corps' new mission became effective 1 October 1987.

HISTORY OF THE DIVERSION

Water has been diverted from Lake Michigan at Chicago into the Mississippi River Basin since the completion of the Illinois and Michigan Canal in 1848. At that time, diversion averaged about 500 cubic feet per second (cfs). The Illinois and Michigan Canal was built primarily to serve transportation needs. The canal provided a connecting watercourse between the Great Lakes and the Mississippi River system.

With the development of the Chicago metropolitan area, drainage and drainage improvements led to severe sanitation problems in the mid to late 1800's. The newly constructed sewers moved water and wastes into the Chicago River, which until 1900 drained to Lake Michigan. The water quality of Lake Michigan deteriorated and contaminated the city's primary water supply.

A second problem that occurred during this time period was an increase in the overbank flooding within the city. As more roads were built and buildings constructed the sewer system was correspondingly expanded. This increased the rate and volume of runoff and resulted in increased flooding.

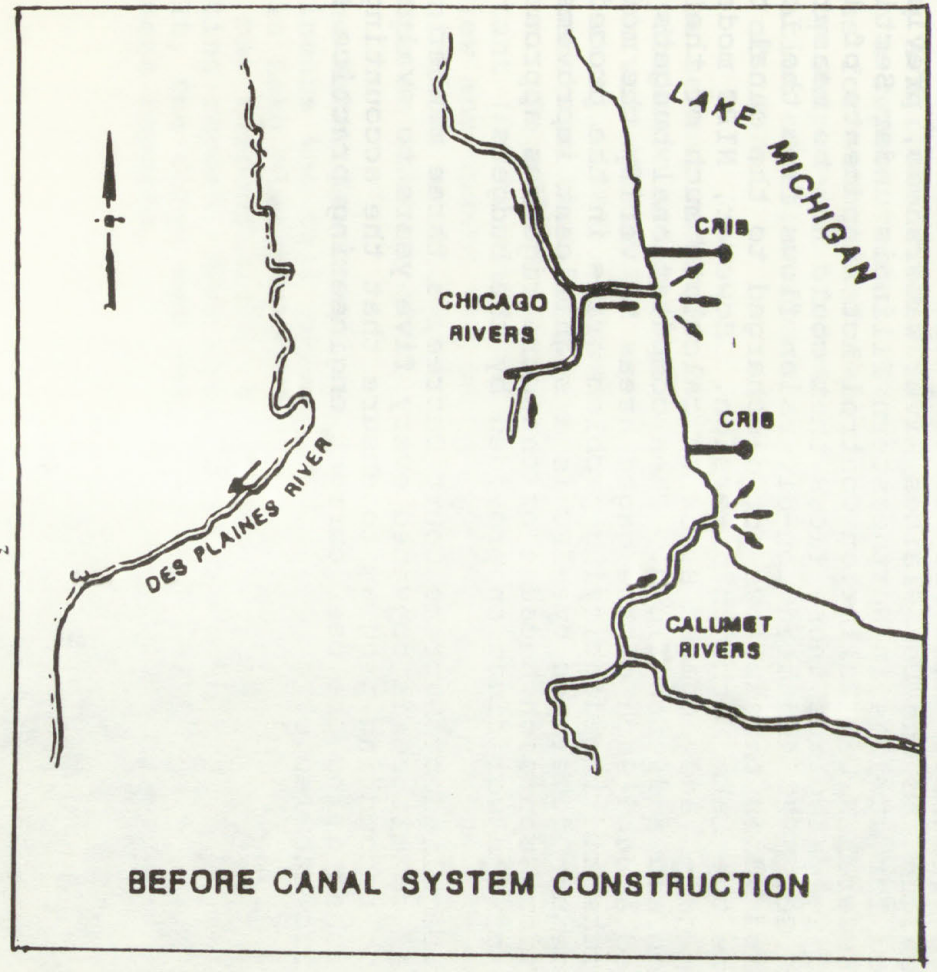
As a solution to the sanitation and flooding problems construction of the Chicago Sanitary and Ship Canal (CSSC) was undertaken. This construction allowed the flow direction of the Chicago River to be reversed (Figure 1). Construction of the Chicago Sanitary and Ship Canal was completed in 1900 by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) (formerly Metropolitan Sanitary District of Greater Chicago, MSDGC). The Sanitary and Ship Canal followed the course of the older I and M Canal. This canal is much larger than the I and M canal and can handle the Chicago River flow as well as increased shipping. The Chicago River Controlling Works was constructed at the mouth of the Chicago River. The lock regulates the amount of Lake Michigan water allowed to pass into the river and restricts river flooding from entering Lake Michigan.

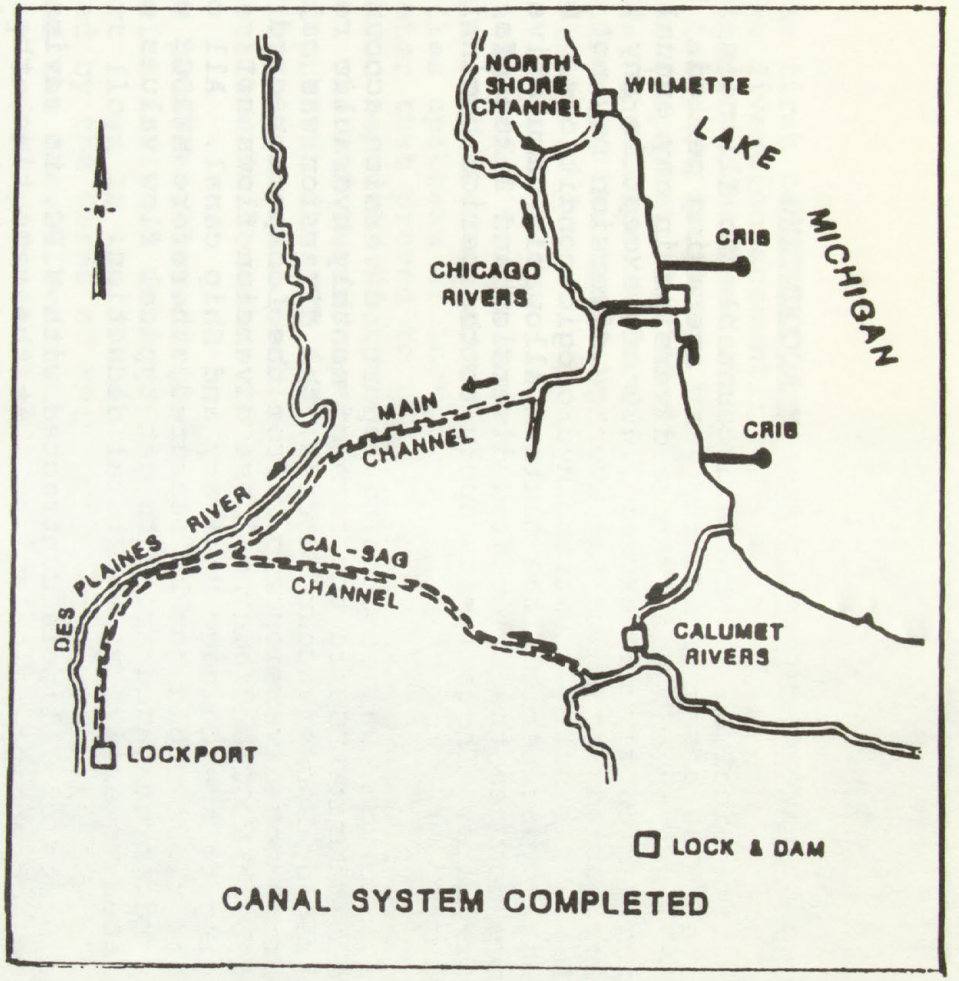
Between 1907 and 1910 the MWRDGC constructed a second sanitary canal called the North Shore Canal. It extended from Lake Michigan at Wilmette in a southerly direction 6.14 miles to the north branch of the Chicago River. The Wilmette Controlling Works regulates the amount of Lake Michigan flow allowed down the channel.

Construction of a third canal, the Calumet Sag Canal, was completed in 1922. The canal connects Lake Michigan through the Grand Calumet River, to the Sanitary and Ship Canal. This canal was constructed to carry sewage from South Chicago, Illinois and East Chicago, Indiana. The O'Brien Lock and Dam located on the Calumet River, regulates the flow of Lake Michigan waters down the canal.

Figure 1

Development of the Chicago Canal System





BACKGROUND OF LAKE MICHIGAN DIVERSION ACCOUNTING

The Lake Michigan diversion accountable to Illinois is limited to 3,200 cfs over a forty year averaging period. During the forty year period, the average diversion in any annual accounting period may not exceed 3,680 cfs except in any two accounting periods in which the average diversion may not exceed 3,840 cfs as a result of extreme hydrologic conditions. During the first 39 year period, the maximum allowable cumulative difference between the calculated diversion and 3,200 cfs is 2,000 cfs-years. These limits apply to the period beginning with WY81.

Prior to the 1983 accounting report, diversion accounting was done by the MWRDGC in the form of monthly hydraulic reports. As required by Supreme Court Decree, the diversion was calculated by deducting non-diversion flows from the Lockport record measured by MWRDGC and adding those diversion flows not discharging to the Chicago Sanitary and Ship canal. All of the deductible flows could not be measured, therefore MWRDGC used flow records from gaged areas to get typical flow values and then extrapolated to arrive at the total deduction.

The State of Illinois contracted with NIPC, to revise the diversion accounting calculations. At the same time, the State of Illinois moved from monthly hydraulic reports to annual accounting reports. NIPC adapted computer models of the diverted Lake Michigan and the Des Plaines River watersheds, previously developed for studies in Northeastern Illinois under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500), to calculate those flows that could not be measured. Like MWRDGC, NIPC deducted non-diversion flows from the Lockport record and added those flows not discharged to the canal to calculate the Lake Michigan diversion. However, NIPC modeled both the gaged and ungaged areas to calculate much of the deduction and addition flows. Then computational budgets were developed around each of the gaged areas to verify the models. The budgets aid in identifying problem areas in the procedure. The procedure developed by NIPC is a significant improvement over the previous approach because of the more rigorous approach and because of the verification provided by the budgets.

As required by Supreme Court Decree, a three member technical committee is convened every five years to evaluate the diversion accounting program to ensure that the accounting is accomplished using the best current engineering practice and scientific knowledge.

The first technical committee was convened during the period that the diversion accounting was done by MWRDGC. The committee was primarily concerned with the rating of the various components at the Lockport facility, the primary diversion measurement location (Espey et al, 1981). In response to the Committee's concerns, the Corps' Waterways Experiment Station (WES) revised the ratings of the two sets of Lockport sluice gates (Hart and McGee, 1985).

In response to the Committee's concerns, the State of Illinois installed an acoustic velocity meter (AVM) at Romeoville five miles upstream of Lockport. The AVM is a highly accurate flow meter that proved to provide better flow measurements than the MWRDGC reported Lockport flows and the new Corps rating curves. The AVM became operational 12 June 1984. However, USGS did not publish the AVM flows until 1 October 1985. Because of significant equipment problems with the AVM, a replacement AVM was installed in November 1988.

To provide flows during periods of malfunction, various regression analyses were done to relate the MWRDGC reported Lockport flows to the AVM flows. Several sets of equations were proposed by the Corps of Engineers, the USGS, Harza Engineering Co., and the Second Technical Committee. The report, Chicago Sanitary and Ship Canal at Romeoville Acoustical Velocity Meter Backup System, was completed September 1989 (USACE, 1989). The regression equations that were ultimately used to estimate missing AVM flows from WY86 through WY91 were developed by the USGS in a report tentatively titled "Discharge and Regression Analyses for Acoustical Velocity Meter Data for the Chicago and Sanitary Ship Canal at Romeoville, Illinois." The final publication of this report is expected to be available in the spring of 1993.

The second and most recent technical committee reviewed the NIPC hydrologic and hydraulic computer models and agreed that the approach was consistent with what was required by the decree (Espey et al, 1987). However, the committee felt that some of the parameters used in the models were out of date and in need of revision. To address the committee's concerns, the Corps hired a consultant (C. B. Burke Engineering, Ltd.) in September of 1988 to review and update the modeling parameters. The final report concerning the updating of modeling parameters was submitted to the Corps in October 1990.

The Water Resources Development Act of 1986 gave the Corps of Engineers the full responsibility for computation of the Illinois Lake Michigan diversion as of 1 October 1987. When the Corps' new responsibility became effective, the WY84 diversion accounting report, developed by NIPC, had not been certified. As a result, the Corps was responsible for the WY84 and all subsequent reports.

NIPC completed the WY84 diversion accounting report in April of 1988. It was subsequently reviewed by the Corps. The Corps found the report to be adequate with two exceptions. First, the 1984 accounting was completed with the modeling parameters questioned by the second technical committee. Second, MWRDGC reported Lockport flows, adjusted using the WES rating curves, were used rather than AVM flows. The Corps, knowing that the modeling parameters required updating and that AVM flows for the period prior to installation could be calculated accurately using regression equations, refrained from certifying the WY84 report until these issues were resolved.

NIPC completed the WY85 diversion accounting report in December of 1988 and the report was reviewed by the Corps. Like the WY84 report, the WY85 accounting was done with the modeling parameters questioned by the second technical committee. Additionally, NIPC used the AVM flows published by the U.S. Geological Survey (USGS) in their WY85 Water Resources Data for Illinois report. Since the publication of the WY85 USGS report, more reliable equations have been developed for calculating flows when the AVM was malfunctioning. These equations are periodically reviewed and updated as necessary.

Upon completion of the analysis of the modeling parameters by Christopher B. Burke Engineering, LTD, the WY84 and WY85 diversion flows were recalculated using the revised modeling parameters and the Romeoville AVM flows. The diversion flows were certified by the Corps of Engineers and transmitted to all interested parties in the Lake Michigan Diversion Accounting 1989 Annual Report (USACE, 1990).

The computation of Illinois' diversion from Lake Michigan for WY86 was undertaken as a joint effort between NIPC (under contract to the Corps of Engineers) and the Corps of Engineers. The computation of Illinois' diversion from Lake Michigan for WY87, WY88 and WY89 were performed solely by the Corps of Engineers.

DIVERSION ACCOUNTING PROCEDURES

The Lake Michigan diversion accountable to the State of Illinois is calculated by measuring the flow in the Chicago Sanitary and Ship Canal at Romeoville and deducting flows that do not constitute Lake Michigan diversion and are not accountable to the State of Illinois. Finally, additions are made to the Romeoville record for diversions that are not discharged to the canal. The deductions include groundwater water supply pumpage whose effluent is discharged to the canal, runoff from the Des

Plaines River watershed that is discharged to the canal, Lake Michigan water supply pumpage from Indiana that is discharged to the canal, and water supply pumpage from Lake Michigan used for Federal facilities that is discharged to the canal. The additions to the Romeoville record include flows diverted from the canal upstream of Romeoville, and Lake Michigan water supply whose effluent is not discharged to the canal. This procedure represents the accounting method required by the Supreme Court Decree.

The diversion accounting results are presented as a series of columns that are listed in Table 1. Column 1 through Column 3 compute the total flow in the Sanitary and Ship Canal. Column 4 through Column 7 presents the deductions from the Canal system flows with the total deduction being presented in Column 8. Column 9 presents the additions to the Canal system record. Column 10 is the computed Lake Michigan diversion accountable to Illinois and is equal to the canal system flow minus the deductions plus the additions. Columns 11 through 13 are independent flow estimates for the three sources of diversion: water supply pumpage from Lake Michigan, runoff from the diverted Lake Michigan Watershed, and direct diversion through the lakefront structures. Column 11 through Column 13 are not used in the diversion calculation but are included as another estimate of the diversion for verification of the accounting flows in Column 10. The sum of Column 11 through Column 13 should theoretically equal the flow in Column 10.

In addition to the diversion calculations presented in the 13 columns, 14 computational budgets are prepared as input to the diversion calculation and to verify the estimated flows that cannot be measured. A summary of these budgets is presented in Table 2. Budgets 1 and 2 do not compare simulated to measured flows but are summations of critical water supply pumpage data. Budget 3 through Budget 6 partition stream gage records into runoff and sanitary/industrial discharge components to estimate a portion of the runoff from the diverted watershed that is used as input to Column 12, "Runoff from the Diverted Lake Michigan Watershed." Budget 7 through Budget 13 compare simulated to measured flows at MWRDGC facilities. These budgets are for verification of the diversion accounting procedures and give an indication of the accuracy of the diversion accounting. Budget 14 compares canal system inflows and outflows.

Table 1

Description of the Diversion Accounting Columns

Column No.	Description
1	Chicago Sanitary and Ship Canal (CSSC) at Romeoville AVM Gage Record
2	Diversion from the CSSC above the Romeoville AVM Gage
3	Total Flow Through the CSSC
4	Groundwater Pumpage Discharged into the CSSC and Adjoining Channels
5	Water Supply Pumpage from Indiana Reaching the CSSC
6	Runoff from the Des Plaines River Watershed which Reaches the CSSC
7	Lake Michigan Pumpage by Federal Facilities which Discharge to the CSSC and Adjoining Channels
8	Total Deduction from the CSSC Romeoville AVM Gage Record
9	Lake Michigan Pumpage Which is not Discharged into the CSSC
10	Total Diversion Accountable to the State of Illinois
11	Pumpage from Lake Michigan Which is Accountable to State of Illinois
12	Runoff from the Diverted Lake Michigan Watershed
13	Direct Diversions Through Lake Front Control Structures Which is Accountable to the State of Illinois

Table 2

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
1	Diverted Lake Michigan Pumpage	This budget sums Lake Michigan water diverted by the State of Illinois in the form of municipal and industrial water supply. The results of this budget are used in Column 11.
2	Groundwater Discharged to the CSSC	This budget sums groundwater pumpages that are discharged to the CSSC. The results of this budget are used in Column 4.
3	North Branch Chicago River at Niles, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
4	Little Calumet River at the IL-IN State Line	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
5	Thorn Creek at Thornton, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
6	Little Calumet River at South Holland, IL	This budget performs a simple separation of stream flow into sanitary and runoff portions. The results this budget are used in Budget 14 and Column 12.
7	MWRDGC Northside Water Reclamation	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Northside Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Northside service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used on Budget 14 and Columns 6 and 12.

Table 2 (cont)

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
8	MWRDGC Upper Des Plaines Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Upper Des Plaines Pumping Station. This budget provides a calibration point to verify models of the Des Plaines River watershed
9	MWRDGC Mainstream TARP Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Mainstream TARP Pumping Station. The results of this simulation are used in Budgets 10 and 14 and Columns 6 and 12. The budget also provides internal verification of the accounting procedures.
10	MWRDGC Stickney Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Stickney Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Stickney service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Columns 6 and 12.
11	MWRDGC Calumet TARP Pumping Station	This budget performs hydrologic and hydraulic simulation of the MWRDGC Calumet TARP Pumping Station. The results of this simulation are used in Budgets 12 and 14 and Columns 6 and 12. The budget also provides internal verification of the accounting procedures.

Table 2 (cont)

Description of the Diversion Accounting Computational Budgets

Budget No.	Title	Description
12	MWRDGC Calumet Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Calumet Water Reclamation Facility. The simulations estimates the runoff from portions of the Lake Michigan and Des Plaines River watersheds within the Calumet service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Columns 6 and 12.
13	MWRDGC Lemont Water Reclamation Facility	This budget performs hydrologic and hydraulic simulation of the service basin tributary to the MWRDGC Lemont Water Reclamation Facility. The simulations estimates the runoff from portions of the Des Plaines River watershed within the Lemont service basin that is diverted to the CSSC in the form of inflow-infiltration. The budget provides an internal verification of the accounting procedures. The results of this budget are used in Budget 14 and Column 6.
14	Chicago Canal System	This budget performs a water balance of the Chicago Canal System which includes the CSSC and adjoining channels. This budget provides a verification point for the accounting procedures.

REVISIONS TO THE LAKE MICHIGAN DIVERSION ACCOUNTING PROCEDURES

There were two major revisions to the WY89 diversion accounting procedure. One revision was the modification of the hydraulic sewer routing model (SCALP) for the Calumet Water Reclamation Facility. The revision included improvements in the simulated sanitary interceptor discharges from special contributing areas (SCAs) that comprise the Calumet facility service basin. The changes to the sewer routing model are discussed in detail in the section, BUDGET12: CALUMET WATER RECLAMATION FACILITY. The second major revision to the diversion accounting procedure was the modification of the Calumet TARP Tunnel Network (TNET) dynamic hydraulic model. Changes to the model included modifications to the estimated groundwater infiltration into TARP through the tunnel walls as well as modifications to the estimated unrestricted inflows to TARP from separately sewered areas. These modifications to the Calumet TARP model are discussed in detail in the section, BUDGET 11: CALUMET TARP PUMPING STATION. These revisions will have a subtle impact on the actual diversion computation since the above changes are expected to impact two components which are deductions to the AVM gage record, groundwater pumpage reaching the CSSC (Column 4) and runoff from the Des Plaines River watershed reaching the CSSC (Column 6).

ACCOUNTING RESULTS

The WY89 diversion accounting monthly summary is presented in Table 3. Table 3 shows the total WY89 Lake Michigan diversion accountable to the State of Illinois is 3,377.9 cfs (Column 10). This is 177.9 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average (Table 4), rounded to the nearest cfs, beginning with WY81 is 3,443 cfs and the cumulative deviation from the 3,200 cfs average is -2,189 cfs-years. The negative cumulative deviation indicates a water allocation deficit and the maximum allowable deficit is 2,000 cfs-years. Tabular data on daily diversion flows is presented in Appendix A.

Table 3

Lake Michigan Diversion Accounting – WY 1989

Summary of Diversion Flows (cfs)

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13
OCT 88	3235.5	1.2	3236.7	79.5	27.8	68.2	2.2	177.7	103.6	3162.6	1745.9	478.0	552.4
NOV 88	3928.4	0.6	3929.0	110.5	27.2	262.2	2.5	402.3	99.5	3626.2	1672.1	1366.6	180.9
DEC 88	2782.2	1.1	2783.3	80.9	27.2	154.6	2.6	265.3	102.0	2619.9	1663.7	567.9	144.8
JAN 89	2743.2	2.1	2745.3	77.1	27.3	151.3	1.8	257.5	96.9	2584.7	1674.0	694.4	76.3
FEB 89	2346.6	1.6	2348.4	63.9	27.2	102.7	2.2	196.0	93.9	2246.2	1664.0	376.6	69.9
MAR 89	3099.1	1.0	3100.1	94.5	27.4	185.6	2.7	309.6	92.7	2883.2	1652.5	805.6	66.8
APR 89	2617.5	1.6	2619.1	61.3	27.5	104.7	2.1	195.7	95.9	2519.4	1674.1	432.0	100.8
MAY 89	2813.8	0.6	2814.4	67.3	28.0	56.1	1.5	152.8	112.0	2773.6	1796.4	378.4	182.8
JUN 89	4483.4	1.2	4484.5	80.6	28.4	152.5	1.5	262.9	137.2	4358.9	1989.0	1186.1	402.2
JUL 89	4317.1	0.9	4318.0	86.9	29.6	93.8	1.5	211.7	139.5	4245.8	2215.4	636.9	777.5
AUG 89	4738.7	3.4	4742.1	97.2	28.3	111.2	2.0	238.7	116.5	4619.9	1947.5	715.5	1168.8
SEP 89	5027.4	0.6	5028.0	83.2	27.9	178.5	1.8	291.3	107.2	4843.9	1794.7	868.3	1422.7
AVERAGES	3515.2	1.3	3516.5	82.0	27.8	134.9	2.0	246.8	108.2	3377.9	1791.9	708.8	430.7

COMPUTATIONS:

1. COLUMN 3 EQUALS THE SUM OF COLUMN 1 AND COLUMN 2.
2. COLUMN 8 EQUALS THE SUM OF COLUMN 4 THROUGH COLUMN 7.
3. COLUMN 10 EQUALS COLUMN 3 MINUS COLUMN 8 PLUS COLUMN 9.

DEDUCTIONS FROM THE ROMEOVILLE GAGE RECORD

ADDITIONS TO THE ROMEOVILLE GAGE RECORD

NOTES:

1. ALL VALUES ARE ROUNDED TO THE NEAREST TENTH.
2. MATHEMATICAL COMPUTATIONS BETWEEN COLUMNS UTILIZE UNROUNDED VALUES.
3. AVERAGE VALUES FOR WY89 WERE COMPUTED USING DAILY VALUES.

Table 4

Status of the State of Illinois' Diversion from Lake Michigan Under the 1980 Modified U.S. Supreme Court Decree

Accounting Year	Certified Flow, cfs	Running Average, cfs	Cumulative Deviation, cfs
1981	3,106	3,106	+ 94
1982	3,087	3,097	+ 207
1983	3,613	3,269	- 206
1984	3,432	3,309	- 438
1985	3,472	3,342	- 710
1986	3,751	3,410	- 1,261
1987	3,774	3,462	- 1,835
1988	3,376	3,451	- 2,011
1989	3,378	3,443	- 2,189

DISCUSSIONS OF RESULTS

The following is a discussion of the column functions and computational budgets. The discussion of the column functions describes the purpose of each column as well as some observations on the WY89 values in the columns. The discussion of the computational budgets presents the purpose of each budget and the results of the budget flow balances. The results of the computational budgets are used in the diversion calculations where seven budgets are used to verify the diversion simulation models. The columns are discussed first followed by the discussion of the budgets.

COLUMNS

The columns display the components of the diversion calculation and include the Romeoville flow as well as the various deductions and additions to the Romeoville record. The final three columns display the three diversion components (Lake Michigan pumpage accountable to Illinois, runoff from the diverted watershed, and direct diversion through the lakefront control structures) and the sum of the three columns should theoretically equal the Romeoville based diversion calculation. A comparison of the sum of these three columns to the calculated diversion is presented in the discussion of Column 11 through Column 13.

COLUMN 1: CHICAGO SANITARY AND SHIP CANAL (CSSC) AT ROMEOVILLE, USGS AVM GAGE RECORD

The discharge at Romeoville for WY89 is 3,515.2 cfs. For days when the AVM was inoperable, the flow at the Romeoville site was calculated from regression equations.

COLUMN 2: DIVERSIONS FROM THE CSSC ABOVE THE GAGE

Argonne Laboratories and Uno-ven Corporation were the only diversions from the Chicago Sanitary and Ship Canal upstream of the Romeoville gage in WY89. The average withdrawal upstream of the AVM for WY89 is 1.3 cfs.

COLUMN 3: TOTAL FLOW THROUGH THE CSSC

Column 3 is the sum of Column 1 and Column 2 and represents the total flow entering the canal system. The average canal flow is 3,516.5 cfs for WY89.

COLUMN 4: GROUNDWATER DISCHARGED TO THE CSSC AND ADJOINING CHANNELS

Column 4 is groundwater water supply pumpage by communities, industrial users, and other private users as reported by the Illinois State Water Survey (ISWS) whose effluent is discharged to the CSSC. It also includes the groundwater seepage into the TARP system that is discharged to the canal. This quantity is determined by summing all reported groundwater pumpages tributary to the canal along with the estimated groundwater seepage into the Mainstream TARP (Budget 9) and Calumet TARP (Budget 11) systems. This total is then adjusted by subtracting the groundwater normally tributary to the canal that is contained in the combined sewer overflows that discharge to the Des Plaines River and other watercourses not tributary to the CSSC. This method prevents double accounting of the combined sewer overflow portion of the groundwater supply pumpage.

Using ISWS groundwater records, groundwater pumpages were assumed to reach the CSSC and adjoining channels if they were located in the diverted Lake Michigan watershed in Illinois or if they were located within MWRDGC service boundaries in which their effluent was discharged into the CSSC and adjoining channels. Groundwater seepage into the Mainstream TARP and Calumet TARP systems was determined through simulation and is discussed in Budgets 9 and 11. The groundwater constituent of combined sewer overflows is determined entirely thorough simulation.

Groundwater pumpage from the Lake Michigan watershed whose effluent is discharged to the canal is a deduction except to the extent that the groundwater sources are recharged by Lake Michigan. Current piezometric levels indicate that groundwater is discharging to the lake. Therefore, groundwater pumpage from within the Lake Michigan Watershed that reaches the canal continues to be a deduction. Research literature will be reviewed periodically to verify this assumption.

Column 4 represents a deduction from the Romeoville record and averaged 82.0 cfs for WY89. This is a decrease of 28.2 cfs from WY88. Groundwater pumpage tributary to the canal is composed of 11.7 cfs of groundwater pumpage from the Lake Michigan watershed, 11.3 cfs of groundwater pumpage from outside of the Lake Michigan watershed, 52.5 cfs of groundwater seepage into the Mainstream TARP system, and 6.7 cfs of groundwater seepage into the Calumet TARP system. The total of these components is 82.2 cfs. However, the deduction from the Romeoville gage record is 82.0 cfs since 0.2 cfs of this groundwater supply pumpage was determined, through simulation, to be discharged to the Des Plaines River and other watercourses not tributary to the CSSC in the form of combined sewer overflows.

COLUMN 5: WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CHICAGO SANITARY AND SHIP CANAL

Column 5 represents the computation of Indiana water supply reaching the canal through the Grand Calumet and the Little Calumet Rivers. In the case of the Little Calumet River, a drainage divide exists east of the confluence with Hart Ditch. Therefore, flows from Hart Ditch, including virtually all dry weather flows, normally flow westward into Illinois. Under high flow conditions, the drainage divide may shift westward and a portion of the Hart Ditch flows may be diverted eastward to Burns Ditch and ultimately to Lake Michigan. However, it is believed that the occurrence in the shift in the drainage divide is infrequent and the flow that is diverted eastward is insignificant. Therefore, it is assumed that all effluent discharged into Hart Ditch and the Little Calumet River west of the divide flow westward. For WY89, total flow in the Little Calumet River was 72.4 cfs, with 4.8 cfs of that flow being determined to be Indiana water supply.

The Grand Calumet River has a summit. On one side of the summit, the flow is toward Lake Michigan. On the other side of the side of the summit, the flow is toward the Calumet Sag Channel. However, the location of the summit is variable and highly influenced by Lake Michigan levels (USGS, 1984). Thus the calculation of this deduction from the Romeoville record is influenced by Lake Michigan levels. In the absence of a stream

gaging station on the Grand Calumet River to measure westward flow into Illinois, flow is computed based on a statistical relationship of which the principal variable is lake levels.

Flow in the Grand Calumet River is estimated to be in excess of 90% sanitary effluent. Therefore, it is assumed that the portion of this flow that is attributable to domestic water supply is equal to the sum of the daily water supply for East Chicago, Hammond, and Whiting unless this sum is greater than the flow in the Grand Calumet River. In the case that the combined water supply for these communities is in excess of the flow in the Grand Calumet River, it is assumed that the flow consists entirely of effluent that originates from water supply.

The total Grand Calumet flow reaching Illinois in WY89 was computed as 23.0 cfs. It was determined that all of the 23.0 cfs was water supply pumpage. Therefore, the total WY89 Indiana water supply deduction, including the flow from the Little Calumet and Grand Calumet Rivers is 27.8 cfs. This is slightly less than the Indiana water supply deduction for WY88 of 31.3 cfs.

COLUMN 6: RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CHICAGO SANITARY AND SHIP CANAL

The WY89 average discharge of Des Plaines River watershed runoff reaching the canal (Column 6) is 134.9 cfs. The infiltration and inflow discharged to the water reclamation plants is 82.7 cfs, the infiltration and inflow reaching the canal through combined sewer overflows is 9.3 cfs, and the runoff from the Lower Des Plaines and Summit Conduit areas is 42.9 cfs. The deduction is largely determined by simulation but it is also influenced by the O'Hare basin flow transfer that contributed 10.1 cfs of the 82.7 cfs runoff to the water reclamation facilities during WY89. The deductible Des Plaines River watershed runoff increased 29.1 cfs from WY88 to WY89 as a result of significantly greater precipitation during WY89.

COLUMN 7: LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES WHICH DISCHARGE TO THE CSSC

Column 7 represents Lake Michigan diversions for Federal use, not chargeable to the State of Illinois, and is typically comprised of water supply used by federal facilities. This flow is included with the Lake Michigan water usage by federal facilities to developing this column total. Column 7 represents a deduction from the Romeoville record and the total amount of the WY89 deduction is 2.0 cfs.

COLUMN 8: TOTAL DEDUCTIONS FROM THE CSSC ROMEOVILLE GAGE RECORD

Column 8 is the sum of Columns 4, 5, 6, and 7 and represents the total deduction from the Romeoville record. The total deduction for WY89 is 246.8 cfs.

COLUMN 9: LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL

This column represents water supply pumpage from Lake Michigan that is not discharged to the canal. The water supply pumpage not discharged to the canal is composed of two components:

(1) Lake Michigan water supply used by communities serviced by water reclamation facilities that do not discharge to the CSSC (107.0 cfs). This is a decrease of 0.8 cfs from WY88.

(2) The sanitary portion of combined sewer overflows attributable to Lake Michigan domestic water supply that does not discharge to the CSSC (1.2 cfs).

The communities that make up the flow in the first component are suburbs whose treated effluent is discharged to the Des Plaines River and other watercourses not tributary to the CSSC. These communities include Elk Grove Village, Hoffman Estates, Mount Prospect, Schaumburg, Hanover Park, Rolling Meadows, Streamwood, Arlington Heights, Buffalo Grove, Palatine, Wheeling, Lincolnshire, Riverwoods, Libertyville, Illinois Beach State Park, Winthrop Harbor, Zion, Waukegan, 76 percent of North Chicago, and 38.2 percent of Des Plaines. It should also be noted that the Lake Michigan water supply component of the O'Hare flow transfer is subtracted from the total Lake Michigan water supply of the above communities since (1) the O'Hare flow transfer is treated at the Northside WRP which discharges sanitary effluent that is tributary to the CSSC and (2) the entire Lake Michigan water supply component of the O'Hare flow transfer is from communities contained in the above list. The Lake Michigan water supply for these communities is measured while the sanitary portion of the CSO's is derived through simulation. Column 9 represents an addition to the Romeoville record and the total WY89 addition is 108.2 cfs. This is a decrease of 0.7 cfs from WY88 to WY89.

COLUMN 10: TOTAL DIVERSION

Column 10 is equivalent to Column 3 with the deduction of Column 8 and the addition of Column 9. The total diversion for WY89 is 3,377.9 cfs. This amount is 177.9 cfs greater than Illinois's long term diversion allocation of 3,200 cfs. The 40-year running average diversion, rounded to the nearest cfs, beginning with WY81, is 3,443 cfs and the cumulative deviation from the 3,200 cfs allocation is -2,189 cfs. The negative deviation indicates that the cumulative diversion is greater than an average of 3,200 cfs for the period.

COLUMN 11 THROUGH COLUMN 13: LAKE MICHIGAN DIVERSION COMPONENTS

Column 11 through Column 13 represent the three Lake Michigan diversion components: Lake Michigan pumpage accountable to Illinois (1,791.9 cfs), runoff from the diverted Lake Michigan watershed (708.8 cfs), and direct diversion through the lakefront structures (430.7 cfs) which also accounts for the 0.2 cfs backflow during WY89. The sum of the columns (2,931.4 cfs) should theoretically equal the total diversion as shown in Column 10 (3,377.9 cfs) with one exception. The Romeoville record receives effluent that is assumed to contain only 90% of the water supply pumpage while Column 11, Lake Michigan water supply pumpage accountable to Illinois, does not account for consumptive use. This is based on a consumptive loss (water supply pumpage that is consumed or lost prior to reaching the water reclamation facilities) estimate of 10% of the water supply pumpage (International Great Lake Diversion Consumptive Use Study Board, 1981).

Because the diversion estimate from Columns 11 - 13 is based on simulation, suspect ratings of the lakefront structures, and simple flow separation techniques, the estimate is not expected to be as accurate as the AVM based calculations. Consequently, a difference between estimates of 446.5 cfs or 13.2% is a fair balance. However, this discrepancy becomes even greater when consumptive use is accounted for in Column 11. The discrepancy in these two estimates is related to the canal system balance in Budget 14, discussed in a subsequent section, and potential sources of the discrepancy are addressed in that budget discussion.

Using the figures from these three columns, 61.1% of the WY89 Illinois diversion is attributable to pumpage from Lake Michigan for domestic water supply. Runoff from the diverted Lake Michigan Watershed accounted for 24.2% of the diversion, and direct diversion through the lakefront structures accounted for 14.7% of the diversion. Water supply from Lake Michigan actually dropped 114.5 cfs from WY88. This is most likely due to the

smaller demand during WY89 since precipitation during WY88 was less than normal while WY89 was above normal. During WY88, 27.6 inches of precipitation were reported at O'Hare Airport while 39.2 inches of precipitation were reported during WY89. This also explains the 189.2 cfs increase in runoff from the Lake Michigan watershed that occurred from WY88 to WY89. A more detailed breakdown of these percentages is shown in Table 5 and Figure 2.

Table 5

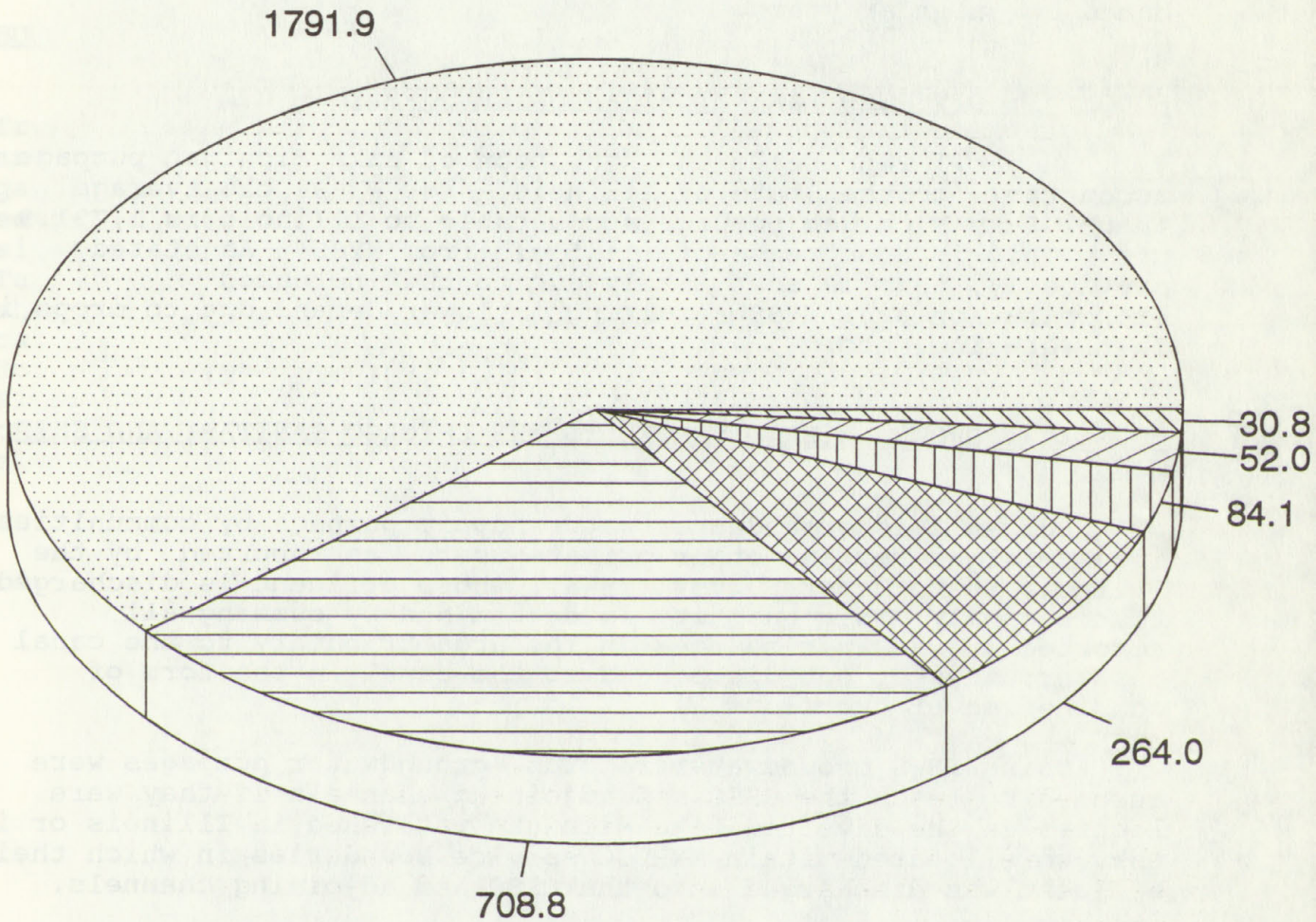
Breakdown of the Diversion by the State of Illinois
Based on Columns 11 Through 13

Category	Flow	Percentage
Lake Michigan Pumpage by the State of Illinois	1,791.9 cfs	61.1 %
Runoff from the Diverted Lake Michigan Watershed	708.8 cfs	24.2 %
Direct Diversions		
Lockages	84.1 cfs	2.9 %
Leakages	30.8 cfs	1.0 %
Navigation Makeup Flow	52.0 cfs	1.8 %
Discretionary Flow	264.0 cfs	9.0 %

BUDGETS

The first two budgets are used to sum the water supply for the area influenced by the diversion. The following four budgets are of stream gage sites that are not simulated and are used as part of the calculation of the runoff from the diverted Lake Michigan watershed. The remaining seven budgets compare measured and simulated flows.

