Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

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General *Superintendent*

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January 23, 2007

Mr. Toby Frevert, Manager
Division of Water Pollution Control
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

Dear Mr. Frevert:

Subject: Evaluation of Management Alternatives for the Chicago Area Waterways: Investigation of Technologies for Supplemental Aeration of the North and South Branches of the Chicago River, Flow Augmentation of the Upper North Shore Channel, and Flow Augmentation and Supplemental Aeration of the South Fork of the South Branch of the Chicago River

The Metropolitan Water Reclamation District of Greater Chicago, at the request of the Illinois Environmental Protection Agency (IEPA), hereby submits the enclosed reports entitled "Technical Memorandum 4WQ: Supplemental Aeration of the North and South Branches of the Chicago River", "Technical Memorandum 5WQ: Flow Augmentation of the Upper North Shore Channel", and "Technical Memorandum 6WQ: Flow Augmentation and Supplemental Aeration of the South Fork of the South Branch of the Chicago River."

Using the services of Consoer Townsend Envirodyne Engineers, Inc., these reports have been developed to evaluate technologies and costs for Supplemental Aeration of the North and South Branches of the Chicago River, Flow Augmentation of the Upper North Shore Channel, and Flow Augmentation and Supplemental Aeration of the South Fork of the South Branch of the Chicago River.

If you have any questions, please contact Mr. Lou Kollias at (312) 751-5190.

Very truly yours,

R Lan VNI--

Richard Lanyon U
General Superintendent

JS:TK
Attachments
cc: L. Kollias, MWRD
R. Sulski, IEPA

TECHNICAL MEMORANDUM 5WQ

FLOW AUGMENTATION OF THE UPPER NORTH SHORE CHANNEL

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

NORTH SIDE WATER RECLAMATION PLANT AND SURROUNDING CHICAGO WATERWAYS

Submitted by:

CTE | AECOM

Revision 4 – January 12, 2007

MWRDGC Project No. 04-014-2P
CTE Project No. 40779

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INTRODUCTION

Background

Consoer Townsend Envirodyne Engineers, Inc. (CTE) was retained in 2005 by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) to provide engineering services to prepare a comprehensive Infrastructure and Process Needs Feasibility Study (Feasibility Study) for the North Side Water Reclamation Plant (WRP). As part of the scope of work for the Feasibility Study, CTE was directed to determine the technologies and costs of water quality management options for the Chicago Area Waterways (CAWs). These water quality management options originated from the on-going Use Attainability Analysis (UAA) of the CAWs currently being conducted by the Illinois Environmental Protection Agency (IEPA).

This report presents the results of a study of one of the options that originated from the UAA, namely flow augmentation of the Upper North Shore Channel (UNSC). Flow augmentation of UNSC is among several water quality management options studied by CTE. Other water quality management options are discussed in separate reports. These reports are not designed to determine which (if any) of the water quality management options should be implemented. Such a determination can only be made by conducting a comparison of the costs and benefits of all the management options and then developing a water quality management plan which combines the most cost effective option into an integrated strategy for improving the water quality of the CAWs. Such an integrated strategy has not been developed at this time.

UAA Process

The Clean Water Act requires the states to periodically review the uses of waterways to determine if changes to the existing water quality standards are needed to support a change in use. Based upon a study of the CAWs, the IEPA has decided that a change may be required in the dissolved oxygen standards for the CAWs.

The IEPA suggested several methods for managing the dissolved oxygen (DO) of the CAWs and asked that the MWRDGC determine the costs for these methods. One of the methods that was suggested by the IEPA was flow augmentation of the UNSC.

Flow Augmentation

Figure 5.1 shows the entire Chicago Area Waterway System. The North Shore Channel (NSC) consists of the approximate 8 mile northern-most segment of the CAWs from the Wilmette Pumping station on Lake Michigan to the junction with the North Branch of the Chicago River. The NSC is a man-made waterway which began operation in 1910. Among other uses, the waterway is the receiving stream for the effluent from the North Side WRP. The UNSC, approximately four miles in length consists of the segment from the Wilmette Pumping Station to the outfall of the North Side WRP.

The IEPA suggested that adding the North Side WRP effluent to the headwaters of the UNSC, instead of its current location, could have the following benefits:

1. Increasing the DO of the waterway segment from the Wilmette Pumping Station to the North Side WRP outfall.
2. Eliminating stagnant conditions upstream of the North Side WRP outfall during dry weather conditions thus improving aesthetics.

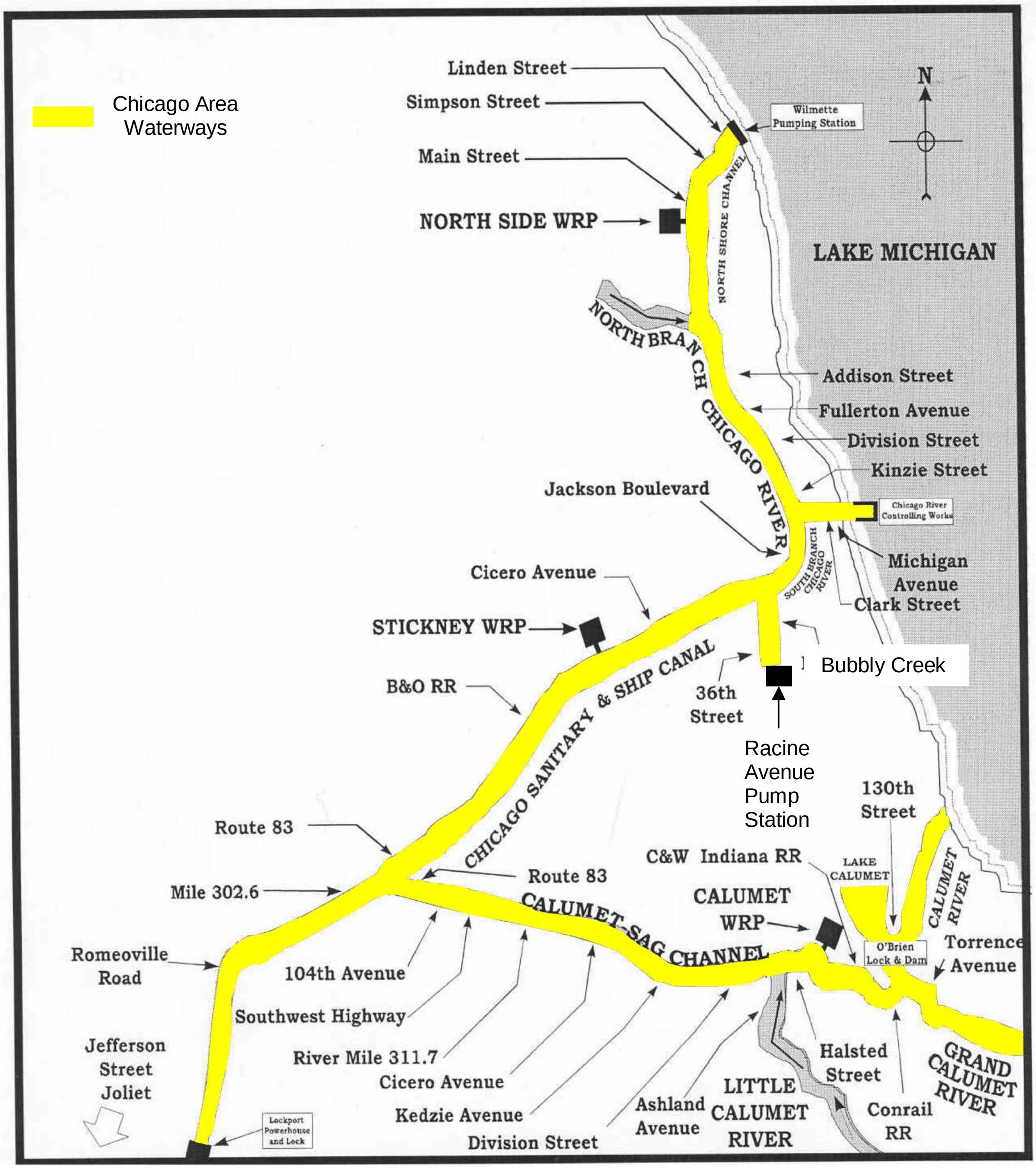

Figure 5.1 – The Chicago Area Waterways

Objective and Scope of Study

The objective of this study is to determine the cost to transfer effluent flow from the North Side WRP to the headwaters of the UNSC. The District directed that CTE investigate two alternatives for flow augmentation of the UNSC:

1. Transfer the effluent to the headwaters of the UNSC without providing any artificial aeration of the transferred flow. In other words, the inherent DO of the North Side WRP effluent (typically about 6.0 mg/l) would not be increased before discharge at Wilmette.
2. Aerate the North Side WRP effluent to saturation DO before discharge at Wilmette.

This report makes no attempt to determine whether flow augmentation is a cost-effective method to increase the DO of the UNSC. To reach such a conclusion, all of the options that have been suggested by the IEPA in the UAA process would have to be studied in an integrated fashion to determine which (if any) of the alternatives, or combination of alternatives, would be the most cost-effective for meeting the future water quality standards as determined by the UAA. Such an analysis is beyond the scope of this study and would require significant input from the various stakeholders in the UAA process.

Water Quality Dissolved Oxygen Standards for the North Shore Channel

Currently under existing Illinois Pollution Control Board (IPCB) General Use standards, the UNSC is required to have a minimum of 5 mg/l of DO at all times, and for 16 of 24 hours in any given day the DO must be above 6 mg/l. For the lower NSC, the IPCB Secondary Contact standards requires the DO to be above 4 mg/l at any time.

So far, the IEPA, through the UAA process, has not reached a final decision as to the future DO water quality standards for the NSC. They have suggested that minimum levels of 4, 5 or 6 mg/l may be required for NSC or the existing General Use standards may remain in effect.

Target Waterway DO Levels for this Study

It is necessary in this study to select a DO target in order to determine the cost for a flow augmentation system for the UNSC. After discussions with the MWRDGC, it was decided that the dissolved oxygen target would be 5 mg/l. This level is within the range of potential DO standards suggested in the UAA. However, recognizing that a rigid DO standard is difficult to meet under all waterway conditions (temperature, wet periods, etc.), it was decided that the target would be 5 mg/l and that achieving this level 90% of the time would be acceptable. It is hoped that the IEPA will adopt a similar approach to a waterway DO standard and recognize that 100% compliance is not possible or necessary. The use of this target for this study in no way represents a recommendation from the MWRDGC.

