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Evaluation of Physical Separation Alternatives

for the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System

TECHNICAL REPORT

TO THE GREAT LAKES COMMISSION
AND THE GREAT LAKES AND
ST. LAWRENCE CITIES INITIATIVE

HDR

Evaluation of Physical Separation Alternatives for the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System

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AC	advisory committee
AGO	America's Great Outdoors
AIS	aquatic invasive species
ANS	aquatic nuisance species
Ave.	avenue
BCC	bioaccumulative chemicals of concern
BEA	business economic area
BG	billion gallons
BNSF	Burlington Northern Santa Fe Railroad
BRC	Beltway Railway Company
Cal-Sag Channel	Calumet-Saganashkee Channel
CAWS	Chicago Area Waterway System
CAWS-ET	Rapid Evaluation Tool
CBA	cost and benefit analysis
CBOD	carbonaceous biochemical oxygen demand
CDOT	Chicago Department of Transportation
CDWM	Chicago Department of Water Management
CFR	Code of Federal Regulations
cfs	cubic feet per second
cfu	colony-forming units
CIP	capital improvement plan
CMAP	Chicago Metropolitan Agency for Planning
CN	Canadian National
COB	container on barge
CPRS	Canadian Pacific Rail System
CRCW	Chicago River Controlling Works
CREATE	Chicago Region Environmental and Transportation Efficiency
CRL	Chicago Rail Link
CSO	combined sewer overflow
CSS	Chicago South Shore and South Bend Railroad
CSSC	Chicago Sanitary and Ship Canal
CSXT	CSX Transportation
ct	count
CWA	Clean Water Act
d/s	downstream
DNA	deoxyribonucleic acid
DNR	Department of Natural Resources
DO	dissolved oxygen
DWP	Detailed Watershed Plan
EC	Executive Committee
EJ&E	Elgin, Joliet and Eastern Railway
EPA	Environmental Protection Agency
et al.	and other authors
GIS	geographic information system

GLC/CI	Great Lakes Commission/Great Lakes and St. Lawrence Cities Initiative
GLMRIS	Great Lakes and Mississippi River Interbasin Study
GLRC	Great Lakes Regional Collaboration Strategy
GM	geometric mean
I	Interstate
IAC	Illinois Administrative Code
IAIS	Iowa Interstate
IHB	Indiana Harbor Belt
IL	Illinois State Route
IPCB	Illinois Pollution Control Board
ISWS	Illinois State Water Survey
JWPP	Jardine Water Purification Plant
L&D	Lock and Dam
l/s	lakeside
LC	lead consultant
LIRI	Local Industrial Retention Initiative
MARAD	Maritime Administration
mg/L	milligrams per liter
MG	million gallons
MGD	million gallons per day
mL	milliliters
MP	mile point
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
N	nitrogen
N	north
N/A	not applicable
NDC	Navigation Data Center
NEPA	National Environmental Policy Act
NESP	Navigation and Ecosystem Sustainability Program
NETS	Navigation Economic Technologies Program
ng/L	nanograms per liter
NIRPC	Northwestern Indiana Regional Planning Commission
NO_2	nitrogen dioxide
NO_3	nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRDC	Natural Resource Defense Council
NS	Norfolk Southern
NS	North Shore
NSC	North Shore Channel
O&M	operation and maintenance
P	phosphorus
PAH	polyaromatic hydrocarbons
PCB	Pollution Control Board
PCB	polychlorinated biphenyls
PEC	probable effects concentration
$PM_{2.5}$	particulate matter 2.5 microns in diameter or less

PMD	planned manufacturing district
PPP	public-private partnership
PS	pump station
r/s	riverside
RAP	risk analysis process
RAPS	Racine Avenue Pump Station
RG	resource group
ROW	right-of-way
SG	stakeholder group
SMO	stormwater management ordinance
SROI	sustainable return on investment
St.	street
TARP	Tunnel and Reservoir Plan
TEU	twenty-foot equivalent unit
TIF	Tax Increment Financing
TIP	Transportation Improvement Program
TSS	total suspended solids
UPRR	Union Pacific Railroad
u/s	upstream
USEPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
USGS	United States Geological Survey
VE	value engineering
W	west
WPDES	Wisconsin Pollutant Discharge Elimination System
WRP	water reclamation plant
WTP	willingness to pay
WWTP	wastewater treatment plant
yr	year

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S. EXECUTIVE SUMMARY

The threat of Asian carp entering the Great Lakes is one of the highest-profile issues—both ecologically and economically—in the Great Lakes region. There are four species of Asian carp, but the bighead and silver carp have generated the most interest from the media, environmental and conservation groups, the fishing industry, the U.S. government and Congress, the eight Great Lakes states, Canada, and many other stakeholders. These two species of Asian carp have been migrating up the Mississippi River system since the early 1990s. In addition, the black carp was recently discovered in the lower Mississippi River and could be the most detrimental of all. The discovery of another carp species migrating northward, as well as the 39 high-risk aquatic invasive species (AIS) identified by the U.S. Army Corps of Engineers that could transfer between basins (USACE, 2011d), highlights the need for controlling the free movement of all AIS between the two basins.

The Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative (GLC/CI) have adopted policies in support of ecological separation with physical barrier(s) as the best long-term solution for preventing Asian carp and other AIS from freely invading the Great Lakes or Mississippi River basins via the Chicago Area Waterway System (CAWS). In a resolution approved in February 2010, the Great Lakes Commission called for ecological separation as the best long-term solution while recommending an immediate commitment by the federal government of significant resources to investigate and identify alternatives for existing uses of the CAWS. The Cities Initiative adopted a resolution on June 17, 2010 calling for the restoration of the natural divide between the two basins. This report presents a detailed investigation that identifies and evaluates separation alternatives along with plans for implementing those alternatives and installing barriers while maintaining or improving flood management, water quality, and transportation.

For the purposes of this report, *ecological separation* is defined as a physical barrier to prevent the free transfer of water and waterborne aquatic organisms via the CAWS. For clarity, this report uses the term *physical separation* or just *separation*.

A. BASELINE CONDITIONS

Baseline conditions were determined first to ensure that the projected levels of investment reflected those associated with separation. The baseline conditions used for this study are summarized in Table S-1 and represent activities that are in place, programmed, or authorized ("current and planned" conditions); activities that are most likely to occur within the period of the project but are not yet programmed or planned ("anticipated" conditions); and trends that are beyond the current limits of planning, technology, or regulations that could become a factor ("emerging" conditions).

Table S-1. Summary of Baseline Conditions

Area	Current and Planned	Anticipated	Emerging
Flood Management	• Tunnel and Reservoir Plan (TARP) completed • Green infrastructure (as part of flood management programs/ordinances) • U.S. Army Corps of Engineers (USACE) Little Calumet River Flood Control Project • Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) Recommended Flood Control Project from Detailed Watershed Plans	• Improved local/regional conveyance to TARP	• N/A
Water Quality	• Disinfection at North Side and Calumet Wastewater Treatment Plants (WWTP)	• Disinfection at Stickney WWTP • Some level of nutrient removal at North Side, Calumet, and Stickney WWTPs (minimum level of assumed moderate Mississippi River standards, see Part II.D.2)	• Constituents not currently regulated for WWTPs • Remediation of contaminated sediments
Transportation	• Panama Canal expansion • Chicago Park District harbor improvements • Programmed road improvements • Chicago Region Environmental and Transportation Efficiency (CREATE Rail) • Chicago–St. Louis High-Speed Rail	• *GO TO 2040* Regional Projects • Illiana Expressway	• N/A
AIS Controls	• Continuation of ongoing and emerging programs and efforts for implementing AIS-control measures (for example, electric barrier, Great Lakes and Mississippi River Interbasin Study [GLMRIS], additional research)		

B. Barrier Types and Examples

Although other technologies might exist for ecological separation, this study considers only physical barriers. The barrier would be a physical structure that is water-impermeable, and the barrier type would vary by location. The impermeable barrier structures were assumed to be one of the following four types: (A) sheet pile, (B) land bridge (earthen fill, concrete, seawall, etc.) with no industrial cargo transfer, (C) land bridge (earthen fill, concrete, seawall, etc.) with industrial cargo transfer, and (D) constructed barrier (earthen fill, concrete, seawall, etc.) with intermodal facility. All barrier types could accommodate limited recreational vessel transfers.

At some locations, a one-way barrier (with additional AIS control measures) was considered as a temporary measure to provide limited separation while improvements are constructed. Ultimately, the size of the waterway, the flow regime, commercial shipping, and recreation were used to determine feasible barrier types for each potential barrier location.

Figure S-1 and Figure S-2 show conceptual renderings of land bridge barriers that would include recreational boat transfer and disinfection; barge, ship, and rail commodity transfer; land-use opportunities; and other infrastructure improvements.

Figure S-1. Conceptual Rendering of South Branch Barrier

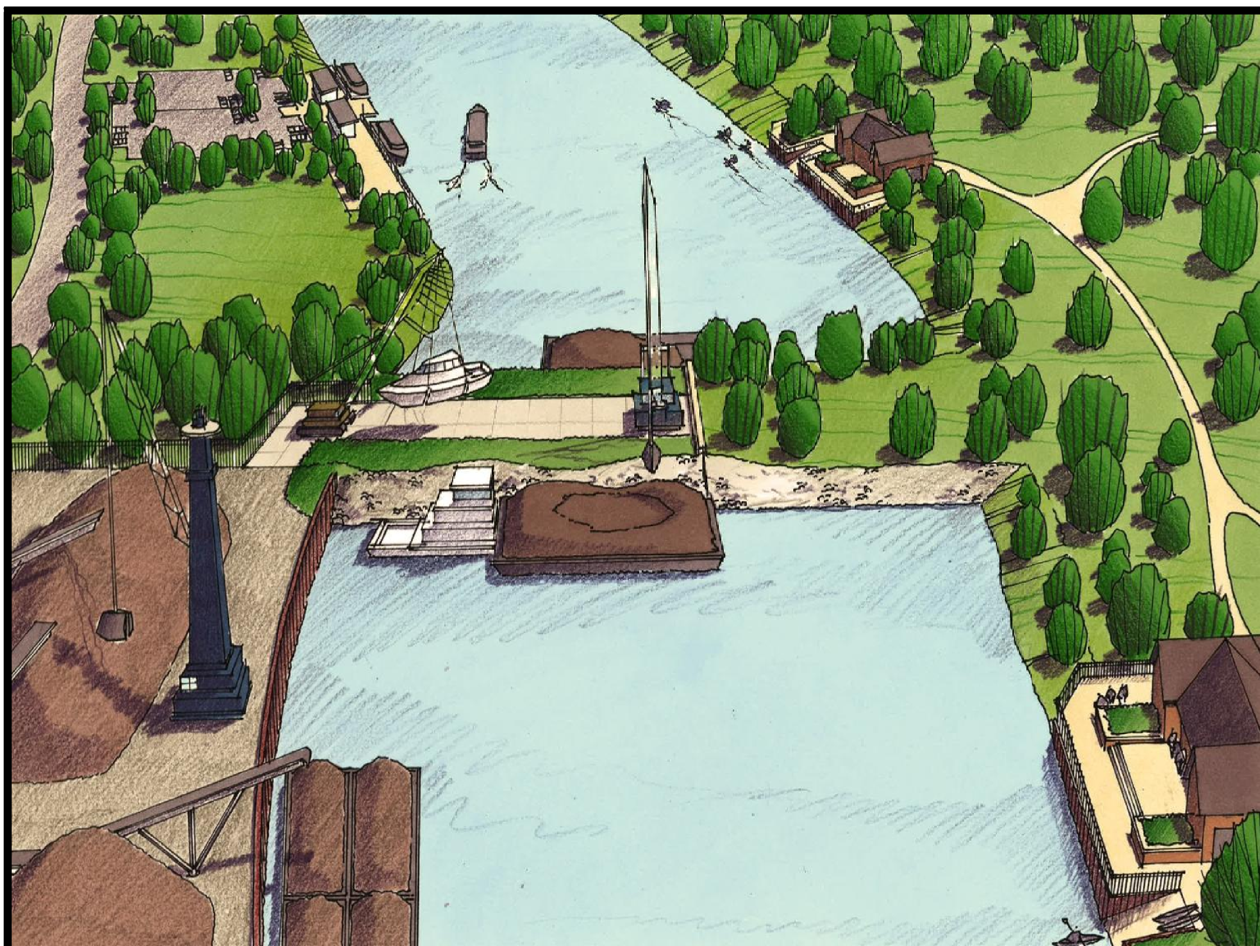


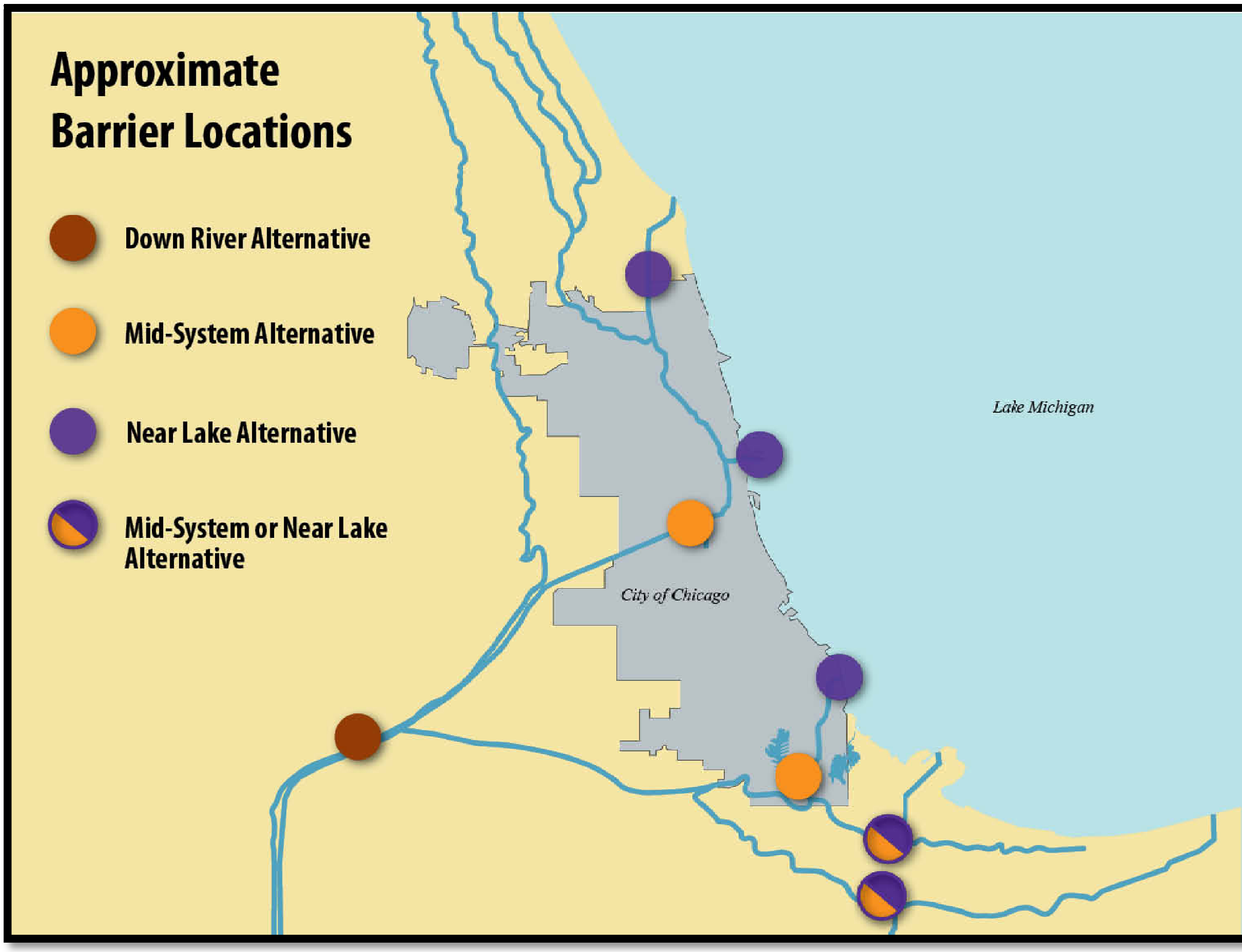
Figure S-2. Conceptual Rendering of Lake Calumet Port Terminal

C. Evaluation of Alternatives

This study evaluated placing barriers to prevent the free movement of AIS between the Illinois River and Lake Michigan through the CAWS with broader goals of maintaining or improving flood management, water quality, and transportation. After analyzing 20 potential barrier locations, three separation alternatives (Figure S-3) using one or more of those locations were chosen for detailed analysis. The three alternatives chosen were a **Down River Alternative**, a **Mid-System Alternative**, and a **Near Lake Alternative**; the names refer to each alternative's proximity to Lake Michigan.

The alternatives illustrate the range of complexities and improvement opportunities associated with separation that result when barriers are placed at different locations in the CAWS. The actual barrier locations described in these alternatives are approximate and are intended to illustrate the range of issues that would result from placing barriers at different locations in the CAWS. Further, it is possible that a barrier location for a given alternative could be substituted with a barrier location from a different alternative.

Figure S-3. Potential Separation Alternatives



1. Down River Alternative

The Down River Alternative consists of placing a single physical barrier between the Lockport Lock and Dam and the confluence of the Cal-Sag Channel and the CSSC (Figure S-3). The Down River Alternative addresses the broader goals of the GLC/CI by enhancing flood management, improving the quality of WWTP effluent discharges, and developing new intermodal connections. It is anticipated that, upon addressing all permitting and regulatory issues, a one-way AIS barrier could be in place by 2022 and a barrier providing complete separation by 2029.

Flood management would be improved by constructing additional tunnel, piping, and pumping infrastructure to provide additional flood water conveyance. In addition, allowing flood water to flow into Lake Michigan would increase the number of conveyance release points from one downriver constriction point to three lakeside locations. The baseline assumption for this alternative includes completing TARP by 2029, which is assumed to address the majority of flood and combined sewer overflow (CSO) issues. Green infrastructure and sewer separation investments would help reduce flood water inflows, and floodplain storage would provide additional stormwater storage.

Water quality would be improved by upgrading the three WWTPs that discharge to the CAWS, since effluent discharges would need to be compliant with Lake Michigan water quality standards. Building green infrastructure would also positively affect water quality by capturing stormwater contaminants.

Transportation improvements would include enhanced waterborne traffic and improved distribution of commodities with the addition of a central hub that would include rail, truck, and barge transfer.

2. Mid-System Alternative

The Mid-System Alternative would require four barriers to separate the two basins (Figure S-3). The Mid-System Alternative addresses the broader goals of the GLC/CI initiative by enhancing flood management, improving the quality of the North Side WWTP effluent discharge, and improving transportation to capture emerging opportunities for increased container traffic. It is anticipated that, upon addressing all permitting and regulatory issues, a one-way AIS barrier could be in place by 2022 on the Chicago River System, and a barrier providing complete separation could be in place by 2022 and 2029 on the Calumet River and Chicago River Systems, respectively.

Flood management would be improved by adding conveyance from the CAWS to Lake Michigan at the Wilmette Pump Station and the Chicago Control Works through the operation of these facilities as "default open." The baseline assumption for this alternative includes completing TARP by 2029, which is assumed to address the majority of flood and CSO issues. Green infrastructure and sewer separation investments would help reduce flood water inflows, and floodplain storage would provide additional stormwater storage.

Water quality would be improved by upgrading the North Side WWTP to meet Lake Michigan water quality standards. Building green infrastructure would also positively affect water quality by capturing stormwater contaminants.

Transportation improvements would include enhanced freight movement with the construction of a commodity transfer site that would include additional barge, ship, rail, and truck transfer infrastructure. In addition, the emerging container market could be enhanced by integrating barge, ship, rail, and truck facilities at this location.

3. Near Lake Alternative

The Near Lake Alternative would require five barriers to separate the two basins (Figure S-3). The Near Lake Alternative addresses the broader goals of the GLC/CI by increasing flood management, improving Lake Michigan water quality, and improving transportation opportunities. It is anticipated that, upon addressing all permitting and regulatory issues, separation barriers could be in place by 2026 on the Calumet River System and by 2029 on the Chicago River System.

Flood management would be improved by constructing additional tunnel, piping, and pumping infrastructure to provide additional flood water conveyance, as well as adding additional reservoir storage capacity. The baseline assumptions of this alternative include completing TARP by 2029, which will address the majority of flood and CSO issues. Green infrastructure and sewer separation investments would help reduce flood water inflows, and floodplain storage would provide additional stormwater storage.

Water quality would be positively affected by building green infrastructure to capture stormwater contaminants.

Constructing a new in-lake port and harbor would increase freight movement and shipping because the infrastructure for the different modes of transportation (truck, rail, barge, and ship) would be modernized.

D. Economic Analysis

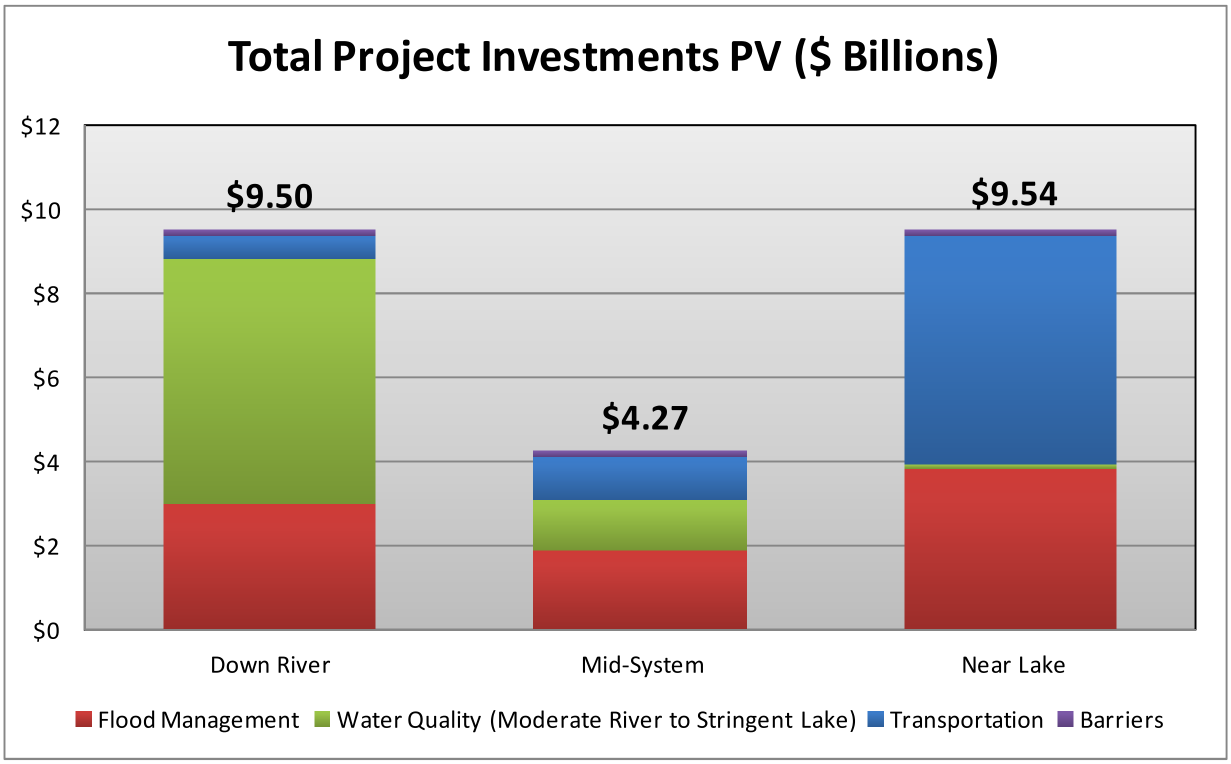
The three alternatives were subjected to an economic analysis. Figure S-4 summarizes the investments over and above those for the baseline conditions for each alternative. The actual cost of the barriers under all three alternatives is in the range of $100 million to $150 million (depending on the number and type of barriers required for each alternative), which constitutes a small percentage of the total investment for each alternative.

The investments varied with each alternative due to the wide-ranging costs of infrastructure proposed as opportunities to improve the CAWS and the elements to address challenges that result from placing barriers. The Down River Alternative was the most expensive ($3.94 billion to $9.54 billion) due largely to WWTP upgrades, followed by the Near Lake Alternative ($9.5 billion), which includes major investments for constructing a new in-lake harbor and port. The Mid-System Alternative was the most cost-effective alternative ($3.26 billion to $4.27 billion) in terms of infrastructure investments.

The range in estimated investments for the Down River and Mid-System Alternatives is a result of the variation assumed for WWTP upgrades between the Stringent River (Standards) to Stringent Lake (Standards) Scenario and the Moderate River to Stringent Lake Scenario. Based on the best available information at the time of this study, the most likely scenario for WWTP upgrades (that is, the upper bound of investments presented) was assumed to be the Moderate River to Stringent Lake Scenario, which is presented in Figure S-4.

