



**US Army Corps  
of Engineers®  
Chicago District**

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**LAKE MICHIGAN  
DIVERSION ACCOUNTING  
WATER YEAR 2003  
ANNUAL REPORT**

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## **EXECUTIVE SUMMARY**

This document is the Water Year (WY) 2003 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 the 1980 amendment to the 1967 U. S. Supreme Court Decree. Additionally, this report serves to summarize the Corps' major accomplishments 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 computed by the Corps of Engineers for WY 2003, 1 October 2002 through 30 September 2003.

The Lake Michigan Diversion Accounting Report for WY 2003 has been completed. The State of Illinois diverted 2,398 cfs during WY 2003. This diversion is 802 cfs less than the 3,200 cfs 40 year average diversion specified in the modified decree. The running average of the diversion for WY 1981 through WY 2003 is 3,234cfs, or 34 cfs over the annual allocation. Also, the annual average diversion has exceeded the 3,680 cfs annual limit three times, once more than the maximum number of times allowed in the decree. Additionally, the absolute annual maximum of 3,840 cfs has been exceeded during the WY93 accounting period. The cumulative deviation is -776 cfs-years at the end of WY2003. The negative sign indicates a cumulative flow deficit. The maximum allowable cumulative flow deficit specified in the decree is -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) 2003 Annual Report on Lake Michigan Diversion Accounting presents activities by the Corps of Engineers in accounting for the 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 diversion flows for WY 2003, a description of the sources of the diversion, a description of the accounting procedures, and a summary of all significant activities that occurred during WY 2003 through to the present.

## **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 by 449 U.S. 48, 101 S. CT. 557 (1980), the Corps of Engineers monitors the measurement and computation of 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 has been diverted from Lake Michigan at Chicago into the Mississippi River Watershed since the completion of the Illinois and Michigan (I & M) Canal in 1848. At that time, the diversion averaged about 500 cubic feet per second (cfs). The I & M Canal was built primarily to serve transportation needs by providing a connecting watercourse between the Great Lakes and the Mississippi River system.

With the development of the Chicago metropolitan area, sewer 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. The increase in impervious area from the newly constructed roads and buildings increased the rate and volume of stormwater 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. Construction of the CSSC 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 MWRDGC. The CSSC followed the course of the older I & M Canal. The CSSC is much larger than the I & M canal and can handle the Chicago River flow, as well as increased shipping. In 1938, the Chicago River Controlling Works (CRCW) was constructed at the mouth of the Chicago River. The CRCW regulates the amount of Lake Michigan water allowed to pass into the river and restricts river flooding from entering Lake Michigan. The Lockport Lock and Dam controls the water level in the CSSC.

Between 1907 and 1910, the MWRDGC constructed a second canal called the North Shore Channel. It extended from Lake Michigan at Wilmette in a southerly direction 6.14 miles to the north branch of the Chicago River. The Wilmette Pumping Station, also known as the Wilmette Controlling Works, regulates the amount of Lake Michigan flow allowed down the channel through the use of one vertical lift gate. The four abandoned 250 cfs pumps have not been used for diversion since 70's.

Construction of a third canal, the Calumet Sag Channel, was completed in 1922. The canal connects Lake Michigan through the Grand Calumet River, to the CSSC. The Calumet Sag Channel was constructed to carry sewage from South Chicago, Illinois and East Chicago, Indiana. The Blue Island Lock and Dam controlled flow through the canal. The O'Brien Lock and Dam, which replaced the Blue Island Lock and Dam, was completed in 1967 and is located on the Calumet River. The O'Brien Lock and Dam regulates the flow of Lake Michigan waters down the Calumet Sag Channel. Figure 2 shows the affected watershed.