Flow Augmentation Modeling

In order to determine the capacity of a flow augmentation system including the amount of transferred flow and the need for aeration of this flow, an existing water quality model of the CAWs was used. This model was developed by Marquette University for the MWRDGC.

This model is described in the report entitled, "Preliminary Calibration of a Model for Simulation of Water Quality During Unsteady Flow in the Chicago Waterway System and Proposed Application to Proposed Changes to Navigation make-Up Diversion Procedures", dated August, 2004. This report was produced by Dr. Charles Melching from the Institute for Urban Environmental Risk Management at Marquette University (Milwaukee, Wisconsin) for the MWRDGC.

The Marquette Model was used to simulate the two flow augmentation alternatives described previously:

1. Transfer of unaerated North Side Effluent to Wilmette
2. Transfer of aerated North Side Effluent to Wilmette

The model allowed CTE to determine the effects of various versions of these alternatives on the DO levels of the NSC. The model can simulate the DO in the waterway as a result of a simulated amount of flow augmentation with a certain simulated dissolved oxygen concentration.

For the unaerated flow augmentation alternative, historic North Side effluent flow and DO levels were used as inputs into the model. For an unaerated flow augmentation simulation run, the model simulated the historic flow and DO of the North Side effluent and simulated the resulting hourly in-stream DO in the waterway. For the alternatives where the unaerated flow was simulated, the historic DO in the North Side effluent was assumed for the transferred flow on each day in the data base. Typically the DO level was approximately 6 mg/l.

For the aerated flow augmentation alternative, various constant flows varying from 50 to 240 mgd of North Side Effluent at saturated DO concentrations were used as inputs into the model. For the aerated flow alternative, the flow being transferred was assumed to be aerated to saturation at the temperature for a particular day. This DO was typically above 8 mg/l.

The time periods simulated in the Marquette Model were:

Year	Time Period
2001	July 12 to September 14
2001	September 1 to November 10
2002	May 1 to August 11
2002	August 10 to September 23

These time periods were chosen by Marquette University since this data base was the most complete of any available.

In order to determine the percent compliance for the alternatives, the time periods in the data base in the Marquette Model were used. Percentage compliance was based upon determining the percent of time that hourly DO stream DO levels were at or above 5 mg/l for the time periods in the Marquette Model data base.

The Marquette Model runs conducted for this study had the following general assumptions.

1. Tunnel and Reservoir Plan (TARP) Tunnels are fully operational
2. TARP Reservoirs are not on-line
3. Other IEPA requested water quality management options are not on-line

WATER QUALITY MODELING RESULTS

Modeling Runs for Flow Augmentation Without Aeration of the Transferred Flow

After discussions with CTE, Marquette University conducted a number of modeling runs to determine the impact upon DO in the UNSC for various diversions of North Side WRP effluent to the Wilmette Pumping Station without aeration of the transferred flow. Diversion flow amounts were determined by taking the percentage of actual flow produced by the North Side WRP on a given day. Actual daily DO measurements in the North Side effluent were used as inputs to the model. These modeling runs showed that 100% diversion of the flow from the North Side WRP to the headwaters of the UNSC was not sufficient to keep dissolved oxygen levels above 5 mg/l 90% of the time. Appendix B contains a report prepared by Marquette University of these modeling runs.

Table 5.1 shows the percentages of time that dissolved oxygen levels are higher than target concentrations at Simpson Street (Midpoint of UNSC) for various transfers (without aeration) of flow from the North Side WRP to Wilmette for the time period of July 12 – November 10, 2001. The percent transfer is the percentage of North Side WRP flow diverted to Wilmette. The wet periods listed in Table 5.1 correspond to times when waterway flows at Romeoville (Chicago Sanitary and Ship Canal) were higher than dry weather flow. This was the method used by Marquette to differentiate between wet and dry periods.

TABLE 5.1
PERCENTAGE OF TIME DISSOLVED OXYGEN LEVELS ARE HIGHER THAN TARGET LEVELS AT SIMPSON STREET FOR JULY 12-NOVEMBER 10, 2001 FOR DIFFERENT TRANSFERS OF NORTH SIDE WRP EFFLUENT

DO TARGET LEVELS

% Transfer	3 mg/l		4 mg/l		5 mg/l		6 mg/l	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
10	58.4	77.5	27.8	64.4	6.7	41.8	0.0	19.6
50	100	99.3	99.6	95.2	84.7	78.1	44.5	33.6
75	100	99.5	99.9	97.9	93.9	85.2	56.7	40.5
100	100	100	100	99.1	96.8	88.9	65.9	44.8

Table 5.1 shows that diverting 100% of the North Side WRP effluent during dry weather flow will only achieve a target dissolved oxygen level of 5 mg/l, 88.9% of the time at Simpson Street, the approximate mid-point of the UNSC.

Table 5.2 shows the percent of time that the dissolved oxygen levels at Main Street (near end of UNSC) are higher than target dissolved oxygen levels for various amounts of flow augmentation for the time period of July 12 – November 10, 2001.

TABLE 5.2
PERCENTAGE OF TIME DISSOLVED OXYGEN LEVELS ARE HIGHER THAN TARGET LEVELS AT MAIN STREET FOR JULY 12-NOVEMBER 10, 2001 FOR DIFFERENT TRANSFERS OF THE NORTH SIDE WRP EFFLUENT

TARGET DO LEVELS

% Transfer	3 mg/l		4 mg/l		5 mg/l		6 mg/l	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
10	28.3	61.1	7.8	41.6	0.0	24.2	0	5.8
50	99.7	94.8	89.1	86.0	62.9	47.3	19.0	17.9
75	100	98.0	97.7	90.6	79.7	64.8	42.0	26.6
100	100	98.7	99.8	94.5	81.0	74.1	49.3	31.3

Again the wet periods in Table 5.2 correspond to periods of flow higher than normal at Romeoville. Table 5.2 shows that diverting 100% of the North Side WRP effluent to Wilmette will only result in dissolved oxygen levels higher than 5 mg/l at Main Street, 74.1% of the time during dry weather flow.

Based upon the modeling runs shown in Table 5.1 and 5.2, it was concluded that the capacity of the flow augmentation pumping station and force main should equal 100% of the North Side WRP effluent to the Wilmette Pumping Station. Since the maximum flow capacity of the North Side WRP is 450 mgd, the pumping station would be sized to pump 450 mgd with the largest pump out of service. It should again be stated that the percent compliance was determined for a data base where the actual historic flow from the North Side WRP was simulated for a given day. So although the modeling runs show that 100% transfer of the historic flow are needed to even approach the DO target, the pumping station may actually not be operating at 450 mgd but merely transferring the effluent flow for a given day. However on some days, the entire maximum plant flow would be transferred to the UNSC. Further study would be needed to determine the impacts the resulting water levels in the NSC to ensure that the transferred flow would not adversely impact water levels in the UNSC.

Figure 5.2 shows the percent compliance in the UNSC with the target 5 mg/l dissolved oxygen water quality standard assuming 100% transfer of North Side WRP effluent to the headwaters of the UNSC at Wilmette. The percent compliance is based upon the entire data base in the current Marquette Model. Two conditions are shown. The baseline (dotted line) is the existing condition with the North Side WRP effluent being discharged at its current location near Howard Street. The solid line is the flow augmentation simulation. As can be seen, 90% compliance is achieved for about ¾ of the length of the UNSC. At Main Street and downstream on the UNSC, percent compliance is less than 90%.

Figure 5.3 shows percent compliance for both the UNSC and the lower NSC assuming 100% transfer of the North Side WRP effluent to the headwaters of the UNSC at Wilmette. As can be seen, percent compliance remains below 90% downstream of the North Side WRP outfall until the Devon Avenue in-stream aeration station. In Figure 5.3, it is interesting to note that the

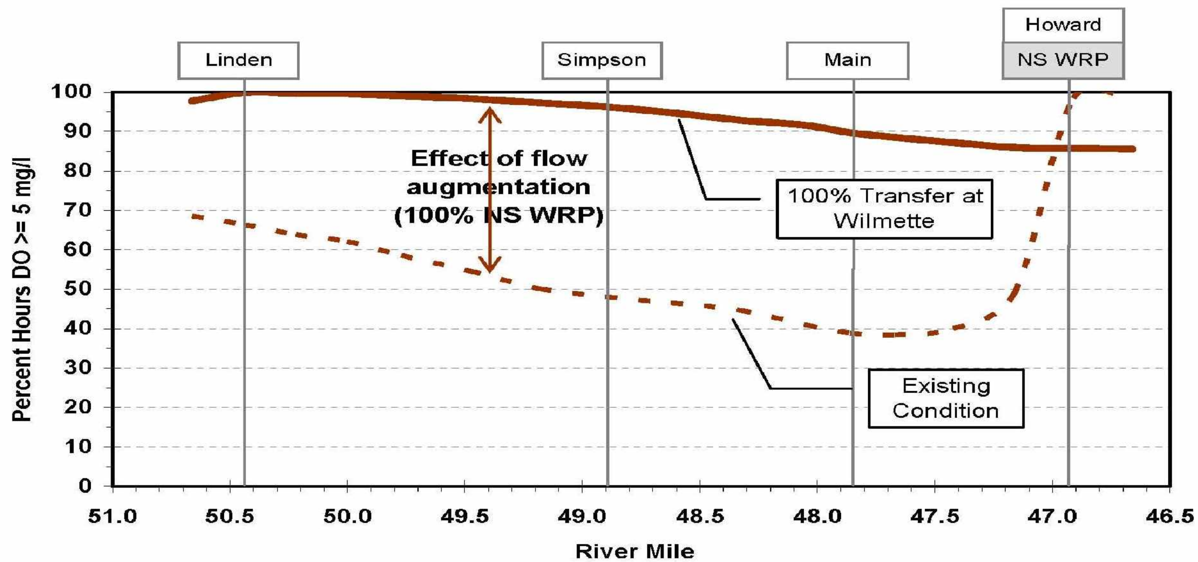

Figure 5.2 - % Compliance with Minimum 5 mg/l Waterway Dissolved Oxygen Concentration for 100% Flow Transfer (up to 450 mgd) from North Side WRP to Wilmette without Aeration of Transferred Flow, All Time Periods