Figure 2
Component Breakdown of Illinois' Diversion
Based on Columns 11 through 13



DIVERSION COMPONENTS

WATER SUPPLY	61.1 %	RUNOFF	24.2 %
DISCRETIONARY	9.0 %	LOCKAGES	2.9 %
NAV MAKEUP	1.8 %	LEAKAGES	1.0 %

BUDGET 1 AND BUDGET 2: WATER SUPPLY PUMPAGE

Budgets 1 and 2 are summations of critical water supply pumpage data. Budget 1 sums Lake Michigan water supply diverted by the State of Illinois. The Lake Michigan water supply data is supplied by the state as daily values for primary users and monthly data for secondary users. Budget 2 sums groundwater pumpages in the Lake Michigan and Des Plaines River watersheds that are diverted to the Chicago Sanitary and Ship Canal. Groundwater pumpage data is recorded as a total annual withdrawal based on calendar years.

BUDGET 1: DIVERTED LAKE MICHIGAN WATER SUPPLY

Budget 1 represents the summation of Lake Michigan pumpage accountable to the State of Illinois. For WY89, the average annual Lake Michigan pumpage accountable to Illinois is 1,791.9 cfs. This is a decrease of 114.5 cfs from WY88. As stated previously, this is most likely due to the increased precipitation over WY88 resulting in lower demand due to drops in lawn watering, etc.

BUDGET 2: GROUNDWATER DIVERTED TO THE CHICAGO SANITARY AND SHIP CANAL

Budget 2 is groundwater water supply pumpage by communities, industrial users, and other private users, as reported by the Illinois State Water Survey (ISWS), whose effluent is discharged to the canal. This quantity is determined by summing all reported groundwater sources in the area tributary to the canal less groundwater not discharged to the canal in the form of combined sewer overflows.

Using ISWS groundwater records, groundwater pumpages were assumed to reach the CSSC and adjoining channels if they were located in the diverted Lake Michigan watershed in Illinois or if they were located within MWRDGC service boundaries in which their effluent was discharged into the CSSC and adjoining channels.

The total groundwater pumpage by communities, industrial users, and other private users whose sanitary effluent is tributary to the canal is 22.9 cfs for WY89. It was determined through simulation that 0.2 cfs of this flow never reached the canal. Instead it was discharged to the Des Plaines River or other watercourses not tributary to the canal in the form of combined sewer overflows. The total groundwater pumpage reaching the canal represents a decrease of 18.8 cfs from WY88 to WY89.

In addition to groundwater supply pumpage there was also a significant amount of groundwater infiltration into the two TARP systems that ultimately reached the canal. Mainstream TARP and Calumet TARP accounted for 52.5 cfs and 6.7 cfs, respectively, of groundwater discharged to the canal during WY89. Groundwater infiltration into the Calumet TARP system was significantly less than in previous years due to changes in the simulation model. This will be described in detail in the section discussing Budget 11.

BUDGETS 3 THROUGH BUDGET 6: STREAM GAGING STATIONS

The stream gage budgets are used to make estimates of runoff from portions of the diverted Lake Michigan watershed. Sanitary and other point source flows are subtracted from the stream gaging record to develop the runoff estimates. The runoff estimates are used in Column 12. The flows at the stream gaging sites is also part of Budget 14, the canal system budget. Table 6 presents the estimated runoff from these budgets. It should be noted that Budgets 4 through 6 are a composite calculation of the runoff above the Little Calumet River at South Holland gage. It should also be noted that the Little Calumet River is a losing stream, i.e. it recharges groundwater. The computations in deriving runoff account for this when recharge is significant (i.e., when groundwater recharge is computed).

Table 6

Stream Gage Flow Separation

Budget	Location	Flow cfs	Sanitary cfs	Runoff cfs
3	North Branch Chicago River at Niles, IL	83.9	18.9	65.0
4	Little Calumet River at IL-IN State Line	72.4	3.9	68.5
5	Thorn Creek at Thornton, IL	116.2	16.8	99.4
6	Little Calumet River at South Holland, IL_1	191.2	179.7	11.5

1 Incremental Runoff

BUDGETS 7 THROUGH BUDGET 13: MWRDGC WATER RECLAMATION FACILITIES

The budgets for the water reclamation plants compare the simulated flows to the measured inflows at the MWRDGC facilities and perform verifications of the diversion accounting program. The simulated flows were developed from an estimated sanitary flow with a daily, weekly, and monthly flow variation and from precipitation-based runoff simulations. The estimated sanitary flow input to the simulation model is based on the population estimates for each plant's service basin. Per capita sanitary flows are determined based on the service basin's water supply minus an assumed 10 percent consumptive loss. Simulated flows were compared with recorded inflows at each facility to assess the accuracy of the simulations.

The discussion of the budgets will concentrate on the results of each simulation as the development of these models have been discussed in previous reports. A summary of the simulation results is presented in Table 7.

BUDGET 7: NORTHSIDE WATER RECLAMATION FACILITY

Budget 7 analyzes the water balance at the MWRDGC Northside Water Reclamation Facility (Figure 3). The balance for WY89 of the inflow to the Northside facility is good. The simulated to adjusted recorded inflow ratio (S/R) for the Northside WRP is 0.97, indicating that the simulated inflow volume is slightly less than the adjusted observed inflow volume. The coefficient of correlation (R) of simulated to observed flow is 0.80, indicating that the model predicted the inflow hydrograph to the Northside facility very well.

BUDGET 8: UPPER DES PLAINES PUMP STATION

Budget 8 analyzes the water balance at Upper Des Plaines Pump Station (UDPPS) (Figure 4). The pump station budget is used to verify simulated flows. However it has no direct impact on the diversion calculation.

TABLE 7

WY 1989 SUMMARY OF SIMULATION STATISTICS

Budget No.–>	7	8	9	10	11	12	13	14
Description	Northside WRP (1)	Upper Des Plaines Pump Station (1),(3)	Mainstream TARP Pump Station (2)	Stickney WRP (1)	Calumet TARP Pump Station (2)	Calumet WRP (1)	Lemont WRP (1)	Chicago Canal System Balance (1)
Mean Recorded Flow, cfs	422.0	82.3	86.6	1152.3	31.9	421.3	2.3	3043.5
Max. Recorded Flow, cfs	682.8	179.7	359.9	2134.0	122.3	709.9	6.5	13410.0
Min. Recorded Flow, cfs	330.3	21.3	14.2	688.6	0.0	296.7	0.8	1671.7
Mean Simulated Flow, cfs	407.2	67.8	89.1	1187.7	27.5	419.0	1.8	3523.7
Max. Simulated Flow, cfs	680.8	186.0	186.8	2589.8	89.4	784.7	4.9	13754.0
Min. Simulated Flow, cfs	307.0	43.3	38.8	819.1	6.5	303.9	1.2	1877.5
Mean S/R	0.97	0.82	1.03	1.03	0.86	0.99	0.78	1.16
Max. S/R	1.42	3.79	7.30	1.66	6.14	1.53	3.67	1.56
Min. S/R	0.65	0.43	0.25	0.56	0.27	0.66	0.36	0.78
Correlation	0.80	0.47	0.55	0.74	0.68	0.72	0.72	0.95

(1) Based on daily values.
(2) Based on weekly values.
(3) Does not include days with missing records.

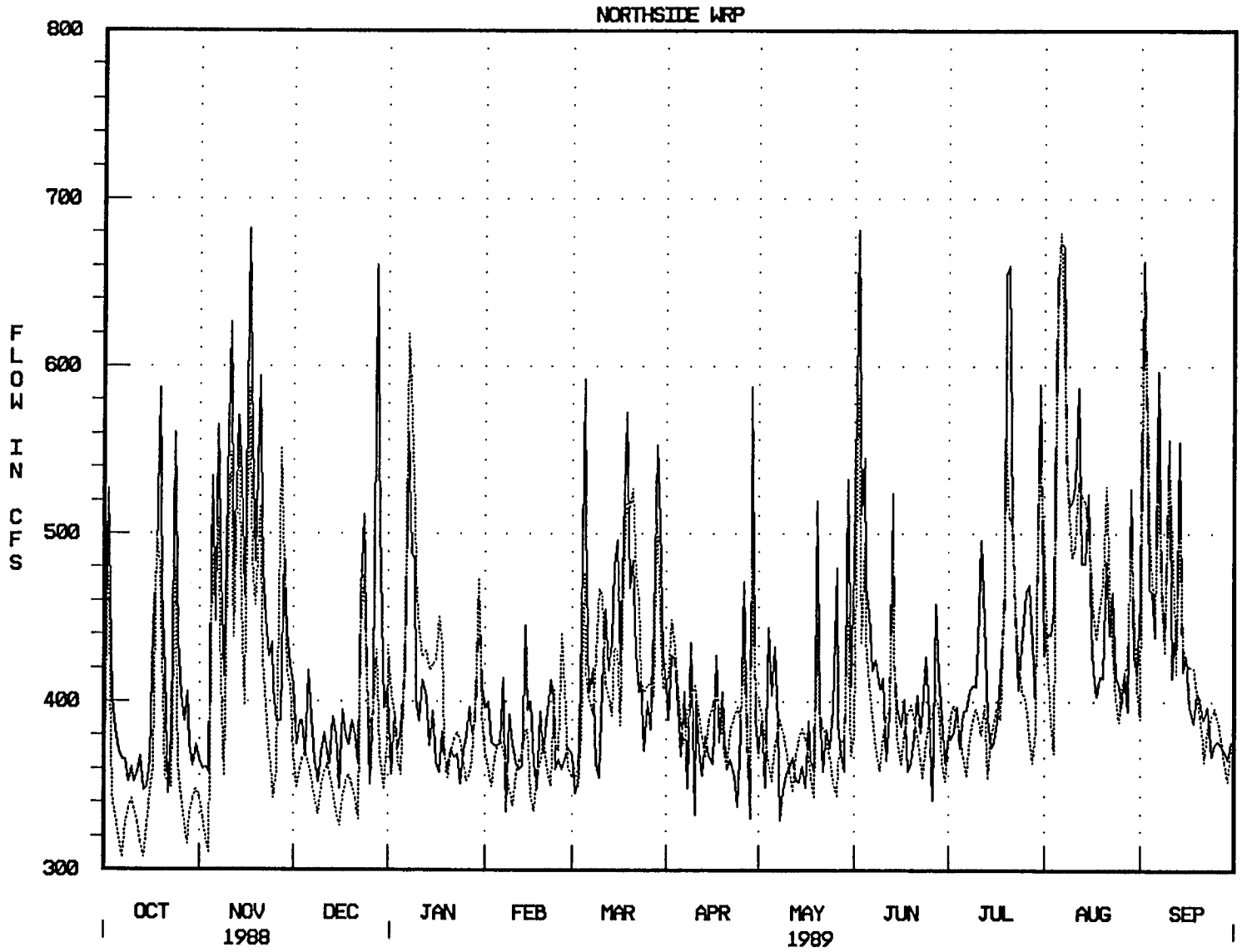


FIGURE 3

OBSERVED FLOW
SIMULATED FLOW

Budget 7 - Simulation of the MWRDGC Northside Water Reclamation Facility

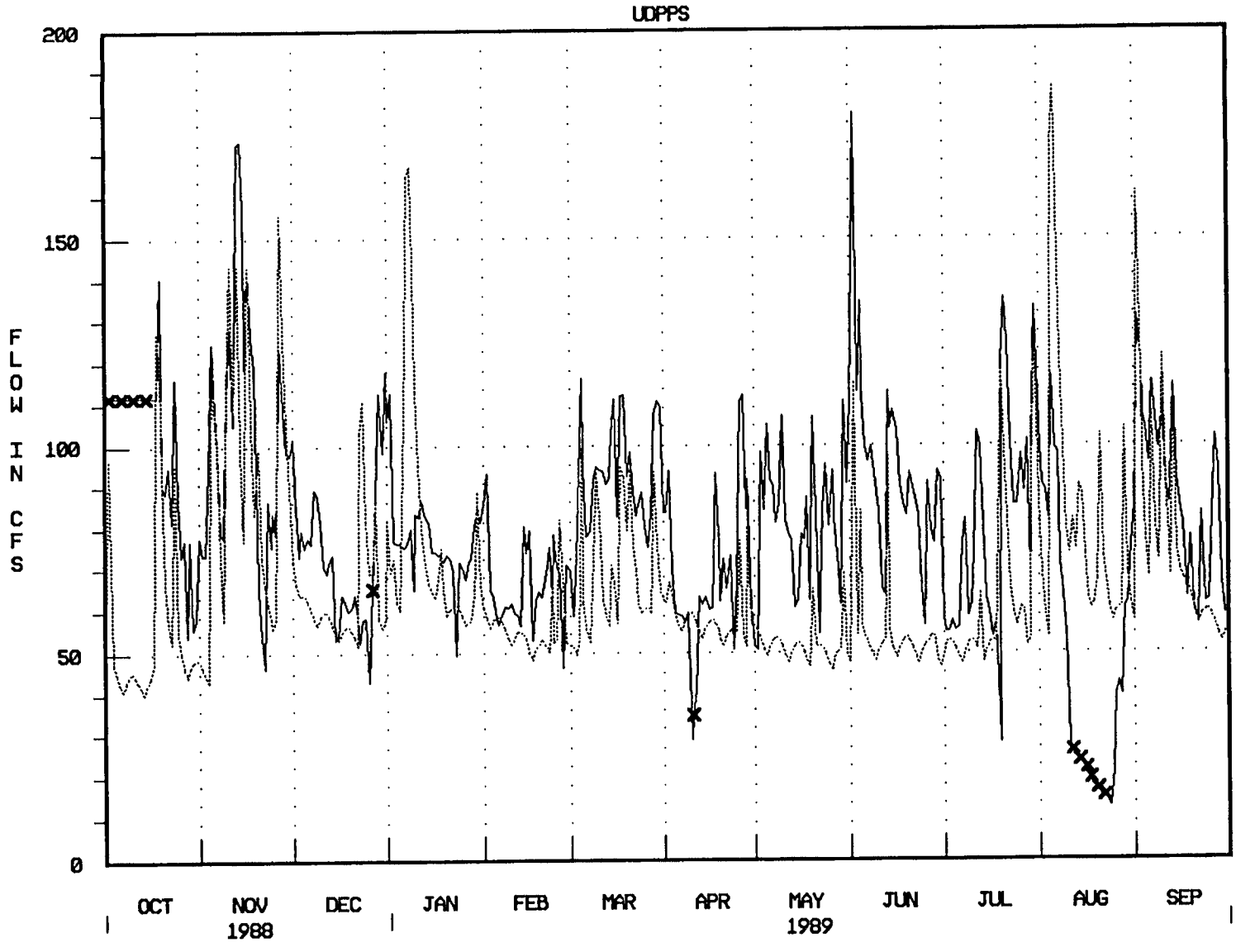


FIGURE 4

UPPER DES PLAINES PUMP STATION OBSERVED FLOW
UPPER DES PLAINES PUMP STATION SIMULATED FLOW

Budget 8 - Simulation of the MWRDGC Upper Des Plaines Pump Station

The balance at UDPPS for WY89 was fair. The simulated to recorded flow ratio (S/R) for the UDPPS is 0.82, indicating that the simulated inflow volume to UDPPS is less than the recorded inflow volume. However, the daily S/R ratio shows a high degree of variability, indicating that the trends within the recorded and simulated inflow may not correspond very well. The coefficient of correlation (R) of simulated to recorded flow is 0.47, indicating the time series trends in the simulated inflow compared marginally with the time series trends of recorded inflow.

While the statistical results for WY87, WY88 and WY89 at the Upper Des Plaines Pump Station have improved since WY86, this does not lead to the conclusion that flow measurement alternatives should not be investigated. This site has continued to experience its share of problems. During WY89, 31 days of records were unavailable that were attributable to meter malfunctions, problems with the recording charts which made data transformation undoable, and various other reasons. In view of the significant quantity of missing data (8.5 % missing data), the quantitative analyses of the simulation are of limited value. Second, the accuracy of the flow meters at the pump station is questionable and unmetered bypass flows are a frequent occurrence. Therefore, total flow may not be measured in storm events and the recycling of flow is possible. Further investigation of the accuracy of flow measurement at the pump station is required to verify and calibrate the simulation models that compute the deductible runoff from the Des Plaines watershed contained in Column 6.

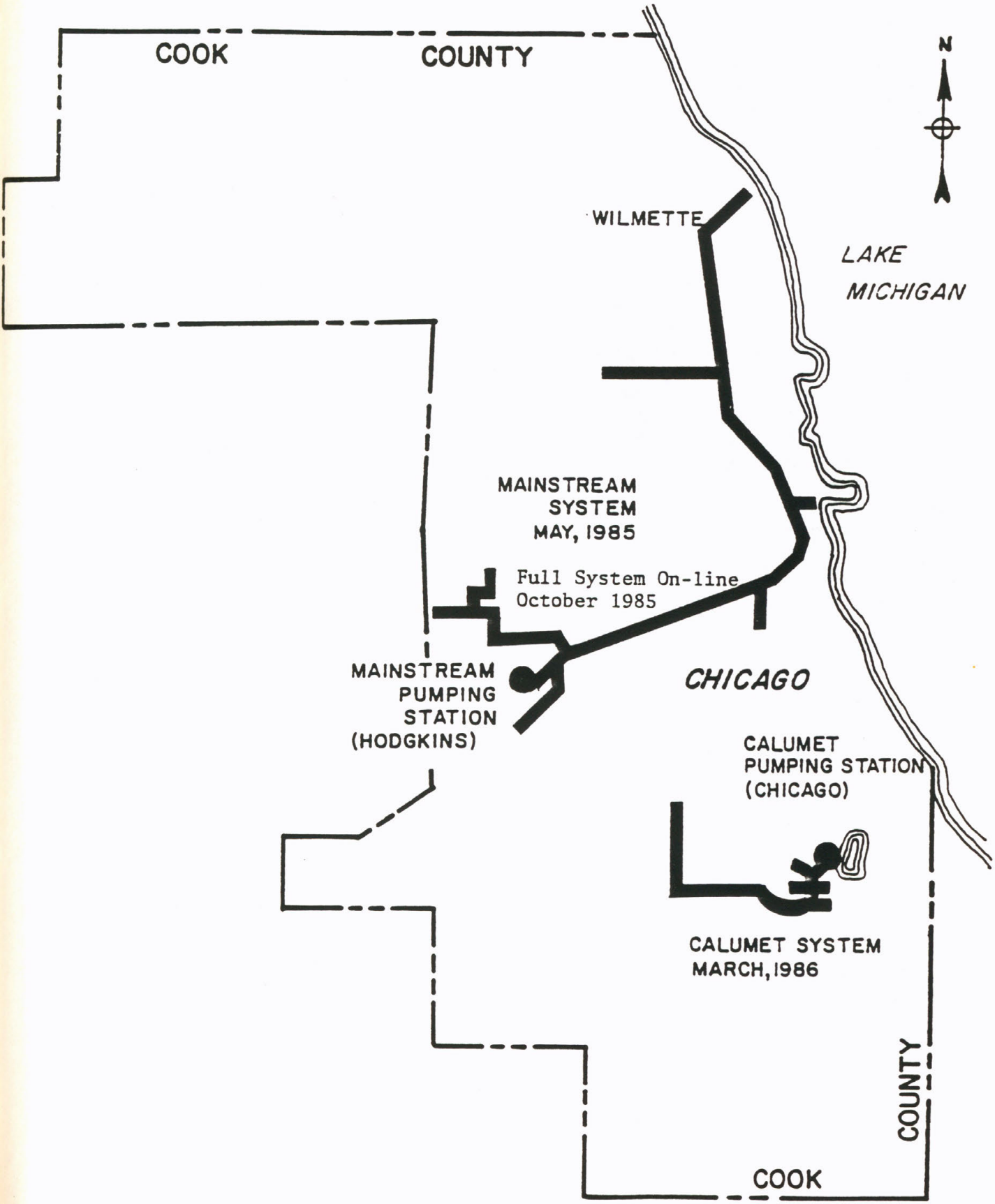
BUDGET 9: MAINSTREAM TARP PUMPING STATION

Budget 9 analyzes the water budget at the MWRDGC Mainstream TARP Pumping Station. The results of Budget 9 are used as input to Budget 10 in addition to providing a verification point for simulated flows. The modeling of Mainstream TARP is performed using the Tunnel Network (TNET) dynamic hydraulic model. A simplified map of Mainstream TARP is contained in Figure 5. A more in-depth description of Mainstream TARP and the simulation model is contained in the Water Year 1986 report (USACE, 1991).

In analyzing the balance at the Mainstream TARP Pumping Station, weekly flows were used rather than daily flows. While MWRDGC maintains daily pumpage records, days with no pumpage occur frequently. Therefore, it is not possible to compute a daily S/R ratio.

Figure 5

Map of Mainstream and Calumet TARP



The balance for WY89 of the inflow to the Mainstream Pumping Station is good. The simulated to recorded flow ratio (S/R) for the Mainstream Pumping Station is 1.03, indicating that the simulated inflow volume is slightly greater than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.55, indicating that the model prediction of trends in the inflow at the pump station was fair.

From a review of the plot of the simulated versus recorded flow at the pump station (Figure 6), it appears that the model responds similarly to recorded pumpage record. However, the model tends to have slightly lower peak flows except during the winter months when simulated flows are greater than recorded flows. Additionally, base flows appear to be overestimated in the simulation. This is probably due to overestimation of groundwater infiltration into the TARP tunnels.

In summary, it appears that the simulation of the Mainstream TARP system is reasonable. However, there is concern regarding the estimation of pumpage volume and the difference in simulated and recorded pumpage time series. A review of MWRDGC information regarding Mainstream TARP indicates that bypass flows are discharged to TARP, when available, via drop shaft 11 (DSN 11). Coordination with MWRDGC established that this is a frequent occurrence. This may account for the simulation of a pumpage volume that is less than the recorded pumpage volume. Records concerning the dates and pumpages back to TARP were not maintained for WY89. Therefore, data necessary to evaluate the impact of pumping back into TARP is not available. Therefore, it was decided that the model would not be adjusted so as to avoid double accounting of flows.

BUDGET 10: STICKNEY WATER RECLAMATION FACILITY

Budget 10 analyzes the water balance at the MWRDGC Stickney Water Reclamation Facility (Figure 7). Simulated Mainstream TARP pumpages from Budget 9 are combined with simulated interceptor inflow to Stickney Water Reclamation Facility to derive the total simulated inflow to the Stickney Facility. Total simulated inflow is compared with recorded inflow to assess the accuracy of the simulation.

Overall, the balance for WY89 of the inflow to the Stickney facility is very good. The simulated to recorded flow ratio (S/R) for the Stickney is 1.03, indicating that the simulated inflow volume is slightly greater than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.74, indicating that the model predicted the inflow hydrograph to the Stickney facility very well.

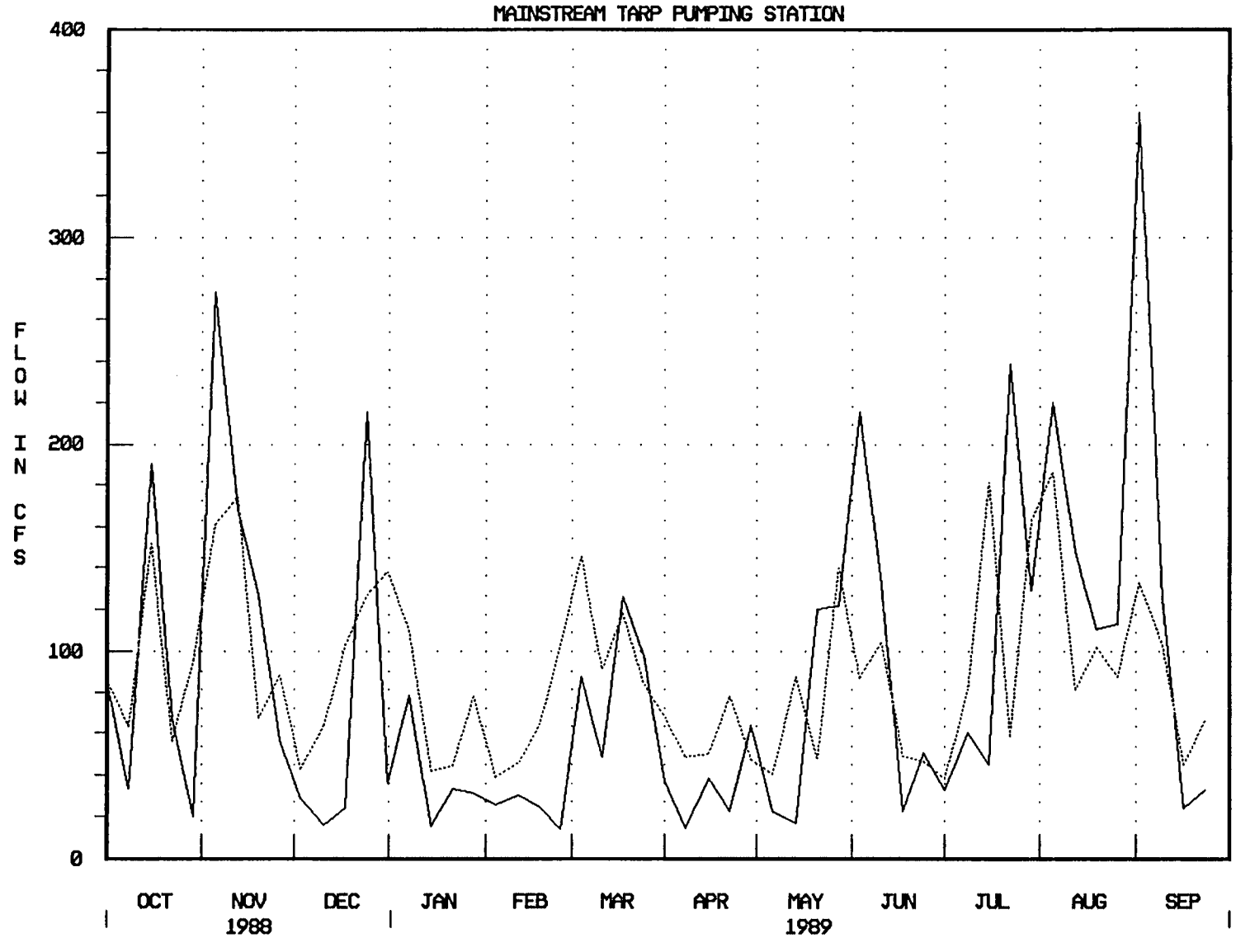


FIGURE 6

Budget 9 - Simulation of the MWRDGC Mainstream TARP Pumping Station

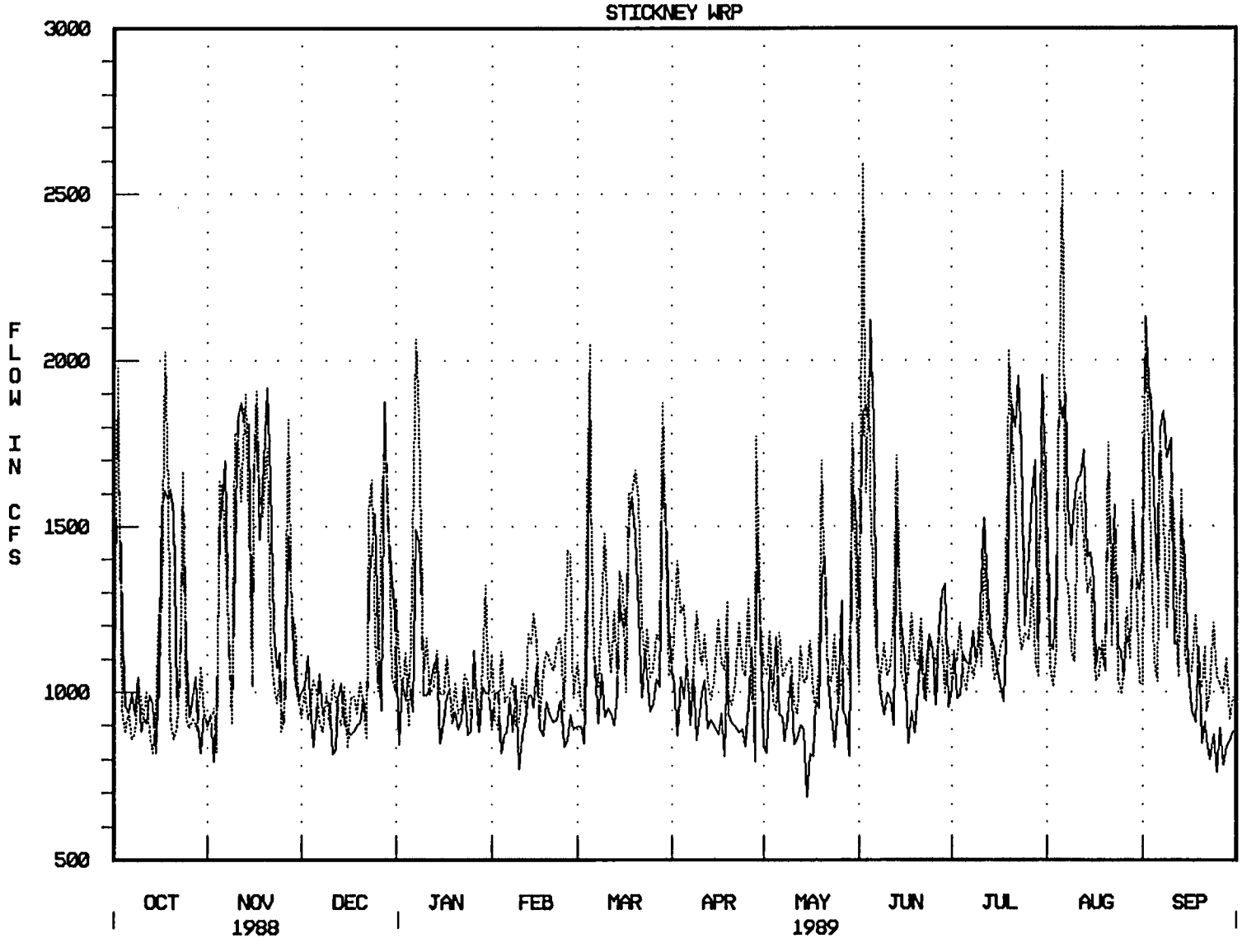


FIGURE 7

——— OBSERVED FLOW
..... SIMULATED FLOW

Budget 10 - Simulation of the MWRDGC Stickney Water Reclamation Facility

BUDGET 11: CALUMET TARP PUMPING STATION

Budget 11 analyzes the water budget at the MWRDGC Calumet TARP Pumping Station (Figure 8). The results of Budget 11 are used as input to Budget 12 in addition to providing a verification point for simulated flows. The modeling of Calumet TARP is performed using the Tunnel Network (TNET) dynamic hydraulic model. A simplified map of Calumet TARP is contained in Figure 5. A more in-depth description of Calumet TARP and the simulation model is contained in the Water Year 1987 report (USACE, 1992).

In analyzing the balance at the Calumet TARP Pumping Station, weekly flows were used instead of daily flows. While MWRDGC maintain daily pumpage records, days with no pumpage occur frequently. Therefore, it is not possible to compute a daily S/R ratio.

The balance for WY89 of the inflow to the Calumet Pumping Station is good. The simulated to recorded flow ratio (S/R) for the Calumet TARP Pumping Station is 0.86 indicating that the simulated inflow volume is slightly less than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.68, indicating that there was a fairly good agreement between the trends in the simulated and observed inflow.

The Calumet TARP model performance was greatly enhanced for WY89. The S/R ratio improved from 1.26 in WY88 to 0.86 in WY89 while the coefficient of correlation improved from 0.61 to 0.68. The reasons for the improvements were due to modifications to the estimated groundwater infiltration through the tunnel walls and modifications to unrestricted separately sewered areas.

During initial Calumet TARP simulation runs it was seen that the simulated dry-weather flow (groundwater infiltration + unrestricted sanitary flow) into the Calumet TARP system was significantly greater than the recorded dry-weather flow. Consequently, dry-weather periods during WY89 were analyzed. Dry-weather periods were identified as periods when the hydraulic SCALP model yielded no interceptor overflows and when the precipitation gages in the Calumet service basin recorded no rainfall. Eight different dry-weather periods were identified with the number of days for an individual period ranging from 9 to 18 days. Recorded Calumet TARP pumpages were compared to simulation results. The recorded dry-weather TARP pumpage was 7.3 cfs while the simulated dry weather TARP flow was initially 37 cfs.

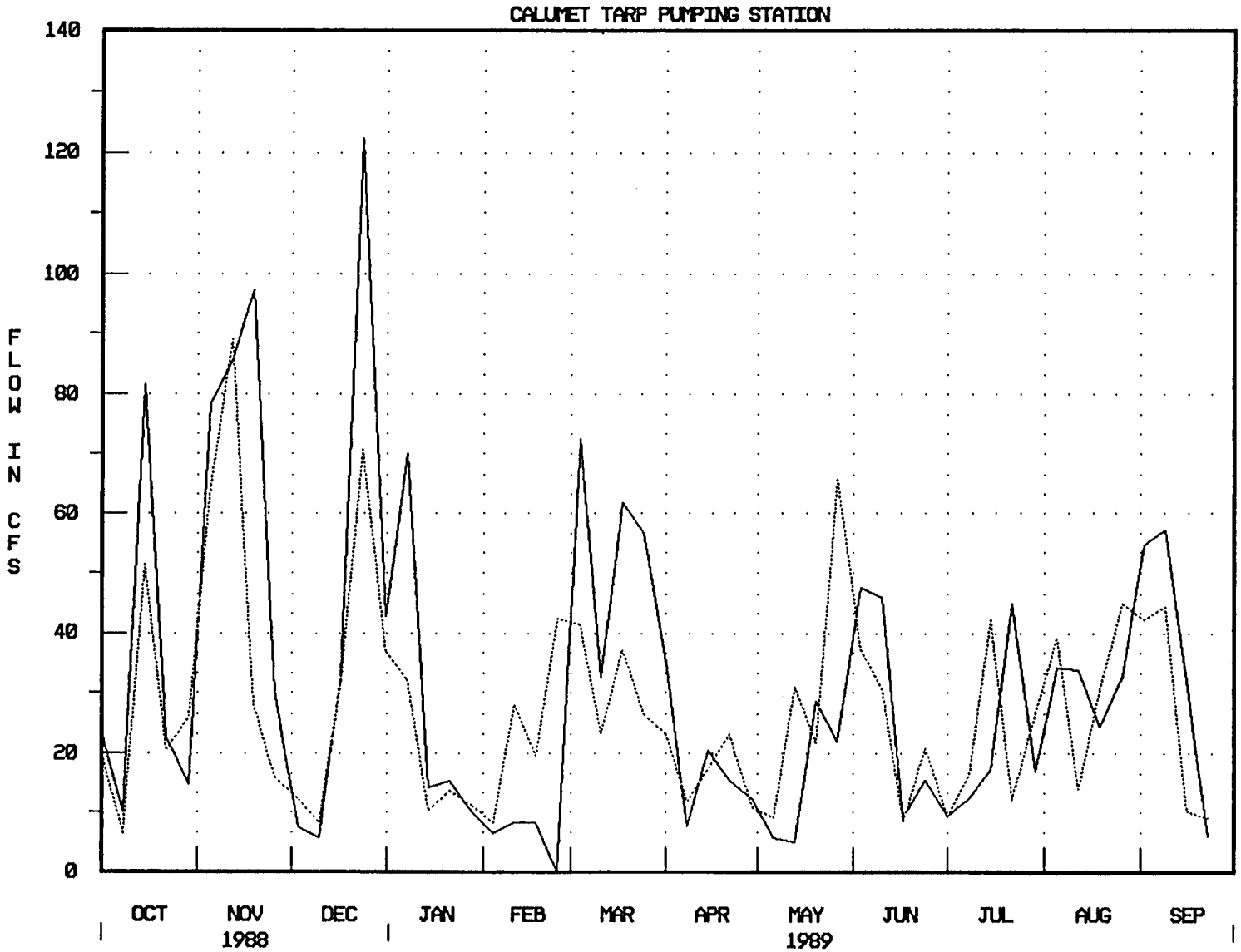


FIGURE 8

——— OBSERVED FLOW TO CALUMET WRP
..... SIMULATED FLOW TO CALUMET WRP

Budget 11 - Simulation of the MWRDGC Calumet TARP Pumping Station

It was obvious that changes to the model had to be made to obtain a better simulation of dry-weather TARP flows. Because the degree to which separately sewered areas flow unrestricted into the TARP tunnels is unknown, assumptions as to the extent of unrestricted flows into Calumet TARP had to made for two major separately sewered special contributing areas (SCAs). Since the area input into the SCALP model for each separately sewered special contributing area (SCA) is an effective area and not the actual area it has been difficult to obtain delineations of the separately sewered areas, some of which have subareas that flow unrestricted into Calumet TARP.

For WY87 and WY88 the assumption was made that 50 percent of all flows in two primary separately sewered SCAs (CA19R-1 and CA1W) remained in the interceptors that led to the Calumet Water Reclamation Facility while 50 per cent of the flow drained to the Calumet TARP tunnels. Additionally, the groundwater infiltration rate was set at a constant and uniform inflow of 17.03 cfs which was based on an analysis of dry weather flows during WY87. However, this previous analysis greatly overestimates the dry weather flow into TARP for WY89. Therefore, a more detailed analysis was done for WY89.

An attempt was made as to limit the inflow into Calumet TARP from the two major separately sewered SCAs as well as from groundwater infiltration. By routing only 9 percent of the interceptor flow from the two separately sewered SCAs into TARP the unrestricted TARP flow was reduced from 20 cfs to 3.6 cfs during dry-weather periods. Additionally, the groundwater infiltration rate was lowered to 3.7 cfs so that the total simulated dry-weather inflow to TARP would match the recorded TARP pumpage records for the eight dry-weather periods that were previously identified.

Using these modeling parameters, periods of low flow TARP pumpage matched very well with the simulated flows; however, it was impossible to match peak flows and annual accumulated volumes during the water year. Additionally, the model was very unstable under these modeling conditions.

Since MWRDGC has been unable to verify the extent of unrestricted dry-weather inflows to TARP, it was decided that two separately sewered SCAs (CA19R-1 and CA1W) and one combined SCA (CA14) would be modeled such that only the interceptor overflow would be routed to the TARP tunnels. Essentially all of the SCAs are modeled in this manner in SCALP by setting a cutoff flow, Qsplit, above which flows are routed to TARP and below which flows remain in the interceptors that convey the flows to a treatment facility.

SCALP was then run with new Qsplit values for the three SCAs. Overflows from the separately sewered SCAs, CA19R-1 and CA1W, remained unrestricted in that no control gates were modeled to restrict incoming flows to TARP. It is known from construction drawings that a majority of the flows entering Calumet TARP from these two SCAs are unrestricted. However, it is unknown as to the extent of dry-weather flows routed to Calumet TARP from these two SCAs. After SCALP was run with the new Qsplit values, the total overflows routed to TARP (SCALP output) during the dry weather periods were subtracted from the recorded Calumet TARP pumpage records to determine the revised simulated groundwater infiltration into the Calumet TARP tunnels. The average recorded dry-weather TARP pumpage was 7.32 cfs while the total simulated dry-weather interceptor overflows was 0.29 cfs. This resulted in a revised simulated groundwater infiltration rate of 7.03 cfs which was used as input to the TARP model.