The alternative investment estimates represent median present value lifecycle costs using a 3% discount rate. Flood management costs include all investments associated with sewer separation, floodplain storage, tunnels, conveyance, and green infrastructure; water quality costs include investments associated with the upgrades of the Calumet, North Side, and Stickney WWTPs and flow augmentation; and transportation costs include all investments associated with new port development, facilitating cargo transfer over the barrier, lifting and disinfecting recreational boats, new dry dock facilities, and intermodal facilities. In addition to the infrastructure investments described above, separation would require extra handling of cargo and would likely shift some cargo to other modes, thereby incurring economic costs of up to $1.5 billion over the nearly 50-year project lifecycle.

Figure S-4. Total Project Investments, Present Value in Billions of Dollars



The magnitude of the benefits of reduced AIS risk and damage is not easily quantifiable based on the data that is currently available. However, basic scenario or "case study" analysis demonstrates that these benefits, even for preventing a single AIS transfer, could be as much as $5 billion over 30 years. These estimates are derived from historical data on the impact of AIS such as sea lamprey, zebra mussel, and transportation-borne AIS in the Great Lakes. Furthermore, the level of analysis and modeling associated with this study did not provide specific measures to allow the team to quantify the benefits of improved water quality conditions and a more resilient flood-management system.

Based on the estimated project investments for each alternative, projections were made for what society (households) would have to be willing to pay annually to at least cover the investments associated with separation. The analysis reveals that households in the Great Lakes basin would have to be willing to pay, on average, about $1 a month or $11.14 annually from now through 2059 for the Mid-System Alternative (assuming that the Moderate River to Stringent Lake Scenario is the most likely WWTP upgrade scenario). If the Mississippi River basin is included as well, households would have to be willing to pay about $0.33 a month (or $3.97 annually). While it is not known at this time whether households are willing to pay these amounts for AIS risk reduction, these estimates provide a reference point for future discussion, public education and outreach, and additional studies to better quantify the impacts of AIS if they become established.

E. Conclusions

In conclusion, this study:

- Establishes that physical separation can be accomplished.
    - Identifies possible locations and options (alternatives) for physical barriers to prevent the free movement of Asian carp and other AIS between the Great Lakes and the Mississippi River basins via the CAWS.
- Documents the existing challenges for the CAWS.
    - Describes separation alternatives that can maintain or enhance flood management, water quality, and transportation for the CAWS.
- Supports a holistic vision for the CAWS.
    - Identifies the benefits, challenges, and investments that are needed to install physical barriers to separate the Great Lakes basin from the Mississippi River basin while presenting the needed synergistic improvements to flood management, water quality, and transportation.
- Demonstrates that separation can be started now, through a phased approach.
    - Identifies opportunities for components of an overall approach to separation that can be built into existing and planned capital-improvement projects.
    - Recognizes the need and value of maintaining and operating the existing electrical barriers while the one-way barriers are implemented along with the monitoring and rapid response planning that have been conducted by state and federal agencies.

- Identifies political and institutional barriers that can be overcome to start the separation process.

This study has shown that separation can be accomplished and that it can be done in a way that maintains or improves other uses of the CAWS. A robust land-use planning process, continued stakeholder and agency engagement, and financing evaluations can advance the current work toward realizing the vision of separating the Mississippi River and Great Lakes basins while maintaining or improving the flood management, water quality, and transportation systems of the CAWS for the 21st century.

I. INTRODUCTION

A. BACKGROUND OF THE STUDY

As part of the initiative **Envisioning a Chicago Area Waterway System for the 21st Century,** led by the Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative (GLC/CI), a study was conducted to develop alternatives for separating the Great Lakes basin from the Mississippi River basin in the Chicago area to prevent the spread of Asian carp and other aquatic invasive species (AIS) while also maintaining or enhancing other beneficial uses of the waterway system. This report documents the findings of this study. This report:

- Establishes that physical separation can be accomplished.
  - Identifies possible locations and options (alternatives) for physical barriers to prevent the free movement of Asian carp and other AIS between the Great Lakes and the Mississippi River basins via the Chicago Area Waterway System (CAWS).
- Documents the existing challenges for the CAWS.
  - Describes separation alternatives that can maintain or enhance flood management, water quality, and transportation for the CAWS.
- Supports a holistic vision for the CAWS.
  - Identifies the benefits, challenges, and investments that are needed to install physical barriers to separate the Great Lakes basin from the Mississippi River basin while presenting the needed synergistic improvements to flood management, water quality, and transportation.
- Demonstrates that separation can be started now, through a phased approach.
  - Identifies opportunities for components of an overall approach to separation that can be built into existing and planned capital-improvement projects.
  - Recognizes the need and value of maintaining and operating the existing electrical barriers while the one-way barriers are implemented along with the monitoring and rapid response planning that have been conducted by state and federal agencies.
  - Identifies political and institutional barriers that can be overcome to start the separation process.

The GLC/CI have adopted policies in support of ecological separation as the best long-term solution for preventing Asian carp and other AIS from freely invading the Great Lakes or Mississippi River basins via the CAWS. In a resolution approved in February 2010, the Great Lakes Commission called for ecological separation as the long-term solution while recommending an immediate commitment by the federal government of significant resources to investigate and identify alternatives for existing uses of the CAWS. The Cities Initiative adopted a resolution on June 17, 2010 calling for the restoration of the natural divide between the two basins. This report presents a detailed investigation that identifies and evaluates separation alternatives along with plans for implementing those alternatives and installing barriers while maintaining or improving flood management, water quality, and transportation.

For the purposes of this report, *ecological separation* is defined as a physical barrier to prevent the free transfer of water and waterborne aquatic organisms via the CAWS. For clarity, this report uses the term *physical separation* or just *separation*.

The threat of Asian carp (Figure I-1) entering the Great Lakes is one of the highest-profile issues—both ecologically and economically—in the Great Lakes region. There are four species of Asian carp present in the United States, but the bighead and silver have generated the most interest from the media, environmental and conservation groups, the fishing industry, the U.S. federal government and Congress, the eight Great Lakes states, Canada, and many other stakeholders. These two species of Asian carp have been migrating up the Mississippi River system since the early 1990s. In addition, black carp was recently discovered in the lower Mississippi River and could be the most detrimental of all. The discovery of another carp species migrating northward, as well as the 39 high-risk AIS identified by the USACE that could transfer between basins (USACE, 2011d), highlights the need for controlling the free movement of all AIS between the two basins.

State and federal agencies have tried to prevent Asian carp from migrating from the Mississippi River basin to the Great Lakes basin by maintaining electrical barriers, implementing an intensive monitoring program, and applying a piscicide (rotenone) to prevent Asian carp from migrating via the Chicago Sanitary and Ship Canal (CSSC). Despite these preventive measures, water samples have shown the presence of Asian carp DNA on the Great Lakes side of the barrier. Because of this, there has been increasing pressure from various stakeholders, including environmental groups and Great Lakes states, to permanently separate the two basins.

Figure I-1. Asian Carp

Source: Asian Carp Regional Coordinating Committee, 2011

As the potential for the transfer of Asian carp and other AIS between the Mississippi River and the Great Lakes basins increases, the need to prevent the negative economic and biological impacts of this transfer has also increased. The potential effects of an Asian carp invasion on the $7 billion Great Lakes fishing industry (White et al., 2004) are of great concern to the GLC/CI and many stakeholders throughout the region. Historically, AIS that have originated in the Great Lakes (such as the zebra mussel) have migrated throughout the Mississippi River basin and beyond, causing adverse impacts to water intakes and supply pipes as well as to native mussels, ecosystems, water quality, and recreation. This latest threat is coming from the other direction, against the flow of the river, toward the Great Lakes.

With $2 million from six regional funders, the GLC/CI is leading this study to analyze a wide range of issues associated with physical separation as a potential solution to the AIS threat and to identify improvements to the CAWS that could be implemented in conjunction with the separation alternatives. The six funders supporting the project are the Joyce Foundation, the C.S. Mott Foundation, the Great Lakes Fishery Trust, the Great Lakes Protection Fund, the Wege Foundation, and the Frey Foundation.

B. Purpose of the Study

The purpose of this study is to define the benefits, challenges and needed investments associated with alternatives for physically separating the Mississippi River and the Great Lakes basins while at the same time evaluating opportunities to maintain or enhance flood management, water quality, and transportation in the CAWS. The need for improvement in each of these three functions is described below.

- *Flood Management:* The Chicago area experiences frequent floods in streets and residential areas as well as backups in sanitary sewer lines that cause basement flooding. This flooding is caused by the limited capacity of sewer pipes, the amount of impervious cover in the area, the hydraulic capacity of the various CAWS channels, and water levels in Lake Michigan. The watershed of the CAWS contains both separated and combined sewer systems. Excess floodwater combined with sewage creates both water quality and public health concerns. This report presents alternatives for separation in the context of addressing these concerns. The separation alternatives include improvements to reduce the risk of overbank flooding, combined sewer overflows (CSOs), and backflows of CSO discharges to Lake Michigan.
- *Water Quality:* Wastewater treatment effluents, CSOs, and urban runoff all contribute to degraded water quality in the CAWS. The three major wastewater treatment plants (WWTPs) that discharge treated effluent to the CAWS will require upgrades to remain compliant with future water quality standards. The sewage collection system also needs major investments and upgrades. The collection system, which includes 263 combined sewer outfalls that discharge to the CAWS, begins to produce CSOs with individual storm

rainfall volumes of 0.67 inch; and rainfall events above 1.5 inches require use of TARP and result in substantial CSOs (NRDC, 2010b). Any alternatives to separate the Great Lakes and the Mississippi River basins must address these shortcomings that impair water quality in the CAWS.

- *Transportation:* The total bulk freight tonnage for Chicago-area locks has been declining for the past several years and will likely continue, given current market conditions. Most freight in the Chicago area is carried by truck and rail. Today, waterborne transportation makes up about only 3% of freight movements in the region. Most freight carried on the water is relatively heavy, bulk commodity goods whose delivery is not time sensitive (CMAP, 2010). Improvements to CAWS infrastructure, specifically to the Lockport, T.J. O'Brien, and Chicago Locks, have lagged behind investments in roads and rail. With the impending opening of an enlarged and improved Panama Canal, the Chicago region has an opportunity to attract additional freight to the area and become a primary hub for conveying waterborne freight. This report presents alternatives for separation that can preserve the existing use of the CAWS so that waterborne shipping and recreational, commercial, and cargo travel can benefit from the full use of the Chicago-area transportation network.

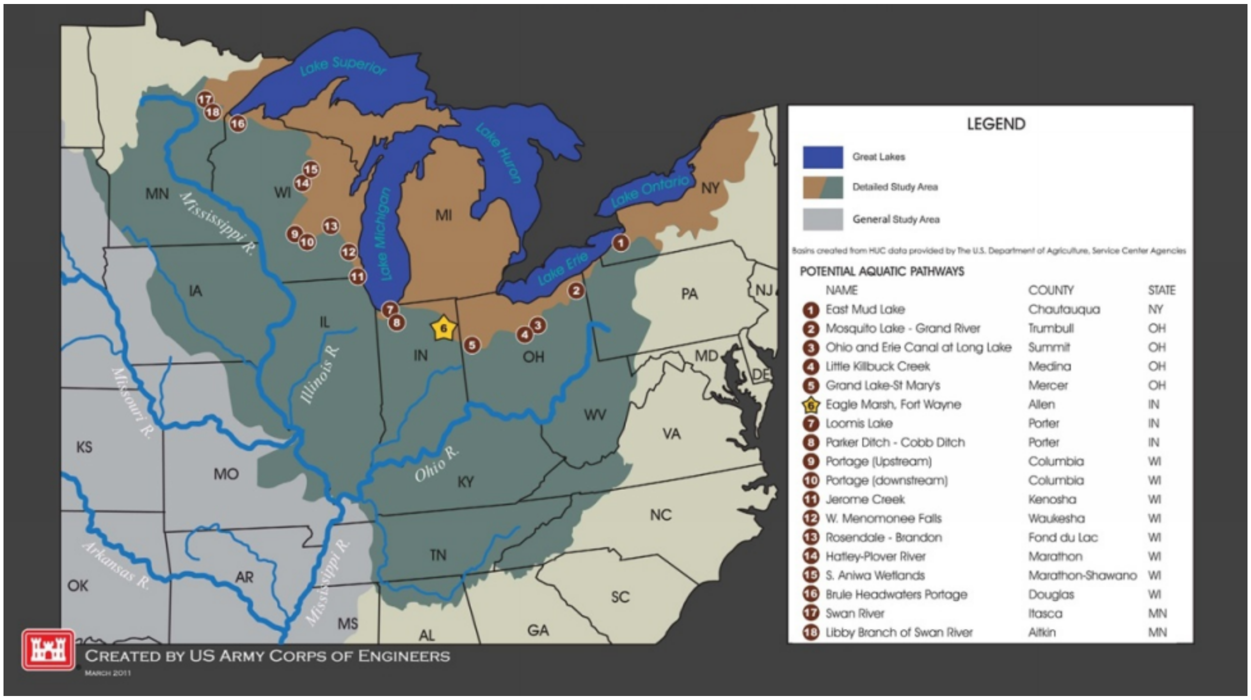
Numerous federal, state, and local agencies, as well as the public and diverse stakeholders, have identified the need for improvement in the three functions of the CAWS discussed above. However, there is no governance and funding framework to systematically address these needed improvements. This report identifies a broad range of challenges to barrier placement, opportunities for improvement of the CAWS, and investments that are needed to successfully separate the Great Lakes and the Mississippi River basins in the CAWS. This report is intended to inform the political, social, and regulatory discussions necessary to take effective action to address AIS prevention in the context of these critically needed improvements in the CAWS.

C. Other Studies

The USACE is conducting the Great Lakes and Mississippi River Interbasin Study (GLMRIS) to explore a broad range of options and technologies, including physical separation, that could be applied to prevent the transfer of aquatic nuisance species (ANS) between the Great Lakes and the Mississippi River basins through aquatic pathways. One of the objectives of the GLC/CI project and this technical report is to support and inform the GLMRIS.

The initial results of the GLMRIS have identified a list of ANS that could transfer between the Great Lakes and the Mississippi River basins. A total of 39 high-risk species have been identified that could transfer between the two basins via the CAWS (USACE, 2011d). Of these species, 10 are high risk for transferring to the Great Lakes basin from the Mississippi River basin and 29 are high risk for transferring to the Mississippi River basin from the Great Lakes basin. The report notes that these 39 species are likely to have a moderate to severe impact on the basin being invaded. Another report identified 18 connections between the two basins (Figure I-2), but this number is likely to be reduced upon further evaluation (USACE, 2010). These results demonstrate that the threat of AIS transfer is real and not limited to Asian carp.

Figure I-2. Other ANS Pathways



The GLMRIS recently released a baseline assessment of existing cargo traffic on the CAWS based on lockage data only. The report is limited to barge traffic and does not include data with respect to laker vessels that traverse the CAWS' deep draft channels. The data in the GLMRIS assessment confirms the validity of the data used in this study with respect to trends, commodities, and directional travel on the CAWS. The historic lockage information reflects a flat to declining trend for cargo traffic on the CAWS for nearly the past two decades. Coal is the largest commodity shipped (26% of all shipments by weight), and most barges are headed upbound toward the Chicago area, Lake Michigan, and steel producers at Indiana Harbor and Burns Harbor in Indiana. Of particular interest is the fact that 28% of all CAWS traffic never leaves the CAWS and 87% of this traffic does not pass through any lock at all (USACE, 2011a).

While the GLC/CI study is concerned with physical separation only, other studies have addressed the use of technology to restrict the movement of AIS. Studies such as *Feasibility Study to Limit the Invasion of Asian Carp into the Upper Mississippi River Basin* (FISHPRO, 2004) and *Preliminary Feasibility of Ecological Separation of the Mississippi River and the Great Lakes to Prevent the Transfer of Aquatic Invasive Species* (Brammeier et al., 2008) include discussion of both separation and non-separation technologies that could reduce the risk of AIS movement. As part of the GLMRIS, USACE recently published the paper *Inventory of Available*

Controls for Aquatic Nuisance Species of Concern – Chicago Area Waterway System, which identified a range of options or technologies available to prevent transfer via the CAWS for the 39 high-risk ANS previously identified (USACE, 2011d). Some of the controls described include those that modify flow within a waterway, such as physical separation of the basins; those that modify the water quality of a waterway; chemical applications; and collection and removal of ANS from a waterway. Physical separation of the basins was one of the few options or technologies that would be applicable to all ANS.

While the use of non-separation technologies to address AIS is feasible under certain circumstances, these technologies have limitations compared to physical separation. These limitations are expressed in terms of risk tolerance or percentage of effectiveness and are linked to operational maintenance. Some of the technologies reported in the literature are electrical barriers, screening (rotating drums or traveling screens), floating curtains, acoustic deterrents (air cannons and sound projection), air bubble curtains, strobe lighting, and a combination of these technologies. Each of these technologies can restrict the movement of some species of AIS via free-flowing water at various life stages, but they will not deter or restrict *all* AIS movement. Preventing the movement of water between the Mississippi River and the Great Lakes basins can reduce the risk of transferring AIS via free-flowing water to essentially zero. Physical separation provides a reliable AIS risk-reduction strategy for a wide range of AIS species and life stages.

D. Description of the Study

The first step in the study process was to gather and evaluate existing data related to the CAWS to establish baseline conditions for physical separation. Next, potential locations for physical separation (that is, where to place barriers) were identified, evaluated and ultimately developed into three alternatives for physical separation with associated enhancement of the CAWS. This process involved engaging stakeholders; engineering and environmental consultants; and local, state, and federal agencies. The GLC/CI led a series of interactive meetings, seminars, and technical sessions that included input from an Advisory Committee (AC) and a panel of peer reviewers. Once developed, these three alternatives were then subjected to an economic analysis.

In keeping with that methodology, this report describes the study baseline conditions for the CAWS, the process that was used to develop and analyze alternatives, the detailed evaluation of alternatives, the economic analysis of the three alternatives, and the findings of the study. It will serve as a useful tool to develop and realize a vision for the future of the CAWS. The product of this study is a report, and the key result is impetus for strategic discussions and actions on the future of environmental, transportation, and economic functions of the CAWS.

II. Baseline Conditions

In 1889, when the Illinois state legislature created the Sanitary District of Chicago, a process began that created the CAWS as it is known today. Today, leaders are calling for the city of Chicago and the greater community to rediscover the CAWS as a treasured asset. The GLC/CI proposes to enhance this vision by demonstrating that restoring the natural divide with physical separation barriers between the Great Lakes and Mississippi River basins is feasible and is the best way to restrict the waterborne movement of AIS through the CAWS. This enhanced vision with physical separation barriers can be accomplished in a way that prompts necessary investments to maintain or improve the flood management, water quality, and transportation functions of the CAWS.

In 1900, technologies did not exist to treat all of the pollutants discharged into the CAWS. Diverting the Chicago River was the solution to the threat posed by the continued degradation of Lake Michigan and the drinking water it supplied to the rapidly growing city of Chicago. Today, technology exists to allow high-quality, treated effluent to return to Lake Michigan, thereby making separation possible.

However, current problems still exist in the CAWS that must be resolved. Flood management, water quality, and transportation conditions remain degraded and in need of investments. The full potential of the CAWS has not been realized because the system has been devoted almost exclusively to conveying wastewater and stormwater as well as to industrial and commercial transportation. The following section establishes a reasonable baseline from which to evaluate the benefits and challenges that separation would entail for the CAWS.

Baseline conditions without a separation project (that is, “without project conditions”) must be established in order to determine and compare the impacts, improvements, required investments, and benefits associated with a separation project. This section summarizes the data collection process for developing baseline conditions as well as the elements and assumptions that make up the baseline conditions.

In order to represent the uncertainty in future conditions, baseline conditions are categorized as (1) current and planned, (2) anticipated, or (3) emerging. *Current and planned conditions* represent activities that are either in place, programmed, or authorized for completion. *Anticipated conditions* represent activities that are most likely to occur within the period of the separation project but that lack formal approval or authorization and for which the actual timeframe and specific details are unknown. *Emerging conditions* represent trends beyond the current limits of planning, technology, or regulation that could be a factor in the future. A brief summary of CAWS baseline conditions is provided below and summarized in Table II-1, and more detailed technical information is provided in Appendix A.

Table II-1. Summary of Baseline Conditions

Area	Current and Planned	Anticipated	Emerging
Flood Management	• TARP completed • Green infrastructure (as part of flood management programs/ordinances) • USACE Little Calumet River Flood Control Project • MWRDGC Recommended Flood Control Project from Detailed Watershed Plans	• Improved local/regional conveyance to TARP	• N/A
Water Quality	• Disinfection at North Side and Calumet WWTPs	• Disinfection at Stickney WWTP • Some level of nutrient removal at North Side, Calumet, and Stickney WWTPs (minimum level of assumed moderate Mississippi River standards, see Part II.D.2)	• Constituents not currently regulated for WWTPs • Remediation of contaminated sediments
Transportation	• Panama Canal expansion • Chicago Park District harbor improvements • Programmed road improvements • CREATE Rail • Chicago–St. Louis High-Speed Rail	• *GO TO 2040* Regional Projects • Illiana Expressway	• N/A
AIS Controls	• Continuation of ongoing and emerging programs and efforts for implementing AIS-control measures (for example, electric barrier, GLMRIS, additional research)		

A. History and Background of the CAWS

The conditions in the Chicago region before Euro-American settlement included flat topography and many swamps. The Chicago River System was a low-gradient river that was narrow, shallow, and bordered by woodlands and tall-grass prairies (Figure II-1). A sub-continental drainage divide separated the Mississippi River basin from the Great Lakes basin (Figure II-2). This natural divide is located in the vicinity of what is now South Harlem Avenue. Historically, during the spring, a large slough (known as Mud Lake) occasionally allowed a water connection between the Des Plaines River and Lake Michigan via what was then known as the West Fork of the Chicago River.

Figure II-1. Pre-settlement Vegetation

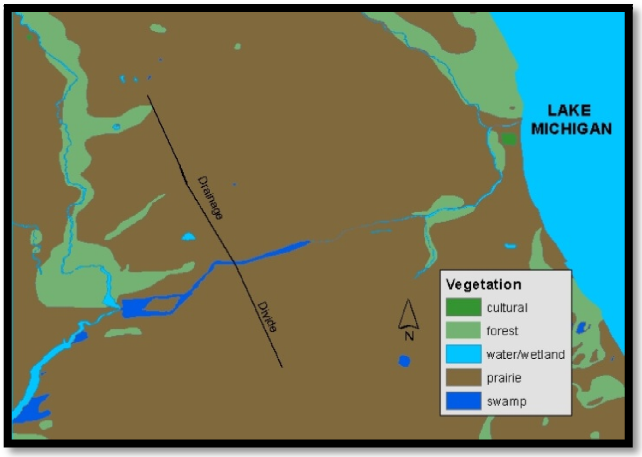
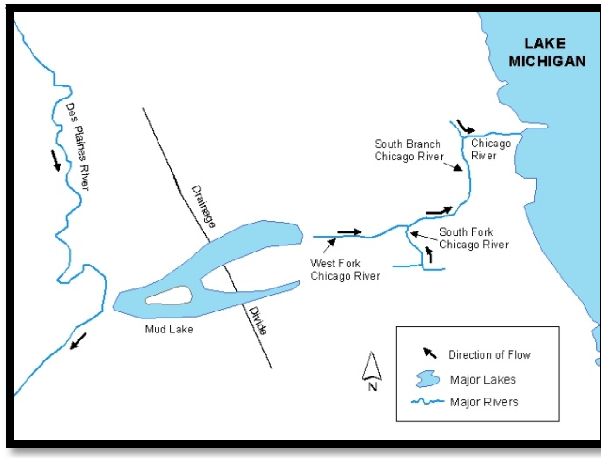


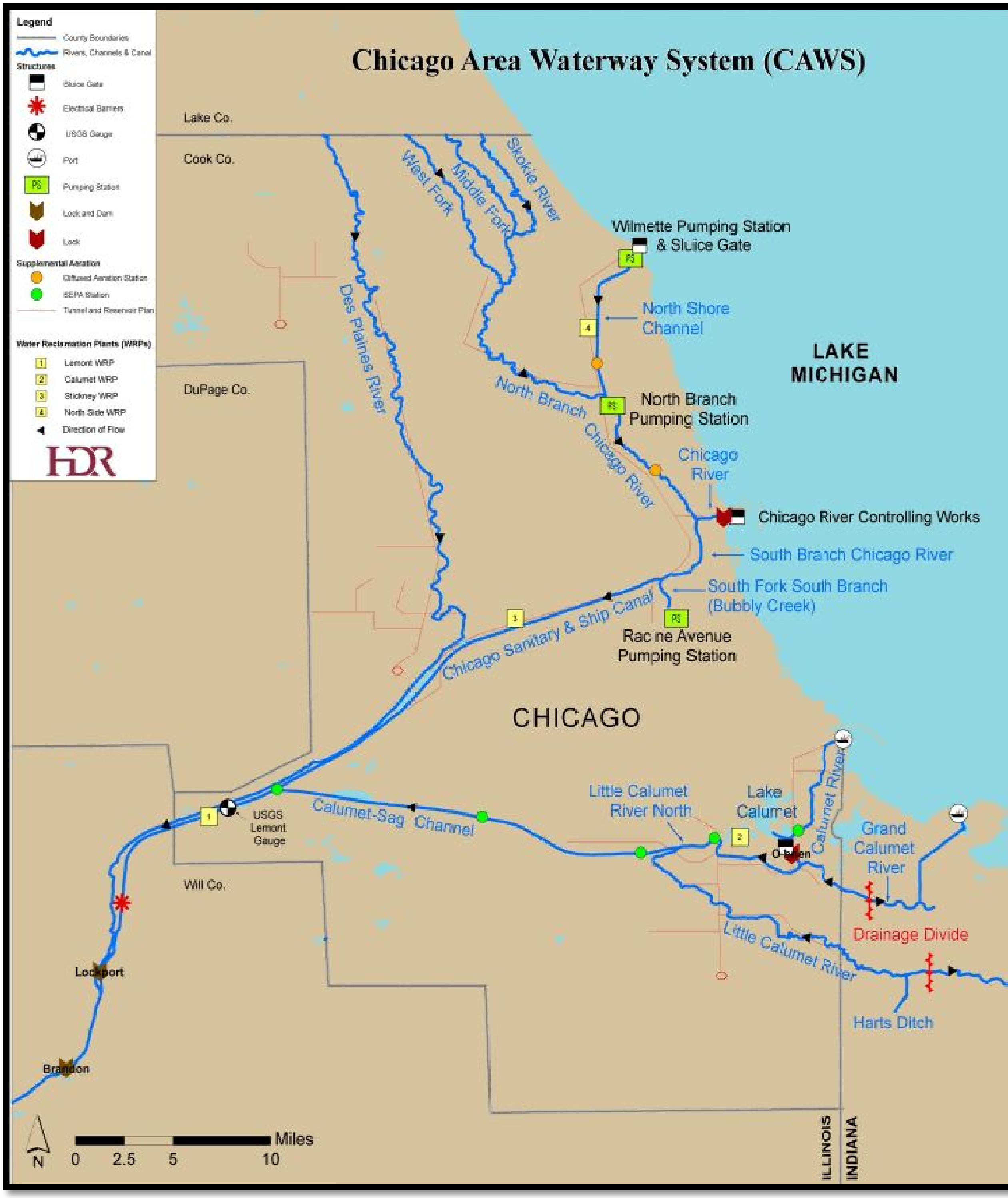
Figure II-2. Pre-settlement Hydrology



Early Euro-American settlers used Chicago-area waterways for drinking water, food, safe harbor, and transportation. As the city of Chicago rapidly developed between 1860 and 1900, wetlands and swamps were drained and were replaced by paved surfaces. In addition, the North and South Branches of the Chicago River became home to multiple industries. As a result of intense urban development, peak flood water flows intensified, and untreated sewage from the greater metropolitan area was discharged to local waterways that flowed into Lake Michigan. Since Lake Michigan was the primary source of drinking water for Chicago-area residents, the untreated wastes contaminated drinking water in the lake, causing a substantial increase in waterborne diseases between 1865 and 1885.