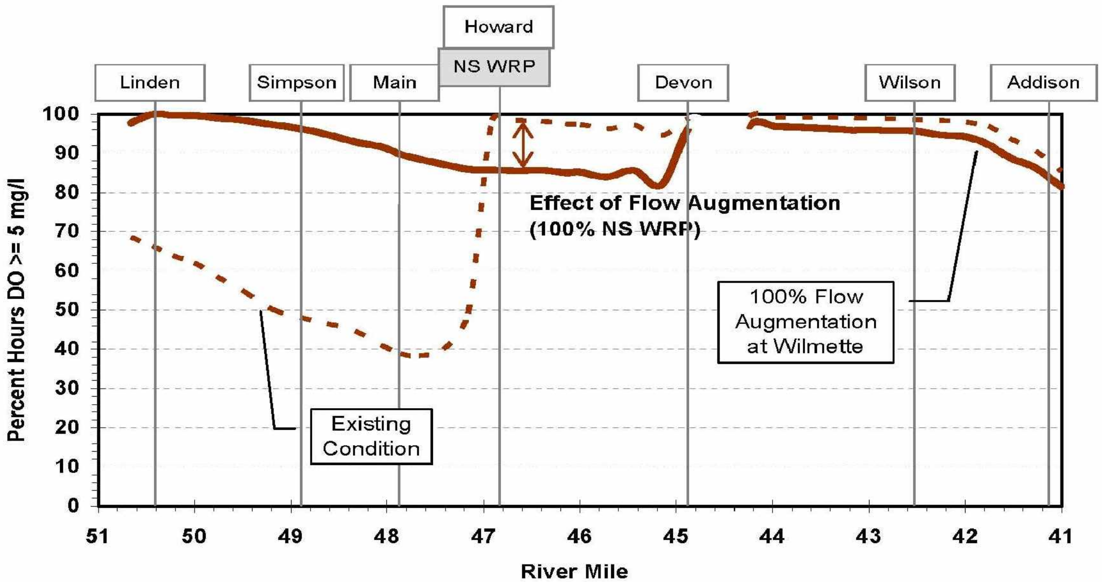

Figure 5.3 – 100% Flow Transfer of North Side Effluent to Wilmette without Aeration of Transferred Flow Reduces Compliance Below the North Side WRP

baseline (dotted line) condition (existing discharge from the North Side WRP at its current location at Howard Street) actually has a higher compliance than the flow augmentation simulation (solid line) immediately downstream of the North Side WRP. Said another way, flow augmentation actually makes the dissolved oxygen level worse downstream of the North Side WRP compared to the existing situation.

It should be emphasized that the percent compliance for the 100% transfer of unaerated North Side WRP effluent may be sufficient to meet the UAA objectives. The target DO objectives chosen for this report may be conservative and not necessary to maintain current or future uses for the NSC. It should also be understood that changing the DO target level will significantly influence the cost for flow augmentation. Obviously, a numerically higher DO standard than 5 mg/l or 100% compliance with the 5 mg/l DO standard will incur additional capital and operation and maintenance expenditures than that found in this report.

Figure 5.4 is a map showing the approximate 4 mile 450 mgd pipeline from the North Side WRP to Wilmette. The suggested route is along and parallel to the UNSC since the MWRDGC owns all or almost all of the land along the UNSC. There is sufficient space on the North Side WRP property to accommodate the pump station without interfering with current or proposed future processes.

CTE investigated the North Side WRP Master Plan process layout for the ultimate planning year of 2040. The pump station and U-Tube aeration system has a small footprint (5,000 sf) and can be accommodated on the 2040 layout. The pump station and U-Tube aeration system could be located adjacent to the proposed filtration and effluent disinfection systems. Even if space becomes a premium at North Side due to unforeseen circumstances, the pump station and U-Tube aeration system could be located on the banks of the NSC near the current outfall from the North Side WRP.

Modeling Runs for Flow Augmentation with Aeration of the Transferred Flow

Since the inherent DO in the 100% transfer of North Side WRP effluent was not sufficient to meet the DO target level of 5 mg/l, 90% of the time, along the entire length of the UNSC, it was logical to conduct modeling runs to determine if aeration of transfer flow to saturated DO levels would meet the target. The DO in the North Side WRP effluent is generally about 6 mg/l which is significantly lower than the saturation DO of about 8.5 mg/l at summer water temperatures (approximately 72 degrees F). Thus, force main aeration to increase North Side WRP effluent DO to saturation holds the possibility of achieving the DO target during the summer months when oxygen depletion rates are the highest.

The Marquette Model was used to simulate aerated (to saturation) North Side WRP modeling effluent flow augmentation of the UNSC. A report authored by Marquette University of these modeling runs can be found in Appendix C. Saturated DO concentrations are dependent upon temperature, but typically saturated DO is about 8 to 10 mg/l. The modeling runs show that a constant transfer of 100 mgd of aerated North Side Effluent to Wilmette will meet the DO target for this report. This constant flow can be achieved since flows of North Side Effluent always exceed 100 mgd.

Figure 5.5 shows the percent compliance in the UNSC with the 5 mg/l dissolved oxygen water quality standard assuming 100 mgd of transferred flow aerated to saturation. Two conditions are shown. The baseline (dotted line) is the existing condition with the North Side WRP effluent being discharged near Howard Street. The solid line is the flow augmentation (with aeration) simulation. As can be seen, 90% compliance is achieved for the entire length of the UNSC pumping 100 mgd of aerated North Side effluent to the headwater of the UNSC at Wilmette.

Figure 5.6 shows the approximate 4 mile 100 mgd pipeline from the North Side WRP to Wilmette. This pipeline is used for flow augmentation of the channel. The suggested route is along and parallel to the NSC. There is sufficient space at the North Side WRP to accommodate the pump station and force main aeration system without interfering with current or proposed future processes.

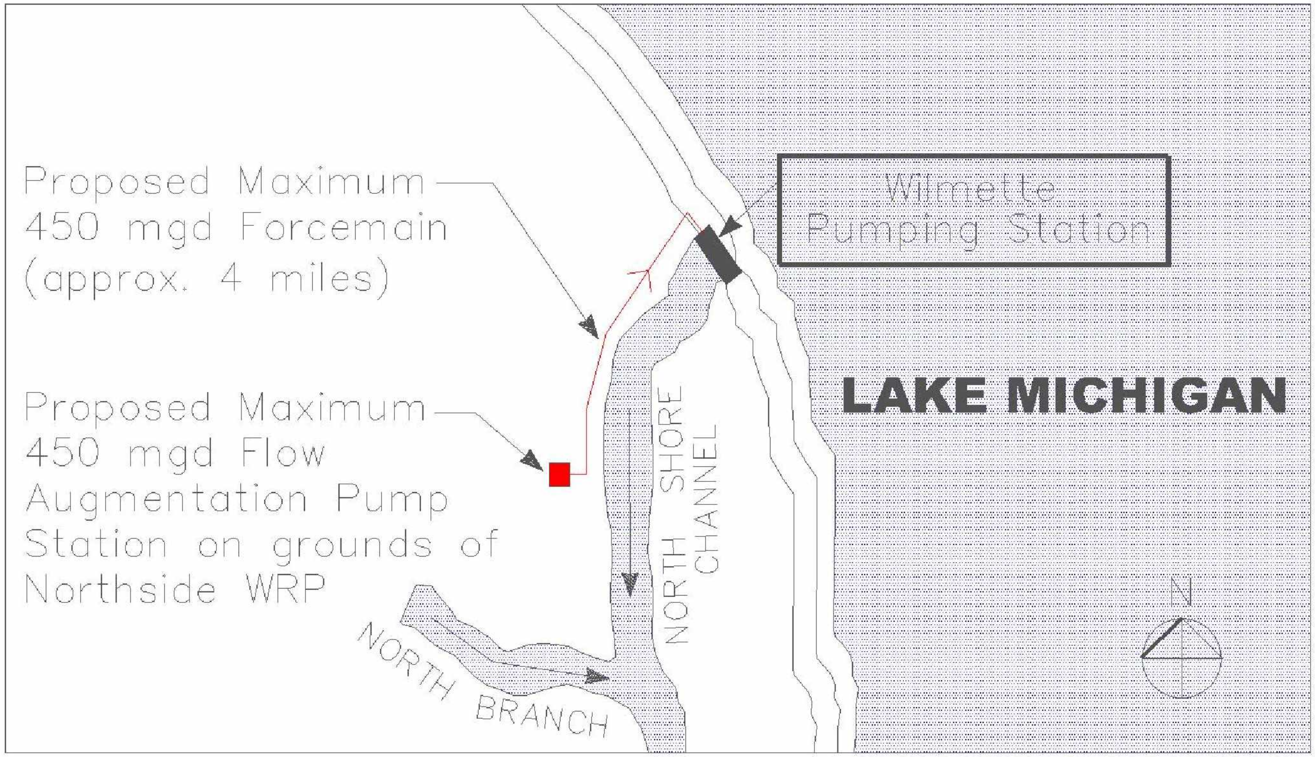

Figure 5.4 – Flow Augmentation Pumping Station and Pipeline for the Upper North Shore Channel without Aeration of Transferred Flow

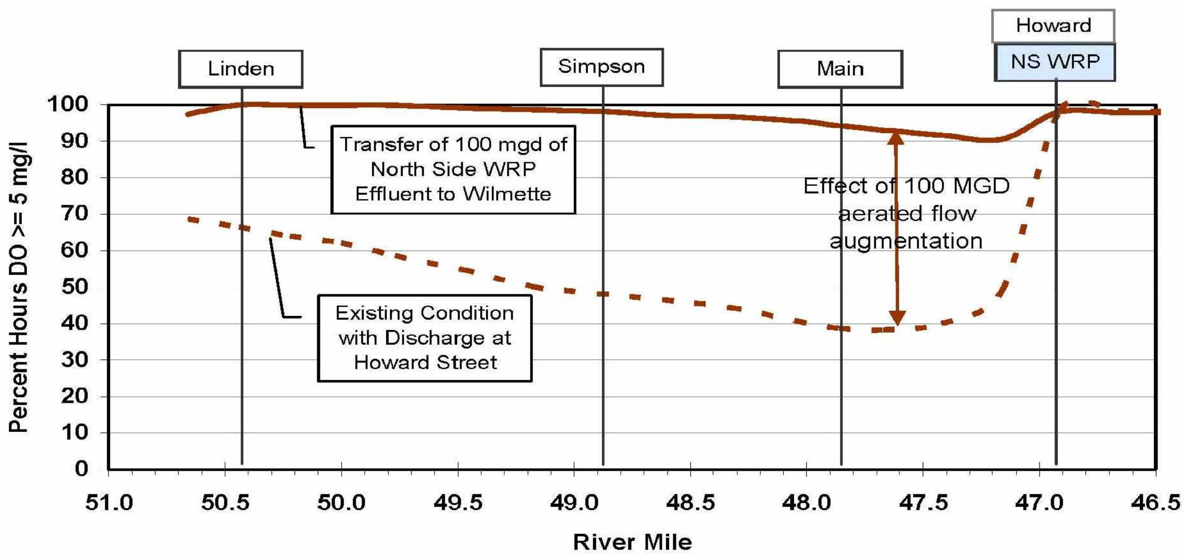

Figure 5.5 – % Compliance with Minimum 5 mg/l Dissolved Oxygen for 100 MGD of Aerated Flow Augmentation, All Time Periods