BUDGET 12: CALUMET WATER RECLAMATION FACILITY

Budget 12 analyzes the water balance at the MWRDGC Calumet Water Reclamation Facility (Figure 9). Simulated Calumet TARP pumpages from Budget 11 are combined with simulated interceptor inflows to the Calumet Water Reclamation Facility to derive the total simulated inflow to the Calumet Facility. Total simulated inflow is compared with recorded inflow to assess the accuracy of the simulation.

The annual simulated to recorded flow ratio (S/R) and the coefficient of correlation for the Calumet Water Reclamation Facility have improved greatly and are now considered very good. The S/R ratio has improved from 0.80 to 0.99 from WY88 to WY89 while the coefficient of correlation has improved form 0.52 to 0.72 from WY88 to WY89.

The improvement in the water balance at the Calumet Water Reclamation Facility is due to improvements in the Calumet TARP model previously described in the section on Budget 11 as well as improvements in the simulated sanitary discharges from the special contributing areas that comprise the Calumet facility service basin. The revised sanitary discharges were derived from water supply pumpage records. Per capita sanitary usage for each SCA was calculated by dividing the WY89 water supply pumpage by population records. These revised per capita sanitary usage values were input into the hydraulic model (SCALP) for the Calumet basin.

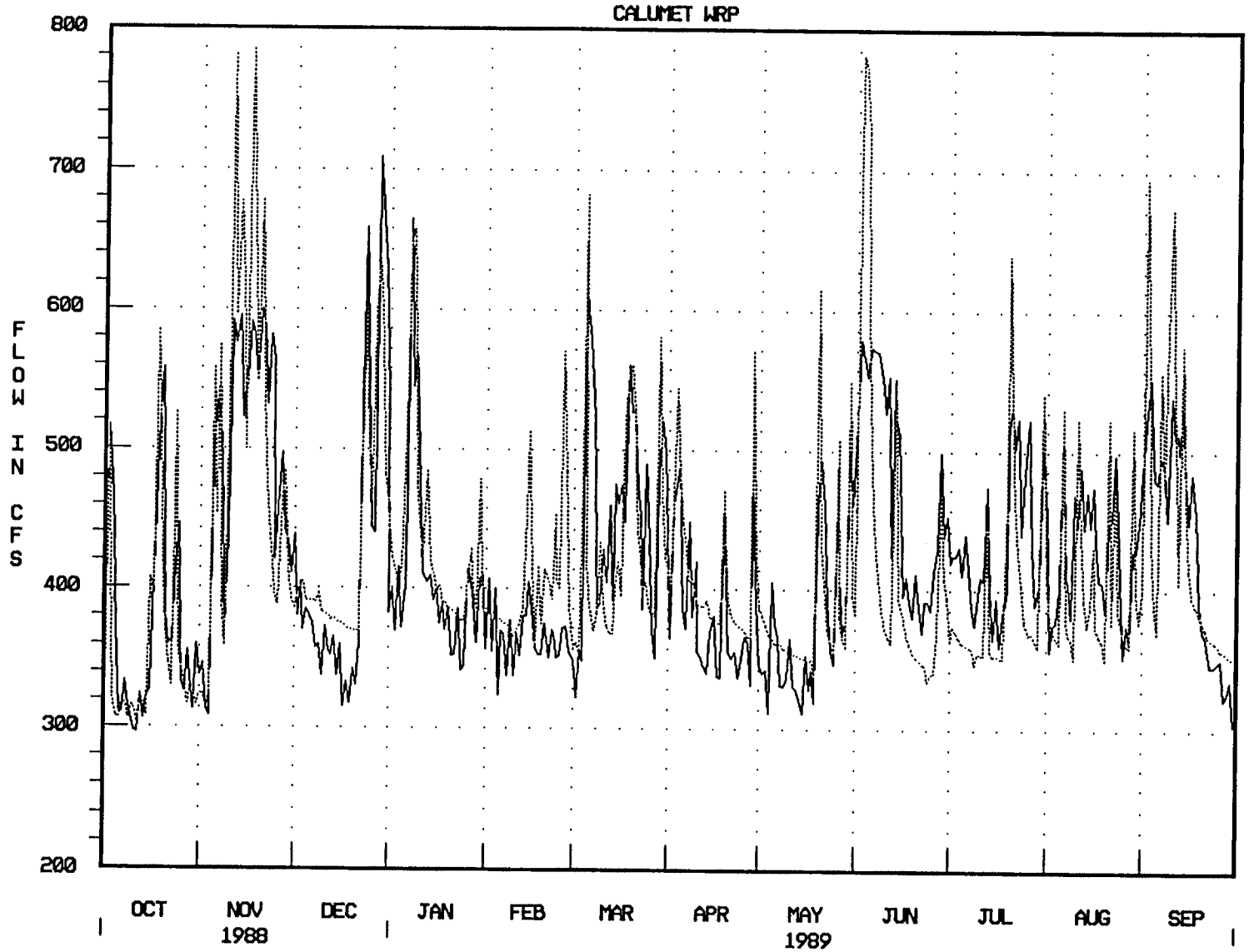


FIGURE 9

OBSERVED FLOW
SIMULATED FLOW

Budget 12 - Simulation of the MWRDGC Calumet Water Reclamation Facility

Although changes in the sanitary discharge for the Calumet basin are more likely a result of population changes rather than changes in the per capita usage, the population changes since 1980 could only be represented by changes in the per capita sanitary usage since revised population data was not available. Since population has generally increased in the Calumet service area since 1980, the modification to the hydraulic model parameter for per capita sanitary usage resulted in a larger simulated dry-weather interceptor flow which is reflected in the increased S/R ratio. additionally, the coefficient of correlation increased significantly.

The hydraulic response to storm events at the Calumet facility was compared to that of the Northside and the Stickney facilities. Base flow at Calumet is about 320 to 360 cfs while peak storm flows in response to inflow-infiltration are on the order of 420 to 460 cfs. At Northside and Stickney, peak flows can be twice as high or greater relative to base flow. Therefore, it appears that the model is simulating proper hydraulic response, but the treatment facility cannot accommodate the storm inflow. This will be investigated at a later date.

BUDGET 13: LEMONT WATER RECLAMATION FACILITY

Budget 13 analyzes the water balance at the MWRDGC Lemont Water Reclamation Facility (Figure 10). Overall, the balance for WY89 of the inflow to the Lemont facility is good. The simulated to recorded flow ratio (S/R) for the Lemont is 0.78, indicating that the simulated inflow volume was somewhat less than the recorded inflow volume. The coefficient of correlation (R) of simulated to recorded flow is 0.72, indicating that the model predicted the inflow hydrograph to the Lemont facility well.

BUDGET 14: CHICAGO CANAL SYSTEM BALANCE

Budget 14 compares the inflows and outflows to the canal system (Figure 11). The inflow components include direct diversions through the lakefront structures, stormwater runoff discharged to the canal system, and domestic water supply whose effluent discharges to the canal system. The outflows from the canal system include the discharge at Lockport, backflows through the lakefront structures, and withdrawals upstream of Lockport by Argonne National labs and Uno-ven corporation. The individual components are presented in Table 8 for WY89.

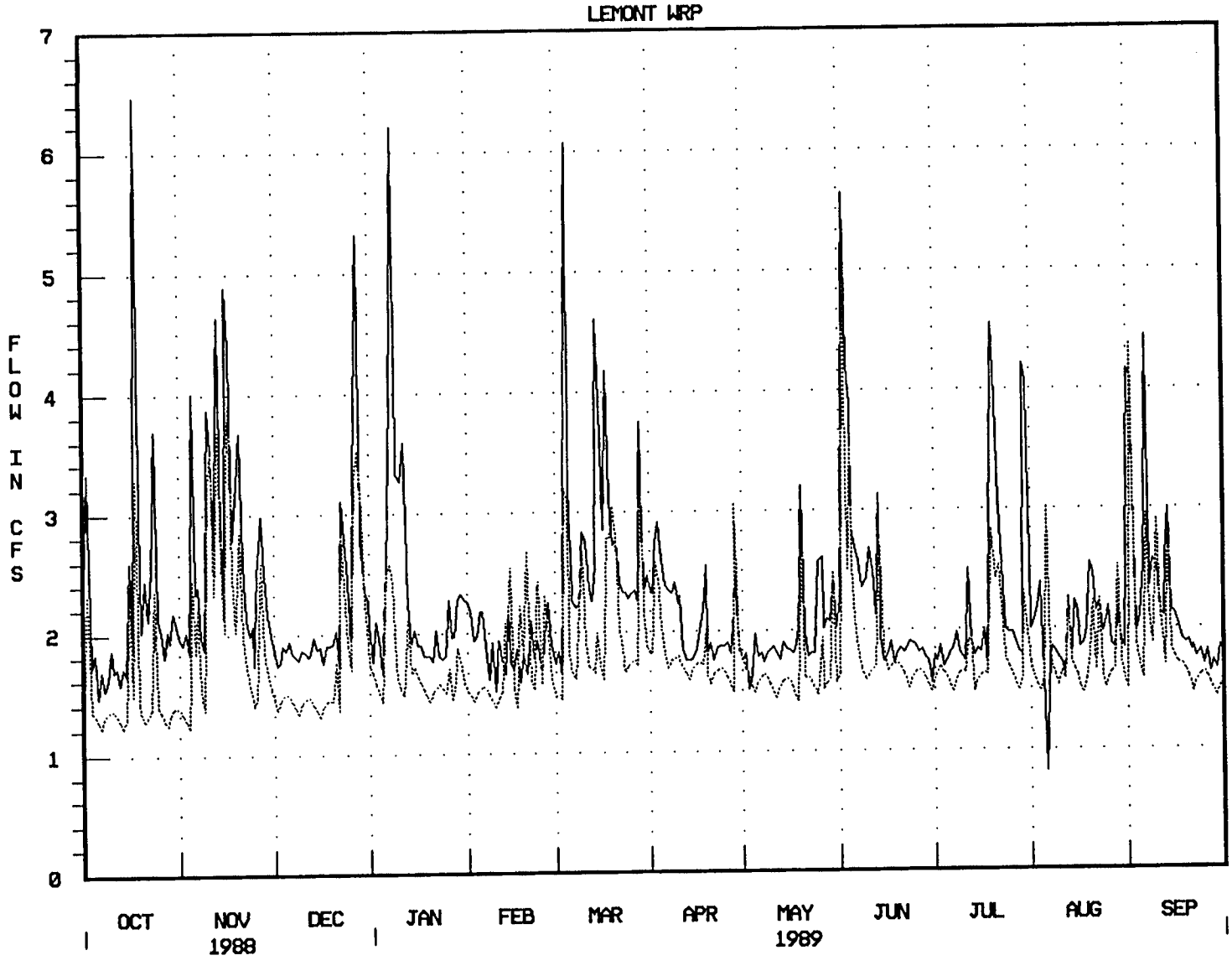


FIGURE 10

OBSERVED FLOW
SIMULATED FLOW

Budget 13 - Simulation of the MWRDGC Lemont Water Reclamation Facility

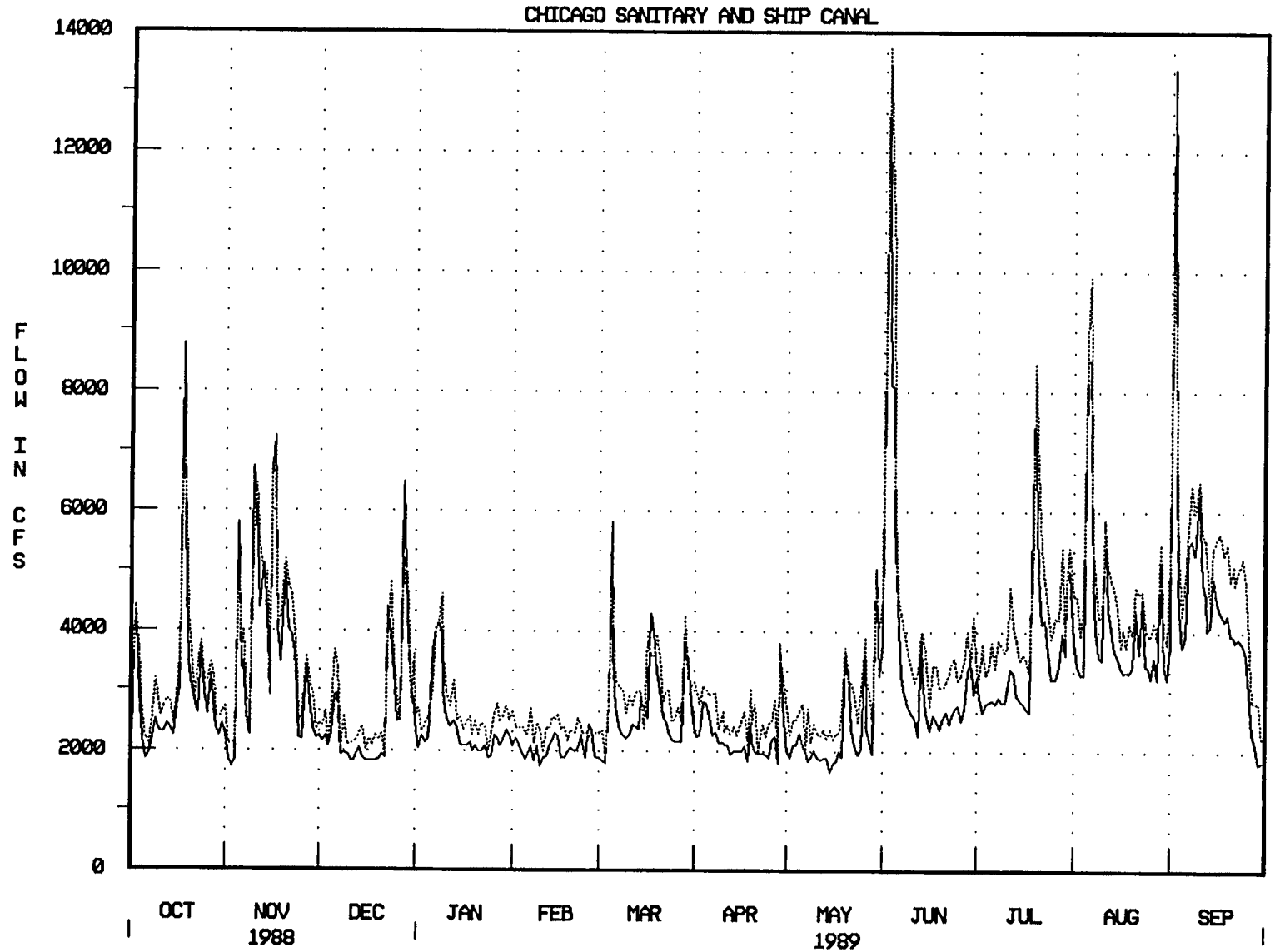


FIGURE 11

CANAL SYSTEM INFLOWS
CANAL SYSTEM OUTFLOWS

Budget 14 - Canal System Balance

TABLE 8

SUMMARY OF FLOW COMPONENTS FOR
CANAL SYSTEM BALANCE – WY1989

INFLOWS (cfs)	
Lake Controlling Structures (measured)	
– Wilmette Controlling Works	20.1
– Chicago River Controlling Works	212.3
– O'Brien Lock and Dam	198.5
Streamflows (measured)	
– North Branch Chicago River at Niles	83.8
– Little Calumet River at South Holland	191.2
Streamflow (estimated)	
– Grand Calumet River at Holman Ave.	23.0
MWRDGC Water Reclamation Facilities (measured)	
– Northside	422.0
– Stickney	1152.3
– Calumet	421.3
– Calumet TARP Pumpage to River	0.0
– Lemont	2.3
Other Point Sources (measured)	6.2
Summit Conduit (simulated)	1.8
Combined Sewer Overflows (simulated)	183.7
Direct Runoff to CSSC (simulated)	125.0
TOTAL INFLOWS (cfs)	3043.5

OUTFLOWS (cfs)	
Cal–Sag Flow Transferred to Calumet WRP as Steel Mill Blow–down	1.6
Lake Front Backflows	0.2
Argonne Laboratory	0.5
Uno–ven Corporation	6.2
USGS AVM Record	3515.2
TOTAL OUTFLOWS (cfs)	3523.7

DIFFERENCE (cfs)	–480.2

Overall, the balance for WY89 of the inflow to the canal system to the outflows from the canal system is fair. The S/R (outflow/inflow) for the canal system is 1.16, indicating that the inflow to the canal system is less than the outflow from the canal system. The average measured/simulated inflow was 3043.5 cfs while the average measured/simulated outflow was 3523.7 cfs. This is a difference of 480.2 cfs (13.6%) for WY89 as compared to 469.8 cfs (13.3%) for the previous water year, WY88.

The coefficient of correlation (R) of inflow to outflow is 0.95, indicating that the time series trends of inflow to outflow are well correlated. Therefore, based on the fact that the inflow is well correlated with the outflow, it appears that there is a moderately variable to constant underreported or unreported inflow.

Possible sources of the canal system flow imbalance may include underreporting of the lakefront flows through the sluice gates and locks and unaccounted for flow sources. The underreporting of the lakefront flows could be the result of both inaccurate rating curves for the lakefront control structures and leakage through those structures. Flow meter measurements at the lakefront direct diversion points were done to assess if leakage is significant. This study (USACE, 1990) showed that, given the accuracy limits of the Price AA current meter, lakefront flows are underreported, but the magnitude of underreporting could not be determined. Unaccounted flows could also include unreported discharges to the canal.

AREAS FOR IMPROVEMENT IN THE DIVERSION ACCOUNTING PROCEDURES

As a result of reviewing and calculating the WY89 diversion accounting, and referencing the results of the WY84 through WY88 diversion accounting, a number of areas of potential improvement have become evident. The following paragraphs discuss those areas where improvement is needed.

O'HARE AND EGAN BASIN TRANSFER

A portion of the flows originating in the O'Hare and Egan Water Reclamation Plants' (WRP) service basins are transferred east to the Northside WRP. The extent of the O'Hare service area being diverted is not known and the diverted flow is not measured. Thus an estimate of the annual basin transfer is provided by MWRDGC. The total O'Hare-Egan flow transfer for WY88 was estimated by the MWRDGC to be 31.0 cfs (20 MGD).

This transfer is significant to diversion accounting in light of the fact that the O'Hare and Egan facilities discharge outside of the CSSC while the Northside facility discharges flows

that reach the CSSC. Therefore, this transfer contains two components that are deductions to the flow measured in the CSSC. The two deductible components are groundwater pumpage contained in the sanitary portion of the transfer, and diverted Des Plaines River watershed runoff. These two deductible components are contained in Columns 4 and 6, respectively.

To determine the two deductible components requires an estimate of the sanitary and runoff portions of the flow transfer. Presently the sanitary and runoff portions of the flow transfer are estimated using the same constituent (sanitary, inflow, and infiltration) proportions simulated for the Upper Des Plaines Pump Station by SCALP (Special Contributing Area Program). Additionally, estimates must be made of the groundwater and Lake Michigan water components contained in the sanitary portion of the transfer. For WY88 it was estimated that the water supply for the O'Hare and Egan service basins was composed of 4.6 percent groundwater (1.0 cfs) and 95.4 percent Lake Michigan Water (19.9 cfs). The diverted Des Plaines River watershed runoff was estimated at 10.1 cfs.

For future accounting, simply measuring the basin transfer will not provide any information on the component makeup of the transfer. Thus, a review of the complex hydraulics and hydrology is necessary to determine the best procedure for estimating these flows. Several alternatives, including flow measurement and modeling are under consideration at this time. A more detailed discussion of the O'Hare and Egan basin transfer can be found in the Lake Michigan Diversion Accounting WY86 Report (USACE, 1991).

GRAND CALUMET RIVER

The flow in the Grand Calumet River drains both to the Lake Michigan via Indiana Harbor and to the Calumet Sag Channel which is tributary to the CSSC. When lake levels are high a larger portion of the flow drains to the Calumet Sag Channel. The Grand Calumet River flow calculation is currently based on a regression equation relating Lake Michigan stages and measured flows in Hart Ditch to the Grand Calumet River flow. Through current meter measurements by MWRDGC and other agencies it was determined that the accuracy of these regression equations are in question.

The Grand Calumet River flow to Illinois is important to diversion accounting because the majority of the flow in the Grand Calumet River is water supply effluent. This is a deduction to the AVM gage record and is contained in Column 5, Water Supply Pumpage from Indiana Reaching the CSSC. The Indiana water supply deduction is equal to the total water supply pumpage discharged to the Grand Calumet River if the pumpage rate is less than the calculated river flow. The deduction is equal to the

river flow if the pumpage rate is greater than the river flow since under these conditions it is assumed that the river flow is composed entirely of sanitary effluent.

This procedure is the only method currently available to calculate the Indiana deduction. A stream gage has been installed for WY90 in the West Branch of the Grand Calumet River to measure flow into Illinois. This should increase the accuracy of this computation significantly. The same computational procedure for separating stream flow into sanitary and runoff will be used with the Grand Calumet stream gage record.

MWRDGC CALUMET WATER RECLAMATION FACILITY

The MWRDGC Calumet Water Reclamation Plant (WRP) balance was discussed in a previous section. For WY87, the Corps of Engineers attempted to improve the SCALP (Special Contributing Area Loading Program) hydraulic simulation model so as to better reflect more recent hydraulic conditions of the Calumet service basin. However, the response of the revised simulation model for WY87 did not result in an improved response. The response for WY88 did however show an improved correlation as it rose from 0.42 for WY87 to 0.52 for WY88. Results for WY89 showed a significant improvement as a result of improved simulation estimates of sanitary discharges and improvements to the Calumet TARP model discussed in previous sections. The improvement of the simulation response was reflected in the correlation coefficient which rose to 0.72 for WY89. However, problems arise with the model during storm events since the Calumet Facility's maximum capacity is only slightly larger than the base flow of the Calumet service basin. The Calumet facility will be increasing its capacity soon, and these changes will be incorporated into the model when they become active.

Review of recent sewer studies and field evaluation of the sewer system may be required to develop a model that would more accurately represent the hydraulic response of the Calumet WRP service basin. Additionally, a portion of the Calumet WRP service area in the vicinity of the Calumet River needs to be investigated to correct errors regarding the presence of combined versus separate sewers.

MWRDGC UPPER DES PLAINES PUMP STATION

A review of the Upper Des Plaines pump station and its flow record indicates that the flow at the pump station is suspect and subject to operator error. Better flow measurement is needed at the pump station. With better flow measurement, this will become the most important balances for calibrating and verifying the simulation models of the Des Plaines watershed. In the diversion

calculation, the primary use of the models is to calculate the deduction for runoff from the Des Plaines watershed discharged to the canal. Runoff from the Des Plaines watershed is deductible. The Upper Des Plaines Pump Station is the only point at which a model of inflow-infiltration can be calibrated and extrapolated to the remaining Des Plaines River watershed. Installation of better flow measurement equipment at the pump station would facilitate model calibration.

CANAL SYSTEM BALANCE

As discussed previously, the canal system balance indicated that the total inflows were 13.6% less than the outflows. Flow meter measurements at the lakefront direct diversion points were conducted in July 1990 to assess if leakage is still significant. This study (USACE, 1990) showed that, given the accuracy limits of the Price AA current meter in extremely low velocity profiles, the lakefront flows are underreported. However, sound conclusions cannot be drawn regarding the magnitude of the underreporting. Consequently, plans are underway to conduct flow measurements at CRCW during WY93. The measurements of leakage through the lock, sluice gates, and crib walls at CRCW will be more accurate since a highly sensitive doppler velocity meter will be used instead of a Price AA current meter which was employed during July 1990. The doppler velocity meter has a lower minimum threshold of approximately 0.03 feet per second while the Price AA meter has a minimum threshold of approximately 0.10 feet per second.

In addition to the problems previously noted, there may be unreported discharges to the CSSC and adjoining waterways that affect the canal system balance. Reconnaissance missions will be made in the future to determine if there are any unreported discharges to the canal system.

PRECIPITATION DATA

The runoff simulation models used to accomplish the diversion accounting are driven by precipitation and other meteorologic data. In performing the WY83 diversion accounting, NIPC discovered problems with the precipitation data related to shielding of the rain gages by buildings and other obstructions. To address this problem, the Illinois State Water Survey (ISWS) was contracted to assess the problem and adjust the precipitation data. The ISWS has also adjusted the WY84 though WY89 data used for Lake Michigan diversion accounting. To resolve the problem, a precipitation gage network of 25 gages was installed by the ISWS under contract with the Corps. However, no data will be available from the network until WY90. Prior to WY90, the precipitation data will be adjusted as in the past.

TUNNEL AND RESERVOIR PLAN

There are several areas where the TARP models can be improved. First, modeling of dry weather flow can be improved to more accurately simulate MWRDGC operational procedures. Second, the incorporation of a pseudo-forecasting algorithm would allow the model to simulate MWRDGC dewatering procedures prior to a storm. Third, dynamic constituent (I-I versus sanitary versus groundwater) tracking can be incorporated to allow more accurate determination of the deductible components of TARP flow. Fourth, the inclusion of an algorithm to operate gaged dropshafts based on average water surface elevation in a tunnel reach would provide better simulation of gage operations.

Additionally, better estimates of the simulated groundwater infiltration rates for the Mainstream TARP model are necessary to better match the simulated to the recorded dry-weather flows. Procedures for accomplishing this are similar to those used for improving the simulated groundwater infiltration rates for Calumet TARP as previously discussed. This will be done for WY90 and should result in more accurate simulations of Mainstream TARP baseflows as well as improvements in the correlation between simulated and recorded TARP flows.

SUMMARY

In compliance with the modified 1980 U.S. Supreme Court decree, the WY89 diversion was computed using the best engineering technology available to date as applied to the diverted watersheds.

Overall, the simulations that comprise a significant portion of the diversion accounting computations worked well. The two most significant budgets to the diversion accounting computations, Budget 7, Northside Water Reclamation Facility, and Budget 10, Stickney Water Reclamation Facility, performed well. Together, Budgets 7 and 10 compute the majority of the deductible Des Plaines River watershed runoff. These budgets have simulated to recorded ratios of 0.97 and 1.03 and correlations of 0.80 and 0.74, respectively. Given the complexity of the hydrologic cycle in the heavily urbanized Chicago metropolitan area, and given the number of human and other factors that cannot be adequately represented in numerical modeling procedures, the results of these two budgets are very good. Other simulation budgets have performed reasonably well, but there is room for improvement. Areas of improvement previously outlined will be considered in order to improve the accuracy of the diversion computation.

The WY89 diversion accountable to the State of Illinois is 3,377.9 cfs. This is 177.9 cfs greater than the 3,200 cfs average specified by the Decree. The 40 year running average beginning with WY81 and rounded to the nearest cfs is 3,443 cfs, and the cumulative deviation from the 3,200 cfs average is -2,189 cfs-years. The negative cumulative deviation indicates a water allocation deficit and the maximum allowable deficit is 2,000 cfs-years.

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Lake Michigan Diversion Accounting

Water Year 1989 Report

Appendix A

Summary of Daily Diversion Flows

COLUMN COMPUTATIONS:

1. COLUMN 3 = COLUMN 1 + COLUMN 2
2. COLUMN 8 = COLUMN 4 + COLUMN 5 + COLUMN 6 + COLUMN 7
3. COLUMN 10 = COLUMN 3 – COLUMN 8 + COLUMN 9

NOTES:

1. ALL VALUES ARE ROUNDED TO THE NEAREST TENTH.
2. MATHEMATICAL COMPUTATIONS BETWEEN COLUMNS UTILIZE UNROUNDED VALUES.

LEGEND:

DEDUCTIONS FROM THE ROMEOVILLE GAGE RECORD

ADDITIONS TO THE ROMEOVILLE GAGE RECORD

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Oct-88	2885	1.2	2886.2	25.6	27.8	42.6	2.2	98.2	100.9	2886.9	1781.0	214.4	294.0
02-Oct-88	4364	1.2	4365.2	304.8	27.8	256.0	2.2	590.8	104.5	3878.9	1711.1	1623.8	496.0
03-Oct-88	3638	1.2	3639.2	45.3	27.8	19.8	2.2	95.0	102.1	3646.3	1788.6	158.2	639.0
04-Oct-88	2559	1.2	2560.2	22.9	27.8	15.3	2.2	68.3	102.3	2594.2	1740.8	73.1	320.0
05-Oct-88	2178	1.2	2179.2	79.3	27.8	15.9	2.2	125.2	102.1	2156.1	1768.6	85.1	126.0
06-Oct-88	2084	1.2	2085.2	47.2	27.8	14.7	2.2	91.8	99.7	2093.1	1757.7	56.7	157.0
07-Oct-88	2584	1.2	2585.2	25.6	27.8	13.3	2.2	68.9	100.4	2616.6	1775.5	37.1	468.0
08-Oct-88	3190	1.2	3191.2	74.9	27.8	13.9	2.2	118.8	100.5	3172.9	1760.8	56.9	698.0
09-Oct-88	2803	1.2	2804.2	67.4	27.8	14.1	2.2	111.5	97.5	2790.2	1689.4	55.1	703.0
10-Oct-88	2542	1.2	2543.2	25.7	27.8	12.4	2.2	68.0	104.2	2579.4	1808.5	39.8	633.0
11-Oct-88	2708	1.2	2709.2	92.9	27.8	13.8	2.2	136.8	105.8	2678.4	1784.3	74.0	644.0
12-Oct-88	2828	1.2	2829.2	46.5	27.8	12.9	2.2	89.4	103.7	2843.4	1784.4	33.3	667.0
13-Oct-88	2794	1.2	2795.2	25.6	27.8	12.1	2.2	67.9	103.5	2830.8	1780.5	26.6	660.0
14-Oct-88	2437	1.2	2438.2	60.1	27.8	12.4	2.2	102.5	103.7	2439.4	1811.0	40.1	644.0
15-Oct-88	2879	1.2	2880.2	79.3	27.8	126.1	2.2	235.4	102.9	2747.7	1848.8	404.0	576.0
16-Oct-88	3481	1.2	3482.2	145.6	27.8	46.6	2.2	222.0	102.6	3362.7	1740.7	361.1	459.0
17-Oct-88	7092	1.2	7093.2	139.2	27.8	614.6	2.2	783.8	119.3	6426.6	1744.2	5456.8	195.0
18-Oct-88	5908	1.2	5909.2	391.2	27.8	182.9	2.2	604.1	105.7	5410.9	1761.8	2255.5	116.0
19-Oct-88	4262	1.2	4263.2	27.6	27.8	106.6	2.2	164.2	105.1	4204.1	1751.9	617.1	333.0
20-Oct-88	3594	1.2	3595.2	25.2	27.8	64.8	2.2	120.0	104.0	3579.2	1737.2	289.3	439.0
21-Oct-88	2862	1.2	2863.2	25.4	27.8	41.5	2.2	96.9	103.5	2869.8	1717.8	218.4	893.0
22-Oct-88	3414	1.2	3415.2	110.5	27.8	31.6	2.2	172.1	102.6	3345.5	1724.1	191.6	678.0
23-Oct-88	3831	1.2	3832.2	199.7	27.8	212.9	2.2	442.6	106.2	3495.9	1660.7	1194.2	526.0
24-Oct-88	3161	1.2	3162.2	25.2	27.8	43.2	2.2	98.4	103.4	3167.2	1723.1	329.5	610.0
25-Oct-88	3125	1.2	3126.2	25.4	27.8	32.2	2.2	87.6	103.6	3142.2	1733.3	191.0	725.0
26-Oct-88	3471	1.2	3472.2	63.8	27.8	28.0	2.2	121.8	103.3	3453.7	1726.6	167.4	1360.0
27-Oct-88	3161	1.2	3162.2	67.4	27.8	24.7	2.2	122.1	104.0	3164.0	1719.8	137.0	691.0
28-Oct-88	2561	1.2	2562.2	25.7	27.8	23.0	2.2	78.7	104.8	2588.1	1692.5	111.2	607.0
29-Oct-88	2532	1.2	2533.2	120.7	27.8	25.5	2.2	176.2	103.1	2460.1	1671.7	148.2	604.0
30-Oct-88	2627	1.2	2628.2	22.9	27.8	20.7	2.2	73.7	101.9	2656.4	1722.3	85.8	629.0
31-Oct-88	2727	1.2	2728.2	25.7	27.8	21.4	2.2	77.1	104.7	2755.8	1702.8	85.1	533.0
OCT 88	3235.5	1.2	3236.7	79.5	27.8	68.2	2.2	177.7	103.8	3162.6	1745.9	478.0	552.4

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Nov-88	2081	0.6	2081.6	44.7	27.2	21.9	2.5	96.3	98.1	2083.3	1708.4	93.5	91.0
02-Nov-88	2093	0.6	2093.6	90.6	27.2	22.7	2.5	142.9	99.6	2049.3	1719.4	114.1	117.0
03-Nov-88	2155	0.6	2155.6	25.7	27.2	21.0	2.5	76.4	99.9	2179.1	1723.9	82.8	97.0
04-Nov-88	5137	0.6	5137.5	116.7	27.2	430.1	2.5	576.5	107.7	4668.8	1707.9	2923.2	143.0
05-Nov-88	3678	0.6	3678.6	296.2	27.2	182.1	2.5	507.9	97.6	3268.2	1653.2	1093.7	127.0
06-Nov-88	3991	0.6	3991.6	45.7	27.2	205.2	2.5	280.6	98.5	3809.5	1626.9	1197.7	80.0
07-Nov-88	2821	0.6	2821.6	126.1	27.2	88.0	2.5	243.8	97.6	2675.4	1685.6	545.5	99.0
08-Nov-88	2781	0.6	2781.6	25.3	27.2	49.2	2.5	104.2	97.8	2775.1	1705.6	278.2	303.0
09-Nov-88	5501	0.6	5501.5	50.9	27.2	726.4	2.5	807.1	108.4	4802.8	1687.3	3306.0	179.0
10-Nov-88	6449	0.6	6449.5	250.9	27.2	586.9	2.5	867.5	101.6	5683.9	1688.4	3468.5	87.0
11-Nov-88	5426	0.6	5426.5	293.0	27.2	343.3	2.6	666.1	97.2	4857.7	1686.1	1808.0	92.0
12-Nov-88	4925	0.6	4925.5	83.6	27.2	611.3	2.4	724.5	105.4	4306.5	1658.4	2331.1	413.0
13-Nov-88	4988	0.6	4988.5	232.1	27.2	344.8	2.5	606.5	96.0	4478.0	1635.1	1655.0	125.0
14-Nov-88	3035	0.6	3035.6	29.5	27.2	209.2	2.5	268.4	97.7	2864.9	1685.0	911.3	109.0
15-Nov-88	6787	0.6	6787.5	62.7	27.2	530.8	2.5	623.2	104.8	6269.1	1711.6	3133.1	80.0
16-Nov-88	6570	0.6	6570.5	93.9	27.2	730.5	2.5	854.1	102.7	5819.1	1704.9	4555.2	51.0
17-Nov-88	4112	0.6	4112.5	258.1	27.2	388.3	2.5	676.1	98.4	3534.8	1688.7	2030.8	71.0
18-Nov-88	4216	0.6	4216.5	277.2	27.2	248.1	2.5	555.0	99.5	3760.0	1686.9	1218.5	70.0
19-Nov-88	5191	0.6	5191.5	149.6	27.2	404.6	2.5	584.1	99.9	4707.3	1658.0	2331.1	85.0
20-Nov-88	4760	0.6	4760.5	60.2	27.2	213.1	2.5	303.0	97.2	4554.7	1623.0	1291.5	312.0
21-Nov-88	4594	0.6	4594.5	27.2	27.2	147.3	2.5	204.2	98.1	4488.4	1678.0	855.4	1059.0
22-Nov-88	3978	0.6	3978.6	26.5	27.2	111.9	2.5	168.1	99.4	3908.9	1666.9	625.6	1018.0
23-Nov-88	3145	0.6	3145.6	114.2	27.2	96.6	2.5	240.4	98.5	3003.6	1704.9	538.6	95.0
24-Nov-88	2436	0.6	2436.6	24.8	27.2	84.4	2.5	138.9	97.0	2394.6	1628.7	411.3	69.0
25-Nov-88	2614	0.6	2614.6	24.9	27.2	79.5	2.5	134.2	97.1	2577.5	1617.8	365.3	95.0
26-Nov-88	3549	0.6	3549.6	274.2	27.2	357.7	2.5	661.6	100.7	2988.6	1613.0	1621.4	62.0
27-Nov-88	3125	0.6	3125.6	30.1	27.2	233.3	2.5	293.1	98.7	2929.1	1585.1	839.4	68.0
28-Nov-88	2942	0.6	2942.6	129.1	27.2	164.7	2.5	323.5	99.0	2717.0	1676.6	567.7	74.0
29-Nov-88	2334	0.6	2334.6	24.9	27.2	129.4	2.5	184.1	99.5	2249.0	1686.4	443.5	72.0
30-Nov-88	2439	0.6	2439.6	24.9	27.2	102.5	2.5	157.1	99.3	2380.7	1662.4	362.5	83.0
NOV 88	3928.4	0.6	3929.0	110.5	27.2	262.2	2.5	402.3	99.5	3626.2	1672.1	1366.6	180.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Dec-88	2385	1.1	2386.1	106.5	27.2	96.4	2.6	234.8	102.3	2253.6	1650.2	375.5	98.0
02-Dec-88	2674	1.1	2675.1	25.5	27.2	85.3	2.7	140.7	102.5	2636.9	1656.8	301.1	85.0
03-Dec-88	2066	1.1	2067.1	27.4	27.2	81.9	2.6	139.2	100.9	2028.8	1646.5	279.0	91.0
04-Dec-88	2735	1.1	2736.1	73.0	27.2	90.1	2.6	183.0	100.2	2653.3	1618.3	287.6	466.0
05-Dec-88	3689	1.1	3690.1	64.5	27.2	77.7	2.7	172.1	101.7	3619.6	1659.5	260.6	958.0
06-Dec-88	3364	1.1	3365.1	25.6	27.2	74.7	2.6	130.2	102.1	3337.0	1695.1	231.0	931.0
07-Dec-88	2031	1.1	2032.1	25.7	27.2	73.1	2.6	128.5	102.2	2005.8	1676.3	220.5	73.0
08-Dec-88	2569	1.1	2570.1	118.4	27.2	75.5	2.6	223.7	102.3	2448.7	1666.1	265.3	87.0
09-Dec-88	2088	1.1	2089.1	25.1	27.2	69.6	2.7	124.6	101.6	2066.1	1667.4	199.8	83.0
10-Dec-88	2104	1.1	2105.1	89.9	27.2	70.4	2.5	190.0	99.3	2014.4	1636.5	229.2	78.0
11-Dec-88	2149	1.1	2150.1	44.3	27.2	67.2	2.6	141.3	100.6	2109.3	1611.4	189.7	86.0
12-Dec-88	2140	1.1	2141.1	24.9	27.2	64.9	2.6	119.6	101.3	2122.8	1677.9	171.2	60.0
13-Dec-88	2297	1.1	2298.1	24.9	27.2	63.7	2.8	118.6	102.5	2282.0	1705.2	180.1	76.0
14-Dec-88	2403	1.1	2404.1	114.3	27.2	65.3	3.0	209.9	103.8	2298.0	1695.5	219.7	76.0
15-Dec-88	2005	1.1	2006.1	25.0	27.2	60.6	2.7	115.5	102.2	1992.7	1696.3	162.8	76.0
16-Dec-88	2179	1.1	2180.1	77.8	27.2	61.2	2.6	168.8	102.0	2113.3	1697.0	183.4	72.0
17-Dec-88	2086	1.1	2087.1	66.7	27.2	59.5	2.6	156.1	102.0	2033.0	1679.8	174.5	73.0
18-Dec-88	2255	1.1	2256.1	25.0	27.2	56.6	2.7	111.5	101.2	2245.9	1657.7	144.8	69.0
19-Dec-88	2180	1.1	2181.1	91.2	27.2	57.7	2.6	178.7	103.7	2106.1	1705.0	179.8	75.0
20-Dec-88	2275	1.1	2276.1	44.8	27.2	77.8	2.7	152.5	102.2	2225.8	1737.1	182.2	69.0
21-Dec-88	1940	1.1	1941.1	25.1	27.2	59.3	2.7	114.3	101.9	1928.7	1704.8	145.9	75.0
22-Dec-88	3783	1.1	3784.1	47.3	27.2	462.9	2.7	540.2	109.8	3353.7	1701.2	1922.5	188.0
23-Dec-88	4822	1.1	4823.1	311.0	27.2	360.9	2.6	701.7	101.8	4223.2	1668.4	1779.3	53.0
24-Dec-88	3524	1.1	3525.1	102.0	27.2	227.7	2.6	359.5	99.7	3264.3	1659.7	957.5	58.0
25-Dec-88	2960	1.1	2961.1	28.0	27.2	142.8	2.4	200.4	99.8	2860.5	1571.3	583.7	54.0
26-Dec-88	2468	1.1	2469.1	191.9	27.2	374.7	2.6	596.5	101.0	1973.7	1573.1	999.5	59.0
27-Dec-88	5180	1.1	5181.1	144.1	27.2	742.8	2.3	916.5	107.3	4372.0	1642.3	2952.9	54.0
28-Dec-88	4913	1.1	4914.1	317.2	27.2	441.2	2.5	788.1	99.7	4225.8	1665.6	1759.2	59.0
29-Dec-88	2851	1.1	2852.1	65.3	27.2	241.2	2.3	336.0	101.6	2617.7	1660.1	730.6	61.0
30-Dec-88	3594	1.1	3595.1	29.5	27.2	165.5	2.6	224.9	101.8	3472.0	1658.5	596.4	77.0
31-Dec-88	2539	1.1	2540.1	123.4	27.2	154.6	2.6	307.7	100.9	2333.3	1633.5	740.9	68.0
DEC 88	2782.2	1.1	2783.3	80.9	27.2	154.6	2.6	265.3	102.0	2619.9	1663.7	567.9	144.8