The Sanitary District of Chicago was formed in 1889 (now known as the Metropolitan Water Reclamation District of Greater Chicago, or MWRDGC). MWRDGC was charged with developing a long-term plan to protect Chicago's drinking water source (that is, Lake Michigan). A key component of the plan was constructing three waterways that reversed the flow of the North and South Branches of the Chicago River and the Calumet and Little Calumet rivers away from Lake Michigan and diverted the water, including sewage, downstream into the Illinois and Mississippi rivers. Construction of the Chicago Sanitary and Ship Canal (CSSC), the North Shore Channel (NSC), and the Cal-Sag Channel was completed in 1900, 1910, and 1922, respectively. These canals and channels, together with the Chicago, Calumet, and Little Calumet rivers, are collectively known as the CAWS, shown in Figure II-3.

Figure II-3. Chicago Area Waterway System (CAWS)



Once the CAWS was completed, raw sewage, industrial waste, and urban flood waters from the Chicago area were directed away from Lake Michigan. Locks were constructed at the Chicago

River Control Works (CRCW, at the mouth of the Chicago River at Lake Michigan) and at T.J. O'Brien Lock to allow barge traffic to move from the CAWS to Lake Michigan. In addition, the Wilmette Pump Station and Sluice Gates were constructed. Gates at the locks and pump stations control the flow of Lake Michigan water into the CAWS and the Mississippi River basin in order to augment low flows and improve water quality (discretionary diversion).

This system of canals and locks allows the free movement of water from the Great Lakes basin to the Mississippi River basin. It has also created an aquatic pathway for AIS in both directions. After the CAWS was constructed, water was allowed to be diverted from Lake Michigan to the Mississippi River via the Illinois Waterway System. The amount of flow is currently regulated based on a U.S. Supreme Court consent decree that allows no more than 3,200 cubic feet per second (cfs) annually over a 40-year period to be diverted from Lake Michigan into the CAWS (U.S. Supreme Court, 1980). Appendix A includes a copy of the decree.

As currently configured, the CAWS consists of 10 modified natural waterways, one altered lake, two constructed channels (Cal-Sag Channel and NSC), and one canal (CSSC) as shown in Figure II-3. The three constructed waterways in the CAWS make up 63% of its length. The banks consist of steel sheet piling, limestone rock, riprap, and/or limited earthen side slopes (Figure II-4). The Ecological Integrity Technical Memorandum in Appendix A includes further information describing the CAWS.

Figure II-4. South Branch Chicago River

B. Data Collection

Baseline conditions are those conditions that existed as of January 1, 2011. In addition, readily available information was used to document the current and planned, anticipated, and emerging conditions of the CAWS. Two types of data were targeted: (1) data sets and models that have been peer reviewed and (2) data sets and models that are considered reliable by agencies involved in managing the CAWS, the basins affecting the CAWS, and the adjoining Great Lakes and Mississippi River basins. As the study progressed and new data were made available, they were added to the baseline conditions. For example, in May 2011, MWRDGC authorized the implementation of disinfection treatment at the North Side and Calumet WWTPs in response to an order from the U.S. Environmental Protection Agency (USEPA). This decision was then added to the baseline conditions.

At the start of the study, stakeholder groups were engaged to identify concerns and information that could be investigated and incorporated into the study. Interviews were conducted with representatives from the U.S. Army Corps of Engineers (USACE), Illinois Environmental Protection Agency (Illinois EPA), Illinois Department of Natural Resources (Illinois DNR), MWRDGC, various departments of the City of Chicago, and other stakeholder representatives. A list of questions was developed to allow the interviewers to standardize the questioning and recording of responses. Various documents were discovered from these interviews that provided needed data and information. Appendix A includes the list of stakeholders interviewed, the interview form, and a summary list of the information gathered.

C. Current and Planned Conditions

1. Flood Management

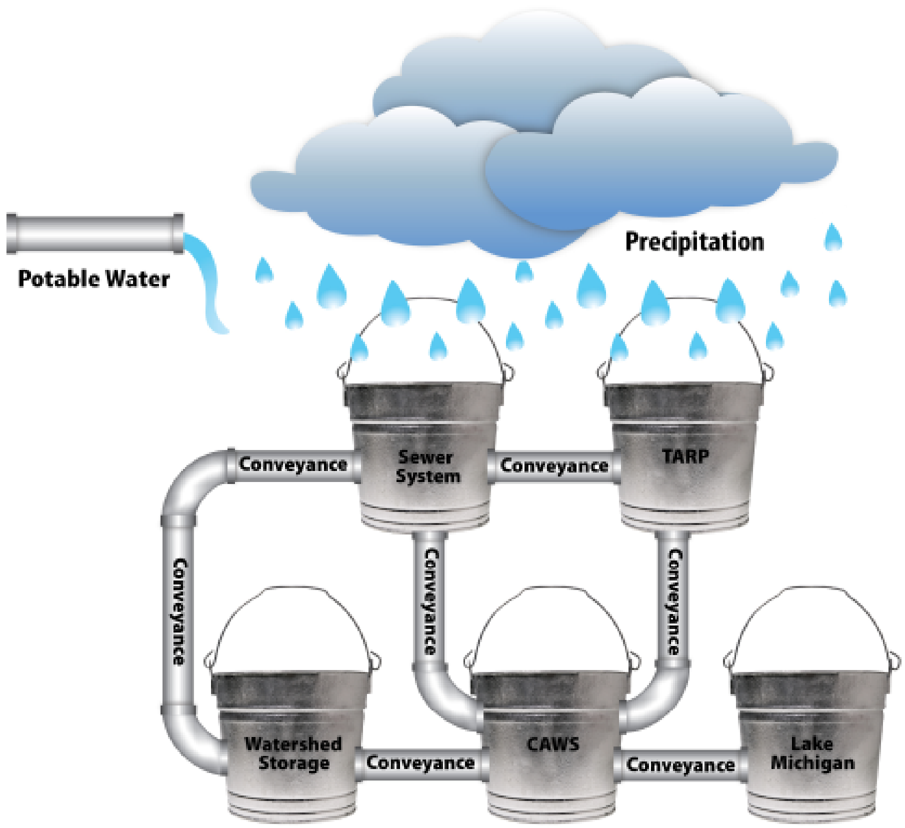
The main sources of water to the CAWS are precipitation and Lake Michigan. Most of the "dry-weather flow" in the CAWS is from Lake Michigan. Lake Michigan water enters the system through the potable water supply system, which includes the Jardine Water Purification Plant (JWPP). Once this potable water is used by residents and businesses in Chicago, it enters the CAWS as treated wastewater effluent. This makes up the majority of the system's dry-weather flow. Additionally, a regulated amount of Lake Michigan water enters the CAWS through direct diversions for water quality and navigation purposes. The remaining inflows to the CAWS enter as "flood water flows" and consist of precipitation in the form of direct runoff and combined sewer overflows.

The CAWS and surrounding watersheds consist of an intricate and complex network of channels, pipes, tunnels, reservoirs, and waterways. This complex system behaves like an interconnected system of "pipes" and "buckets," as shown in Figure II-5. The "pipes" represent various open waterways, sewers, and tunnels connecting the larger water bodies represented by storage "buckets," where the majority of water resides.

During dry weather and smaller floods, water flows to the CAWS are conveyed and/or stored in one or more of the following: (1) local and interceptor sewers, including combined sewer overflow (CSO) outfall facilities; (2) watershed streams and reservoirs; and (3) TARP.

During larger floods, the capacity of the "pipes" and "buckets" is exceeded, and flooding-induced CSOs spill into the CAWS waterways, as well as streets and basements, until the capacity of the channel is exceeded. At that time, excess flood water and sewage are discharged to Lake Michigan, thereby degrading the quality of the lake.

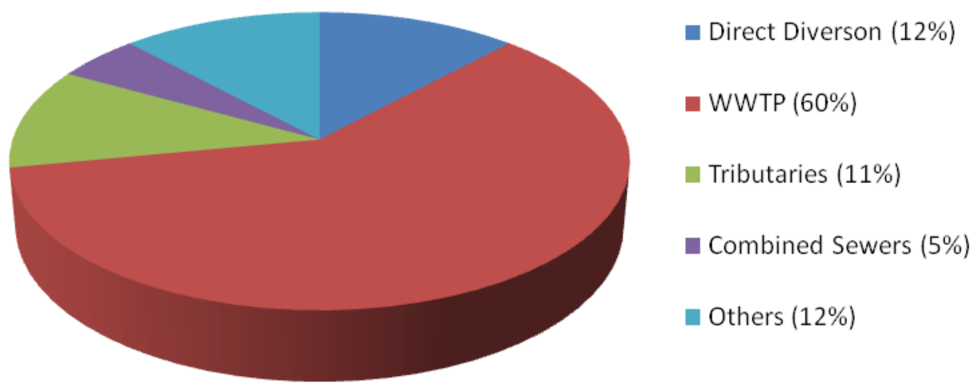
Figure II-5. CAWS Water Management



More specifically, the water sources to the CAWS consist of (1) WWTP effluent, (2) major tributaries, (3) Lake Michigan direct diversion, (4) flood-induced CSOs, and (5) other sources (Figure II-6). The largest source of water to the CAWS (about 1,900 cfs, or 60%) is WWTP effluent (Figure II-6).

The total outflow of water from the CAWS is estimated by the U.S. Geological Survey's (USGS) surface water discharge monitoring gages located at Romeoville/Lemont on the CSSC. Between 1984 and 2010, the estimated mean annual flow at the discharge monitoring gages was 3,130 cfs. The maximum instantaneous flow was 19,466 cfs in February 1997. Generally, depending on the location and day, 60% to 75% of the water in the CAWS is generated from Lake Michigan, either as WWTP effluent or as discretionary flows (portion of Lake Michigan direct diversions).

Figure II-6. Major Sources of Water to the CAWS



WASTEWATER TREATMENT PLANTS

Between 1997 and 2006, 60% of the water in the CAWS was treated wastewater, as shown in Figure II-6. Three major WWTPs discharge treated effluent to the CAWS (Calumet, North Side, and Stickney) as shown in Figure II-7. Mean design flows range from 333 million gallons per day (MGD) at the North Side WWTP to 1,200 MGD at the Stickney WWTP.

Table II-2. Wastewater Treatment Plant Flows, 1997–2006

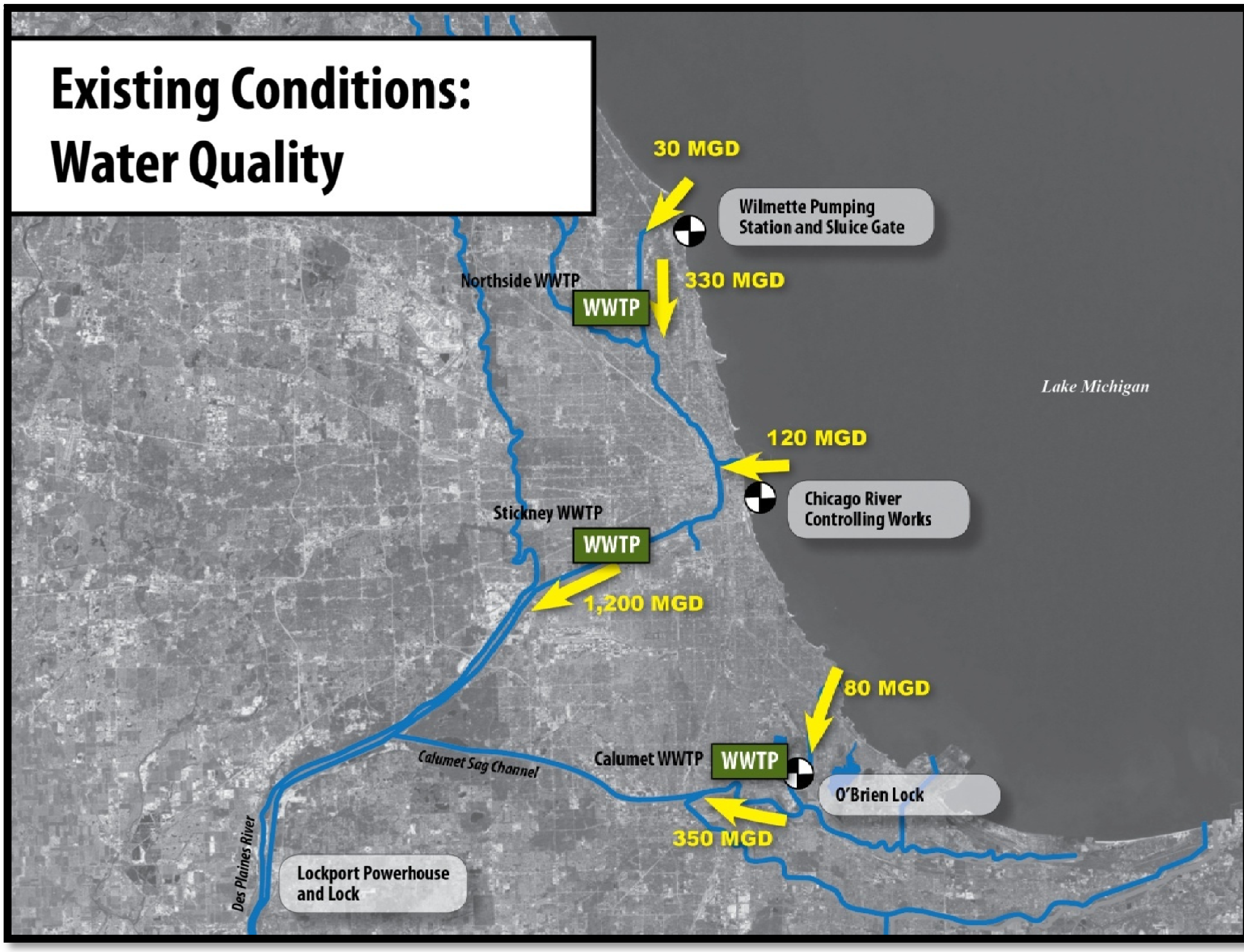
WWTP	Mean Design Flow (cfs)	(MGD)	Mean Flow (cfs)	(MGD)	Maximum Design Flow (cfs)	(MGD)	Maximum Flow (cfs)	(MGD)
Calumet	549	354	393	254	667	430	991	639
North Side	516	333	386	249	698	450	783	505
Stickney	1,860	1,200	1,104	712	2,232	1,440	2,725	1,758

Source: MWRDGC Website, 2011

Notes: cfs – cubic feet per second

MGD – million gallons per day

Figure II-7. Mean WWTP Design Flows and Discretionary Diversions



TRIBUTARY FLOWS

The major tributaries within the CAWS that discharge to the CSSC and Cal-Sag Channel are the Grand Calumet River, the Little Calumet River, and the North Branch of the Chicago River. Table II-3 shows the estimated minimum, maximum, and mean annual tributary flows. Maximum flows during wet-weather events are reported to be 25 times the mean dry-weather flow.

Table II-3. Estimated Major Annual Tributary Flows to the CAWS

USGS Monitoring Station Name	Minimum Flow (cfs) (MGD)		Maximum Flow (cfs) (MGD)		Mean Flow (cfs) (MGD)	
North Branch Albany[a]	4	3	3,580	2,310	143	92
Grand Calumet Hohman[b]	0	0	701	452	25	16
Little Calumet South Holland[c]	8	5	4,760	3,077	190	123

Source: USGS Website, 2011
Notes:
[a] Period of record: 1989–present
[b] Period of record: 1991–present
[c] Period of record: 1947–present

LAKE MICHIGAN DIRECT DIVERSION FLOWS

The quantity of water that can be diverted from Lake Michigan into the CAWS is limited to 3,200 cfs annually over a 40-year period. The diversion water includes domestic water supply, direct diversion from the lake, and surface runoff from the direct watershed that historically discharged to Lake Michigan but was diverted to the Mississippi River basin after the CAWS was constructed. Flow in the CAWS is managed by the USACE according to the rules and regulations in the 1930, 1967, and 1980 U.S. Supreme Court Consent Decrees and in Title 33 of the Code of Federal Regulations (CFR), Parts 207.420 and 207.425. A copy of the most recent decree is provided in Appendix A. The CFR regulations also provide for the maintenance and operation of navigable water depths for commercial navigation throughout the CAWS.

The direct diversion of water from Lake Michigan is summarized in Table II-4, while the locations of discretionary diversions are shown in Figure II-7. Direct diversion of water from Lake Michigan into the CAWS occurs at the Wilmette Pump Station, the Chicago River Lock and Controlling Works, and the T.J. O'Brien Lock. In addition, direct diversion of water is apportioned as follows: (1) water for lockage of recreational and commercial boats to and from Lake Michigan (lockages), (2) water estimated to pass in an uncontrolled manner through the three lakefront controlling structures (leakages), (3) water used to maintain regulated navigational depths following a drawdown of the waterways (navigational makeup water), and (4) water used for augmenting low flows and improving water quality in the CAWS (discretionary diversion).

Table II-4. Direct Diversion Flows from Lake Michigan, 1997–2006

Lakefront Controlling Structure	Mean Lockage (cfs)	Mean Leakage (cfs)	Mean Navigational Makeup (cfs)	Mean Discretionary Diversion (cfs)	Total Diversion (cfs)
Wilmette Pump Station	0.0	0.6	0.0	40.0	40.6
Chicago River	22.0	17.0	15.0	124.0	178.0
T.J. O'Brien Lock	33.0	9.4	18.0	90.0	150.4
TOTAL	**55.0**	**27.0**	**33.0**	**254.0**	**369.0**

Source: MWRDGC Website, 2011

Note: cfs – cubic feet per second

COMBINED FLOOD WATER AND SEWAGE OVERFLOWS

A flood water and sewage overflow, or combined sewer overflow (CSO), is a storm-induced discharge of untreated wastewater combined with flood water to waterways during precipitation events. Half of the CAWS drainage area (375 square miles) is served by combined sewers. Combined sewers convey raw sewage and flood water from minor storms to WWTPs. During larger storms, the capacity of these sewers is exceeded, and the combined flood water and sewage is allowed to discharge into waterways to prevent sanitary sewers from backing up in the Chicago area. During major storms, it is necessary to release combined flood water and sewage into Lake Michigan, as discussed in more detail below.

There are 263 gravity-combined sewers that discharge to the CAWS (Table II-5) during larger storms. At such times, combined flood water and sewage is discharged into the CAWS to help prevent widespread flooding of basements in the Chicago area. Generally, an individual storm with rainfall volumes of 0.67 inch begins to produce CSOs. Rainfall events above 1.5 inches require use of the TARP system and result in substantial CSOs (NRDC, 2010b). Between 2000 and 2010, there were a total of 416 overflows (96.7 billion gallons) to the CAWS from five of the pump stations operated by MWRDGC. The frequency and amount of overflows for each station are listed in Table II-6.

Table II-5. Combined Sewers That Discharge to the CAWS

Waterway	CSO Outfalls
North Shore Channel (above North Side WWTP outfall)	23
North Shore Channel (below North Side WWTP outfall)	22
North Branch Chicago River	64
Chicago River	18
South Branch Chicago River	47
Bubbly Creek	10
Chicago Sanitary and Ship Canal	47
Calumet River	7
Grand Calumet River	7
Little Calumet River	21
Cal-Sag Channel	14
TOTAL	**263**

Source: MWRDGC Website, 2011

Table II-6. Combined Sewer Pump Station Flows, 2000–2010

Pump Station	Total Number of Overflows	Mean Annual Number of Overflows	Mean Overflow (MG)	Maximum Overflow (MG)	Total Overflow (MG)
North Branch	165	15	130	1,349	21,490
Racine Ave.	165	15	401	4,019	66,191
95th St.	15	1	57	137	848
122nd St.	7	1	2	4	17
125th St.	64	6	128	801	8,179

Source: MWRDGC Website, 2011

Note: MG – million gallons

The CSO problem is a major limiting factor in realizing a new and expanded vision for the CAWS. The discharge of combined flood water and sewage degrades water quality and aesthetics in the CAWS and causes basement and overbank flooding. Several programs are in place to continue to reduce the volume and frequency of CSO discharges to the CAWS. These programs are discussed in the following sections and are incorporated into the baseline conditions.

Climate Change and Extreme Storms

Climate dynamics, whether driven by greenhouse gases or natural fluctuations in the earth's climate, can have a dramatic effect on water management in the Chicago area. For the purposes of this study, historical fluctuations in precipitation and Lake Michigan water levels have been used to address potential variability and effects on the CAWS. The analysis has addressed a reasonable range of design conditions traditionally considered for the Chicago area. However, extreme events, such as probable maximum precipitation events, probable maximum flood events, or extreme droughts, have not been fully vetted or analyzed.

While it is common practice to conduct a formal risk analysis to select the appropriate level of flood design for study purposes, it was not within the scope of this study to conduct such an analysis. In lieu of formal risk analysis results, the 100-year flood event is a common industry benchmark used for analysis and comparative purposes. Therefore, the 100-year flood, based on historical data and published design guidelines including Illinois State Water Survey (ISWS) Bulletin 70 (Huff and Angel, 1989) for the Chicago area, was used as the point of reference for baseline conditions and for comparing alternatives with baseline conditions. Statistically, a 100-year flood has a 1% chance of occurring each year, or a 26% chance of occurring over a 30-year period.