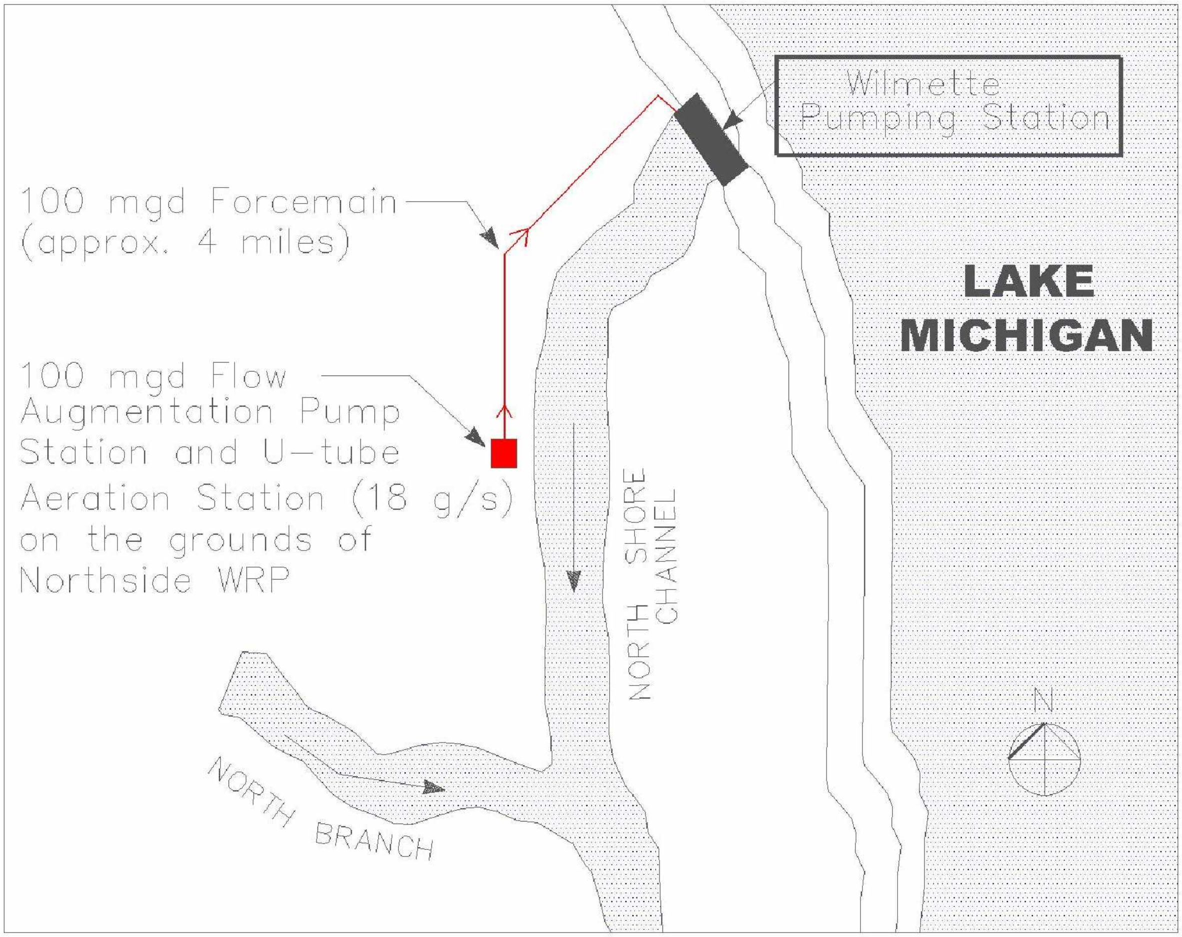

Figure 5.6 – Flow Augmentation of the Upper North Shore Channel with Aeration of the Transferred Flow

COST OF FLOW AUGMENTATION WITHOUT AERATION OF THE TRANSFERRED FLOW

Appendix A contains the unit costs used to determine the capital and operation and maintenance costs for this technical memorandum.

Appendix D contains the detailed spreadsheet used to determine the capital costs for the pumping station (450 mgd) and force main for flow augmentation of the UNSC without aeration.

Appendix E contains the detailed spreadsheet used to determine the operation and maintenance costs for the flow augmentation pump station and force main without aeration.

Table 5.3 contains a summary of the Capital and Operation and Maintenance Costs for Flow Augmentation of the UNSC without aeration of the transferred flow.

TABLE 5.3
SUMMARY OF COSTS FOR FLOW AUGMENTATION (WITHOUT AERATION) OF TRANSFERRED FLOW

Capital Cost ($)	Annual Cost ($)	Total Present Worth ($)
$394,000,000	$2,700,000	$447,000,000

COSTS OF FLOW AUGMENTATION WITH AERATION OF THE TRANSFERRED FLOW

Appendix F contains the detailed capital cost estimate for the pumping station (100 mgd), force main and force main aeration system for flow augmentation of the UNSC. Costs were estimated for a force main aeration system using compressed air U-Tubes.

Compressed air U-Tubes are commonly used to aerate force mains for sewage pumping stations to control odors. Thus, this is a proven technology for force main aeration. Also compressed air U-tubes were a short-listed technology for supplemental aeration (see TM-4WQ). Compressed air U-tubes produce dissolved oxygen levels far above saturation and thus only a portion of the transferred flow needs to be aerated. If this water quality management option should proceed to implementation, a more detailed study of force-main aeration alternatives should be conducted to select a final candidate for design purposes.

The U-tubes aeration system used for force-main aeration was based upon adding sufficient supersaturated water to bring 100 mgd of North Side WRP to saturated DO at atmospheric pressure. The U-tube station would divert a portion of the 100 mgd flow and return the aerated flow back to the force main. The resulting mixture would be saturated with DO at atmospheric pressure. Thus, 100 mgd of aerated North Side effluent flow would be added to the NSC at Wilmette. This flow is sufficient to meet the waterway DO target of 5 mg/l, 90% of the time and helps to reduce stagnant conditions in the NSC during dry weather.

Appendix G contains the detailed maintenance and operation costs for flow augmentation with aeration of the transferred flow.

Table 5.4 contains a summary of the capital and operation and maintenance costs for flow augmentation with aeration of the transferred flow.

TABLE 5.4
SUMMARY OF COSTS FOR FLOW AUGMENTATION (WITH AERATION) OF TRANSFERRED FLOW

Item	Capital Costs	Annual Costs	Total Present Worth
FORCE MAIN AERATION U-Tubes (compressed air)	$3,500,000	$65,000	$4,800,000
FLOW AUGMENTATION	$56,000,000	$679,000	$69,500,000
TOTAL	$60,000,000	$744,000	$74,880,000

SUMMARY

A study was conducted to determine the costs for flow augmentation of the UNSC using effluent flow from the North Side WRP. The effluent discharge point for the North Side WRP would be moved from its current location at Howard Street to the headwaters of the UNSC at Wilmette.

Two flow augmentation alternatives were studied including:

1. Using the unaerated North Side WRP Effluent
2. Aerating the North Side WRP Effluent to saturation DO before discharge at Wilmette

Using a water quality model developed by Marquette University, the amount of flow for the above two alternatives to produce a waterway target DO level of 5 mg/l, 90% of the time, was determined. This target level was selected for this report based upon a consensus decision with the MWRDGC. The on-going IEPA UAA process may lead to a different target which of course would yield a different cost estimate than that contained in this report.

The Modeling runs conducted by Marquette University (Appendix B and C) showed the following:

1) For the unaerated flow augmentation scenario, the entire available flow (up to 450 mgd at maximum flow) from the North Side WRP was not sufficient to meet the DO target
2) For the aerated flow alternative, a constant flow of 100 mgd was needed from the North Side WRP to meet the target

The total present worth of the unaerated alternative was $447 million. The total present worth of the aerated alternative was $74.9 million. Aerating the augmented flow lowers the pumping rate from 450 mgd to 100 mgd and the pumping station cost savings are significantly more than the cost of the force main aeration system.

It should be made clear that this is a planning level study for which the principal objective is to determine the relative cost associated for flow augmentation of the UNSC. As such, it is not designed to reach a conclusion as to which alternative would be selected for possible implementation in the future. Before any conclusions are to be reached, it is necessary to know the exact waterway target DO level. Also a more detailed study of force main aeration alternatives should be conducted to select a final candidate for design purposes. For this report, compressed air U-Tube aeration was used for cost estimating purposes.

It should also be stated that there are other water quality management options which IEPA has requested for study by the MWRDGC. A decision as to the implementation of flow augmentation of the UNSC must be reached by conducting an integrated study of all options. Thus a decision on the implementation of a certain option, or combination of options, must be made considering the cost and water quality impacts of the other IEPA suggested options along with potential expansions, modifications and improvements at the MWRDGC treatment plants which discharge to the CAWs.

APPENDIX A
Unit Costs Used in Cost Estimates

UNIT COSTS USED IN COST ESTIMATES

Life cycle cost (LCC) analysis requires the development of certain constants that will be used throughout the evaluation of alternatives. Values used for constants are presented below. These values have been developed in consultation with District staff and represent actual values or agreed upon assumptions.

