



**US Army Corps  
of Engineers**  
Chicago District

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# **Lake Michigan Diversion Accounting - 1986 Annual Report**

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**January 1987**

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ANNUAL REPORT

MONITORING OF DIVERSION  
OF LAKE MICHIGAN WATER  
AT CHICAGO, ILLINOIS

INTRODUCTION

1.1 EXECUTIVE SUMMARY

This document is an 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. The report provides an overview and audit of flow measurements and accounting conducted by the State of Illinois.

(6) The 198<sup>7</sup> Annual Report on Lake Michigan Diversion includes a summarization of all events occurring during the 198<sup>7</sup> water year. Since completion of the 198<sup>7</sup> Annual Report, <sup>the 198<sup>4</sup></sup> ~~no additional~~ water year accounting reports <sup>7</sup> have been submitted by the State of Illinois for review. Therefore, the 198<sup>7</sup> Annual Report ~~does not~~ includes <sup>an analysis of the 198<sup>4</sup></sup> a water year accounting report. <sup>7</sup>

Major events covered in this report include the performance and evaluation to date of the newly installed Acoustic Velocity Meter to measure flow passing through Lockport, progress made in the development of a computerized water budget system to account for diversion flows, and the convening of the second technical committee.

The following conclusions were reached:

a. Despite some problems, the development and refinement of the new accounting system is proceeding well. Major difficulties with the Acoustic Velocity Meter are in the process of being resolved. The new accounting system produces overall results which are substantiated using state-of-the-art measuring techniques.

b. Based on a detailed analysis by Corps' hydrologic experts, it was concluded that the current procedures for hydrologic simulation are consistent with the "best current engineering practice and scientific knowledge" as required by the Supreme Court decree.

## 1.2 BACKGROUND

The City of Chicago, as well as some of its suburbs, have drawn on Lake Michigan as the source of their municipal water supply for practically their entire history. When the flow of the Chicago River was reversed and the Chicago Sanitary and Ship Canal was completed, this flow of water was effectively diverted from the Lake Michigan (St. Lawrence and Atlantic Ocean) watershed to the Illinois River (Mississippi and Gulf of Mexico) watershed. This practice continues today, although closely controlled by the State of Illinois, with oversight by the U. S. Army Corps of Engineers, as decreed by the U. S. Supreme Court. This report is one of a series of Annual Reports prepared by the Corps of Engineers on the monitoring activities of the Corps to the parties to the U. S. Supreme Court litigation and to the general public. The report discusses the Corps' activities, findings and conclusions, and other events concerning the accounting of Lake Michigan water diversion for the period October 198~~8~~<sup>1</sup> through September 198~~8~~<sup>6</sup>, inclusive.

## 1.3 AUTHORITY FOR REPORT

Under the provisions of the U. S. Supreme Court decree in 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 charged with monitoring the measurement and computation of diversion of Lake Michigan water by the State of Illinois. The responsible state agency is the Illinois Department of Transportation-Division of Water Resources (IDOT). Under the terms of the modified decree, the Corps is required to report annually on the diversion activities of the State of Illinois.

## 1.4 HISTORY

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). Upon completion of the Chicago Sanitary and Ship Canal in 1900, the flow direction of the Chicago River was reversed and a permit was issued by the Secretary of War for the diversion of 4,167 cfs, later increased to 8,500 cfs. Figures 1-1 and 1-2 show the schematic flow reversal and affected watershed.

During the 1920's, the states of Wisconsin, New York, Michigan, and Ohio, concerned about the effect of diversion on lowering Lake Michigan levels, sought an injunction to prohibit the State of Illinois from diverting Lake Michigan water. The Supreme Court issued a decree in 1930 establishing a phased reduction in the diversion down to an annual average of 1,500 cfs, in addition to domestic pumpage, by 30 December 1938.

Another U. S. Supreme Court decree in 1967 limited the diversion of Lake Michigan water by the State of Illinois and its municipalities, this time including domestic pumpage, to an average of 3,200 cfs over a five year period effective 1 March 1970.

The 1967 U. S. Supreme Court decree was amended on 1 December 1980 in response to action brought by the State of Illinois to modify the accounting procedures to improve their efficiency. This modified decree extended the period for determining the running average diversion rate allowable from five years to forty years and changed the beginning of the accounting year from 1 March to 1 October.

Three specific provisions of the amended decree affected the role of the Corps of Engineers in the Diversion Monitoring Program. First, although the State of Illinois is primarily responsible for measurement and computation of diversion flows, the decree allows the Corps to take over this function if it and the State reach a cost sharing agreement. No agreement was reached due to a lack of funding arrangement. Therefore, the measurement and computations of the diversion are currently being done by IDOT through its consultants, the Northeastern Illinois Planning Commission (NIPC), the Metropolitan Sanitary District of Greater Chicago (MSDGC), and the United States Geological Survey (USGS).

Second, the supervisory role for the Corps is increased, in that the Corps is responsible for auditing the State's computations and measurements.

Third, every five years the Chief of Engineers shall appoint a three-member Technical Committee to determine if the best current engineering practice and scientific knowledge for measuring the diversion is being employed and to make recommendations as appropriate. The decree stipulates that "...the members should be selected on the basis of recognized experience and technical expertise in flow measurement or hydrology," and be reconvened at least once every five years. The first Technical Committee was convened in June 1981 and completed its work in April 1982. The second Technical Committee was convened in July 1986, and is expected to complete its work by mid June 1987.

Also based on the <sup>has</sup> Water Resources Development Act of 1986, PL 99-662, the Corps of Engineers <sup>December</sup> will have the total responsibility for the measurements and computations necessary to account for the amount of water diverted from Lake Michigan at Chicago, starting on 1 October 1987 (see section 4.3).

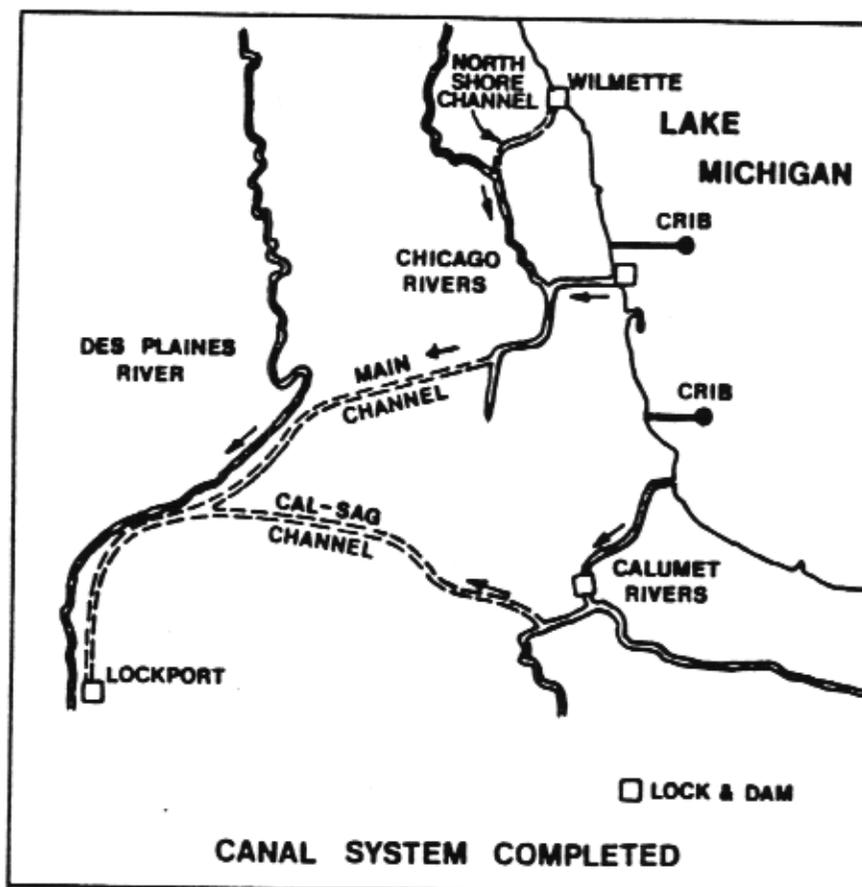
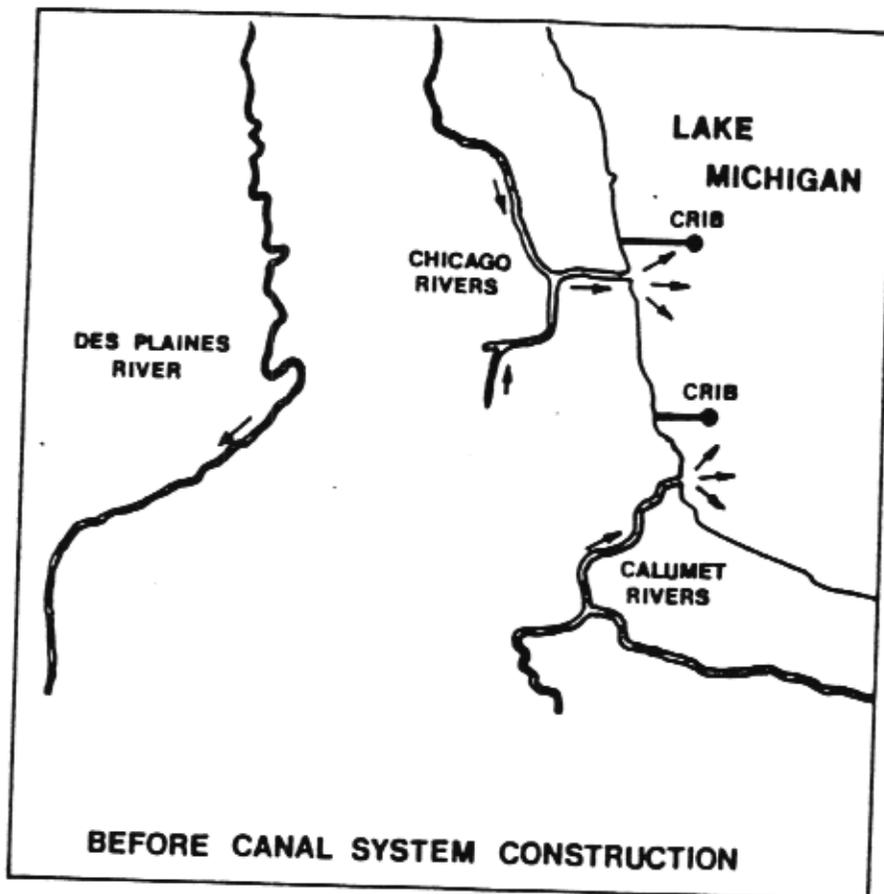


FIGURE 1-1

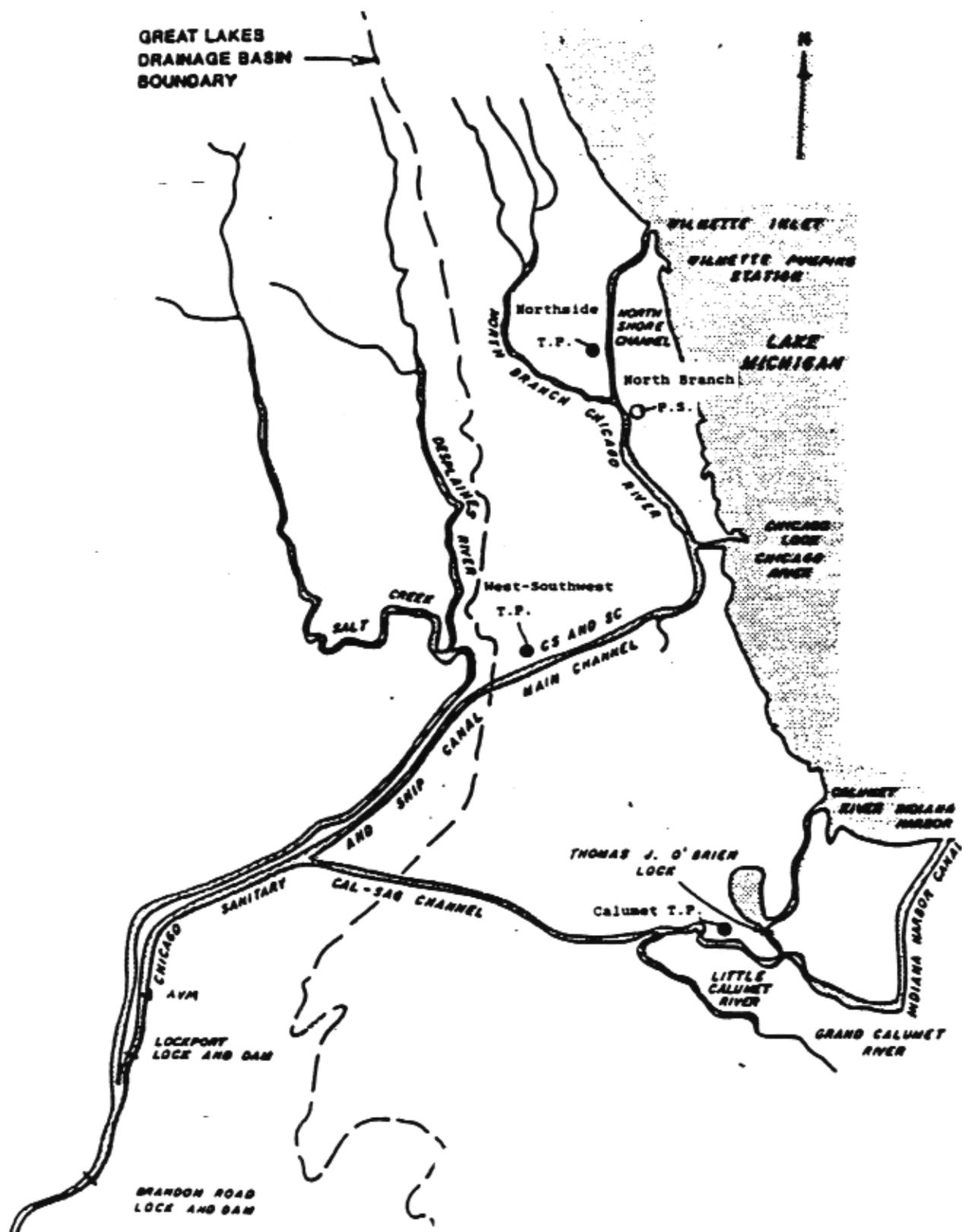


Figure 1-2 Lake Michigan Diversion at Chicago

2.1 OUTSTANDING 1985 ACTIONS

The Corps' 1985 Annual Report (page 15) discussed several IDOT recommendations regarding future actions. A status summary of these actions is included below:

a. IDOT Recommendation:

Further investigations into the accuracy of recorded flows at the Controlling Works and Powerhouse at Lockport are needed. Particular attention is needed to quantify submergence at the Controlling Works and its cause.

Status:

Under the Corps' expanded role in both the areas of direct funding and computational responsibilities as provided in PL 99-662, the Corps has held some initial informal discussions directly with the USGS regarding the establishment of headwater and tailwater gages at the Controlling Works. The need for additional actions or evaluations at the Lockport powerhouse and/or Controlling Works will follow the report of the 2nd three member committee.

b. IDOT Recommendation:

The MSDGC should incorporate the revised COE ratings for free flow discharge into their calculations of discharge for the Controlling Works and Powerhouse. The MSDGC should also establish a continuous record of tailwater elevations at a suitable location downstream of the Controlling Works.

Status:

MSDGS, as of July 1985, no longer prepares the detail hydraulic Lockport daily reports for IDOT relating to Lake Michigan diversion. A rough document called LMO-6 now substitutes the MSD Lockport records. The Metropolitan Sanitary District was encouraged to adopt the newly established theoretical sluice gate ratings curves but has chosen not to do so. The cost of relocating and establishing continuous gages at the Controlling Works is also beyond MSD's available funding limits.

c. IDOT Recommendation:

Further investigation is needed to determine the reasons for imbalances between estimated and recorded flows at the three major MSDGC treatment plants. Areas for investigation include the following:

1. Model assumptions with respect to sanitary return flow and infiltration and inflow quantities.
2. Possible leakage from the Canal through combined sewer overflow structures.
3. Possible unreported major discharges to the plant from groundwater or surface water supply return flows.

Status:

IDOT through its agent NIPC has reviewed some of these factors in preparation of the 1984-85 water year reports. No additional actions are currently scheduled.

d. IDOT Recommendation:

The monitoring of flow at the Upper Des Plaines Pumping Station should be discontinued for diversion accounting purposes due to uncertainties in its record which cannot be resolved without significant increased maintenance and flow monitoring changes.

Status:

The Corps in the 1985 report, agreed to discontinue the use of this flow measurement in the computation procedure; however, it is expected that total flow records at this gage will continue to be used as a system check for any significant shifts in output trends from this service area. Data derived from the records should be provided in tabular format. Any recommendations by the 2nd three member technical committee will be taken into consideration.

e. IDOT Recommendation:

Investigations into the possibility of long-term biases among precipitation gages reporting to NOAA, MSDGC and the City of Chicago should be undertaken based on significant differences noted during the 1983 water year.

Status:

The Illinois State Water Survey is currently under contract to IDOT regarding an evaluation of these concerns. A draft report has been prepared and a final report will be available during early 1987. The content of these investigations will be reported in the 1987 annual report.

f. IDOT Recommendation:

Flow monitoring at the Summit Conduit should be discontinued due to problems with frequent gage malfunctions, the relatively small amount of flow from this area, and the ability to reasonably estimate flows from this area using purpage data and runoff simulation.

Status:

The Corps pending any comments in the 2nd three member committee report will make a decision in 1987 regarding the use of this gage in the future.

g. IDOT Recommendation:

The flow transfer from the MSDGC's design O'Hare service area to the Northside Treatment Plant should be metered to provide a better estimate of quantity and flow variations.

Status:

If this flow transfer is not discontinued in the next two years, we concur with IDOT's recommendation that the line be metered.

## 2.2 FIELD CHECKS

During the 198~~6~~<sup>7</sup> accounting year (October through September), the Corps conducted several independent field inspection visits of facilities related to diversion accounting. Additional information in the form of MFR's is included in the correspondence portion of this report. An itemization and brief synopsis of these visits is as follows;

a. 7 November 1985 - field inspection of the O'Hare Water Reclamation Plant. The purposes of the visit were to determine how flows were measured and how flow diversion from the design area to the MSDGC's Northside Sewage Treatment Plant is determined.

b. 16 April 1986 - field inspection of MSDGC's Calumet Sewage Treatment Plant. The purposes of the visit were to inspect the flow measurement system used by the MSDGC to determine flows through the treatment plant, evaluate ability to estimate bypass flow, and inspect precipitation equipment. A general review of quality control was also intended.

c. 25 July 1986 - field inspection of the MSDGC's Northside Sewage Treatment Plant. The purpose of the visit was to view the metering system used in the plant to measure total sewage effluent passing through the facility.

Additionally, Corps' personnel were present to observe a series of discharge measurements conducted by the USGS (see table 3-1). These measurements were made in the Chicago Sanitary and Ship Canal at Romeoville.

## 2.3 MASTER PLAN

As part of the Corps' monitoring responsibilities under the modified Supreme Court decree and in fulfillment of a principal recommendation made by the first technical committee, a master plan for Lake Michigan diversion monitoring activities was developed. The purpose of the master plan is to define the responsibilities of the Corps of Engineers with regard to Lake Michigan diversion, establish routine annual goals and objectives, establish a generic annual schedule of activities and provide specific short and long range objectives for the program. As an integral part of this master plan, a series of standard operating procedures (SOP's) will be maintained. Draft SOP's will be available by October ~~1987~~. The master plan will be reviewed and updated periodically. Appendix C contains the master plan - dated ~~8 August 1986~~.

## 2.4 IN-HOUSE STUDIES

During accounting year 1986, the Corps commenced a review of inflow and infiltration records within areas serviced by the Metropolitan Sanitary District of Greater Chicago (MSDGC). Personnel from the MSDGC are providing assistance to the Corps in this study. The main objective of the study was to determine if any new studies quantifying inflow and infiltration values had been made. In a previously completed study report, the MSDGC indicated that inflow and infiltration could be minimized through rehabilitation of all existing old or deficient sewers. A total of 127 local agencies were asked to institute a sewer rehabilitation program in order to upgrade, replace or repair existing deficient sewers within their localities. The EPA has provided sewer rehabilitation grants to those agencies. The rehabilitations made were so minimal that new quantitative analyses of inflow and infiltration were not warranted.

During accounting year 1986, the Corps reviewed and developed several regression models for predicting AVM flow rates for times when the AVM system was not operating. It is intended that a regression model system using input from other sources of total flow measurement in the canal will form the basis of the backup system. To date candidate regression models have been developed by the USGS, CORPS, and HARZA. An acceptable regression model has not been selected at this time mainly because of the questionable accuracy of the AVM record (see section 3.2) and the importance of having a long and reliable enough AVM record for the development of the regression model itself. It is anticipated now that problems with the basic AVM system have been corrected, that the USGS will provide a recommendation on the backup system by the Spring of 1987. Based on this, the Corps should be able to certify a backup procedure by the summer of 1987. Three-member committee recommendations will be considered in the finalization of this backup system. (Correspondence on this matter is included in Appendix C).