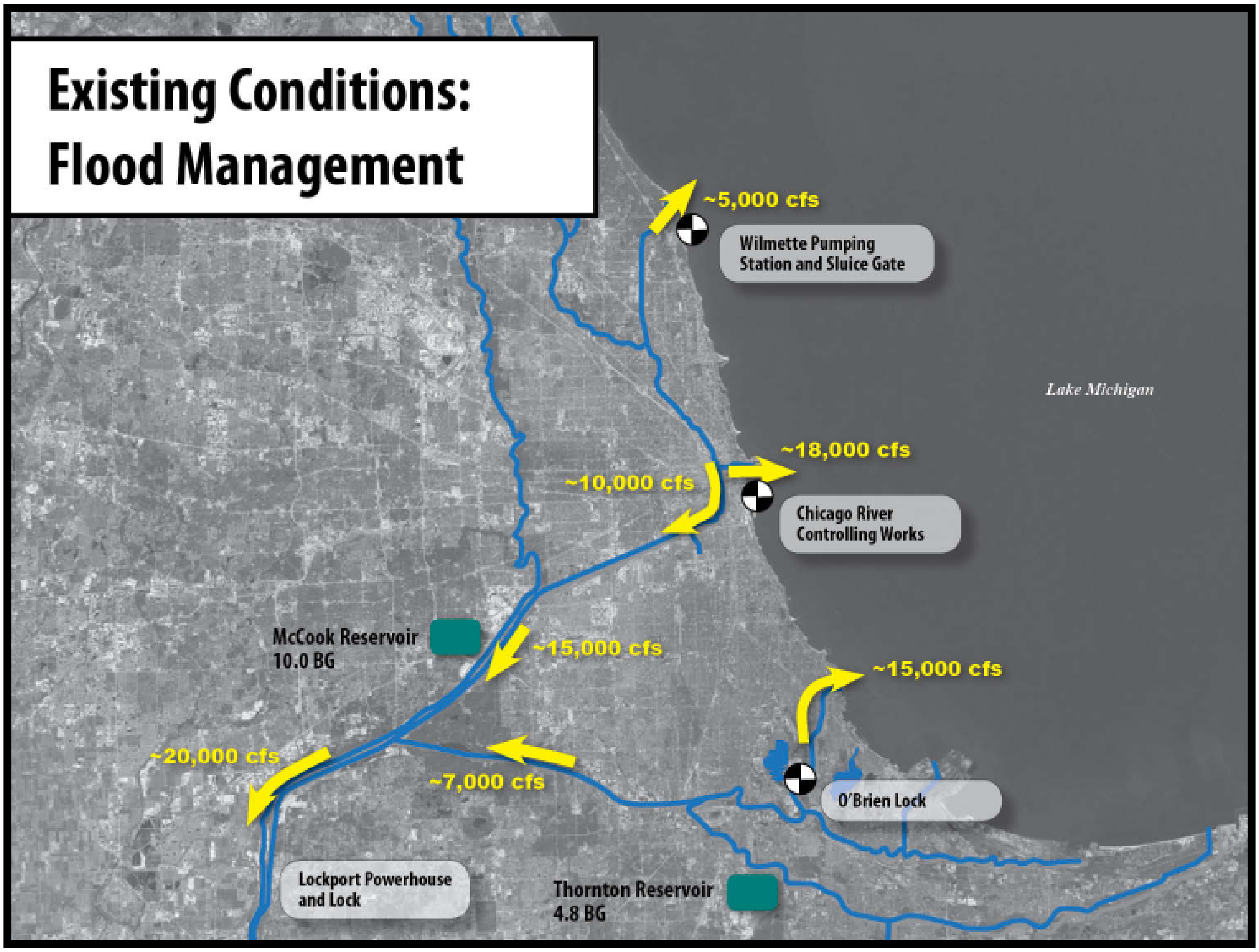
TARP and Lake Michigan Backflows

In 1975, MWRDGC began construction of the TARP for flood management and water quality improvement. TARP is designed to capture discharges from combined sewers and convey the untreated wastes to aerated reservoirs rather than let them overflow to area waterways. After being stored in the reservoirs, the untreated water is pumped to WWTPs for treatment. To date, 109 miles of tunnels are fully operational, providing 2.3 billion gallons of storage.

Two large open-surface-storage reservoirs, Thornton and McCook, are scheduled to be completed by 2015 and 2029, respectively. These are designed to hold 4.8 billion and 10.0 billion gallons, respectively. Thornton reservoir has an additional 3.1 billion gallons of non-TARP overbank flood storage. The O'Hare reservoir, which was completed in 1998, provides an additional 342 million gallons of storage. Since TARP became operational in 1985, more than 975 billion gallons of CSOs have been captured and conveyed to WWTPs for treatment.

Under current conditions, it is necessary to release flood waters into Lake Michigan during major precipitation events. An operational plan is in place that dictates that gates and/or locks at the Wilmette Pump Station, Chicago Controlling Works, and T.J. O'Brien Lock are opened to prevent flooding. The potential backflow capacities at these three locations are shown in Figure II-8. In addition, Figure II-8 shows the anticipated TARP storage capacities for Thornton and McCook reservoirs when they are completed in 2015 and 2029, respectively.

Figure II-8. Existing Flood Management Conditions – Conveyance Capacities



Since 1985, 37 floods have caused combined flood water and sewage to flow into Lake Michigan. These discharges to Lake Michigan have occurred at the three lakefront control structures, as summarized in Table II-7. In the table, *annual probability* refers to the percent chance of a backflow occurring in any given year. For example, based on historical data, there is a 40% chance that backflows will occur at CRCW in a given year. *Return period* is the estimated average frequency of backflows based on annual probability. For example, on average, backflows at the CRCW occur once every 2.6 years.

Table II-7. Historical Backflows to Lake Michigan, 1984–2010

Lake Michigan Backflow Location	Number of Backflows	Annual Probability of Backflow (nearest 5%)	Return Period/Expected Frequency (years)
Wilmette Pump Station	23	90	1.1
Chicago River Controlling Works	10	40	2.6
T.J. O'Brien Lock	4	15	6.5

Source: MWRDGC Website, 2011

The former MWRDGC director has estimated that, after TARP is completed, the system will still discharge CSO to the CAWS between one and 10 times per year, with more frequent overflows in the North Shore Channel and the North and South Branches of the Chicago River (Lanyon, 2011). The projected backflows (emergency stormwater releases) to Lake Michigan once TARP is completed are listed in Table II-8.

Table II-8. Projected Backflows to Lake Michigan

Lake Michigan Backflow Location	Annual Probability of Backflow (%)	Return Period (years)
Wilmette Pump Station	75	1.3
Chicago River Controlling Works	20	5
T.J. O'Brien Lock	10	10

Source: Durgunoglu et al., 1992

One of the outcomes of TARP, in addition to reducing the frequency and volume of combined flood water and sewage discharge to the CAWS, is reducing the combined flood and sewage releases to Lake Michigan. Table II-7 lists the annual probability of the CAWS discharging combined flood and sewage flows to Lake Michigan over a 16-year period from 1984 to 2010. On average, a discharge occurs once every year to once every 6.5 years, depending on the location. Table II-8 lists the modeled overflow rates with TARP fully implemented. TARP is projected to reduce the risk of discharge to Lake Michigan to, on average, one discharge every 15 months to 10 years, depending on the location. However, even with TARP fully implemented, discharges to Lake Michigan will continue to occur fairly frequently. The combined overflow problem will continue to be a limiting factor in realizing a new and expanded vision for the CAWS.

GREEN INFRASTRUCTURE

Existing and proposed flood water management ordinances for the City of Chicago, MWRDGC, and Lake County encourage use of green technologies (such as rain gardens, bioswales, and pervious pavements). Furthermore, these existing and proposed ordinances have requirements for minimizing impervious area and have generally resulted in more widespread application of green infrastructure. Depending on the ordinance, they aim to treat and capture the first 0.5 or 1.0 inch of direct runoff. Based on data collected by the City of Chicago from 2008 to 2011, an estimated 80 million gallons of green infrastructure storage will be added each year through application of the current ordinance requirement of capturing the first 0.5 inch of runoff (City of Chicago, 2011). This information was used as the baseline condition for green infrastructure.

ONGOING AND FUTURE PROJECTS

The Northwest Indiana Little Calumet River Flood Control and Recreation Project is currently under construction. This project will provide a 200-year level of flood protection by constructing 22 miles of levees and floodwalls, installing a control structure at Hart Ditch, building almost 17 miles of hiking trails, and preserving more than 550 acres of wetlands. The project also involves relocating 7 miles of river channel to allow better water flow, modifying highway bridges to permit the unobstructed flow of water, and installing a flood warning system. The project will protect more than 9,500 homes and businesses in Gary, Griffith, Hammond, and Highland, Illinois, and Munster, Indiana, thereby preventing nearly $11 million in average annual flood damage. Construction began in 1990; the flood-protection features are expected to be complete in 2012 and the entire project by 2015.

In 2010 and 2011, MWRDGC completed six Detailed Watershed Plans (DWPs) regarding flood water management in Cook County. These DWPs include recommended alternative projects for addressing regional watershed flood management problem areas. Preliminary design has proceeded for many of these recommended alternative projects. For the purposes of this study, the recommended alternative projects identified in the three DWPs involving watersheds within the CAWS were included in current and/or future baseline conditions. These DWPs include the North Branch Chicago River, Cal-Sag, and Little Calumet basins.

In summary, flood management is an ongoing issue within the CAWS. Projects such as TARP, the Northwest Indiana Little Calumet River Flood Control and Recreation Project, and the MWRDGC Detailed Watershed Plans are specific programs and projects designed to address known problem areas. Green infrastructure is currently targeted on a case-by-case basis to improve overall flood management and water quality as development or redevelopment occurs. Ongoing investments are necessary and planned to address the flooding problems in the Chicago area and are included in the baseline conditions.

2. WATER QUALITY

WASTEWATER WATER QUALITY STANDARDS

Illinois' current water quality standards and associated wastewater discharge requirements include three basic resource classifications or "use classes." Most of the state waters fall within a General Use class, a classification intended to protect ecological and recreational uses. The CAWS does not fall within this use class; rather, it has a separate classification, Secondary Contact and Aquatic Life, which has associated standards intended to recognize the unique character and limitations of the system. This classification has lower ecological expectations with less stringent water quality standards and limited recreational use. As stated above, through improvements made during the Clean Water Act era, both the actual conditions in, and public opinion of, the CAWS as an environmental resource have improved greatly. Consequently, standards for the system are currently being revised to upgrade both the use classification and the associated water quality standards.

The third use class in Illinois' regulations applies to Lake Michigan and its tributaries. Historically, Illinois has viewed Lake Michigan as its highest-quality and most-valued water resource. The standards adopted to protect Lake Michigan are significantly more protective than the General Use classification and, of course, the Secondary Contact and Aquatic Life classification that applies to the CAWS. This three-tiered classification system was used as the basis for comparing the water quality effects of the separation options presented below. Some results of the current reclassification mentioned above, such as the requirement to disinfect treated wastewater at the MWRDGC's North Side and Calumet WWTPs, have been factored into this assessment, while other results of the reclassification are more speculative.

In general, all three major WWTPs operate efficiently and produce high-quality effluent that is in compliance with, and at times well below, current effluent discharge permit limits. *Effluent quality* from wastewater treatment refers to the efficiency and extent that pollutants in the sewage are broken down or removed. Note that, while the three major WWTPs produce high-quality effluent at this time, and this high-quality effluent constitutes the majority of dry-weather flow within the CAWS, other factors such as inherently low-flow/low-velocity, limited-habitat, legacy sediments and CSOs affect the overall water quality of the CAWS and result in degraded water quality. Consequently, water quality and overall environmental conditions in the CAWS are not dominated by wastewater effluent. The current permit limits for the three major MWRDGC treatment plants and their 2010 average effluent quality are presented in Table II-9.

Wastewater effluents that discharge to the CAWS are not currently disinfected. However, the Illinois Pollution Control Board (Illinois PCB) is finalizing new regulatory requirements that the North Side and Calumet WWTPs add a disinfection process as part of revising the CAWS standards. The effective compliance date to have the disinfection equipment installed and operational is March 1, 2016. Therefore, disinfection at these facilities is included in the baseline conditions for this study. Additional discussion about wastewater treatment standards and requirements anticipated in the future is provided below.

Table II-9. Select NPDES Permit and Plant Performance Information for Three Major MWRDGC WWTPs

WWTP – Permit Number Parameter	Monthly Average	Weekly Average	Daily Maximum	2010 Effluent [a] Mean	Maximum	Minimum
North Side – Permit IL0028088						
CBOD [b] (mg/L)	10	12		<2	11	<2
TSS [c] (mg/L)	12	18		5	18	2
Ammonia – N (mg/L) Apr–Oct Nov–Mar	 2.5 4		 5 8	<0.3 [d]	2.2 [d]	<0.1 [d]
Total – P (mg/L)	No Limit			1.4	2.3	0.4
NO_2 – N (mg/L)	No Limit			<0.2	1.3	<0
NO_3 – N (mg/L)	No Limit			8.9	11.7	3.7
Fecal Coliform (count/100 mL)	No Limit			GM [e]: 7986	80,000	2,700
Calumet – Permit IL0028061						
CBOD (mg/L)	10	20		<3	8	<2
TSS (mg/L)	15	25		6	13	2
Ammonia – N (mg/L) Apr–Oct Nov–Mar	 2.5 4.0		 5 8	<0.3	2.4	<0.2
Cyanide (mg/L)	0.15		0.3	<0.006	<0.005	0.014
Total - P	No Limit			3.8	9.7	1.0
NO_2 + NO_3 – N (mg/L)	No Limit			8.3	17.0	3.3
Fecal Coliform (count/100 mL)	No Limit			GM: 6,304	24,000	1,600
Stickney – Permit IL0028053						
CBOD (mg/L)	10	15		<3	10	<2
TSS (mg/L)	12	20		<5	12	<4
Ammonia – N (mg/L) Apr–Oct Nov–Mar	 2.4 4.0		 5 8	<0.6	3.6	<0.1
DO [f], Minimum (mg/L)			6 (minimum)	8.3	10.3	6.4
Total – P (mg/L)	No Limit			1.3	3.4	0.2
NO_2 – N (mg/L)	No Limit			<0.3	2.1	<0
NO_3 – N (mg/L)	No Limit			8.6	16.3	3.3
Fecal Coliform (count/100 mL)	No Limit			GM: 7,363	86,000	1,400

Notes:
[a] MWRDGC
[b] Carbonaceous biochemical oxygen demand
[c] Total suspended solids
[d] Annual ammonia data from plant effluent are not seasonal
[e] Geometric mean
[f] Dissolved oxygen

Beyond the influence of wastewater effluent, the chemical quality of water in the CAWS is affected by a number of physical, chemical, and biological parameters including runoff from combined sewers and separate storm sewers. Based on the *Illinois Integrated Water Quality Report and Section 303(d) List*, the CAWS waterways are designated as impaired because they do not meet certain water quality standards (Illinois EPA, 2010). Three chemical constituents (dissolved oxygen, total phosphorus, and total mercury) and one biological indicator (fecal coliform) were selected to describe the chemical integrity of the CAWS. Data for each of these parameters are summarized below and presented in Appendix A.

From 2005 to 2009, all 10 waterways in the CAWS had mean dissolved oxygen values below the minimum value required for early life stage protection in fish (< 5 mg/L). Except for the Calumet River, nine of the 10 waterways in the CAWS had a mean total phosphorus value in water greater than the 0.076 mg/L reference condition for rivers and streams in Ecoregion VI (northern half of Illinois). Currently, there is no State of Illinois standard for phosphorus in flowing waters. The highest mean total mercury values were measured in Bubbly Creek and in the Grand Calumet River. Except for the Calumet River and the Chicago River, eight of the 10 waterways in the CAWS had a geometric mean of fecal coliforms greater than the 200 cfu/mL (colony-forming units per milliliter) standard for General-Use waters in Illinois.

As with most waterways that serve large, industrialized urban areas, major environmental improvements were made to the CAWS during the Clean Water Act era. The conditions of the CAWS have improved greatly since the initial Earth Day wakeup call in the 1970s. Today the waterway is in transition toward being perceived as a valued community resource, not merely as a drainage conduit. Nevertheless, some system limitations persist, and the CAWS' environmental conditions fall short of public expectations. The primary factors that affect the baseline conditions and limit the current ecological value of the waterway are:

- Sediment contamination from legacy pollutants.
- Influx of new pollutants via periodic CSOs.
- Basic stream morphology. The system is inherently low gradient due to the flat topography of the area, which limits its ability to purge sediment contaminants and limits natural re-aeration.
- Limited habitat to support ecological functions.
- Bacterial contamination from urban runoff and CSOs, which limits recreational uses.

SEDIMENT CHEMISTRY

Aquatic sediments become contaminated with inorganic and organic chemicals, which are adsorbed to particulate matter. In most aquatic systems, the concentrations of chemical constituents in bottom sediments are greater than the concentrations in the overlying water column. As a result of human activities, past and present contaminants in aquatic sediments originate from point-source wastewater discharges, periodic overflows from combined sewers, nonpoint-source runoff, and atmospheric deposition.

Six heavy metals, six polychlorinated biphenyls (PCBs), and 15 polycyclic aromatic hydrocarbons (PAHs) were selected to describe the sediment chemistry in the CAWS and assess the effects of contaminated sediments on the benthic community. Metals and persistent organic chemicals measured in sediment were compared to the consensus-based probable effects concentration (PEC) thresholds (MacDonald et al., 2000). A PEC concentration denotes the sediment concentration level at which toxic effects are probable or likely to occur for both tolerant and sensitive organisms.

The bulk of sediment samples that exceeded the PEC for cadmium, chromium, copper, lead, mercury, and zinc were collected from Bubbly Creek, Chicago River, Chicago Sanitary and Ship Canal, Grand Calumet River, North Branch of the Chicago River, and South Branch of the Chicago River. The highest mean concentrations of total PCBs in sediment were found in the Chicago Sanitary and Ship Canal and the North Branch of the Chicago River. Sediment samples that exceeded the PEC for total PAHs were collected from the Chicago River, North Branch of the Chicago River, and South Branch of the Chicago River. Contaminated sediments will most likely need to be removed in order for improvements in ecological health and water quality to occur within the CAWS, regardless of whether separation occurs.

3. Transportation

Illinois is the freight capital of North America. The Greater Chicago area has historically played a major role as a freight hub in the United States. Railroads, interstates, airports, and waterways all converge in Greater Chicago, making it a strategic location as a national freight hub. The extensive Chicago waterway system provides full connectivity between Chicago, the Great Lakes, and the Mississippi River, but only 3% of the total is moved by water. More than 500 freight trains operate in the region daily. An expansive interstate system carries more than half of the region's freight each year, and O'Hare International Airport is one of the largest U.S. foreign-trade gateways (CMAP, 2010a).

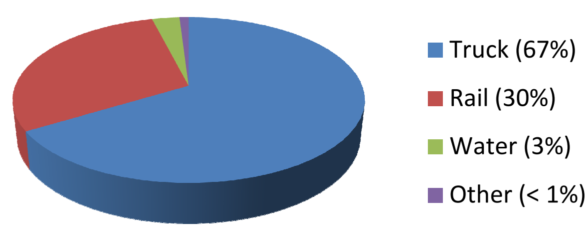
In 2010, the Chicago Metropolitan Agency for Planning (CMAP) developed freight system recommendations for the *GO TO 2040* Plan. CMAP estimates that about 1.5 billion tons of freight were moved within the greater Chicago business economic area (BEA) by truck in 2007, which is more than twice the rail volume and about 67% of the annual regional freight tonnage, as shown in Figure II-9 (CMAP, 2010a). Less than 1% was moved by air. Reports prepared for CMAP as part of freight system planning state that "the much lower comparative water tonnage shows that the maritime network may be underutilized, given the high amount of capacity for the region (both inland waterways and on the Great Lakes with access to the St.

Lawrence Seaway) and the region's reliance on heavier commodities such as steel manufacturing inputs, agricultural produces and byproducts, and construction materials" (Bretthauer, 2007).

The total tonnage moved by both truck and rail in the U.S. and the Chicago area is expected to increase substantially over the next 30 years. CMAP's forecasts indicate that waterborne freight is also expected to grow, but at a slower pace, and would carry a smaller portion of total regional freight (Bretthauer, 2007). There is also speculation that the demand for coal, the largest single commodity carried on the CAWS, will decrease as a result of the scheduled and potential closure of three Chicago-area power plants.

That being said, the U.S. Department of Transportation (USDOT) believes that the nation's waterways can and should carry a higher volume of cargo in order to relieve some of the nation's congestion on highways and rail, as evidenced by the development and funding of the Marine Highway Program in 2010. The ability of Chicago's rail network, port, roads, and airports to carry freight efficiently will affect the overall competitiveness of the region's and nation's economy (USDOT-Maritime Administration, 2010).

Figure II-9. Freight Movements in the Chicago Area by Mode in 2007



Source: CMAP, 2010a

WATERBORNE INFRASTRUCTURE, TRAFFIC, AND OPERATIONS

There are several major harbors, more than 150 cargo-handling terminals and barge facilities, and three locks located on the CAWS. Figure II-10 shows the waterborne infrastructure within the CAWS. Most of the harbors, marinas, and small craft facilities on the CAWS are located on Lake Michigan, the Chicago River, and the Calumet River. The USACE website and navigational charts were used to identify the locations and characteristics of water-based operation installations and other infrastructure that affects traffic and operations on the CAWS and nearby in Indiana. Most mooring and industrial facilities are located on the Calumet River and the Chicago Sanitary and Ship Canal (USACE, 1998).

Figure II-10. Waterborne Infrastructure on the CAWS

INFRASTRUCTURE

There are multiple harbors on the CAWS and two additional harbors nearby in Indiana. The Calumet Harbor is the central element of the Port of Chicago (Figure II-11). It is the 33rd leading U.S. port and the second-largest port on the Great Lakes in terms of tonnage. Calumet Harbor is the primary link between the Inland Waterway System, the Great Lakes, and foreign ports. The harbor is interconnected to 154 commercial ports, since it ships to 74 ports and receives from 80 ports. The harbor channel extends down the Calumet River to Lake Calumet for 1.3 miles.

The Chicago Harbor in downtown Chicago is another element of the Port of Chicago and is the secondary link of the Great Lakes and the Inland Waterway System. The Chicago Harbor handles limited freight, but most of the recreational and commercial tour vessels on the CAWS use the Chicago Harbor. There are additional recreational vessel harbors on Lake Michigan, the Calumet River, and the Little Calumet River.

Figure II-11. Port of Chicago at Calumet River

Indiana Harbor is the 42nd leading U.S. port in terms of tonnage and is interconnected with 83 commercial ports. It is ranked first in tonnage among the 25 federal harbors on Lake Michigan. Burns Harbor in Indiana handles shipments to and from the CAWS and handles more ocean-going cargo than any other U.S. Great Lakes port. Additional details about Chicago-area harbors and ports are included in Table II-10.

Table II-10. Chicago-Area Harbors and Ports

Name	Location	Operations and Facilities
Chicago Harbor	Lake Michigan at Chicago River	1.7 million tons shipped, 149,000 tons received; 711,000 commercial passengers per year
Calumet Harbor	Lake Michigan at Calumet River	2nd-largest Great Lakes Port (in tonnage); 14.6 million tons shipped or received annually
Iroquois Landing Lakefront Terminus	Lake Michigan at Calumet River; Calumet Harbor	27-foot-deep navigational channel; 3,000 linear feet of berthing space; two 110,000-square-foot transit sheds; Intermodal facilities
Lake Calumet	Junction of Grand Calumet and Little Calumet Rivers	Three transit sheds (315,000 square feet total); 800,000 barrels liquid bulk storage capacity; two grain elevators (14-million bushel capacity)
Chicago Park District Harbors	Lake Michigan	Nine recreational vessel harbors; 5,100 boat slips; additional 2,700 slips planned
Other	Calumet River and Little Calumet River	Eight recreational vessel harbors, marinas, and private docks
Indiana Harbor	Lake Michigan, 6 miles southeast of Calumet Harbor	15.4 million tons shipped or received annually; ranked 1st in tonnage of federal harbors on Lake Michigan
Burns Harbor	Lake Michigan at Portage	Handles about 500,000 trucks, 10,000 railcars, 400 barges, and 100 ships per year

Sources: USACE, 2007a, 2007b; Illinois Int'l Port District, 2011; Ports of Indiana, 2011a, 2011b; Chicago Park District, 2007.

There are three primary locks on the CAWS system: the Chicago Harbor Lock, the T.J. O'Brien Lock, and the Lockport Lock and Dam (L&D) (Figure II-3 and Figure II-12). The Chicago Harbor Lock handles primarily non-cargo traffic including commercial passenger ferries and tour boats, recreational vessels, governmental vessels, and commercial fishing. The T.J. O'Brien Lock handles both recreational vessels and barges, while the Lockport Lock handles primarily barges. The number of non-cargo, passenger, and cargo vessels for each lock is listed in Table II-11.