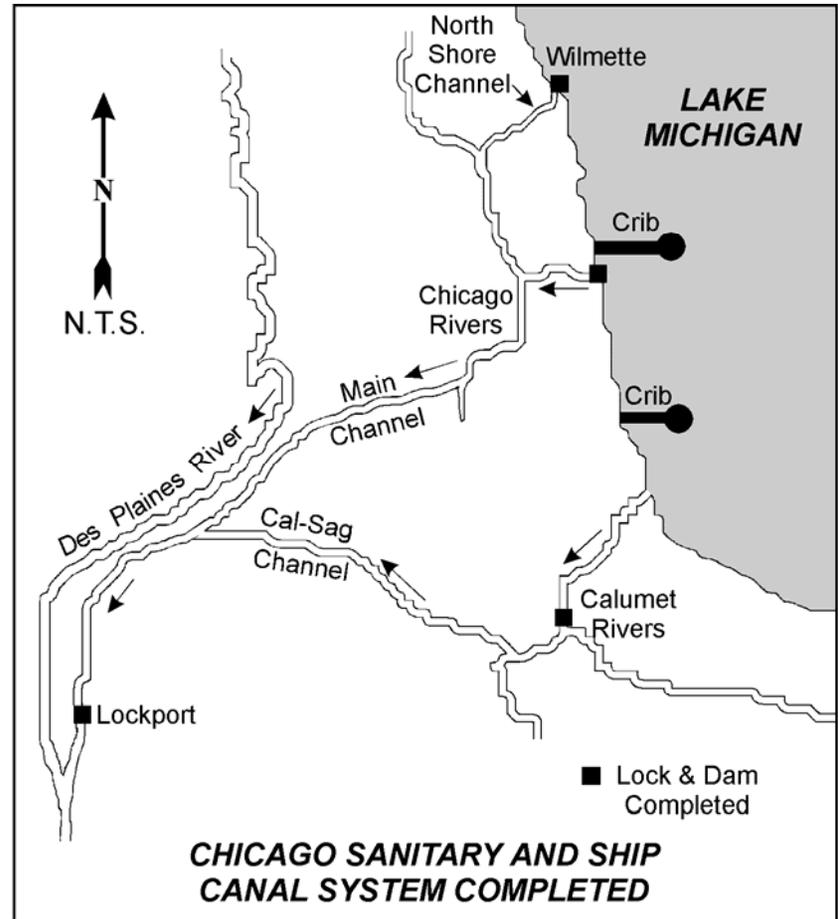
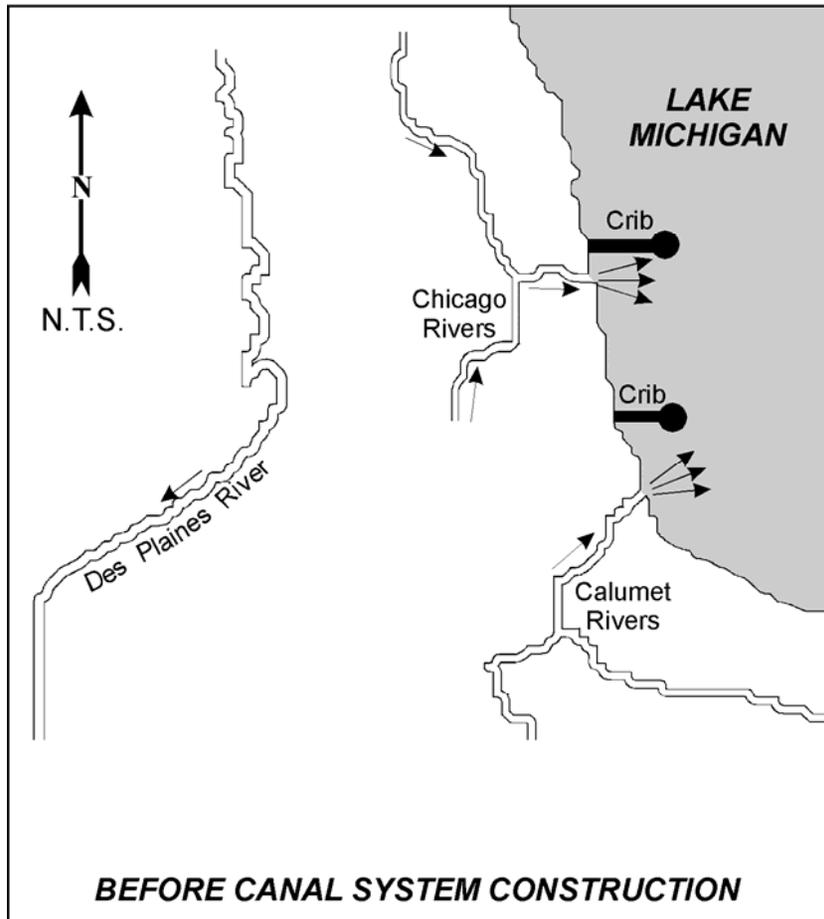