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jan-89	2716	2.1	2718.1	45.9	27.3	109.6	1.8	184.5	96.3	2629.8	1581.0	521.1	80.0
02-Jan-89	2309	2.1	2311.1	24.7	27.3	102.3	1.8	156.0	97.2	2252.3	1621.5	419.5	66.0
03-Jan-89	2449	2.1	2451.1	131.3	27.3	88.8	1.7	249.1	95.2	2297.2	1690.2	396.8	78.0
04-Jan-89	2540	2.1	2542.1	27.7	27.3	81.1	1.8	137.9	96.6	2502.8	1693.3	342.4	77.0
05-Jan-89	3013	2.1	3015.1	43.0	27.3	461.4	1.8	533.3	102.9	2584.7	1713.8	1557.4	187.0
06-Jan-89	4013	2.1	4015.1	354.3	27.3	456.4	1.8	839.7	102.9	3278.3	1677.2	2188.8	88.0
07-Jan-89	4156	2.1	4158.1	243.4	27.3	429.7	1.8	702.2	104.3	3560.3	1659.1	2475.3	76.0
08-Jan-89	4612	2.1	4614.1	133.6	27.3	278.6	1.8	441.2	95.5	4268.4	1635.2	2056.1	47.0
09-Jan-89	3563	2.1	3565.1	27.1	27.3	199.4	1.8	255.6	97.4	3406.9	1701.7	1183.4	69.0
10-Jan-89	2972	2.1	2974.1	132.2	27.3	157.7	1.8	318.9	97.0	2752.1	1713.2	872.6	69.0
11-Jan-89	2730	2.1	2732.1	24.6	27.3	139.5	1.8	193.1	96.9	2635.9	1701.3	672.0	76.0
12-Jan-89	3159	2.1	3161.1	31.6	27.3	177.3	1.8	238.0	97.3	3020.4	1705.8	800.4	74.0
13-Jan-89	2512	2.1	2514.1	123.9	27.3	140.3	1.8	293.3	96.9	2317.7	1691.8	583.2	82.0
14-Jan-89	2568	2.1	2570.1	25.5	27.3	118.8	1.8	173.3	94.1	2490.9	1677.2	482.7	79.0
15-Jan-89	2327	2.1	2329.1	24.8	27.3	106.4	1.8	160.3	94.1	2262.9	1638.6	412.3	57.0
16-Jan-89	2483	2.1	2485.1	99.7	27.3	110.5	1.8	239.1	97.3	2343.3	1696.5	450.4	59.0
17-Jan-89	2557	2.1	2559.1	43.4	27.3	113.0	1.8	185.4	97.4	2471.1	1713.6	398.6	69.0
18-Jan-89	2266	2.1	2268.1	24.9	27.3	102.1	1.8	156.0	96.1	2210.2	1685.2	356.6	73.0
19-Jan-89	2465	2.1	2467.1	110.8	27.3	98.4	1.8	238.3	97.0	2325.9	1696.9	388.8	79.0
20-Jan-89	2262	2.1	2264.1	25.7	27.3	92.5	1.8	147.2	97.5	2214.4	1693.2	343.1	94.0
21-Jan-89	2442	2.1	2444.1	25.7	27.3	90.1	1.7	144.8	96.6	2395.9	1652.5	316.2	72.0
22-Jan-89	2384	2.1	2386.1	72.3	27.3	89.8	1.8	191.1	96.5	2291.5	1659.8	301.2	62.0
23-Jan-89	1969	2.1	1971.1	64.4	27.3	87.6	1.8	181.1	97.5	1887.6	1701.6	288.3	67.0
24-Jan-89	2310	2.1	2312.1	25.7	27.3	82.0	1.8	136.6	96.2	2273.6	1689.3	263.3	85.0
25-Jan-89	2618	2.1	2620.1	65.2	27.3	104.0	1.8	198.2	95.4	2517.3	1659.4	383.9	77.0
26-Jan-89	2777	2.1	2779.1	87.9	27.3	98.6	1.8	215.5	94.7	2658.3	1672.1	528.3	80.0
27-Jan-89	2467	2.1	2469.1	27.5	27.3	88.7	1.8	145.3	94.1	2417.9	1657.6	389.9	74.0
28-Jan-89	2545	2.1	2547.1	47.1	27.3	121.2	1.8	197.4	92.4	2442.2	1656.6	469.6	75.0
29-Jan-89	2747	2.1	2749.1	126.9	27.3	156.8	1.8	322.8	93.9	2520.2	1604.7	790.1	55.0
30-Jan-89	2477	2.1	2479.1	25.1	27.3	104.0	1.8	158.1	94.6	2415.5	1664.0	438.8	66.0
31-Jan-89	2632	2.1	2634.1	125.0	27.3	93.8	1.8	247.9	94.9	2481.1	1690.0	456.9	72.0
JAN 89	2743.2	2.1	2745.3	77.1	27.3	151.3	1.8	257.5	96.9	2584.7	1674.0	694.4	76.3

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Feb-89	2406	1.6	2407.6	25.0	27.2	83.3	2.1	137.6	83.9	2363.9	1654.3	369.2	81.0
02-Feb-89	2359	1.6	2360.6	25.0	27.2	79.0	2.2	133.3	82.7	2320.0	1671.5	323.2	69.0
03-Feb-89	2392	1.6	2393.6	130.2	27.2	79.8	2.2	239.4	92.0	2246.1	1661.3	348.5	84.0
04-Feb-89	2287	1.6	2288.6	24.9	27.2	73.0	2.2	127.3	82.3	2253.6	1624.1	248.8	64.0
05-Feb-89	2251	1.6	2252.6	25.0	27.2	70.5	2.2	124.8	82.1	2219.9	1615.4	240.8	68.0
06-Feb-89	2684	1.6	2685.6	42.1	27.2	69.0	2.2	140.5	84.1	2639.2	1666.1	246.1	83.0
07-Feb-89	2106	1.6	2107.6	86.5	27.2	68.9	2.2	184.7	93.0	2015.9	1682.4	258.0	60.0
08-Feb-89	2448	1.6	2449.6	25.0	27.2	65.0	2.2	119.5	84.5	2424.6	1683.0	214.9	78.0
09-Feb-89	2333	1.6	2334.6	44.3	27.2	64.2	2.3	138.0	84.2	2290.8	1698.4	212.3	50.0
10-Feb-89	1980	1.6	1981.6	89.5	27.2	63.8	2.2	182.7	85.0	1893.9	1687.7	229.5	70.0
11-Feb-89	2405	1.6	2406.6	24.9	27.2	59.8	1.9	113.7	81.7	2384.5	1660.0	207.5	68.0
12-Feb-89	2363	1.6	2364.6	95.9	27.2	105.4	2.2	230.6	92.7	2226.6	1649.0	353.3	72.0
13-Feb-89	2551	1.6	2552.6	54.4	27.2	126.9	2.3	210.7	84.1	2436.0	1672.1	467.3	57.0
14-Feb-89	2493	1.6	2494.6	41.9	27.2	178.7	2.2	250.0	95.3	2339.8	1700.5	721.5	65.0
15-Feb-89	2584	1.6	2585.6	129.4	27.2	78.9	2.2	237.6	92.6	2440.6	1698.0	422.9	72.0
16-Feb-89	2356	1.6	2357.6	22.9	27.2	73.3	2.1	125.4	84.6	2326.8	1685.9	235.5	66.0
17-Feb-89	2390	1.6	2391.6	30.9	27.2	133.2	2.3	193.5	84.9	2292.9	1692.2	355.0	69.0
18-Feb-89	2149	1.6	2150.6	111.1	27.2	84.0	2.3	224.5	81.8	2017.9	1660.7	262.3	59.0
19-Feb-89	2331	1.6	2332.6	27.7	27.2	157.4	2.2	214.6	92.9	2210.9	1623.8	365.7	64.0
20-Feb-89	2270	1.6	2271.6	26.0	27.2	69.2	2.2	126.6	84.4	2239.4	1663.7	350.1	65.0
21-Feb-89	2566	1.6	2567.6	113.1	27.2	69.1	2.2	211.6	84.6	2450.5	1668.1	350.8	68.0
22-Feb-89	2381	1.6	2382.6	31.9	27.2	197.9	2.2	259.2	89.3	2219.7	1658.3	684.6	74.0
23-Feb-89	2273	1.6	2274.6	120.5	27.2	181.7	2.3	331.7	95.1	2038.0	1668.0	491.1	87.0
24-Feb-89	2309	1.6	2310.6	27.9	27.2	79.0	2.3	136.4	93.1	2267.3	1671.4	254.7	85.0
25-Feb-89	2229	1.6	2230.6	110.7	27.2	267.6	2.3	407.8	88.2	1921.0	1638.4	998.3	83.0
26-Feb-89	2235	1.6	2236.6	154.8	27.2	166.4	2.3	350.6	94.0	1980.0	1619.9	879.6	59.0
27-Feb-89	2285	1.6	2286.6	25.4	27.2	74.0	2.3	128.9	83.9	2251.5	1664.5	229.5	70.0
28-Feb-89	2293	1.6	2294.6	119.2	27.2	57.3	2.2	205.9	83.7	2182.4	1654.3	228.3	68.0
FEB 89	2346.8	1.6	2348.4	63.9	27.2	102.7	2.2	196.0	83.9	2246.2	1664.0	376.8	69.9

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Mar-89	2343	1.0	2344.0	25.7	27.4	43.7	2.7	99.4	93.6	2338.2	1688.8	139.8	82.0
02-Mar-89	1867	1.0	1868.0	25.3	27.4	38.1	2.6	93.4	88.3	1862.9	1648.1	122.3	82.0
03-Mar-89	2833	1.0	2834.0	122.4	27.4	357.1	2.7	509.6	75.5	2419.9	1643.3	842.3	78.0
04-Mar-89	4901	1.0	4902.0	188.4	27.4	722.6	2.7	941.0	99.6	4060.6	1631.7	2830.6	56.0
05-Mar-89	4243	1.0	4244.0	291.0	27.4	121.6	2.8	442.9	90.9	3892.0	1624.1	1090.4	78.0
06-Mar-89	3162	1.0	3163.0	58.2	27.4	67.1	2.9	155.6	92.2	3099.6	1667.4	587.5	93.0
07-Mar-89	3044	1.0	3045.0	25.2	27.4	53.4	2.8	108.8	90.9	3027.1	1665.8	423.9	87.0
08-Mar-89	3000	1.0	3001.0	109.4	27.4	161.7	2.8	301.2	94.7	2794.5	1681.5	577.2	63.0
09-Mar-89	2616	1.0	2617.0	173.3	27.4	266.8	2.9	470.4	95.5	2242.1	1662.8	824.8	81.0
10-Mar-89	2925	1.0	2926.0	64.1	27.4	137.0	2.9	231.4	93.2	2787.9	1661.6	612.1	68.0
11-Mar-89	2751	1.0	2752.0	25.1	27.4	81.9	2.9	137.2	89.6	2704.4	1653.8	632.3	74.0
12-Mar-89	2949	1.0	2950.0	131.0	27.4	67.8	2.5	228.6	90.0	2811.4	1606.1	646.9	61.0
13-Mar-89	3000	1.0	3001.0	25.2	27.4	57.2	2.7	112.4	91.1	2979.7	1657.3	475.9	75.0
14-Mar-89	2965	1.0	2966.0	68.0	27.4	134.4	2.6	232.4	93.7	2827.3	1647.7	853.5	57.0
15-Mar-89	2361	1.0	2362.0	169.1	27.4	124.9	2.6	323.9	92.4	2130.5	1658.7	757.1	41.0
16-Mar-89	3903	1.0	3904.0	28.0	27.4	89.9	2.7	148.0	90.7	3846.7	1667.4	476.5	35.0
17-Mar-89	3579	1.0	3580.0	50.0	27.4	431.8	2.6	511.7	97.2	3165.5	1648.9	1816.1	105.0
18-Mar-89	3553	1.0	3554.0	186.9	27.4	369.8	2.6	586.7	91.9	3059.3	1642.8	1588.7	44.0
19-Mar-89	3908	1.0	3909.0	190.4	27.4	360.6	2.7	581.1	90.8	3418.2	1621.6	1225.8	35.0
20-Mar-89	3551	1.0	3552.0	155.9	27.4	344.8	2.6	530.7	95.2	3116.6	1651.4	1107.2	62.0
21-Mar-89	2808	1.0	2809.0	76.2	27.4	193.0	2.7	299.2	92.4	2602.3	1678.7	784.6	60.0
22-Mar-89	2985	1.0	2986.0	27.1	27.4	137.2	2.8	194.4	93.3	2884.9	1655.7	568.6	58.0
23-Mar-89	2999	1.0	3000.0	131.1	27.4	126.0	2.8	287.2	92.2	2805.0	1676.0	556.0	58.0
24-Mar-89	2499	1.0	2500.0	27.4	27.4	97.9	2.8	155.5	91.7	2436.2	1645.0	372.9	62.0
25-Mar-89	2488	1.0	2489.0	24.8	27.4	88.3	2.8	143.3	88.6	2434.3	1643.4	323.4	65.0
26-Mar-89	2708	1.0	2709.0	74.3	27.4	84.4	2.7	188.7	90.3	2610.6	1600.4	329.0	77.0
27-Mar-89	2491	1.0	2492.0	79.1	27.4	82.6	2.8	191.8	91.8	2392.0	1651.2	306.1	78.0
28-Mar-89	4221	1.0	4222.0	134.1	27.4	372.3	2.8	536.5	99.1	3784.6	1657.9	1649.1	67.0
29-Mar-89	3203	1.0	3204.0	190.7	27.4	237.0	2.8	457.8	92.5	2838.7	1670.8	1206.4	68.0
30-Mar-89	3087	1.0	3088.0	24.5	27.4	160.0	2.5	214.3	93.0	2966.7	1662.8	714.9	67.0
31-Mar-89	3128	1.0	3129.0	27.7	27.4	124.0	2.6	181.7	91.7	3039.0	1655.7	530.6	55.0
MAR 89	3099.1	1.0	3100.1	94.5	27.4	195.9	2.7	309.6	92.7	2883.2	1652.5	805.6	66.8

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Apr-89	3018	1.6	3019.6	63.0	27.5	105.4	2.5	198.4	95.0	2916.3	1638.2	440.7	81.0
02-Apr-89	2745	1.6	2746.6	84.7	27.5	182.5	2.5	297.2	94.1	2543.6	1548.0	719.7	61.0
03-Apr-89	3091	1.6	3092.6	34.7	27.5	218.6	2.6	283.6	96.4	2905.5	1652.8	1069.4	55.0
04-Apr-89	3016	1.6	3017.6	125.5	27.5	182.0	2.5	337.6	96.2	2776.3	1637.0	1054.6	47.0
05-Apr-89	2927	1.6	2928.6	43.0	27.5	138.1	2.5	211.1	96.6	2814.2	1673.0	717.4	58.0
06-Apr-89	2942	1.6	2943.6	27.1	27.5	115.5	2.6	172.7	96.4	2867.3	1665.4	559.3	71.0
07-Apr-89	2967	1.6	2968.6	24.7	27.5	102.5	2.6	157.2	99.0	2909.5	1651.5	455.8	69.0
08-Apr-89	2333	1.6	2334.6	127.4	27.5	100.2	2.6	257.7	94.7	2171.6	1633.1	462.5	80.0
09-Apr-89	2634	1.6	2635.6	24.8	27.5	91.1	2.5	145.9	94.1	2583.8	1601.7	357.4	78.0
10-Apr-89	2310	1.6	2311.6	24.6	27.5	86.1	2.2	142.6	96.3	2265.3	1676.6	308.5	64.0
11-Apr-89	2419	1.6	2420.6	100.1	27.5	86.5	2.6	218.8	96.0	2297.8	1660.8	323.7	78.0
12-Apr-89	2248	1.6	2249.6	42.4	27.5	84.5	2.5	156.9	95.4	2188.1	1664.0	275.7	98.0
13-Apr-89	2391	1.6	2392.6	26.2	27.5	82.9	2.5	141.1	95.9	2347.5	1666.4	260.7	101.0
14-Apr-89	2257	1.6	2258.6	25.0	27.5	79.7	2.3	134.6	95.8	2219.9	1672.3	244.5	98.0
15-Apr-89	2465	1.6	2466.6	115.0	27.5	80.5	2.5	225.6	96.4	2337.5	1672.2	286.4	138.0
16-Apr-89	2658	1.6	2659.6	24.9	27.5	74.3	2.5	129.2	94.4	2624.8	1665.4	224.5	135.0
17-Apr-89	2087	1.6	2088.6	24.9	27.5	71.5	2.5	126.5	96.2	2058.3	1688.7	232.5	73.0
18-Apr-89	3018	1.6	3019.6	151.7	27.5	102.9	2.3	284.3	96.6	2831.9	1680.4	475.4	95.0
19-Apr-89	2446	1.6	2447.6	30.2	27.5	82.4	1.6	141.8	95.8	2401.3	1674.3	344.5	97.0
20-Apr-89	2776	1.6	2777.6	24.6	27.5	74.6	1.6	128.5	95.6	2745.0	1685.3	256.9	123.0
21-Apr-89	1995	1.6	1996.6	24.9	27.5	68.5	1.6	122.5	95.7	1969.9	1709.2	222.3	132.0
22-Apr-89	2448	1.6	2449.6	116.8	27.5	67.7	1.6	213.6	94.6	2330.7	1670.2	255.6	149.0
23-Apr-89	2238	1.6	2239.6	25.6	27.5	61.1	1.6	115.8	94.2	2218.0	1665.0	193.7	171.0
24-Apr-89	2445	1.6	2446.6	25.6	27.5	58.0	1.6	112.7	97.6	2431.5	1737.9	183.2	113.0
25-Apr-89	2484	1.6	2485.6	165.3	27.5	89.3	1.6	283.7	97.7	2299.7	1768.5	375.9	115.0
26-Apr-89	2834	1.6	2835.6	25.1	27.5	57.7	1.6	111.9	95.8	2819.6	1752.5	233.3	121.0
27-Apr-89	1887	1.6	1888.6	25.3	27.5	53.3	1.6	107.7	95.9	1876.8	1765.4	196.6	133.0
28-Apr-89	3601	1.6	3602.6	159.3	27.5	349.0	1.6	537.4	100.7	3165.9	1701.1	1441.6	106.0
29-Apr-89	3119	1.6	3120.6	99.1	27.5	111.7	1.6	239.9	94.4	2975.2	1667.3	491.3	133.0
30-Apr-89	2727	1.6	2728.6	24.9	27.5	79.8	1.6	133.7	93.8	2668.7	1660.1	297.6	150.0
APR 89	2617.5	1.6	2619.1	61.3	27.5	104.7	2.1	195.7	95.9	2519.4	1674.1	432.0	100.8

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-May-89	2257	0.6	2257.6	25.7	28.0	64.8	1.5	119.9	111.0	2248.7	1717.8	224.2	99.0
02-May-89	2500	0.6	2500.6	120.9	28.0	59.7	1.5	210.0	110.5	2401.1	1705.4	255.1	98.0
03-May-89	2498	0.6	2498.6	25.2	28.0	50.9	1.5	105.5	110.6	2503.7	1726.9	182.5	132.0
04-May-89	2676	0.6	2676.6	25.5	28.0	47.3	1.5	102.3	110.1	2684.4	1739.7	167.4	109.0
05-May-89	2780	0.6	2780.6	130.5	28.0	48.6	1.5	208.5	110.1	2682.2	1685.0	251.4	109.0
06-May-89	1966	0.6	1966.6	25.2	28.0	42.9	1.5	97.5	109.7	1977.8	1647.5	174.4	120.0
07-May-89	2733	0.6	2733.6	25.2	28.0	41.3	1.5	96.0	109.8	2746.4	1644.1	152.9	135.0
08-May-89	2143	0.6	2143.6	54.9	28.0	40.9	1.5	125.2	110.6	2128.9	1719.7	164.8	109.0
09-May-89	2448	0.6	2448.6	83.1	28.0	40.3	1.5	152.9	110.4	2406.0	1719.2	172.2	112.0
10-May-89	2293	0.6	2293.6	25.2	28.0	36.2	1.5	90.8	110.7	2313.4	1769.0	125.8	130.0
11-May-89	2227	0.6	2227.6	25.2	28.0	34.0	1.5	88.7	110.8	2249.7	1796.9	114.6	132.0
12-May-89	2383	0.6	2383.6	107.9	28.0	35.3	1.5	172.6	112.0	2323.0	1793.5	149.6	147.0
13-May-89	2166	0.6	2166.6	25.2	28.0	30.8	1.5	85.4	109.9	2191.0	1772.4	100.2	165.0
14-May-89	2343	0.6	2343.6	25.2	28.0	29.4	1.5	84.1	109.6	2369.2	1805.5	94.5	168.0
15-May-89	2168	0.6	2168.6	103.4	28.0	31.1	1.5	163.9	112.0	2116.7	1857.6	137.0	139.0
16-May-89	2317	0.6	2317.6	25.3	28.0	27.0	1.5	81.8	113.8	2349.3	1983.2	88.7	151.0
17-May-89	2293	0.6	2293.6	25.7	28.0	25.5	1.5	80.6	110.9	2323.9	2013.8	82.2	170.0
18-May-89	2702	0.6	2702.6	108.6	28.0	26.4	1.5	164.4	115.7	2653.9	1905.6	127.3	136.0
19-May-89	3740	0.6	3740.6	115.3	28.0	226.1	1.5	370.9	115.9	3485.6	1723.9	1427.7	120.0
20-May-89	3158	0.6	3158.6	176.8	28.0	65.4	1.5	271.6	111.0	2998.0	1725.9	970.4	162.0
21-May-89	3132	0.6	3132.6	27.1	28.0	50.3	1.5	106.8	111.9	3137.7	1780.8	390.3	84.0
22-May-89	2923	0.6	2923.6	25.0	28.0	37.4	1.5	91.8	112.6	2944.2	1832.0	233.2	111.0
23-May-89	2485	0.6	2485.6	127.7	28.0	34.6	1.5	191.7	117.3	2411.1	1974.9	223.2	166.0
24-May-89	3006	0.6	3006.6	25.2	28.0	26.6	1.5	81.3	114.4	3039.7	1950.3	139.9	132.0
25-May-89	3892	0.6	3892.6	41.9	28.0	88.5	1.5	159.9	118.8	3849.5	1844.9	953.8	694.0
26-May-89	3187	0.6	3187.6	84.0	28.0	38.3	1.5	151.8	113.1	3148.9	1830.2	500.6	138.0
27-May-89	2998	0.6	2998.6	63.6	28.0	31.1	1.5	124.1	110.6	2985.1	1828.6	294.6	186.0
28-May-89	2430	0.6	2430.6	25.4	28.0	25.7	1.5	80.5	109.7	2458.8	1804.4	187.6	184.0
29-May-89	4742	0.6	4742.6	148.6	28.0	275.1	1.5	453.2	115.4	4404.8	1673.8	2268.8	138.0
30-May-89	4084	0.6	4084.6	212.4	28.0	50.7	1.5	292.5	112.4	3904.5	1835.4	723.7	200.0
31-May-89	4559	0.6	4559.6	25.6	28.0	76.3	1.5	131.4	114.6	4542.9	1880.4	652.5	990.0
MAY 89	2813.8	0.6	2814.4	67.3	28.0	58.1	1.5	152.8	112.6	2773.6	1796.4	378.4	182.8

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jun-89	13746	1.2	13747.0	84.2	26.4	1155.4	1.5	1269.5	147.9	12626.0	1738.8	9053.1	74.0
02-Jun-89	12004	1.2	12005.0	236.3	26.4	424.9	1.5	691.0	133.6	11448.0	1833.9	5414.6	486.0
03-Jun-89	10263	1.2	10264.0	185.9	26.4	637.8	1.5	853.5	141.2	9551.9	1682.9	5220.6	432.0
04-Jun-89	6719	1.2	6720.2	206.6	26.4	307.1	1.5	543.5	133.8	6310.5	1684.1	2840.3	134.0
05-Jun-89	4582	1.2	4583.2	89.6	26.4	180.6	1.5	300.3	135.6	4418.5	1787.6	1677.9	120.0
06-Jun-89	4268	1.2	4269.2	26.0	26.4	113.9	1.5	169.8	137.4	4236.9	1953.1	1083.5	110.0
07-Jun-89	3995	1.2	3996.2	27.6	26.4	81.4	1.5	138.8	137.0	3994.5	2056.9	846.7	132.0
08-Jun-89	3595	1.2	3596.2	116.0	26.4	66.2	1.5	214.0	137.5	3519.7	2092.4	720.2	178.0
09-Jun-89	3392	1.2	3393.2	25.3	26.4	53.3	1.5	106.5	137.3	3422.0	1923.8	515.4	150.0
10-Jun-89	3143	1.2	3144.2	25.3	26.4	47.7	1.5	102.9	134.1	3175.4	1893.5	425.8	179.0
11-Jun-89	3322	1.2	3323.2	118.2	26.4	47.4	1.5	195.5	135.5	3263.3	1914.0	394.5	167.0
12-Jun-89	3953	1.2	3954.2	134.0	26.4	343.1	1.5	506.9	144.2	3591.6	1762.6	1442.9	163.0
13-Jun-89	3953	1.2	3954.2	195.8	26.4	262.0	1.5	487.7	137.4	3603.9	1797.9	993.4	167.0
14-Jun-89	3636	1.2	3637.2	24.8	26.4	111.0	1.5	165.7	135.0	3606.5	1808.4	393.5	149.0
15-Jun-89	2742	1.2	2743.2	25.7	26.4	78.3	1.5	133.8	135.1	2744.5	1751.9	319.7	137.0
16-Jun-89	3399	1.2	3400.2	25.6	26.4	61.3	1.5	116.8	135.6	3419.0	1776.8	255.1	654.0
17-Jun-89	3432	1.2	3433.2	121.0	26.4	55.8	1.5	206.6	132.6	3359.2	1826.2	260.7	570.0
18-Jun-89	3058	1.2	3059.2	25.2	26.4	46.7	1.5	101.8	133.0	3090.4	1843.4	195.1	533.0
19-Jun-89	3046	1.2	3047.2	25.2	26.4	43.2	1.5	98.3	136.9	3085.9	2066.7	172.8	555.0
20-Jun-89	3127	1.2	3128.2	130.2	26.4	44.3	1.5	204.3	139.2	3063.1	2108.6	218.7	539.0
21-Jun-89	3295	1.2	3296.2	25.3	26.4	38.1	1.5	93.2	138.3	3341.3	2181.0	151.1	552.0
22-Jun-89	3427	1.2	3428.2	25.7	26.4	36.0	1.5	91.5	139.0	3474.7	2312.4	147.7	544.0
23-Jun-89	3553	1.2	3554.2	88.2	26.4	35.7	1.5	153.8	139.3	3539.8	2363.4	206.4	499.0
24-Jun-89	3171	1.2	3172.2	61.5	26.4	33.8	1.5	125.1	137.4	3184.6	2300.9	154.7	676.0
25-Jun-89	3265	1.2	3266.2	25.3	26.4	30.7	1.5	85.9	134.2	3314.5	2265.5	119.1	635.0
26-Jun-89	3458	1.2	3459.2	79.1	26.4	36.2	1.5	145.1	139.5	3453.6	2384.1	212.7	479.0
27-Jun-89	3975	1.2	3976.2	83.3	26.4	49.8	1.5	162.9	136.3	3949.7	2101.4	777.3	457.0
28-Jun-89	3439	1.2	3440.2	27.6	26.4	58.8	1.5	116.3	137.4	3461.3	2125.7	754.3	587.0
29-Jun-89	4227	1.2	4228.2	126.4	26.4	54.1	1.5	210.3	137.8	4155.8	2078.6	375.2	845.0
30-Jun-89	3316	1.2	3317.2	25.3	26.4	39.3	1.5	94.4	137.3	3360.1	2252.0	220.6	1162.0
JUN 89	4483.4	1.2	4484.5	80.6	26.4	152.5	1.5	262.9	137.2	4356.9	1989.0	1186.1	402.2

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Jul-89	3186	0.9	3186.9	25.0	29.2	33.2	1.4	88.8	138.6	3236.7	2394.4	178.4	756.0
02-Jul-89	3780	0.9	3780.9	25.0	29.2	29.9	1.5	85.5	133.4	3828.8	2270.7	155.5	657.0
03-Jul-89	3263	0.9	3263.9	103.5	29.2	30.6	1.4	164.7	136.6	3235.8	2278.4	177.2	769.0
04-Jul-89	3347	0.9	3347.9	25.1	29.2	25.9	1.5	81.6	137.4	3403.6	2330.2	122.6	747.0
05-Jul-89	3827	0.9	3827.9	25.4	29.2	24.1	1.4	80.0	138.6	3886.4	2467.4	108.7	744.0
06-Jul-89	3387	0.9	3387.9	107.5	29.2	25.4	1.5	163.5	141.8	3366.2	2688.9	151.7	735.0
07-Jul-89	3848	0.9	3848.9	25.6	29.2	21.0	1.5	77.2	143.8	3915.4	2719.8	97.8	750.0
08-Jul-89	3750	0.9	3750.9	37.6	29.2	19.4	1.5	87.6	142.0	3805.2	2619.9	95.8	796.0
09-Jul-89	3621	0.9	3621.9	100.0	29.2	21.5	1.4	152.1	138.9	3608.7	2658.1	134.8	679.0
10-Jul-89	3744	0.9	3744.9	25.6	29.2	17.6	1.5	73.8	141.6	3812.5	2999.4	88.4	690.0
11-Jul-89	4730	0.9	4730.9	163.2	29.2	102.5	1.4	296.3	143.2	4577.7	2411.3	315.6	695.0
12-Jul-89	4065	0.9	4065.9	38.8	29.2	110.0	1.4	179.4	141.1	4027.5	2016.1	549.6	632.0
13-Jul-89	3828	0.9	3828.9	133.6	29.2	25.1	1.4	189.3	139.0	3778.6	2048.2	198.0	781.0
14-Jul-89	3497	0.9	3497.9	25.1	29.2	18.7	1.5	74.5	140.3	3563.7	2178.0	87.0	827.0
15-Jul-89	3594	0.9	3594.9	25.2	29.2	17.2	1.4	73.0	138.1	3660.0	2246.2	81.1	803.0
16-Jul-89	3501	0.9	3501.9	52.3	29.2	17.2	1.4	100.1	137.6	3539.4	2285.0	88.0	802.0
17-Jul-89	3296	0.9	3296.9	80.0	29.2	17.2	1.5	127.8	142.7	3311.8	2372.4	100.0	755.0
18-Jul-89	5482	0.9	5482.9	42.1	29.2	435.3	1.5	508.0	154.0	5128.9	2094.2	2949.4	739.0
19-Jul-89	8460	0.9	8460.9	282.9	29.2	467.1	1.4	780.5	149.1	7829.5	1880.9	4535.5	1046.0
20-Jul-89	6695	0.9	6695.9	320.4	43.5	261.4	1.4	626.8	139.5	6208.5	1621.0	2027.4	370.0
21-Jul-89	5408	0.9	5408.9	165.7	29.2	218.4	1.4	414.7	138.0	5130.2	1820.8	1438.8	285.0
22-Jul-89	4816	0.9	4816.9	42.6	29.2	135.9	1.4	209.1	133.7	4741.5	1845.2	722.3	613.0
23-Jul-89	4398	0.9	4398.9	28.0	29.2	70.1	1.4	128.7	133.0	4403.2	1881.8	395.5	674.0
24-Jul-89	3839	0.9	3839.9	74.4	29.2	48.7	1.5	153.6	137.3	3823.6	2142.3	283.1	780.0
25-Jul-89	4205	0.9	4205.9	80.0	29.2	45.3	1.6	156.1	139.7	4189.5	2158.7	251.1	527.0
26-Jul-89	4170	0.9	4170.9	108.4	29.2	59.2	1.5	198.2	139.3	4111.9	2129.3	513.1	574.0
27-Jul-89	5398	0.9	5398.9	83.9	29.2	31.5	1.4	146.0	138.7	5391.6	2214.9	190.6	1243.0
28-Jul-89	3888	0.9	3888.9	25.3	29.2	26.2	1.5	82.1	137.0	3943.8	2062.2	131.8	1586.0
29-Jul-89	4800	0.9	4800.9	34.4	29.2	227.8	1.4	292.8	140.2	4648.3	1995.0	1532.8	1231.0
30-Jul-89	5409	0.9	5409.9	206.7	29.2	221.5	1.7	459.1	136.9	5087.6	1760.8	1512.5	794.0
31-Jul-89	4598	0.9	4598.9	180.7	29.2	101.6	1.4	312.9	136.8	4422.8	1885.0	530.8	1023.0
JUL 89	4317.1	0.9	4318.0	86.9	29.6	93.8	1.5	211.7	139.5	4245.8	2215.4	636.9	777.5

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Aug-89	4596	3.4	4599.4	25.0	26.3	63.1	2.0	118.4	113.6	4594.5	2014.6	249.4	1247.0
02-Aug-89	3936	3.4	3939.4	25.0	26.3	43.2	2.0	98.5	117.7	3958.5	2215.1	175.9	1135.0
03-Aug-89	4469	3.4	4472.4	111.6	26.3	39.5	2.0	181.5	119.9	4409.8	2338.9	197.8	927.8
04-Aug-89	8836	3.4	8839.4	261.5	26.3	268.5	2.0	560.4	126.4	8405.3	2231.2	4759.4	1510.8
05-Aug-89	9922	3.4	9925.4	407.7	26.3	533.6	2.0	971.6	126.4	9082.2	2049.6	4025.1	2414.0
06-Aug-89	5354	3.4	5357.4	58.5	26.3	181.0	2.0	269.9	116.9	5204.4	1800.3	977.6	1192.0
07-Aug-89	4887	3.4	4890.4	102.4	26.3	132.6	2.0	265.3	113.2	4738.3	1853.4	635.2	1087.0
08-Aug-89	4221	3.4	4224.4	25.6	26.3	94.5	2.0	150.5	114.5	4188.4	1900.9	439.7	912.0
09-Aug-89	4234	3.4	4237.4	36.4	26.3	70.5	2.0	139.2	114.5	4212.7	1872.4	410.0	642.0
10-Aug-89	5688	3.4	5691.4	145.0	26.3	127.3	2.0	302.7	117.2	5506.0	1897.0	1714.3	831.0
11-Aug-89	5082	3.4	5085.4	255.5	26.3	100.8	2.0	386.6	117.9	4816.7	1914.8	691.8	1381.0
12-Aug-89	4848	3.4	4851.4	96.3	26.3	182.7	2.0	311.3	114.7	4656.8	1875.4	728.5	955.0
13-Aug-89	4696	3.4	4699.4	89.3	26.3	99.1	2.0	218.8	115.4	4596.0	1863.9	381.2	1092.0
14-Aug-89	4381	3.4	4384.4	137.0	26.3	84.5	2.0	251.9	115.2	4247.7	1902.3	423.0	921.0
15-Aug-89	3738	3.4	3741.4	30.2	26.3	63.3	2.0	123.8	115.2	3732.7	1886.9	457.8	775.0
16-Aug-89	4005	3.4	4008.4	25.1	26.3	51.3	2.0	106.7	113.9	4015.6	1900.8	254.4	1169.0
17-Aug-89	3736	3.4	3739.4	57.3	26.3	46.6	2.0	134.2	114.5	3719.7	1965.2	217.1	1220.0
18-Aug-89	4128	3.4	4131.4	83.1	26.3	43.6	2.0	157.2	117.2	4091.4	1994.3	202.9	1190.0
19-Aug-89	3925	3.4	3928.4	22.8	26.3	89.9	2.0	143.1	113.3	3898.7	1966.6	211.9	1325.0
20-Aug-89	4739	3.4	4742.4	224.7	26.3	181.8	2.0	436.8	116.2	4421.8	1840.4	1095.5	893.0
21-Aug-89	4614	3.4	4617.4	40.0	26.3	60.5	2.0	130.8	113.8	4600.4	2003.1	226.3	1234.0
22-Aug-89	4676	3.4	4679.4	169.6	26.3	172.5	2.0	372.4	119.4	4426.4	1978.2	654.6	1585.0
23-Aug-89	4070	3.4	4073.4	25.6	26.3	61.0	2.1	117.2	117.1	4073.3	1893.9	231.4	1203.0
24-Aug-89	3905	3.4	3908.4	25.7	26.3	49.2	2.0	105.2	113.7	3916.9	1866.7	180.1	1274.0
25-Aug-89	3890	3.4	3893.4	25.1	26.3	41.6	2.0	97.0	114.7	3911.2	1922.1	139.4	1267.0
26-Aug-89	4161	3.4	4164.4	125.0	26.3	40.8	2.0	196.2	115.3	4083.5	1868.0	180.8	1457.0
27-Aug-89	3851	3.4	3854.4	25.1	26.3	34.4	2.0	89.8	114.9	3879.5	1913.9	115.5	1169.0
28-Aug-89	5441	3.4	5444.4	132.5	26.3	300.2	2.0	463.0	120.2	5101.6	1911.1	1296.2	1290.0
29-Aug-89	3927	3.4	3930.4	163.6	26.3	83.7	2.0	277.7	116.6	3769.3	1910.2	449.6	905.0
30-Aug-89	3799	3.4	3802.4	25.8	26.3	56.7	2.0	112.8	113.2	3802.8	1930.3	226.9	783.0
31-Aug-89	5145	3.4	5148.4	30.5	26.3	49.2	2.0	110.1	115.7	5154.0	1868.1	229.8	1247.0
AUG 89	4738.7	3.4	4742.1	97.2	26.3	111.2	2.0	238.7	116.8	4619.9	1947.5	715.5	1168.8

LAKE MICHIGAN DIVERSION ACCOUNTING WY 1989	ROMEOVILLE GAGE RECORD	DIVERSIONS ABOVE THE GAGE	TOTAL FLOW THROUGH THE CANAL	GROUNDWATER PUMPAGE DISCHARGED INTO THE CANAL	WATER SUPPLY PUMPAGE FROM INDIANA REACHING THE CANAL	RUNOFF FROM THE DES PLAINES RIVER WATERSHED REACHING THE CANAL	LAKE MICHIGAN PUMPAGE BY FEDERAL FACILITIES DISCHARGED TO THE CANAL	TOTAL DEDUCTION FROM THE ROMEOVILLE GAGE RECORD	LAKE MICHIGAN PUMPAGE NOT DISCHARGED TO THE CANAL	TOTAL DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS	PUMPAGE FROM LAKE MICHIGAN ACCOUNTABLE TO THE STATE OF ILLINOIS	RUNOFF FROM THE DIVERTED LAKE MICHIGAN WATERSHED	DIRECT DIVERSION ACCOUNTABLE TO THE STATE OF ILLINOIS
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13
01-Sep-89	10993	0.6	10994.0	99.0	27.9	1246.2	1.8	1374.9	116.6	9735.4	1852.9	8545.4	381.0
02-Sep-89	6042	0.6	6042.6	221.4	27.9	277.7	1.8	528.7	105.5	5619.4	1754.1	1740.9	636.0
03-Sep-89	5280	0.6	5280.6	175.8	27.9	173.3	1.8	378.8	107.1	5008.9	1686.0	848.0	884.0
04-Sep-89	4248	0.6	4248.6	24.8	27.9	111.4	1.8	165.9	104.2	4186.9	1735.3	490.2	833.0
05-Sep-89	4898	0.6	4898.6	25.1	27.9	83.3	1.8	138.1	107.9	4868.4	1842.3	351.2	1370.0
06-Sep-89	5680	0.6	5680.6	119.8	27.9	476.9	1.8	626.4	113.1	5167.4	1806.8	1918.8	1121.0
07-Sep-89	6429	0.6	6429.6	267.7	27.9	260.4	1.8	557.7	107.7	5979.6	1863.0	1145.6	1922.0
08-Sep-89	5953	0.6	5953.6	49.1	27.9	175.3	1.8	254.0	110.7	5810.2	1822.8	912.2	1859.0
09-Sep-89	6522	0.6	6522.6	117.0	27.9	424.1	1.8	570.8	108.9	6060.6	1739.2	1943.1	1987.0
10-Sep-89	5607	0.6	5607.6	211.4	27.9	226.7	1.8	467.7	105.8	5245.6	1688.1	1048.5	2052.0
11-Sep-89	5493	0.6	5493.6	26.2	27.9	146.5	1.8	202.4	105.8	5397.0	1803.5	587.3	2040.0
12-Sep-89	5200	0.6	5200.6	24.7	27.9	109.7	1.8	164.1	107.2	5143.8	1785.2	401.6	1712.0
13-Sep-89	4519	0.6	4519.6	178.6	27.9	365.4	1.8	573.7	110.0	4055.9	1734.6	1401.6	512.0
14-Sep-89	5385	0.6	5385.6	90.7	27.9	181.9	1.8	292.3	105.1	5198.4	1739.4	791.7	1979.0
15-Sep-89	5529	0.6	5529.6	24.6	27.9	129.6	1.8	183.9	106.1	5451.8	1749.2	542.9	2110.0
16-Sep-89	5636	0.6	5636.6	24.9	27.9	103.7	1.8	158.2	106.0	5584.4	1730.3	408.6	2147.0
17-Sep-89	5276	0.6	5276.6	120.9	27.9	92.8	1.8	243.4	105.3	5138.5	1721.6	387.6	2122.0
18-Sep-89	5428	0.6	5428.6	25.6	27.9	78.2	1.8	133.5	106.6	5401.6	1835.9	286.0	2079.0
19-Sep-89	4868	0.6	4868.6	25.7	27.9	72.3	1.8	127.7	107.1	4848.0	1866.8	252.8	2093.0
20-Sep-89	5074	0.6	5074.6	121.2	27.9	71.8	1.8	222.7	106.5	4958.4	1878.7	281.5	2024.0
21-Sep-89	4777	0.6	4777.6	25.3	27.9	64.9	1.8	119.9	106.5	4766.2	1848.9	215.3	2022.0
22-Sep-89	4994	0.6	4994.6	25.2	27.9	62.3	1.8	117.1	107.7	4985.1	1835.3	200.1	2142.0
23-Sep-89	5222	0.6	5222.6	134.3	27.9	63.7	1.8	227.6	104.7	5099.6	1747.3	244.6	2026.0
24-Sep-89	4800	0.6	4800.6	25.2	27.9	57.2	1.8	112.0	102.5	4791.0	1725.4	174.5	1951.0
25-Sep-89	3919	0.6	3919.6	25.2	27.9	54.8	1.8	109.6	106.1	3916.1	1802.0	164.2	1230.0
26-Sep-89	2839	0.6	2839.6	25.2	27.9	52.3	1.9	107.2	108.1	2840.6	1813.8	154.9	663.0
27-Sep-89	2818	0.6	2818.6	110.4	27.9	53.1	1.8	193.2	105.1	2730.6	1815.5	186.0	416.0
28-Sep-89	2818	0.6	2818.6	25.2	27.9	47.7	1.8	102.6	109.0	2822.0	1836.6	131.5	108.0
29-Sep-89	2183	0.6	2183.6	25.2	27.9	45.5	1.8	100.4	107.8	2190.9	1883.8	123.1	124.0
30-Sep-89	2392	0.6	2392.6	109.3	27.9	46.6	1.8	185.6	109.9	2313.9	1896.7	168.6	135.0
SEP 89	5027.4	0.6	5028.0	83.2	27.9	178.5	1.8	291.3	107.2	4843.9	1794.7	868.3	1422.7

APPENDIX F

CURRENT METER MEASUREMENTS OF DISCRETIONARY AND LEAKAGE FLOWS AT THE CHICAGO RIVER CONTROLLING WORKS, O'BRIEN LOCK AND DAM, AND THE WILMETTE CONTROLLING WORKS

OCTOBER 1990

CURRENT METER MEASUREMENTS OF DISCRETIONARY AND LEAKAGE FLOWS

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G. Calculations of Coefficients for Two-Point and Three-Point Methods

BACKGROUND

1. The Army Corps of Engineers, Chicago District is responsible for the computation of diverted Lake Michigan flows accountable to the State of Illinois. The Corps' computation of the diversion is performed by deducting all flows not attributable to Lake Michigan from the flow measured by the Acoustical Velocity Meter (AVM) on the Chicago Sanitary and Ship Canal (CSSC) at Romeoville, Illinois and by adding all diverted Lake Michigan waters that bypass the AVM.