Figure II-12. Photographs of CAWS Locks

Source: USACE Website, 2011

Table II-11. CAWS Navigation Data

Name	Location	Non-cargo Vessels/Year (average 2000–2010)	Commercial Passengers/Year* (average 2000–2010)	Cargo Vessels (2010)
Chicago Harbor Lock	Chicago River/Lake Michigan	41,071 (70% recreational)	711,902	175 (102,000 tons)
T.J. O'Brien Lock	Calumet River	21,279 (85% recreational)	479	5,065 (5 million tons)
Lockport Lock	Chicago Sanitary and Ship Canal	3,026 (72% commercial)	164	9,644 (9 million tons)

Sources: USACE, 2011b
*Includes tour boats and other vessels

WATERBORNE TRANSPORTATION CHARACTERISTICS

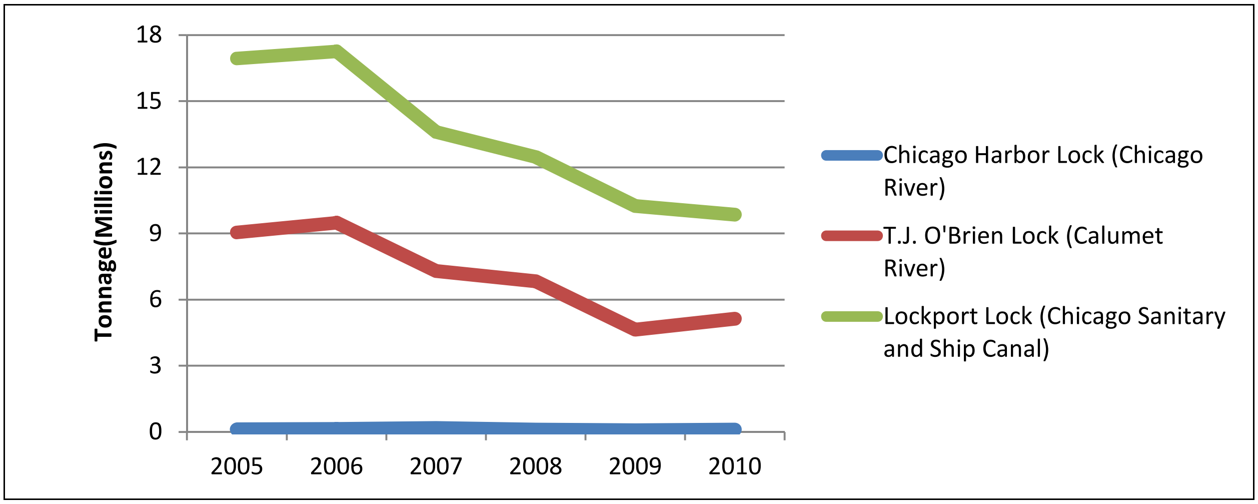
Waterborne transportation on the CAWS consists of cargo shipping, commercial tours and water taxis, and recreation. According to reports prepared for the CMAP *GO TO 2040* Plan, waterborne freight in the Chicago business economic area (BEA, which includes all counties within the CMAP northeastern Illinois region and additional counties as described in Appendix A) consists primarily of relatively heavy, low-value goods. Nearly 73 million tons of waterborne freight moved in the entire Chicago BEA region in 2007 (60% inbound to destinations in the area, 26% outbound, and 12% between points within the BEA) (CMAP, 2007).

For the CAWS specifically, the USACE GLMRIS cargo report released in December 2011 states that about 16 million tons of commodity traffic moved on the CAWS in 2008, which is about 43% of traffic on the entire Illinois Waterway. About 71% of this traffic moved through the Lockport L&D; 36% moved through T.J. O'Brien Lock, and less than 1% moved through the Chicago Lock.

Overall, traffic on the CAWS decreased between 1994 and 2009 from 25 million tons to 13 million tons, an annual decline of about 4% and total decline of about 48%. Over the same period, traffic on the Illinois Waterway declined at a lower rate, about 2%. Figure II-13 shows total CAWS freight tonnage for Chicago-area locks since 2005.

The trend of declining waterway shipping is likely to continue without infrastructure investments that would make waterborne transportation more attractive to shippers.

Figure II-13. Total Tonnage Trends for CAWS Locks



Coal is the most common commodity moved on the CAWS, followed by metallic ores and non-metallic minerals. However, movement of coal is predicted to decline, due in part to the nation's shift to more efficient and cleaner energy sources and to more stringent emissions regulations. The scheduled closure of the Stateline coal-fired power plant in Indiana, along with the potential closure of two coal-fired power plants in the Chicago area (Fisk and Crawford power plants), could further reduce the demand for coal shipments (USSEC, 2011; Daniels, 2011). Large increases in the shipped volumes of farm products, waste and scrap materials, and primary metal products are predicted by 2040 (CMAP, 2007).

Internal traffic, or that which does not pass through any lock, makes up about 28% of all traffic on the CAWS. The 2011 USACE GLMRIS cargo report states that, in the past 15 years, traffic at each of the locks diminished at a faster rate than traffic on the CAWS as a whole, which highlights the importance of the CAWS' internal traffic. In fact, the report estimates that 87% of internal cargo traffic on the CAWS does not travel through any lock at all (USACE, 2011a).

Additional USACE data was sought to gain a better understanding of the volumes and types of commodities being shipped at various points within the CAWS. "Past the point" data for the years 2001–2009 were obtained from the USACE to describe the types of commodities being transported, the vessel type, the tonnage, and the direction at various mile markers along the CAWS system (USACE, 2011e) (Figure II-14).

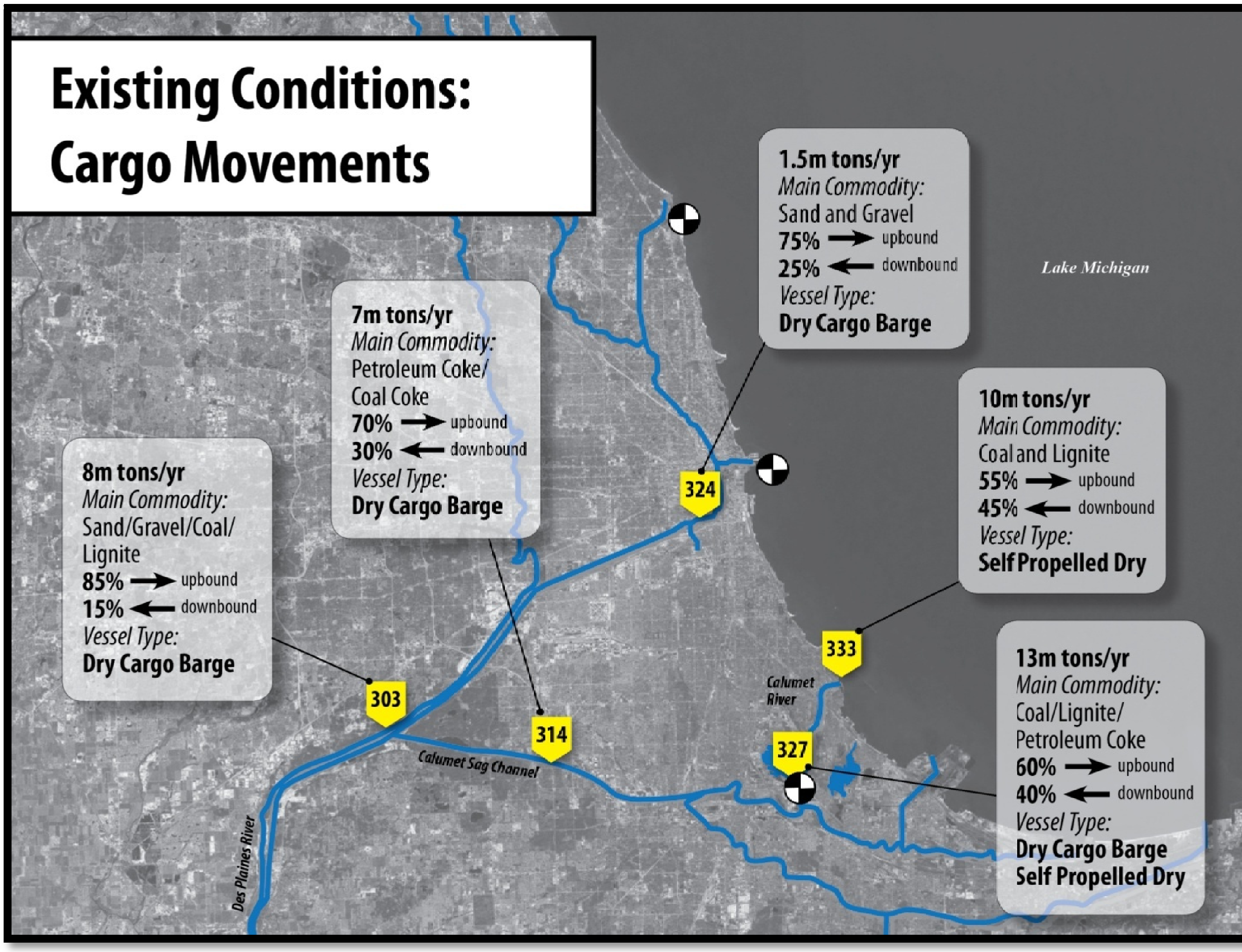
Figure II-14. Barge Traffic on the CAWS

It is important to note that, while this information provides more insight to the cargo movements on the CAWS than the lock data, it is still not a comprehensive origin-and-destination source. A comprehensive origin-destination analysis is needed to fully understand the magnitude of the movements and the impacts that separation could have on these movements.

The USACE "past the point" data show that the majority of barge traffic is shipping to destinations on the south CAWS or out to the Great Lakes. Smaller quantities, primarily sand and gravel, are shipped on the Chicago River (Figure II-15). Most coal that is shipped on the Chicago Sanitary and Ship Canal is headed to the Crawford and Fisk power plants in Chicago. If these plants are closed, it could reduce the demand for coal on this waterway. Total freight volumes are highest on the Calumet River, past the T.J. O'Brien Lock, and most of the cargo transported there is coal and petroleum coke. The scheduled closure of the Stateline power plant could reduce the demand for coal on the Calumet River, although it appears that most of the facility's coal shipments are brought in by rail.

There are currently five commercial tour operators and water taxis operating along the Lake Michigan shoreline and Chicago River. On a daily basis, these operators together run a total of 24 tours on the river and/or lake, 30 tours on the river, and nine tours on the lake only. A total of 28 eastbound and 28 westbound water taxis also run each day, typically between Union Station, Michigan Avenue, and Navy Pier. Although there has been some fluctuation, the number of commercial passengers passing through the Chicago Lock has increased in the past 5 years. Between 2009 and 2010, there was a 15% increase to more than 800,000 passengers (USACE, 2011b).

Figure II-15. Industrial Cargo Existing Conditions



The majority of recreational and commercial tour traffic occurs between May and October. In 2010, more than 23,000 recreational boats passed through the Chicago Lock, and more than 12,000 passed through the T.J. O'Brien Lock (USACE, 2010a,b,c,d). Human-powered craft, canoes, kayaks, and sculls remain almost exclusively within the river system. About 2,550 boats (45% of boats moored in Lake Michigan harbors) pass through the locks every spring and summer to gain access to boat slips and other mooring facilities on Lake Michigan (Schwieterman, 2010). The remaining boats moored in Lake Michigan Harbors use marinas or boat ramps on the Lake Michigan shore in Illinois, Indiana, or Wisconsin.

The City of Chicago has initiated programs to enhance recreational opportunities on Chicago's river system (City of Chicago, Office of the Mayor, 2011). In September 2011 Mayor Emanuel announced plans to make the Chicago River the next "recreational frontier." Four new boathouses will be developed to improve recreational opportunities along the river. The boathouse sites were chosen to line up with improvements that the Chicago Department of

Transportation is making to extend trails along the river. These trails will provide easier and more consistent river access for runners, bikers, and walkers. The four new boathouses are located at the following locations:

- River Park Boat House, 5100 N. Francisco—located at Argyle and the river
- Clark Park Boat House, 3400 N. Rockwell—located at Roscoe and Rockwell, east of the river
- Ping Tom Memorial Park Boat House, 300 W. 19th Street—located north of 18th Street, through the under-bridge connection, west of the St. Charles line railroad tracks
- 28th and Eleanor Boathouse—located between Loomis and Fuller Streets on Eleanor, across the river from Ashland Avenue

ROADS

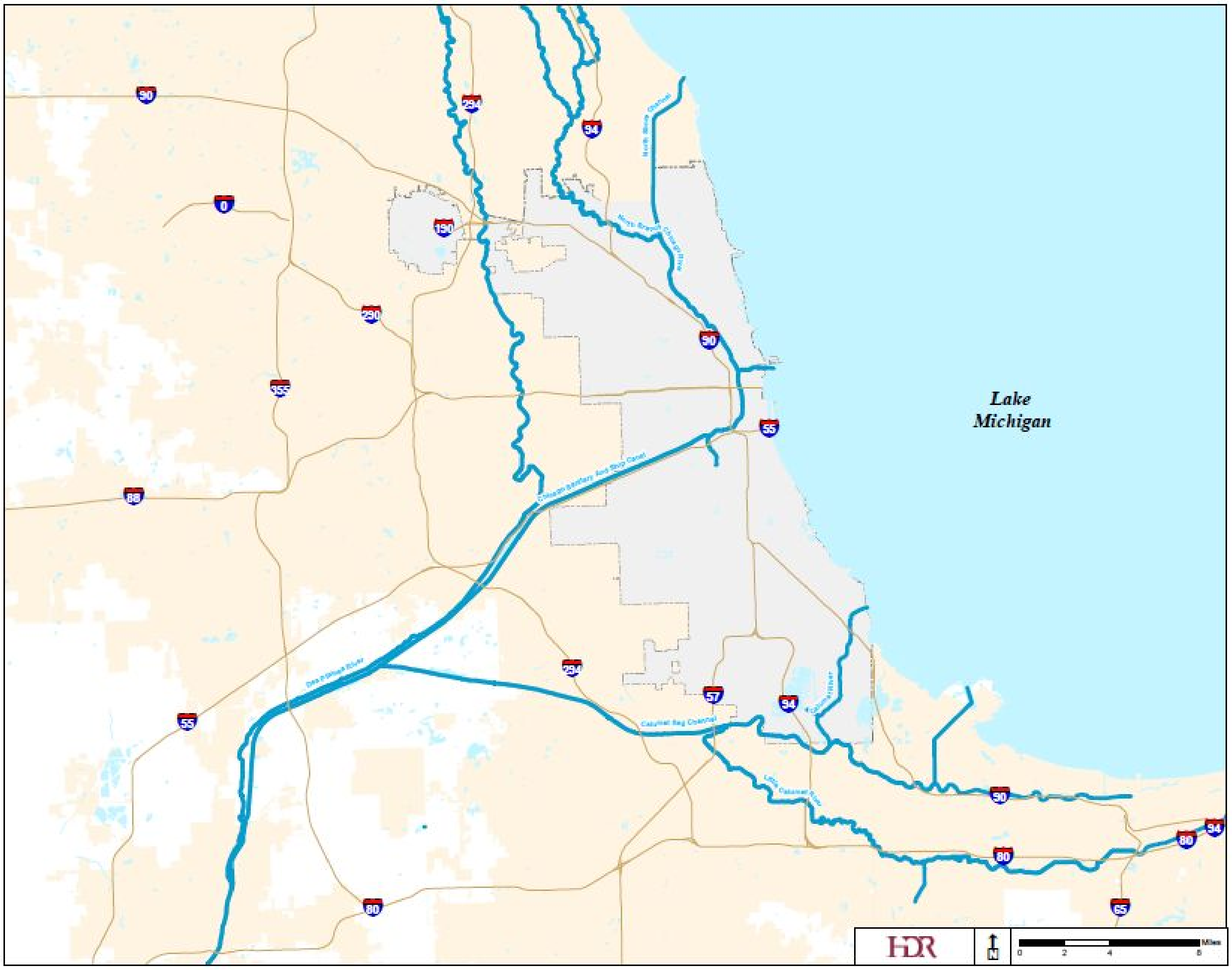
The largest mode share for freight travel in the Chicago area is trucking. A number of interstates and arterials parallel or cross the CAWS, including Interstate (I) 90/94, I-55, I-294, I-57, and I-355 (Figure II-16). A complete listing of road locations, average daily traffic volumes, and truck volumes was compiled to determine potential impacts to the transportation system and opportunities to expand the transportation system. Also, the *2010–2015 Transportation Improvement Program* (TIP) for Northeastern Illinois lists programmed road projects that have the potential to affect the CAWS (CMAP, 2011).

The Texas Transportation Institute's 2010 Urban Mobility Study ranks Chicago #1 for congestion (most congested) out of over 400 metropolitan areas. The Metropolitan Planning Council has estimated that the annual cost of congestion to the region is over $7 billion.

The CMAP *GO TO 2040* long-range transportation plan includes six major regional projects that will increase the capacity of the interstate system, thereby reducing congestion and travel times for freight transportation. Collectively, these improvements will influence the pattern of truck traffic within the region. There could be new opportunities to enhance the connection between the CAWS and the interstate at the new I-294/I-57 interchange. Another project, the Illiana Expressway, is listed on the Northwestern Indiana Regional Planning Commission's (NIRPC) *Connections 2030 Regional Transportation Plan*. This project will link I-57 in Illinois with I-65 in Indiana. The *GO TO 2040* Plan regional projects include:

- Central Lake County Corridor: IL 53 North and IL 120 Limited Access
- Elgin O'Hare expressway and West O'Hare Bypass Improvements
- I-294/I-57 Interchange (adjacent to Little Calumet River and Cal-Sag Channel)
- I-80 Add Lanes
- I-88 Add Lanes
- I-94 Add Lanes North

Figure II-16. Existing Interstates within Chicago Area



While these regional projects will increase capacity, the projected increase in truck freight traffic will continue to strain highway infrastructure and heighten the negative social effects associated with it, such as traffic delay, noise, and air pollution. The CMAP *GO TO 2040* Plan states that "our region needs infrastructure and policies to enhance freight's benefits to the economy while reducing its negative impacts on our quality of life" (CMAP, 2010a).

RAILROADS

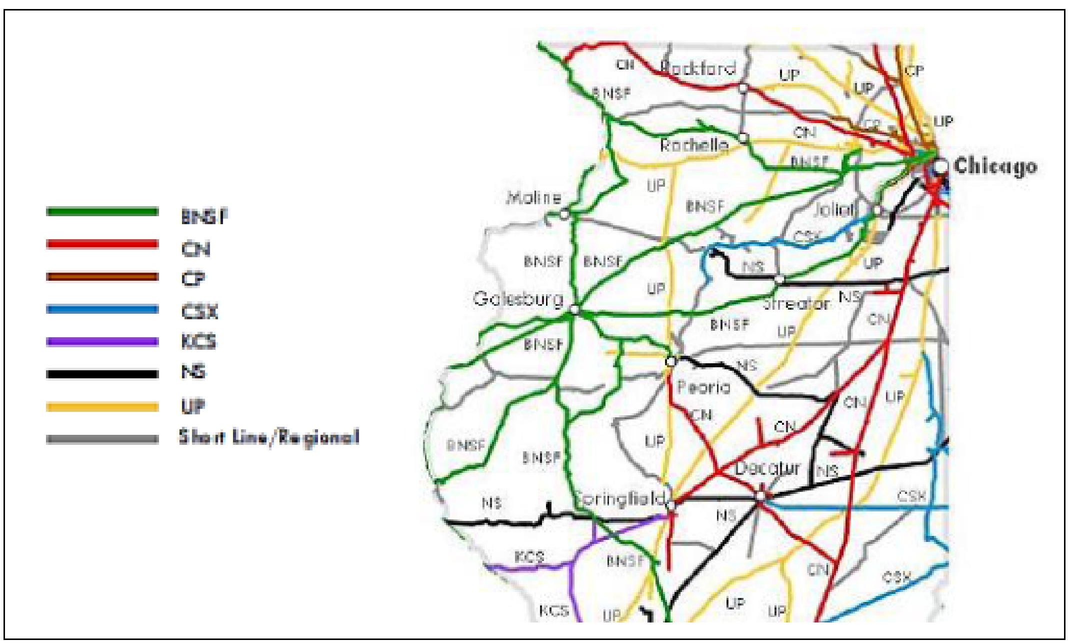
INFRASTRUCTURE

Chicago is the only metropolitan area in which six of the nation's seven Class I railroads have major terminals (Table II-12 and Figure II-17). Nearly 500 freight trains per day operate in the Chicago region. In 2007, regional rail tonnage was estimated at more than 631 million tons, with about 24,000 trailers and containers and about 16,800 carload units moving into, out of, or through the region daily. Each of the Class I railroads that operates in the Chicago area (Table II-12) has invested $1.5 million in capital to meet increasing demands in the past few years. Refer to Appendix A for further details.

Table II-12. Railroads in the Study Area

Class I Railroads
Burlington Northern Santa Fe (BNSF)
Canadian National (CN)
CSX Transportation (CSXT)
CP Rail System (CPRS)
Norfolk Southern (NS)
Union Pacific Railroad (UPRR)
Other Railroads
Belt Railway Company (BRC)
Indiana Harbor Belt (IHB)
Chicago Rail Link (CRL)

Figure II-17. Major Railroads



A number of railroads parallel or cross the CAWS and several intermodal facilities are present. The UPRR and BNSF rail tracks run parallel to the Des Plaines River. At Joliet, the CSX and CN rail tracks join to the UPRR and BNSF. The former Joliet Arsenal property has been developed into two rail freight facilities. The CenterPoint Intermodal Center–Joliet (CIC-Joliet) is the largest master-planned inland port in North America. It is adjacent to the I-55/I-80 interchange and is anchored by the UPRR-Joliet Intermodal Terminal. It is near the Des Plaines River but not connected to it. The CenterPoint Intermodal Center-Ellwood is located about 2 miles to the south and is anchored by the BNSF Logistics Park.

Logistics Park Calumet North is bounded by the Calumet River to the north, Lincoln Highway (Route 30) to the south, the Illinois-Indiana state line to the east, and the Will County–Cook County line to the west. The CN Intermodal Terminal in Harvey, Illinois; the UPRR Intermodal Terminal in Dolton, Illinois; the Indiana Harbor Belt Terminal in Riverdale, Illinois; the CSX Intermodal Terminal in Riverdale, Illinois; and the IAIS Intermodal Terminal in Blue Island, Illinois, are all located here. These assets are linked together by an extensive expressway network, which will be enhanced with the construction of the I-294/I-57 interchange. While these facilities are close to the Little Calumet River and Cal-Sag Channel, they are mostly separated from the rivers by forest preserve and open space that lines the riverfront. Therefore, there is currently limited direct interface between barge, rail, and trucking in this area.

FUTURE RAILROAD IMPROVEMENTS

Although the Chicago rail system is one of the most extensive in the nation, Chicago-area freight rail traffic suffers from congestion, low operating speeds, and delays due to traffic demands that exceed the capacity of the rail system. The Chicago Region Environmental and Transportation Efficiency (CREATE) Program was established in 2005 by the Class I railroads, the federal government, the State of Illinois, Metra, Amtrak, and the City of Chicago. The goals of the CREATE Program are to improve freight and passenger rail operations and to improve highway operations in the Chicago metropolitan area while reducing the environmental effects of rail operations on the general public.

The CREATE Program includes the development of four freight and passenger rail transportation corridors in the Chicago metropolitan area and rail-highway grade separation projects (over- or under-passes to grade-separate railroads and highways) on existing rail lines (CREATE, 2011). Figure II-18 shows the CREATE Program corridors as of February 2011.

In addition to the CREATE improvements, the State of Illinois and UPRR are improving trackage between St. Louis and Chicago to facilitate high-speed passenger rail. These improvements will include an additional mainline track as well as signal and crossing improvements, which will increase freight capacity and operations on this line (IDOT, 2003).

Figure II-18. CREATE Program Corridors

Note: Viaduct projects in the City of Chicago are not displayed.

CREATE
KEEPING THE GO IN CHICAGO

Freight rail traffic is also forecasted to grow, and the improvements described above will help to alleviate some of the congestion and operational difficulties currently experienced on the system. Rail is more cost effective, more fuel efficient, and more environmentally desirable than an over-reliance on highways for freight transport. Moving freight by rail intermodal rather than by truck alone significantly reduces emissions, thereby improving air pollution.

Chicago's status as a national freight hub depends on access to intermodal facilities. About one-half of all intermodal facilities in Chicago are within 0.5 mile of the Class I railroads. Chicago's 21 intermodal freight hubs, which are operated by six rail companies, are becoming congested with no land available to expand into. The yards are being consolidated outside the traditional seven-county Greater Chicago Metro Chicago Region in an effort to reduce costs and to improve the throughput of containers in and out of the freight hubs (Vickerman, 2011). This has resulted in increased concentration, amalgamation, and abandonment of secondary lines. As a result, moving cargo by truck and rail in the future will likely cost more and will probably take longer, since traffic is expected to outgrow any improvements in capacity, and congestion is expected to increase.