## 2.5 CONTRACTED STUDIES

The Corps of Engineers contracted its Hydrologic Engineering Center (HEC) in Davis, California to perform an analysis of the hydrologic simulation procedures used by the State of Illinois to account for annual diversions from Lake Michigan. Upon completion of the analysis, the HEC prepared a report entitled, "Lake Michigan Diversion Accounting-Evaluation of Hydrologic Simulation Procedures." (Reference 3) This report, dated June 1986, was provided to all parties of the litigation by a series of letters dated 30 June 1986. The report was also provided to other interested agencies involved in diversion accounting. In summary, the report concluded that the current procedures for hydrologic simulation are consistent with the "best current engineering practice and scientific knowledge as required by the Supreme Court Decree. The weakest aspect of use of the simulation techniques is the lack of a basis for calibrating model parameters for ungaged watersheds." The report recommended that additional attempts at calibration be made in the future after more data becomes available and sources of discrepancies in other flow components are determined. The members of the second three-member committee will take the findings of this report into consideration in their analysis of the simulation model.

Computational services were contracted from the North Pacific Division office to store, compile and execute the NIPC Lake Michigan Diversion Accounting computer program.

## 2.6 SECOND THREE-MEMBER COMMITTEE

As required under the provisions of the modified Supreme Court decree of 1 December 1980, the second technical committee was appointed by the Chief of Engineers in February 1986 and convened in July 1986. The committee members are Dr. William H. Espey (chairman), Mr. Harry Barnes and Mr. David E. Westfall. The focal point of the committee's review is the new diversion accounting system developed by IDOT. ~~The first workshop was held in Chicago on July 14-18, 1986. The purpose of the workshop was to provide an overview of the Lake Michigan diversion accounting procedures to the committee members. The workshop was principally of a technical nature, including presentations by the Corps, State of Illinois (IDOT), and the Northeastern Illinois Planning Commission. Field investigations of various areas involved in diversion accounting were also included.~~

The second workshop was held in Chicago on September 9-11, 1986. The purpose of the workshop was to provide additional information to the committee for its review and evaluation. During the course of the workshop, a presentation on the operation of the acoustical velocity meter (AVM) was provided by the U. S. Geological Survey (USGS). Additionally, IDOT gave a presentation on the State of Illinois' water allocation program. An additional field trip to the Tunnel and Reservoir Plan (TARP) Mainstream Pumping Station was also included.

All parties of the litigation were invited to attend the above workshop. Although none of the parties attended (with the exception of the State of Illinois), position statements were provided by the states of Minnesota and Wisconsin. Additionally, an acknowledgement telephone call was made by the State of Michigan. (See Appendix C).

Following the completion of the 3rd and 4th workshops, the committee members will be meeting in private sessions in order to consolidate their individual findings. The final report of the committee is expected to be available in early to mid-April 1987. Copies of the report will be provided to all parties of the litigation as well as other involved agencies.

## IDOT ACTIVITIES DURING 1986

### 3.1 LAKEFRONT LEAKAGE

At the Chicago Harbor, inner south breakwater structure, adjacent to the mouth of the Chicago River, overtopping and weep hole flow has caused extensive leakage through the structure. This was especially true with high lake levels. Approximately 1200 lineal feet of structure was affected. The severe leakage was through the cutoff wall portion of the breakwater. An average leakage was estimated at about 50-100 cfs, on the annual average. In June 1986 the State of Illinois prepared plans and specs to modify the section and eliminate the major portion of this lakefront leakage. At the end of 1986 the construction had been completed. Figure 3-1 shows the facility prior to and during construction. This component of flow is important in Lake Michigan diversion allocation especially as it adversely affects the State's water allocation amounts.

### 3.2 ACOUSTIC VELOCITY METER

Rather than incur high expense of revising and recalibrating flow through structures at Lockport Powerhouse, IDOT and the USGS agreed to cost share the purchase of a new Acoustic Velocity Meter (AVM). The meter is located on the Sanitary and Ship Canal upstream from Lockport at the Romeoville bridge (see figure 3-2). The device, built by Sarasota Automation, was installed in March 1984 and started collecting canal flow data June 12, 1984. Some of the AVM features are shown on photographs in figures 3-3 through 3-5. Until September 1986 data was stored at the site on paper tape and could also be accessed by (deckwriter) computer terminal. Since September 1986, the data is also transmitted by a data collection platform. An on-site data logger was recently added to increase the data storage capability.

Calibration of the AVM, which was completed in March 1985, consisted of seven sets of field measurements taken using standard Price AA current meters. The last set of these measurements was completed on March 4, 1985. Total flows for each set of field measurements were calculated and compared to the flows reported by the AVM for the same time period. Table 3.1 lists the log of USGS calibrations. Calibration checks are to continue quarterly to insure that the accuracy of the AVM is maintained.

A system flaw was found in March 1985 with a breakdown of the AVM device. A passing vessel severed the AVM transducer communications cable rendering the AVM inoperable. No data were gathered for thirty days. Following its repair in April 1985, the AVM was not recalibrated until a field check on August 29, 1985 discovered the AVM was recording only 80% of field measured flow. Subsequently, additional sets of field measurements have been made. The dates of these measurements are as follows: 17 October 1985, 19 November 1985, 20 November 1985, 20 December 1985, 10 January 1986, 4 April 1986, 1 July 1986, 14 July 1986, 7 August 1986, 22 September 1986 and 25 September 1986. It was not until the 22 September 1986 adjustment and subsequent field checks that the AVM system was again functioning with the system accuracy intended.

For the period of 21 March 1985 - 22 September 1986, the USGS has been evaluating various procedures for adjusting the AVM records in order to produce a certifiable record of total flow at Lockport. Since September 1986, the USGS has been reevaluating the validity of the adjustment factors used with the available AVM record in producing the Lockport, Illinois, total flow record as published in the book "Water Resources Data for Illinois Water Year 1985." These evaluations by the USGS as well as recommended proposals by them for a backup system for computing the total flow measurements at Lockport, Illinois, are expected by January 1987.

Table 3-1

SUMMARY OF DISCHARGE MEASUREMENTS  
CHICAGO SANITARY & SHIP CANAL AT ROMEOVILLE

No.	Date	Measured Discharge(cfs)	AVM Discharge(cfs)	Shift Adjustment(cfs)	Adjusted(cfs)	% Difference
1	22 March 1984	6304	6310	None	6310	-0.1
2*	12 June 1984	3799	3591	None	3591	+5.8
3	29 June 1984	3437	3426	None	3426	+0.3
4	16 October 1984	7672	8758	None	8758	-12.4
5	25 February 1985	5774	6117	None	6117	-5.6
6*	4 March 1985	17,696	17,908	None	17,908	-1.2
7	4 March 1985	17,885	17,842	None	17,842	+0.2
8*	29 August 1985	3499	2685	814	3499	0.0
9	17 October 1985	2638	1486	1152	2638	0.0
10	19 November 1985	6813	6383	410	6793	+0.3
11	20 November 1985	8618	8230	410	8640	-0.2
12	20 December 1985	2967	2675	410	3085	-3.8
13	10 January 1986	1375	944	410	1354	+1.6
14	4 April 1986	1895	1392	410	1802	+5.2
15*	1 July 1986	5192	4827	450	5277	-1.6
16	14 July 1986	3096	2678	450	3128	-1.0
17*	7 August 1986	4653	4134	450	4584	+2.2
18	22 September 1986	3102	2541	450	2991	+2.0
19	25 September 1986	4464	4389	None	4389	+1.7

\* Corps personnel present

NOTE: Modified version of Conversion Table A used to adjust AVM readings from 19 April 1985 to 5 November 1985 inclusive. From 6 November 1985 to 5 June 1986 inclusive, a straight correction of 410 cfs is applied. From 6 June 1986 to 22 September 1986 inclusive, a straight correction of 450 cfs is applied. AVM adjusted discharges, when applicable, are obtained by adding AVM discharges to corresponding shift adjustments.

Percentage differences are determined as follows:

(a) no adjustment cases:  $\frac{\text{Measured Discharge} - \text{AVM Discharge}}{\text{AVM Discharge}}$  (b) shift adjustment:  $\frac{\text{Measured Discharge} - (\text{AVM Discharge} + \text{Shift})}{(\text{AVM Discharge} + \text{Shift})}$



Chicago Harbor breakwater leakage



Figure 3-1 New parapet seal cutoff wall under construction

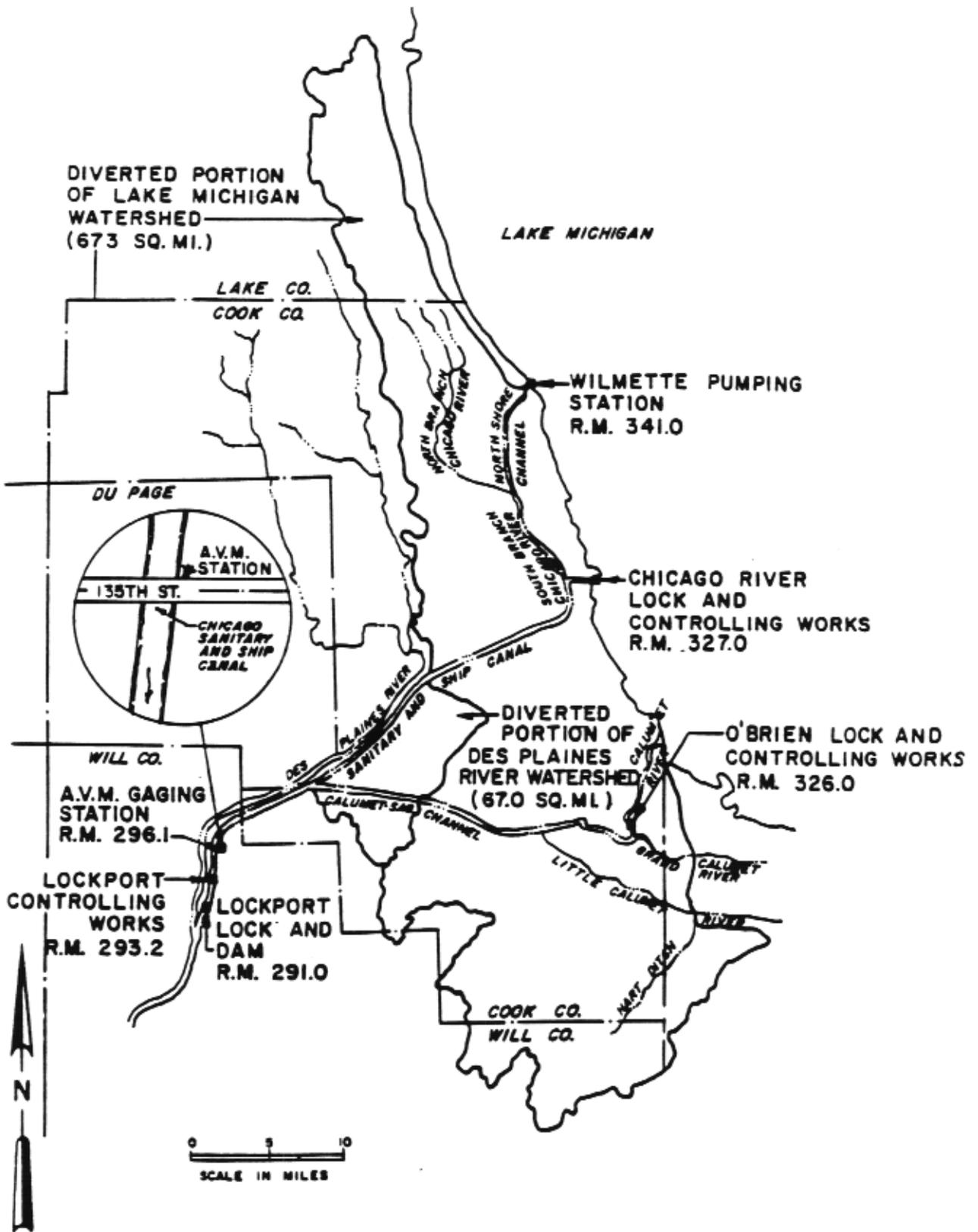
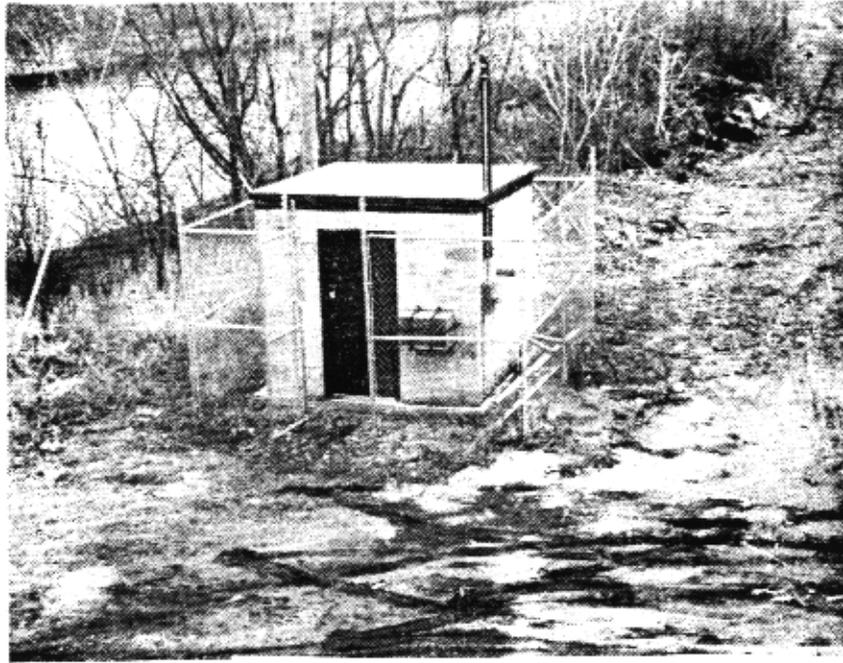


Figure 3-2 Acoustic Velocity Location Plan



AVM shelter 8 X 8 concrete block constructed Mar 1984

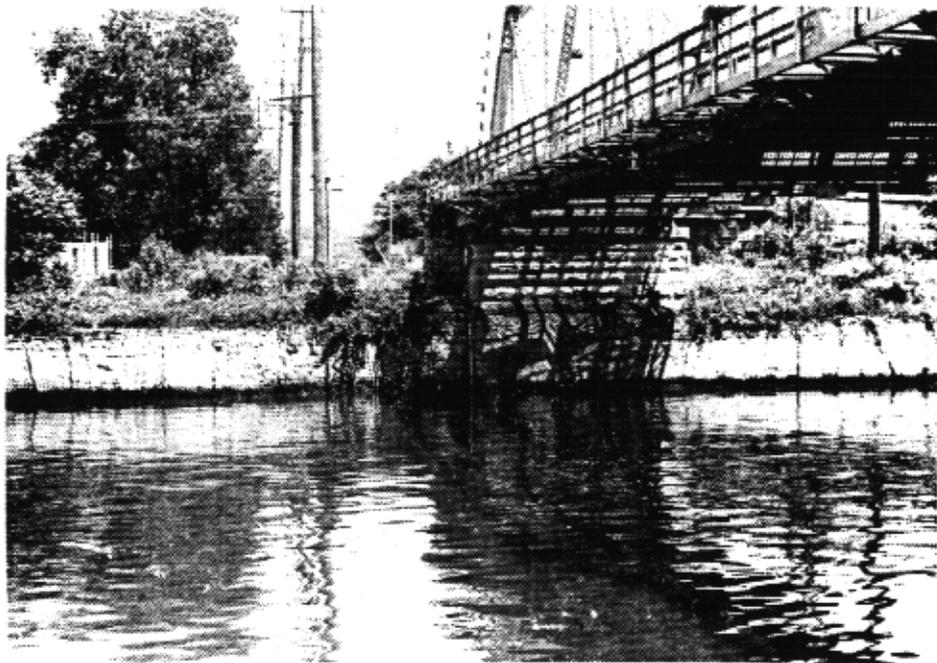
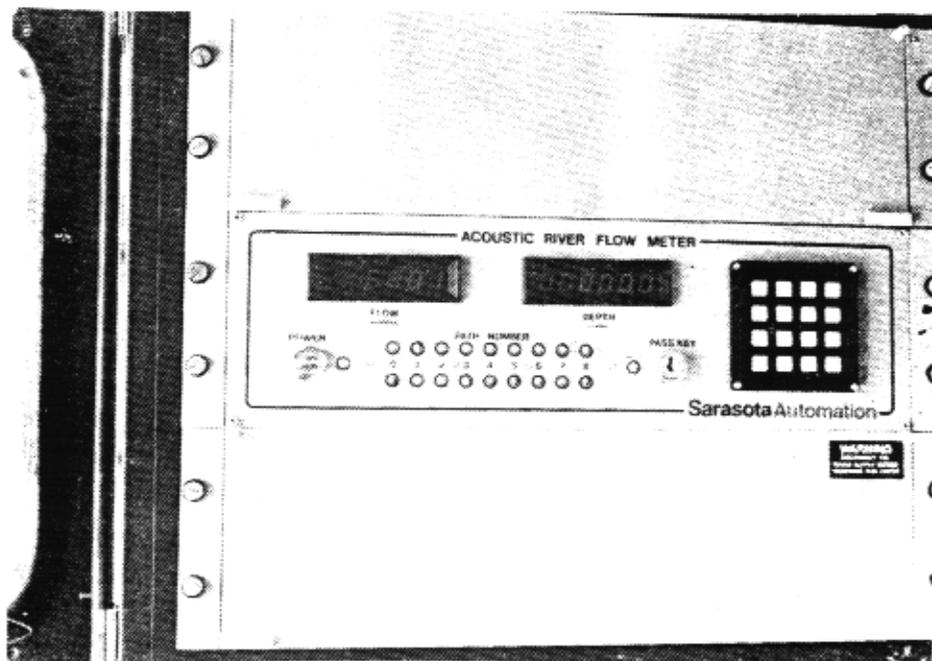


Figure 3-3 Romeoville bridge crossing over Chicago Sanitary Ship Canal



AVM Control panel

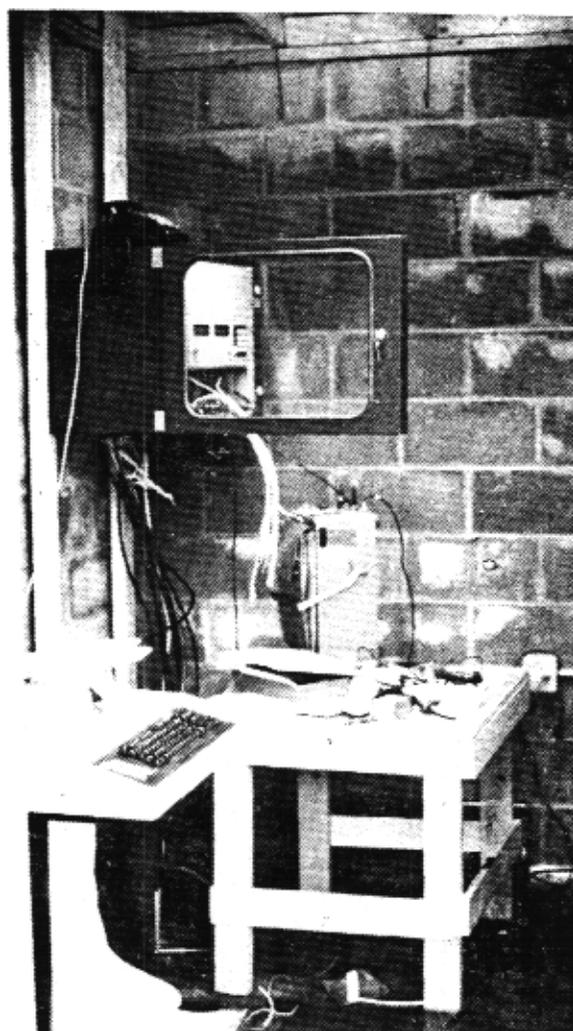
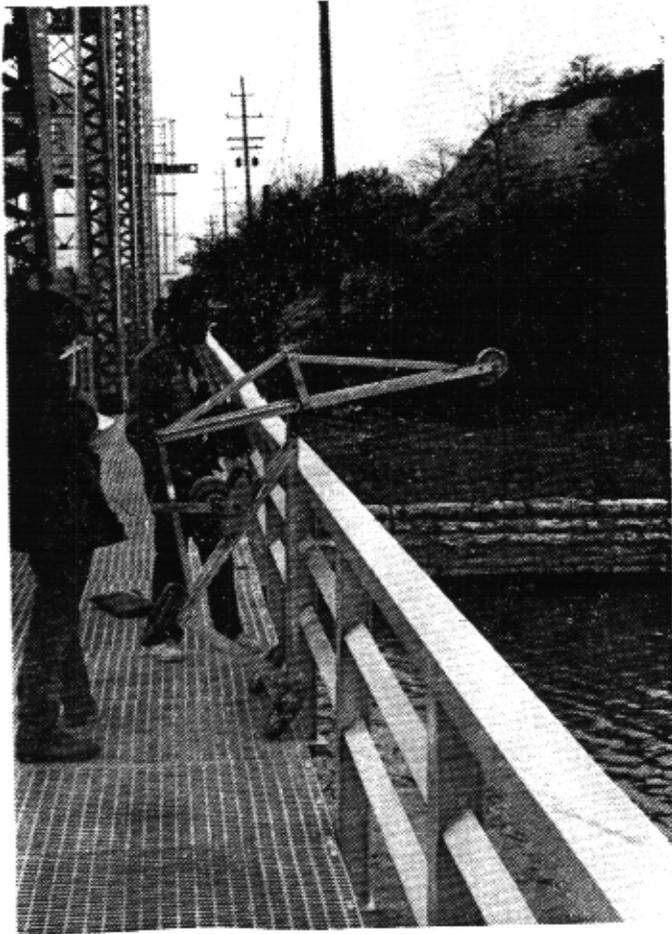