FIGURE 1 DEVELOPMENT OF THE CHICAGO SANITARY AND SHIP CANAL SYSTEM

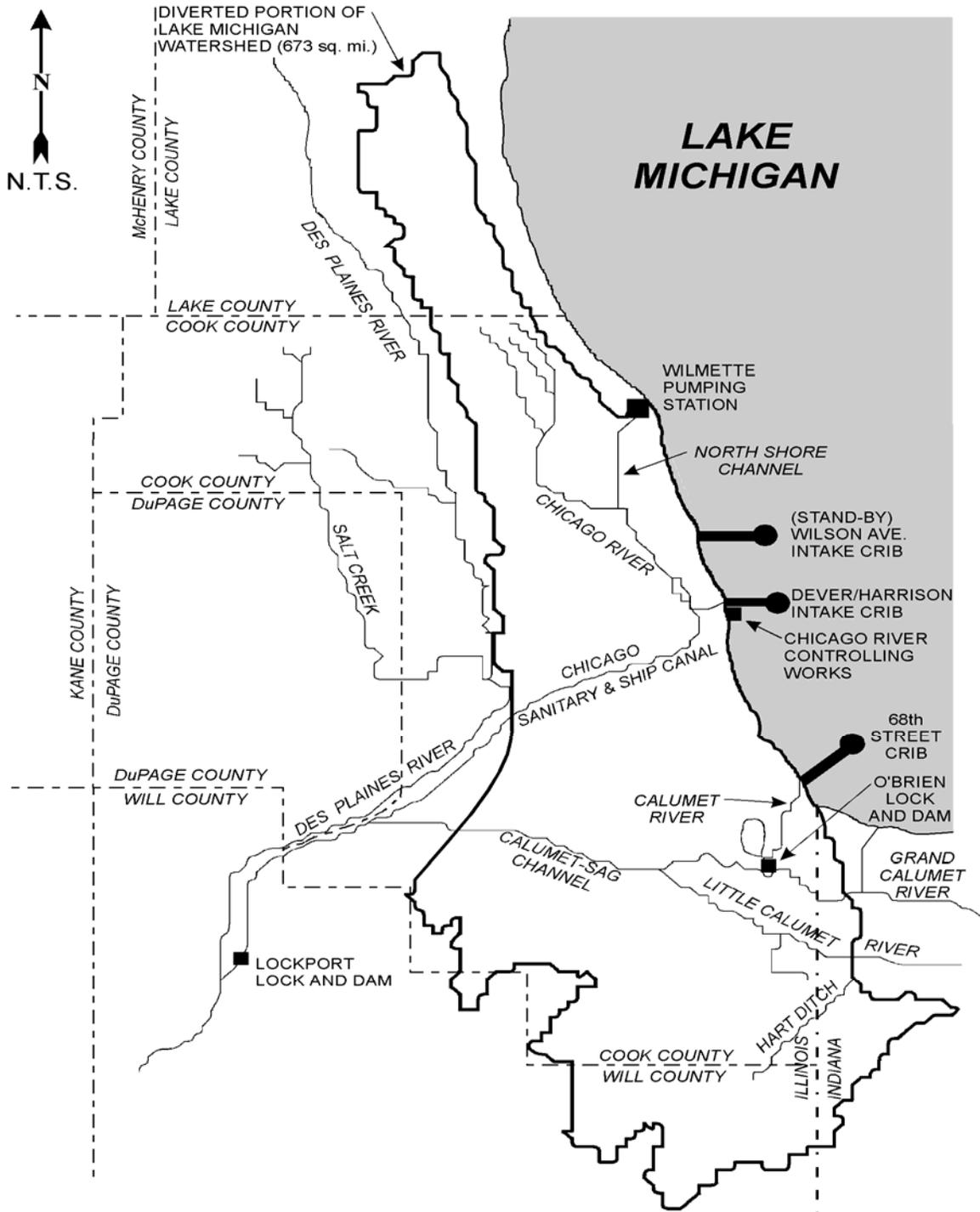


FIGURE 2 LOCATION PLAN - LAKE MICHIGAN DIVERSION AT CHICAGO

**SIGNIFICANT HYDROLOGIC EVENTS**

During WY 2003, an average total of 29.03 inches of precipitation fell at the 25 Illinois State Water Survey (ISWS) raingages that make up the Lake Michigan Diversion Accounting raingage network. The average total precipitation for WY 2003 is 21 percent less than the 13-year (1990-2002) average of 36.77 inches for the 25 raingage network and was about 80% of the 1971-2000 Chicago O’Hare Airport annual precipitation average of 36.27 inches. Table 1 tabulates the recorded monthly rainfall data during WY 2003, and the deviation from the ISWS 13-year annual and monthly average precipitation.

TABLE 1 WY 2003 MONTHLY AND ANNUAL PRECIPITATION (INCHES)  
Illinois State Water Survey Average Across the 25 Raingage Network

<u>Month</u>	<u>WY 2003 Precipitation</u>	<u>1990-2002 Average Precipitation</u>	<u>Deviation</u>	<u>Percent of Average</u>
Oct-02	1.79	3.34	-1.55	54%
Nov-02	1.23	2.93	-1.70	42%
Dec-02	1.54	1.71	-0.17	90%
Jan-03	0.30	2.19	-1.89	14%
Feb-03	0.19	1.87	-1.68	10%
Mar-03	1.42	2.32	-0.90	61%
Apr-03	3.67	3.66	0.01	100%
May-03	5.42	3.95	1.47	137%
Jun-03	1.49	4.13	-2.64	36%
Jul-03	6.61	3.38	3.23	196%
Aug-03	2.90	4.28	-1.38	68%
Sep-03	2.48	3.01	-0.53	82%
Annual	29.03	36.77	-7.74	79%

Eight heavy precipitation events occurred in Water Year 2003. Six events occurred during the warm months, July and August. Five events included one or more gages exceeding at least the two-year recurrence interval. Three events included gages that exceeded at least the five-year recurrence interval, and one event included gages that exceeded the 25-year intervals. This later event occurred on July 27, 2003.

Two small backflow events at the lakefront pump stations occurred in WY 2003. The total amount of reversed flow on May 12 and August 22, 2002 was 113.1 million gallons.