1.	Present Worth Factors for Life-Cycle Costs	
	• Years	20
	• Annual interest rate	3%
	• Annual inflation rate	3%
	• Annuity Present Worth Factor (with inflation)	19.42
2.	Design Life	
	• Structural Facilities	20
	• Mechanical Facilities	20
3.	Electrical Cost	$0.075/kW-hr
4.	Labor Rates Per Hour Including Benefits (1)	
	• Electrician	$159.50/hr
	• Operations	$90.00/hr
	• Maintenance	$90.00/hr
5.	Parts and Supplies	5 percent
6.	Contractor Overhead and Profit (2)	15%
7.	Planning Level Contingency (3)	30%
8.	Engineering Fees including Construction Management (4)	20%

(1) A multiplier of 2.9 was used to reflect benefits as provided by the District.
(2) Percent of Total Construction Cost
(3) Percent of Total Construction Cost plus Contractor Overhead and Profit
(4) Percent of Total Construction Cost, Contractor Overhead and Profit plus Contingency

APPENDIX B

Report Authored by Marquette University Entitled:

"Progress on Flow Augmentation Simulations for the North Shore Channel"

APPENDIX C

Report Authored by Marquette University Entitled:

"North Shore Channel Flow Augmentation with Aeration"

APPENDIX D
Capital Cost Estimates for
Flow Augmentation without Aeration

APPENDIX E
Operation & Maintenance Cost Estimates for Flow Augmentation without Aeration

APPENDIX F
Capital Cost Estimates for
Flow Augmentation with Aeration

APPENDIX G
Operation & Maintenance Cost Estimates for Flow Augmentation with Aeration

APPENDIX B

Report Authored by Marquette University Entitled:

"Progress on Flow Augmentation Simulations for the North Shore Channel"

May 31, 2005

PROGRESS ON FLOW AUGMENTATION SIMULATIONS FOR THE NORTH SHORE CHANNEL

The first set of simulations considering moving a portion of the North Side Water Reclamation Plant (NSWRP) effluent to the upstream end of the North Shore Channel (NSC) has been completed. Two types of flow transfer have been considered: the transfer of (1) a fixed amount (50 or 100 mgd) and (2) a percentage (10, 50, 75, or 100%) of the NSWRP effluent have been evaluated for the periods July 12 – September 14, 2001 and September 14 – November 10, 2001. The minimum one hour flow from the NSWRP was 110 mgd. Thus, it was necessary to consider a percentage flow transfer rather than a fixed amount transfer to evaluate higher transfer levels. The percentage of hours that target dissolved oxygen (DO) concentrations of 3, 4, 5, and 6 mg/L are equaled or exceeded for the total period of July 12 – November 10, 2001 are listed in Tables 1-3 for Simpson Street, Main Street, and Addison Street, respectively. The wet periods listed in these tables correspond to times when flows at Romeoville were higher than typical dry weather flows (as listed in the appendix).

Table 1. Percentage of time that dissolved oxygen concentrations are higher than the target concentrations at Simpson Street for July 12 – November 10, 2001 for different transfers of the North Side Water Reclamation Plant effluent

Scenario	3 mg/L Dry	3 mg/L wet	4 mg/L dry	4 mg/L wet	5 mg/L dry	5 mg/L Wet	6 mg/L dry	6 mg/L wet
Measured	55.3	22.1	48.3	12.6	37.9	6.9	28.7	3.5
Calibrated	62.8	19.1	50.5	17.2	37.2	12.3	26.3	6.1
50 mgd	92.0	79.7	74.2	41.5	46.6	13.0	23.4	0.0
100 mgd	98.5	98.9	92.2	92.8	67.4	60.2	27.9	5.5
10 %	77.5	58.4	64.4	27.8	41.8	6.7	19.6	0.0
50 %	99.3	**100.0**	95.2	99.6	78.1	84.7	33.6	44.5
75 %	99.5	**100.0**	97.9	99.9	85.2	93.9	40.5	56.7
100 %	**100.0**	**100.0**	99.1	**100.0**	88.9	96.8	44.8	65.9

Table 2. Percentage of time that dissolved oxygen concentrations are higher than the target concentrations at Main Street for July 12 – November 10, 2001 for different transfers of the North Side Water Reclamation Plant effluent

Scenario	3 mg/L dry	3 mg/L wet	4 mg/L dry	4 mg/L wet	5 mg/L dry	5 mg/L Wet	6 mg/L dry	6 mg/L wet
Measured	42.8	13.8	33.7	7.7	22.9	4.4	12.5	3.0
Calibrated	47.2	22.1	36.2	15.4	19.7	6.3	9.2	0.0
50 mgd	72.0	35.2	48.3	9.6	27.0	3.8	6.1	0.0
100 mgd	90.6	88.9	74.6	73.3	35.0	8.9	13.4	0.0
10 %	61.7	28.3	41.6	7.8	24.2	0.0	5.8	0.0
50 %	94.8	99.7	86.0	89.1	47.3	62.9	17.9	19.0
75 %	98.0	**100.0**	90.6	97.7	64.8	79.7	26.6	42.0
100 %	98.7	**100.0**	94.5	99.8	74.1	87.0	31.3	49.3

Table 3. Percentage of time that dissolved oxygen concentrations are higher than the target concentrations at Addison Street for July 12 – November 10, 2001 for different transfers of the North Side Water Reclamation Plant effluent

Scenario	3 mg/L dry	3 mg/L wet	4 mg/L Dry	4 mg/L wet	5 mg/L dry	5 mg/L Wet	6 mg/L dry	6 mg/L wet
Measured	99.7	99.1	98.1	98.3	86.5	95.1	43.1	53.5
Calibrated	**100.0**	**100.0**	97.5	99.6	79.3	87.2	28.8	42.5
50 mgd	**100.0**	**100.0**	97.0	98.6	78.0	81.1	27.2	35.2
100 mgd	99.6	**100.0**	94.8	97.0	77.3	79.9	25.3	35.4
10 %	**100.0**	**100.0**	97.4	99.2	79.8	83.5	29.1	36.0
50 %	99.4	**100.0**	94.9	96.9	76.4	80.7	25.3	38.3
75 %	98.7	**100.0**	94.1	96.8	74.6	79.1	24.8	39.1
100 %	97.9	**100.0**	93.3	96.1	74.1	78.2	24.8	39.6

The simulation results for Simpson Street and Main Street show the improvement of DO concentrations in the upper NSC resulting from the flow transfer whereas the simulation results at Addison Street show the change in DO concentrations downstream from the NSWRP resulting from the transfer. It can be seen that even transferring the complete NWWRP flow does not result in attainment of DO concentrations in excess of 4 mg/L at Simpson Street and 3 mg/L at Main Street during dry weather 100 percent of the time. Whereas these target DO concentrations are achieved 100 percent of the time during wet weather. Surprisingly, for nearly all target DO concentrations and all transfer scenarios higher percentages of compliance are achieved for wet weather than for dry weather. Thus, extra flow for dilution of combined sewer overflows (CSOs) is effective in improving DO concentrations in the upper NSC during storms.

The surprising result that transferring even the entire flow from the NSWRP to the upstream end of the NSC does not result in DO concentrations greater than 4 mg/L at all times during dry weather flow is because of two causes. The first is that for most days in July and August 2001 the DO concentration in the NSWRP effluent is 6 mg/L or less (Figure 1). Thus, there is a small margin between the effluent DO concentration and the 4 mg/L target, and the carbonaceous biochemical oxygen demand (CBOD) and ammonia loads and sediment oxygen demand are sufficient to reduce DO concentrations below the 4 mg/L and 3 mg/L targets. The second is that occasionally higher concentrations of CBOD and ammonia are present in the NSWRP effluent. Figure 2 shows the simulated hourly and daily mean DO concentrations at Simpson Street and Main Street on the upper NSC resulting from a 100 percent transfer of the NSWRP effluent to the upstream end of the NSC. The occasional instances of low DO concentrations are the result of periods with relatively higher CBOD and ammonia concentrations in the NSWRP effluent. For example, on July 17, 2001, the daily mean CBOD and ammonia concentrations in the NSWRP effluent were 10.0 and 3.49 mg/L, respectively (and the daily mean DO concentration was 5.4 mg/L). Whereas, these concentrations are not high relative to the NSWRP permit limitations and general performance of wastewater treatment plants nationwide, they are more than double and triple, respectively, the CBOD and ammonia concentrations in the NSWRP effluent on most days. Thus, occasional higher concentrations in the effluent, and the small difference between the effluent DO concentration and DO concentration targets means that 100 percent compliance with targets will be difficult to achieve.

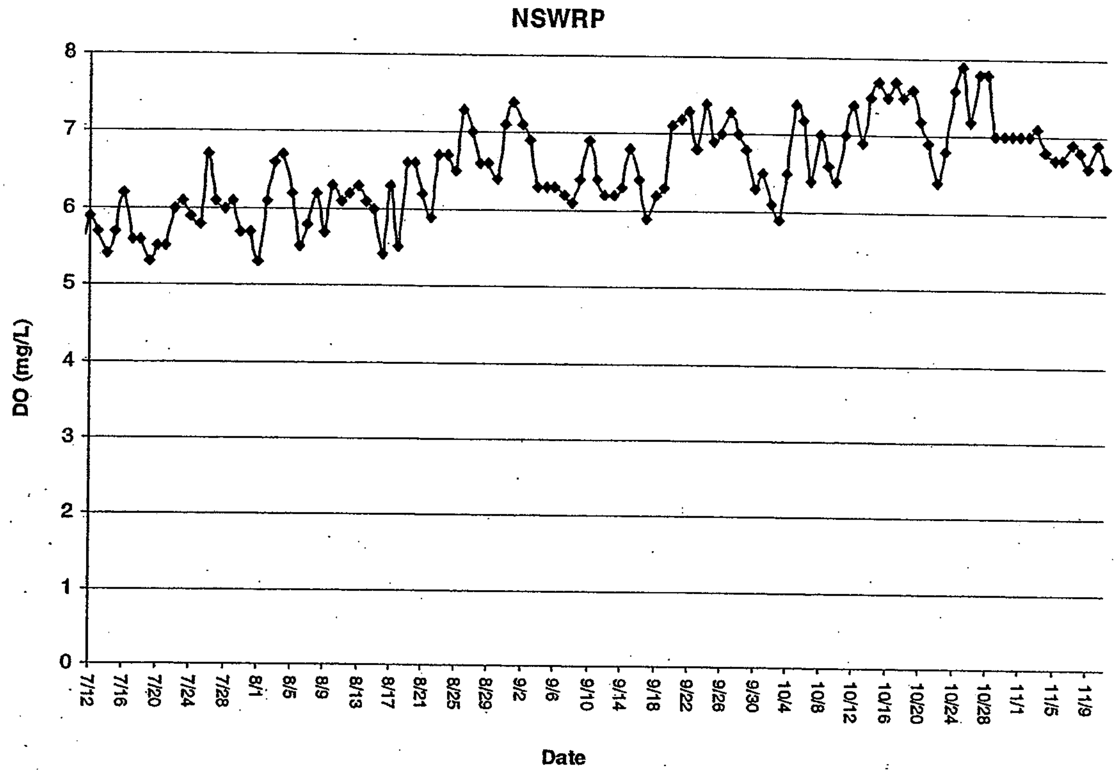

Figure 1. Daily mean dissolved oxygen concentration in the North Side Water Reclamation Plant Effluent for July 12 – November 10, 2001.