Figure 3-4 Inside AVM shelter with deckwriter in foreground



USGS velocity measurements near AVM site (mile, 296.1)

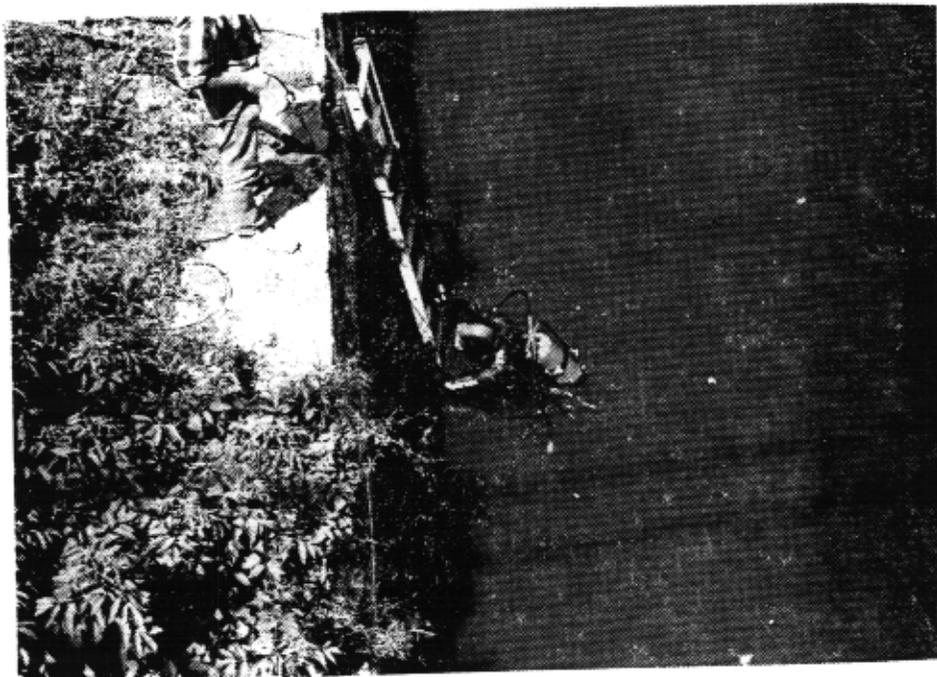


Figure 3-5 Diver inspecting transducers and AVM cables

### 3.3 CONTRACTURAL SERVICES

The following contractual services were in effect during the course of the 1986 accounting year:

(a) IDOT and its consultant, the Northeastern Illinois Planning Commission (NIPC) continue to work on the preparation of the 1984 Annual Lake Michigan Diversion Accounting Report. At the earliest a draft of this report is to be available in January 1987.

(b) Preparation of a report by the Illinois State Water Survey, as an agent of IDOT, regarding examination of Chicago precipitation patterns, review of the available precipitation data collection network, and analysis of the data to be used in the hydrologic simulation model. The study was necessitated due to substantial differences in recorded precipitation data between reporting stations noticed during review of 1983 water year information and the possibility of long-term biases among reporting precipitation gages. (Reference paragraph 2.1e regarding this study).

(c) Conversion of the accounting model software for execution on a personal computer. IDOT has contracted its agent, NIPC, to accomplish this task.

(d) Investigation of the impact of the acoustical velocity meter on Lake Michigan diversion accounting. IDOT has hired Harza Engineering Company to perform this study (reference 5). The purpose of the study was to determine the long-term differences which could be expected between measured AVM flows and those flows historically calculated at Lockport as well as relationships to relate the AVM flows to Lockport flows. The final report, as prepared by Harza Engineering, was submitted on December 16, 1986.

(e) Analysis of leakage at the lakefront, navigational make-up water, and impact of TARP on accounting. This is an additional study being completed by Harza Engineering under contract to IDOT. The purpose of the study is to quantify the leakage through the lakefront structures as well as evaluating impact of the leakage on total flow entering the Chicago Sanitary and Ship Canal. The study will also address new components of the TARP system and their impact on the diversion accounting system in terms of future needs for direct diversions from Lake Michigan. The expected completion date for this study is spring 1987.

IDOT also requested NIPC to incorporate the new online TARP system components in its computerized accounting program.

### 3.4 ONLINE TARP SYSTEM IMPACTS

During an average year, an abundance of storms causes a combination of raw sewage and stormwater to discharge into Chicago's waterways, causing pollution as well as flooding problems. The need to end the pollution caused by combined stormwater and sewage gave birth to the MSDGC's Tunnel and Reservoir Plan (TARP). The purpose of TARP is threefold: (a) to prevent backflows into Lake Michigan, source of the area drinking water; (b) eliminate waterway pollution caused by combined sewer overflows; and (c) provide an outlet for flood waters. TARP is designed in two phases. TARP Phase I when completed will consist of three separate systems. Each system will terminate at its own sewage facility. The three systems are: (1) the Main Stem system, (2) the O'Hare system and (3) the Calumet system. TARP Phase I, a system of deep shafts, tunnels and pumping stations, will be used primarily for pollution control whereas TARP Phase II, a system of storage reservoirs, will be used for flood control. The currently constructed 31 miles of TARP tunnels, ranging from 13 to 33 feet in diameter, have a storage capacity of 1 billion gallons. (See figure 3.6).

Sewage and stormwater entering the tunnels through drop shafts in the main stem is carried to the TARP Mainstream Pumping Station in Hodgkins, Illinois, where the flow is pumped to the MSD's West-Southwest Treatment Plant.

The O'Hare system TARP tunnels collect combined sewer overflows which are later treated at the O'Hare Treatment Plant.

The Calumet system tunnel and reservoir leg has its flow discharged to the MSDGC Calumet Treatment Plant.

With respect to diversion accounting, the TARP system is expected, over a number of years, to substantially reduce the needs for two primary components of direct diversion. These components are discretionary flows and navigational make-up water. Specifically, it is expected that the improvement of water quality in the Sanitary and Ship Canal as a result of the TARP system will alleviate the need to divert Lake Michigan water for dilution purposes. Similarly, it is expected that the storage capabilities of the TARP system will alleviate the need to divert lake water in order to maintain adequate navigational stages in the canal. As a result, the State of Illinois' allocations for these components will continue to be gradually reduced.

As shown on figure 3-6 the O'Hare System and a portion of the mainstream system have been completed and comprise the currently constructed 31 miles of TARP tunnel. The Salt Creek leg, near Western Springs, currently under construction; once constructed will divert water away from the Des Plaines watershed. The measuring techniques to record this flow have been discussed with MSD. Initially the consensus of opinion is that it will be difficult if not impossible to measure or adequately record flows inside the deep tunnels. Unsteady flow conditions, surges, below ground maintenance problems and other factors would first have to be overcome. Flow recording instrument manufacturers will be consulted, field demonstrations and possible solutions will then be sought.

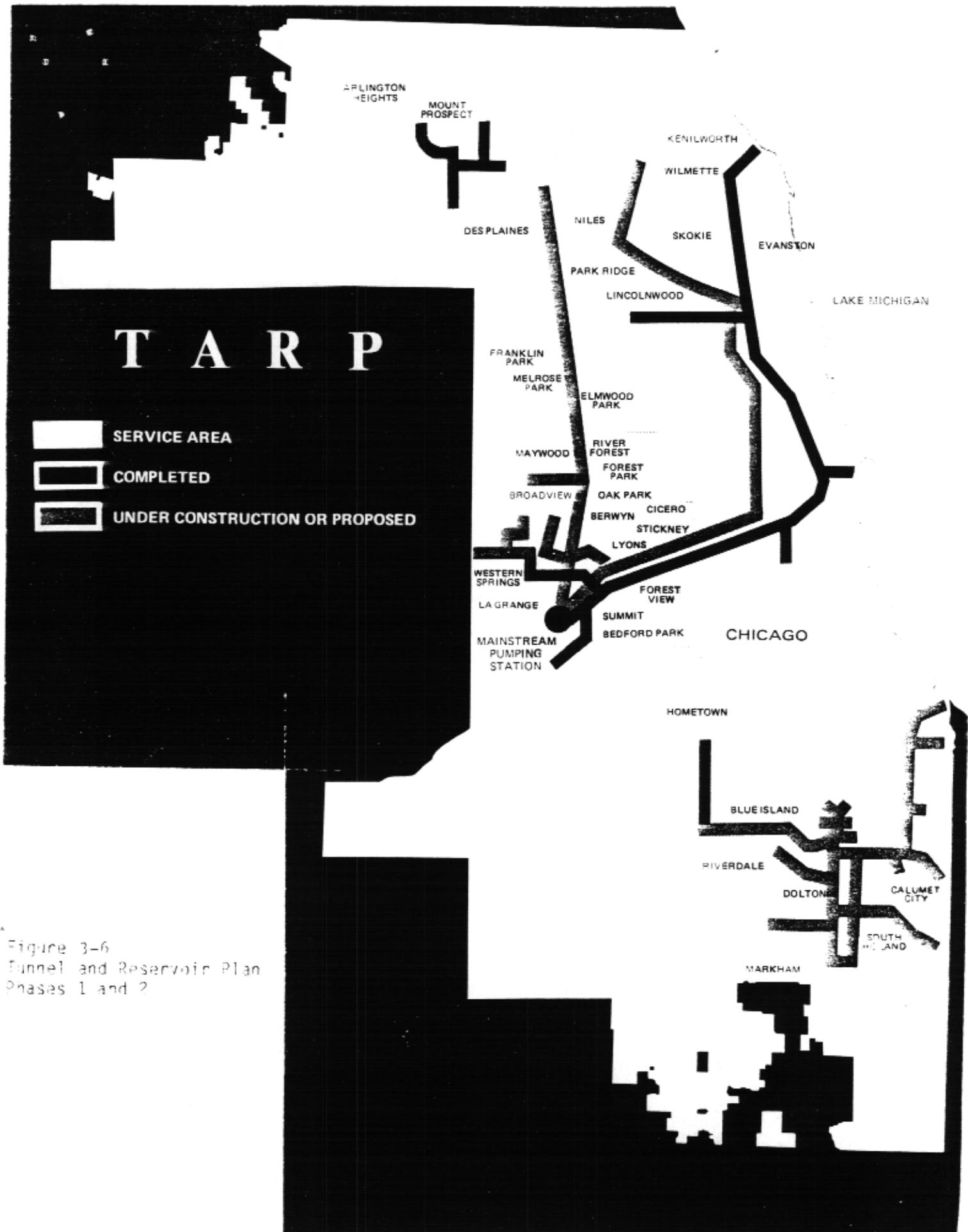


Figure 3-6  
Tunnel and Reservoir Plan  
Phases 1 and 2

## PROJECTED ACTIVITIES

### 4.1 WATER YEAR ACCOUNTING REPORTS

The Corps maintained close contact with IDOT and its agent, the Northeastern Illinois Planning Commission (NIPC), during the development of the new accounting procedure. The new accounting system was first used in the accounting for Water Year 1983 as reported in the 1985 annual report. (Reference 6). A primary component of the new accounting procedure is the hydrologic model which accounts for many of the flows throughout the diversion area. The basic model is a variation of the hydrocomp Model originally developed by NIPC to conduct Section 208 Water Quality Studies. It has been used for several studies by NIPC and other agencies, including the Corps, in its Chicago Underflow Plan (CUP) study. A simplified schematic flow chart of the accounting process components is shown on figure 4-1. (Reference 1)

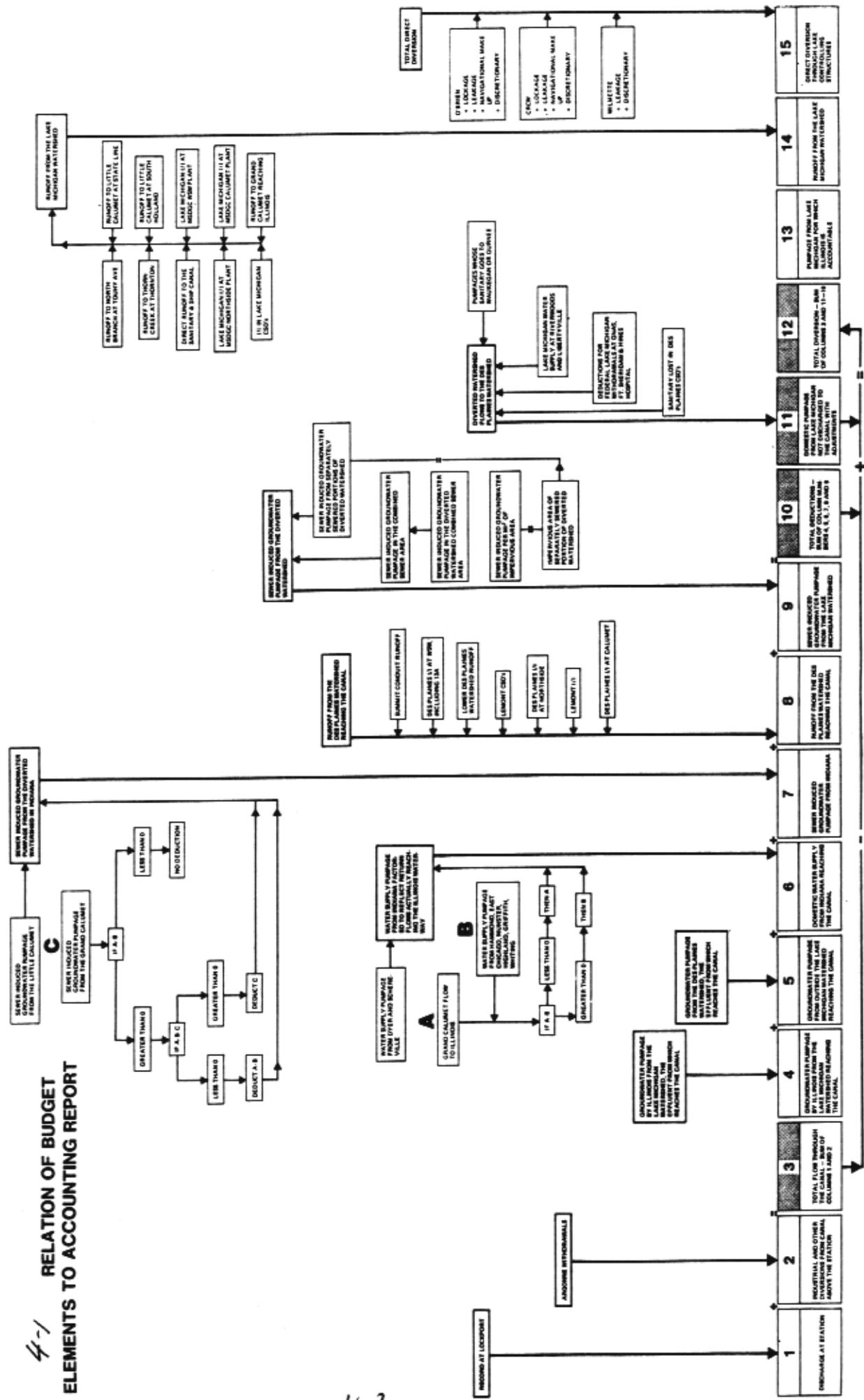
An integral part of the accounting system is the water budget system employed in the model which allows component verification at various checkpoints. Simulated flows (the sum of individual components) for a watershed sub-area are compared with recorded measurement at metered points such as sewage treatment plants or pumping stations. A variance in the comparison may provide indications of errors in the raw data or in the accounting system itself.

The 1984 Accounting report will be similar to the published 1983 Annual report in that the MSD Lockport flow records were used. Starting with the 1985 accounting report the USGS data, as recorded by the AVM, will be used as the measured flow at Lockport. While the 1984 accounting report is soon to be released in draft form by IDOT, the anticipated completion date for the 1985 accounting report is still pending.

### 4.2 SECOND 3-MEMBER COMMITTEE SCHEDULE

The second three-member committee is expected to finalize its work during accounting year 1987. As discussed previously, following a final open workshop to be held in January 1987, the committee members will meet privately in order to consolidate these findings. A draft report is expected in March 1987. The final committee report will be available by mid-April 1987.

4-1  
**RELATION OF BUDGET  
 ELEMENTS TO ACCOUNTING REPORT**



4-2

#### 4.3 IMPACT OF NEW WATER RESOURCES BILL

The Water Resources Development Act of 1986, PL99-662, the first water projects authorization bill approved by Congress in 10 years, was signed into law on November 17, 1986. This bill has extensive provisions for the Corps with respect to diversion accounting. Specifically, as of October 1, 1987, the law gives the Corps total responsibility for the measurements and computations necessary to compute the amount of water diverted from Lake Michigan. Section 1142 of the law regarding measurement of Lake Michigan diversion states as follows: "Beginning October 1, 1987, the Secretary, in cooperation with the State of Illinois, shall carry out measurements and make necessary computations required by the decree of the United States Supreme Court relating to the diversion of water from Lake Michigan and shall coordinate the results with downstate interests. The measurements and computations shall consist of all flow measurements, gage records, hydraulic and hydrologic computations, including periodic field investigations and measuring device calibrations, necessary to compute the amount of water diverted from Lake Michigan by the State of Illinois and its municipalities, political subdivisions, agencies, and instrumentalities, not including water diverted or used by Federal installations."

The above duties represent a substantial increase in responsibility for the Corps in addition to a departure from the Corps' supervisory role as stipulated under the modified Supreme Court Decree. The Chicago District Corps of Engineers will hold coordination meetings with the State of Illinois, to become familiar with the costs of gathering data and the methods of computing of the diversion amounts starting in the second quarter of FY 87.

#### 4.4 OTHER ACTIVITIES AND STUDIES

Other activities and studies discussed in Section 2.1 above, are being carried over into calendar year 1987 and will again be reported in the next annual report.

## CONCLUSIONS

### 5.1 SUMMARY

The Lake Michigan diversion accounting program has been going through significant modifications of the technical methodology used in computing total flows at Lockport and in the computation of the deductions. As discussed in the Corps' review, some minor inconsistencies still exist within the accounting system. Notwithstanding these inconsistencies, the results represent an improvement in the accounting procedures. Just as the physical features of the diversion area are dynamic, so is the accounting system itself.

It is expected that the implementation of the first Technical Committee's recommendations will, over the next several years, continue to improve the diversion monitoring system. The review by the second Technical Committee, scheduled for completion in the spring of 1987, will result in future improvements to the overall system as well.

Based on the review of the State of Illinois' FY 86 accounting program, data collected by agencies of the State of Illinois, computation sheets, field investigations and special studies conducted by or for the Corps of Engineers, the Corps reaches the following conclusions:

- a. The current procedures for hydrologic simulation are consistent with the "best current engineering practice and scientific knowledge" as required by Supreme Court Decree.
- b. A backup system to the AVM for measuring Lockport flows is necessary and will be developed.

## REFERENCES

1. NIPC Lake Michigan Diversion Accounting Manual of Procedures, June 1985.
2. COE, Lockport Power Plant Sluice Gate and Control Works Discharge Evaluation, September 1985.
3. COE, Lake Michigan Diversion Accounting - Evaluation of Hydraulic Simulation Procedures, June 1986.
4. Keifer, Flows Crossing the Lake Michigan Diversion Boundary in Indiana, September 1978.
5. Harza, Investigation of the Impacts of the Acoustical Velocity Meter on Lake Michigan Diversion Accounting, September 1986.
6. COE, 1985 Annual Report on Lake Michigan Diversion (including State of Illinois Water Year 1983 Accounting Report), February 1986.

APPENDIX A  
SIGNIFICANT HYDROLOGIC EVENTS

APPENDIX A  
SIGNIFICANT HYDROLOGIC EVENTS

The following is a detailed itemization of events of strictly a hydrologic nature which occurred during accounting year 1986:

18-19 November 1985 - Heavy rain was experienced in the Chicago area which resulted in localized flooding. The storm resulted in peak flows of approximately 22,000 cubic feet per second (cfs) being recorded at Lockport. No backflows into Lake Michigan occurred as a result of this storm event. Precipitation amounts recorded during the storm were as follows: Kankakee - 2.28", Lockport - 1.3", and O'Hare Airport - 1.17".

24-30 September 1986 - A series of major rainstorms occurring in the Chicago area resulted in severe localized flooding. The storms were concentrated in Lake County, located in the northern sections of the area. A backflow into Lake Michigan was necessary as a result of the series of storm events. The backflow event occurred on 3 October 1986 at the Wilmette Pumping Station. Water was allowed to backflow into the lake only after the TARP tunnel system had reached its capacity. The volume of the backflow was 53 million gallons.