**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 WY 1981 through WY 2002. The WY 2003 Lake Michigan Diversion Accounting Report is certified and included as appendix A of this Water Year 2003 Annual Report. The State of Illinois diverted 2,398 cfs during WY 2003. This diversion is 802 cfs less than the 3,200 cfs 40 year average diversion specified in the 1980 modified decree. Table 3 shows the accounting year, the certified flows, the running average flows, and the cumulative deviation from the allowable diversion of 3,200 cfs.

The running average diversion for the period WY 1981 through WY 2003 is 3,234 cfs, 34 cfs greater than the 3,200 cfs 40 year average diversion specified by the modified decree. Also, the annual average diversion has exceeded the 3,680 cfs annual limit three times, once more than the maximum number of times allowed in the decree. Additionally, the absolute annual maximum of 3,840 cfs has been exceeded during the WY93 accounting period. The cumulative deviation, the sum of the differences between the annual average flows and 3,200 cfs, is -776 cfs-years at the end of WY 2003. The negative cumulative deviation indicates a cumulative flow deficit. The decree specifies a maximum allowable deficit of -2,000 cfs-years over the first 39 years of the 40-year averaging period.

Data collection and compilation for the WY 2003 accounting report were done by the Corps. Hydrologic and hydraulic modeling and diversion accounting for Water Year 2003 were also performed by the Corps. Data collection and compilation for this report began in Fiscal Year (FY) 2004.

TABLE 2 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-yrs)
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
1990	3,531	3,452	-2,520
1991	3,555	3,461	-2,875
1992	3,409	3,457	-3,084
1993	3,841	3,487	-3,725
1994	3,064	3,456	-3,589
1995	3,197	3,439	-3,586
1996	3,108	3,418	-3,494
1997	3,114	3,400	-3,408
1998	3,060	3,382	-3,268
1999	2,909	3,357	-2,977
2000	2,584	3,318	-2,361
2001	2,698	3,289	-1,859
2002	2,919	3,272	-1,578
2003	2,398	3,234	-776

## **SOURCES OF DIVERSION**

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

Domestic pumpage from Lake Michigan is used for water supply and its effluent is discharged to the canals by 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 be discharged 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, and the CSSC ultimately drains into the Illinois River and the Mississippi River. The drainage area of the diverted Lake Michigan watershed is approximately 673 square miles.