Recommended Further Flow Augmentation Scenarios

Increasing the DO concentration in the NSWRP effluent combined with transferring a portion of the NSWRP effluent to the upstream end of the NSC may be an effective and efficient way to achieve full compliance with various target DO concentrations (4, 5, or 6 mg/L) in the upper NSC using Simpson Street and Main Street as the indicator sites. Marquette University would like some guidance from the Metropolitan Water Reclamation District of Greater Chicago (District) and/or the CTE Team preparing the NSWRP facilities plan regarding DO concentrations in the NSWRP effluent that are reasonably achievable. Once such a recommendation in the form of a percentage of the saturation DO concentration or a fixed DO concentration is obtained from the District and/or CTE the flow augmentation scenarios will be redone and refined to determine if full compliance with the DO concentration targets of 4, 5, and 6 mg/L can be met for July 12-November 10, 2001 and May 1-September 24, 2002. Improvement in DO concentrations on the lower NSC and North Branch Chicago River in response to increased effluent DO concentrations also will be reported.

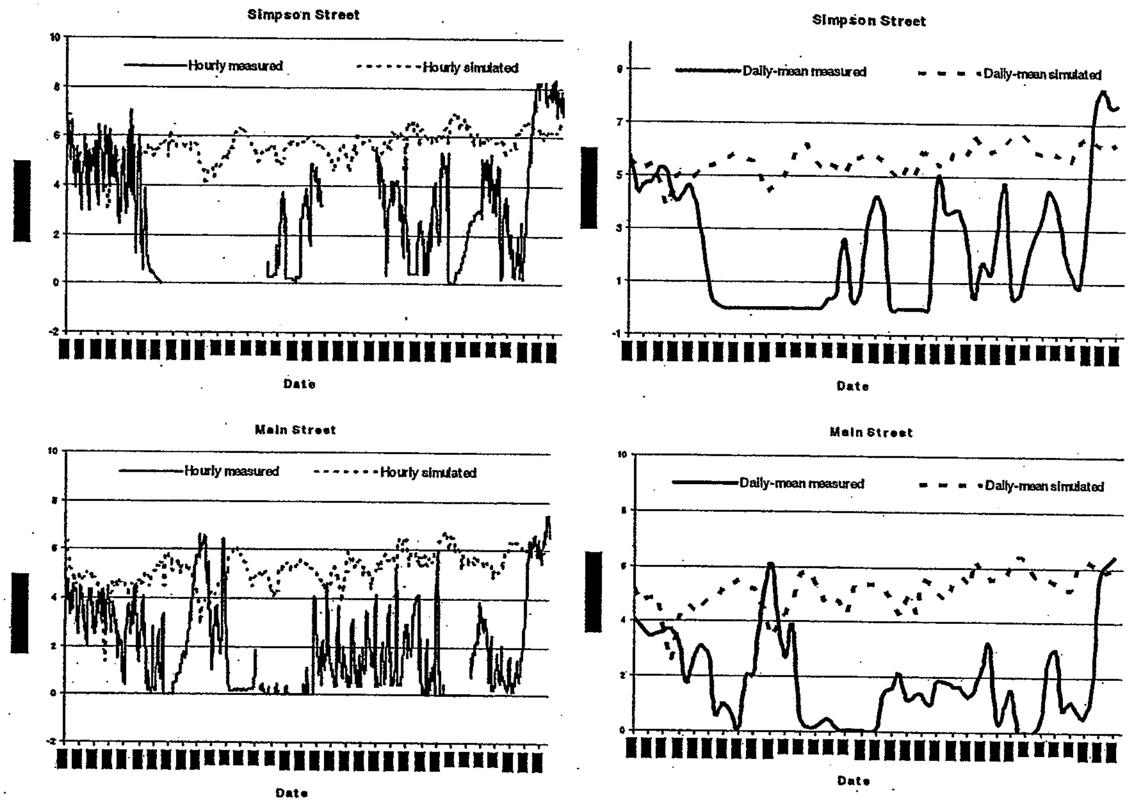

Figure 2. Simulated hourly and daily mean dissolved oxygen concentrations at Simpson Street and Main Street on the North Shore Channel for a 100 percent transfer of the effluent of the North Side Water Reclamation Plant to the upstream end of the North Shore channel compared with measured concentrations for July 12 to September 14, 2001.

Other Noteworthy Simulation Results

Two aspects of the simulation results require discussion. The first is that the transfer of NSWRP effluent to the upstream end of the NSC results in a decrease in the percentage of time that DO concentrations comply with the various DO concentration targets at Addison Street. Because of the longer traveltime for the transferred flow to reach Addison Street biological processes act to reduce DO concentrations at Addison Street. This is somewhat offset by the increased oxygen load produced by the Devon Avenue instream aeration station. That is, keeping the operating hours for the station the same, the lower the percentage of DO saturation coming into the station the higher the increase in DO load from the station.

It is our understanding that the instream aeration stations at Devon Avenue and Webster Street are turned on when DO concentrations go below target values. Marquette University requests that the District provide the operational guidelines for the instream aeration stations so that station operations can be adjusted to reflect the higher DO concentrations resulting when NSWRP effluent DO concentrations are increased.

The second aspect of the results that requires discussion is the reduction in the percentage of the time in compliance with various target DO concentrations when small amounts of effluent (50 mgd or 10 percent) are transferred to the upstream end of the NSC relative to the no transfer (calibrated model) case. For the no transfer case compliance with the various target DO concentrations is achieved at certain times. For some of these times the addition of a CBOD and ammonia load in the transferred effluent may result in a decrease in DO concentrations below the targets. For small flow transfers the number of hours with reduced DO may be greater than the number of hours improved by the effluent transfer. At higher levels of flow transfer, the number of hours improved is substantially more than those that are adversely affected.

APPENDIX C

Report Authored by Marquette University Entitled:

"North Shore Channel Flow Augmentation with Aeration"

NORTH SHORE CHANNEL FLOW AUGMENTATION WITH AERATION

It was previously found that even shifting the entire NSWRP effluent discharge to the upstream end of the North Shore Channel (NSC) could not achieve 100 percent compliance with a 4 mg/L DO criterion at Main Street during the period July 12 to November 10, 2001. It was speculated that this resulted because DO concentrations in the NSWRP effluent often were relatively low (between 5 and 6 mg/L) in July and August 2001. CTE's review of aeration technologies found that it would be relatively easy to bring the flow to saturation in the force main used to transfer flow from the NSWRP to the upstream end of the NSC. Thus, it was decided to consider a case of flow augmentation wherein oxygen would be added to the NSWRP effluent in the force main.

Daily mean temperature data for the NSWRP effluent for the periods July 12 to November 10, 2001 and May 1 to September 23, 2002 were used to determine the saturation DO concentration in the force main. Some of this DO would be consumed during travel from the NSWRP to the upstream end of the NSC, but this would be matched by a decrease in the BOD. Thus, for simplicity the quality of the transferred flow was taken as that of the NSWRP effluent with the DO concentration raised to saturation. The transfer amount was taken as the lesser of the selected transfer value or the actual effluent flow for a particular hour.

Table 4 lists the percentage of time compliance is achieved with DO criteria of 4, 5, and 6 mg/L for dry weather and wet weather periods. In this case wet weather is defined as periods when flow at Romeoville exceeds 100 m^3/s (3,530 cfs) for an extended period.

Table 4. Percentage of time that dissolved oxygen (DO) concentrations are higher than the target concentrations at Main Street for July 12 – November 10, 2001 and May 1 – September 23, 2002 for different transfers of North Side Water Reclamation Plant effluent brought to saturation DO concentration.

Scenario	4 mg/L Dry	4 mg/L Wet	5 mg/L Dry	5 mg/L Wet	6 mg/L Dry	6 mg/L Wet
50 mgd	94.7	68.5	81.4	49.6	56.9	29.7
80 mgd	98.1	89.2	94.8	79.0	78.2	56.0
90 mgd	98.5	90.9	96.0	84.4	83.2	64.9
100 mgd	98.8	92.5	96.6	88.0	86.8	72.1
120 mgd	99.1	94.6	98.0	90.5	92.6	81.6
130 mgd	99.2	95.7	98.5	91.6	93.9	85.7
140 mgd	99.4	96.3	98.7	92.2	94.6	88.2
150 mgd	99.6	96.7	98.9	93.2	95.4	89.3
170 mgd	99.8	97.6	99.1	94.4	97.3	90.4
180 mgd	99.9	98.0	99.2	95.1	97.7	91.1
190 mgd	100.0	98.2	99.4	95.3	98.0	91.4
200 mgd	100.0	98.9	99.6	95.7	98.3	91.8
220 mgd	100.0	99.5	99.7	96.4	98.6	92.8
230 mgd	100.0	99.6	99.8	96.7	98.7	93.3
240 mgd	100.0	99.6	99.8	97.0	98.8	93.7

As shown in Figure 3 high flow periods at Romeoville correspond to high flow periods for the major tributaries (Little Calumet River and North Branch Chicago River at Albany Avenue) to the CWS and at internal points (North Branch Chicago River at Grand Avenue) in the CWS. Thus, using high flows at Romeoville to define wet weather periods appears to be reasonable.