4. Additional Baseline Conditions

Aquatic Invasive Species

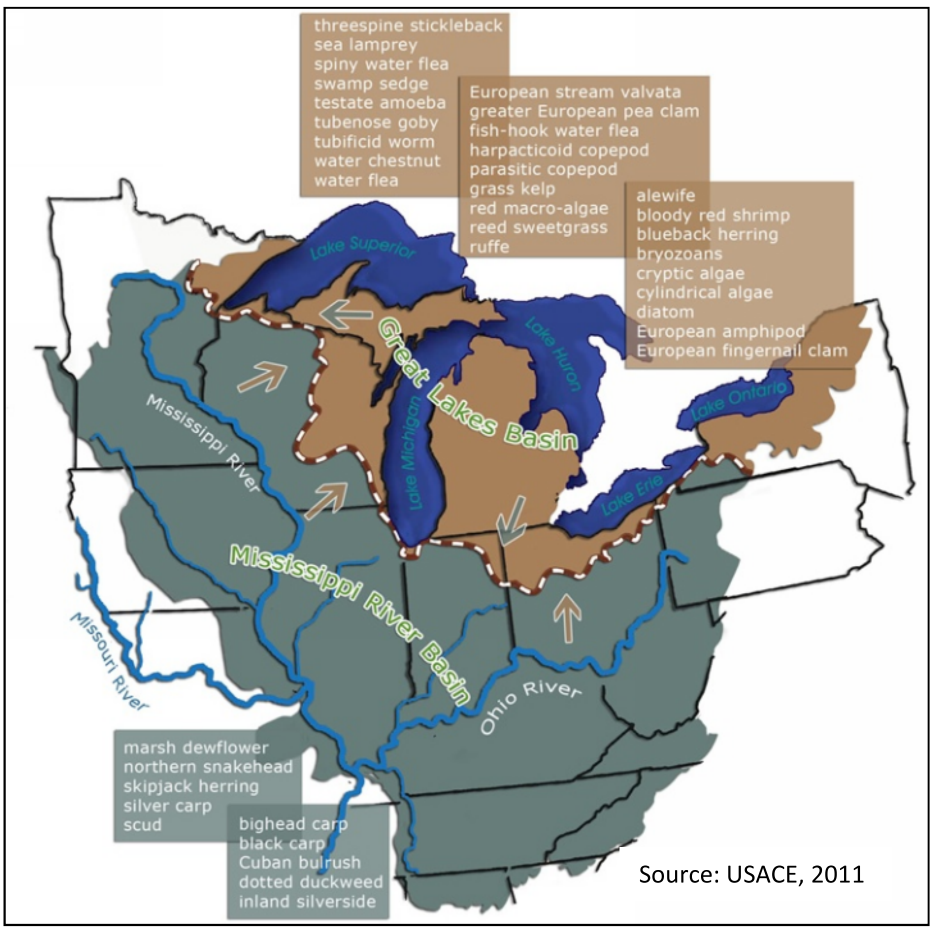
The baseline conditions include existing AIS and the condition that additional AIS discoveries are likely in the future. In 1999, Executive Order 13112 was signed by the President, thereby establishing the National Invasive Species Council. According to the Order, AIS are defined as non-native species whose introduction causes or is likely to cause economic or environmental harm or harm to human health. AIS are a significant threat to the ecological and economic health of the Great Lakes. More than 180 non-native aquatic species have become established in the Great Lakes, and 254 species have been recorded between the Great Lakes and Mississippi River basins combined (USACE, 2011d).

Recent changes to the requirements for ballast water management have clearly helped limit the transfer of AIS, but more controls are needed and are being developed. Meanwhile, the original installation of an electric barrier to limit the transfer of round goby has been upgraded with the addition of two more barriers in response to Asian carp. So far, these barriers appear to be effective in restricting the major movement of these current invaders, but, with the discovery of Asian carp DNA lakeside of these barriers, their effectiveness is being called into question. It is known that these barriers are not fully effective for preventing the movement of the smaller members of the carp population and other aquatic species, and, eventually, the effectiveness of the electric barriers will be compromised.

Currently, the most imminent AIS threat to the Great Lakes is the introduction of Asian carp. It is reported that over the last two fiscal years (FY 2010 and FY 2011) a combined total of $100 million was allocated to preventing the Asian carp from entering the Great Lakes (Bolen, 2012). However, 10 invasive species have been identified as high risk regarding the potential to disperse to the Great Lakes, and 29 species have been identified as high risk regarding the potential to disperse to the Mississippi River (USACE, 2011d).

Figure II-19 shows the potential high-risk AIS poised to transfer between the respective basins (USACE, 2011d). The GLC/CI has said that it is their position that the future of the CAWS should include separation to prevent the free-water transfer of AIS via the CAWS (pending evaluation and accommodation of uses for the CAWS). Currently, the efforts by state and federal agencies to prevent the movement of Asian carp into the Great Lakes include operation of electrical barriers, intensive monitoring, and rapid response planning. Costs of operating and maintaining the electrical barrier are reported to be $8 million annually (Wethington, 2012).

Figure II-19. High-Risk AIS in the Mississippi River and Great Lakes Basins



Source: USACE, 2011

Due to the considerable concern over the potentially devastating effects that an Asian carp invasion would have on the Great Lakes and St. Lawrence River region, many resources have been, and will continue to be, dedicated to AIS prevention. In the near term, federal and state agencies are implementing a comprehensive control strategy to monitor and control the movement of Asian carp toward Lake Michigan. Strategies could include the following activities:

- General monitoring efforts
- Environmental DNA (eDNA) testing
- Operation and maintenance of the electric barriers
- Eradication operations
- Short-term control strategy measures
- Additional studies (for example, risk assessment, threat identification, evaluation of solutions, etc.)

AIR QUALITY

The U.S EPA current non-attainment air quality conditions were considered for the baseline scenario. The area is classified as non-attainment for both ozone and $PM_{2.5}$ (particulate matter 2.5 microns in diameter or less). However, both parameters are in monitored attainment, and the paperwork has been submitted to U.S. EPA to reclassify the area attainment for both. Illinois EPA expects official reclassification within months. The process includes a public notice in the Federal Register and a comment period prior to finalization. Changing transportation, recreation, and industrial patterns driven by a new vision for the CAWS will affect the air quality due to either reduced or increased emissions.

REGULATORY ISSUES

Regulatory and legal issues involving various stakeholders and agencies associated with the CAWS pose a challenge to implementing a new vision for the CAWS. To prevent delays, thorough investigation and analysis will be required for any separation option that requires modifying CAWS operations. While analyzing these issues is beyond the scope of the current study, a brief listing of potential regulatory issues related to separation is included in Table II-13. Some of the agencies and governmental units that will require policy and permitting coordination include MWRDGC, USACE, Illinois EPA, U.S. EPA, U.S. Coast Guard, and different departments within the City of Chicago.

Table II-13. Potential CAWS Regulatory Issues

Regulation	Governing Body	Flood Management	Water Quality	Transportation
Water Quality Standards 35 IAC Part 302	State	X	X	X
Water Use Designations and Site-Specific Water Quality Standards 35 IAC Part 303	State	X	X	X
Effluent Standards 35 IAC Part 304	State	X	X	X
Performance Criteria 35 IAC Part 306	State	X	X	
Disposal of Wastes from Watercraft 35 IAC Part 308	State		X	X
Permits 35 IAC Part 309	State	X	X	
Pre-treatment Programs 35 IAC Part 310	State	X	X	
Procedures for Determining Water Quality–Based Permit Limitations for NPDES[a] Discharges to the Lake Michigan Basin 35 IAC Part 352	State	X	X	
Combined Sewer Overflow Exception Criteria and First Flush Determinations 35 IAC Part 375	State	X	X	
Effluent Disinfection Exemptions 35 IAC Part 378	State	X	X	
Swimming Facility and Bathing Beach Code 77 IAC Part 820	State	X	X	
Marine Sanitation Devices 33 CFR Part 159	Federal		X	X
Chicago River, Illinois; Sanitary District controlling works, and the use, administration, and navigation of the lock at the mouth of the river, Chicago Harbor 33 CFR 207.420	Federal	X	X	X
Calumet River, Illinois.; T.J. O'Brien Lock and Controlling Works and the use, administration, and navigation of the lock 33 CFR 207.425	Federal	X	X	X

Regulation	Governing Body	Flood Management	Water Quality	Transportation
Water Quality Planning and Management 40 CFR Part 130	Federal	X	X	X
Water Quality Guidance for the Great Lakes System 40 CFR Part 132	Federal	X	X	X
Marine Sanitation Device Standard 40 CFR Part 140	Federal		X	X
U.S. Supreme Court Decree	U.S. Supreme Court and Great Lakes States	X	X	X
Diversion Accounting Rules	Federal	X	X	X
Allocation of Water from Lake Michigan	State	X	X	X

Note:

[a] National Pollutant Discharge Elimination System

D. Anticipated and Emerging Conditions

Baseline conditions (that is, "without project") were established to differentiate activities and investments that would proceed with or without a separation project from those activities and investments that would be required to support the goals of a separation project. The difference between these baseline (that is, "without project") and "with project" activities was used to determine investments required for separation as well as potential benefits associated with separation.

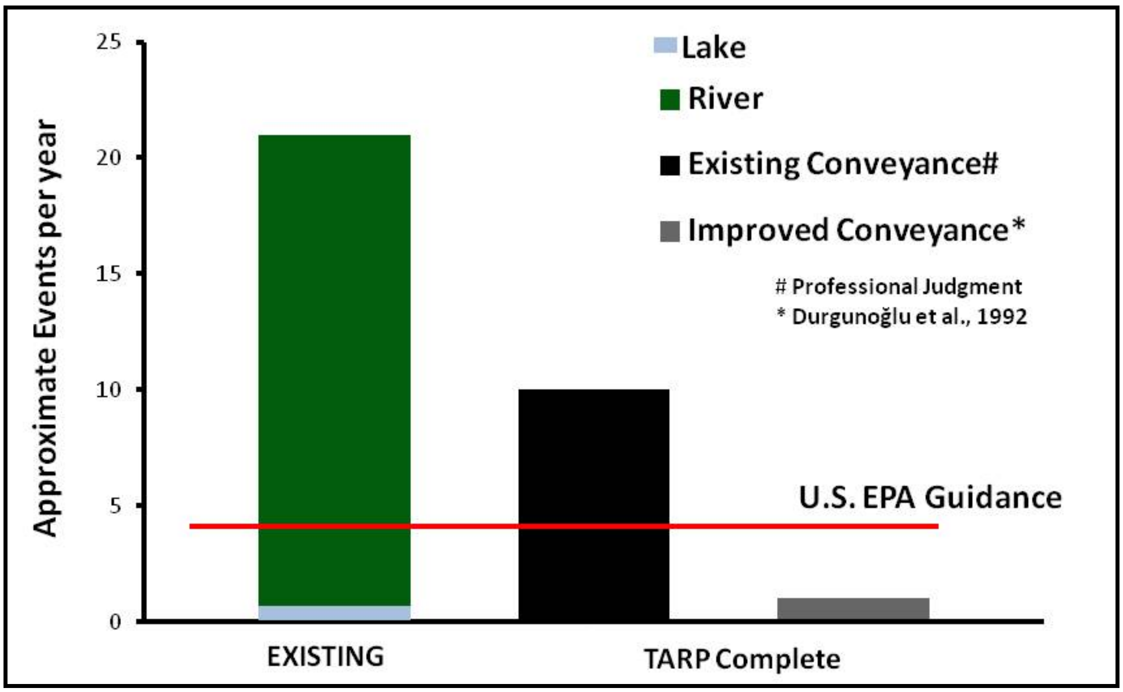
Anticipated conditions represent activities that are most likely to occur within the study period of the separation project but that lack formal approval or authorization and for which the actual timeframe and specific details are unknown. *Emerging conditions* represent trends beyond the current limits of planning, technology, or regulation that could be a factor in the future.

1. Flood Management

TARP and CSOs

At the scheduled completion of two large storage reservoirs for TARP in 2015 and 2029, about 14.8 billion gallons of reservoir storage will be added to the combined flood water and sewage system. The former MWRDGC director has estimated that, with the completion of these TARP reservoirs, up to 10 overflow events per year could still occur from numerous existing overflow discharge locations into the CAWS (one overflow event can consist of anywhere between one and all 263 combined sewer outfalls discharging to the CAWS) (Lanyon, 2011). Additional research suggests that overflow events could be reduced to as few as one or fewer per year if the full TARP reservoir capacity is used (Durgunoglu et al., 1992). The limiting factor in reducing overflow events with TARP completed will likely be the ability to convey flows through local sewers and regional interceptor sewers/tunnels to the TARP reservoirs. In other words, enough flow conveyance capacity must be provided to make full use of reservoir storage. Figure II-20 compares the potential CSO frequency under existing conditions and with TARP reservoirs completed (with existing conveyance and improved conveyance). Included is the U.S. EPA guidance that targets a goal of no more than four overflow events each year.

Figure II-20. CAWS CSO Frequency



Improved conveyance to allow TARP reservoirs to be fully operational is not part of the programmed and authorized TARP project for current/future conditions. However, it is anticipated that improved conveyance for local sewers and regional interceptor sewers/tunnels will be addressed by area municipalities and agencies regardless of a separation project. Therefore, for the purposes of this study, the improved conveyance required to fully use TARP is defined as an anticipated condition included with the baseline condition.

GREEN INFRASTRUCTURE

Current flood-management programs within the CAWS area encourage the use of green technologies, and implementing these existing ordinances was included as the current baseline condition for green infrastructure. Green infrastructure could reduce the flows to the local conveyance systems and TARP, thereby reducing the likelihood of an overflow event. While use of large-scale green infrastructure is still emerging, it is difficult to predict anticipated or emerging implementation for the project timeline; therefore, beyond the current baseline condition assumption for green infrastructure, no additional benefits were included in anticipated/emerging conditions regarding green infrastructure.

2. WATER QUALITY

WASTEWATER WATER QUALITY STANDARDS

Effluent water quality standards are likely to become more stringent over time. Predicting the standards and their timing is a challenging undertaking that goes beyond the scope of this study. However, costs for upgraded treatment to meet potential future standards without separation must be compared to potential costs for upgraded treatment with any of the proposed barriers and, subsequently, more stringent effluent quality requirements. This allows for the determination of costs that can be attributed to separation. Three future wastewater treatment requirements that fall into the anticipated and emerging category are discussed below. It was assumed that there is enough social and political will to allow new discharges to the Great Lakes and that the anti-degradation process would influence, but would not prevent, issuance of a permit.

DISINFECTION

Disinfection at Stickney WWTP is anticipated in the future but has not been mandated at this time. Since disinfection is planned and has been authorized by MWRDGC for the Calumet and North Side WWTPs, it is anticipated that disinfection will be required at the Stickney WWTP at some future time within the study period for the separation project.

NUTRIENTS

Potential alternatives for separation could change the final destination of the effluent from one or more of the WWTPs that discharge to the CAWS. Due to the national attention on nutrient loadings to the Gulf of Mexico and state/local Chicago area initiatives to improve water quality in the Chicago River, it is anticipated that, within the study period of the separation project, nutrient reduction will be required at some level, whether wastewater effluent is discharged to the Mississippi River System or Lake Michigan. The recently released *Gulf Coast Ecosystem Restoration Strategy* (U.S. EPA, 2011) includes reducing the flow of excess nutrients into the gulf as one of the key initiatives. The strategy calls for work in the gulf and upstream in the

Mississippi River basin to reduce the flow of excess nutrients into the gulf by supporting state nutrient reduction frameworks, new nutrient reduction approaches, and targeted watershed work to reduce agricultural and urban sources of excess nutrients. It is anticipated that discharges to Lake Michigan would likely require more stringent phosphorus removal.

EMERGING CONTAMINANTS

Although dependent on discharge location (Mississippi River versus Lake Michigan), regulatory requirements for constituents not currently regulated are expected to emerge within the study period for the separation project at some level and would apply with or without the barrier separation project. Treatment for emerging contaminants of concern, such as endocrine disruptors, mercury, and other toxics of concern, requires specialized treatment such as reverse osmosis or adding hydrogen peroxide with ultraviolet light treatment for removal.

While these emerging contaminants are a concern to all Great Lakes dischargers, affordable treatment technology is not currently available, and this level of treatment is generally not required at other wastewater plants that discharge to the Great Lakes. Most municipalities are addressing these concerns through source control and aggressive industrial pretreatment enforcement. Given the uncertainty of these potential regulations and the limits of current treatment technology, these emerging regulations were considered part of the baseline condition. Emerging potential regulatory requirements that would require alternate methods of control and or monitoring include the following:

a. Monitoring Requirements – Constituents that are not currently regulated, but might be regulated in the future, would require additional monitoring.
b. Coincidental Removal – As treatment technologies advance to remove nutrients and other more conventional pollutants, there would be enhanced removal of certain emerging constituents as a result.
c. Source Control – In certain cases, the most reasonable form of control is removing the constituents from the wastewater stream at the source using pre-treatment programs, product bans, and other best management practices.
d. Advanced Treatment – If source control and coincidental removal do not control the contaminant to acceptable levels, additional advanced treatment processes (for example, reverse osmosis or advanced oxidation) could be required.

POTENTIAL REGULATORY REQUIREMENTS

Based on available information, the potential permit limit scenarios shown in Table II-14 were assumed. In addition to nutrients, Table II-14 lists other constituents, such as mercury, that could receive lower standards in the future, with a range of possible regulatory requirements. These estimates were developed based on items noted in the table. Potential future regulatory requirements for nitrogen and phosphorus could be met with currently practiced wastewater treatment technologies, which are described in Appendix A.

Based on the best available information at the time of this study regarding potential wastewater quality standards and regulatory requirements for nutrient removal and the anti-degradation process, the “Moderate” Mississippi River System and “Stringent” Great Lakes System potential regulatory requirements listed in Table II-14 were assumed as the most likely scenario for the purposes of this study.

For reference purposes only, data are provided for Milwaukee to illustrate a typical large municipal discharger to Lake Michigan. It should be noted that the Milwaukee permit is currently expired; the updated permit has not yet been issued and might be different from the current permit. This Milwaukee discharge to Lake Michigan has been in place for some time. After Earth Day, Illinois systematically followed policies to prevent new sources to be discharged to Lake Michigan and to divert those that were historically discharged to Lake Michigan.

Since then, Illinois has diverted all previous wastewater discharges away from Lake Michigan. This general policy and the current Illinois water quality standard-use class for Lake Michigan and its tributaries, and the fact that this would be a new load to Lake Michigan thereby triggering anti-degradation, are the reasons that the forecasts are much more demanding than what Wisconsin is currently requiring for Milwaukee.

Table II-14. Potential Ranges of Future Regulatory Requirements

Parameter	Great Lakes System			Mississippi River System		
	Stringent	Moderate	Milwaukee[m]	Stringent	Moderate	Current
CBOD (mg/L)	4 [a]	4 [a]	30	10	10	10
TSS (mg/L)	5 [a]	5 [a]	30	12	12	12
Ammonia N (mg/L) Apr–Oct Nov–Mar	0.2 [b] 0.8 [b]	1.5 [c] 4 [c]	6.7 [n] 16.7	0.2 [b] 0.8 [b]	1.5 [c] 4 [c]	2.5 4
Total – P (mg/L)	0.1 [d]	0.1 to 1 [e]	1	0.5 to 1 [e]	1 [e]	—
Total – N (mg/L)	3 [d]	6 [f]	—	3 [d]	6 [e]	—
Bacteria (ct/100 mL)	126 [g]	126 [g]	400 [o]	200 [h]	400 [i]	—
Mercury (ng/L)	1.3 [j]	12 [k]	Monitor [p]	12 [k]	—	500 [l]
Other BCC [q] and Emerging Contaminants	Advanced Treatment/ Monitoring/ Coincidental Treatment/ Source Control	Monitoring/ Coincidental Treatment/ Source Control	—	Monitoring/ Coincidental Treatment/ Source Control	Monitoring	—

Notes:

[a] Current Lake Michigan basin effluent standards.

[b] Assuming toxicity to freshwater mollusks is the basis for revised federal ammonia criteria (about 20% of moderate values).

[c] Effluent limits based on current Lake Michigan basin tributary water quality standard for un-ionized ammonia.

[d] Current practical limit of technology. Treatment includes nitrification/denitrification and biological phosphorus removal via activated sludge, chemical addition, enhanced settling and fermentation, and anaerobic digestion; water quality-based requirements based on targets and ecoregional criteria.

[e] Treatment-based requirement; treatment includes advanced biological phosphorus removal via activated sludge and anaerobic digestion; water quality-based requirements based on targets and ecoregional criteria.

[f] Current reasonable technology limit. Treatment includes advanced nitrification/denitrification via activated sludge and anaerobic digestion; water quality-based requirements based on targets and ecoregional criteria.

[g] *E. coli* (ambient Lake Michigan water quality standard).

[h] Fecal – Current ambient water quality standard for General Use Water.

[i] Current Illinois effluent standard.

[j] Current Lake Michigan ambient water quality standard.

[k] Current water quality standard for General Use Water.

[l] Current Chicago Waterway System ambient water quality standard.

[m] Current Milwaukee (WPDES) Permit, WPDES No: WI-0036820-02-0, expired 03/31/2008.

[n] Ammonia limits shown are a range based on pH and temperature (currently in Milwaukee's WPDES permit; see note m above).

[o] Fecal.

[p] Monitor mercury; exceeding a trigger limit requires a pollutant minimization plan.

[q] Bioaccumulative chemicals of concern.

CONTAMINATED SEDIMENTS

As described previously in the Current and Planned Conditions section, contaminated sediments have been reported in sediment samples from many of the CAWS waterways. However, the full extent, depth, and characterization of these contaminated sediments are largely unknown and would require extensive investigation and analysis to determine these specifics. While some targeted, localized sediment remediation efforts have occurred in the CAWS, no programmatic strategy currently exists for removing contaminated sediments in the broader system.

Although dependent on discharge location (Mississippi River versus Lake Michigan), regulatory requirements for remediation of contaminated sediments are expected to emerge within the study period for the separation project at some level and would apply with or without the barrier separation project. Given the uncertainty of these potential regulations, the limits of current treatment technologies, and the uncertainty of the extent of contaminated sediments in the CAWS, sediment remediation is considered a baseline condition.

3. TRANSPORTATION

The Panama Canal expansion anticipated by 2015 is included in the baseline conditions. With this expansion will come the opportunity for additional container cargo to reach the United States. Because the CAWS does not currently serve the container-on-barge market, it is not included in the baseline condition; however, the opportunity for waterways to serve this new market sector is strong, given the limited capacity of the highway and rail system, as described previously.

This new opportunity is also strengthened by the fact that the federal government is displaying a growing interest in improving waterborne transportation for both bulk and container cargo. In August 2011, USDOT Secretary LaHood said that "shifting some of our freight from the highways to open inland waterways is a fuel-efficient, cost-effective way to move goods and reduce roadway congestion. The recommendations developed by the Marine Transportation System National Advisory Council will help us increase transportation efficiency, improve the environment, and grow the economy" (USDOT, Maritime Administration, 2011).

The Illinois River and the Mississippi River System, along with the Great Lakes, have historically served the nation's mid-country bulk markets with barge transportation services. These waterway systems can and will evolve into dual roles, much like the highway and rail systems do today, by serving both bulk and container markets.

The USDOT Maritime Administration (MARAD) implemented the Marine Highways Program in April 2010. The Marine Highway Program identifies 11 corridors, four connectors, and three crossings that can serve as extensions of the nation's surface transportation system. These corridors identify routes where water transportation presents an opportunity to offer relief to landside corridors that suffer from traffic congestion, excessive air emissions, other environmental concerns, and other challenges. Marine highways present a unique opportunity for developing container load centers that can offer a “triple play” of intermodal services: truck–rail–barge.

Two proposed marine highway corridors that could have a direct effect on the Chicago transportation system are the M-55 corridor and the M-90 corridor. The M-55 corridor includes the Mississippi and Illinois Rivers from New Orleans, Louisiana, via St. Louis, Missouri, to Chicago, Illinois. The corridor would help relieve landside traffic congestion on I-55. The USDOT says that this corridor is plagued by major freight and rail bottlenecks, particularly in Chicago and St. Louis.

The M-90 corridor includes the Great Lakes, Erie Canal, and connecting commercial navigation channels, ports, and harbors from Albany, New York, to Chicago, Illinois, and Duluth, Minnesota. The corridor would help relieve congestion on I-80 and I-90, which experience major freight truck bottlenecks at several points already, and these bottlenecks are expected to worsen. The M-90 corridor provides benefits to both I-90 and I-80, offering greater capacity between western Lake Superior to the East Coast via the St. Lawrence Seaway. According to USDOT, “new and expanded waterborne services offer the opportunity to absorb some of the future traffic congestion forecast for the corresponding landside corridor” (USDOT Maritime Administration, 2011).

Water ports, by nature, are intermodal. Freight traveling by water must arrive and depart by another transportation mode. Intermodal connectors are roads that provide access to water ports or rail services. Truck congestion on or near the intermodal connections affects ports that rely on trucks for commodity transfer. Improvements to roads that connect to ports increase the efficiency of ports, benefit trade, and contribute to regional productivity. Transporting freight by water is the most energy-efficient choice, as evidenced by the fact that barges move a ton of cargo at 576 miles per gallon of fuel. A rail car would move the same ton of cargo 413 miles, and a truck only 155 miles. Further, one 15-barge tow equals 216 rail cars, or 1,050 trucks.

Containerized shipments make up the largest proportion of world trade. This form of shipping is forecasted to continue to grow and be the dominate method of trade. The Maritime Administration Advisory Council forecasts that “container volume is expected to more than double in the next 20 years, and nearly all non-bulk cargo will be containerized. Ports must plan now to ensure that they have the people, training, technology, transportation, assets, and the infrastructure to provide efficient and reliable transportation services. Solutions must be flexible to accommodate changes that will inevitably occur" (USDOT Maritime Administration, 2011).