At the Lockport Powerhouse all sluices were opened on 3 October; at the controlling works all the gates were also opened. MSDGC reported an instantaneous peak flow for that day of 32,440 cfs. The AVM was out of operation due to a power surge through the telephone lines serving the deckwriter terminal. The USGS did make a discharge measurement which reported a flow of 16,039 cfs.

APPENDIX B  
SIGNIFICANT NON-HYDROLOGIC EVENTS

Appendix B  
Significant Non-Hydrologic Events

2 October 1985 - Letter sent from Chicago District to the Northeastern Illinois Planning Commission (NIPC) with copy furnished to Illinois Department of Transportation (IDOT) regarding Corps' requested recheck of the adjustments to flow at Lockport Powerhouse and Controlling Works for selected dates during 1983 accounting year. Letter stated that Corps completed review of provided sluice computations and that overall error was judged to be within acceptable limits. Additionally, letter requested NIPC to make required changes to 1983 diversion accounting report and forward results to IDOT.

4 October 1985 - Letter sent from Chicago District to Corps' North Central Division (NCD) providing detailed FY 86 diversion monitoring schedule. Tasks discussed included second technical committee formation, new accounting model review, field investigations, Corps' master plan, IDOT's annual accounting reports, and Corps' annual report.

16 October 1985 - Letter sent from NCD to Chicago District providing comments on Corps' annual report covering 1983 diversion accounting year summary as prepared by IDOT. Letter also requested District's recommendation regarding use of acoustical velocity meter (AVM) as the primary measurement system of flows at Lockport.

17 October 1985 - Advertisement printed in Commerce Business Daily (CBD) requesting resumes from qualified individuals for formation of second three-member technical committee. Additionally, United States Geological Survey (USGS) performed discharge measurement in Chicago Sanitary and Ship Canal at Romeoville.

31 October 1985 - Letter sent from Chicago District to IDOT (copy furnished with enclosure to USGS) forwarding copy of summary report prepared by Chicago District regarding review of proposed AVM backup system for measurement of Lockport flows.

5 November 1985 - Letter sent from Chicago District to IDOT regarding newly developed diversion accounting program. Letter stated that Chicago District had requested the assistance of the Corps' Hydrologic Engineering Center (HEC) to review IDOT's Lake Michigan diversion accounting program (model and H&H simulations) to determine its adequacy and applicability. Additionally, letter stated that a meeting had been scheduled for 20 November 1985 with HEC, NCD, and Chicago District personnel to allow for further discussions of the subject and requested IDOT's attendance at the meeting (IDOT's consultant, NIPC, also requested to attend).

27 November 1985 - Letter sent from IDOT to Chicago District forwarding final copy of Lake Michigan Diversion Accounting Report for the 1983 accounting year. Letter also addressed concerns outlined in Chicago District's 12 November letter above (with regard to AVM system). Letter expressed similar concerns on part of IDOT with regard to calibration problems since 21 March 1985 breakdown. Letter stated that a recent service examination revealed an error in the stage data used to compute discharge and emphasized two subsequent calibrations (19 Nov 85 & 20 Nov 85) completed by the USGS showing 3.7% and 5.4% differences, respectively, between measured discharge and AVM discharge. Letter further stated that USGS planned additional calibration checks in near future. Letter also emphasized that AVM record was correctable and USGS would prepare a written report discussing the problem and corrective steps taken. Finally, letter expressed confidence in IDOT's decision to use the AVM system and stated that responsibility for verifying the discharge data and development of a backup system rested solely with the USGS.

9 December 1985 - Letters sent from Chicago District to all parties of diversion litigation forwarding copy of list of respondents (individuals and corporations) to CBD announcement for second technical committee. Letter requested parties to provide Chicago District with any information that would lead to disqualification of any of the respondents.

17 December 1985 - Letter sent from State of Ohio to Chicago District in response to 9 December letter above. Letter stated that investigation process regarding three-member committee applicants had begun and that Ohio would provide a formal response as soon as possible.

20 December 1985 - Letter sent from State of Illinois to Chicago District in response to 9 December letter above. Letter stated objection to appointment of A. Epstein & Sons due to the fact that Division of Water Resources had current contract with Epstein that was expected to continue for several months. Letter also expressed State's interest in reviewing resumes and qualifications of list of finalists for appointment to second technical committee. Additionally, USGS performed discharge measurement in Chicago Sanitary and Ship Canal at Romeoville.

23 December 1985 - Letter sent from State of Minnesota to Chicago District in response to 9 December letter above. Letter stated explicit objection to appointment of A. Epstein and Sons. Letter also suggested that no consultants from Chicago area be appointed to serve on the committee in order to prevent any built-in biases or conflicts.

10 January 1986 - USGS performed discharge measurement in Chicago Sanitary and Ship Canal at Romeoville.

13 January 1986 - Corps' Hydrologic Engineering Center (HEC) provides cost proposal to Chicago District regarding evaluation of hydrologic simulation procedures used in the new diversion accounting system as developed by IDOT/NIPC. Proposal outlined specific tasks for accomplishing the evaluation and stated that work could be completed within three calendar months after authorization of funds.

9 April 1986 - Meeting held between representative of HEC, Mr. John Peters, and NIPC personnel for discussion of new Lake Michigan diversion accounting program and procedures.

10 April 1986 - Meeting held between representative of HEC, Mr. John Peters, and Corps' personnel for discussion of new Lake Michigan diversion accounting program and procedures. During course of meeting, Mr. Peters stated that HEC's report regarding evaluation of hydrologic simulation procedures employed in Lake Michigan diversion accounting would be available for review by 30 April 1986.

11 April 1986 - Meeting held between Corps, IDOT, and USGS for mutual discussion of AVM situation.

16 April 1986 - Corps' personnel visit MSDGC's Calumet Sewage Treatment Plant for purposes of inspection and observation.

29 April 1986 - Letter sent from Chicago District to MSDGC requesting access to records related to quantification of inflow leakage and infiltration within the MSD service areas. Information obtained was to be used by Chicago District in preparation of report pertaining to the study and evaluation of flows associated with inflow and infiltration.

2 May 1986 - Letter sent from HEC to Chicago District forwarding draft report regarding evaluation of hydrologic simulation techniques for use in Lake Michigan diversion accounting. Letter requested comments on the draft report.

8 May 1986 - Letters sent from Chicago District to IDOT and USGS forwarding draft copy of Chicago District report on Chicago Sanitary and Ship Canal flows for 1985 as measured by the AVM at Romeoville. Letters requested any comments to be provided to Chicago District.

20 May 1986 - Letter sent from Chicago District to HEC in response to above 2 May letter. Letter enclosed comments from NCD and Chicago District regarding HEC's draft report.

30 May 1986 - Letter sent from USGS to Chicago District in response to 8 May letter above. Letter stated that USGS recommended use of MSD records as one means of estimating periods of missing AVM records, but expressed some technical concerns about their use for the long term.

13 June 1986 - Letter sent from HEC to Chicago District forwarding final report regarding evaluation of hydrologic simulation techniques for use in Lake Michigan diversion accounting. Letter also responded to NCD comments on draft report as provided in 20 May letter above.

17 June 1986 - Letters sent from Chicago District to IDOT, NIPC, and MSDGC informing these agencies that negotiations with members of the second three-member technical committee had been completed. Letters provided further information regarding planned dates and activities for first committee workshop.

31 July 1986 - Letters sent from Chicago District to all parties of diversion litigation. Letters informed parties that first workshop with second technical committee had been completed along with forwarding copies of Corps' presentation and a Memorandum for Record (MFR) covering workshop proceedings. Letters additionally informed parties of dates for second workshop (9 Sept.-12 Sept. 86) and extended invitation to all parties to attend and make presentations to committee members if desired.

7 August 1986 - USGS performed discharge measurement in Chicago Sanitary and Ship Canal at Romeoville.

29 August 1986 - Letter sent from Chicago District to MSDGC (copy furnished to IDOT) requesting access to MSD facilities (Lockport Lock and Dam, Powerhouse, Controlling Works, TARP) during day of 10 September for purposes of visit by technical committee members.

5 September 1986 - Letter sent from MSDGC to Chicago District in response to 29 August letter above. Letter confirmed arrangements for visits to TARP and Lockport. Additional letter sent from State of Wisconsin to Chicago District enclosing position statement regarding review of Lake Michigan diversion flow measurements and accounting procedures. Additional letter sent from State of Minnesota to Chicago District in acknowledgement of 31 July letter above.

8 September 1986 - Letter sent from USGS to Chicago District in response to 28 July letter above forwarding requested information regarding AVM system.

9 September 1986 - 12 September 1986 - Second workshop held at Chicago District with members of second technical committee. Participating agencies included Corps, IDOT, USGS, and NIPC. Field investigation of Main Pumping Station for TARP was included.

22 September 1986 - USGS performed discharge measurement in Chicago Sanitary and Ship Canal at Romeoville.

23-24 September 1986 - Sarasota Automation Inc. representatives together with USGS personnel visit AVM site, determine operability of system. Rock Island District connects Sutron data collection platform. (See enclosed memo)

25 September 1986 - USGS performed discharge measurement in Chicago Sanitary and Ship Canal at Romeoville.

26 September 1986 - Major AVM malfunction due to weather conditions.

APPENDIX C  
CORRESPONDENCE



DEPARTMENT OF THE ARMY  
HYDROLOGIC ENGINEERING CENTER, CORPS OF ENGINEERS  
609 SECOND STREET  
DAVIS, CALIFORNIA 95616

REPLY TO  
ATTENTION OF

WRSC-HEC

13 June 1986

SUBJECT: Lake Michigan Diversion Accounting

Commander  
U.S. Army Engineer District, Chicago  
ATTN: Harry Krampitz/NCCED-H  
219 S. Dearborn Street  
Chicago, IL 60604-1797

1. Reference is made to DA Form, Order No. NCC-IA-86-38, dated 21 January 1986, which authorized HEC to perform an evaluation of the use of hydrologic simulation for the subject accounting; and to NCCED-H, dated 20 May 1986, subject as above, which transmitted comments on HEC's draft report.
2. Enclosed are ten copies of the final version of the report "Evaluation of Hydrologic Simulation Procedures." Your comments as well as comments obtained from an HEC in-house review have been incorporated in the final report. In addition, a number of the comments from NCD's review are incorporated. Enclosed also is a list of responses to each of NCD's findings.
3. If you have any questions regarding the report, please contact John Peters or Art Pabst at FTS 460-1748.

Encls  
as

*Bill S. Eichert*  
BILL S. EICHERT  
Director  
Hydrologic Engineering Center

28 OCT 1985

NCCED-B

Hydrologic Engineering Center  
609 S. Second Street  
Davis, California 95616

ATTN: WRSC-HEC (Arthur Pabat)

Reference is made to a phone conversation between Mr. Harry Krampitz of my office and Mr. Arthur Pabat of your office, sometime this month, regarding support from HEC for special assistance in the Lake Michigan Diversion Accounting Program.

Enclosed is a DA Form 2544. Please expedite and send back our copies as soon as possible. If you have any question address them to Mr. Krampitz, FTS 353-6474.

FOR THE COMMANDER:

Encl

IGNAS JUZEKAS  
Chief, Engineering Division

*JP*  
PANGLOSS AN/gu/

NO

1

NCC

NO

10 July 1985

## MEMORANDUM FOR RECORD

SUBJECT: Visit to MSDGC West - Southwest S.T.P. at Stickney

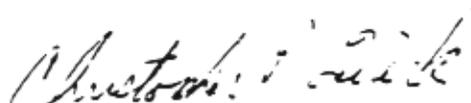
1. The purpose of Captain Hurt, Chris Quirk and Harry Krampitz visit to the W-SW sewage treatment plant on 10 July 1985, was to determine the methods of plant influent measurements throughout the plant along with instrument calibration techniques employed. The accuracy of flow measurement through the plant is of importance for the Lake Michigan NIPC diversion accounting computer program.

2. The MSDGC measures influent flow to the W-SW plant before its Imhoff tanks and before the aeration basins. Inflow measurements are recorded as sewage enters at the West end where primary treatment is performed. This sewage is then pumped to the Southwest side for further treatment. Sewage entering the Southwest plant is also measured including any recycled sludge. Four venturis are used to measure flow at both ends of the plant. Any overflow that may occur during high flow volume conditions is discharged into the Chicago Ship Canal untreated. The overflow is unmeasured but can be calculated indirectly since it is equal to the difference between the flow through the West and Southwest venturi metering stations.

3. As was stated earlier, our primary concern was to obtain information on how flows are accounted for along with the frequency of equipment calibration. The trip allowed us to inspect the gaging station where flows are measured, and to see the venturi's at the Southwest station. We also were able to observe the operations in the main control building. We were unable to receive a hard copy of flow logs or to obtain any information on venturi instrument calibration. However we did receive a contact to call back on further instrumentation information. Captain Hurt recorded some of the highlights of the visit on video tape.

4. The following persons were points of contact during the visit:

Earl Knight - assistant chief engineer	780-4000
Allan Crowther - Engineer of Plant Operations	780-4003
Richard Heil - Assistant Engineer TPO	780-4008

  
Christopher P. Quirk  
Civil Engineer

## Enclosures

1. Location Map
2. Plan View of Plant
3. Sample record keeping chart

29 JUL 1985

## MEMORANDUM FOR RECORD

SUBJECT: MSD visit to inspect precipitation gage

1. On the morning of 25 Jul 85, Harry Krampitz and Christopher Quirk of NCCED-H went over to MSD's office on 100 E. Erie Street. The main purpose of the visit was to inspect the rain gage which is located on the roof of MSD's office. We were assisted by Mr. Ram Kaduri and Mr. Patel of MSD.
2. The brand and type of rain gage in use is the Belford Tipping Bucket gage. Mr. Koduri noted that the gage is insulated and heated when necessary. Harry Krampitz was able to take pictures of the exterior and interior mechanism of the gage.
3. The Tipping Bucket gage operates by rain initially landing on the 8 inch cone on top of the gage. The moisture is then funnelled through a hole at the base of the cone. The moisture is received onto the tipping bucket which acts much in the same way as a see-saw. When one bucket fills, it tips and the other side fills. Every time a bucket fills and tips, a tick mark is recorded downstairs in the MSD Water Control Office.
4. Mr. Koduri explained that calibration of the precipitation gage is performed by pouring water into the mouth of the gage, and then checking the number of ticks recorded. Frequency of calibration was not discussed during the visit. However, while we were on the roof, we checked the precision of the gage by tipping the bucket four times. When we returned to the control office, we observed that four new marks were recorded on the gage graph.
5. When we were in the MSD office, Harry Krampitz brought up the question of the large discrepancies in total precipitation between the MSD and NIPC gage readings. After double checking the data put out in the MSD monthly report and NIPC's gage readings it was determined that large differences in precipitation did exist. Mr. Koduri had no explanation for this but said that he would investigate the problem and get back to NCCED-H.

*Christopher P. Quirk*CHRISTOPHER P. QUIRK  
Civil Engineer

MEMORANDUM FOR RECORD

SUBJECT: Calumet Sewage Treatment Works Visit

1. On 16 April 1986, I met with Mr. Ed Pytel, Mr. Greg Cargill, and Mr. Ramon Grant at Calumet Sewage Treatment Works, 400 E. 130th Street.

2. The purpose of the visit was to inspect the flow measurement system used by MSD to determine flows through the Calumet Treatment Plant, evaluate ability to estimate bypass flow, and inspect precipitation equipment. A general review of quality control was also intended.

3. Summary of System.

a. Calumet Sewage Treatment plant serves the geographical area of southern Chicago metro area. Sewage is carried by laterals and interceptors to main trunk lines which enter the plant site at four points. The four mains are located at invert elevations varying from -17 to -32 feet CCD. Four pumps lift the sewage to surface level into the surge chamber.

b. A fifth inflow was placed inline in early 1986 with the activation of the Calumet stem of TARP. Flow from TARP is pumped over 300 feet from the tunnel up to the surge chamber.

c. Sewage is routed through the screening plant to the metering vault where the plant flow is metered. From the metering vaults, sewage flows to the grit chambers and on to primary and secondary treatment banks.

d. Flows are measured at the pump stations, in the metering vaults and at the aeration banks. Only the metering vaults provide a high degree of accuracy. The metering vaults consist of 2 sets of 48" venturii tubes. Each tube feeds a bank of aeration tanks. Each vault has 3 tubes.

e. No metering is made on flows leaving the plant. An exhaustive water balance is not feasible due to the lack of outflow measurements and the precision of measurements available at the pump stations.

4. Main Pumps.

Of 4 main pumps, 2 are of fixed speed operation. Flow is calculated based on a rate times  $\times$  time of operation. The other two pumps are of variable speed operation. Flows are difficult to calculate since an assumed or average speed over a given time period must be used. Flows determined by pump speed are considered to be estimates only and accuracy is within 20%.

## 5. TARP.

Flows from TARP are measured by sonic (acoustical) velocity meters located on the outflow tubes of each pump. Continuous metering is made during all pumping operations. The accuracy is between 2-5%. The sonic velocity meters (SVMs) are extremely sensitive to alignment and are therefore ~~physically located~~ placed away from operator areas and in locations relatively free of vibration.

## 6. Meter Vaults.

a. Each meter vault serves a bank of aeration banks. The vault serving banks A, B, and C is the oldest. E & F banks are recent expansion and have a new vault. Each bank has its own feed tube flowing through the meter vault. The tube feeds a 48" metal venturii tube.

b. Flow velocity is calculated from the differential head between inflow and outflow. Manufacturer's specs determine total flow. Differential head is metered at a bank of manometers located on the second level of the vault. Recordings are made on circular pen plotters located on the top level of the vault as well as being telemetered to the main control room.

c. Weekly back flush of the pressure ports is accomplished using high pressure water. Rodding ports are located in the tubes in the event that the back flush is unsuccessful. It is noted that the ports are covered with standard plugs and showed no evidence of recent removal.

d. Monthly calibration of chart and control <sup>room</sup> meters is conducted using direct manometer readings. Unusual manometer readings are assumed to indicate plugging of pressure ports and require backflush or rodding of the ports.

e. Flow measurements are considered to be accurate within 5%.

f. Within the past 2 years, a feed tube to an aeration bank was shut down for maintenance. Inspection of the concrete tube indicated neither significant wear nor caking of deposits on the walls. MSD feels that this indicates that the same condition exists in the venturii tubes. With no wear or deposition of sediment to change tube dimensions, the manufacturers' specs should still be accurate.

## 7. Precipitation Gages.

a. MSD maintains several rain gages within the Calumet service area. The gage readings at the plant gage and at the East Hazelcrest pump station are received both at the Calumet Control center and at MSD operations in Chicago. The personnel at Calumet are unaware of discrepancies between Calumet and MSD recordings.

CCED-H  
SUBJECT:

Calumet Sewage Treatment Works Visit

b. The Calumet gage is calibrated quarterly using a standard calibration beaker. The gage is of tipping bucket type with an on site counter which is initialized daily. Telemetry to MSD is by pulse generation and telephone line.

c. The gage is located on the S-W corner of the lab building. The pump house is located approximately 35 feet to the east and is approximately 20 feet higher. The gage is therefore open to weather in three quadrants and partially protected against very high winds on the forth.

*Richard D. Hunt*  
CPT, CG

29 July 1986

SUBJECT: Field Visit to North Side Sewage Treatment Plant

1. On 25 July 1986, CPT R. Hurt conducted a field visit to the North Side Sewage Treatment Plant operated by the Metropolitan Sanitary District of Greater Chicago. CPT Hurt was met by Mr. David Jaeschke of the Plant Operations division.
2. The purpose of the visit was to view the metering system used by the North Side Plant to measure total sewage effluent passing through the plant. The measurements of the effluent bear significant impact on the accounting of Lake Michigan diversions through the Illinois Waterway.
3. Mr. Jaeschke began with a discussion of how flow was measured at the plant. Flow is metered after primary settling. Some flow, about 3 MGD, is pumped directly to the West-Southwest Sewage Treatment Plant after primary settling. This flow, the sludge from the primary clarifiers, is not metered. The remainder of the plant flow passes through the plant metering station which is composed of four venturii tubes. Flow measurement is made by measuring the head differentials as the effluent flows through the tube. Three measurement systems are used. Pitot tubes provide direct head differential at the metering sight. The pitot tubes are used to calibrate the electronic pressure transducers which provide the primary recording system. A backup to the pressure transducers is provided by stand tubes on the outflow side of the venturii. The stand pipes are fitted with floats which are connected to paper chart recorders.
4. In answer to questions by CPT Hurt, Mr. Jaeschke stated that the North Side Plant provides backup sludge handling for the John Bacon plant through the Upper Des Plaines Interceptor number 22. No plans are being made to discontinue the flow through the interceptor, even though it does represent a portion of the O'Hare WRP design area. Mr. Jaeschke indicated that the estimate of 23 CFS flow through the line to the North Side Plant sounded substantially low. No better estimate was available.
5. Mr. Jaeschke also indicated that no effect on dry weather flows by TARP had been noticed. He pointed out that many of the outfalls located along the upper reaches of the North Branch of the Chicago River are above the normal surface level of the river. It was noted that prior to TARP, the City of Chicago had been responsible for the maintenance and care of the outfall tide gates. With TARP, MSD has taken over maintenance.
6. A tour of the metering facility followed. The system was simple, well maintained, and afforded substantial backup and cross checking. A broken pitot tube was found which the operations office was aware of. The tube had been reported by the morning shift. The meter recording system included a cumulative digital recorder for the pressure transducers as well as paper charts on the stand pipes. An inspection of the records showed approximately 4 MGD (at 416 MGD) difference in the instantaneous flow at the time of the visit. (The stand pipes were recording 420 MGD).
7. A secondary item of interest is that the MSD rain gage located at the

North Side Plant records in tenths of an inch. It is a standard tipping bucket type. Other MSD rain gages measure one-hundredths of an inch.