2. The diversion accounting computations are summarized as a series of flow columns. The annual summary tables of the diversion flows for Water Years 1984 and 1985 are shown in Table 1 and 2, respectively. Column 11 contains the official computed Lake Michigan diversion accountable to Illinois. As previously summarized, the official diversion contained in Column 11 is computed by first measuring the canal system flow at Romeoville. The flows at Romeoville are presently measured by the AVM and are contained in Column 1. The total flow through the canal system (Column 3) is calculated by adding any diversions (withdrawals) upstream of the AVM (Column 2). The small value contained in Column 2 during WY84 and WY85 is the withdrawal of water from the CSSC by Argonne National Labs. Some additions and subtractions to the flow of Column 3 must be made in order to arrive at Illinois' official diversion contained in Column 11. As shown in Tables 1 and 2, Column 11 equals Column 3 minus Column 8 plus Column 9 minus Column 10. Column 8 is the total deduction from the Romeoville gage record and is composed of the sum of Columns 4, 5, 6, and 7. Column 4 contains the effluent whose source is groundwater supply pumpage by Illinois' communities and industries as reported by the State. Column 5 contains the groundwater supply pumpage from the Des Plaines River watershed whose sanitary effluent reaches the canal. Column 6 contains the domestic pumpage from Indiana whose sanitary effluent reaches the canal. Column 7 contains the runoff from the Des Plaines River watershed that reaches the canal. Column 9 contains water supply pumpage from Lake Michigan, the effluent of which is not discharged to the canal. This constitutes an addition to the Romeoville gage record. Column 10 constitutes a deduction from the Romeoville gage record and is composed of withdrawals for federal use that enter the canal.

3. Columns 12, 13, and 14 are independent flow estimates for the three sources of diversion: water supply pumpage from Lake Michigan (Column 12), runoff from the diverted Lake Michigan watershed (Column 13), and direct diversion through the lakefront control structures (Column 14). Column 14 is made up of four components of flow: lockages, leakages through lock gates and sluice gates, navigational makeup flow (flows necessary to maintain minimum navigable depth), and discretionary flow (flows required to maintain water quality in the canal). Navigational make-up and discretionary flows are regulated by the Metropolitan Water Reclamation

TABLE 1

LAKE MICHIGAN DIVERSION ACCOUNTING - WATER YEAR 1984

SUMMARY OF DIVERSION FLOWS (cfs)

	ROMEOVLL GAGE RECORD	DIVERSN ABOVE GAGE	TOTAL FLOW THRU CANAL	GRNDWTR PUMPAGE FROM LAKE MICH. WATRSHD IN ILLINOIS	GRNDWTR PUMPAGE FROM DES PLAINES WATRSHD	WATER SUPPLY PUMPAGE FROM INDIANA REACHNG CANAL	RUNOFF FROM DES PLAINES WATRSHD REACHNG CANAL	TOTAL DEDUCT. FROM ROMEOVLL GAGE RECORD	LAKE MICH. PUMPAGE NOT DISCHRG TO CANAL	FEDERAL LAKE MICH. WTHDRWL REACHNG CANAL	TOTAL DIVERSN	PUMPAGE FROM LAKE MICH. ACCT. TO ILLINOIS	RUNOFF FROM THE DIVERTD WATRSHD	DIRECT DIVERSN THRU LAKE CONTROL STRUCT.
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14
OCT, 1983	3428.3	0.4	3428.7	48.5	51.2	57.0	118.1	274.8	28.1	2.5	3179.4	1526.0	546.4	756.1
NOV, 1983	3379.5	0.2	3379.7	48.5	50.7	46.2	282.6	428.0	29.4	2.5	2978.6	1484.2	1099.8	254.9
DEC, 1983	3566.4	0.3	3566.7	48.5	51.0	37.7	216.1	353.2	27.1	2.0	3238.6	1510.6	986.6	116.7
JAN, 1984	2519.8	0.2	2520.0	48.5	51.0	31.0	116.8	247.3	28.5	1.1	2300.1	1584.2	341.9	138.8
FEB, 1984	3549.9	0.2	3550.1	48.5	50.7	36.0	340.1	475.4	29.7	1.2	3103.3	1556.1	1281.5	113.7
MAR, 1984	4120.4	0.2	4120.6	48.5	50.7	43.9	348.6	491.7	30.1	1.1	3658.0	1535.4	1654.0	119.8
APR, 1984	3870.0	0.3	3870.3	48.5	50.7	58.0	385.9	543.1	29.5	1.0	3355.7	1485.6	1422.9	215.4
MAY, 1984	4091.0	0.4	4091.4	48.5	50.8	66.1	223.6	389.0	30.0	1.1	3731.4	1539.5	1207.5	422.0
JUN, 1984	4230.0	0.6	4230.6	48.5	51.0	80.2	107.8	287.5	31.2	1.1	3973.2	1817.7	545.7	1070.4
JUL, 1984	4285.5	0.8	4286.3	48.5	51.0	98.0	47.4	244.8	34.3	1.3	4074.5	1992.7	247.6	1610.1
AUG, 1984	4202.6	0.8	4203.4	48.5	51.0	91.4	73.4	264.3	34.9	1.4	3972.7	2122.6	221.0	1391.2
SEP, 1984	4246.7	0.5	4247.2	48.5	50.9	69.6	109.9	278.9	29.5	401.1	3596.7	1658.2	427.9	978.5
WY 1984	3790.6	0.4	3791.0	48.5	50.9	59.7	196.5	355.5	30.2	34.2	3431.5	1652.0	829.0	601.3

COL#3 = COL#1 + COL#2 COL#8 = COL#4 + COL#5 + COL#6 + COL#7 COL#11 = COL#3 - COL#8 + COL#9 - COL#10
COL#14: DIRECT DIVERSIONS ACCOUNTABLE TO THE STATE OF ILLINOIS

STATUS OF ILLINOIS' LAKE MICHIGAN DIVERSION
UNDER 1980 AMENDED U.S. SUPREME COURT DECREE

Accounting Year	Annual Diversion (% of 3200 cfs)	40 Year Running Average	Deviation from 3200 cfs: Annual	Deviation from 3200 cfs: Cumulative Sum (cfs-years)
1981	3106.0 cfs (97.1%)	3106.0	+ 94.0	+ 94.0
1982	3087.0 cfs (96.5%)	3096.5	+ 113.0	+ 207.0
1983	3613.1 cfs (112.9%)	3268.7	- 413.1	- 206.1
1984	3431.5 cfs (107.2%)	3309.4	- 231.5	- 437.6

LAKE MICHIGAN DIVERSION ACCOUNTING - WATER YEAR 1985

SUMMARY OF DIVERSION FLOWS

DATE	ROMEOVLL GAGE RECORD 1	DIVERSN ABOVE GAGE 2	TOTAL FLOW THRU CANAL 3	GRNDWTR PUMPAGE FROM LAKE MICH. WATRSHD IN ILLINOIS 4	GRNDWTR PUMPAGE FROM DES PLAINES WATRSHD 5	WATER SUPPLY PUMPAGE FROM INDIANA REACHNG CANAL 6	RUNOFF FROM DES PLAINES WATRSHD REACHNG CANAL 7	TOTAL DEDUCT. FROM ROMEOVLL GAGE RECORD 8	LAKE MICH. PUMPAGE NOT DISCHRG TO CANAL 9	FEDERAL LAKE MICH. WTHDRWL REACHNG CANAL 10	TOTAL DIVERSN 11	PUMPAGE FROM LAKE MICH. ACCT. TO ILLINOIS 12	RUNOFF FROM THE DIVERTD WATRSHD 13	DIRECT DIVERSN THRU LAKE CONTROL STRUCT. 14
OCT, 1984	3699.5	0.4	3700.0	27.7	46.7	66.6	124.5	265.5	33.1	2.0	3465.6	1556.7	423.2	986.4
NOV, 1984	2904.6	0.3	2904.9	27.7	46.7	73.8	225.2	373.4	32.9	2.1	2562.3	1498.0	735.6	135.9
DEC, 1984	3017.4	0.3	3017.6	27.7	46.6	73.6	304.1	452.0	33.8	1.8	2597.7	1503.4	982.1	134.3
JAN, 1985	3165.3	0.3	3165.6	27.7	46.8	76.4	230.9	381.8	33.7	2.2	2815.3	1548.2	703.9	130.3
FEB, 1985	4056.5	0.3	4056.7	27.7	46.4	79.2	354.5	507.8	36.3	2.1	3583.2	1574.6	1694.0	173.9
MAR, 1985	4690.1	0.3	4690.3	27.7	46.3	76.8	516.5	667.4	36.3	2.0	4057.3	1548.0	2082.5	141.9
APR, 1985	3682.4	0.3	3682.7	27.7	46.7	77.7	270.8	422.9	33.3	2.2	3290.9	1547.2	903.1	251.9
MAY, 1985	3165.9	0.4	3166.3	27.7	46.7	86.5	86.7	247.7	34.8	2.1	2951.3	1704.7	373.0	418.1
JUN, 1985	3695.7	0.4	3696.1	27.7	46.7	92.2	59.2	225.8	36.5	2.3	3504.4	1861.3	352.7	841.4
JUL, 1985	4442.8	0.6	4443.4	27.7	46.7	97.1	51.2	222.7	39.7	2.7	4257.7	2013.9	430.5	1332.3
AUG, 1985	4535.7	0.4	4536.1	27.7	46.7	85.2	70.7	230.3	36.7	2.0	4340.5	1819.0	501.4	1399.9
SEP, 1985	4428.3	0.4	4428.7	27.7	46.7	82.5	60.5	217.5	36.2	1.7	4245.7	1767.3	305.2	1580.3
WY 1985	3789.4	0.4	3789.8	27.7	46.7	80.6	195.4	350.4	35.3	2.1	3472.5	1662.5	785.5	630.1

COL#3 = COL#1 + COL#2 COL#8 = COL#4 + COL#5 + COL#6 + COL#7 COL#11 = COL#3 - COL#8 + COL#9 - COL#10

COL#14: DIRECT DIVERSIONS ACCOUNTABLE TO THE STATE OF ILLINOIS

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1981	3106.0 cfs (97.1%)	3106.0	+ 94.0	+ 94.0
1982	3087.0 cfs (96.5%)	3096.5	+ 113.0	+ 207.0
1983	3613.1 cfs (112.9%)	3268.7	- 413.1	- 206.1
1984	3431.5 cfs (107.2%)	3309.4	- 231.5	- 437.6
1985	3472.5 cfs (108.5%)	3342.0	- 272.5	- 710.1

District of Greater Chicago (MWRDGC) through the opening and closing of sluice gates at the three lakefront control structures: Chicago River Controlling Works (CRCW), O'Brien Lock and Dam, and Wilmette Controlling Works.

4. In addition to the diversion calculations presented in the 14 columns, there exists 13 water budgets (Table 3) that serve as input to the diversion calculations and that verify the estimated flows that are determined through hydrologic and hydraulic simulation. The first three budgets are direct summations of water supply pumpage data used in the actual computation of Illinois' diversion. Budgets 5 through 8 and Budget 12 are budgets that compare the simulated flows to the measured inflows at four water reclamation plants and one pump station. The purpose of these budgets is to calibrate and verify the simulation models which estimate the three sanitary treatment plant influent components: infiltration, inflow, and sanitary flow. Budget 4 and budgets 9 through 11 are budgets of stream gage sites used to make estimates of runoff from portions of the diverted Lake Michigan watershed. Budget 13 compares the inflows and outflows to the canal system.

5. The budget of interest for the purpose of this report is Budget 13. In Budget 13, a comprehensive comparison of inflows to and outflows from the canal system is performed. Inflows to the canal system include direct diversion through the lakefront structures, stormwater runoff discharged to the canal system, and domestic water supply effluent that is discharged to the canal system. The outflows from the canal system include the discharge at Romeoville measured by the AVM, backflows through the three lakefront control structures, and the withdrawal upstream of Romeoville by Argonne National Labs. The comparison of canal inflows and outflows for WY84 and WY85 is presented in Table 4 and Table 5. Table 4 indicates that during WY84 the inflows are 431.1 cfs (11%) less than the outflows. Table 5 indicates that during WY85 the inflows are 508.3 cfs (13%) less than the outflows. Since almost 100% of the outflow is measured by the AVM, which has been verified to have an accuracy of approximately 2%, it appears that a significant portion of inflows are not being reported or that some inflows are being underreported.

6. Although Columns 12 through 14 are not used in the actual diversion calculation, they provide a verification of the diversion flow computed in Column 11. They also emphasize the existence of unreported and/or underreported flows found in Budget 13. Theoretically, the sum of Columns 12, 13, and 14 should equal the total diversion presented in Column 11. As shown in Tables 1 and 2, the difference between the flow of Column 11 and the sum of the flows for Columns 12 through 14 in Water Year 1984 and 1985 is 349.2 cfs and 394.4 cfs, respectively. The diversion estimate from Columns 12 through 14 is based on simulation, flow separation techniques, and rating tables for the three lakefront structures. Consequently, the diversion estimate derived from Columns 12 through 14 is

TABLE 3

WATER BUDGETS

Budget	Description
1	Lake Michigan Water Supply
2	Groundwater Supply Lake Michigan Watershed
3	Groundwater Supply Des Plaines Watershed
4	North Branch Chicago River at Touhy Avenue
5	Northside Water Reclamation Plant
6	Upper Des Plaines Pump Station
7	West - Southwest Water Reclamation Plant
8	Calumet Water Reclamation Plant
9	Little Calumet River at State Line
10	Thorn Creek at Thornton
11	Little Calumet River at South Holland
12	Lemont Water Reclamation Plant
13	Lockport Powerhouse and Controlling Works

TABLE 4

Water Year 1984
SUMMARY OF FLOW COMPONENTS ABOVE ROMEOVILLE (Budget 13)

INFLOWS TO THE CHICAGO SANITARY AND SHIP CANAL	
Lake Controlling Structures (Measured)	
Wilmette	38.8
CRCW	278.6
O'Brien	283.5
Streamflows (Measured)	
North Branch at Touhy	140.8
Little Calumet at South Holland	215.7
MSDGC Treatment Plants (Measured)	
Northside	420.2
West - Southwest	1162.7
Calumet	358.6
Adjustment for Interlake - Riverdale	-2.5
Lemont	2.0
Other Point Sources (Measured)	5.4
Summit Conduit (Estimated)	9.7
Grand Calumet Streamflow (Estimated)	61.3
Combined Sewer Overflows in Ungaged Watershed (Simulated)	212.3
Direct Runoff in Ungaged Watershed (Simulated)	140.5
COE Emergency Nav. Make - up (Estimated)	32.8
TOTAL	**3360.4**

OUTFLOWS FROM THE CHICAGO SANITARY AND SHIP CANAL	
Argonne Withdrawal (Measured)	0.4
AVM @ Romeoville Recorded Flow	3790.6
Lake Controlling Structures (Measured) Backflows	0.5
TOTAL	**3791.5**
DIFFERENCE BETWEEN INFLOWS AND OUTFLOWS	**-431.1**

TABLE 5

Water Year 1985
SUMMARY OF FLOW COMPONENTS ABOVE ROMEOVILLE (Budget 13)

INFLOWS TO THE CHICAGO SANITARY AND SHIP CANAL	
Lake Controlling Structures (Measured)	
Wilmette	26.8
CRCW	306.2
O'Brien	297.2
Streamflows (Measured)	
North Branch at Touhy	107.7
Little Calumet at South Holland	180.8
MSDGC Treatment Plants (Measured)	
Northside	438.8
West - Southwest	1115.9
Calumet	336.9
Adjustment for Interlake - Riverdale	-2.5
Lemont	1.8
Other Point Sources (Measured)	6.1
Summit Conduit (Estimated)	11.7
Grand Calumet Streamflow (Estimated)	105.3
Combined Sewer Overflows in Ungaged Watershed (Simulated)	209.3
Direct Runoff in Ungaged Watershed (Simulated)	145.1
TOTAL	**3287.1**

OUTFLOWS FROM THE CHICAGO SANITARY AND SHIP CANAL	
Argonne Withdrawal (Measured)	0.4
AVM @ Romeoville Recorded Flow	3789.6
Lake Controlling Structures (Measured) Backflows	0.9
TOTAL	**3790.9**
DIFFERENCE BETWEEN INFLOWS AND OUTFLOWS	**-503.8**

not as accurate as the AVM based diversion estimate contained in Column 11. However, the differences of 10% and 11% for WY84 and WY85 are larger than would be anticipated. By comparing Column 1 (the AVM measured flow) with Column 11 (the total diversion) it becomes obvious that Column 11 is composed primarily of the flows measured by the AVM. Consequently, greater confidence is placed in the flow of Column 11 than in the sum of Columns 12 through 14. Additionally, the sum of Columns 12 through 14 was less than the flow in Column 11 for both water years. Therefore, it is probable that there exists flows that are not being reported and/or flows that are being underreported. This supports the conclusion drawn from Budget 13.

7. It is due to the discrepancy in inflows and outflows found in Budget 13 and the discrepancy between the flows of Column 11 and the sum of flows of Columns 12 through 14 that an investigation was deemed necessary to determine the reasons for the discrepancies. Flow discrepancies for both WY84 and WY85 are similar in magnitude and percentage of total flow. This implies that the sources of error are probably the same.

8. Possible sources of the canal flow imbalance found in Budget 13, and supported by the diversion flow estimate imbalance between Column 11 and Columns 12 through 14, include unreported discharges to the canal system, groundwater seepage into the canal system, and underreporting of inflows to the canal system. Unreported discharges include any point source discharges to the canal system that are unknown to the State of Illinois and the Army Corps of Engineers. If any unreported point source discharges are occurring, the magnitude is anticipated to be much smaller than the flow discrepancy previously discussed. The degree of groundwater seepage to and from the canal system is unknown. The estimation of groundwater seepage would require an extensive and costly effort that would include the drilling and monitoring of several observation wells in the vicinity of the canal and its tributaries. Underreporting of inflows to the canal system may include underreporting of the following: combined sewer overflows (CSO), direct runoff to the canal, and direct diversion flows through the three lakefront control structures. CSO's and direct runoff to the canal are simulated with models that have been reasonably calibrated and verified. Underreporting of flows through the lakefront control structures could be the result of both inaccurate rating tables and leakages through those structures.

9. Flow through the lakefront control structures is the most readily analyzed potential source of the canal system imbalance. The effort to check this possible source of error does not require as extensive an effort as compared to the effort involved in verifying all point source discharges, quantifying groundwater seepage, or further verifying the simulation techniques for determining CSO's and direct runoff. Therefore, it was determined that the lakefront control structures would be an appropriate starting point for an investigation into the flow imbalance.

10. It should be emphasized that the components of direct diversion do not enter directly into the diversion calculation. The direct diversion flows are already accounted for in the flows measured by the AVM. Although the canal system flow balance does not enter into the calculation of Illinois' diversion, identifying the sources of discrepancy of this flow balance improves the credibility of the Corps' modeling and accounting procedures by reducing the amount of uncertainty inherent with the nature and complexity of diversion accounting.

11. It is important to note that prior to WY87 a 1,100 foot section of the Chicago harbor wall was at 3.0 feet CCD and in need of repair. Because of this fact it is probable that a significant amount of unreported water overtopped the harbor wall as well as leaking through the wall. Analysis of the inflows and outflows for WY84 and WY85 showed that an increase in lake level resulted in an increase in the flow imbalance. However, it is difficult to determine how much of the flow imbalance was due to overtopping and leakage through the harbor wall because higher lake levels also tend to increase the leakage through the sluice gates and lock gates as well as increasing the discretionary and navigation make-up flow through open sluice gates.

PURPOSE

12. The flow measurements during the period of 23 through 27 July 1990 were conducted in order to assess the accuracy of the MWRDGC reported direct diversion flows. This was necessary to evaluate potential source(s) of the canal system flow imbalance detected in Budget 13 and suggested by the discrepancy between Column 11 and the sum of Columns 12 through 14 of the annual diversion reports for WY84 and WY85. It was anticipated that part of this flow imbalance could be explained through flow measurements, provided that the measured flows were greater than those reported by the MWRDGC. The purpose of this report is to present the results of these flow measurements and to make recommendations for future measurements of direct diversion flows.

AUTHORITY

13. Under the provisions of the U.S. Supreme Court Decree in Wisconsin, et al v. Illinois et al, 388 U.S. 426,87 S. Ct. 1774 (1967) as modified by 449 U.S. 48, 101 S. Ct. 557 (1980), the Corps is responsible for monitoring the measurement and computation of Lake Michigan water by the State of Illinois. The Water Resources Development Act of 1986 gives the Corps total responsibility for the computation of diversion flows as formerly done by the State of Illinois. This responsibility became effective 1 October 1987. The terms and conditions of the Supreme Court Decree specify that "all measurements and computations required by this decree shall be

made...using the best current engineering practice and scientific knowledge." In keeping with the terms of the decree, flow measurements were required in order to determine sources of the canal system flow imbalance.

PROCEDURES

14. A field survey was conducted on 7 March 1990 to determine possible locations for the flow measurements. A location at all three lakefront control structures was determined. The measurements were to be conducted from the Columbus Drive bridge approximately 2/3 mile downstream of the Chicago River Controlling Works, the 130th Street bridge approximately 1/2 mile upstream of O'Brien Lock and Dam, and the Linden Avenue bridge approximately 900 feet downstream of the Wilmette Pumping Station. Pictures were taken at each site for reference and are included in Appendix C.

15. The period of 23 July through 27 July 1990 was selected for the measurements. This period was selected since the sluice gate flows during that time of year represented an approximation of the average sluice gate flow during the discretionary period (mid-June through thru mid-November). An alternate measurement period was set in the event that inclement weather prohibited at least three measurements from being taken at each of the three sites. This alternate period was scheduled to be 20 August through 24 August 1990.

16. An initial navigation notice was sent out on 22 May 1990 to all appropriate parties. Since the locks would be closed while the measurements were taken, recent lockage data was used to determine the times of measurement best suited to avoiding periods of heavy river traffic. A second navigation notice containing the times of measurement was sent out on 26 June 1990 to all appropriate parties. Both navigation notices are contained in Appendix A. One complete measurement at each of the three sites was accomplished per day according to the schedule contained in the navigation notice. The measurement at Wilmette Pumping Station concluded the daily activities.

17. In addition to the navigation notices, the Coast Guard, Milwaukee group was informed of the proposed activities so that notices would be issued via marine radio one week prior to the measurements. Additionally, the Coast Guard issued daily notices during the period 23 - 27 July 1990 two hours prior to each measurement.

18. At the start of each day, the MWRDGC was called via mobile telephone to obtain the sluice gate settings at all three sites. The lock operator was contacted at least 15 minutes prior to the start of the discharge measurements as a reminder to keep the lock closed during the measurements occurring upstream or downstream of

the lock. This was necessary to avoid unsteady flow conditions during the measurements. Upon completion of each measurement the lock operators were informed to proceed with normal lock operations and the MWRDGC dispatcher was contacted in order to obtain upstream and downstream elevations at the control structure. These elevations were recorded at half-hour increments over the measurement period. The dispatcher was also asked to verify that the sluice gate settings remained constant during the measurement.

19. The flow measurements were accomplished by first sounding the river bottom to provide a profile of the channel section and to determine the depths at which each measurement would be taken. The metering locations were set at the center of each panel (partial cross section). Cross sections of the three sites are shown in Figures B-1, B-2, and B-3. The measurements on the Chicago River downstream of the Chicago River Controlling Works used 10 discharge panels each 20 feet wide. The measurements on the Calumet River upstream of the O'Brien Lock used 11 discharge panels each 20 feet wide. The measurements on the North Shore Channel downstream of the Wilmette Pumping Station used 5 discharge panels each 14 feet wide. Current meter readings were taken every one-tenth of the total depth at the metering location in accordance with the "Vertical-Velocity Method" contained in the U.S. Geological Survey's (USGS) "National Handbook of Recommended Methods for Water-Data Acquisition" Sec. 1.B.2.c. Due to time constraints for each measurement and in order to limit the length of time the locks were shut down, it was necessary to deviate from the 25 partial cross sections (panels) suggested by the USGS in Sec. 1.B.2.b.4 of the "National Handbook of Recommended Methods for Water-Data Acquisition." However, the USGS states that fewer partial cross sections can be used at a smooth cross section that has a good velocity distribution, a condition initially believed to exist at the three measurement sites. Even with fewer than the ideal number of partial cross sections, the USGS' recommendation that no partial cross section contain more than 10 percent of the total flow was nearly met at two of the sites, CRCW and O'Brien Lock and Dam.

20. The measuring rig was placed along the upstream face of the bridge from which the measurements were taken. Pictures of the three bridges from which the measurements were taken are shown in Figures C-4 through C-9. A Price AA current meter, as shown in Figure C-10, was lowered to the surface and the depth gage zeroed out. The meter was then lowered to the 9/10 depth location. Simultaneously the stop watch and counter box were started. After a duration of 40 or 60 seconds, both were shut off simultaneously and the number of counts (revolutions of the bucket wheel) were recorded. Sixty second durations were used on 23, 24, and 27 July while forty second durations were used on 25 and 26 July.

21. Three different Price AA meters were used to dampen out any minor errors attributable to one particular meter. The pygmy meter shown in Figure C-11 was not used as it appeared in need of cali-

bration. On Wednesday 25 July, an attempt was made at all three sites to use the Marsh-McBirney electromagnetic meter shown in Figures C-12 and C-13. However, the meter gave erroneous readings while remaining in a stationary position. The meter was in obvious need of recalibration.

22. The rig used in conjunction with the Price AA current meter is shown in Figure C-14. The meter was suspended by a cable from the bridges previously mentioned. The meter elevation was read from the depth gage pictured in Figure C-15. The counter used was an analog type and required a separate power source as shown in Figure C-14. To zero out the depth gage shown in Figure C-15 the current meter was lowered so that the bucket wheel centerline was at the water surface as shown in Figure C-16. The cable line was flagged with fluorescent tape to make it more visible to boaters. After the depth gage was zeroed out, the meter was lowered to nine-tenths the total depth at its particular station and the first reading was taken over a 40 or 60 second duration. Subsequent readings were taken by raising the meter at increments of one-tenth the total depth.

RESULTS

23. The measured flow included both flow through open sluice gates and leakage occurring through lock gates and any closed sluice gates. The sluice gate settings at all three sites remained unchanged during the flow measurements. At the CRCW, all four sluice gates (situated at the Columbia Yacht Club located approximately 1/4 mile southwest of the lock in the same harbor) were open 1.5 feet. The four gates situated at the lock remained closed and, since their repair approximately 2 years ago, have only been used during extreme flooding for reverse flows or to aid in ice removal. At O'Brien Lock and Dam, gates 1,2, and 3 remained closed while gate #4 was open 3 feet. The single sluice gate at Wilmette Controlling Works remained open 1.0 feet. According to MWRDGC, these gate settings reflect the predominant setting during the discretionary period.

24. A direct comparison of the measured flows against the MWRDGC flows recorded in the monthly LMO-6 reports would be incorrect since the flows contained in these reports are average daily flows. Copies of the July LMO-6 reports for the three lakefront control structures are contained in Appendix D. Instead of using the average daily flows recorded in these LMO-6 reports, instantaneous MWRDGC flows were calculated over the actual period of each individual measurement. This period normally spanned over one to three hours. The instantaneous MWRDGC discretionary flows were calculated by using the rating tables provided by the MWRDGC for the three lakefront control structures. The instantaneous leakage at each site was calculated from a single equation (one for each control structure) developed by the MWRDGC. The equation contains varia-

bles for both the head across the gates and the number of lockages occurring over one day. The latter term was not part of the leakage equation for the Wilmette CW since locks do not exist at this site. The head across the gates used in the leakage equation was determined from the circular water surface elevation charts that record real-time headwater (upstream) and tailwater (downstream) elevations at the three control structures.

25. The rating tables and leakage equations used to calculate instantaneous discretionary and leakage flows are the same as those used by the MWRDGC in calculating the daily average flows recorded in the monthly LMO-6 reports. Examples of the MWRDGC rating tables, leakage equations, and circular water surface elevation charts are included in Appendix E. Appendix F contains the calculations of the instantaneous MWRDGC flows that utilize the elements of Appendix E.

26. The actual comparison of the measured flows to the instantaneous MWRDGC flows appears in Table 6 on the following page. The results in Table 6, with full consideration of the accuracy problems which are discussed later in the report, show that during the week of 23 through 27 July 1990, lakefront direct diversions were underreported by an average of 352 cfs at CRCW, 398 cfs at O'Brien Lock and Dam, and 103 cfs at Wilmette Controlling Works.

27. There exists an unstable relationship between the reported and measured flows as evidenced by the wide variance in the U.S. Army Corps of Engineers (USACE)/MWRDGC flow ratios. Instability of the coefficients could be the result of inaccuracies of the actual gate openings, rating tables, leakage equations, and flow measurements.

28. The results presented thus far concerning the possible underreporting of flows require further verification through additional measurements. Although preliminary conclusions can be drawn from one week of measurements (five measurements at each site) it is inappropriate to place significant emphasis on the results without confirmation from a larger set of data. In order to improve the confidence and accuracy of the results, future measurements will be required so as to expand the size of the data set. Expansion of the data set would include a wider range of sluice gate settings and a wider range of upstream and downstream water surface elevations (head across the gates).

TABLE 6

MWRDGC Reported Flows vs. Corps' Measured Flows

CRCW

	MWRDGC Disc.	MWRDGC Leak.	MWRDGC Sum	USACE Sum	Diff.	USACE/MWRDGC Flow Ratio
7-23	426	30	456	907	-451	1.99
7-24	457	32	489	836	-347	1.71
7-25	452	32	484	933	-449	1.93
7-26	460	32	492	573	- 81	1.16
7-27	440	31	471	902	-431	1.92
		AVERAGE=	478	830	-352	

O'Brien

	MWRDGC Disc.	MWRDGC Leak.	MWRDGC Sum	USACE Sum	Diff.	USACE/MWRDGC Flow Ratio
7-23	283	20	303	540	-237	1.78
7-24	289	20	309	718	-409	2.32
7-25	301	21	322	951	-629	2.95
7-26	300	21	321	666	-345	2.07
7-27	287	20	305	673	-368	2.21
		AVERAGE=	312	709	-398	

Wilmette

	MWRDGC Disc.	MWRDGC Leak.	MWRDGC Sum	USACE Sum	Diff.	USACE/MWRDGC Flow Ratio
7-23	110	2	112	198	-86	1.77
7-24	121	3	124	246	-122	1.98
7-25	119	3	122	226	-104	1.85
7-26	124	3	127	237	-110	1.87
7-27	123	3	125	218	-93	1.74
		AVERAGE=	122	225	-103	

RECOMMENDATIONS/DISCUSSIONS

29. Improvements to the present reporting procedures of the direct diversion flows should be investigated to minimize error in the reported flows. Therefore, options for future measurements will be discussed. Since all of the options include or recommend current meter measurements, the applicability of the two-point and three-point methods will be discussed and recommendations will be made for improving the accuracy and safety of future current meter measurements. Finally, the benefits of having in-house current measuring capabilities will be presented.

OPTIONS FOR FUTURE MEASUREMENTS

30. Future measurements and analyses are required to determine accurately the amount of the flow imbalance attributable to the underreporting of direct diversion flows. The options for accurately estimating these direct diversion flows include a regression analysis, installation of gaging stations at the three lakefront control structures, and development of revised rating curves and/or tables.

31. The first option, a regression analysis, would require several more flow measurements at the three lakefront control structures to provide a reliable data base. This larger data set is necessary for regression analyses. It is necessary that this database include flows over a wide range of gate settings and various upstream and downstream water surface elevations. After a series of measurements have been collected, regression equations can be evaluated. Due to the dynamic condition of the sluice gates, ie. physical wear and maintenance, the leakage rates and accuracy of the rating tables are expected to change over time. It is probable that the changes in the leakage rates and accuracy of the rating tables will vary in relation to maintenance of the sluice gates. However, these changes are expected to be small due to the relatively small amount of leakage that occurs as compared to the total sluice gate flow. To account for any subtle changes in the leakage rate and changes in the accuracy of the rating tables, periodic current meter measurements are required to verify the regression equations. If necessary, the regression equations would be updated to reflect these changes.

32. The second option, installation of gaging stations, requires hardware purchase and installation of an AVM at each of the three lakefront control structures. Additionally this option also necessitates ongoing data collection, maintenance, and calibration as well as the annual costs associated with each task. Calibration of the gages is accomplished by periodic current meter measurements. This option also requires the development of regression equations in order to provide a backup system in the event one of the gages malfunctions or is damaged.

33. The third option is the development of new or revised rating curves and/or tables for the sluice gates. This would encompass a thorough evaluation of existing operational and hydraulic conditions with development of equations for the purpose of calculating sluice gate flow at various gate settings and water surface elevations. Like the option of gaging stations, calibration and verification of these equations is accomplished through current meter measurements. This option requires that daily records of the gate settings and upstream and downstream stages be obtained from MWRDGC. In order to estimate flows through the lock gates, revised estimating procedures would be required.

34. Determination of the appropriate method for future analyses of the sluice gate flow at the three lakefront control structures involves consideration of the cost, accuracy, and benefits/disadvantages of each of the three options. The cost of the first option, development of regression equations, depends on the desired size of the database. One week of flow measurements (5 measurements at each site) costs approximately $6,500 when accomplished through resources from the Detroit District. With in-house equipment and staffing, the cost for one week of measurements is reduced to approximately $5,000. Provided that the number of flow measurements at each site is less than 50, and provided that the Chicago District has in-house flow measuring capabilities, the total cost for this option will probably not exceed $75,000 ($50,000 for the measurements and $25,000 for the regression analysis). If the measurements are conducted by the Detroit District the total cost would rise to approximately $90,000 ($65,000 for the measurements). The accuracy of this option is difficult to determine at this point. However, this is probably the least accurate of the three options being evaluated. The accuracy of the developed regression equations is dependent on the accuracy achieved through the flow measurements. The accuracy may be limited by inconsistencies between the operation of the sluice gates and the reported sluice gate openings as well as inconsistencies of the recorded water surface elevations that determine the reported flows. Despite these accuracy limitations, the reliability of the regression equations can be improved by increasing the size of the database. While this option may yield the least accurate results, expanding the database allows greater estimating accuracy of the sluice gate and leakage flows than is currently possible through the MWRDGC reported flows. The disadvantage of this method is that traffic on the waterways is disrupted during the current meter measurements. Additionally, every measurement requires the cooperation of MWRDGC and the Coast Guard. Frequent measurements will require a significant amount of cooperation from these agencies.