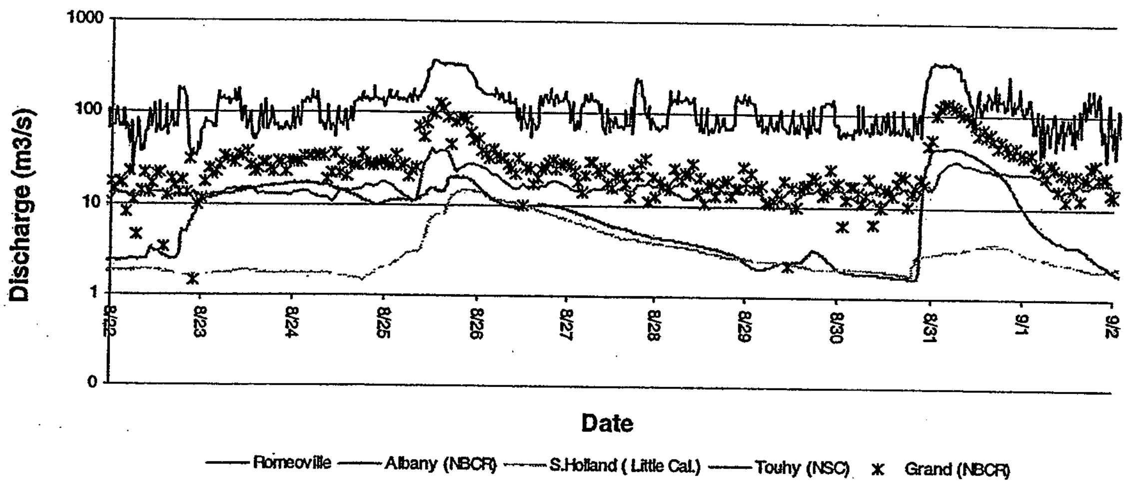

Figure 3. Measured flows on the North Branch Chicago River (NBCR) at Touhy Avenue and Albany Avenue, the Little Calumet River at South Holland, the Chicago Sanitary and Ship Canal at Romeoville and simulated flows on the North Branch Chicago River at Grand Avenue for August 22 to September 2, 2001.

The results in Table 4 indicate that a transfer of 190 million gallons per day (mgd) is necessary to achieve DO concentrations in excess of 4 mg/L at Main Street 100 percent of the time during dry weather periods. The DO criterion of 5 mg/L could only be met 99.8 percent of the time at Main Street. The problem date is July 17, 2001, on which the effluent CBOD and ammonia concentrations were 10.0 mg/L and 3.49 mg/L, respectively. This relatively higher load (yet still within the NSWRP permit limits) results in DO concentrations less than 5 mg/L at Main Street. The NSWRP effluent flows on July 17, 2001, ranged between 200 and 240 mgd. Thus, diversions greater than 240 mgd had no effect on the simulated DO concentrations as shown in Figure 4.

In the charge to CTE for the NSWRP Facility Plan a target of 95 percent compliance with DO criteria of 4, 5, and 6 mg/L during all periods (wet and dry) was set for developing cost estimates. This may be a practical and environmentally safe target percentage for compliance. The allowance of variance from the criterion 5 percent of the time was selected to provide relief for wet weather periods, however, as defined here wet weather periods account for 34 percent of the simulated periods. Thus, 95 percent compliance accounts for compliance for around 85 percent of wet weather periods assuming nearly 100 percent compliance during the dry weather periods. Further, the simulated periods are dominated by summer (July-September) conditions during which temperature stresses on DO concentrations are greatest. That is, 95 percent compliance in the summer implies much higher compliance over an entire year.

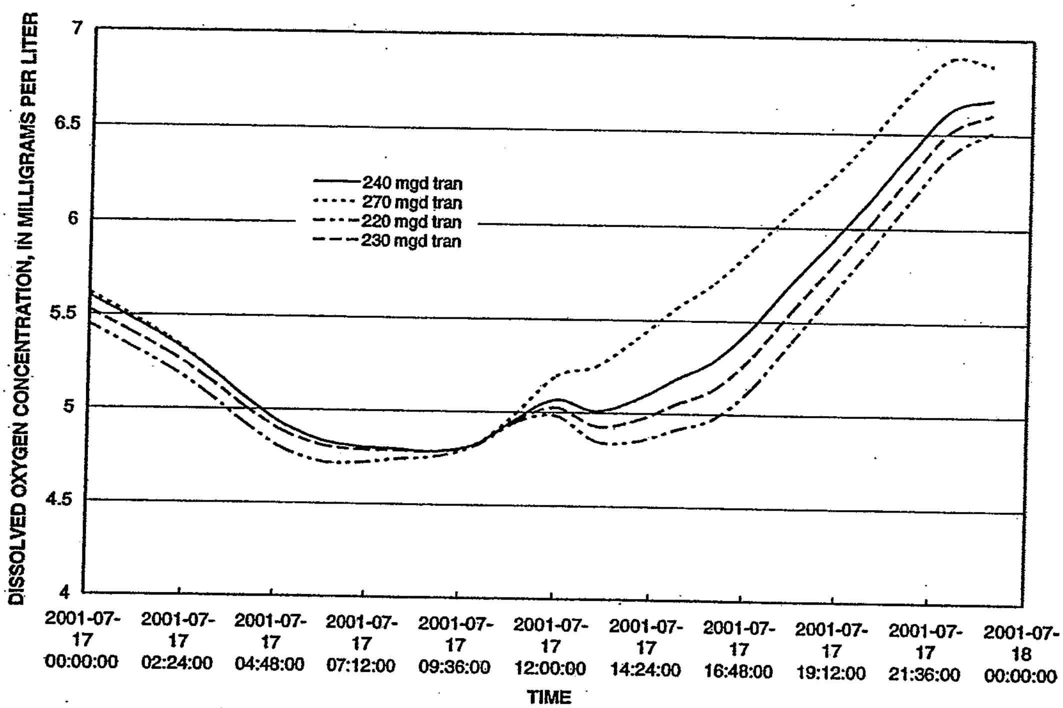

Figure 4. Simulated dissolved oxygen concentrations at Main Street on the North Shore Channel for July 17, 2001, for different flow augmentation with aeration scenarios.

Table 5 and Figure 5 list and show, respectively, the overall percentage compliance with the 4, 5, and 6 mg/L DO criteria resulting from different amounts of flow transfer from the NSWRP to the upstream end of the NSC. Ninety five percent compliance with the 4, 5, and 6 mg/L criteria is achieved with a transfer of 80, 120, and 170 mgd, respectively, of aerated effluent. Strictly speaking a transfer of 170 mgd will result in 94.9 percent compliance with a 6 mg/L criterion, but given the implicit safety factor of focusing on summer periods, it is felt that this transfer would be sufficient.

EVALUATE THE EFFECT OF TRANSFERS OF 80, 120, 170, AND 190 MGD OF AERATED EFFLUENT ON DOWNSTREAM LOCATIONS AND SUMMARIZE HERE.

Table 5. Percentage of time that dissolved oxygen (DO) concentrations are higher than the target concentrations at Main Street for all periods during July 12 – November 10, 2001 and May 1 – September 23, 2002 for different transfers of North Side Water Reclamation Plant effluent brought to saturation DO concentration.

Scenario	> 4 mg/L	> 5 mg/L	> 6 mg/L
50 mgd	85.7	70.5	47.6
80 mgd	95.1	89.4	70.6
90 mgd	95.9	92.1	76.9
100 mgd	96.7	93.7	81.7
120 mgd	97.6	95.5	88.8
130 mgd	98.0	96.1	91.1
140 mgd	98.3	96.5	92.4
150 mgd	98.6	96.9	93.3
170 mgd	99.1	97.5	94.9
180 mgd	99.3	97.8	95.5
190 mgd	99.4	98.0	95.8
200 mgd	99.6	98.3	96.1
220 mgd	99.8	98.6	96.6
230 mgd	99.9	98.7	96.9
240 mgd	99.9	98.9	97.1

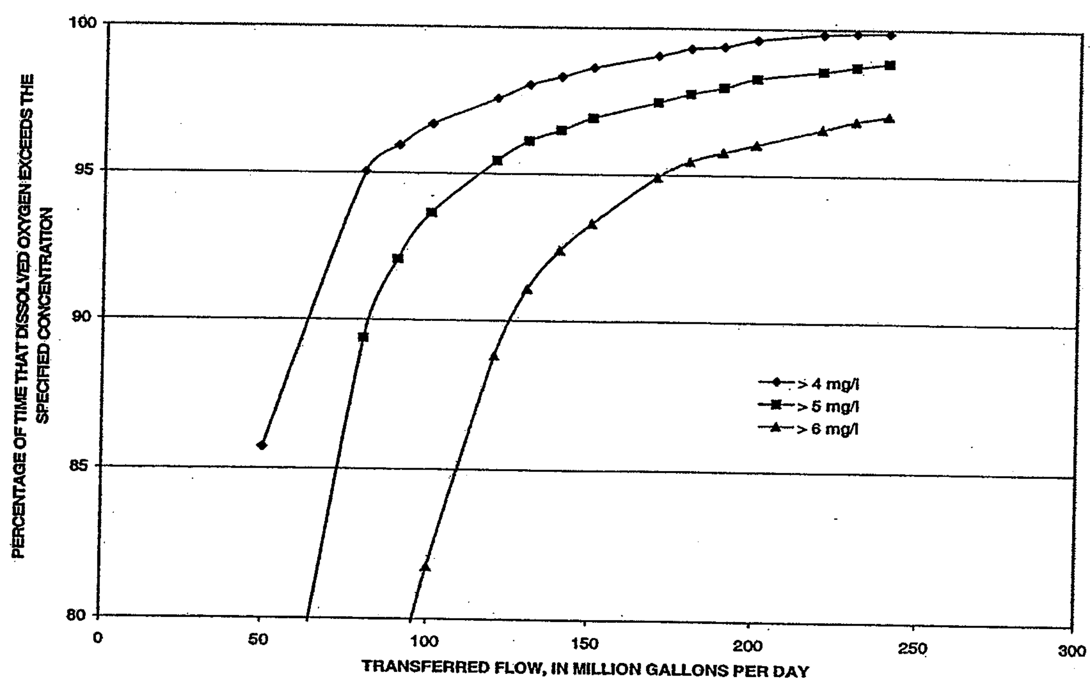

Figure 5. Relationship between aerated North Side Water Reclamation Plant effluent and percentage compliance at Main Street with dissolved oxygen concentration criteria of 4, 5, and 6 mg/L.