The USDOT anticipates that, in the next few years, at least 30% of West Coast port growth will be diverted via the Panama Canal expansion (15%) and by a round-the-world route via the Suez Canal (15%) to East Coast ports. This anticipated growth is driving an increase in Gulf Coast container-handling capacity. The Gulf Coast has plans for total container capacity in excess of 9 million twenty-foot equivalent units (TEUs) over the next decade, up from 2 million TEUs currently. Near the Mississippi River's base (from New Orleans to Mobile, Alabama), the capacity could exceed 4 million TEUs alone. The Mississippi River and the Illinois River serve a large manufacturing base, which can support a container-on-barge business along the rivers, into Chicago and then into the Great Lakes. Today, this base is served by rail services from the West Coast as well as by truck and rail from the East and Gulf Coasts.

Within the area served by the Great Lakes and the St. Lawrence Seaway, the region's population, employment, gross domestic product, and trade are projected to grow significantly through 2050, and the region's freight traffic is expected to expand at an even faster rate. The USDOT anticipates that a growing share of traffic moved by all modes of transportation will be by containers (including truck trailers). The total market for containerized traffic, which includes raw materials, food, and semi-finished and finished products, to and from the region is expected to more than double by 2050, from 35 million to over 70 million forty-foot units annually. This growth will create transportation challenges that require innovative solutions (USDOT Maritime Administration, 2007).

Within the greater Chicago area, the net effect of continued economic growth, increased trade with Asian markets, and capacity limitations on the region's highways and railroads creates an increased potential for water to play a greater role in the transportation of container traffic.

More information on this potential opportunity is included in Parts IV and V and in the CAWS Transportation Market Assessment in Appendix A.

4. Land-Use Planning

The State of Illinois, the City of Chicago, and the southern Chicago suburbs have developed plans that enhance the economic and open space opportunities along the CAWS. The barrier location alternatives developed as part of this study use the framework provided by these plans. Inherent in any infrastructure improvement is the need to be consistent with and support the land-use planning goals of the community and region. The Chicago area is a rich mixture of land-use types, and the areas adjacent to the CAWS are no exception. All along the system, industrial, open space, residential, and commercial land uses coexist. The types of infrastructure improvements that would be needed to realize a new vision for the CAWS support the various industrial and open space planning goals of the communities, which are described here.

INDUSTRIAL RETENTION

The City of Chicago established industrial corridors in the 1990s to focus its industrial retention efforts. The Calumet River Corridor is one such corridor. The Calumet Corridor is heavily industrialized and contains almost 60% of the land in Chicago that is available for industry (Figure II-21). At the same time, there is a great amount of existing rail in the Calumet Area, making it North America's largest center for intermodal freight shipping.

Since at least 2002, Chicago and the south suburbs have been developing plans to retain and enhance existing businesses and industries in the Calumet area as well as to attract new industrial and business development, thereby creating new job opportunities. The Calumet Area Land Use Plan was developed by the City of Chicago, as was the establishment of a Tax Increment Financing (TIF) district for the Calumet area (City of Chicago, 2002).

Currently, the City of Chicago is developing the Chicago Sustainable Industries Plan to further retain the manufacturing base and enhance the industrial nature of the corridors. Phase 1, released in March 2011, describes the corridors for protection. The Calumet Corridor is one such corridor and includes Planned Manufacturing Districts (PMDs) (Figure II-22). About 71% of the Calumet Corridor is within a PMD. The corridor contains 4,200 acres of land, with 67 businesses providing nearly 4,900 jobs. The Calumet Area Industrial Council Local Industrial Retention Initiative (LIRI) was also developed to interact with area companies to retain or expand those companies within the city (City of Chicago, 2011).

In 2007, the Chicago Southland Economic Development Corporation developed the Calumet River Corridor Economic Development Vision and Strategy*.* The purpose of this program is to create a framework for developing and investing in the seven south suburban communities that comprise the Calumet River Corridor: Robbins, Blue Island, Calumet Park, Riverdale, Dolton, Calumet City, and Burnham. The project focused on the Calumet River system as an important environmental amenity and economic asset. It highlights the fact that there is already direct access to all major modes of transportation, including interstate highways, rail freight lines, intermodal freight yards, waterways connecting Lake Michigan and the Mississippi River, international airports, multiple regional commuter-rail lines, and various domestic and commercial markets (Chicago Southland Economic Development Corp., 2007).

Figure II-21. Calumet Area Land Use Map

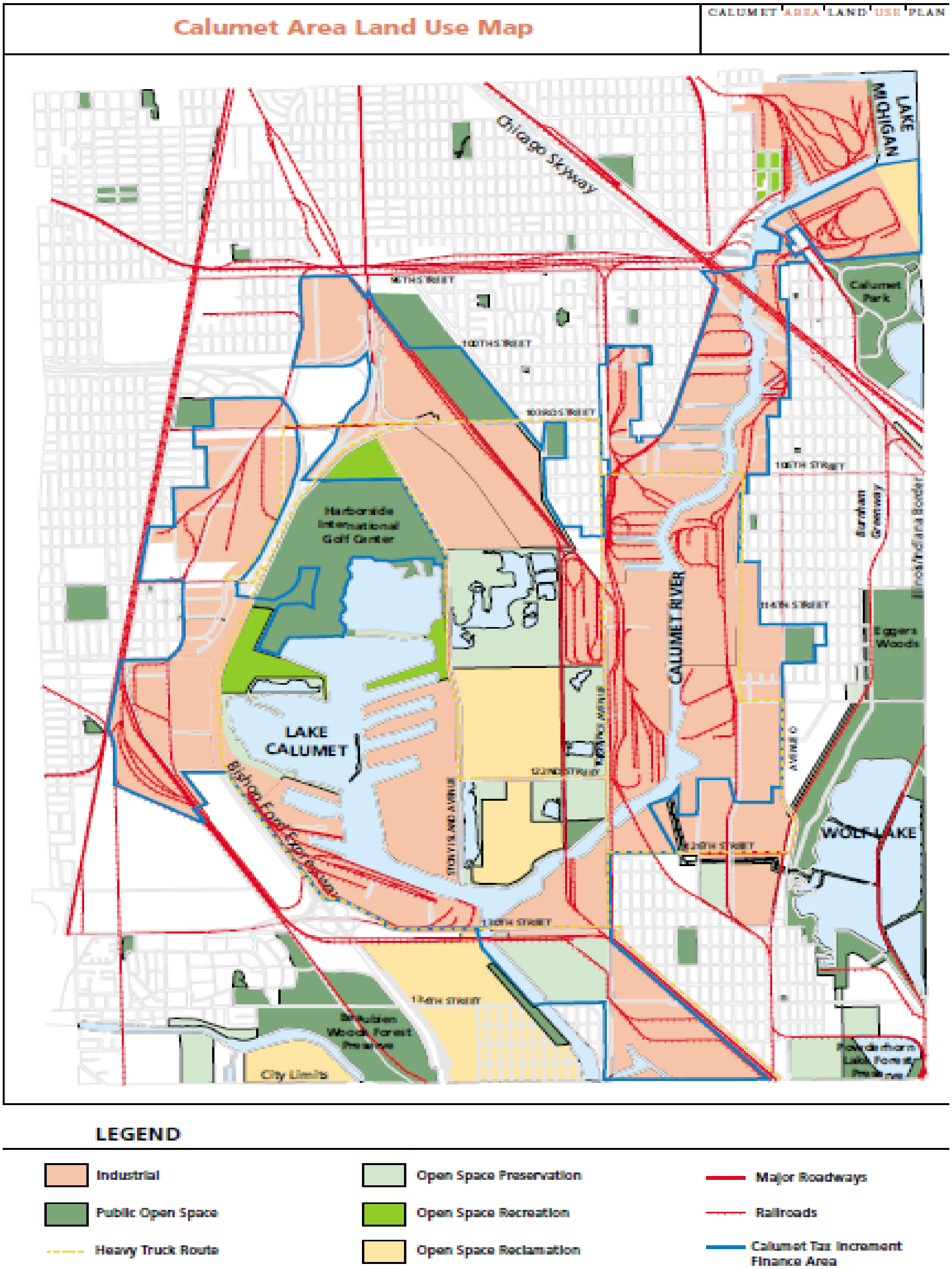
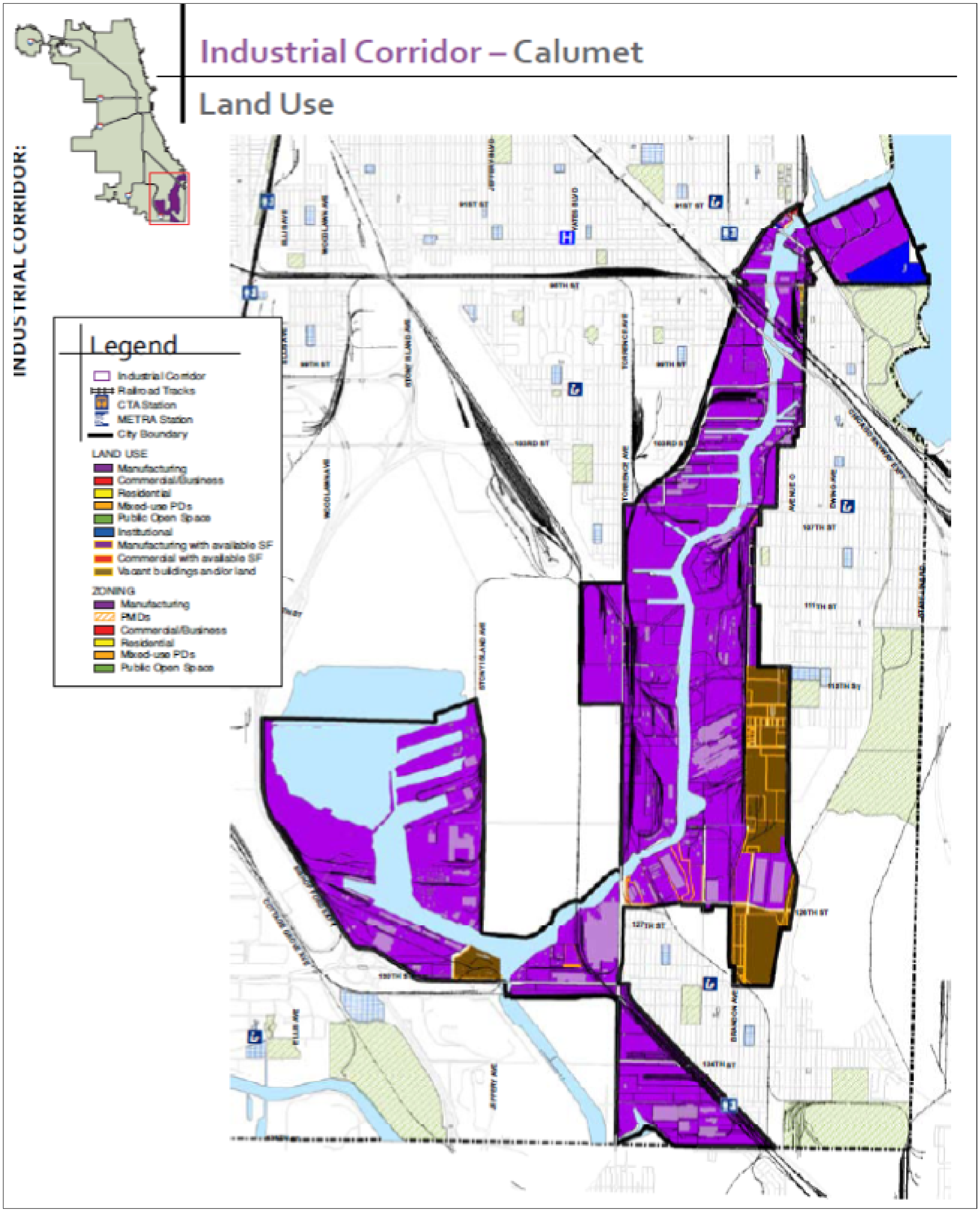
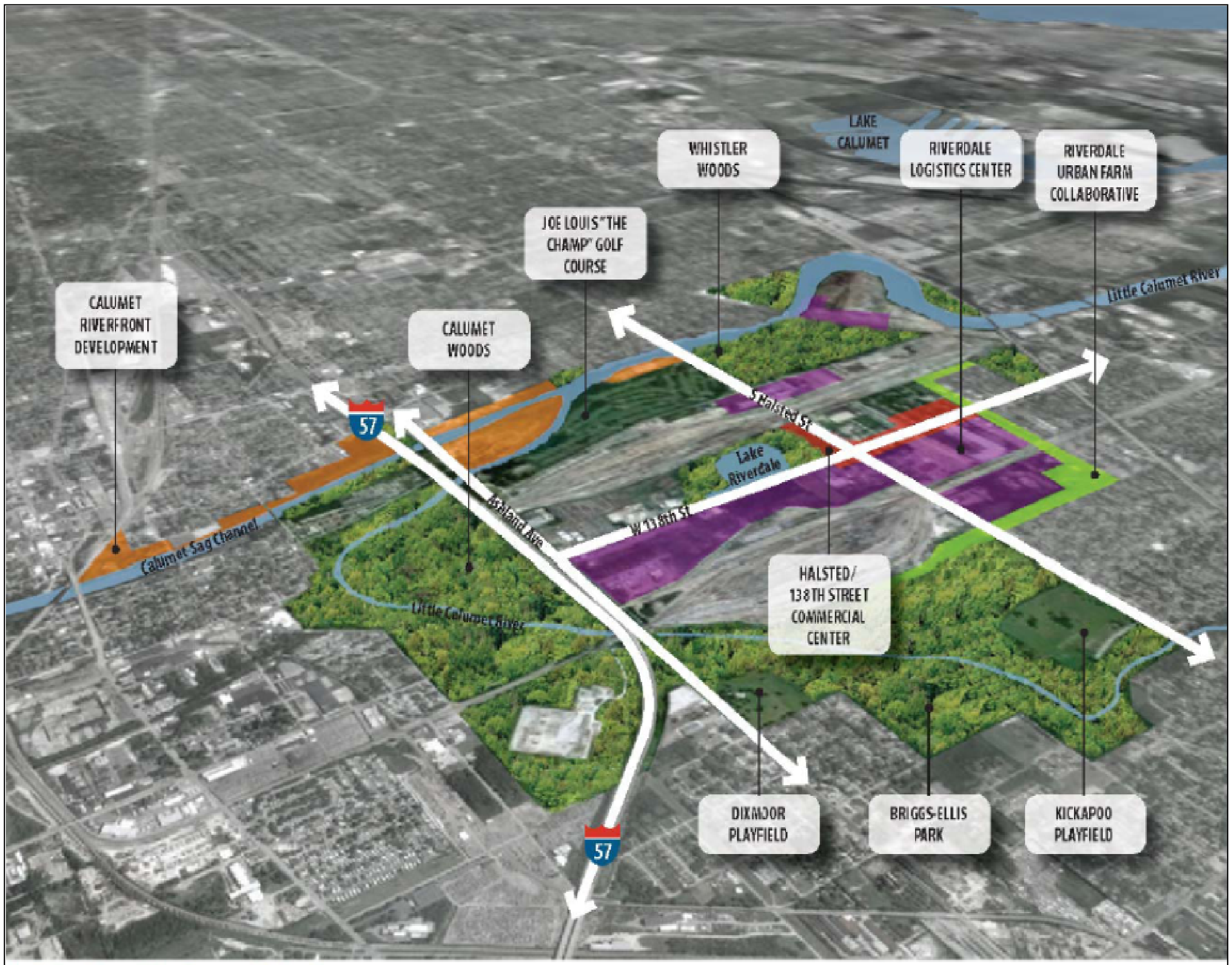


Figure II-22. Industrial Corridor – Calumet Land Use



The South Suburban Mayors and Managers Association (SSMMA) developed the Lake Riverdale Sustainable Master Plan in 2010 (Figure II-23). This plan describes strategies and ideas for promoting industrial redevelopment and open space opportunities in the south suburbs near the Little Calumet River and the Cal-Sag Channel. The plan emphasizes its unique location with regard to transportation, including water. While many of the properties adjacent to the water are proposed for open space enhancement and residential development, there is one property currently owned by Arcelor Mittal that is targeted for waterside industrial redevelopment to take advantage of the existing channel-side docking facility (SSMMA, 2010).

Figure II-23. Lake Riverdale Proposed Development Areas



▲ Lake Riverdale Proposed Development Areas

OPEN SPACE AND RECREATION PRESERVATION

The industrial land in the Calumet area exists side by side with Chicago's most important wetlands and natural habitats, and the aforementioned plans recognize the need to protect these resources. Implementation of the various plans has now taken shape as Millennium Reserve (Figure II-24), the largest open space project in the country, which will ultimately provide public recreation opportunities in 140,000 acres of land in the Calumet region. In late December 2011, Illinois Governor Pat Quinn announced the restoration of 15,000 acres of open space in the Calumet Core Reserve to start the project, dedicating $18 million from the Illinois Jobs Now! Capital Program.

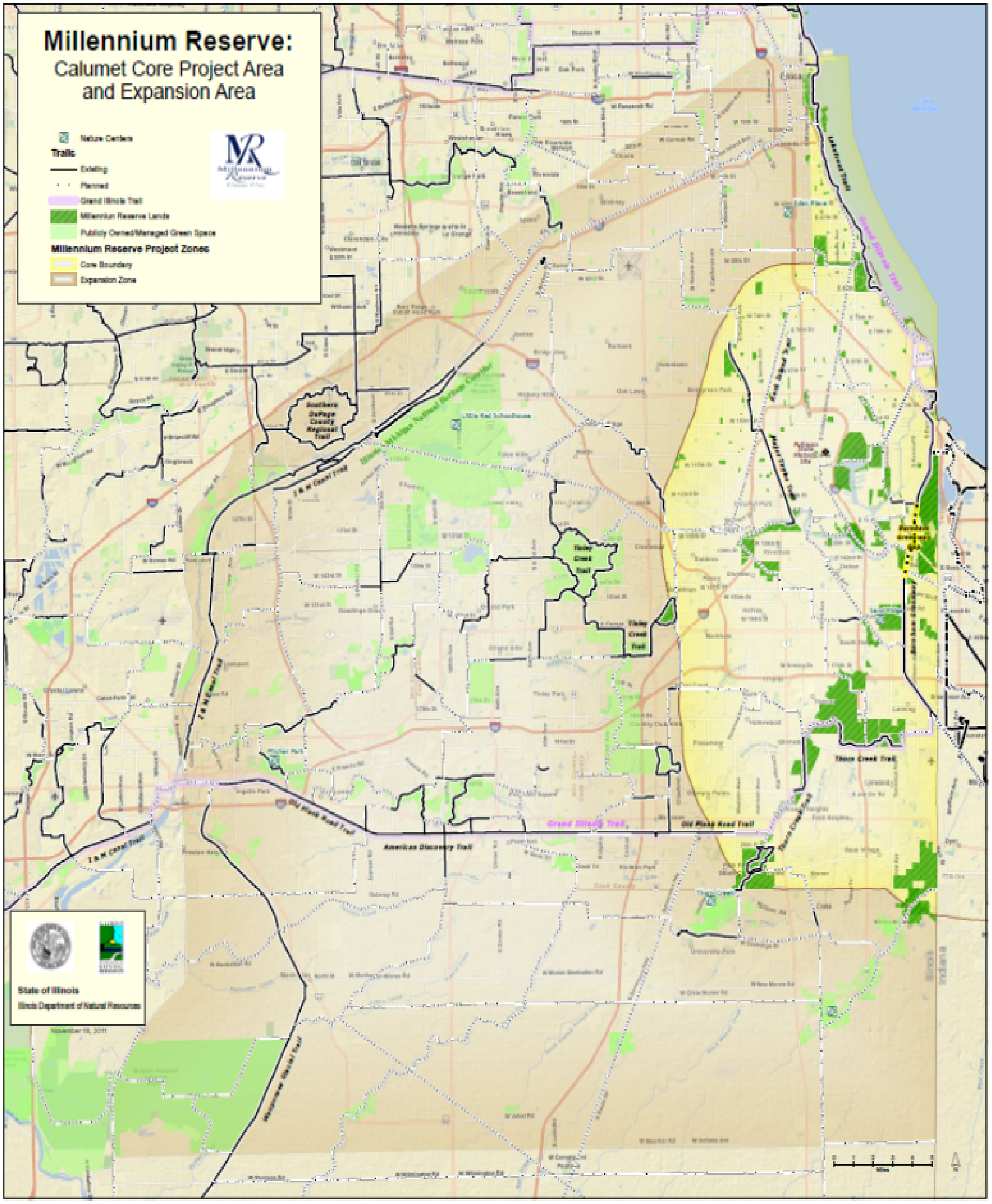
Illinois is also partnering with the City of Chicago, the Chicago Park District, the Forest Preserve District of Cook County, and other groups on a number of projects to restore and conserve the Calumet area's natural resources, which will collectively help form the Millennium Reserve. The program has gained recent acknowledgement as part of the federal America's Great Outdoors (AGO) program. The Illinois Department of Natural Resources also recognizes that these natural areas are of statewide significance and are home to some threatened and endangered species (State of Illinois, 2011).

The State of Illinois believes that the Millennium Reserve will be a catalyst to promote economic growth in the area. Specifically, it is envisioned that the Millennium Reserve will improve the economy by the following means:

- Modernizing the Illinois International Port District
- Creating a destination region for tourists and visitors
- Increasing property values for home owners near the Reserve

The aforementioned plans describe the State of Illinois' and Chicago area communities' goals and expectations for developing the southern Chicago region and are consistent with the goals identified for this study.

Figure II-24. Millennium Reserve – Calumet Core Project Area and Expansion Area



E. Summary

The baseline conditions described in this section were established to determine and compare potential impacts, improvements, required investments, and benefits associated with a separation project. These baseline conditions provided the foundation to differentiate activities that would proceed with or without a separation project from those activities that would be required to support the goals of a separation project. The activities were differentiated as "baseline" and "project" activities to determine the various elements that would constitute a separation alternative and the associated investments and benefits.

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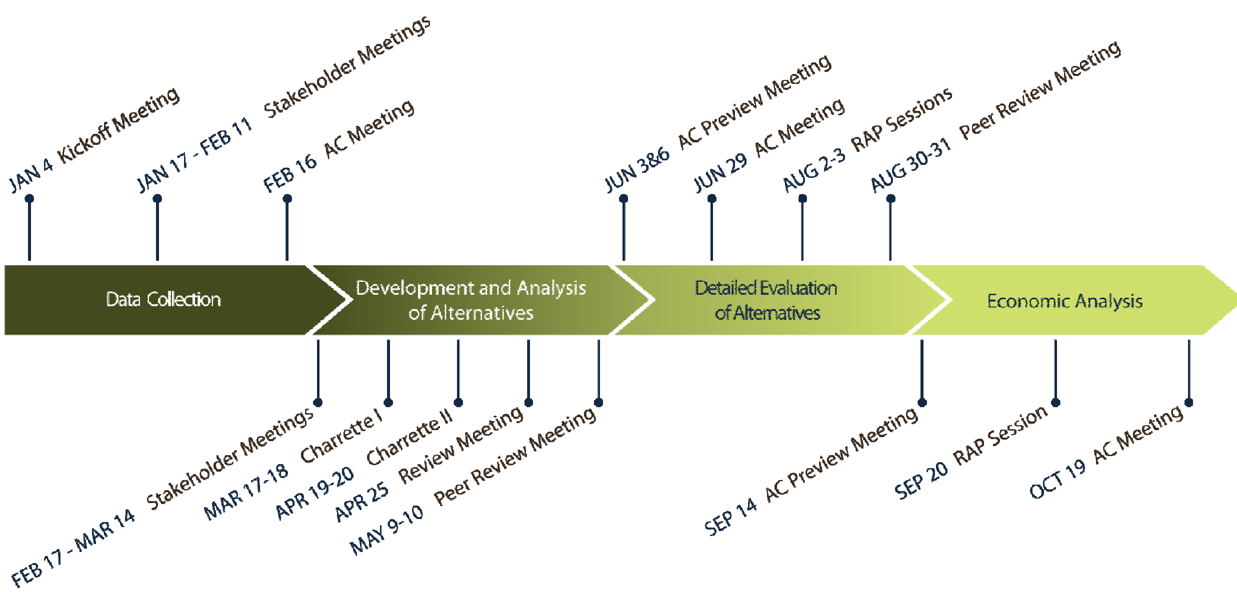
III. Development and Analysis of Alternatives

The development and analysis of alternatives included input from stakeholders, peer reviewers, and the study's AC. While the process was not consensus-driven, it was realized that input was needed to fully understand how placing physical barriers in the CAWS would affect the current conditions in and uses of the system. Opportunities for review and comment were offered throughout the study process to allow collaboration with a variety of different stakeholders and groups. In addition, two intensive peer review sessions were conducted. The result of this process was the development of three possible alternatives for separation, based on a preliminary list of 20 barrier locations. These alternatives illustrate a range of considerations related to flood management, water quality and transportation, and provide a solid foundation for advancing the dialogue on separation.