35. Installation and hardware costs of the second option, gaging stations (AVM's) at each control structure, are estimated at approximately $250,000. Additional costs of this option include approximately $105,000 per year for data collection, maintenance,

and calibration. This option yields the most accurate results of the three options. The primary advantage of this option over the others is that the measured flows include all the components of direct diversion: discretionary and navigation makeup flows through the sluice gates, leakage through the lock gates and sluice gates, lockage flows, and flow reversals. The accounting of all the direct diversion components in one measurement results in more available time to investigate other potential source(s) of the flow imbalance.

36. The estimated cost for the third option, development of new or revised rating curves and/or tables, is approximately $100,000. The accuracy of this approach falls somewhere between the other two options. The estimated error for this option is expected to be under 10 percent. The disadvantage of this option is that leakage through the sluice gates is not accounted for.

37. The least costly option is a regression analysis. The total cost for 50 measurements at each site along with the development of regression equations is approximately $75,000 with in-house capabilities or $90,000 if conducted by the Detroit District. While this method is the least costly, it is probably also the least accurate. The most accurate option is the installation of gaging stations at each of the three control structures. This option is also the most comprehensive in that it accounts for all the direct diversion components. However, the installation cost of approximately $250,000 coupled with the annual cost of approximately $105,000 for data collection, maintenance, and calibration may make this option infeasible. The option of developing new or revised sluice gate rating curves and/or tables for the three control structures falls somewhere between the other two options in terms of cost and accuracy. The cost to develop new rating tables is approximately $100,000 while the estimated error is expected to be under 10 percent.

APPLICABILITY OF TWO-POINT AND THREE-POINT METHODS FOR FUTURE CURRENT METER MEASUREMENTS

38. Due to the fact that all three options for future analyses of the direct diversion flows include current meter measurements, consideration was given to shortening the amount of time necessary to conduct each measurement. Consequently, the applicability of the two-point and three-point methods for flow measurements was determined. The two-point, three-point, and vertical-velocity methods are outlined in Section 1.B.2.c.1.b.3, 4, and 5 of the USGS "National Handbook of Recommended Methods for Water-Data Acquisition." The accuracy of the vertical-velocity method is greater than any other current meter method according to the USGS. The accuracy of this method is realized by integrating the 10-point vertical velocity curve in calculating the mean velocity for each partial section. However, the price paid to achieve this accuracy is the time required in the field to measure 10 points along each

partial section. The two-point and three-point methods differ from the vertical-velocity method in that only two or three points, instead of ten, are measured along each vertical (partial cross section). The two-point method averages the velocities at the 0.2 and 0.8 depths and uses this average as the mean velocity in the vertical. At sections with normally distributed velocities in the vertical, this method has been shown to give more consistent and accurate results than any of the other methods except the vertical-velocity curve method. The three-point method calculates a mean velocity by averaging the 0.2 and 0.8 depth observations and then averaging the result with the 0.6 depth measurement. This method is used when the velocities in the vertical are abnormally distributed. After review of the field measurements it was apparent that abnormal velocity distribution exists at CRCW and O'Brien Lock and Dam.

39. In order to assess the applicability of the two-point and three-point methods, flows were developed for each method by using the measurements of the vertical-velocity method that was applied in the field. Coefficients relating these methods to the vertical-velocity method were calculated to determine if the two or three-point method could be used to estimate accurately the results of the vertical velocity method. If the coefficients of one of the methods proved to be stable, consideration would be given toward applying that method in the field. Application of the two-point or three-point method in the field would result in fewer measurements along each partial section so that an increased number of partial cross sections could be measured. Therefore, it would be possible to meet the USGS recommendations that at least 25 partial cross sections be measured and that no more than 10 percent of the total flow be contained in any one partial section. Application of the vertical-velocity method, although the most consistent and accurate of the methods, makes meeting these recommendations impractical due to the extreme amount of time necessary to obtain the measurements. For example, the measurement of 25 partial sections requires approximately 6 hours to complete one flow measurement at either CRCW or O'Brien Lock and Dam.

40. The coefficients developed for the two-point and three-point methods are presented in Table 7. The complete development of the coefficients is presented in Appendix G. The coefficients for both methods prove to be unstable. Therefore, neither method should be used to estimate the flow near the three control structures. The suitability of the two-point or three point methods could not be determined at the Wilmette Controlling Works since at some shallow partial sections it was not possible to obtain measurements at the 6/10 and 8/10 depth observation. The reason for this was the one foot distance from the sounding weight bottom to the centerline of the Price AA meter's bucket wheel exceeded the distance from the channel bottom to the depth of the desired measurement. Because of this limitation the Price AA and Pygmy-type current meters are unable to obtain measurements at the 8/10 depth location at partial sections less than 5 feet deep.

TABLE 7

TWO-POINT AND THREE-POINT METHOD COEFFICIENTS FOR CRCW AND O'BRIEN LOCK AND DAM

CHICAGO RIVER CONTROLLING WORKS

DATE	VERTICAL VELOCITY METHOD (CFS)	2-POINT METHOD (CFS)	COEFFICIENT
23 July 1990	907	744	1.22
24 July 1990	836	832	1.00
25 July 1990	933	1020	.91
26 July 1990	573	583	.98
27 July 1990	902	944	.96

DATE	VERTICAL VELOCITY METHOD (CFS)	3-POINT METHOD (CFS)	COEFFICIENT
23 July 1990	907	947	.96
24 July 1990	836	854	.98
25 July 1990	933	991	.94
26 July 1990	573	489	1.17
27 July 1990	902	876	1.03

O'BRIEN LOCK AND DAM

DATE	VERTICAL VELOCITY METHOD (CFS)	2-POINT METHOD (CFS)	COEFFICIENT
23 July 1990	540	489	1.10
24 July 1990	718	710	1.01
25 July 1990	951	558	1.71
26 July 1990	666	560	1.19
27 July 1990	673	635	1.06

DATE	VERTICAL VELOCITY METHOD (CFS)	3-POINT METHOD (CFS)	COEFFICIENT
23 July 1990	540	590	.92
24 July 1990	718	746	.96
25 July 1990	951	791	1.20
26 July 1990	666	583	1.14
27 July 1990	673	622	1.08

PROBABILITY OF HIGH BIASED MEASUREMENTS

41. Through field observations of the current meter measurements it is apparent that several reasons exist for the measured flows to exhibit a high bias. An attempt should be made to eliminate the possibility of upward biased flows for any future current meter measurements. A list of the reasons for the measured flows to exhibit a high bias follows: inadvertent counts caused by turning on the power, upward rounding of counts upon switching off the power, the presence of lateral flow components, the presence of vertical flow components, wind induced reverse flows, and meter sway at the 9/10 depth observation.

42. Electrical surges caused by switching on the power to the counter box inadvertently caused the counter to count 1/2 revolution of the bucket wheel. This occurred during approximately half of the point measurements. Additionally, shutting off the power caused the counter to round up to the next highest whole number upon shut-off. This occurred at times when the counter was at half step intervals between whole numbers. The initial 1/2 count caused by turning on the power and the problem of rounding up 1/2 count upon shutting off the power are significant when measuring small velocities. Because the three measured sites exhibited low flow velocities, the surge induced 1/2 count and the rounding up of 1/2 count are the two primary reasons for the probable existence of high biased flow measurements at the three measured sites.

43. Additionally, the presence of lateral horizontal flow components, vertical flow components, and wind induced flow reversals would also lead to suspicions concerning the possibility of upward biased flow measurements. Because of the inability of the Price AA current meter to measure flow direction, most of the measured flows were assumed as flowing in the direction of the channel. This direction was normal to the cross section since the cross section was perpendicular to the channel. It was possible to determine the direction of some surface flows by observing the meter. However, due to poor water visibility, visual determination of the flow direction was only possible down to the 1/10 depth location. Consequently, horizontally skewed flows (lateral horizontal flows) and wind induced reverse flows could be accurately identified only at the 1/10 depth location while the identification of vertical flow components was not possible at any depth.

44. It is possible that horizontally skewed and/or vertical flow components exist at some locations. The possibilities of these types of flows existing at the measurement sites are greatest near the banks and behind mooring piers at both CRCW and O'Brien Lock and Dam. There exists one pier at Columbus Drive along the north bank of the Chicago River and there also exists one pier at 130th Street along the east bank of the Calumet River. Due to the inability of the Price AA current meter to determine these flow components, any horizontally skewed flows or vertical flows were unfor-

tunately measured along with, and added to, the flow component normal to the plane of the partial cross sections.

45. While the presence of horizontally skewed or vertical flows are unconfirmed, the existence of wind induced reverse flows at the 1/10 depth location were confirmed at O'Brien Lock and Dam on three of the five days. Because the winds were strong and the flow velocity was very low, the depth to which the wind affected the flow is in question. It appeared that in several cases flow reversals occurred down to the 2/10 depth observation and possibly down to the 3/10 depth observation. Because of limited visibility, the only way to identify reverse flows at these depths was by quickly raising the meter from the lower depths up to the surface so that the tailpiece of the meter could be sighted as an indicator of flow direction. Since the Price AA meter cannot decipher flow direction; any lateral flows, vertical flows, or flow reversals were recorded as occurring normal to the plane of the cross section except in those locations where a visual identification of flow direction was possible.

46. Another reason for the possible existence of high biased measured flows is meter sway at the 9/10 depth location. This sway was caused by the quick submergence of the meter down to the 9/10 depth location, the first measurement point along each partial cross section. The speed at which the meter was lowered would sometimes cause drift in the line resulting in the meter swaying back and forth. Eventually it would come to rest. If the meter was not allowed sufficient time to stabilize, that first measurement point (9/10 depth) could tend to be on the high side.

47. Upstream and downstream sway is not critical provided that the sway is parallel to the direction of flow and provided that the sway velocity does not exceed the velocity of the water. If the sway velocity is less than the stream velocity and the sway direction is parallel to the flow direction, the lesser flows measured on the downstream swing are offset by the increased flows measured on the upstream swing. However, if the velocity of the river is low or if the sway contains lateral components, the problem of sway is much more critical. If the sway velocity exceeds the stream velocity, the relative reverse (negative) flow on the downstream swing is measured as positive and does not offset the increase in flow measured on the upstream sway. Instead, the downstream measured flow is added to the increased flows measured on the upstream swing. Any lateral component of sway, sway in a direction other than parallel to the flow direction, also contributes a high bias to the measurement. Therefore, high biased flow measurements occur if the sway velocity exceeds the stream velocity and/or if the sway is in a direction other than parallel to the direction of flow. Since the point velocities at the measurement sites on the Chicago and Calumet rivers sometimes fell below 0.10 fps, sway is a significant concern. Consequently, care must be taken in the field to limit or remove sway entirely during the measurements.

IMPROVING THE ACCURACY OF FUTURE CURRENT METER MEASUREMENTS

48. Due to the probability that the measured flows contained in this report may exhibit a high bias, recommendations will be made for improving future current meter measurements so as to minimize or eliminate the likelihood of upward bias. As previously presented, problems associated with the counter included erroneous initial counts of one-half revolution of the bucket wheel upon switching the power on and rounding up one-half count upon power shut-off. Therefore, it is recommended that a digital indicator is used in place of the analog counter box containing a spool-type counter. A digital indicator eliminates the possibility of erroneous counts due to electrical surges and rounding upon power shut-off. It also eliminates the need for stopwatches and cumbersome battery packs. Several digital indicators are capable of direct display of flow velocity and almost all digital indicators are compatible with either Price AA or Pygmy-type current meters.

49. Because of the possible existence of lateral horizontal flow components, vertical flow components, and wind induced flow reversals it is recommended that an electromagnetic-type current meter, such as a Marsh-McBirney electromagnetic current meter, be used for future measurements at CRCW and O'Brien Lock and Dam. Marsh-McBirney electromagnetic current meters are capable of accurately measuring both the X and Y directional vectors in a horizontal plane. This allows the calculation of both the direction and magnitude of the true horizontal water velocities. Additionally, the Marsh-McBirney electromagnetic current meters are equipped with a spherical sensor that detects vertical motion, thus eliminating the possibility of vertical velocity components being translated into the horizontal components - a problem that exists with the current Price AA and Pygmy-type current meters.

50. Another reason for recommending the use of an electromagnetic current meter at the three measurement sites is that they have a much lower minimum threshold value (0.02 fps). In comparison, the Price AA current meter has a minimum threshold value of 0.10 fps which equals the lowest mean velocity for a partial section measured during the period 23 through 27 July 1990. Some point velocities measured along the partial sections at both CRCW and O'Brien Lock and Dam were below the Price AA minimum threshold value of 0.10 fps. Consequently, the use of a Price AA meter is questionable at these sites. Pygmy-type current meters accurately measure velocities as low as 0.05 fps. However, this is only slightly more appropriate than the Price AA meter at these sites. The most appropriate meter for use at these sites is an electromagnetic current meter because of its capability to measure accurately flows down to 0.02 fps. This type of meter may even be capable of separately measuring the extremely small leakage flows occurring at the three lakefront control structures when all sluice gates are closed.

51. One final advantage of using an electromagnetic current meter is its ability to obtain measurements at the lower measurement points in shallow sections. This capability is necessary at the Wilmette Controlling Works where some partial sections near the banks contain shallow depths (see Appendix B). The electromagnetic current meter contains a sensor that is usually mounted approximately 8 inches above the bottom of the mounting rod (see Figure 12 of Appendix C). Consequently, the electromagnetic current meter is able to obtain measurements at the 9/10 depth location at partial sections with depths down to 6.7 feet and at the 8/10 depth location at partial sections with depths down to 3.3 feet. Because some electromagnetic current meters have sensors that are mounted closer to the bottom of the mounting rod, the meters are able to obtain measurements at the 8/10 and 9/10 depth locations at even shallower partial sections. On the other hand, the Price AA and Pygmy current meters are constructed such that the distance from the bottom of the sounding weight to the centerline of the bucket wheel is approximately one foot. Consequently, the Price AA or Pygmy current meters are unable to obtain measurements at the 9/10 depth location at partial sections less than 10 feet deep or at the 8/10 depth location at partial sections less than 5 feet deep. Because of this limitation a determination could not be made as to the suitability of the two-point or three-point method at the Wilmette Controlling Works (see Table 7 on page 19).

52. Although an attempt was made to use a Marsh-McBirney Model 527 electromagnetic current meter on 25 July 1990, problems encountered in the field made it difficult to evaluate its performance. The first attempt to use the meter was at CRCW. Unfortunately, the meter readings fluctuated over a wide range of values while the meter remained stationary. This either occurred because of electrical interference from the high concentration of utilities at this downtown location or because the meter was in need of repairs or recalibration. Although the attempt to use an electromagnetic current meter was unsuccessful, it is recommended that the application of this type of current meter be further investigated at all three sites because of its low minimum threshold value and because of its ability to measure horizontal flow direction without adding the effects of vertical velocity.

53. Because the velocities on the Chicago and Calumet rivers are quite low, care must be taken to minimize any sway of the meter that would result in upward biased measurements. This is accomplished by lowering the meter at a slow rate and also by allowing sufficient time to pass so that the meter may come to rest in a stationary position prior to taking each point measurement.

54. In order to improve quality control, it is also suggested that the upstream and downstream water surface elevations reported by the MWRDGC for all three lakefront structures be verified in the field. On 26 and 27 July 1990 a discrepancy of 0.15 to 0.20 feet

was found between the stages recorded by the MWRDGC and the stages observed by the lockmaster at O'Brien Lock and Dam. Although both the upstream and downstream stages were usually found to differ by equal amounts, the difference between the stages could have an effect on the accuracy of the discharges determined from sluice gate rating curves and/or tables.

IMPROVING THE SAFETY OF FUTURE CURRENT METER MEASUREMENTS

55. In addition to the previous recommendations for improving the accuracy of the flow measurements by reducing the probability of high bias, a few suggestions will be made for improving the overall safety of future measurements. It is suggested that the field crew be equipped with a marine radio transmitter. This is necessary to issue an immediate warning concerning the flow measurements to any boaters who appear unaware of the measurement activities. Although various steps were taken to inform boaters (warnings issued by the Coast Guard on marine radio, navigation notices mailed to appropriate parties, and highly visible fluorescent tape attached to the cable suspended from the bridges) it appeared that some vessels approached the area of measurement without any caution. In one instance, a barge almost struck the meter while an attempt was made to raise it to safety. In another instance, a speeding recreational boater came very close to running into the suspended cable. Equipping the field crew with a marine radio transmitter allows immediate action to be taken to lessen the chance of accidents occurring in the field.

BENEFITS OF IN-HOUSE FLOW MEASURING EQUIPMENT

56. As previously discussed, the cost savings per week of measurements is approximately $1,500. This is the difference between having the Detroit District conduct the measurements versus having in-house measurement capabilities. The savings become even greater when comparing the in-house measurements against other outside assistance (ie. USGS). The savings increase as the number of measurements increase. Additionally, greater savings are realized in the event of inclement weather. If outside resources are used for the measurements, the Chicago District must pay for the outside labor that remains idle and unproductive during inclement weather. With in-house capabilities, the Chicago District employees are able to stay productive by remaining at or returning to the office during inclement weather.

57. One final benefit of having in-house flow measuring equipment is its availability for use in other areas or other projects. The equipment is not restricted for use at the lakefront control structures, but also may be used for various open channel and closed conduit applications.

CONCLUSIONS

58. The flow measurements showed, with full consideration of the accuracy problems detailed below, that the discretionary sluice gate flow and the leakage flows could be underreported by an average of 352 cfs at CRCW, 398 cfs at O'Brien Lock and Dam, and 103 cfs at Wilmette Controlling Works during the period 23 through 27 July 1990.

59. It should be emphasized that the underreporting of lakefront flows will require further verification. Sound quantitative conclusions cannot be drawn at this point due to:

a. the limited number of flow measurements,

b. and the tendency for the measured flows to exhibit a high bias, demonstrating that flow measurement procedures must be improved to develop a reliable flow measurement database.

60. Additional verification of these results requires that more flow measurements be taken to expand the size of the database to include flows over a wide range of sluice gate settings and upstream and downstream water surface elevations. It is recommended that improvements be made to the flow measurement procedure prior to expanding the database to improve the accuracy and safety of future measurements.

61. Based on the flow measurements, it is probable that there exists some underreported flows at the three lakefront control structures. It is conceivable that the underreporting of lakefront flows is a source of the canal system flow imbalance determined in Budget 13. The results of the initial flow measurements discussed in this report emphasize the need for further analysis of the specific sources and magnitudes of underreported direct diversion flows.

APPENDIX A

NAVIGATION NOTICES FOR CURRENT
METER MEASUREMENTS

FIGURE A-1

Navigation Notice

US Army Corps of Engineers
Chicago District

River: CHICAGO RIVER
CALUMET RIVER

Date: 22 MAY 1990

Location: MILE 0.0, CHICAGO RIVER
MILE 315, CALUMET RIVER, CHICAGO, IL
(130TH ST. BRIDGE)

Effective Period SEE BELOW

111 N. Canal St.
Chicago, Il 60606

In Reply Refer to:
CENCC-CO-O

RESTRICTION DUE TO FLOW MEASUREMENT
CHICAGO RIVER, Mile 0.0
CALUMET RIVER, Mile 315

(Reference NOAA Chart #14926)

1. The U.S. Army Corps of Engineers will be performing current meter measurements at the following sites during the period 23 through 27 July 1990.

a. Chicago River from Columbus Drive bridge. (Appx. 1/2 mile downstream (west) of Chicago Harbor Lock)

b. Calumet River from 130th Street bridge. (Appx. 1/3 mile upstream (north) of O'Brien Lock and Dam)

2. Mariners will not be allowed to pass through the locks during the times of measurement which will be announced via marine radio approximately two hours prior to the actual measurements.

3. Mariners are requested to proceed with caution in the vicinity of the aforementioned bridges during the times of measurement.

4. All inquiries pertaining to this restriction should be directed to the U.S. Army Corps of Engineers, Chicago District at (312) 353-6472.

JAMES E. EVANS, P.E.
Chief, Construction-Operations Division

90-03

FIGURE A-2

Navigation Notic

US Army Corps of Engineers
Chicago District

111 N. Canal St.
Chicago, Il 60606

River: CHICAGO RIVER
CALUMET RIVER

Date: 26 JUNE 1990

Location: MILE 0.0, CHICAGO RIVER
MILE 315, CALUMET RIVER, CHICAGO, IL
(130TH ST. BRIDGE)

Effective Period SEE BELOW

In Reply Refer to: CENCC-CO-O

AMENDENMENT TO NOTICE NO. 90-03

RESTRICTION DUE TO FLOW MEASUREMENT
CHICAGO RIVER, Mile 0.0
CALUMET RIVER, Mile 315

(Reference NOAA Chart #14926)

1. The U.S. Army Corps of Engineers will be performing current meter measurements at the following sites during the period 23 through 27 July 1990.

   a. Chicago River from Columbus Drive bridge. **During the period of 0600 through 0900 hours.** (Appx. 1/2 mile downstream (west) of Chicago Harbor Lock)

   b. Calumet River from 130th Street bridge. **During the period of 1000 through 1400 hours.** (Appx. 1/3 mile upstream (north) of O'Brien Lock and Dam)

2. Mariners will not be allowed to pass through the locks during the times of measurement which will be announced via marine radio approximately two hours prior to the actual measurements.

3. Mariners are requested to proceed with caution in the vicinity of the aforementioned bridges during the times of measurement.

4. All inquiries pertaining to this restriction should be directed to the U.S. Army Corps of Engineers, Chicago District at (312) 353-6472.

Donald Wadleigh
Chief, Operations Branch

90-04

APPENDIX B

FLOW MEASUREMENT CROSS SECTIONS

FIGURE B-1

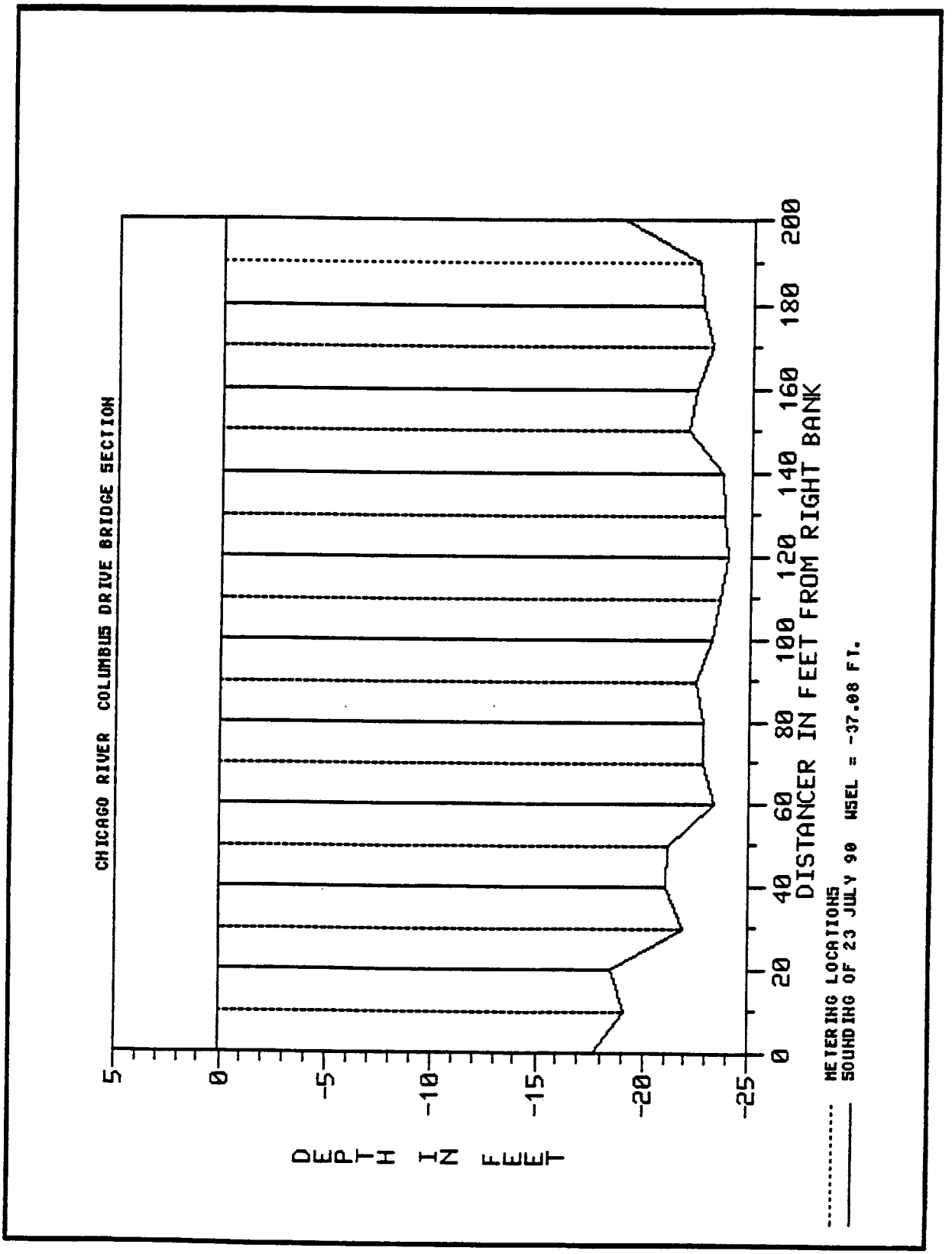

CHICAGO RIVER COLUMBUS DRIVE BRIDGE SECTION
DEPTH IN FEET
5
0
-5
-10
-15
-20
-25
0
20
40
60
80
100
120
140
160
180
200
DISTANCER IN FEET FROM RIGHT BANK
METERING LOCATIONS
SOUNDING OF 23 JULY 90 WSEL = -37.08 FT.

FIGURE B-2

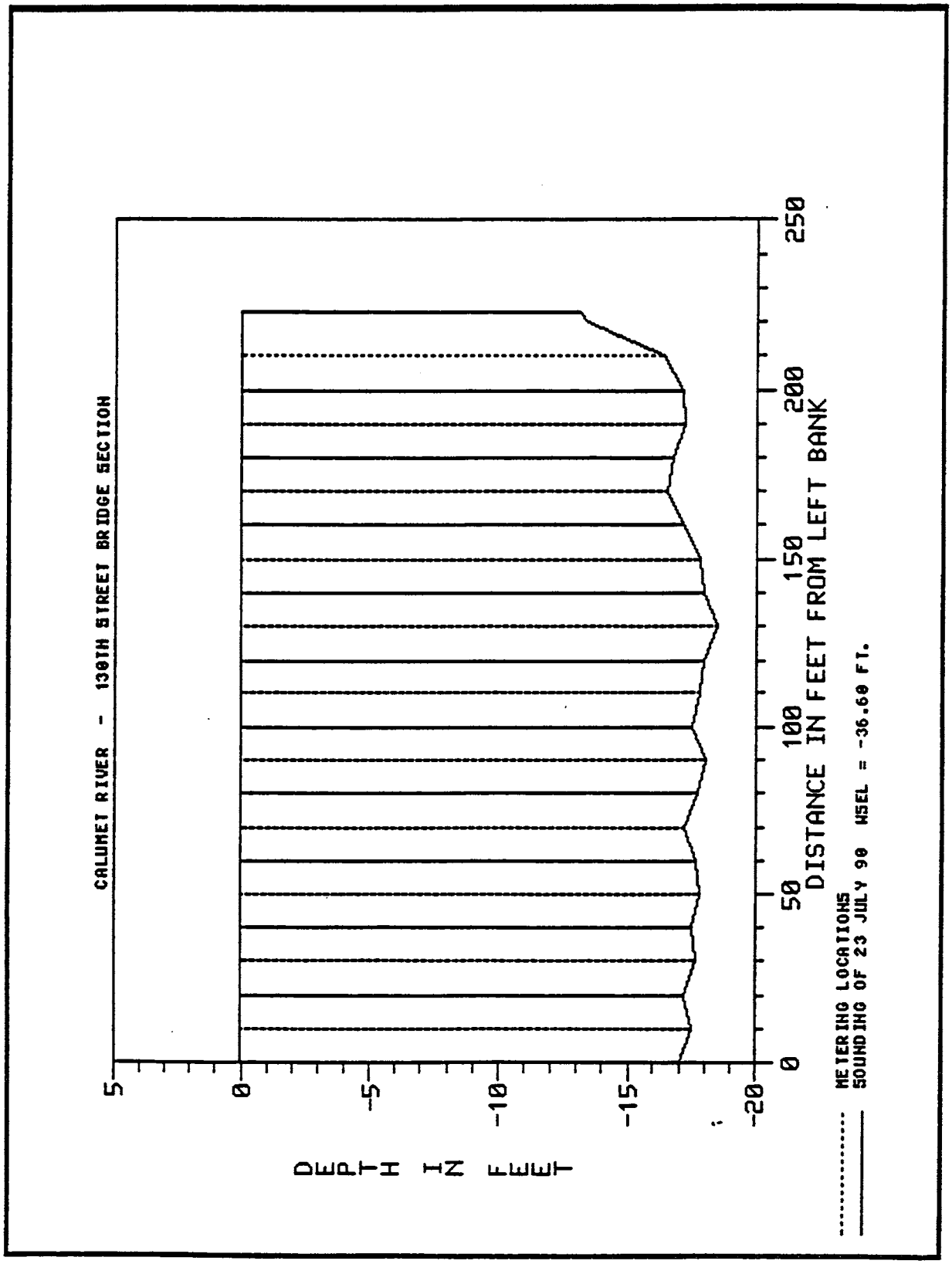
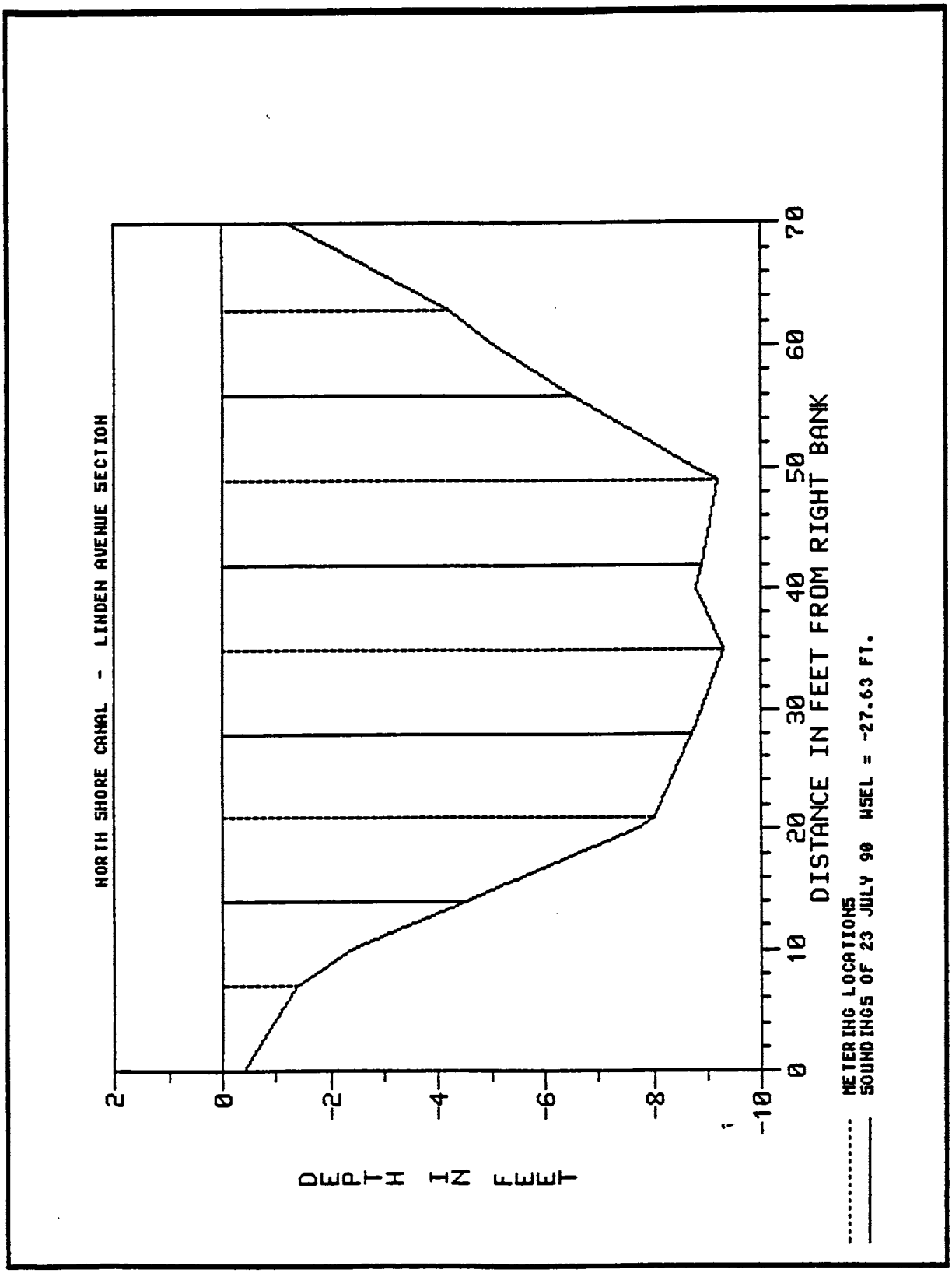
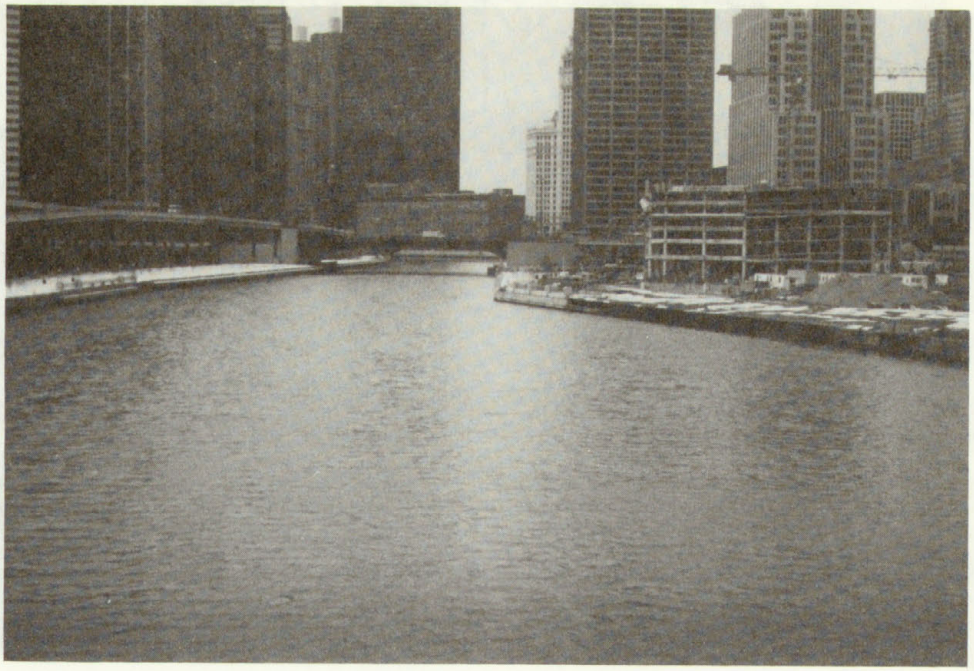

CALUMET RIVER - 130TH STREET BRIDGE SECTION
DEPTH IN FEET
5
0
-5
-10
-15
-20
0
50
100
150
200
250
DISTANCE IN FEET FROM LEFT BANK
METERING LOCATIONS
SOUNDING OF 23 JULY 90 WSEL = -36.60 FT.

FIGURE B-3


NORTH SHORE CANAL - LINDEN AVENUE SECTION
DEPTH IN FEET
2
0
-2
-4
-6
-8
-10
0
10
20
30
40
50
60
70
DISTANCE IN FEET FROM RIGHT BANK
METERING LOCATIONS
SOUNDINGS OF 23 JULY 90 WSEL = -27.63 FT.

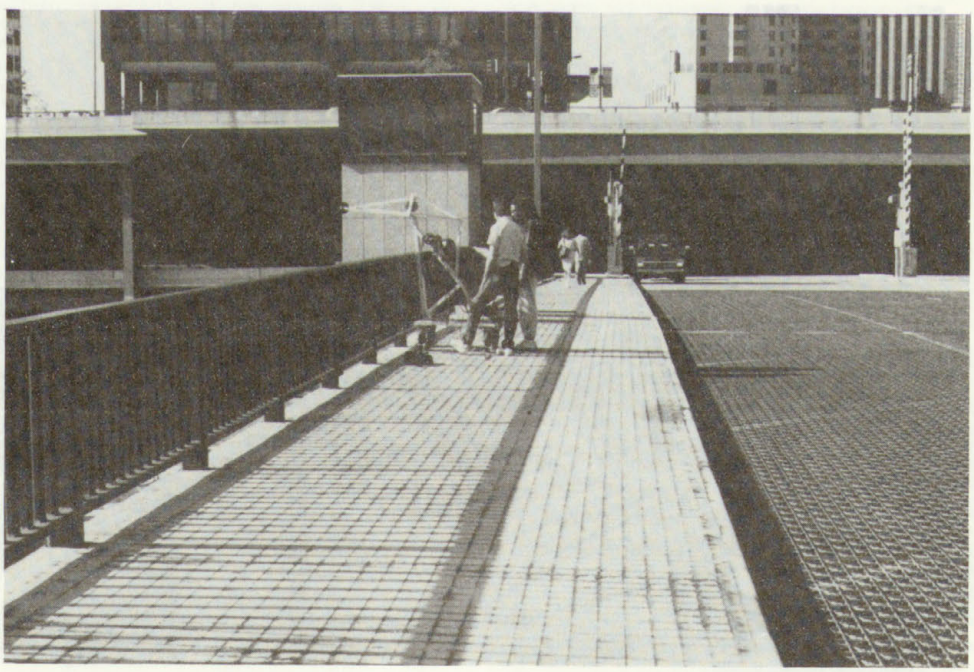
APPENDIX C

PHOTOGRAPHS OF MEASUREMENT SITES AND EQUIPMENT



Date: 3-7-90 **Location:** Columbus Drive/Chicago River
Description: Upstream (east) face of bridge.
Downstream of Chicago River Controlling Works.

FIGURE C-1

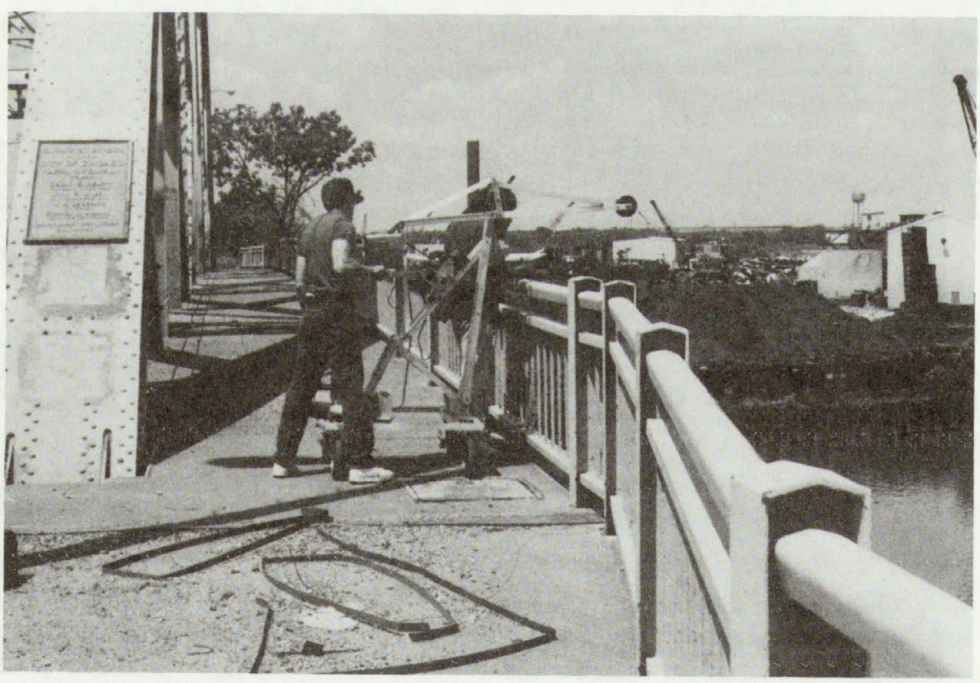


Date: 7-23-90 **Location:** Columbus Drive Bridge
Description: Current meter measurements on upstream side.