APPENDIX D
Capital Cost Estimates for Flow Augmentation without Aeration

TABLE D.1
CAPITAL COST ESTIMATION FOR 450 MGD FLOW AUGMENTATION NORTH SHORE CHANNEL
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$9,286,089
2	SITEWORK								
	Site Restoration	LS	1	$250,000.00	$250,000				$250,000
	Site Utility Relocations and Extensions	LS	1	$150,000.00	$150,000				$150,000
	Trench Excavation	CY	353888	$15.00	$5,308,320				$5,308,320
	Bedding	CY	19055	$30.00	$571,650				$571,650
	Backfill	CY	12444	$20.00	$248,880				$248,880
	Structural Fill	CY	22835	$32.00	$730,720				$730,720
	7 60" DIP Forcemains	LF	166320	$650.00	$108,108,000	40%		$43,243,200	$151,351,200
	Diffuser Pipe into North Shore Channel	LS	1	$30,000.00	$30,000				$30,000
	Dewatering	Day	90	$500.00	$45,000				$45,000
	Sheeting	SF	1800	$20.00	$36,000				$36,000
	SUBTOTAL								
2-16	PUMPING STATION	MGD	450	$60,000.00	$27,000,000				$27,000,000
	SUBTOTAL								**$195,007,859**
	Contractor OH&P @ 15%								**$29,251,179**
	Subtotal								**$224,259,037**
	Planning Level Contingency @ 30%								**$67,277,711**
	Subtotal								**$291,536,748**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$43,730,512**
	Engineering Fees Including CM @ 20%								**$58,307,350**
	Subtotal								**$102,037,862**
	Project Total								**$393,574,610**

APPENDIX E
Operation & Maintenance Cost Estimates for Flow Augmentation without Aeration

TABLE E.1
ANNUAL O&M COSTS FOR NORTH SIDE 450 MGD FLOW AUGMENTATION PUMP STATION

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	**19.42**

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	3350	24	80400.0	$6,030.00	$2,200,950	19.42	$42,742,449
SUBTOTAL					**$2,200,950**		**$42,742,449**

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
LABOR - OPERATOR	2	8	16	$90.00	$525,600	19.42	$10,207,152
ELECTRICIAN	0	0	0	$159.50	$0	19.42	$0
SUBTOTAL					**$525,600**		**$10,207,152**

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES (assume 1% of Total PS costs)	270,000	5%			$13,500	19.42	$262,170
SUBTOTAL					**$13,500**		**$262,170**

TOTAL ANNUAL O&M **$2,740,050**

TOTAL PRESENT WORTH O & M COST **$53,211,771**

APPENDIX F
Capital Cost Estimates for Flow Augmentation with Aeration

TABLE F.1
CAPITAL COST ESTIMATION FOR NORTH SIDE 100 MGD PUMP STATION - AERATED FORCEMAIN
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$1,321,596
2	SITEWORK								
	Site Restoration	LS	1	$100,000.00	$100,000				$100,000
	Site Utility Relocations and Extensions	LS	1	$100,000.00	$100,000				$100,000
	Trench Excavation	CY	77440	$15.00	$1,161,600				$1,161,600
	Bedding	CY	3520	$30.00	$105,600				$105,600
	Backfill	CY	35200	$20.00	$704,000				$704,000
	Structural Fill	CY	21441	$32.00	$686,112				$686,112
	60" DIP Forcemain	LF	23760	$525.00	$12,474,000	40%		$4,989,600	$17,463,600
	Diffuser Pipe into North Shore Channel	LS	1	$30,000.00	$30,000				$30,000
	Dewatering	Day	90	$500.00	$45,000				$45,000
	Sheeting	SF	1800	$20.00	$36,000				$36,000
	SUBTOTAL								
2-16	PUMPING STATION	MGD	100	$60,000.00	$6,000,000				$6,000,000
	SUBTOTAL								**$27,753,508**
	Contractor OH&P @ 15%								**$4,163,026**
	Subtotal								**$31,916,534**
	Planning Level Contingency @ 30%								**$9,574,960**
	Subtotal								**$41,491,494**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$6,223,724**
	Engineering Fees including CM @ 20%								**$8,298,299**
	Subtotal								**$14,522,023**
	Project Total								**$56,013,517**

TABLE F.2
CAPITAL COST ESTIMATION FOR U-TUBE SUPPLEMENTAL AERATION (18 g/s)
PROJECT NO. 40779

DIVISION	ITEM DESCRIPTION	UNITS	NO.	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR % MAT COST	LABOR UNIT COST	LABOR TOTAL COST	INSTALLED COST TOTAL
1	GENERAL REQUIREMENTS								$83,146
2	SITEWORK								
	Cut/Fill	CY	870	$5.00	$4,350				$4,350
	Removable Bollards	EA	7	$300.00	$2,160				$2,160
	Fencing	LS	1	$7,800.00	$7,800				$7,800
	Miscellaneous Sitework	CY	60	$36.00	$2,160				$2,160
	Miscellaneous Sitework	SF	1920	$5.00	$9,600				$9,600
3	CONCRETE								
	Slabs	CY	50	$500.00	$25,200				$25,200
	Wet Well	LS	1	$11,700.00	$11,700				$11,700
9	MASONRY								
	Split Block Masonry Building	SF	1200	$100.00	$120,000				$120,000
10	FINISHES								
	Coatings	LS	1	$12,000.00	$12,000				$12,000
11	EQUIPMENT								
	Vertical turbine Pumps and Appurtenances	EA	5	$76,500.00	$367,200				$367,200
	Blower	EA	3	$4,920.00	$14,760	40%		$5,904	$20,664
	Drill & Prep U-Tube Shaft	FT	115	$1,045.20	$120,198				$120,198
	Casing Material (Welded Steel, 1")	LB	52380	$2.00	$104,760				$104,760
	Install U-Tube Casing	FT	115	$60.00	$6,900				$6,900
	Install Bottom Plug (Concrete and Mortar)	CY	25	$450.00	$11,250				$11,250
	Pump Water from Shaft and Prepare Casing	LS	1	$31,500.00	$31,500				$31,500
	Bubble Collector and Appurtenances	EA	1	$9,600.00	$9,600				$9,600
	Diffusers	LS	1	$7,200.00	$7,200				$7,200
13	SPECIAL CONSTRUCTION								
	Pressure Gages/Transmitters	EA	2	$900.00	$1,800				$1,800
	Flow Meter	EA	2	$8,100.00	$16,200				$16,200
15	MECHANICAL								
	Air Supply Piping and Appurtenances	LF	250	$7.20	$1,800				$1,800
	Control Valve	EA	8	$1,800.00	$14,400				$14,400
	20" Pump control Valve	EA	8	$16,800.00	$134,400				$134,400
	Isolation Valves	EA	10	$8,400.00	$84,000				$84,000
	20" DIP	LF	92	$180.00	$16,470				$16,470
	30" DIP	LF	30	$270.00	$8,100				$8,100
	20" Flexible Piping	LF	180	$180.00	$32,400				$32,400
	Inner Piping system	LF	90	$450.00	$40,500				$40,500
	HDPE Diffuser Pipe	LF	2,400	$15.00	$36,000				$36,000
	Pressure Regulating Station	EA	12	$5,000.00	$60,000				$60,000
	Diffuser Supports	EA	240	$150.00	$36,000				$36,000
	Lateral Installation (Within Water Column)	LF	2,400	$94.00	$225,600				$225,600
16	ELECTRICAL AND INSTRUMENTATION								
	Supply	LS	1	$45,000.00	$45,000				$45,000
	Control systems and Instrumentation	LS	1	$30,000.00	$30,000				$30,000
	Control wiring	LS	1	$6,000.00	$6,000				$6,000
	SUBTOTAL								**$1,746,058**
	Contractor OH&P @ 15%								**$261,909**
	Subtotal								**$2,007,966**
	Planning Level Contingency @ 30%								**$602,390**
	Subtotal								**$2,610,356**
	Misc. Capital Costs								
	Legal and Fiscal Fees @ 15%								**$391,553**
	Engineering Fees Including CM @ 20%								**$522,071**
	Subtotal								**$913,625**
	Project Total								**$3,523,981**

APPENDIX G
Operation & Maintenance Cost Estimates for Flow Augmentation with Aeration

TABLE G.1

ANNUAL O&M COSTS FOR NORTH SIDE 100 MGD PUMP STATION - AERATED FORCEMAIN

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, I	3
INFLATION, J	3
PRESENT WORTH FACTOR	**19.42**

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	744.44	24	17866.7	$1,340.00	$326,067	19.42	$6,332,215
SUBTOTAL					**$326,067**		**$6,332,215**

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
LABOR - OPERATOR	2	8	16	$90.00	$350,400	19.42	$6,804,768
ELECTRICIAN	0	0	0	$159.50	$0	19.42	$0
SUBTOTAL					**$350,400**		**$6,804,768**

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES (assume 1% of Total PS costs)	60,000	5%			$3,000	19.42	$58,260
SUBTOTAL					**$3,000**		**$58,260**

TOTAL ANNUAL O&M	**$679,467**	
TOTAL PRESENT WORTH O & M COST		**$13,195,243**

TABLE G.2
ANNUAL O&M COSTS FOR NORTH SIDE U-TUBE 18 g/s AERATION SYSTEM

PRESENT WORTH FACTOR	
LIFE,N	20
INTEREST, i	3
INFLATION, j	3
PRESENT WORTH FACTOR	19.42

Energy Cost, $
Average $0.0750 $/kWh

ITEM	OPERATING (kW)	TIME OF OPERATION (hrs/day)	POWER USAGE (kw-hr/day)	ENERGY COST ($/day)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
OPERATIONS							
ENERGY - ELECTRICAL	20.07	24	481.8	$36.13	$8,792	19.42	$170,745
SUBTOTAL					**$8,792**		**$170,745**

	NO. OF OPERATORS (per day)	TIME (hrs/day/operator)	TOTAL TIME (hrs/day)	LABOR RATE ($/hr)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
MAINTENANCE							
ROUTINE MAINTENANCE							
Blowers	1	0.1	0.1	$90.00	$3,285	19.42	$63,795
Pumps	1	0.1	0.1	$90.00	$3,285	19.42	$63,795
LABOR - OPERATOR							
Blowers & Pumps	1	0.2	0.2	$90.00	$4,380	19.42	$85,060
ELECTRICIAN	1	0.05	0.05	$159.50	$2,911	19.42	$56,529
SUBTOTAL					**$13,861**		**$269,178**

	CONSTRUCTION COST OF NEW EQUIP. & PIPING ($)	% FOR ANNUAL PARTS AND SUPPLIES	NUMBER OF LAMPS REPLACED PER YEAR (UV ONLY)	COST PER LAMP ($)	ANNUAL COST ($)	PRESENT WORTH FACTOR	PRESENT WORTH ($)
PARTS AND SUPPLIES							
PARTS AND SUPPLIES	862,830	5%			$43,142	19.42	$837,808
SUBTOTAL					**$43,142**		**$837,808**

TOTAL ANNUAL O&M **$65,795**

TOTAL PRESENT WORTH O & M COST **$1,277,731**