CPT Hurt completed the visit at 10:45.

  
RICHARD D. HURT  
CPT, CE  
Civil Engineer

MEMORANDUM FOR RECORD

SUBJECT: O'Hare Water Reclamation Plant Site Visit

1. On 7 November, 1985, CPT Richard Hurt and Mr. John Panganiban visited the O'Hare Water Reclamation Plant. The primary purposes of the visit were to determine how flows were measured and how flow diversion from the design area to the Northside Treatment Plant is determined.
2. The O'Hare Water Reclamation Plant was initially designed to treat sewage from the northwest suburbs. Current operations treat flows exclusively from the deep tunnel system. Dry weather sanitary flow from the Elk Grove interceptor is treated in addition to storm runoff overflow from the surrounding suburbs. Dry weather sanitary flow from most of the northwest area, including Arlington Heights, Palatine, Mount Prospect and portions of Des Plaines is diverted to the Northside Treatment Plant for treatment. The Willard Creek Interceptor is a combined sewer handling both sanitary and storm flows.
3. As all flows are pumped from the deep tunnel, all flows are measured as they enter the plant. Flows enter the plant through one of six discharge tubes. Each discharge tube has its own pump and its own venturi meter. A second metering system is located after the flows pass the fine screens and grit removal chambers. Two large pipes carry the discharge from the grit chambers to the secondary treatment banks. Each of these pipes has a venturi type meter installed. A final metering system is in place at the entrance to each aeration basin. An indirect check can also be made through a pump RPM vs. flow discharge relationship.
4. A central computer monitors and automatically logs all flow data from the primary meters. The flows through the second meter bank are also monitored continuously, but only the primary flow path is logged on a daily basis. Daily hard copy printouts of all flow data are made and reviewed by the plant operator.
5. The total plant flow is determined by summing the metered flow components in any metering system. Cross checking is made between the first bank (tunnel pumpout), the second bank (post grit chamber) or the aeration banks. Daily flows are recorded and tabulated for forwarding to MSD.
6. Some flows originating in the Upper Des Plaines Basin are diverted directly to the Northside Treatment Plant. Those flows move through the Upper Des Plaines diverter #11. Storm flow in diverter #11 is dumped in the deep tunnel when flows reach a predetermined conduit depth. At that time, gate 5 (DS3) opens and all northwest flow is passed to the O'Hare WRP. At this time there is no continuous log meter in the system to measure how much flow reaches the Northside plant. An instantaneous indicator is located in the Upper Des Plaines interceptor #11 at Mt. Prospect Road, but it does not log the data.
7. There is no way of directly determining the amount of storm flow passing through the Upper Des Plaines interceptor #11. It is possible to estimate the amount of diversion to the Northside plant by using upstream head, conduit slope, and conduit configuration downstream. It is not currently being done and would be of questionable accuracy.

8. The plant engineers were not aware of any plans to begin treating all flows from the design area at O'Hare WRP.

#### CONCLUSIONS

9. The methodology and technology utilized at the O'Hare Water Reclamation Plant provide consistent, accurate measurement of sewage flow treated in the plant.

10. Direct physical calibration of the measuring devices is neither physically practical nor feasible except during major maintenance repairs. Indirect verification is continuously conducted through tertiary metering.

11. The total flows from the design area are not being treated and are not anticipated to be treated in the foreseeable future. Only storm overflow is treated for the majority of the area served. Dry weather flow for all but the Elk Grove Village interseptor is diverted to the Northside Treatment Plant. There is no metering system to determine how much flow is diverted. A reasonable alternative for estimating such is through the NIPC model. The NIPC model can be used to estimate total runoff for the design area. By subtracting the treatment flows at the O'Hare WRP, the result represents watershed diversion to NSTP. Some difficulties will arise due to the time lag incurred during pumpout of the deep tunnel storage following storm events.

12. Additional study of the alternative method of estimating diverted flow based upon hydraulic head and system gradient is needed to determine the feasibility and accuracy entailed.

  
Richard Hurt  
CPT, CE

NICHOLAS J. MELAS  
PRESIDENT



John M. Ryan

Chief  
of  
Maintenance and Operations  
751-5732



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December 4, 1984

Mr. Neil R. Fulton, Chief  
Bureau of Resource Management  
Illinois Department of Transportation  
300 North State Street - Suite 1010  
Chicago, Illinois 60610

Dear Mr. Fulton:

Subject: Lake Diversion Accounting

In response to your letter dated October 9, 1984, requesting quantity of recycled flows for the three major MSD plants and leakages through the outfall structures that service the three major sewage treatment plants, the following is pertinent:

(A) Calumet Sewage Treatment Works:

- (i) The recycle flows within the plant range from 2 MGD to 7 MGD with an average of 5 MGD
- (ii) The amount of leakage through back water gates is estimated to be negligible.

(B) North Side Sewage Treatment Works (NSSTW):

- (i) The recycle flow for the plant is approximately 3 MGD.
- (ii) Flow to NSSTW originating from water leaking into the sewer system through the outfall structures is estimated to be less than 1 MGD. Most of the outfall structures have dams that are above the normal canal or river levels.
- (iii) Flow to NSSTW originating outside of the basin comes through Howard #6 Interceptor and is estimated to be 16 MGD.

(C) West Southwest Sewage Treatment Works:

- (i) The recycle flow for the plant is estimated to be approximately 18 MGD.

Mr. Neil R. Fulton

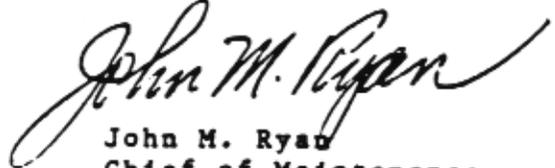
-2-

December 4, 1984

Subject: Lake Diversion Accounting

- (ii) It is estimated that the normally expected volume of canal water leakage into the plant sewer system is between 0.75 MGD to 1.50 MGD. Occasionally, the volume may be substantially greater, as a result of jammed tide gates.

Very truly yours,



John M. Ryan  
Chief of Maintenance  
and Operations

NCCED-H (NCCED-H/7 NOV 85) 2nd End  
SUBJECT: Lake Michigan Diversion Master Plan

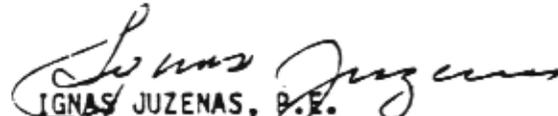
AUG 14 1986

DA, Chicago District, U.S. Army Corps of Engineers, 219 S. Dearborn Street,  
Chicago, Illinois 60604-1797

TO: Cdr, North Central Division, U.S. Army Corps of Engineers, 536 S. Clark  
Street, Chicago, Illinois 60605-1592 ATTN: NCCED-W

1. The final version of the subject document is enclosed. Your comments have been incorporated except in instances where it was felt that the particular comment was not applicable to a document of a general nature.

2. The SOP's covering the specific details of the Lake Michigan diversion monitoring procedures are currently being reviewed. Your office will be provided with copies of these SOP's as soon as they are finalized.

  
IGNAS JUZENAS, P.E.  
Chief, Engineering Division

Enclosures

1. Purpose: This master plan is developed to define the responsibilities of the Corps of Engineers with regard to Lake Michigan Diversion, establish routine annual goals and objectives, establish a generic annual schedule of activities and to provide specific short and long range objectives for the program.
2. Authority: The United States Supreme Court, in ruling over suit brought against the State of Illinois by the states of Wisconsin, Michigan, New York, Pennsylvania, Minnesota, and Ohio, has limited the amount of water which can be diverted from its natural flow through the Great Lakes system into the Mississippi River System. In its decree, the court stipulated that the amount of diversion should be limited to 3200 cfs average on an annual basis, that the State of Illinois would be responsible for the measurement and accounting of such flows, and that the Corps of Engineers should oversee the measurement and computation of flow amounts.
3. Responsibilities of the State of Illinois: The State of Illinois, its agencies or its instrumentalities shall conduct all measurements and computations of runoff, direct diversion, domestic pumpage and other flows required under the decree. The State shall fund such measurements and computations necessary to determine flows using the best current engineering practice and scientific knowledge.
4. Responsibilities of the Corps of Engineers: The measurements and computations made by the State of Illinois shall be done under the continuous supervision and direction of the Corps of Engineers in cooperation and consultation with the United States Geological Survey. Such supervision shall include, but not be limited to, periodic field investigation of measuring device calibration and data gathering. All measurements and computations made by the State of Illinois shall be subject to periodic audit by the Corps of Engineers. An annual report on the measurements and computations required by the decree shall be issued by the Corps of Engineers. The Corps of Engineers shall convene a three-member committee at least each five years after the implementation of the December 1980 modified decree to review and report to the Corps of Engineers and the parties of the decree on the method of accounting and the operation of the accounting procedure. Best current engineering practice and scientific knowledge shall be determined based upon a recommendation from a majority of the members of the committee.
5. The Corps of Engineers shall not be involved in the actual conducting of measurements or computations, but shall maintain an objective attitude allowing unbiased judgement on the methods and procedures used. Of special interest is the calibration of measuring devices and the determination of accuracy of the base data. The Corps shall review calibration procedures used by the State of Illinois and shall be prepared to conduct independent measurements as necessary to determine the accuracy of base data.
6. Procedure: The intent of this Master Plan is to provide a framework through which long and short term planning can be expedited. This framework, based upon the specifics of the modified Supreme Court decree of 1 December 1980, allows flexibility within the program to meet changes in the physical make-up of diversion control structures, as well as allowing for technical advancements in accounting procedures and modifications in the decree itself.

7. The schedule of activities for Fiscal Year 1987, (Appendix A), is designed to provide transition from the current monitoring program into this Master Plan. This schedule also allows for the additional effort required for the review of the program by the second three-member technical committee.

8. A generic annual schedule of events (Appendix B) provides targets for the completion of routine, annual activities. It is anticipated that this schedule will vary little from year to year, yet be flexible enough to accommodate changes within the system as well as unique, non-reoccurring events.

9. The annual schedule follows the fiscal year, identical to the water year calendar. The Corps' Annual Report will cover activities occurring within the 1 October to 30 September period. Events spanning the end of the year, or multiple years, will receive interim reports and will be discussed in detail following completion. The submittal of an accounting report by the State of Illinois shall be treated as a separate event. It is anticipated that multiple accounting reports may be discussed in a single Annual Report. The Corps of Engineers shall publish an annual report each year. A five-year, long range plan, (Appendix C), presents anticipated significant events, modifications to the system or major studies which are required in addition to routine annual activities. The five-year plan will be updated annually and shall include studies or modifications recommended by the State of Illinois, the Corps of Engineers, the three-member technical committee, or other interested parties to the diversion program.

10. Reoccurring Activities: The Corps' supervision of the Lake Michigan diversion monitoring program centers around several annual activities. The primary purpose of these activities is the verification of accuracy and precision of accounting of diversion flows as reported by the State of Illinois.

11. The procedures of routine reoccurring activities are detailed in standard operating procedures (SOPs) maintained by the Chicago District. As the diversion accounting program changes, these SOPs will also be changed to reflect new conditions. The SOP's include methods for verifying computations as well as procedures followed during site inspection visits.

12. The Corps shall visit the primary diversion metering sites at least annually. In conjunction with a physical inspection of the measuring equipment, the Corps shall review maintenance and calibration procedures and records for appropriateness and completeness. Such sites shall include, but not be limited to, the following:

- 1) MSD sewage treatment plants (STP)  
(Calumet, West-Southwest, Northside, and Lemont)
- 2) AVM - Romeoville
- 3) Lockport Controlling Works  
(Controlling works sluices, Powerhouse sluices, Powerhouse operations)
- 4) Major MSD sewage pump stations
- 5) MSD/NOAA precipitation gages located in the Chicago area.

6) Lakefront Controlling Structures  
(Chicago Harbor Lock and Control Structures, O'Brien Lock and Dam,  
Wilmette Controlling Works)

The Corps shall inspect calibration documents for major metering devices. An instrument logbook for each instrument is encouraged. This instrument log is to be maintained at the location of each instrument, where feasible, and is to contain, at a minimum, the following sections:

- (1) Instrument history.
- (2) Service record - manufacturer's repairs, battery replacement dates, cleaning, etc.
- (3) Routine performance test - This section shall include spaces for the date, initials of the technician, comments, and other instrument parameters, if applicable.
- (4) Calibration results.
- (5) Instrument settings and changes during calibration.

13. The Corps shall review calibration schedules of the AVM, pump stations and treatment plants to determine if calibration follows major repairs and maintenances as well as regular periodic checks.

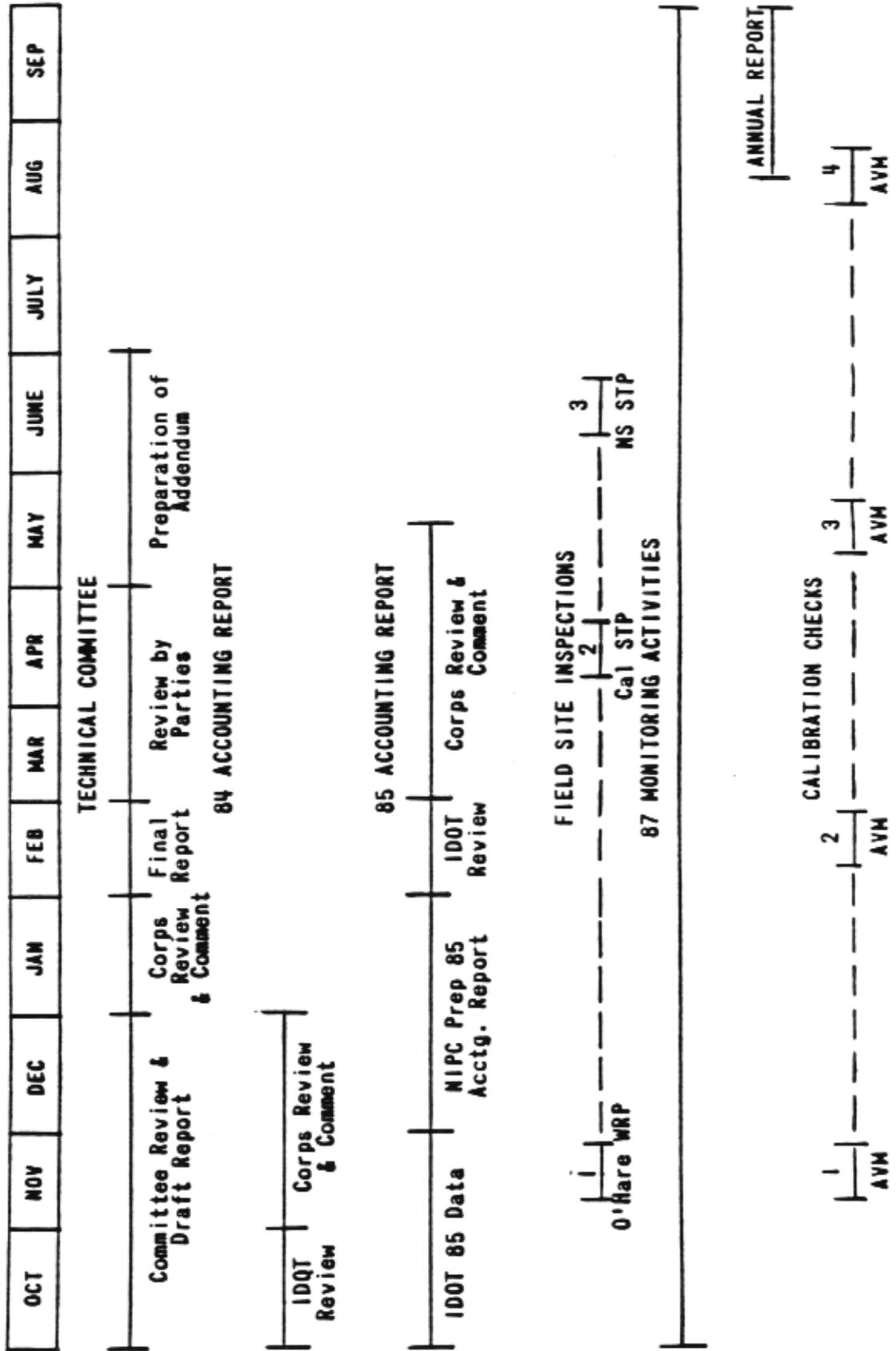
14. The Corps shall conduct flow measurements or equipment calibration tests only when the measurements or calibrations conducted by the responsible agency are suspect. The Corps may then conduct or directly supervise such tests or studies necessary to verify or disprove the suspect data.

15. The Corps shall review all data as it is made available for reasonableness within the context of the limits of the data collection systems. Where possible, data are to be cross checked by comparing with similar data collected through alternative sources.

16. The results of the Corps' supervisory and audit role shall be published in the annual report. Recommendations by the Corps shall be included in the annual report, as well as an updated annual schedule and five-year plan.

# Appendix A

## Lake Michigan Diversion Master Plan Annual Schedule - 1987





APPENDIX C

Lake Diversion  
Master Plan  
5- Year Plan

- 1987 Complete 2nd Technical Committee Review  
Review of Modifications to Accounting Model Required Due to Northwest  
Water Commission Withdrawals  
Study of the Effects of TARP on the Accounting Model  
Review of IDOT Investigation of Flow Imbalances at MSDGC Treatment Plants
- 1988 Implementation of 2nd Technical Committee's Recommendations  
Review of Calibration Procedures for Flow Metering Devices
- 1989 Field Measurement of Flow through Lake Front Structures
- 1990 Effect of New Suburban Water Distribution Systems on Accounting Model  
Commence procurement process for 3rd Technical Committee
- 1991 3rd Technical Committee formation

## MEMORANDUM FOR RECORD

SUBJECT: 2nd Technical Committee for Review of Diversion Flow Measurements and Accounting Procedures-Workshop Meeting 9-11 September 1986

1. Following the contract scope (see enclosure 1) workshop #2 was held in Chicago for three days starting Tuesday, 9 September 1986.
2. The following topics were scheduled and discussed during these information/question and answer sessions:
  - a. The acoustical velocity meter AVM, its track record (since March 1984) historical performances and future anticipated problems.
  - b. Presentation of DRAFT report by Harza Engineering Company entitled, "Investigation of the Impact of the Acoustical velocity meter on Lake Michigan Diversion Accounting."
  - c. Northeastern Illinois Planning Commission mathematical modelling efforts; highlights in the preparation of the 1983 annual reports, data correlation problems in the upcoming 1984 annual report.
  - d. State of Illinois water allocation policies, past/present/and future.
  - e. Question and answer session with Hydrologic Engineering Center representatives regarding conclusion stated in, "Lake Michigan Diversion Accounting - Evaluation of Hydrologic Simulation Procedures," dated June 1986.
  - f. The issue of an AVM backup system; the USGS WY 1985 published flow record at the AVM site - 05536995 Chicago Sanitary and Ship Canal at Romeoville, Illinois (see Enclosure 2) and Sarasota Automation's role in future AVM calibrations.
  - g. Field trip on 10 September 1986 to the Chicago Metropolitan Sanitary District - Mainstream Pumping Station - tunnel and reservoir plan. (See enclosure 3-brochure).
3. The outline agenda and the attendees are shown on enclosure 4.
4. Mr. Allan Noehre (retired) Surface Water Specialist, United States Geological Survey, Urbana, Illinois presented the AVM system and operations narrative. The station's history of downtime and rating measurements during the Water Year 1985 are listed below:

MEMORANDUM FOR RECORD

SUBJECT: 2nd Technical Committee for Review of Diversion Flow Measurements and Accounting Procedures-Workshop Meeting 9-11 September 1986

05536995 Chicago Sanitary and Ship Canal at Romeoville, Illinois. 1984-85

Equipment.-- Acoustical velocity flowmeter, deckwriter, digital water-stage recorder (manometer) in 8'x 8' concrete block shelter and wire-weight gage.

Discharge record.--The flowmeter furnished a satisfactory record throughout the year, except as follows:

- |                    |  |
|--------------------|--|
| November 29, 1984  | Printer failed to advance paper. Realigned paper feed.   |
| March 17, 1985     | Printer jammed. Realigned paper feed.  |
| Mar 21 to Apr 18   | AVM failed. Repairman replaced CPU Timer Module and Path Timer Module on April 4 with no results. On April 18 found underwater cable was cut by barge on March 21. Reconnected wires and repairman replaced constants in the unit, CPU Timer Module and Path Timer Module on April 18. |
| June 6-7           | Barge cut under water cable. Increased depth of chases, replaced underwater cable, and reconnected wires.  |
| June 9-10          | AVM failed. Replaced Signal Detector Module.   |
| June 27-28         | No electrical power to AVM. Called electric company to turn power on.  |
| August 1-12        | AVM failed due to voltage surge from electrical storm. Replaced fuse.  |
| September 20, 1985 | Bottom transducer path not operating. Tighten supporting bolts and realigned bottom path transducers.  |

A linear regression of discharge values at Lockport versus values at Romeoville was used to estimate daily discharge values at Romeoville for the above missing record periods. (Enclosure 5 shows added pertinent information at the AVM site).