FIGURE C-2

Date: 3-7-90 **Location:** 130th Street/Calumet River
Description: Downstream(south) face of bridge.
Upstream of O'Brien Lock.

FIGURE C-3

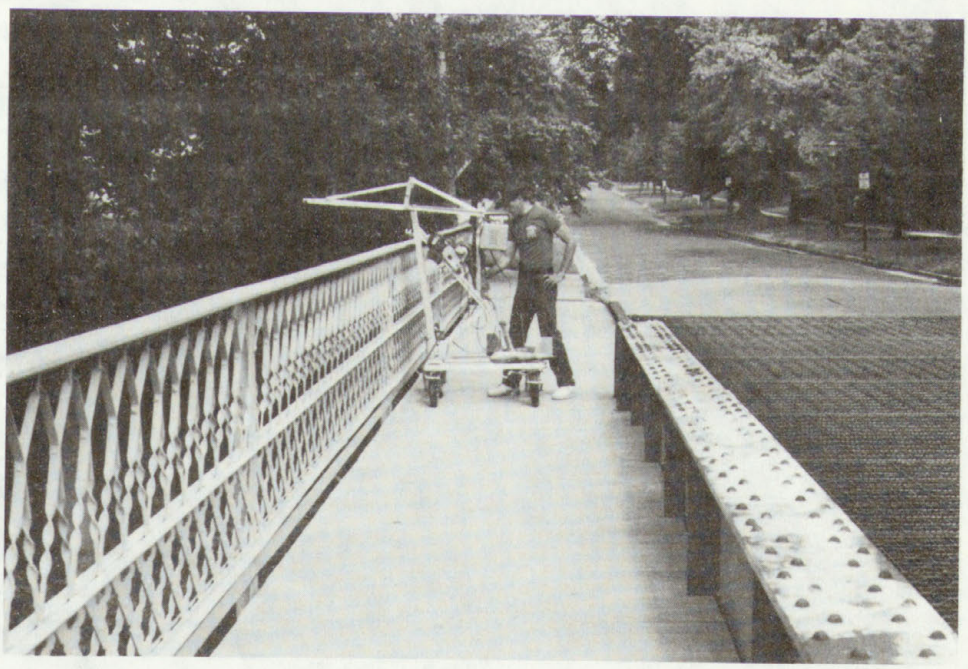


Date: 7-23-90 **Location:** 130th Street Bridge
Description: Current meter measurements on upstream side.

FIGURE C-4

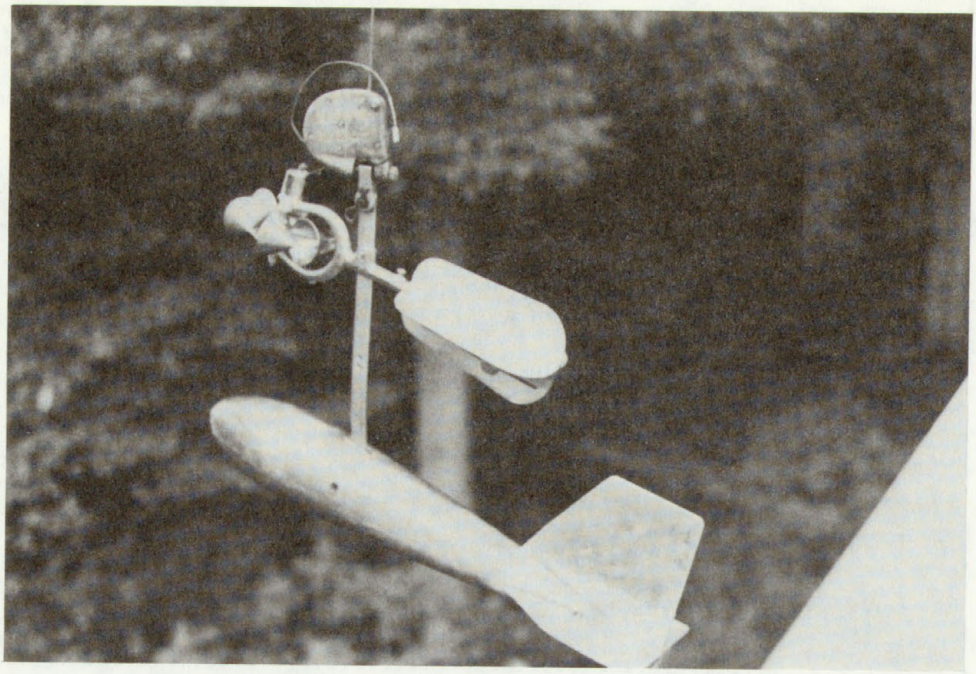
Date: 3-7-90 **Location:** Linden Ave./North Shore Channel
Description: Upstream (north) face of bridge.
Downstream of Wilmette Pumping Station.

FIGURE C-5



Date: 7-23-90 **Location:** Linden Avenue Bridge
Description: Current meter measurements on upstream side.

FIGURE C-6

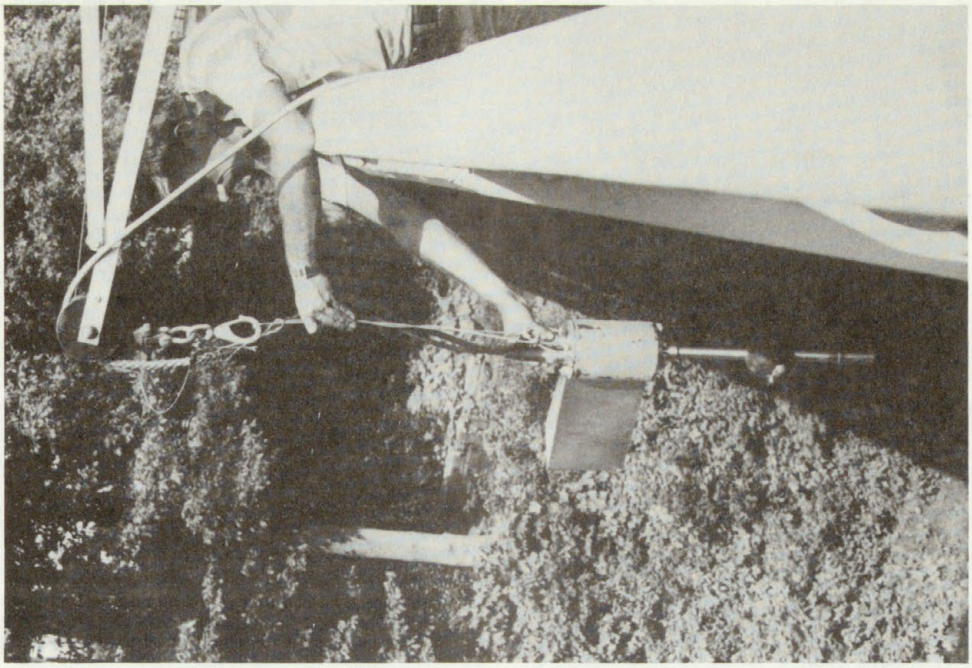


Date: 7-26-90 **Location:** _____
Description: Price AA current meter with lead weight.

FIGURE C-7

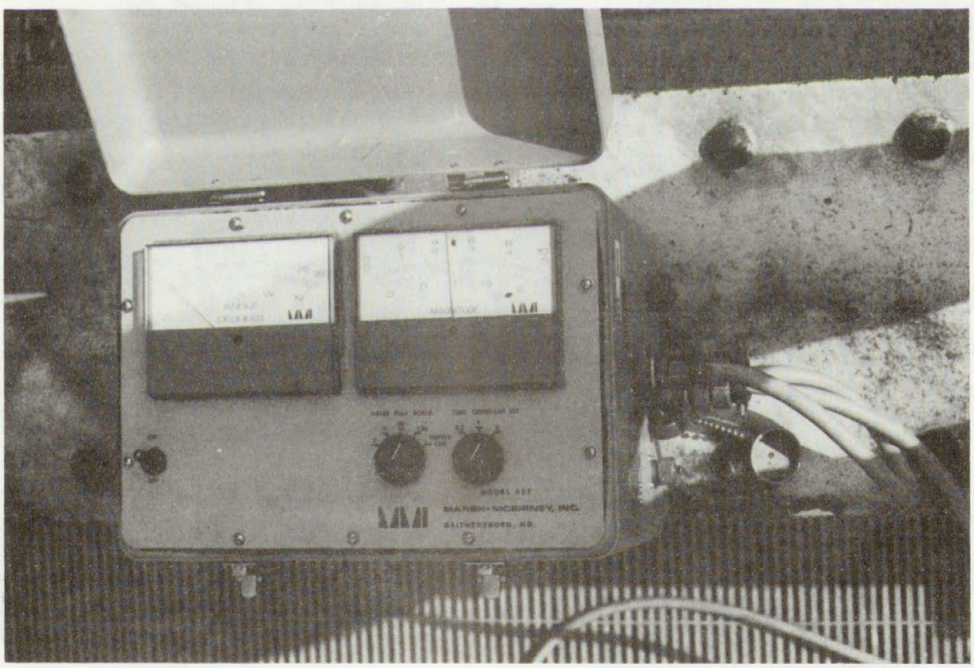
Date: 7-26-90 **Location:** _____
Description: Pygmy current meter with lead weight.

FIGURE C-8



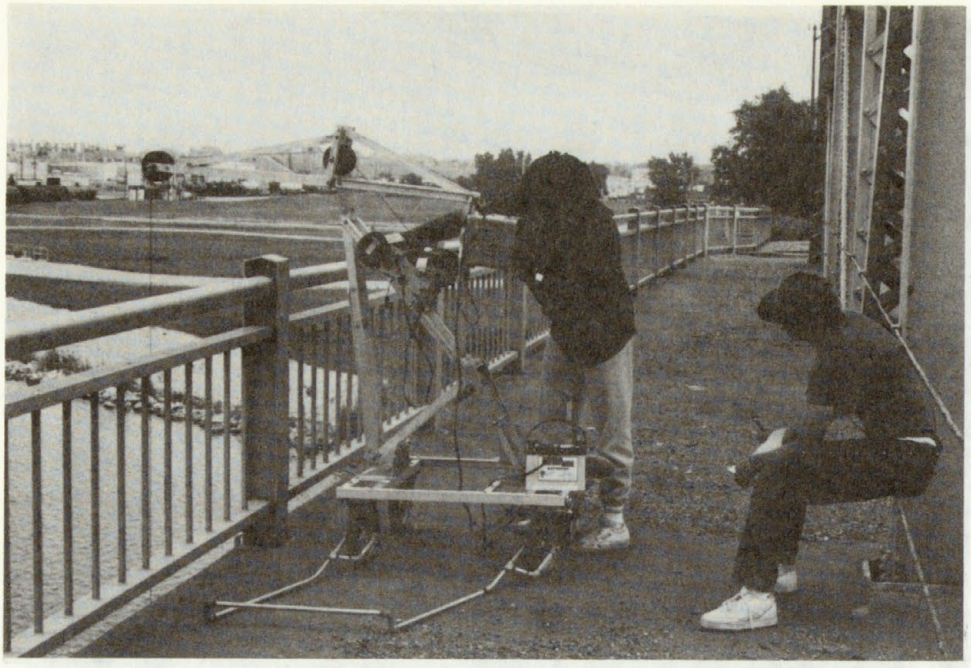
Date: 7-25-90 **Location:** _____
Description: Marsh - McBirney Electromagnetic Current Meter.

FIGURE C-9



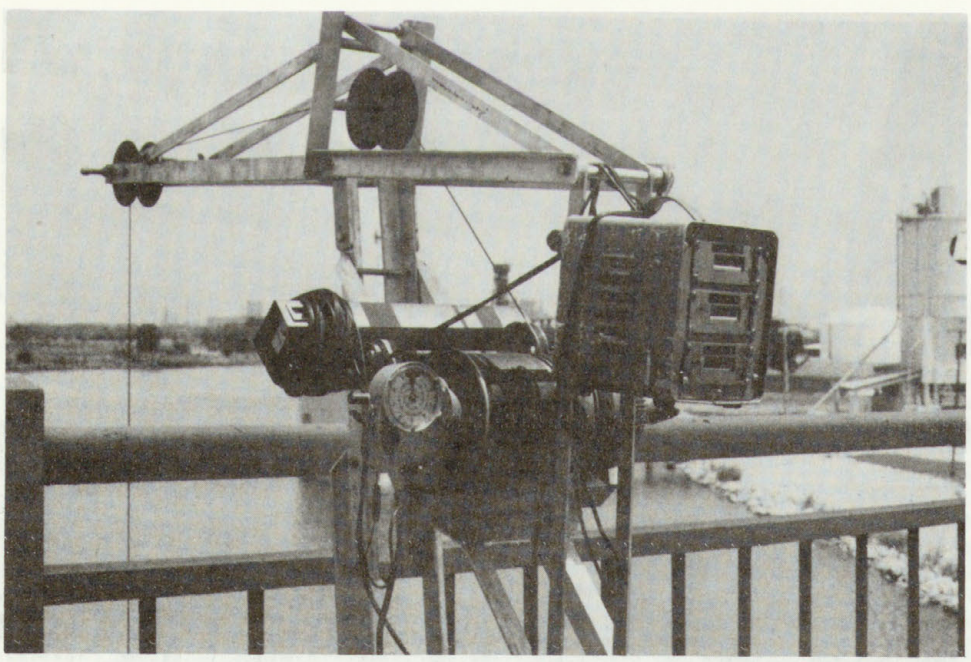
Date: 7-25-90 **Location:** _____
Description: Marsh - McBirney analog processor

FIGURE C-10



Date: 7-23-90 **Location:** 130th Street/Calumet River
Description:
Type A Four-Wheel Truck with
Type A Crane.

FIGURE C-11



Date: 7-23-90 **Location:** 130th Street/Calumet River
Description: Current meter rig showing counter box, Cable spool, and depth gage. Spool crank hidden behind counter box.

FIGURE C-12

Date: 7-26-90 **Location:** Columbus Drive/Chicago River
Description: Price AA current meter with flagged cable. Positioned for zeroing out depth gage - bucket wheel centerline at water surface.

FIGURE C-13

APPENDIX D

JULY 1990 LMO-6 REPORTS

FOR

CHICAGO RIVER CONTROLLING WORKS
O'BRIEN LOCK AND DAM
WILMETTE CONTROLLING WORKS

FIGURE D-1

FORM LMO-6 PAGE 3

DIRECT DIVERSION

CHICAGO RIVER CONTROLLING WORKS JULY 1990

DATE	DIRECT DIVERSION (cfs)					
	Navigational	Lockages		Leakage	Discretionary	Total
	Make-up	Number	Amount			
1	0	55	81	7	440	528
2	0	47	74	11	453	538
3	0	48	68	10	174	252
4	0	60	77	5	410	492
5	0	50	77	9	322	408
6	0	47	74	11	454	539
7	0	58	91	6	453	550
8	0	49	68	9	426	503
9	0	52	75	8	436	519
10	0	50	84	10	315	409
11	0	44	73	12	194	279
12	0	44	80	13	488	581
13	0	44	81	13	490	584
14	0	55	96	8	478	582
15	0	40	64	14	457	535
16	0	48	73	10	293	376
17	0	48	70	10	382	462
18	0	48	68	10	304	382
19	0	52	76	8	243	327
20	67	43	41	9	0	117
21	163	57	92	7	57	319
22	239	51	82	9	298	628
23	0	40	58	13	435	506
24	0	48	74	10	450	534
25	0	45	69	12	447	528
26	0	51	80	9	452	541
27	0	52	78	8	444	530
28	0	53	82	8	451	541
29	0	54	83	8	114	205
30	0	37	60	16	389	465
31	0	44	67	12	447	526
MONTHLY TOTAL	469	1514	2316	305	11196	14286
AVG	15.1		74.7	9.8	361.2	460.8

FIGURE D-2

FORM LMO-6 PAGE 4

DIRECT DIVERSION

O BRIEN LOCK AND DAM JULY 1990

DATE	DIRECT DIVERSION (cfs)					
	Navigational	Lockages		Leakage	Discretionary	Total
	Make-up	Number	Amount			
1	0	28	99	8	377	484
2	0	25	90	9	341	440
3	0	28	90	8	280	378
4	0	32	97	6	271	374
5	171	18	65	12	178	426
6	0	25	92	9	299	400
7	0	29	106	8	298	412
8	0	27	84	8	275	367
9	0	26	87	9	286	382
10	0	20	73	12	221	306
11	0	17	59	13	122	194
12	0	10	41	17	318	376
13	0	12	51	16	322	389
14	0	22	86	11	308	405
15	0	25	95	10	303	408
16	260	7	23	17	210	510
17	163	4	13	18	189	383
18	0	8	25	16	272	313
19	0	10	33	15	153	201
20	0	10	12	9	0	21
21	0	10	35	16	86	137
22	272	19	67	12	192	543
23	0	11	35	14	279	328
24	0	23	79	10	420	509
25	0	21	74	11	293	378
26	0	24	86	10	295	391
27	0	20	68	11	288	367
28	0	32	114	6	294	414
29	0	18	64	12	179	255
30	0	16	61	14	257	332
31	0	18	63	12	291	366
MONTHLY TOTAL	866	595	2067	359	7897	11189
AVG	27.9		66.7	11.6	254.7	360.9

FIGURE D-3

FORM LMO-6 PAGE 5

DIRECT DIVERSION

WILMETTE PUMPING STATION JULY 1990

DATE	DIRECT DIVERSION (cfs)					
	Navigational Make-up	Lockages Number	Lockages Amount	Leakage	Discretionary	Total
1	-----	---	-----	2	114	116
2	-----	---	-----	2	115	117
3	-----	---	-----	2	105	107
4	-----	---	-----	2	90	92
5	-----	---	-----	2	63	65
6	-----	---	-----	2	127	129
7	-----	---	-----	2	123	125
8	-----	---	-----	2	117	119
9	-----	---	-----	2	100	102
10	-----	---	-----	3	0	3
11	-----	---	-----	3	0	3
12	-----	---	-----	3	70	73
13	-----	---	-----	3	90	93
14	-----	---	-----	3	0	3
15	-----	---	-----	3	0	3
16	-----	---	-----	2	75	77
17	-----	---	-----	2	90	92
18	-----	---	-----	2	65	67
19	-----	---	-----	2	24	26
20	-----	---	-----	0	0	0
21	-----	---	-----	3	6	9
22	-----	---	-----	2	75	77
23	-----	---	-----	2	78	80
24	-----	---	-----	2	115	117
25	-----	---	-----	2	116	118
26	-----	---	-----	2	121	123
27	-----	---	-----	2	85	87
28	-----	---	-----	3	0	3
29	-----	---	-----	3	0	3
30	-----	---	-----	2	105	107
31	-----	---	-----	2	119	121
MONTHLY TOTAL				69	2188	2257
AVG				2.2	70.6	72.8

APPENDIX E

MWRDGC
RATING TABLES, LEAKAGE EQUATIONS, AND
CIRCULAR WATER SURFACE ELEVATION CHARTS

FOR

CHICAGO RIVER CONTROLLING WORKS
O'BRIEN LOCK AND DAM
WILMETTE CONTROLLING WORKS

FIGURE E-1

CHICAGO RIVER LOCKS AND SLUICE GATES

GATE OPENING IN FEET
DISCHARGE IN C.F.S.

Head	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'
0.1	15	30	46	61	76	91	106	122	137	152
0.2	22	43	65	86	108	130	151	173	194	216
0.3	26	53	79	106	132	158	185	211	238	264
0.4	30	61	91	122	152	182	213	243	274	304
0.5	34	68	102	136	171	205	239	273	307	341
0.6	37	74	112	149	186	223	260	298	335	372
0.7	40	81	121	161	202	242	282	322	363	403
0.8	40	86	129	172	215	258	301	344	387	430
0.9	46	91	137	182	228	274	319	365	410	456
1.0	48	96	144	192	241	287	337	385	433	481
1.1	51	101	152	202	253	303	354	404	455	505
1.2	53	106	158	211	264	317	370	422	475	528
1.3	55	110	165	220	275	330	385	440	495	550
1.4	57	114	171	228	285	342	399	456	513	570
1.5	59	118	177	236	295	354	413	472	531	590
1.6	61	122	183	244	305	366	427	488	549	610
1.7	63	126	189	252	315	377	440	503	566	629
1.8	65	129	194	259	324	388	453	518	582	647
1.9	66	133	199	266	332	398	465	531	598	664
2.0	68	136	204	272	340	409	477	545	613	681
2.1	70	140	210	280	350	419	489	559	629	699
2.2	72	143	215	286	358	429	501	572	644	715
2.3	73	146	219	292	365	438	511	584	657	730
2.4	75	149	224	298	373	448	522	597	671	746
2.5	76	152	229	305	381	457	533	610	686	762
2.6	78	156	233	311	389	467	545	622	700	778
2.7	79	159	238	317	397	476	555	634	714	793
2.8	81	161	242	323	404	484	565	646	726	807
2.9	82	164	246	328	411	493	575	657	739	821
3.0	84	167	251	334	418	501	585	668	752	835
3.1	85	170	255	340	425	509	594	679	764	849
3.2	86	172	259	345	431	517	603	690	776	862
3.3	88	175	263	350	438	525	613	700	788	875
3.4	89	178	266	355	444	533	622	710	799	888
3.5	90	180	270	360	451	541	631	721	811	901
3.6	91	183	274	366	457	548	640	731	823	914
3.7	93	185	278	371	464	556	649	742	834	927
3.8	94	188	282	376	470	563	657	751	845	939
3.9	95	190	285	380	476	571	666	761	856	951
4.0	96	192	289	385	481	577	673	770	866	962

$C = 0.6$

SLUICE GATES
10' x 10'

FIGURE E-2

O'BRIEN LOCK SLUICE GATE

Gate Openins in FEET — Discharse in C.F.S

HEAD	1	2	3	4	5	6	7	8	9	10
0.1	20	39	59	78	98	117	137	156	176	195
0.2	28	55	83	111	138	166	193	221	249	276
0.3	34	68	102	135	169	203	237	271	305	338
0.4	39	78	117	156	195	234	274	313	352	391
0.5	44	87	131	175	218	262	306	350	393	437
0.6	48	96	144	191	239	287	335	383	431	479
0.7	52	103	155	207	258	310	362	414	465	517
0.8	55	111	166	221	276	332	387	442	497	553
0.9	59	117	176	234	293	352	410	469	528	586
1.0	62	124	185	247	309	371	433	494	556	618
1.1	65	130	194	259	324	389	454	518	583	648
1.2	68	135	203	271	338	406	474	542	609	677
1.3	70	141	211	282	352	423	493	564	634	705
1.4	73	146	219	292	366	439	512	585	658	731
1.5	76	151	227	303	378	454	530	605	681	757
1.6	78	156	234	313	391	469	547	625	703	782
1.7	81	161	242	322	403	483	564	645	725	806
1.8	83	166	249	332	415	497	580	663	746	829
1.9	85	170	256	341	426	511	596	681	767	852
2.0	87	175	262	350	437	524	612	699	786	874
2.1	90	179	269	358	448	537	627	716	806	895
2.2	92	183	275	367	458	550	642	733	825	917
2.3	94	187	281	375	469	562	656	750	843	937
2.4	96	191	287	383	479	574	670	766	862	957
2.5	98	195	293	391	489	586	684	782	879	977
2.6	100	199	299	399	498	598	697	797	897	996
2.7	102	203	305	406	508	609	711	812	914	1015
2.8	103	207	310	414	517	620	724	827	931	1034
2.9	105	210	316	421	526	631	737	842	947	1052
3.0	107	214	321	428	535	642	749	856	963	1070
3.1	109	218	326	435	544	653	762	870	979	1088
3.2	111	221	332	442	553	663	774	884	995	1105
3.3	112	225	337	449	561	674	786	898	1010	1123
3.4	114	228	342	456	570	684	798	912	1025	1139
3.5	116	231	347	462	578	694	809	925	1040	1156
3.6	117	234	352	469	586	703	821	938	1055	1172
3.7	119	238	357	475	594	713	832	951	1070	1189
3.8	120	241	361	482	602	723	843	964	1084	1205
3.9	122	244	366	488	610	732	854	976	1098	1220
4.0	124	247	371	494	618	742	865	989	1112	1236

Based on C=.77

20-Jun-81

FIGURE E-3

WILMETTE SLUICE GATE

Gate Openins in FEET — Discharse in C.F.S

HEAD	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5
0.1	21	65	110	156	203	251	300	349	397	446
0.2	30	92	156	221	287	355	424	493	562	631
0.3	37	113	191	270	352	435	520	604	688	773
0.4	43	130	220	312	406	502	600	697	795	892
0.5	48	146	246	349	454	562	671	780	889	998
0.6	53	160	270	382	497	615	735	854	973	1093
0.7	57	172	291	413	537	665	794	923	1051	1180
0.8	61	184	311	441	574	711	848	986	1124	1262
0.9	64	196	330	468	609	754	900	1046	1192	1338
1.0	68	206	348	493	642	794	949	1103	1257	1411
1.1	71	216	365	517	673	833	995	1156	1318	1480
1.2	74	226	381	540	703	870	1039	1208	1377	1545
1.3	77	235	397	562	732	906	1082	1257	1433	1609
1.4	80	244	412	584	760	940	1122	1305	1487	1669
1.5	83	253	426	604	786	973	1162	1350	1539	1728
1.6	86	261	440	624	812	1005	1200	1395	1590	1785
1.7	88	269	454	643	837	1036	1237	1438	1639	1839
1.8	91	277	467	662	862	1066	1273	1479	1686	1893
1.9	94	284	480	680	885	1095	1307	1520	1732	1945
2.0	96	292	492	698	908	1124	1341	1559	1777	1995
2.1	98	299	504	715	931	1151	1375	1598	1821	2044
2.2	101	306	516	732	952	1178	1407	1635	1864	2093
2.3	103	313	528	748	974	1205	1439	1672	1906	2140
2.4	105	319	539	764	995	1231	1469	1708	1947	2186
2.5	107	326	550	780	1015	1256	1500	1743	1987	2231
2.6	109	332	561	795	1035	1281	1529	1778	2026	2275
2.7	111	339	572	811	1055	1305	1559	1812	2065	2318
2.8	114	345	582	825	1075	1329	1587	1845	2103	2361
2.9	116	351	593	840	1094	1353	1615	1878	2140	2402
3.0	118	357	603	854	1112	1376	1643	1910	2177	2444
3.1	119	363	613	869	1131	1399	1670	1941	2213	2484
3.2	121	369	623	882	1149	1421	1697	1972	2248	2524
3.3	123	375	632	896	1167	1443	1723	2003	2283	2563
3.4	125	380	642	910	1184	1465	1749	2033	2317	2601
3.5	127	386	651	923	1201	1486	1775	2063	2351	2639
3.6	129	391	660	936	1218	1507	1800	2092	2384	2677
3.7	131	397	669	949	1235	1528	1825	2121	2417	2714
3.8	132	402	678	962	1252	1549	1849	2149	2450	2750
3.9	134	407	687	974	1268	1569	1873	2178	2482	2786
4.0	136	412	696	987	1284	1589	1897	2205	2513	2822

Based on C=0.6

26-Sep-81

LEAKAGE FORMULA FOR THREE LAKE MICHIGAN INLETS

CRCW	$QL = 20.32 \sqrt{H}$	$\frac{(24-0.33N)}{24}$
O'BRIEN	$QL = 12.8 \sqrt{H}$	$\frac{(24-0.5N)}{24}$
WILMETTE	$QL = 3.04 \sqrt{H}$	

WHERE:

QL = Leakage (average daily flow, cfs)

H = The difference in water elevation upstream and downstream of the lock or gate.

N = Number of lockages in a day.

FIGURE E-4

Chicago River Controlling Works
(upstream)

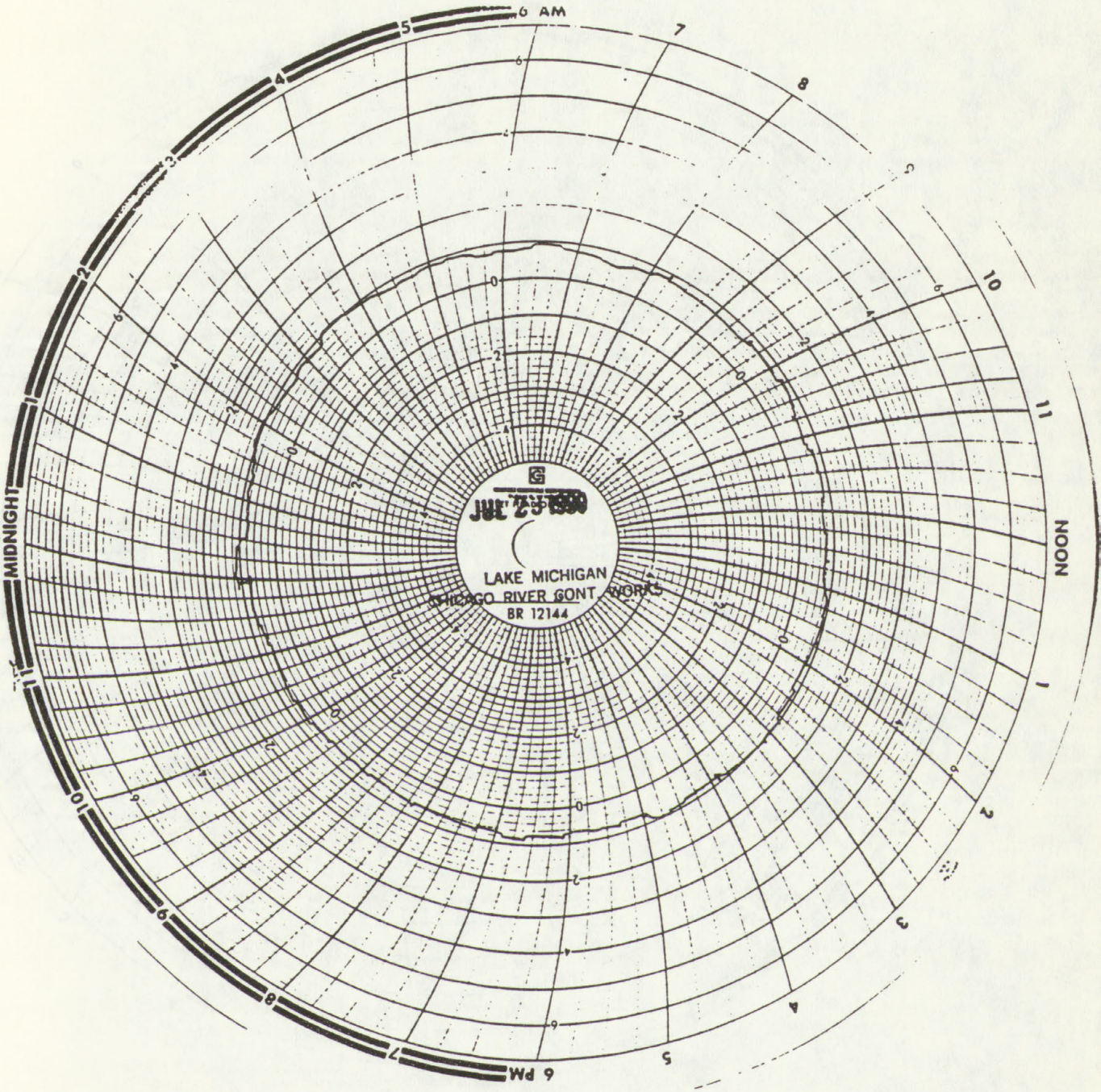


FIGURE E-5

Chicago River Controlling Works
(downstream)

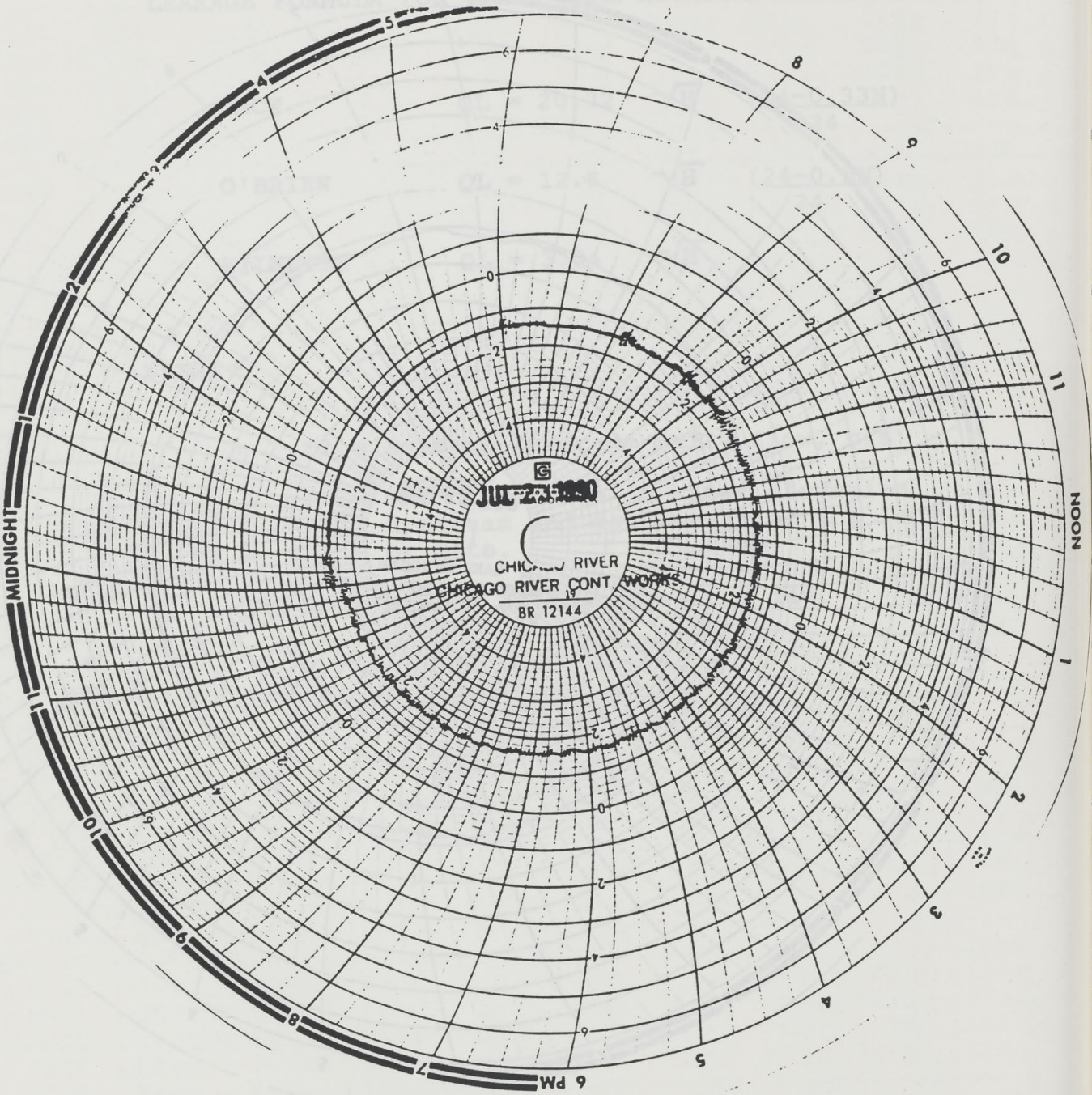


FIGURE E-6

O'Brien Lock and Dam
(upstream)

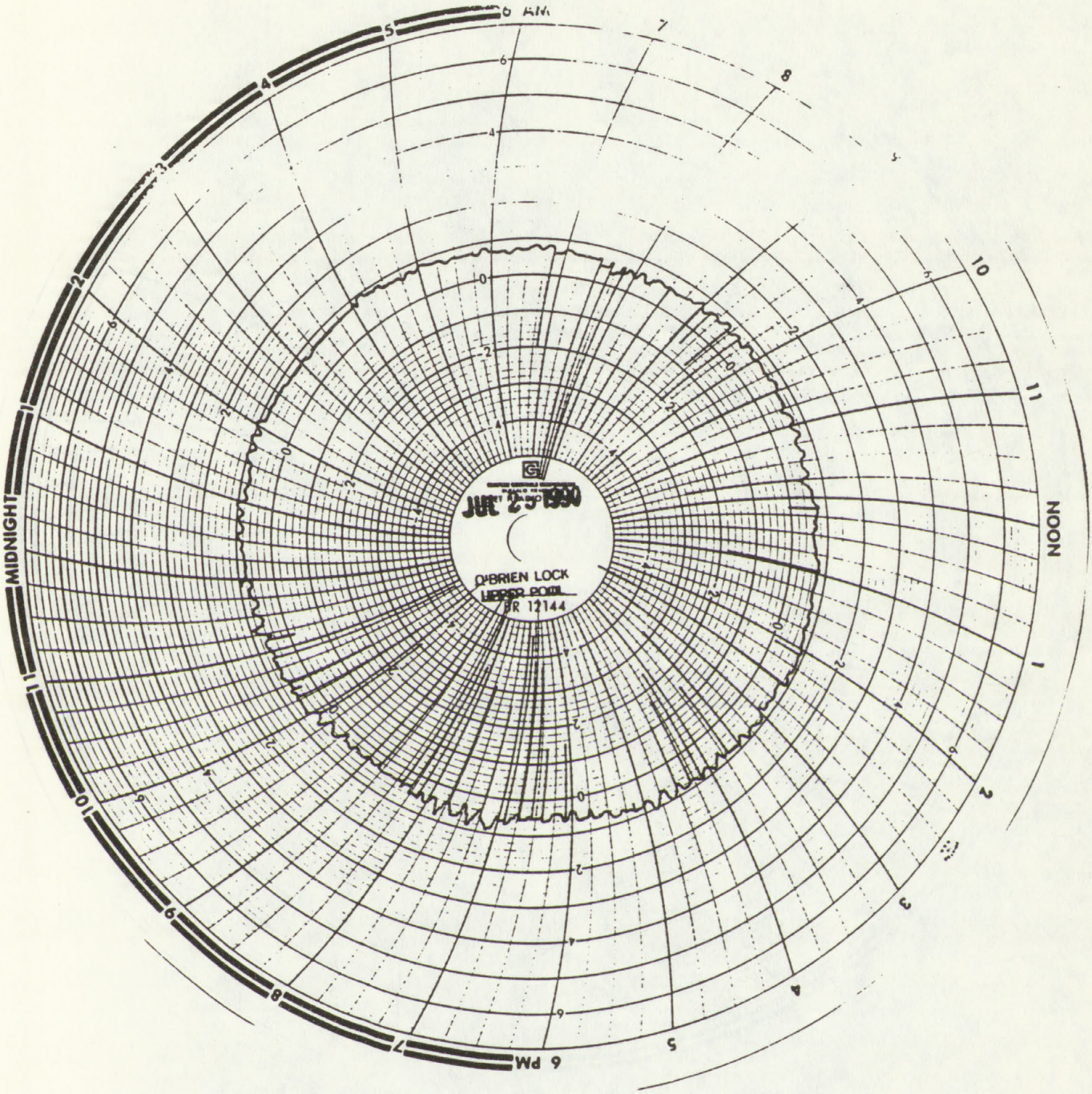


FIGURE E-7

O'Brien Lock and Dam
(downstream)