Direct diversions occur at three lakefront locations — the Chicago River Controlling Works (CRCW), the O'Brien Lock and Dam, and the Wilmette Pumping Station. These controlling structures are located downtown, at the south end, and at the north end of the Chicago area, respectively. The direct diversion at each of these locations consists of four components; lockage, leakage, discretionary flow and navigation makeup flow. The lockage component is the flow used in locking vessels to and from the lake. The leakage component is water estimated to pass, in an uncontrolled way, through or around the three lakefront structures. The purpose of the discretionary diversion is to dilute effluent from sewage discharges and improve water quality in the canal system. Navigation makeup water is made up of two parts. When large storms are forecast, the canal is drawn down before the storm to prevent flooding, and navigation makeup water is used during this draw down period to maintain navigation depths. If the runoff is not enough to refill the canal, additional navigation makeup water is allowed to pass from Lake Michigan to return the canal system to its normal operating stages.

## **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 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 accountable in 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.

The flow measured at Romeoville was approximately 97.7% of the annual diversion during WY 2003. Approximately 89.1% of the diverted water was measured by the AVM during WY 2003.

Deductions from the Romeoville AVM flow include runoff from 217 square miles of the Des Plaines River watershed discharged to the canal, groundwater supply effluent and groundwater seepage into the Tunnel and Reservoir Plan (TARP) tunnels discharged to the canal, and Indiana water supply discharged to the canal through the Calumet River system and the Calumet Sag Channel (see figure 2 for locations). The 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 approximately 10.9% of the diversion in WY 2003. As more communities convert to Lake Michigan water supply, the percentage will increase.

## **DIVERSION BUDGET CHECKS**

Water budgets verify those flows that are 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 canal balance budget for the CSSC. The Upper Des Plaines pump station budget will also become a significant budget after measurement problems are resolved. 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 detail in the WY 2003 accounting reports.

### **ACTIVITIES FOR FY 2003**

The activities in FY 2003 included review of the WY 1998 and WY 1999 Romeoville accounting reports and coordination of activities related to the Fifth Technical Committee. The USGS continued error analysis associated with Lakefront accounting for WY 1997, 1998 and 1999. The final reports on the detailed QA/QC of 12 primary water supply diverters in Chicago and six in the northern Chicago suburbs were published and copies of the report were forwarded to the facility owners. Coordination continued on the effort to implement the one-year Navigation Makeup Reduction demonstration study during FY 2003. A contract was initiated for the Lake Michigan Diversion Accounting computations for WY 2000 and WY 2001.

The section of Fifth Technical Committee members was completed and the Committee was consisted of Dr. William H. Espey (Chairperson), Dr. Charles S. Melching (Modeling Expert) and Mr. Dean M. Mades (Flow Measurement Expert). The Committee commenced its tasks in January 2003. During the first workshop the committee visited AVM sites, including Romeoville, Columbus Drive, O'Brien Lock and Dam and Wilmette Pumping Station. During the second workshop Dr. Espey and Mr. Mades traveled to the USGS-Illinois Water Science Center and Dr. Melching visited the Corps Chicago District to obtain specific information on flow measurements and diversion modeling, respectively. During the third workshop, the Committee was provided guided tours to a couple raingage sites, Evanston Water Treatment Plant and Jardine water purification plant of the City of Chicago. The Committee completed majority of review work by the end of FY 2003.