MEMORANDUM FOR RECORD

SUBJECT: 2nd Technical Committee for Review of Diversion Flow Measurements and Accounting Procedures-Workshop Meeting 9-11 September 1986

Rating:-- Discharge measurements 1-8 obtained during water years 1984 and 1985 and measurement 9 (water year 1986) confirmed that the method used by the acoustical velocity flowmeter (AVM) to compute discharge was acceptable. These discharge measurements were plotted on log-log paper against concurrent AVM values and a straight line was drawn through concurrent values of 3000 and 10,000 ft<sup>3</sup>/s. A percent difference from this equal discharge line was computed for each measurement and was listed on Form 9-207, Discharge Measurement Summary Sheet. Measurement 1-4, and 6-7 confirms the AVM readings are accurate during the period March 22, 1984 to March 20, 1985. Measurement 5 indicates a percentage difference of 8.7% which may be explained by a barge passing through the measurement section during the discharge measurement and the unknown effect on the discharge in the canal caused by the Controlling Works, 2.8 miles downstream which was closed.

Flowmeter repairs were made in April and measurements 8-9 indicated the AVM discharge readings were less than the measured discharge. Measurements 6-11 were used to define Conversion Table A. The conversion table adjusts the AVM readings to the measured discharge. Conversion Table A was used April 19 to November 5, 1985. Some constants stored within the AVM computer memory were found to be in error and were corrected on November 5. The flowmeter was printing the two-minute average value instead of the fifteen minute value.

5. During the question and answer session a number of AVM related topics were brought up, namely, the need for a formal memo of understanding for a backup system to the AVM; the near future site visit (week of 22 Sept. 1986) by Sarasota Automation, USGS and Illinois Department of Transportation representatives to discuss/field check and resolve the above breakdown problems. The future decision and certification of this system is at stake. In regards to the Corps responsibility according to the Federal decree, the State of Illinois and its agent the U. S. Geological Survey are responsible for accurate AVM measurements. In a recent letter Mr. Dan Injerd, Chief, Lake Michigan Management Section made this important statement:

"When we made the decision to switch over to the AVM, of equal or greater importance to our desire to improve flow measurements at Lockport was turning over the primary responsibility for the most important flow measurement in diversion accounting to the federal agency that has the recognized expertise in flow measurement and which was specifically included in the 1980 amendments to the Decree. Thus, while we cost-share with the USGS for operation and maintenance of the AVM system, the responsibility for reporting and verifying the discharge data from this gaging station rests solely with the USGS, as does the development of a backup system to determine flows when this station is out of operation."

MEMORANDUM FOR RECORD

SUBJECT: 2nd Technical Committee for Review of Diversion Flow Measurements  
and Accounting Procedures-Workshop Meeting 9-11 September 1986

6. In the above vein the State of Illinois introduced a draft report entitled, "Investigation of the impact of the Acoustical Velocity Meter on Lake Michigan Diversion Accounting," prepared by Harza Engineering Company, September 1986.
7. In the morning session on Thursday September 11, 1986 the Northeastern Illinois Planning Commission represented by their consultant Donald Hey and Gary Schaefer, Natural Resources Officer, Northeastern Illinois Planning Commission, gave the 3-man committee a general overview of the modelling in the Chicago area especially as adopted to Lake Michigan Division accounting. Mr. Dan Injerd also contributed in the discussion in relation to an ongoing contract with Mr. John Vogel, head of the Climate Information Unit of the Illinois State Water Survey, to evaluate the 13 raingage stations used in the accounting model. These stations owned and operated by either the City of Chicago, National Oceanic and Atmosphere Administration or the Metropolitan Sanitary District of Greater Chicago will be examined for possible exposure, mechanical or electrical problems. Mr. Vogel is scheduled to report to the 3-member committee as to his findings at the next workshop in October.
8. Mr. Dan Injerd (IDOT) next gave an informative presentation on the history of the Lake Michigan water allocation in Illinois.
9. Some of the other parties of the litigation who were invited to the workshop sessions instead sent letters stating position papers to be read to the committee. Enclosure 6 includes such letters.
10. A tentative agenda for the next workshop to be held in Chicago during the week of October 20, 1986 is enclosed. Again all the parties of the litigation are invited to attend.

6 Enclosures  
as stated

Second Technical Committee for Review of  
Lake Michigan Diversion Flow Measurements  
and Accounting Procedures

Third Workshop (21-24 October 1986)

PROPOSED AGENDA

Tue 21 October 1986

9:00 A.M. - 10:00 A.M.	<u>USGS Presentation (AVM System)</u>
10:00 A.M. - 12:00 A.M.	Questions and discussions with USGS and IDOT representatives
1:00 P.M. - 2:30 P.M.	<u>IDOT's - Harza report review</u>
2:30 P.M. - 4:00 P.M.	<u>Presentation by parties of the litigation (if represented)</u>

Wed 22 October 1986

Field trip to extension to sewer system 13A and Lockport powerhouse-  
lock-AVM site.

Thur 23 October 1986

9:00 A.M. - 10:00 A.M.	<u>IDOT/State Water Survey findings of Chicago area precipitation network review.</u>
10:00 A.M. - 11:00 A.M.	<u>MSD report on TARP and its role in Lake Michigan Accounting</u>
11:00 A.M. - 12:00 P.M.	Questions and discussion.
1:00 P.M. - 4:00 P.M.	Committee working sessions private.

Fri 24 October 1986

9:00 A.M. - - -	Committee and Corps representatives progress, schedules, contractual matters, etc.
-----------------	--

AWARD DATE 14 July 1986

SCHEDULE OF ACTIVITIES

<u>Task No.</u>		<u>Completion Time After Contract Award in Weeks</u>
1.	Workshop No. 1 (5 days)	1 14-18 J
2.	Workshop No. 2 (4 days)	5 9-11 S
3.	Workshop No. 3 (4 days)	10 21-24 C
4.	Committee members submit their findings to chairman for consolidation into Draft Report.	12
5.	Workshop No. 4 (closed) Committee members review Draft Report (2 days)	14
6.	Chairman submits Draft Report to Corps of Engineers and committee members for review.	15
7.	Workshop No. 5 (closed) for District and committee to review District comments on Draft Report (2 days).	18
8.	Meeting No. 1 Committee presents Final Report to District and other parties with appropriate presentation by committee members.	21
9.	District provides Final Report to all parties for review and comments.	22

## 05326995 CHICAGO SANITARY AND SEWAGE CANAL AT SOMERVILLE, IL

LOCATION.--Lat 41°38'26", Long 88°03'38", in SE 1/4 SW 1/4, sec. 35, T. 37 N., R. 10 E., Will County, Hydrologic Unit 0710004, on left bank 40 ft upstream from bridge on Somerville Road in Somerville, 5.2 mi upstream from Lockport Lock and Dam, and at mile 6.2.

DRAINAGE AREA.--739 mi<sup>2</sup>.

PERIOD OF RECORD.--October 1984 to September 1985.

GAGE.--Acoustical flowmeter. Datum of gage is 551.89 ft above National Geodetic Vertical Datum of 1929 (U.S. Army Corps of Engineers bench mark).

REMARKS.--Estimated daily discharges: Nov. 29, Mar. 17, Mar. 21 to Apr. 18, June 6, 7, 9, 10, 27, 28, and Aug. 1-12. Records excellent except those for estimated daily discharges, which are good. Estimated daily discharges determined from relation between discharge at site 5.2 miles downstream and present site. The Supreme Court of the United States, on December 1, 1980, amended its Decree of June 12, 1967, allowing the State of Illinois to use a 40-year period to maintain its annual average diversion rate from Lake Michigan of 3,200 ft<sup>3</sup>/s. This diversion rate includes water diverted from the Lake for domestic consumption, for navigation and waste dilution purposes, plus that which is diverted as surface runoff and ground-water base flow.

EXTREMES FOR PERIOD OF RECORD.--Maximum daily discharge, 16,300 ft<sup>3</sup>/s, Mar. 4; minimum daily, 1,930 ft<sup>3</sup>/s, Nov. 24.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1984 TO SEPTEMBER 1985  
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3440	6850	2720	9530	2770	4210	4660	2970	3710	3470	4310	3440
2	3320	4240	2350	6240	2610	3530	3390	2940	3570	3850	3650	3430
3	3280	2960	2510	4800	2190	4670	3710	3070	3430	3770	4490	3370
4	3860	2640	2220	3470	2580	16300	4270	3140	3560	4480	4210	3520
5	3760	2400	2160	3350	2710	11700	5690	3460	3150	5470	3530	3360
6	3690	2370	2220	2840	2830	7530	5320	3020	3420	4230	5910	4580
7	4690	2400	2240	2840	2840	5750	4640	3130	3090	3820	4840	3860
8	3580	2430	2150	3340	2620	4550	3640	3000	3490	4040	3550	5030
9	3400	3900	2140	3030	2220	4750	3520	2730	3490	4740	5130	4710
10	3220	3250	2390	2680	3310	3890	3220	3000	3100	4710	4240	3750
11	3790	2890	2250	2860	2520	4650	3250	3170	4470	3870	3770	3600
12	3480	2420	3220	2720	2450	4060	3410	3140	3420	4240	3530	3810
13	3580	2590	3500	2370	2670	4220	3690	2800	3270	3900	5640	3510
14	4870	2470	5340	2870	2250	3480	4220	3810	3510	4930	5450	3450
15	4820	2300	3310	2720	2490	3730	3540	4430	5410	3930	5020	3400
16	5740	2320	3010	2500	2240	3090	2950	3030	4000	4250	4060	2920
17	3340	2190	2450	2900	2230	3110	3130	3820	3680	3420	3940	3430
18	4360	2110	2560	2880	2340	3140	3210	2900	3670	3280	3500	3120
19	4340	2170	2930	2880	2090	2600	3120	2980	3430	4240	3390	3840
20	3790	2350	2500	3120	2640	2490	3630	3470	3790	4320	3320	3410
21	5280	2350	5180	3140	4710	3130	3150	2890	4080	4400	3280	3370
22	3970	2010	4690	2640	7270	2820	2840	3100	3700	3650	3560	2910
23	3390	2080	2730	2290	13800	3130	3790	2840	3930	3810	3280	5610
24	3390	1930	2970	2410	11800	2840	1950	2930	3230	4080	4600	4640
25	3030	2150	2390	2610	8690	2640	2850	2970	3450	5420	4510	4640
26	2630	2260	2380	2480	6580	3020	3270	3510	3510	4510	3200	4490
27	2860	6970	3030	2270	4740	4000	3220	5150	3970	4850	4650	4540
28	1960	4710	1060	2600	4880	9020	3120	3130	3650	4970	6830	4580
29	2410	2930	4200	2620	---	5420	2970	3520	3320	4510	1980	4620
30	2400	2510	4010	2360	---	4310	3320	3050	3750	4940	3530	4560
31	5020	---	4750	2740	---	4690	---	2820	---	5510	3670	---
TOTAL	114690	87190	93560	98140	112030	144720	108730	99920	109250	133580	130570	118540
MEAN	3700	2900	3010	3166	4001	4733	3626	3223	3643	4309	4212	3951
MAX	5740	6970	5340	9530	13800	16300	5690	5150	5410	5510	6830	5610
MIN	1960	1930	2140	2270	2090	2600	2850	2730	3090	3280	3200	2910
WTR YR 1985 TOTAL		1352920		MEAN	3707	MAX	16300	MIN	1930			

TECHNICAL COMMITTEE FOR REVIEW OF  
LAKE MICHIGAN DIVERSION  
2ND WORKSHOP  
LIST OF ATTENDEES

SEP 11 1986

<u>NAME</u>	<u>AGENCY</u>	<u>PHONE</u>
1. Larry Toler	USGS, Urbana	958-5353
2. Gary Balding	USGS, Urbana	958-5360
3. Verne Schneider	USGS, Reston	959-5305
4. Greg Fisk	USGS, DeKalb	363-4267
5. Allen Noehre	USGS, Retired	(815)-758-5054
6. Neil D. Fulton	IDOT	(312)-793-3123
7. Christopher Burke	Harza	(312)-855-5603
8. Dan Injerd	IDOT	(312)-793-5948
9. Pat Brady	IDOT	(312)-793-5947
10. Harry Krampitz	COE, NCC	(312)-353-6474
11. Harry Barnes	Committee	(601)-681-6438
12. W. H. Espey	"	(512)-327-6840
13. David E. Westfall	"	(312)-663-9444
14. Larry Dunbar	Committee Staff	(713)-781-8800
15. James G. Mazanec	COE, NCD	(312)-353-7132
16. Stephen M. Klawans	COE, NCC	(312)-353-2329
17. Don Leonard	COE, NCD	(312)-353-7132
18. Ignas Juzenas	COE, NCC	(312)-353-6461
19. Gary Schaefer	NIPC	(312)-454-0400
20. Don Hay	NIPC	(312)-922-0777
21. Arlen Feldman	HEC (Part Time)	(916)-460-1748
22. John Peters	HEC (Part Time)	(916)-551-1748
23. Mike O'Grady	MSD, Ch Operator Eng.	

Second Technical Committee for review of  
Lake Michigan Diversion Flow Measurements  
and Accounting Procedures

Second Workshop (9 September-11 September 1986)

AGENDA

9 September 1986

- 1:00 P.M.- 2:30 P.M. USGS Presentation (AVM System & Operations)
- 2:30 P.M.- 3:00 P.M. Break
- 3:00 P.M.- 4:30 P.M. Question & Answer Session (with USGS personnel)

10 September 1986

Field trips to Lockport (Lock & Dam, Powerhouse, Controlling Works) and  
TARP (Extension to Sewer System 13A & main pump station)

11 September 1986

- 9:00 A.M.- 9:30 A.M. Question & Answer Session (with NIPC personnel)
- 9:30 A.M.-10:30 A.M. IDOT Presentation (Allocation of Lake Michigan water)
- 10:30 A.M.-11:00 A.M. Question & Answer Session (with IDOT personnel)
- 12:00 P.M.- 1:00 P.M. Lunch
- 
- 1:00 P.M.- 2:30 P.M. Committee working session (private)
- 2:30 P.M.- 3:00 P.M. Break
- 3:00 P.M.- 4:30 P.M. Committee working session (with COE personnel)
- Discussion of Administrative Matters
- Committee members depart

## Acoustical Velocity Meter Gaging Station

An acoustical velocity meter (A.V.M.) gaging station is operated by the U.S. Geological Survey in cooperation with the Illinois Department of Transportation on the Chicago Sanitary and Ship Canal at Romeoville, Illinois. The gage is located at River Mile 296.1, on the left upstream side of the 135th Street bridge, 1.3 miles east of Romeoville. The location of the gage is shown on Plate 2-1.

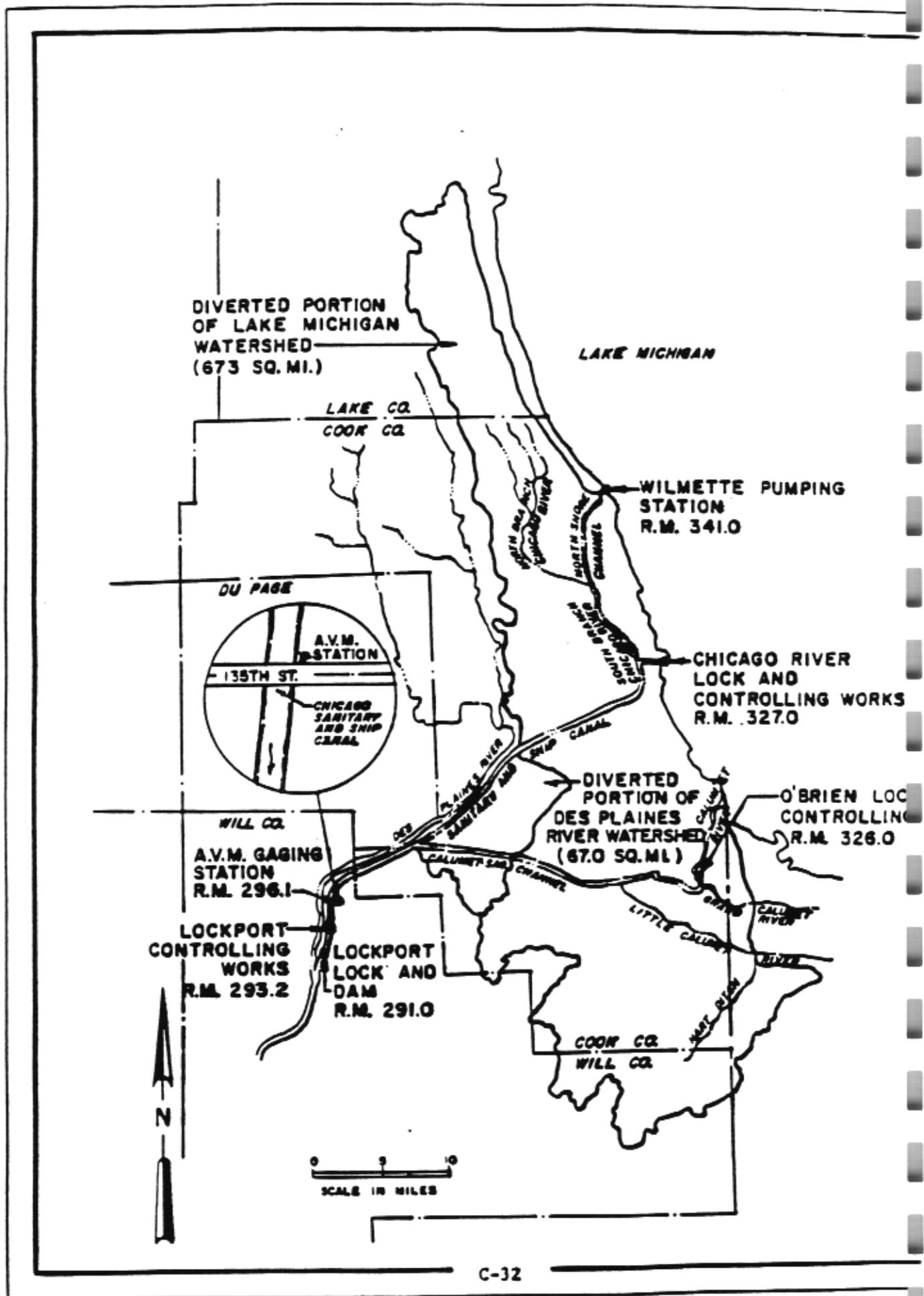
The A.V.M. was installed in March, 1984. Along with the A.V.M., the station includes a bubble gage, digital recorder, and a telemetry system housed in a heated air conditioned 8 foot square concrete block shelter. There are four velocity transducers located on both banks at various depths and one stage transducer. A Type A wire-weight gage is bolted to the handrail of the sidewalk on the upstream side of the bridge. The elevations of the controlling features are listed in Table 3-1 and the locations of the transducers are shown on Plate 3-1.

The channel, which is manmade, is bedrock with near vertical walls. The bottom is flat and even most of the way across, with the depth of 25 feet at normal elevation the same as the gage height. The control for all stages is the MSDGC Powerhouse and the Lockport Controlling Works located downstream of the gage location. When heavy rains are forecasted, the canal is drawn down to provide storage for flood waters from the Chicago area. During this time, the stage at the gage goes down and the velocity goes up, greatly increasing the discharge. According to the manufacturer of the A.V.M., the accuracy of the records should be within 2%.

## ELEVATIONS OF CONTROLLING FEATURES

<u>Item</u>	<u>Elevation<sup>a</sup></u>
Velocity Path No. 1 (lowest) transducer	5.02
Velocity Path No. 2 (middle) transducer	12.67
Velocity Path No. 3 (cross transducer	12.72
Velocity Path No. 4 (highest) transducer	20.32
Stage Transducer	15.98
	<u>Dimension</u>
	<u>(feet)</u>
Length of Paths	234.00

<sup>a</sup>Gage datum is 551.886 feet NGVD.





The State of Wisconsin  
Department of Justice

Maryann Sumi  
Assistant Attorney General  
(608) 286-3881

123 West Washington Avenue  
Mailing Address P.O. Box 7887  
Madison, Wisconsin 53707-7887

Bronson C. La Folle  
Attorney General

Gerald S. Wilentz  
Deputy Attorney General

September 5, 1986

Mr. Harry Krampitz  
Hydraulic and Environmental Engineering Branch  
Chicago District, Corps of Engineers  
219 South Dearborn Street  
Chicago, Illinois 60604-1797

Dear Mr. Krampitz:

Enclosed please find the original and three copies of the State of Wisconsin's Position Concerning Review of Lake Michigan Diversion Flow Measurements and Accounting Procedures, for distribution to the Technical Committee convened in Chicago September 9-12, 1986. Thank you for the opportunity to provide comments to the committee.