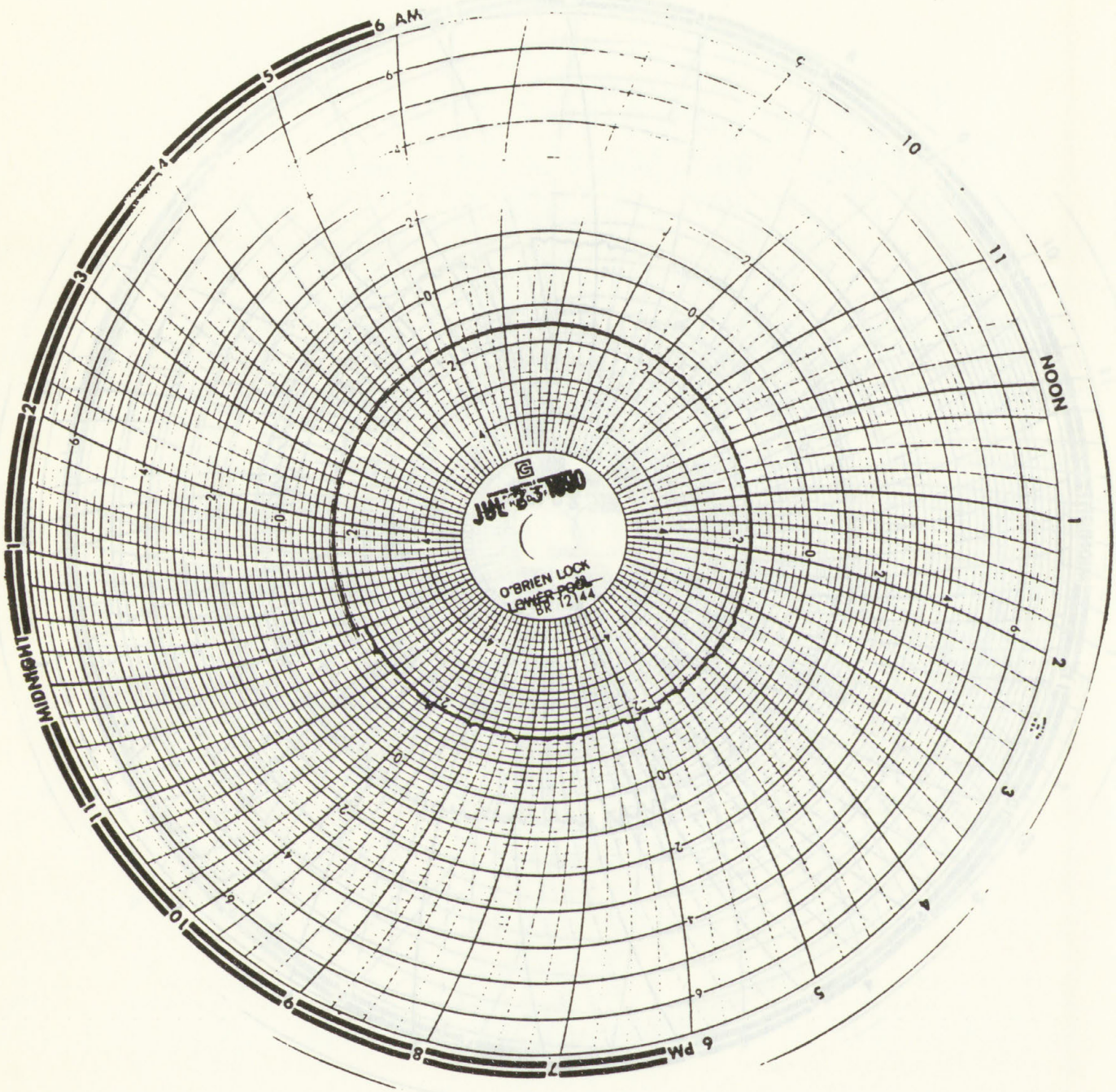


FIGURE E-8

Wilmette Controlling Works
(upstream)

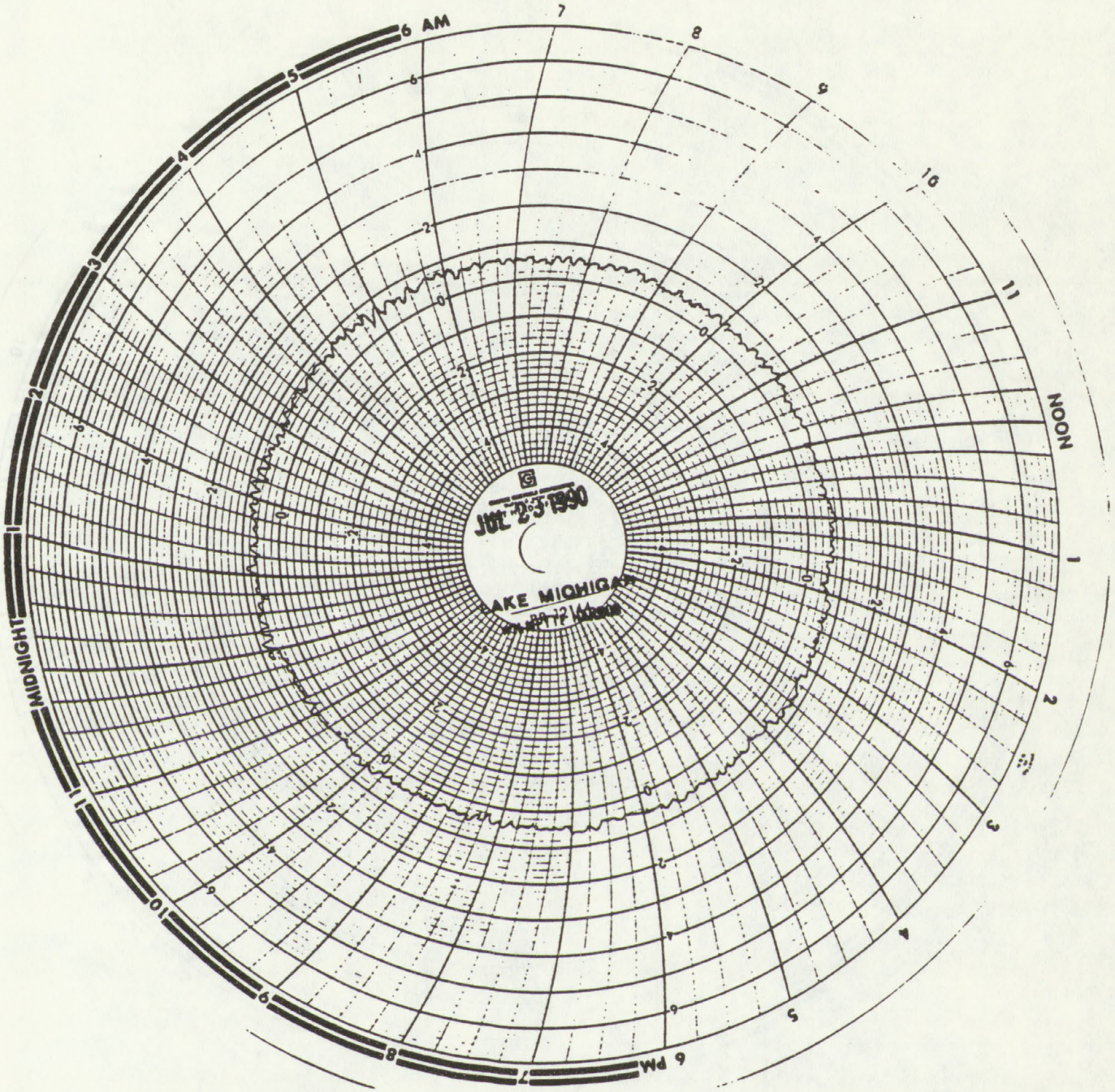
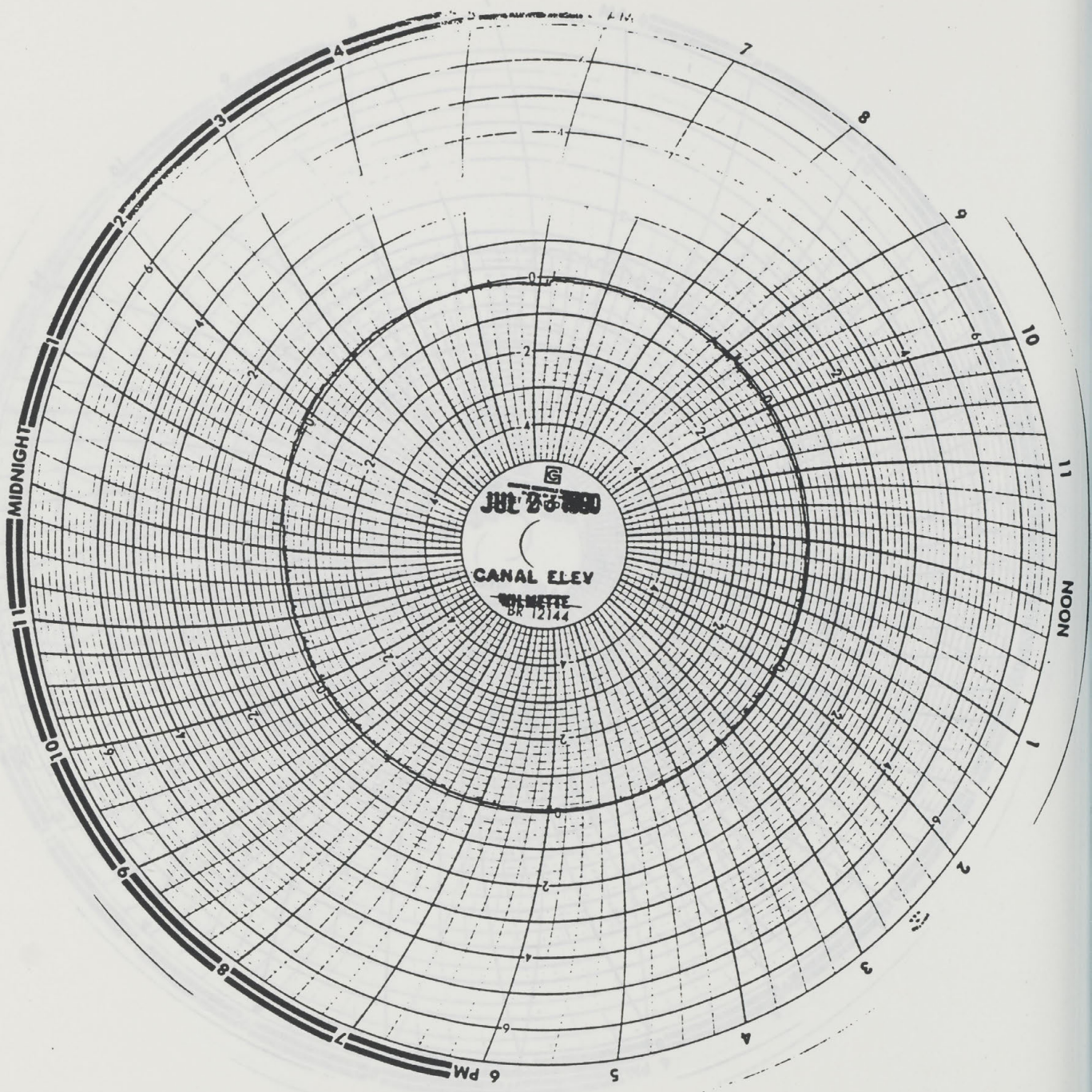


FIGURE E-9

Wilmette Controlling Works
(downstream)



APPENDIX F

CALCULATIONS OF INSTANTANEOUS MWRDGC DISCRETIONARY AND LEAKAGE FLOWS

TABLE F-1

INSTANTANEOUS MWRDGC
DISCRETIONARY AND LEAKAGE FLOWS

DATE	GATE OPENING (ft)	NO.OF OPEN GATES	AVG. HEAD (ft)	FLOW PER GATE (cfs)	TOTAL GATE FLOW (cfs)	LEAKAGE (cfs)	SUM (cfs)
CRCW							
7-23	1.5	4	2.16	106.5	426.0	29.5	455.5
7-24	1.5	4	2.51	114.3	457.2	32.2	489.4
7-25	1.5	4	2.45	113.0	452.0	31.8	483.8
7-26	1.5	4	2.53	114.9	459.6	32.3	491.9
7-27	1.5	4	2.32	110.0	440.0	31.0	471.0
O'BRIEN							
7-23	3	1	2.34	283.4	283.4	19.6	303.0
7-24	3	1	2.43	288.8	288.8	20.0	308.8
7-25	3	1	2.63	300.8	300.8	20.8	321.6
7-26	3	1	2.62	300.2	300.2	20.7	320.9
7-27	3	1	2.37	285.2	285.2	19.7	304.9
WILMETTE							
7-23	1	1	0.64	109.7	109.7	2.4	112.1
7-24	1	1	0.78	120.9	120.9	2.7	123.6
7-25	1	1	0.75	118.5	118.5	2.6	121.1
7-26	1	1	0.82	124.0	124.0	2.8	126.8
7-27	1	1	0.80	122.5	122.5	2.7	125.2

Column Description:

Gate Opening = Vertical opening of sluice gate.

Number of Open Gates = The number of sluice gates with a vertical opening equal to that specified in "Gate Opening".

Avg. Head = Average head across sluice gates during the measurement. See Tables F-2, F-3, and F-4 for water surface elevations. Water surface elevations obtained from MWRDGC circular stage charts (See Figures E-4 through E-9).

Flow per Gate = Flow through one sluice gate as determined by rating tables in Appendix E.

Total Gate Flow = "Number of Open Gates" x "Flow per Gate".

Leakage = Leakage through sluice gates and lock gates as calculated by equations in Appendix E. "Average Head" used as "H" in leakage equation. Number of lockages "N" equal zero.

Sum = "Total Gate Flow" + "Leakage"

TABLE F-2
WATER SURFACE ELEVATIONS (CCD)
AT CHICAGO RIVER CONTROLLING WORKS

DATE	TIME		UPSTREAM ELEV. (LAKE)	DOWNSTREAM ELEV. (RIVER)	HEAD (ft)
7-23	730		+0.60	-1.40	2.00
	800		+0.75	-1.45	2.20
	830		+0.75	-1.45	2.20
	900		+0.70	-1.45	2.15
	930		+0.80	-1.45	2.25
			-----	-----	----
		AVG.=	+0.72	-1.44	2.16
7-24	630		+0.70	-1.85	2.55
	700		+0.60	-1.85	2.45
	730		+0.60	-1.85	2.45
	800		+0.65	-1.85	2.50
	830		+0.60	-1.95	2.55
	900		+0.60	-1.95	2.55
			-----	-----	----
		AVG.=	+0.63	-1.88	2.51
7-25	600		+0.80	-1.70	2.50
	630		+0.75	-1.70	2.45
	700		+0.75	-1.75	2.50
	730		+0.70	-1.75	2.45
	800		+0.65	-1.75	2.40
	830		+0.65	-1.80	2.45
	900		+0.60	-1.80	2.40
			-----	-----	----
		AVG.=	+0.70	-1.75	2.45
7-26	630		+0.75	-1.80	2.55
	700		+0.80	-1.80	2.60
	730		+0.80	-1.80	2.60
	800		+0.65	-1.75	2.40
	830		+0.75	-1.75	2.50
			-----	-----	----
		AVG.=	+0.75	-1.78	2.53
7-27	600		+0.80	-1.45	2.25
	630		+0.80	-1.45	2.25
	700		+0.95	-1.50	2.45
	730		+0.80	-1.55	2.35
	800		+0.75	-1.50	2.25
	830		+0.80	-1.55	2.35
	900		+0.75	-1.55	2.30
			-----	-----	----
		AVG.=	+0.81	-1.51	2.31

TABLE F-3
WATER SURFACE ELEVATIONS (CCD)
AT O'BRIEN LOCK AND DAM

DATE	TIME		UPSTREAM ELEV. (LAKE)	DOWNSTREAM ELEV. (RIVER)	HEAD (ft)
7-23	1200		+0.65	-1.60	2.25
	1230		+0.60	-1.60	2.20
	1300		+0.75	-1.60	2.35
	1330		+0.80	-1.60	2.40
	1400		+0.85	-1.65	2.50
			---	---	---
		AVG.=	+0.73	-1.61	2.34
7-24	1030		+0.40	-1.80	2.20
	1100		+0.65	-1.85	2.50
	1130		+0.70	-1.85	2.55
	1200		+0.55	-1.85	2.40
	1230		+0.60	-1.85	2.45
	1300		+0.65	-1.85	2.50
			---	---	---
		AVG.=	+0.59	-1.84	2.43
7-25	1100		+0.60	-1.95	2.55
	1130		+0.65	-1.95	2.60
	1200		+0.75	-1.95	2.70
	1230		+0.70	-1.95	2.65
	1300		+0.70	-1.95	2.65
	1330		+0.65	-1.95	2.60
	1400		+0.70	-1.95	2.65
			---	---	---
		AVG.=	+0.68	-1.95	2.63
7-26	930		+0.70	-2.00	2.70
	1000		+0.60	-2.00	2.60
	1030		+0.65	-1.95	2.60
	1100		+0.70	-1.95	2.65
	1130		+0.55	-2.00	2.55
			---	---	---
		AVG.=	+0.64	-1.98	2.62
7-27	1000		+0.60	-1.75	2.35
	1030		+0.60	-1.80	2.40
	1100		+0.55	-1.80	2.35
	1130		+0.45	-1.85	2.30
	1200		+0.40	-1.85	2.25
	1230		+0.45	-1.90	2.35
	1300		+0.50	-1.90	2.40
	1330		+0.65	-1.90	2.55
			---	---	---
		AVG.=	+0.53	-1.84	2.37

TABLE F-4

WATER SURFACE ELEVATIONS (CCD)
AT WILMETTE CONTROLLING WORKS

DATE	TIME		UPSTREAM ELEV. (LAKE)	DOWNSTREAM ELEV. (RIVER)	HEAD (ft)
7-23	1700		+0.60	-0.05	0.65
	1715		+0.60	-0.05	0.65
	1730		+0.65	-0.05	0.70
	1745		+0.50	-0.05	0.55
		AVG.=	+0.59	-0.05	0.64
7-24	1530		+0.60	-0.20	0.80
	1600		+0.60	-0.20	0.80
	1630		+0.55	-0.20	0.75
		AVG.=	+0.58	-0.20	0.78
7-25	1630		+0.55	-0.15	0.70
	1700		+0.65	-0.15	0.80
		AVG.=	+0.60	-0.15	0.75
7-26	1330		+0.65	-0.20	0.85
	1400		+0.60	-0.15	0.75
	1430		+0.70	-0.15	0.85
		AVG.=	+0.65	-0.17	0.82
7-27	1430		+0.55	-0.20	0.75
	1500		+0.65	-0.20	0.85
		AVG.=	+0.60	-0.20	0.80

APPENDIX G

CALCULATIONS OF COEFFICIENTS FOR TWO-POINT AND THREE-POINT METHODS

CHICAGO RIVER CONTROLLING WORKS

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-23-90	1	4	8	5	0.173	0.316	0.209	370	0.254	93.81	0.191	70.65
METER S	2	4	11	8	0.173	0.423	0.316	416	0.334	138.95	0.245	101.75
60 SEC.	3	4	6	3	0.173	0.245	0.137	433	0.200	86.55	0.155	67.19
	4	1	7	6	0.066	0.280	0.245	458	0.218	99.74	0.155	71.07
	5	1	5	7	0.066	0.209	0.280	453	0.191	86.50	0.173	78.40
	6	2	7	4	0.102	0.280	0.173	471	0.209	98.36	0.137	64.67
	7	2	5	6	0.102	0.209	0.245	475	0.191	90.70	0.173	82.21
	8	3	5	6	0.137	0.209	0.245	450	0.200	89.95	0.191	85.93
	9	2	6	5	0.102	0.245	0.209	456	0.200	91.15	0.155	70.76
	10	2	5	3	0.102	0.209	0.137	433	0.164	71.07	0.119	51.71
								TOTAL FLOW =		946.79		744.35

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-24-90	1	2	2	1	0.132	0.132	0.096	364	0.123	44.61	0.114	41.36
METER K	2	2	3	2	0.132	0.167	0.132	410	0.149	61.24	0.132	53.92
60 SEC.	3	3	4	5	0.167	0.203	0.239	427	0.203	86.68	0.203	86.68
	4	3	5	5	0.167	0.239	0.239	452	0.221	99.84	0.203	91.76
	5	5	3	4	0.239	0.167	0.203	447	0.194	86.75	0.221	98.73
	6	6	3	2	0.275	0.167	0.132	464	0.185	85.90	0.203	94.19
	7	6	6	5	0.275	0.275	0.239	469	0.266	124.55	0.257	120.36
	8	3	5	3	0.167	0.239	0.167	444	0.203	90.13	0.167	74.26
	9	6	4	4	0.275	0.203	0.203	450	0.221	99.39	0.239	107.44
	10	2	4	3	0.132	0.203	0.167	426	0.176	75.06	0.149	63.63
								TOTAL FLOW =		854.15		832.32

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-25-90	1	5	5	1	0.309	0.309	0.094	366	0.255	93.29	0.201	73.63
METER U	2	4	3	1	0.255	0.201	0.094	412	0.188	77.35	0.174	71.82
40 SEC.	3	4	4	3	0.255	0.255	0.201	428	0.241	103.35	0.228	97.60
	4	4	3	3	0.255	0.201	0.201	453	0.215	97.22	0.228	103.30
	5	5	4	4	0.309	0.255	0.255	447	0.268	119.94	0.282	125.95
	6	4	3	3	0.255	0.201	0.201	464	0.215	99.58	0.228	105.81
	7	3	3	5	0.201	0.201	0.309	468	0.228	106.72	0.255	119.29
	8	4	3	3	0.255	0.201	0.201	442	0.215	94.86	0.228	100.79
	9	5	3	3	0.309	0.201	0.201	448	0.228	102.16	0.255	114.20
	10	4	3	4	0.255	0.201	0.255	424	0.228	96.69	0.255	108.08
								TOTAL FLOW =		991.16		1020.46

CHICAGO RIVER CONTROLLING WORKS

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-26-90	1	3	2	2	0.191	0.137	0.137	365	0.151	55.01	0.164	59.91
METER S	2	2	1	1	0.137	0.084	0.084	411	0.097	39.89	0.110	45.41
40 SEC.	3	2	1	2	0.137	0.084	0.137	428	0.110	47.28	0.137	58.76
	4	3	0	1	0.191	0.000	0.084	453	0.069	31.10	0.137	62.20
	5	2	1	1	0.137	0.084	0.084	448	0.097	43.48	0.110	49.49
	6	3	1	1	0.191	0.084	0.084	465	0.110	51.37	0.137	63.84
	7	2	2	1	0.137	0.137	0.084	469	0.124	58.10	0.110	51.81
	8	3	1	1	0.191	0.084	0.084	444	0.110	49.05	0.137	60.96
	9	1	1	1	0.084	0.084	0.084	450	0.084	37.64	0.084	37.64
	10	4	2	3	0.245	0.137	0.191	426	0.178	75.63	0.218	92.77
								TOTAL FLOW =		488.57		582.80

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-27-90	1	6	4	2	0.255	0.183	0.112	369	0.183	67.63	0.183	67.63
METER U	2	6	4	2	0.255	0.183	0.112	414	0.183	75.87	0.183	75.87
60 SEC.	3	6	3	2	0.255	0.147	0.112	431	0.165	71.27	0.183	78.99
	4	7	3	4	0.291	0.147	0.183	456	0.192	87.65	0.237	108.07
	5	6	5	4	0.255	0.219	0.183	451	0.219	98.81	0.219	98.81
	6	9	5	4	0.362	0.219	0.183	468	0.246	115.10	0.273	127.67
	7	6	5	3	0.255	0.219	0.147	472	0.210	99.18	0.201	94.95
	8	8	5	5	0.327	0.219	0.219	447	0.246	109.94	0.273	121.95
	9	7	4	3	0.291	0.183	0.147	453	0.201	91.13	0.219	99.24
	10	5	2	2	0.219	0.112	0.112	429	0.138	59.41	0.165	70.94
								TOTAL FLOW =		875.99		944.12

O' B R I E N L O C K A N D D A M

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-23-90	1	4	4	1	0.173	0.173	0.066	345	0.146	50.45	0.119	41.20
METER S	2	6	5	0	0.245	0.209	0.000	349	0.166	57.78	0.122	42.68
60 SEC.	3	2	4	1	0.102	0.173	0.066	353	0.128	45.31	0.084	29.53
	4	2	4	1	0.102	0.173	0.066	348	0.128	44.67	0.084	29.11
	5	3	3	4	0.137	0.137	0.173	355	0.146	51.92	0.155	55.09
	6	4	4	1	0.173	0.173	0.066	354	0.146	51.77	0.119	42.27
	7	3	5	2	0.137	0.209	0.102	364	0.164	59.74	0.119	43.47
	8	5	5	1	0.209	0.209	0.066	353	0.173	61.09	0.137	48.47
	9	1	5	1	0.066	0.209	0.066	334	0.137	45.86	0.066	21.97
	10	0	4	5	0.000	0.173	0.209	341	0.139	47.31	0.104	35.61
	11	1	3	13	0.066	0.137	0.495	355	0.209	74.14	0.280	99.53
								TOTAL FLOW =		590.04		488.92

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-24-90	1	5	4	3	0.239	0.203	0.167	333	0.203	67.60	0.203	67.60
METER K	2	5	5	4	0.239	0.239	0.203	337	0.230	77.45	0.221	74.43
60 SEC.	3	2	4	3	0.132	0.203	0.167	342	0.176	60.26	0.149	51.09
	4	3	4	3	0.167	0.203	0.167	337	0.185	62.39	0.167	56.36
	5	3	3	3	0.167	0.167	0.167	345	0.167	57.70	0.167	57.70
	6	7	4	1	0.310	0.203	0.096	344	0.203	69.83	0.203	69.83
	7	5	5	2	0.239	0.239	0.132	354	0.212	75.03	0.185	65.53
	8	4	5	3	0.203	0.239	0.167	343	0.212	72.69	0.185	63.50
	9	2	5	3	0.132	0.239	0.167	324	0.194	62.88	0.149	48.40
	10	5	4	5	0.239	0.203	0.239	332	0.221	73.33	0.239	79.27
	11	3	3	6	0.167	0.167	0.275	345	0.194	66.95	0.221	76.20
								TOTAL FLOW =		746.10		709.91

O' B R I E N L O C K A N D D A M

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-25-90	1	4	4	2	0.255	0.255	0.147	338	0.228	77.08	0.201	68.00
METER U	2	-3	8	5	-0.121	0.470	0.309	341	0.282	96.08	0.094	31.96
40 SEC.	3	-5	3	3	-0.229	0.201	0.201	345	0.094	32.34	-0.014	-4.74
	4	-3	4	5	-0.121	0.255	0.309	339	0.174	59.09	0.094	31.77
	5	-5	4	4	-0.229	0.255	0.255	346	0.134	46.37	0.013	4.55
	6	3	3	2	0.201	0.201	0.147	344	0.188	64.58	0.174	59.96
	7	3	4	4	0.201	0.255	0.255	352	0.241	85.00	0.228	80.27
	8	5	3	3	0.309	0.201	0.201	341	0.228	77.76	0.255	86.92
	9	3	5	3	0.201	0.309	0.201	321	0.255	81.82	0.201	64.58
	10	3	2	2	0.201	0.147	0.147	328	0.161	52.77	0.174	57.17
	11	5	8	2	0.309	0.470	0.147	339	0.349	118.28	0.228	77.30
								TOTAL FLOW =		791.17		557.75

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-26-90	1	1	2	1	0.084	0.137	0.084	345	0.110	38.11	0.084	28.86
METER S	2	1	1	2	0.084	0.084	0.137	349	0.097	33.87	0.110	38.56
40 SEC.	3	5	2	2	0.298	0.137	0.137	354	0.178	62.85	0.218	77.09
	4	2	4	3	0.137	0.245	0.191	349	0.204	71.32	0.164	57.28
	5	1	1	6	0.084	0.084	0.352	357	0.151	53.80	0.218	77.75
	6	3	3	2	0.191	0.191	0.137	356	0.178	63.20	0.164	58.43
	7	4	3	1	0.245	0.191	0.084	366	0.178	64.98	0.164	60.07
	8	1	1	3	0.084	0.084	0.191	355	0.110	39.22	0.137	48.74
	9	4	2	2	0.245	0.137	0.137	337	0.164	55.31	0.191	64.35
	10	-2	6	4	-0.077	0.352	0.245	344	0.218	74.91	0.084	28.78
	11	-7	1	8	-0.346	0.084	0.459	360	0.070	25.29	0.057	20.46
								TOTAL FLOW =		582.87		560.36

O'BRIEN LOCK AND DAM

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)
7-27-90	1	1	6	2	0.076	0.255	0.112	339	0.174	59.09	0.094	31.77
METER U	2	3	2	3	0.147	0.112	0.147	343	0.130	44.43	0.147	50.58
60 SEC.	3	4	2	3	0.183	0.112	0.147	348	0.138	48.20	0.165	57.54
	4	3	3	4	0.147	0.147	0.183	343	0.156	53.65	0.165	56.72
	5	2	4	3	0.112	0.183	0.147	351	0.156	54.90	0.130	45.47
	6	5	4	5	0.219	0.183	0.219	350	0.201	70.41	0.219	76.68
	7	4	4	5	0.183	0.183	0.219	359	0.192	69.01	0.201	72.22
	8	5	3	1	0.219	0.147	0.076	349	0.147	51.46	0.147	51.46
	9	4	6	5	0.183	0.255	0.219	330	0.228	75.25	0.201	66.39
	10	5	2	3	0.219	0.112	0.147	338	0.147	49.84	0.183	61.94
	11	2	1	6	0.112	0.076	0.255	352	0.130	45.60	0.183	64.51
									TOTAL FLOW =	621.83		635.28

WILMETTE CONTROLLING WORKS

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)	Estimated Measurement Locations
7-23-90	1	10	8	6	0.388	0.316	0.245	25	0.316	7.90	0.316	7.90	.2.6.8
METER S	2	16	13	12	0.602	0.495	0.459	102	0.513	52.31	0.531	54.13	
60 SEC.	3	17	16	11	0.638	0.602	0.423	125	0.567	70.81	0.531	66.34	
	4	16	15	11	0.602	0.567	0.423	118	0.540	63.68	0.513	60.52	
	5	13	10	7	0.495	0.388	0.280	56	0.388	21.71	0.388	21.71	.8
									TOTAL FLOW =	216.42		210.61	

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	3 POINT METHOD PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	2 POINT METHOD PANEL FLOW (cfs)	Estimated Measurement Locations
7-24-90	1	14	14	11	0.561	0.561	0.453	23	0.534	12.27	0.507	11.66	.6.8
METER K	2	20	20	17	0.775	0.775	0.668	100	0.748	74.82	0.721	72.14	
60 SEC.	3	17	17	16	0.668	0.668	0.632	122	0.659	80.38	0.650	79.28	
	4	17	17	11	0.668	0.668	0.453	114	0.614	70.01	0.561	63.90	
	5	17	16	12	0.668	0.632	0.489	52	0.605	31.47	0.578	30.08	.8
									TOTAL FLOW =	268.95		257.05	

WILMETTE CONTROLLING WORKS

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	PANEL FLOW (cfs)	Estimated Measurement Locations
7-25-90	1	9	7	5	0.524	0.416	0.309	24	0.416	9.99	0.416	9.99	.6.8
METER U	2	14	10	9	0.792	0.577	0.524	101	0.618	62.37	0.658	66.44	
40 SEC.	3	14	9	9	0.792	0.524	0.524	123	0.591	72.65	0.658	80.91	
	4	13	12	8	0.738	0.685	0.470	116	0.644	74.75	0.604	70.08	
	5	12	9	6	0.685	0.524	0.362	54	0.524	28.27	0.524	28.27	.8
								TOTAL FLOW =		248.03		255.69	

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	PANEL FLOW (cfs)	Estimated Measurement Locations
7-26-90	1	8	8	7	0.459	0.459	0.406	24	0.446	10.70	0.432	10.38	.6.8
METER S	2	11	11	10	0.620	0.620	0.567	101	0.607	61.28	0.593	59.93	
40 SEC.	3	11	13	12	0.620	0.727	0.674	124	0.687	85.21	0.647	80.22	
	4	12	11	9	0.674	0.620	0.513	116	0.607	70.38	0.593	68.83	
	5	10	7	6	0.567	0.406	0.352	54	0.432	23.35	0.459	24.80	.8
								TOTAL FLOW =		250.92		244.15	

DATE METER DURATION	PANEL NO.	BUCKET WHEEL REVOLUTIONS 0.2	0.6	0.8	POINT VELOCITIES (fps) 0.2	0.6	0.8	PANEL AREA (sq.ft.)	3 POINT METHOD MEAN VELOCITY (fps)	PANEL FLOW (cfs)	2 POINT METHOD MEAN VELOCITY (fps)	PANEL FLOW (cfs)	Estimated Measurement Locations
7-27-90	1	14	13	11	0.541	0.506	0.434	23	0.497	11.42	0.488	11.22	.6.8
METER U	2	19	16	13	0.721	0.613	0.506	100	0.613	61.31	0.613	61.31	
60 SEC.	3	17	18	14	0.649	0.685	0.541	123	0.640	78.71	0.595	73.20	
	4	18	16	14	0.685	0.613	0.541	115	0.613	70.50	0.613	70.50	
	5	13	12	10	0.506	0.470	0.398	53	0.461	24.42	0.452	23.95	.8
								TOTAL FLOW =		246.37		240.18	

CHICAGO RIVER CONTROLLING WORKS

TABLE G-4

PANEL	23 JULY 1990 PANEL DISCHARGES			24 JULY 1990 PANEL DISCHARGES			25 JULY 1990 PANEL DISCHARGES			26 JULY 1990 PANEL DISCHARGES			27 JULY 1990 PANEL DISCHARGES		
	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.
1	74	93.81	0.79	44	44.61	0.99	55	93.29	0.59	40	55.01	0.73	63	67.63	0.93
2	133	138.95	0.96	66	61.24	1.08	78	77.35	1.01	49	39.89	1.23	83	75.87	1.09
3	82	86.55	0.95	85	86.68	0.98	98	103.35	0.95	56	47.28	1.18	86	71.27	1.21
4	101	99.74	1.01	95	99.84	0.95	100	97.22	1.03	50	31.10	1.61	91	87.65	1.04
5	91	86.50	1.05	94	86.75	1.08	112	119.94	0.93	63	43.48	1.45	95	98.81	0.96
6	85	98.36	0.86	88	85.90	1.02	102	99.58	1.02	60	51.37	1.17	103	115.10	0.89
7	109	90.70	1.20	117	124.55	0.94	112	106.72	1.05	66	58.10	1.14	109	99.18	1.10
8	94	89.95	1.05	84	90.13	0.93	97	94.86	1.02	71	49.05	1.45	112	109.94	1.02
9	82	91.15	0.90	99	99.39	1.00	103	102.16	1.01	54	37.64	1.43	100	91.13	1.10
10	56	71.07	0.79	64	75.06	0.85	76	96.69	0.79	64	75.63	0.85	60	59.41	1.01
TOTAL =	907	947	0.96	836	854	0.98	933	991	0.94	573	489	1.17	902	876	1.03

PANEL	23 JULY 1990 PANEL DISCHARGES			24 JULY 1990 PANEL DISCHARGES			25 JULY 1990 PANEL DISCHARGES			26 JULY 1990 PANEL DISCHARGES			27 JULY 1990 PANEL DISCHARGES		
	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.
1	74	70.65	1.05	44	41.36	1.06	55	73.63	0.75	40	59.91	0.67	63	67.63	0.93
2	133	101.75	1.31	66	53.92	1.22	78	71.82	1.09	49	45.41	1.08	83	75.87	1.09
3	82	67.19	1.22	85	86.68	0.98	98	97.60	1.00	56	58.76	0.95	86	78.99	1.09
4	101	71.07	1.42	95	91.76	1.04	100	103.30	0.97	50	62.20	0.80	91	108.07	0.84
5	91	78.40	1.16	94	98.73	0.95	112	125.95	0.89	63	49.49	1.27	95	98.81	0.96
6	85	64.67	1.31	88	94.19	0.93	102	105.81	0.96	60	63.84	0.94	103	127.67	0.81
7	109	82.21	1.33	117	120.36	0.97	112	119.29	0.94	66	51.81	1.27	109	94.95	1.15
8	94	85.93	1.09	84	74.26	1.13	97	100.79	0.96	71	60.96	1.16	112	121.95	0.92
9	82	70.76	1.16	99	107.44	0.92	103	114.20	0.90	54	37.64	1.43	100	99.24	1.01
10	56	51.71	1.08	64	63.63	1.01	76	108.08	0.70	64	92.77	0.69	60	70.94	0.85
TOTAL =	907	744	1.22	836	832	1.00	933	1020	0.91	573	583	0.98	902	944	0.96

O'BRIEN LOCK AND DAM

PANEL	23 JULY 1990 PANEL DISCHARGES			24 JULY 1990 PANEL DISCHARGES			25 JULY 1990 PANEL DISCHARGES			26 JULY 1990 PANEL DISCHARGES			27 JULY 1990 PANEL DISCHARGES		
	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	THREE POINT METHOD (cfs)	COEF.
1	38	50.45	0.75	60	67.60	0.89	81	77.08	1.05	41	38.11	1.08	54	59.09	0.91
2	59	57.78	1.02	71	77.45	0.92	116	96.08	1.21	35	33.87	1.03	65	44.43	1.46
3	42	45.31	0.93	65	60.26	1.08	83	32.34	2.57	53	62.85	0.84	56	48.20	1.16
4	52	44.67	1.16	61	62.39	0.98	75	59.09	1.27	63	71.32	0.88	65	53.65	1.21
5	57	51.92	1.10	66	57.70	1.14	80	46.37	1.73	75	53.80	1.39	63	54.90	1.15
6	50	51.77	0.97	69	69.83	0.99	69	64.58	1.07	68	63.20	1.08	66	70.41	0.94
7	55	59.74	0.92	74	75.03	0.99	84	85.00	0.99	59	64.98	0.91	65	69.01	0.94
8	46	61.09	0.75	72	72.69	0.99	92	77.76	1.18	53	39.22	1.35	66	51.46	1.28
9	40	45.86	0.87	62	62.88	0.99	90	81.82	1.10	61	55.31	1.10	63	75.25	0.84
10	48	47.31	1.01	66	73.33	0.90	69	52.77	1.31	93	74.91	1.24	64	49.84	1.28
11	53	74.14	0.71	52	66.95	0.78	112	118.28	0.95	65	25.29	2.57	46	45.60	1.01
TOTAL =	540	590	0.92	718	746	0.96	951	791	1.20	666	583	1.14	673	622	1.08

PANEL	23 JULY 1990 PANEL DISCHARGES			24 JULY 1990 PANEL DISCHARGES			25 JULY 1990 PANEL DISCHARGES			26 JULY 1990 PANEL DISCHARGES			27 JULY 1990 PANEL DISCHARGES		
	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.	VERTICAL VELOCITY METHOD (cfs)	TWO POINT METHOD (cfs)	COEF.
1	38	41.20	0.92	60	67.60	0.89	81	68.00	1.19	41	28.86	1.42	54	31.77	1.70
2	59	42.68	1.38	71	74.43	0.95	116	31.96	3.63	35	38.56	0.91	65	50.58	1.29
3	42	29.53	1.42	65	51.09	1.27	83	-4.74	-17.53	53	77.09	0.69	56	57.54	0.97
4	52	29.11	1.79	61	56.36	1.08	75	31.77	2.36	63	57.28	1.10	65	56.72	1.15
5	57	55.09	1.03	66	57.70	1.14	80	4.55	17.60	75	77.75	0.96	63	45.47	1.39
6	50	42.27	1.18	69	69.83	0.99	69	59.96	1.15	68	58.43	1.16	66	76.68	0.86
7	55	43.47	1.27	74	65.53	1.13	84	80.27	1.05	59	60.07	0.98	65	72.22	0.90
8	46	48.47	0.95	72	63.50	1.13	92	86.92	1.06	53	48.74	1.09	66	51.46	1.28
9	40	21.97	1.82	62	48.40	1.28	90	64.58	1.39	61	64.35	0.95	63	66.39	0.95
10	48	35.61	1.35	66	79.27	0.83	69	57.17	1.21	93	28.78	3.23	64	61.94	1.03
11	53	99.53	0.53	52	76.20	0.68	112	77.30	1.45	65	20.46	3.18	46	64.51	0.71
TOTAL =	540	489	1.10	718	710	1.01	951	558	1.71	666	560	1.19	673	635	1.06

TABLE G-5

TABLE G-6

COEFFICIENTS

DATE	3 POINT METHOD		2 POINT METHOD	
	CRCW	O'BRIEN	CRCW	O'BRIEN
23 JULY 1990	0.96	0.92	1.22	1.10
24 JULY 1990	0.98	0.96	1.00	1.01
25 JULY 1990	0.94	1.20	0.91	1.71
26 JULY 1990	1.17	1.14	0.98	1.19
27 JULY 1990	1.03	1.08	0.96	1.06