### **ACTIVITIES FOR FY 2004 – FY 2006**

The activities in FY 2004 included collection of data for the WY 2002 and WY 2003 Romeoville accounting and continued coordination of activities related to the Fifth Technical Committee. In October 2004, the Technical Committee provided preliminary findings to the parties during the fourth meeting. In July 2004, the fifth Technical Committee published their final report which was included as Appendix B in the WY 2002 Annual Report. Also completed were the Romeoville accounting reports for WY 2000 and WY 2001. Funding for Lakefront accounting was not included in the Energy and Water Appropriations Bill for FY 2004; therefore, the Lakefront accounting activities were halted. However, the stream gage assets deployed at the lakefront controlling works remain in service with a significantly reduced support from the USGS. The AVM gage on the CSSC at Romeoville was being moved to a new location (RM 302) after a decision was made that a second dispersal barrier would be installed on the canal near the existing AVM gage location. The electrical fields generated by the barrier would interfere with the compass that is used with the ADCP for calibration purpose, and could also potentially affect the acoustic signals in water. The new site that is about 6 miles upstream from the existing location was selected with due considerations in diversion flow capture, canal hydraulics and barge fleeting on the CSSC. The USACE, USGS and the 5<sup>th</sup> Technical Committee reached a consensus that the selected new site at Lemont was the best amongst a total of four candidates.

The activities in FY 2005 included data analyses for WY 2002 and WY 2003 Romeoville accounting. The Corps started hydrologic simulations and in the mean time evaluated the recommendations that the fifth Technical Committee had made. Also, data collection

for WY 2004 Romeoville accounting was completed. The Corps established a new Contract with the ISWS to acquire continued services for operating and maintaining the 25-gage raingage network in the diverted watershed.

The activities in FY 2006 included continued modeling and diversion accounting computations for WY 2002 and WY 2003. The AVM on the CSSC at Romeoville was totally removed when the construction of dispersal barrier had reached a point that remaining equipment and cables at the site had to go. Before Romeoville gage was completely decommissioned, more than one year of concurrent data at Romeoville and Lemont had been collected that should suffice for the calibration and independent verification of AVM data at Lemont. In 2006, a dialogue was opened between the Corps and MWRDGC regarding upgrade of the flow measurement capability at the Upper Des Plaines Pumping Station. As part of the pumping station rehabilitation plan, the MWRDGC would replace the aging pumps and the associated flow meters in the pumping station. In addition, a new TARP connecting structure would be constructed near the station to divert combined sewer flows from the intercepting sewer to the deep tunnel during large runoff events and future repairs at the pumping station. To ensure the continuity of data availability and independent verification of flow rates through the pumps, the Corps requested that a separate flow meter in the intercepting sewer be considered. The MWRDGC cooperatively agreed to install an additional flow meter in the incoming intercepting sewer upstream from both the station and the new TARP diversion structure. Rehabilitation will start in FY 2007 and the project will complete in two years. This should fix a long time issue regarding verification of simulated runoff from the Des Plaines watershed that discharges to the CSSC – a deductible component to the flow measured at Romeoville.

### **ACCOUNTING REPORTS**

The Romeoville accounting reports for WY 2000 and WY 2001 (contained in the WY 2000 annual report) were completed and distributed in FY 2004. The Lakefront accounting report for WY 1997 through 2003 were completed in FY 2006 and would be contained in the WY 2001 annual report for its distribution. The Romeoville accounting reports for WY 2002 (contained in the WY 2002 annual report) were completed in FY 2006 and would be distributed in FY 2006. The Romeoville accounting report for WY 2003 is included in this WY 2003 annual report.

## **SUMMARY AND CONCLUSIONS**

### **SUMMARY**

The Lake Michigan Diversion Accounting procedure continues to evolve and improve. Further improvements to the Romeoville Accounting are being implemented and progress continues to be made on the Lakefront Accounting activities.

### **CONCLUSIONS**

The Lake Michigan Diversion Accounting Report for WY 2003 has been completed as required by the Supreme Court Decree. The State of Illinois diverted 2,398 cfs during WY 2003. This flow is 802 cfs less than the 3,200 cfs limit specified in the decree. The running average of the diversion for WY 1981 through WY 2003 is 3,234 cfs, or 34 cfs over the annual allocation. Also, the annual average diversion has exceeded the 3,680 cfs annual limit three times, once more than the maximum number of times allowed in the decree. Additionally, the absolute annual maximum of 3,840 cfs has been exceeded during the WY93 accounting period. The cumulative deviation is – 776 cfs-years at the end of WY 2003. The negative sign indicates a cumulative flow deficit. The maximum allowable cumulative flow deficit specified in the decree is -2,000 cfs-years.

**APPENDIX A**  
**LAKE MICHIGAN DIVERSION ACCOUNTING**  
**WATER YEAR 2003 REPORT**