Sincerely,

Maryann Sumi  
Assistant Attorney General

MS:nk

Enclosures



The State of Wisconsin  
Department of Justice

Maryann Sund  
Assistant Attorney General  
(608) 266-3887

123 West Washington Avenue  
Mailing Address: P.O. Box 7867  
Madison, Wisconsin 53707-7867

September 9, 1986  
Technical Committee Workshop  
Chicago, Illinois

Bronson C. La.  
Attorney General

Gerald S. W.  
Deputy Attorney General

STATE OF WISCONSIN'S POSITION CONCERNING  
REVIEW OF LAKE MICHIGAN DIVERSION FLOW  
MEASUREMENTS AND ACCOUNTING PROCEDURES

As a party to the Supreme Court action entitled Wisconsin, et al. v. Illinois, et al., the State of Wisconsin appreciates the opportunity to present its views to the Technical Committee. We believe the committee's work is an essential part of the new procedure established by the Supreme Court's December 1, 1980 Decree. The committee's October 1981 report of its findings demonstrates the committee's thorough and conscientious identification and evaluation of the problems associated with diversion flow measurements. We are encouraged by the committee's efforts thus far and commend the professionalism and objectivity demonstrated in the committee's work.

Wisconsin's interest and motivation throughout this proceeding is to press for accountability and reliability in diversion flow measurement. Only if diversion flows are accurately known can basin-wide water management be achieved. Similarly, reliability of measurement is the only way to ascertain compliance with the Supreme Court Decree, and the only way to evaluate inevitable future requests for modification of the Decree.

While strict compliance with the diversion allowed in the Decree may seem less important in high-precipitation years, at some point (especially as consumptive uses increase) the need will again arise to account precisely for each cfs diverted. The purpose of the forty-year accounting period established in the 1980 Decree was to build in flexibility for variations in precipitation and for other water management needs. Given that bonus of flexibility, we think it particularly important that Illinois be held to accurate and reliable flow measurement and accounting procedures.

In line with Wisconsin's interest in promoting reliability of the flow measurement and accounting procedures, we believe it vital that Wisconsin and other interested parties continue to be provided notice and an opportunity to be heard on specific proposed changes to the flow accounting procedure. For example, when Illinois in 1984 proposed a deduction for "induced infiltration," Wisconsin and other parties requested further information, analyzed the proposal and submitted written evaluations and objections. In this instance, prompt notification and consideration of parties' comments on a legal/technical issue provided substantive input into a decision of great impact.

The Corps of Engineers' June 1986 Evaluation of Hydrologic Simulation Procedures presents another similar area of concern to Wisconsin. The report indicates that the use of simulation modeling underestimates actual diversion by several hundred cfs. We urge the committee to review the Corps evaluation and recommend whatever action is necessary to correct or account for the disparity between

modelled and measured flows. Again, the State of Wisconsin and other parties need to be kept aware of all significant actions taken by the Corps or the State of Illinois which affect the flow measurement and accounting procedures.

Thank you again for the invitation to provide this statement to the committee. If questions arise, please contact me at (608) 266-3861 or Dr. Kenneth Potter, University of Wisconsin Department of Environmental Engineering, at (608) 262-2471.

  
\_\_\_\_\_  
MARYANN SUMI  
Assistant Attorney General



HUBERT H. HUMPHREY, III  
ATTORNEY GENERAL

STATE OF MINNESOTA  
OFFICE OF THE ATTORNEY GENERAL

ST. PAUL 55155

ADDRESS REPLY TO:  
SUITE 200  
520 LAFAYETTE ROAD  
ST. PAUL, MN 55155  
TELEPHONE: (612) 297-

September 5, 1986

Frank R. Finch, P.E.  
District Engineer  
Chicago District, Corps of Engineers  
219 South Dearborn Street  
Chicago, Illinois 60604-1797

ATTENTION: Hydraulic and Environmental Engineering Branch  
Mr. Steve Klawans

Dear Mr. Finch:

This letter is written in response to your letter of July 31, 1986, notifying Minnesota of the second meeting of the technical committee for review of Lake Michigan diversion flow measurements and accounting procedures, to be held September 9-12, 1986, in Chicago.

As I informed Mr. Klawans by telephone on September 4, 1986, Minnesota continues to maintain interest in Lake Michigan diversion matters, and desires to continue to be informed of technical committee deliberations and other matters, including finalization of the master plan. However, state budgetary cutbacks have limited travel funds to the extent that no representative from Minnesota will be sent to the second meeting of the technical committee. Please supply us, as you did following the first meeting, minutes and reports of the second meeting.

Additionally, I have been asked to request from you copies of reports on diversion flow accounting for 1984 and 1985 water years, when available, and also the Corps' 1986 annual report, when available.

Very truly yours,

*Philip J. Olfelt*  
PHILIP J. OL FELT

Assistant Attorney General

PJO:1kr

cc: Joe Alexander, Commissioner, DNR  
Tom Kalitowski, Executive Director, PCA  
Eldon Kaul, Assistant Attorney General, PCA  
Larry Seymour, Director of Waters, DNR  
Gene Hollenstein, Division of Waters, DNR

C-37

AN EQUAL OPPORTUNITY EMPLOYER

1120-6

22 July 1986

## MEMORANDUM FOR RECORD

SUBJECT: First Workshop Meeting with the Technical Committee for Review of Lake Michigan Diversion at Chicago, Illinois

1. The first workshop meeting was held in Chicago from 14 July 1986 to 18 July 1986. The purpose of the workshop was to provide an overview of the Lake Michigan diversion accounting procedures to the Technical Committee. All parties of the Supreme Court decree were notified telephonically of the workshop. No parties other than the State of Illinois were prepared to attend. All parties will receive a copy of this memorandum.

2. Participating in this workshop were the following individuals:

Committee Members

Dr. William Espey, Jr.

Mr. Harry Barnes, Jr.

Mr. David Westfall

State of Illinois

Mr. Daniel Injerd  
Chief, Lake Michigan Management  
Section, Division of Water  
Resources, Illinois. Dept.  
of Transportation

Mr. Patrick Brady  
Lake Michigan Management Section  
Division of Water Resources  
Illinois Dept. of Transportation

Northeastern Illinois Planning Commission

Dr. Donald Hey, Consultant  
Mr. Gary Schaefer  
Mr. Dennis Dreher

United States Geological Survey

Mr. Greg Fisk  
Hydrologic Technician  
DeKalb Field Office

Corps of Engineers

Mr. Harry Krampitz, Chief,  
Hydraulic & Environmental  
Engineering Branch

Mr. Stephen Klawans,  
Mathematician, Hydraulic &  
Environmental Engineering Branch

CPT Richard Hurt  
Civil Engineer, Hydraulic &  
Environmental Engineering Branch

Mr. John Vento  
Water Control Branch  
North Central Division

3. General background overviews were presented on the afternoon of 14 July 1986 by CPT Hurt of the Corps of Engineers and by Mr. Daniel Injerd of the Illinois Department of Transportation.
4. On the morning of 15 July, a detailed presentation on the automated accounting procedure was given by the Northeastern Illinois Planning Commission. The presentation included a description and explanation of each column of the accounting report, a general description of the water budget system and a review of the balancing system and water balance for the 1983 Water Year. In the afternoon, the committee visited Chicago Harbor to view the leakage along the North-South turning basin wall and at the Chicago Lock and Controlling works.
5. On 16 July, the committee took a field trip to the Romeoville Acoustical Velocity Meter (AVM) site, West-Southwest Sewage Treatment Plant, Calumet Sewage Treatment Plant and Thomas J. O'Brien Lock and Controlling Works. CPT Hurt and John Vento of the Corps of Engineers accompanied the committee, as did Dan Injerd and Pat Brady of the Illinois Department of Transportation. Greg Fisk of USGS was on hand at the AVM to explain its workings and to answer questions regarding operation and maintenance of the system. Also on site were Mr. Chris Burke and Mr. Herb Scholler of Harza Engineering. The firm of Harza Engineering has been retained by the State of Illinois to review the discharge record of the AVM in comparison with Lockport discharge records. Mr. Richard Heil and Mr. Greg Cargill of the Metropolitan Sanitary District of Greater Chicago provided tours of the metering systems at the West-Southwest and Calumet sewage treatment plants respectively.
6. The 17th of July was used for discussion periods between the committee and the Corps of Engineers. Principal topics included AVM records, Corps' records and available data for committee review. The committee spent the afternoon in closed session discussing observations and preparing a list of additional materials needed.
7. On the morning of 18 July, a schedule for the 2nd workshop was developed. A request list for additional materials was given to the Corps. The second workshop will be held on 9 to 12 September 1986. Principal areas of interest are USGS operation of the AVM, Northeastern Illinois Planning Commission detail of the hydrologic accounting model and field trips to the Main TARP Pumping Station and tunnel system 13A.

  
RICHARD D. HURT  
CPT, Corps of Engineers  
Civil Engineer

- 2 Encl
1. Agenda for Workshop #1
  2. Proposed Agenda for Workshop #2

Hydraulic and Environmental  
Engineering Branch

Second Technical Committee for review of  
Lake Michigan Diversion Flow Measurements  
and Accounting Procedures

First Workshop (14 July-18 July 1986)

AGENDA

14 July 1986

A.M.	Travel time
1:00 P.M.-1:30 P.M.	Arrival, Introductions (LTC Finch, Mr. Injerd, Mr. Fulton), Administrative Matters (establishment of future workshop dates)
1:30 P.M.-2:30 P.M.	<u>Review Session (COE only)</u> a. History of diversion (including Supreme Court decrees b. Characteristics of canal system; components of divers measurement points c. Discussion of significant events (milestones in monitoring program; reports produced; future activiti
2:30 P.M.-3:00 P.M.	Break
3:00 P.M.-3:30 P.M.	<u>IDOT Briefing</u>
3:30 P.M.-4:30 P.M.	General Discussion, Question & Answer Session

15 July 1986

9:00 A.M.-10:30 A.M.	<u>NIPC Presentation (Mechanics of new accounting system)</u>
10:30 A.M.-11:00 A.M.	Break
11:00 A.M.-12:00 P.M.	Question & Answer Session (with NIPC personnel)
12:00 P.M.- 1:00 P.M.	Lunch
1:00 P.M.- 2:00 P.M.	<u>MSDGC Presentation (TARP and its impact on accounting sys: Precip Gages, Treatment Plant Records)</u>
2:00 P.M.- 2:30 P.M.	Break
2:30 P.M.- 3:00 P.M.	Question and Answer Session (with MSDGC personnel)
3:00 P.M.- 4:00 P.M.	General Discussion (with COE personnel)

16 July 1986

9:00 A.M. - 10:30 A.M. AVM (Field Visit)  
10:30 A.M. - 11:00 A.M. Travel Time  
11:00 A.M. - 12:30 P.M. West - Southwest STP (Field Visit)  
1:00 P.M. - 2:00 P.M. Lunch  
2:00 P.M. - 3:00 P.M. Travel Time  
3:00 P.M. - 4:00 P.M. Calumet STP (Field Visit)  
4:00 P.M. Return to Office

17 July 1986

To be determined by committee

18 July 1986 (A.M. only)

To be determined by committee

P.M. - Departure of committee members

Hydraulic and Environmental  
Engineering Branch

Second Technical Committee for review of  
Lake Michigan Diversion Flow Measurements  
and Accounting Procedures

Second Workshop (9 September-12 September 1986)

PROPOSED AGENDA

9 September 1986

- 9:00 A.M.- 9:30 A.M. IDOT Presentation (Allocation of Lake Michigan water)  
9:30 A.M.-10:30 A.M. Question & Answer Session (with IDOT personnel)  
10:30 A.M.-11:00 A.M. Break  
11:00 A.M.-12:00 P.M. Question & Answer Session (with NIPC personnel)  
12:00 P.M.- 1:00 P.M. Lunch  
1:00 P.M.- 2:30 P.M. USGS Presentation (AVM System & Operations)  
2:30 P.M.- 3:00 P.M. Break  
3:00 P.M.- 4:30 P.M. Question & Answer Session (with USGS personnel)

10 September 1986

Field trips to Lockport (Lock & Dam, Powerhouse, Controlling Works) and  
TARP (Extension to Sewer System 13A & main pump station)

11 September 1986

- 9:00 A.M.-10:30 A.M. Presentations by parties of litigation (as requested  
by individual states)  
10:30 A.M.-11:00 A.M. Break  
11:00 A.M.-12:00 P.M. Question & Answer Session (with state personnel)  
12:00 P.M.- 1:00 P.M. Lunch  
1:00 P.M.- 2:30 P.M. Committee working session (private)  
2:30 P.M.- 3:00 P.M. Break  
3:00 P.M.- 4:30 P.M. Committee working session (with COE personnel)

12 September 1986

9:00 A.M.-10:00 A.M. Committee working session (private)  
10:00 A.M.-10:30 A.M. Break  
10:30 A.M.-11:00 A.M. Discussion of Administrative Matters  
11:30 A.M. Committee members depart



# Illinois Department of Transportation Division of Water Resources

310 South Michigan Avenue / Room 1606  
Chicago, Illinois 60604

January 27, 1986

LTC Frank R. Finch  
District Engineer  
Corps of Engineers  
Chicago District  
219 S. Dearborn Street  
Chicago, IL 60604-1797

RE: Selection of Second Three-Member Committee

Dear Colonel Finch:

Thank you for the opportunity to comment on the six candidates that have been selected for consideration for the next three-member committee. Upon review of the resumes of these six candidates, we concur with the Chicago District's recommendations that the next three-member committee consist of Dr. John J. Cassidy, Mr. Harry H. Barnes, Jr., and Mr. David E. Westfall. We have no objections to Dr. John J. Cassidy being selected as the chairman of the committee.

It is our feeling that if one of the recommended three candidates cannot serve on the committee, the Corps consider either Dr. Carl F. Nordin or Mr. Sain. We believe that at least two of the committee members should be new members.

I appreciate the opportunity to comment on the selection of the committee. Please keep me advised of the status of the selection of the next three-member committee.

Yours very truly,

Neil R. Fulton  
Chief

BUREAU OF RESOURCE MANAGEMENT

NRF:DI:sn  
10561



# Illinois Department of Transportation

Division of Water Resources  
2300 South Dirksen Parkway/Springfield, Illinois/62764

May 29, 1986

Lt. Colonel Frank R. Finch  
District Engineer  
Department of the Army  
Corps of Engineers  
Chicago District  
219 South Dearborn Street  
Chicago, Illinois 60604

Dear Colonel Finch:

*Frank*

South U.S. Government Inner Breakwater,  
Lake Michigan, Chicago, Illinois

As we have discussed previously, the north-south, inner breakwater south of the Chicago River lock is leaking severely. Because of the seriousness of this problem, we have developed plans and specifications to modify and repair the cutoff wall portion of the breakwater.

Enclosed are two (2) sets of plans and specifications for your review, comments, and/or approval. Note that the "Construction Procedures" allow our contractor to use light vehicles on the top of the breakwater. Also note that the "Dewatering Special Provision" permits the contractor to construct a sandbag or other light portable type cofferdam on the top slab of the breakwater.

If you have any questions or need further information, please call Jim Pence at 217/785-1037. Your earliest attention to this matter will be appreciated.

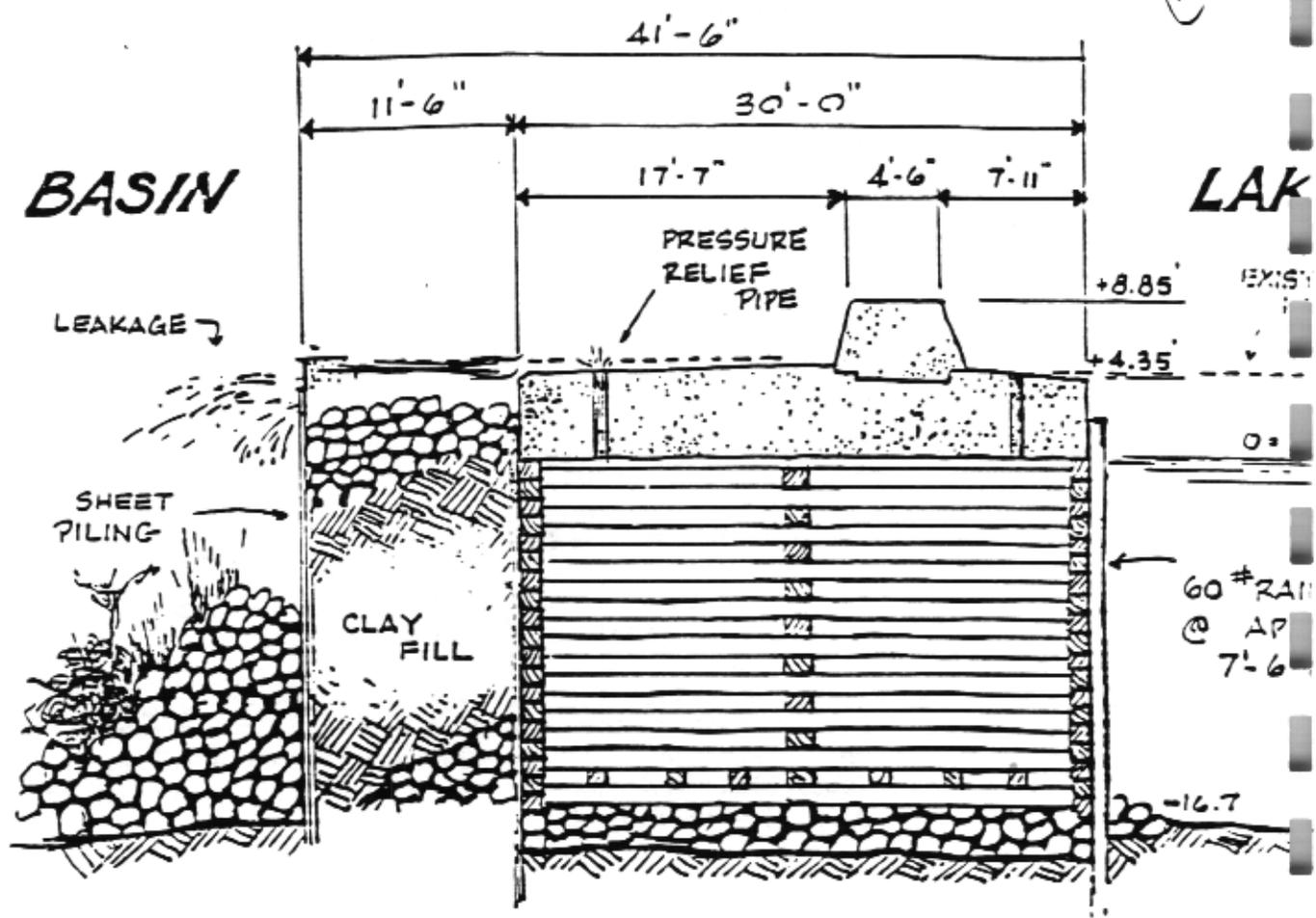
Sincerely,

*Donald R. Vonnahme*

Donald R. Vonnahme  
Director

Enclosures

570-14



YEAR OF COMPLETION 1874  
 CONCRETE SUPERSTRUCTURE 1934

NOTE: not part of enclosure

**CHICAGO HARBOR**  
 INNER BREAKWATER



SARASOTA AUTOMATION INC

October 8, 1986

RECEIVED				
DATE	10/14/86			
TIME				
ADMIN				
H & A				
CD				

OSW - Schmecker

OCT 14 1986

Section 2 ✓

QW				
SW				
FW				
HW				
HW				
HW				

U.S. Geological Survey  
Champagne County Bank Plaza  
102 East Main, 4th Floor  
Urbana, IL 61801

Attn: Larry G. Toler  
District Chief

Dear Mr. Toler:

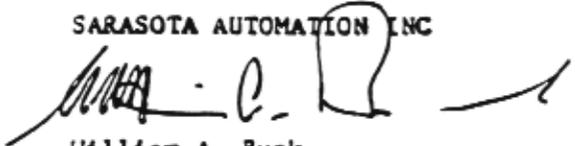
Subject: AVM Romeoville

We have pleasure in enclosing a report prepared by Alan Rowse on his recent visit to the Romeoville gage together with a Table of Site Constants and a Summary of Site Visits made by Sarasota personnel since commissioning in March 1984.

It is our understanding that the damage caused by a lightning strike on the day following Alan's departure has now been rectified and that all is working correctly. We would be interested to learn if the DCP link is functioning and that data is being received at the down link site.

Yours sincerely,

SARASOTA AUTOMATION INC



William A. Buck  
Manager, Special Products

WAB/rm  
CC: Charles Derr/ SAI-H  
Bob Cooke/ SAI-S  
Alan Rowse/ SDPL

Report on Acoustic Gage, Chicago Sanitary & Ship Canal,  
Romeoville from visit on Sept. 23-24, 1986

By A.A. Rowse

On Arrival at the site, the gage appeared to be working. Close inspection revealed the following:

1. The signals being received from the transducers were of adequate strength and were reliably received.
2. The readings for path time difference (Function 64) and hence for resolved water velocity (Function 62) showed excessive variability, almost always reading low. Sometimes half the expected value, but often the values were approximately as expected.

The problem was caused by a fault in the central processor memory on the CPU card. The system made arithmetic errors!

3. The constants stored in the gage, which defined the formula for calculating velocity ("K" on Function 90) and for calculating flow ("W" on Function 91) had both been set high by some 3.5%. This would cause the gage to read high by some 7.5%.
4. The signals on the depth gage were large. This was set up originally because the transducer had been poorly aligned. The result of this was that reflections from the bank and other items in the water were of sufficient strength to be detected. To eliminate these, the system was set to ignore any signals occurring earlier than an equivalent water depth of 21.5 feet.
5. Path lengths and site geometry were checked by USGS personnel and found to be as originally set up in March 1984 and June 1984.
6. The back up battery on the gage memory card ("CRAM") had failed, allowing the gage to lose its constants and data during a power failure, although such a loss had not occurred recently.
7. The RS232 card connected to the telephone modem had a failed output chip, and did not work.
8. The RS232 output for the DCP was plugged into one of the two independent printer sockets, on the back of the gage electronic console. It would therefore not communicate to a DCP with the required protocol.

I have had experience in setting up some 14 permanent multipath gages (of between 6 and 20 paths) in the UK, and experimented on some 20 different rivers with portable equipment. For all these sites the following statements were true:

- a. The gage behaved as an absolute instrument. That is, the system gives accurate values for velocity from the basic physical data of path travel times, time differences, path lengths & angles in accord with well known formulae published in ISO standards (ISO 6416 & 6418).
- b. The best value to use for bed elevation is the mean of all cross sections in the reach covered by the gage. On the Ship Canal, this would be the average of many readings taken across the river in a rectangle 168 ft long by 164 feet wide.
- c. The velocities of all paths show a generally stable relationship to each other. In a deep straight canal, with no great changes in bed elevation, then if one path velocity increased by 50%, all path velocities would increase by some 50%.
- d. This relationship is only affected by the presence of river traffic, when the action of the propellers can produce changes on lower paths. These effects are however temporary, and last for some 3 minutes only.

After discussing the above findings with USGS staff and Mr. H. Barnes, the following actions were taken:

1. The CPU card was changed for a spare held on site by USGS, and the old one taken away for repair.
2. The site constants for path length (Fn83) were set to values agreed with Mr. Barnes; based on a length of 235.00 feet for path 2 (cross path) and the relative timings for all other paths. The values then produced by the gage for velocity of sound (Fn66) were consistent.
3. The site constants for K & W were set to values based solely on river width and angles. All paths now have the same values for K & W and these are the same as were used in April 1985.
4. The RS232 for the telephone modem was changed for a spare held on site by USGS, and the old one taken away for repair. The telephone data system then worked.
5. The batteries on the "CRAM" card and "real time clock" card were replaced, and data then survived power failure.

6. The DCP was connected up to the correct output. It appeared to transfer data as required.
7. The sensitivity of the depth gauge was reduced by a factor of about 8 by changing C5 & C14 to 100 pf on the depth Tx card, which resides in the most right hand position of the lower rack. The minimum depth criterion Fns9.00 was changed so that depths down to 20.0 ft can now be measured.
8. The new set of site constants were noted, and a copy given to Mr. Toler. A further copy is attached.
9. Readings of one minute averaged velocities, depths and flows (Fns 62, 02 & 01) were recorded in the presence of Mr. Barnes over a period of about 2 hours while current meter readings were taken by USGS personnel. The relative values for path velocities were consistent and I believe them to have been correct.

Alan A. Rowse  
Technical Manager

<u>Function</u>	<u>.00</u>	<u>.01</u>	<u>.02</u>	<u>.03</u>	<u>.04</u>	<u>Notes</u>
10	16	16	16	16	--	
12	255	--	--	--	--	
13	35.00	--	--	--	--	
15	41111	--	--	--	--	
30	10	--	--	--	--	
31	9985.75	--	--	--	--	System will set this
32	1.000	--	--	--	--	
33	127	--	--	--	--	
34	127	--	--	--	--	
36	255	--	--	--	--	
39	0.80000	--	--	--	--	
51	15.98	--	--	--	--	Depth gage datum
52	1.000	--	--	--	--	
53	127	--	--	--	--	
54	4	--	--	--	--	System will set this
56	255	--	--	--	--	
80	--	2	4	6	8	Path address
81	--	5.02	12.67	12.72	20.32	Path elevation
83	--	232.95	235.00	233.78	234.36	Path Length
84	--	0	0	0	0	
85	--	85	85	85	167	
86	--	2	2	2	2	
90	--	164.00	164.00	164.00	164.00	K
91	--	82.00	82.00	82.00	82.00	W (=1/2 river width)
97	32000	--	--	--	--	
98	2.00	--	--	--	--	Min water depth over p
99	15	15*	0+			Averaging period

Notes

- means that the value does not have to be set.

\* This will decrement every minute. After 15 mins it will be reset.

+ This will increment every minute. After 15 mins it will be reset.

Chicago Ship Canal Romeoville

Summary of Site Visits

1. 19th to 23rd March 1984  
Gauge installed by A R = Bill Buck.  
USMP7 suite of program. No American avera
2. 16th to 18th April 1984  
Transducers refixed. A R in attendance  
USMP8 suite of programs. Telephone modem
3. 11th June 1984  
Transducers refixed JDN in attendance
4. 5th November 1984  
Signal Detector failed. Dry Joint. Bob C
5. 4th April 1985  
RS232 failed & jammed processor Bob Cook  
Replaced, but gauge would not work.
6. 17 - 18th April 1985  
Gauge checked and found all cables to far  
and path 2 on near, cut under water. RS21  
DCP plugged in with provisional prom. Cab  
for paths 1, 3 & 4 temporarily reconnected.  
A R & BC  
  
Noted: 1. CPU Timer is old design. No hard  
autoreset.  
2. RS232 in posn 2 can corrupt CRAM if m
7. November 1985  
Visit by Bob Cooke Connected Sutron
8. 23-24th September 1986  
Visit to check reason for gauge reading  
A R & Charles Derr & Representatives of  
committees. CPU suspected of producing  
erroneous random low readings (No other  
had any effect). Batteries dead on CRAM  
Clock. RS232 for telephone had blown Tx o  
chip. Constants reset to original values  
or less). Big check gauging v. 1 min rea  
taken. Depth Tx card C5 & C14 changed to  
to reduce gain & enable gate to open earl  
DCP output connected to Sutron unit.



# United States Department of the Interior

## GEOLOGICAL SURVEY

Champaign County Bank Plaza  
102 East Main Street  
Fourth Floor  
Urbana, IL 61801  
May 30, 1986

Mr. Ignas Juzenas  
Chief, Engineering Division  
Chicago District, Corps of Engineers  
219 S. Dearborn Street  
Chicago, IL 60604

Dear Mr. Juzenas,

Thank you for the opportunity to review Richard Hurt's draft copy of a report on the Chicago Sanitary and Ship Canal flows for 1985. Your efforts seem to confirm that MSD data could be used to estimate discharge for periods of missing record at the AVM site. It is, however, the policy of the U.S. Geological Survey to use actual records to compute discharge if records are available. We have no indications our records are erroneous and therefore our published records will be those based on the AVM data.

Although we recommend the MSD records as one means of estimating periods of missing records, we have some technical concerns about their use for the long term. A major concern is the discontinuity in the discharge range of 5000 ft<sup>3</sup>/S caused by the use of two equations. This problem seems to persist regardless of the discharge selected for the breakpoint.

Sincerely,

  
Larry G. Toler  
District Chief

cc: Dan Injerd



DEPARTMENT OF THE ARMY  
CHICAGO DISTRICT, CORPS OF ENGINEERS  
219 SOUTH DEARBORN STREET  
CHICAGO, ILLINOIS 60604-1797

7

31 OCT 1985

REPLY TO  
ATTENTION OF  
Hydraulic & Environmental  
Engineering Branch

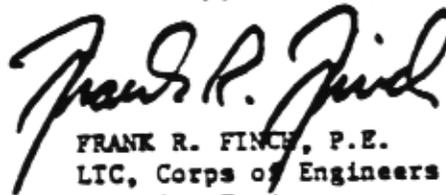
Mr. Neil Fulton  
Chief, Bureau of Resource Management  
Illinois Department of Transportation  
Division of Water Resources  
310 South Michigan Avenue, Room 1606  
Chicago, Illinois 60604

Dear Mr. Fulton:

Our office has recently completed a review of the proposed acoustical velocity meter (AVM) backup system for measurement of Lockport flows. The review was based on the USGS backup proposal dated 18 July 1985.

A copy of the report highlighting our findings is enclosed for your information. Any comments regarding the content of the report should be directed to Captain Richard Hurt of my staff, at (312) 886-0455.

Sincerely,



FRANK R. FINCH, P.E.  
LTC, Corps of Engineers  
District Engineer

Enclosure

CF w/encl:  
Mr. Allen W. Noehre  
Surface Water Specialist  
USGS  
Champaign County Bank Plaza  
102 E. Main Street, 4th Fl.  
Urbana, IL 61801

Review of Alternative Backup Systems for Acoustical Velocity Flowmeter (AVM)

Purpose: To review proposed AVM backup system procedures and results for accuracy and predictability.

Procedures Used: Using the raw data from the USGS backup proposal dated 18 July 1985 and MSDGC daily Lockport flows as reported to Rock Island District (and subsequently to Chicago District), the Corps independently developed regression equations to predict AVM flows. Base data was taken from reported flows for periods of 1-20 March 1985 and 18 April-6 May 1985. The Corps utilized a TI55 hand-calculator to assist in the computation analysis. The basic procedure was a standard least squares fit straight line representation of data. The raw data from the USGS report was broken into two sets with separate regression analyses completed. Corps' results were then compared with USGS derivations.

Results: (A) Brandon Road regression analysis

As stated above, the raw data for this total analysis was separated into two sets. The results of the two analyses are as follows:

(1) Brandon Rd. Flow - Riverside Flow > 3980

slope	= .890	USGS regression equation:
intercept	= .373	$V_2 = \text{antilog}(1.121 \log V_1 - .41)$
standard dev.	= .195	
variance	= .033	COE regression equation:
correlation	= .999	$V_2 = \text{antilog}(1.124 \log V_1 - .42)$

The above analysis was done using available USGS base input data and based on a least squares fit of common logarithms of data values. The low standard deviation and high correlation coefficient indicate that this routine should lend itself extremely well to flow predictions. Three additional USGS points were located in the above upper range but were not listed as base input data. These points may account for the slight difference in the developed equations.

(2) Brandon Rd. Flow - Riverside Flow < 3980

slope	= 1.17	USGS regression equation:
intercept	= -.729	$V_2 = \text{antilog}(0.565 \log V_1 + 1.56)$
standard dev.	= .150	
variance	= .022	COE regression equation:
correlation	= .869	$V_2 = \text{antilog}(.855 \log V_1 + .623)$

The above analysis was also done using available USGS base input data and based on a least squares fit of common logarithms of data values. As can be seen from the above, the Corps was unable to duplicate the USGS developed equation. Additionally, further investigation of the mathematical derivations could not be done as the computer program used by the USGS was not available to the Corps for this review.

### (B) Corps' regression analysis

The Chicago District utilized standard linear regression analysis procedures to develop a prediction tool for AVM flows utilizing daily Lockport flows as reported to Rock Island District by MSDGC. The daily data is less accurate than the monthly flows previously reported by MSDGC. The daily flows are derived by powerhouse operators based upon remote meters for sluice gates and control works. The average error (difference) in the daily readings is less than 5% over an average 30-day period. The daily Lockport readings for the periods 1-20 March 1985 and 18 April-6 May 1985 were plotted against AVM readings for those dates (fig. 1). The data were divided into three groups of (1) greater than 6000 cfs (MSD), (2) March-less than 6000 cfs (MSD) and (3) April/May-less than 6000 cfs (MSD). Least squares fit analyses of all groups provided equations of representative lines for the data groups. The data groups for less than 6000 cfs tended to be tightly grouped, showing good correlation to the representative line.

$$\begin{aligned} > 6000 \text{ cfs} & \quad y = e.535 \ln X + 4.048 \\ \text{where} & \quad y = \text{AVM flows} \\ & \quad x = \text{Lockport daily flows} \end{aligned}$$

$$\begin{aligned} < 6000 \text{ cfs} & \quad - \text{March} \\ & \quad y = e.7947 \ln X + 1.7324 \end{aligned}$$

$$\begin{aligned} < 6000 \text{ cfs} & \quad - \text{April/May} \\ & \quad y = e.9152 \ln X + .0831 \end{aligned}$$

The three group breakdown was used due to a perceived error in the AVM data after 22 March 1985. The plots of the less than 6000 cfs data tend to indicate a definite shift in AVM readings following the AVM repair.

#### Recommendations:

The USGS procedure is theoretically sound and should provide reasonable back-up for the AVM. The Corps recommends the use of daily flows at Lockport as reported to Rock Island District as the data base rather than Brandon Road flows. The Corps also recommends that a minimum of one week's flows be determined in the event of required back-up. While the observable error for a single day prediction may be as high as 30%, the error for a weeklong period drops to less than 10%. The Corps further recommends that the base data for the regression analysis be taken from a period of at least 90 consecutive days during the original AVM calibration period (July 1984 - March 1985).

APPENDIX OF COMPUTATIONS

Derivation of Regression Equations

Mathematical theory:

$V_1$  = Brandon Rd. discharge - Riverside discharge

$V_2$  = AVM discharge (at Romeoville)

Let  $\bar{Y}$  =  $\log V_1$

$\bar{X}$  =  $\log V_2$

$\bar{Y} = m \bar{X} + b$  ( $m$  = slope;  $(0, b)$  =  $y$  intercept)

$$\therefore \bar{X} = \frac{\bar{Y} - b}{m}$$

$$\therefore \log V_2 = \frac{\log V_1 - b}{m} \text{ and } V_2 = \text{antilog} \left( \frac{\log V_1 - b}{m} \right)$$

or  $V_2 = \text{antilog} (1/m \log V_1 - b/m)$

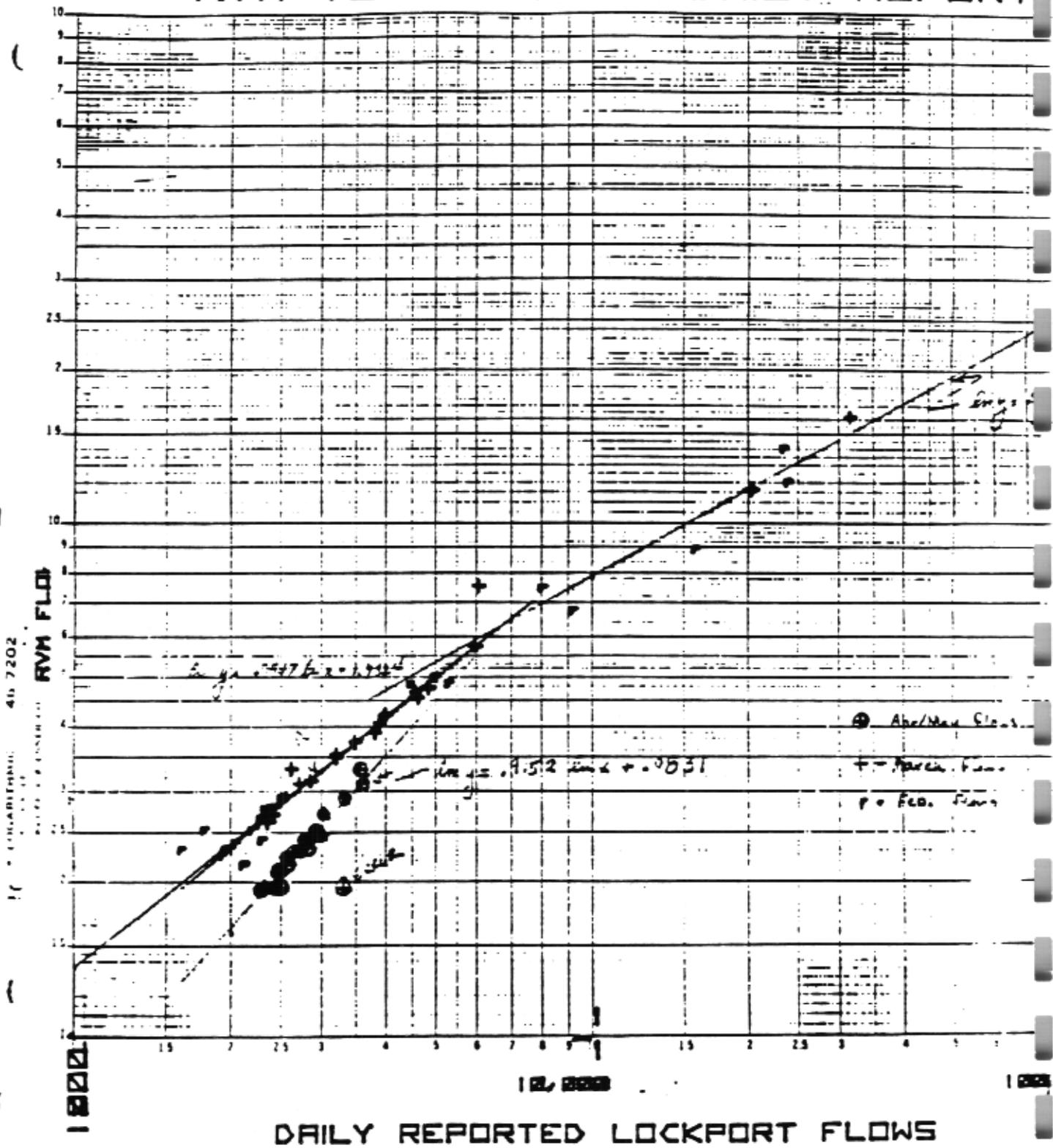
For  $V_1 > 3980$  ( $b = .373$ ;  $m = .890$ )

$$\therefore V_2 = \text{antilog} (1/.890 \log V_1 - .373/.890) \text{ or } \boxed{V_2 = \text{antilog} (1.124 \log V_1 - .42)}$$

For  $V_1 < 3980$  ( $b = -.729$ ;  $m = 1.17$ )

$$\therefore V_2 = \text{antilog} (1/1.17 \log V_1 - -.729/1.17) \text{ or } \boxed{V_2 = \text{antilog} (.855 \log V_1 + .62)}$$

# RVM VS LOCKPORT DAILY REPORT



Figure

November 27, 1985

Mr. Ignas Juzenas, Chief  
Engineering Division  
Chicago District  
Corps of Engineers  
219 S. Dearborn St.  
Chicago, IL 60604

Dear Mr. Juzenas:

Attached is a copy of the Lake Michigan Diversion Accounting Report for the 1983 water year. This is the final version, and reflects the comments of the Chicago District. Please note that while we show columns for induced infiltration, we have not included this component as a deduction to the Lockport record.

I would appreciate receiving a copy of the Corps report on Lake Michigan diversion prior to it being distributed to the other parties.

Regarding your letter of November 12, 1985 concerning the AVM system, be assured that we also have been concerned with the inability to calibrate the AVM with USGS field measurements since the March 21, 1985 breakdown. We are encouraged that a recent examination by the manufacturers serviceman revealed a error in the stage data used to compute discharge. Two subsequent calibration checks by the USGS on November 19 & 20, 1985 yielded the following results:

	<u>11/19/85</u>	<u>11/20/85</u>
Measured discharge	6660 cfs	8507 cfs
AVM discharge	6413 cfs	8051 cfs
Difference	247(3.7%)	456(5.4%)

It should be noted that both calibrations occurred during periods of changing stage and discharge. The USGS plans additional calibration checks in the near future.

If subsequent calibration checks reveal that the AVM is again measuring discharge within acceptable limits, it appears that

Mr. Ignas Juzenas  
Page 2  
November 27, 1985

the type of error will enable the USGS to correct the AVM discharge data from March through November, 1985. The USGS plans to prepare a written report discussing this problem and what steps they have taken to correct the problems which have been encountered.

While the problems that have been experienced with the AVM over the last year have certainly been disappointing, to a certain extent they were expected since a new flow measurement technology was being used and that it would take some time for USGS personnel to become proficient in servicing and maintaining this type of equipment. Nevertheless, I remain confident that our decision to switch to a AVM system will in the long run produce a vastly improved flow measurement record at Lockport and at this point I do not share your opinion that 'the known inaccuracies of the old Lockport system are preferable to the unknown inconsistencies of the AVM'.

There is another important point to this discussion that I wish to reiterate. When we made the decision to switch over to the AVM, of equal or perhaps greater importance to our desire to improve flow measurements at Lockport was turning over the primary responsibility for the most important flow measurement in diversion accounting to the federal agency that has the recognized expertise in flow measurement and which was specifically included in the 1980 amendments to the Decree. Thus, while we cost-share with the USGS for operation and maintenance of the AVM system, the responsibility for reporting and verifying the discharge data from this gaging station rests solely with the USGS, as does the development of a backup system to determine flows when this station is out of operation. We will continue to be an active participant in the development of work plans concerning calibration and backup procedures, and trust that we can continue in a spirit of cooperation among the three agencies.

Please feel free to call if you have any questions.

Very truly yours,



Daniel Injerd, Chief  
Lake Michigan Management Section

Enclosure

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cc: Larry Toler, USGS