A. Overview of the Study Process

A robust analytical process was used that included data collection, conceptual visioning sessions, peer reviews, collaboration with the study's AC and Resource Group (RG), and an economic analysis (Figure III-1). These components are briefly discussed below; Appendix B provides a more detailed description of the study process.

Figure III-1. Study Process (2011)



The study process engaged a variety of stakeholders, including environmental advocates, private/industrial groups, and local, state, and federal agencies, using a series of interactive meetings, seminars, and technical sessions to develop three alternatives for physical separation and enhancement of the CAWS. The first set of meetings focused on data collection, as previously described in Part II, Baseline Conditions.

The development and analysis of alternatives began with two conceptual visioning sessions, referred to as Charrettes I and II in Figure III-1 above, during which technical experts in flood management, water quality, and transportation worked together to identify barrier locations, barrier types, preliminary alternatives, and associated benefits or challenges. Evaluation tables, included as Table III-1 and Table III-2, were completed during this process. Appendix B also includes background information developed for Charrette I as well as the summaries of Charrettes I and II. The GLC/CI was consulted throughout the process to report preliminary findings and receive additional guidance.

During the development and analysis of alternatives, two external peer reviews were completed to provide an opportunity for outside experts to evaluate the study methodology and preliminary results. The peer review team consisted of five experts in the fields of engineering, water quality, transportation planning, and economics with specific knowledge of the Chicago metropolitan area and the CAWS. The reviews scrutinized the assumptions, baseline conditions, barrier location evaluation, and selected alternatives. Appendix C includes summaries of each peer review.

The AC for this study represented a broad array of stakeholders, including groups that were interested in or would be affected by separation (or the lack of separation). The AC was formally convened four times during the study to provide guidance and input at critical points, with an emphasis on developing and evaluating the alternatives for separation. Additional opportunities for input were provided between meetings and through small-group “preview” meetings held in advance of full AC meetings. AC meetings were open to members of the RG—which was made up of governmental and quasigovernmental entities with a direct interest in the study—and other interested parties.

Figure III-2. Collaboration

AC meetings brought enhanced transparency to the study process and proved valuable to developing the study findings. Appendix D includes a list of the attendees, meeting minutes, and presentations for each AC meeting, which are also available on the project website (www.glc.org/ans/chicagowaterway). While the AC and the RG provided valuable input that greatly improved the analysis, it should be made clear that the AC and RG did not review the draft of this report and have not endorsed it. The opinions and conclusions in this report are those of HDR and its team of consultants.

The information discussed during the Charrettes, the direction provided by the GLC/CI, the insight from the peer review team, and the feedback provided by the AC were incorporated into the analysis presented below. Evaluation criteria (Appendix D) were developed to address the goals that were established early in the study process. These were used in the development of alternatives. After the alternatives were defined, an economic analysis was completed to describe the cost and benefits of each alternative. This began with a risk analysis process (RAP) session to develop and refine a list of cost and benefit categories for preventing AIS transfer, flood management, water quality, and transportation. This analysis is further described in Part V, Economic Analysis.

B. Development and Analysis of Alternatives

1. Evaluation of Preliminary Barrier Locations

The first step in the evaluation process was to identify locations for placing barriers. As shown in Figure III-3, 20 potential barrier locations were identified based on considerations such as the locations of existing WWTPs, waterway confluences, and transportation infrastructure. The locations represent a general area and not a specific location.

Each barrier location was evaluated based on its impact on important CAWS functions of flood management, water quality, transportation, and recreation using the scores "+" (benefit or improvement), "0" (no change), or "–" (negative impacts) based on existing data and professional judgment (Table III-1 and Table III-2). Potential impacts such as reduced conveyance, stagnation, and interruption of waterborne traffic for the riverside and the lakeside of each barrier location were identified. The evaluation table was divided into the Upper CAWS (North Branch, Chicago River, South Branch, CSSC) and the Lower CAWS (Calumet River, Grand Calumet River, Little Calumet River, and Cal-Sag Channel) to help describe and evaluate the barrier locations.

An example of the methodology used to evaluate each location is provided in this discussion using Location 2, which is the North Side WWTP. Flood management received a "+" score because the volume would be reduced for all flood water and overflows lakeside of the barrier flowing to the lake. Water quality received a "–" score since there would be an area of stagnation riverside of the barrier down to the North Side WWTP, which would require flow augmenttation. Transportation received a "0" score since there would be no impacts to existing boat traffic. The results of this process were used to refine the list of locations; those locations with the lowest scores were dismissed, leaving 12 of the original 20 locations for further evaluation.

GENERAL TRENDS

Placing physical barriers in the CAWS has significant implications for the types of investments that are needed and the opportunities that are created. In general, more flood water and water quality challenges were identified for the Upper CAWS, and more transportation challenges were identified for the Lower CAWS. In many cases, investments required to address these challenges would result in overall improvements to the CAWS.

Challenges and opportunities were identified for flood management for each alternative, mostly related to conveyance. Water quality challenges were identified due to stagnation, CSOs, and contaminated sediments. However, because future regulatory changes might require removing the contaminated sediments, the impacts of these sediments might not be an issue, and, if so, the project would not need an investment for removing the sediments. Several challenges were identified for transportation because placing barriers would restrict barge or industrial use. However, improvements were identified for Lake Calumet with regard to developing a new multi-modal facility. Recreational and commercial traffic would be affected at most locations, as the connection to Lake Michigan would be disrupted, and investments would be required to address this challenge.

Figure III-3. Preliminary Barrier Locations

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Table III-1. Upper CAWS Barrier Location Evaluation Table

Location	Flood Management (+,0,-)	Water Quality (+,0,-)	Transportation (+,0,-)	Recreation (+,0,-)	Total (+,0,-)	Comments on Key Elements
1 Wilmette Pump Station (PS)	(-) No backflow (outlet) to lake aggravates existing flooding	(-) No flow diversion; sediment issues	(0) No issues (already blocked by PS)	(0) Limited issues (already blocked by PS)	-2	Barrier location near upstream extent of TARP, so limited issue regarding CSOs; barrier would require improvement for larger flood events due to removing backflow to lake. Water quality issues in reach north of North Side WWTP would develop because of stagnation (no lake diversion).
2 R/S North Side WWTP	(+) Reduction in volume	(-) Flow stagnation d/s of barrier (no source of flow)	(0) No issues (no industrial use in NSC)	(-) Local population use of NSC would be eliminated	-1	CSO discharges to lake l/s; CSOs to dry ditch r/s of barrier. Reduction in stormwater volume r/s of barrier by diverting CSOs l/s of barrier to lake, reducing flooding r/s.
3 Chicago Locks	(-) No backflow (outlet) to lake	(-) Stagnation, DO issues in Chicago River without diversion	(-) Limited barge/ industrial use	(-) Barrier to CAWS for commercial/private boats	-4	Lack of source water to improve stagnation and DO issues on Chicago River. Significant improvement required for increased flooding risk downtown Chicago.
4 Mouth of South Branch	(-) No backflow (outlet) to lake	(-) Stagnation r/s of barrier; CSOs to lake	(-) Barrier to barge/ industrial use	(+) River becomes lake (no locking needed)	-2	L/s of barrier, water quality improves (lake quality) except CSO discharges. R/s stagnation and DO issues. Increased flooding potential because RAPS would not have backflow outlet to lake.
5 L/S Racine Ave. Pump Station (RAPS)	(-) No backflow (outlet) to lake	(0) Stagnation both sides of barrier; no RAPS CSO to lake	(-) Barrier to barge/ industrial use of CSSC	(0) Limited recreational use r/s of RAPS	-2	Dry-weather stagnation issues both sides of barrier, but no CSOs from RAPS to lake. Barrier assumed to be l/s of Fisk power plant (barge access to r/s CSSC for coal would remain).
6 L/S RAPS	(-) Lose stormwater storage/ conveyance in CAWS r/s	(-) L/s CSOs to lake and r/s stagnation issues	(-) Barrier to barge/ industrial use of CSSC	(0) Limited recreational use r/s of RAPS	-3	Lose access by barge for coal supply to Fisk power plant.
7 L/S Stickney WWTP	(-) Lose stormwater storage/ conveyance in CAWS r/s	(-) RAPS CSOs to lake and stagnation issues l/s	(-) Barrier to barge/ industrial use of CSSC	(0) Limited recreational use r/s of RAPS	-3	Lose access by barge for coal supply to Fisk power plant. Issues regarding industrial transportation (barge, etc.) increase as barrier location moves farther r/s along CSSC. Locations 4, 5, and 6 more positive than Location 7 ➔ screen out Location 7.
8 R/S Stickney WWTP	(-) Lose stormwater storage/ conveyance in CAWS r/s	(-) Stickney and RAPS CSOs to lake; r/s stagnation issues	(-) Barrier to barge/ industrial use of CSSC	(0) Limited recreational use r/s of RAPS	-3	Lose access by barge for coal supply to Fisk power plant. Issues regarding industrial transportation (barge, etc.) increase as barrier location moves farther r/s along CSSC. Locations 4, 5, and 6 more positive than Location 8 ➔ screen out Location 8.
9 L/S Lockport	(-) Lose outlet for CAWS (not able to draw down)	(-) Stickney and RAPS CSOs to lake; l/s stagnation issues	(-) Barrier to use of CSSC and Cal-Sag Channel	(-) No connection to CAWS including Cal-Sag Channel	-4	Lose ability to draw down water levels in CAWS before storm events, thereby increasing the potential flooding risk in the CAWS. Locations 4, 5, and 6 more positive than Location 9 ➔ screen out Location 9.
16 CSSC and Cal-Sag Confluence	(-) Lose outlet for CAWS (not able to draw down)	(-) Stickney and RAPS CSOs to lake; l/s stagnation issues	(-) Barrier to use of CSSC and Cal-Sag Channel	(-) No connection to CAWS including Cal-Sag Channel	-4	Lose ability to draw down water levels in CAWS before storm events, thereby increasing the potential flooding risk in the CAWS. Locations 4, 5, and 6 more positive than Location 16 ➔ screen out Location 16.
18 Chicago River	(-) No backflow (outlet) to lake	(-) L/s of barrier CSOs to lake and stagnation issues	(-) Limited barge/ industrial use	(-) Barrier to CAWS for commercial/private boats	-4	CSOs to lake and stagnation issues limited to Chicago River. Recreation access maintained on Chicago River, but lose connection to North and South Branches.
19 L/S North Side WWTP	(-) Lose backflow outlet to lake	(-) L/s of barrier flow stagnation issues and CSOs to lake	(0) No issues (no industrial use in NSC)	(+) More lakeside recreation l/s of barrier	-1	Lose diversion from lake for WQ/flushing and CSOs to lake l/s of barrier. L/s of barrier would become "lake water."

r/s – riverside
l/s – lakeside

Table III-2. Lower CAWS Barrier Location Evaluation Table

Location	Flood Management (+,0,-)	Water Quality (+,0,-)	Transportation (+,0,-)	Recreation (+,0,-)	Total (+,0,-)	Comments on Key Elements
10 Little Calumet	(-) Lose backflow outlet for releasing additional stormwater to lake	(0) Limited change from existing conditions	(0) No issues (no existing industrial use)	(0) No issues (no/limited existing use)	-1	Barrier near natural divide. Barrier independent of all locations on Calumet ➔ barrier must be used in addition to barriers located on Calumet.
11 D/S Calumet WWTP	(-) Lose backflow outlet for releasing additional stormwater to lake	(-) Flow stagnation d/s of barrier (no source of flow)	(-) Barrier to barge/ industrial use between Cal-Sag Channel and T.J. O'Brien Lock	(-) Lose connection to Lake Michigan	-4	Requires Calumet WWTP plant upgrade; limited opportunities for augmenting flow d/s of barrier, since Little Calumet River has limited flow to flush Cal-Sag Channel during dry weather. Locations 12 and 20 more positive than Location 11 ➔ screen out Location 11.
12 U/S Calumet WWTP	(-) Lose backflow outlet for releasing additional stormwater to lake	(0) U/s of barrier becomes lake; limited CSOs in u/s reach	(-) Barrier to barge/ industrial use of Cal-Sag Channel and T.J. O'Brien Lock	(-) Lose connection to Lake Michigan	-3	Stagnation u/s of barrier to Grand Calumet River. Similar to Location 14 except not at existing lock facility; easier to provide effluent from WWTP for augmenting flow and would eliminate need for barrier Location 13 (Grand Calumet River).
13 Grand Calumet	(-) Lose backflow outlet for releasing additional stormwater to CAWS	(0) Limited issue on CAWS and on Indiana	(0) No issues (no existing industrial use)	(0) No issues (no/limited existing use)	-1	Barrier near natural divide. Barrier independent of Location 20 on Calumet and dependent of Location 12 ➔ barrier must be used in addition to barrier 20, but not needed with barrier 12.
14 T.J. O'Brien Lock	(-) No backflow (outlet) to lake	(0) Same as existing conditions except during extreme storms	(-) Barrier to barge/ industrial use between Cal-Sag Channel and Lake Calumet	(-) Lose connection to Lake Michigan	-3	T.J. O'Brien Lock does have existing releases to lake during extreme storms; barrier would prevent backflow to lake; improvement would require water source lakeside for stagnation; would require barge transfer/lift. Locations 12 and 20 more positive than Location 14 ➔ screen out Location 14.
15 Lake Michigan/ Calumet	(-) Lose backflow outlet for releasing additional stormwater to lake	(-) No mixing with lake water d/s of barrier and stagnation d/s	(-) Barrier to barge/ industrial use of Lake Calumet and Cal-Sag Channel	(-) Lose connection to Lake Michigan	-4	Prevents "laker" ships from entering Lake Calumet; improvement could provide opportunity to improve port, but terminals for "laker" ships (about 35) would need to be relocated. Locations 12 and 20 more positive than Location 15 ➔ screen out Location 15.
17 Cal-Sag Channel	(0) Lose backflow outlet for releasing additional stormwater to lake, but much of flood storage volume remains	(-) CSOs and WWTP to lake	(-) Barrier to barge/ industrial use between Cal-Sag Channel, CSSC, and T.J. O'Brien Lock	(-) Lose connection to Lake Michigan	-3	Less release to Cal-Sag Channel because of barrier, but more releases to Lake Michigan; advantage over Location 11 is no barrier required on Little or Grand Calumet Rivers (locations 10 and 13). Locations 12 and 20 more positive than Location 17 ➔ screen out Location 17.
20 Lake Calumet	(-) No backflow (outlet) to lake	(0) Lake Calumet water level would decrease; limited CSO issues and already stagnant	(+) Provides potential for multi-modal shipping center to maximize shipping efficiency	(-) Lose connection to Lake Michigan	-1	Significant wetland improvement required. Existing stagnation issues likely not significantly increased and limited CSO improvement issues; improvement could provide potential multi-modal shipping transportation opportunity including container on barge.

r/s – riverside
l/s – lakeside
u/s – upstream

2. Evaluation of Barrier Location Pairings

Early in the evaluation process, it was realized that there were more ways to achieve separation by placing multiple barriers than by placing a single barrier. This stemmed from the fact that there are five connections between the CAWS and Lake Michigan. As the evaluation process proceeded, this concept became more evident, so barrier locations were combined to form pairings. The 13 resulting pairings were categorized by location in relation to the Upper CAWS and Lower CAWS and were again assigned a "+", "0", or "–" for ecological health, flood management, transportation, and recreation, as shown in Table III-3 and Table III-4. Each pairing was evaluated based on potential challenges and how the barriers could function together. As a result, each pairing received a total score ranging from -1 to -4, based on the combination of scores for individual areas. This process was conducted for each of eight different pairings for the Upper CAWS and an additional five pairings for the Lower CAWS.

The evaluation process conducted for the location pairings is described here using the Pairing 1 and 18 (Table III-3), which consists of a physical barrier placed at each location. Location 1 is the Wilmette Pump Station, and Location 18 is the Chicago Lock. Ecological health and flood management both received a "–" score due to potential stagnation and flooding issues. If the Wilmette Pump Station were closed, stagnation could occur between the pump station and the effluent discharge point of the North Side WWTP, and the flow would need to be augmented. Also, there would be no opportunity for flow diversion or backflow through either location to reduce the amount of flood water. Transportation also received a "–" score. Traffic would not be affected for Location 1 but would be significantly affected at Location 18 since all traffic to and from Lake Michigan would be blocked. This alternative (Pairing 1 and 18) received a total score of -4 due to "–" scores for all four areas.

General Trends

The general trends for the barrier location pairings for the Upper and Lower CAWS were very similar to the general trends discussed above for the initial barrier locations. These trends included issues for flood management since there would be no backflow outlet to Lake Michigan, for water quality due to stagnation, and for transportation due to limitations that would be imposed on barge or industrial traffic. There was also a mixture of challenges, opportunities, and benefits for recreation depending on access to Lake Michigan.

Once the issues and challenges were documented for every pairing, total scores and major challenges were reviewed in order to refine the list of pairings that should be further evaluated. As a result, four of the original 13 pairings were retained for further evaluation, as indicated in Table III-3 and Table III-4.

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Table III-3. Upper CAWS Pairings Evaluation Table

Pairing	Flood Management (+,0,-)	Water Quality (+,0,-)	Transportation (+,0,-)	Recreation (+,0,-)	Total (+,0,-)	Comments on Key Elements
1 & 3 Wilmette PS & Chicago Locks	(-) No backflow to lake aggravates existing flooding	(-) No flow diversion; stagnation on NSC and Chicago River	(-) Limited barge/industrial use but no connection to CSSC	(-) Barrier to CAWS for commercial, private, and public safety use	-4	Lack of source water to improve stagnation and DO issues on Chicago River. Significant improvement required due to increased flooding risk in downtown Chicago. Connection between CAWS and Lake Michigan for recreation is lost.
1 & 18 Wilmette PS & Chicago River	(-) No backflow to lake aggravates existing flooding	(-) No flow diversion; issues w/ stagnation but less severe than 3	(-) Limited barge/industrial use but no connection to CSSC	(-) Limits CAWS/lake access r/s of Chicago River only (less negative than 3)	-4	Stagnation issues on Chicago River less severe than barrier 3 location. Recreation scenario more positive than barrier 3 location. Pairing 1 & 18 more positive than Pairing 1 & 3 ➔ screen out Location 3 and Pairing 1 & 3.
2 & 18 R/S NS WWTP & Chicago River	(-) No backflow to lake downtown aggravates existing flooding	(-) Flow stagnation r/s of Location 2 (no source of flow); CSOs to lake	(-) Limited barge/industrial use but no connection to CSSC	(-) Limits CAWS/Lake access r/s of Chicago River only (less negative than 3)	-4	More CSOs to Lake Michigan than Pairing 1 & 18. Requires additional treatment for North Side WWTP (flows to lake). Potential for "credit" to diversion account with return of North Side WWTP to lake. Pairing 1 & 18 more positive than Pairing 2 & 18 ➔ screen out Location 2 and Pairing 2 & 18.
4 Mouth of South Branch	(-) No backflow (outlet) to lake	(-) Stagnation r/s of barrier; CSOs to lake	(-) Barrier to barge/industrial use of North Branch and Chicago River only	(+) River becomes lake (no locking needed)	-2	North Side WWTP requires additional treatment. Significant CSO improvement required. RAPS conveyance issue (no backflow to Lake Michigan). Significant water quality improvement issues with moderate flood management improvement required.
5 L/S Racine Ave. PS (RAPS)	(-) No backflow (outlet) to lake	(0) Stagnation both sides of barrier; no RAPS CSO to lake	(-) Barrier to barge/industrial use of CSSC	(0) Limited recreational use r/s of RAPS	-2	Assuming Fisk power plant remains in operation, barrier location would be l/s of Fisk. Potential for augmenting flow l/s of barrier (with Lake Michigan water) and r/s of barrier with Stickney water. Note: If Fisk plant were offline and CSOs were already addressed through other means, then barrier could be placed at Location 6 (same flow augmentation scenario).
4/5* South Branch L/S RAPS	(-) No backflow (outlet) to lake	(0) Stagnation both sides of barrier; no RAPS CSO to lake	(-) Barrier to barge/industrial use of North Branch and Chicago River only	(+) River becomes lake (no locking needed)	-1	Merged Locations 4 and 5 into single barrier location. Location 4 at mouth of South Branch is very congested with significant infrastructure, and Location 5 is moved l/s of Fisk plant and other l/s barge terminals. Revisions to Locations 4 and 5 resulted in similar likely location between mouth of South Branch and RAPS.
6 L/S Racine Ave. PS (RAPS)	(-) Lose stormwater storage/conveyance in CAWS r/s	(-) L/s CSOs to lake and r/s stagnation issues	(-) Barrier to barge/industrial use of CSSC	(0) Limited recreational use r/s of RAPS	-3	Significant CSO improvement issue with RAPS l/s. Dry-weather stagnation issues l/s of RAPS with possible improvement by using new WWTP to treat sanitary flows currently going to Stickney along CSSC between RAPS and Stickney. Pairing 4 & 5 more positive than Location 6 ➔ screen out Location 6. Lose access by barge for coal supply to Fisk power plant.
19 & 18* L/S NS WWTP & Chicago River	(-) Lose backflow (outlet) to lake	(-) L/s of barrier flow stagnation issues and CSOs to lake	(-) Barrier to barge/industrial use of Chicago River only	(0) More lakeside recreation l/s of barrier on NSC; barrier to CAWS for commercial, private, and public safety use	-3	CSOs l/s larger than Pairing 1 & 18, but manageable. Significant flood management improvement issue with loss of backflow outlets to Lake Michigan at Wilmette and Chicago Rivers. Pairing 19 & 18 more positive than Pairing 1 & 18 ➔ screen out Location 1 and Pairing 1 & 18.

r/s – riverside
l/s – lakeside
u/s – upstream
* Paired barrier locations retained for further review

Table III-4. Lower CAWS Pairings Evaluation Table

Pairing	**Flood Management** (+,0,-)	**Water Quality** (+,0,-)	**Transportation** (+,0,-)	**Recreation** (+,0,-)	**Total** (+,0,-)	**Comments on Key Elements**
12 & 10* **U/S Calumet WWTP & Little Calumet**	(-) Lose backflow outlet for releasing additional stormwater to lake	(0) L/s of barrier becomes lake; limited CSOs in l/s reach	(-) Barrier to barge/industrial use of Cal-Sag Channel and T.J. O'Brien Lock	(-) Lose connection to Lake Michigan	-3	Stagnation l/s of barrier to Grand Calumet River. Similar to Location 14 except not at existing lock facility; easier to provide effluent from WWTP for augmenting flow and would eliminate need for barrier Location 13 (Grand Calumet River).
11 & 10 **D/S Calumet WWTP**	(-) Lose backflow outlet for releasing additional stormwater to lake	(-) Flow stagnation r/s of barrier (no source of flow)	(-) Barrier to barge/industrial use between Cal-Sag Channel and T.J. O'Brien Lock	(-) Lose connection to Lake Michigan	-4	Requires Calumet WWTP plant upgrade; limited opportunities for augmenting flow r/s of barrier since Little Calumet River has limited flow to flush Cal-Sag Channel during dry weather. Locations 12 and 20 more positive than Location 11 ➔ screen out Location 11.
14 & 10 & 13 **T.J. O'Brien Lock**	(-) No backflow (outlet) to lake	(0) Same as existing conditions except during extreme storms	(-) Barrier to barge/industrial use between Cal-Sag Channel and Lake Calumet	(-) Lose connection to Lake Michigan	-3	T.J. O'Brien Lock does have existing releases to Lake Michigan during extreme storms; barrier would prevent backflow to lake; improvement would require water source l/s for stagnation; would require barge transfer/lift. Locations 12 and 20 more positive than Location 14 ➔ screen out Location 14.
15 & 10 & 13 **Lake Michigan/ Calumet**	(-) Lose backflow outlet for releasing additional stormwater to lake	(-) No mixing w/ lake water r/s of barrier and stagnation r/s	(-) Barrier to barge/industrial use of Lake Calumet and Cal-Sag Channel	(-) Lose connection to Lake Michigan	-4	Prevents "laker" ships from entering Lake Calumet; improvement could provide opportunity to improve port, but terminals for "laker" ships (about 35) would need to be relocated. Locations 12 and 20 more positive than Location 15 ➔ screen out Location 15.
20 & 10 & 13* **Lake Calumet, Little Calumet, Grand Calumet**	(-) No backflow (outlet) to lake	(0) Lake Calumet water level would decrease; limited CSO issues and already stagnant	(+) Provides potential for multi-modal shipping center to maximize shipping efficiency	(-) Lose connection to Lake Michigan	-1	Significant wetland improvement required. Existing stagnation issues likely not significantly increased and limited CSO improvement issues; improvement could provide potential multi-modal shipping transportation opportunity including container on barge.

r/s – riverside
l/s – lakeside
u/s – upstream
* Paired barrier locations retained for further review

C. Selection and Further Analysis of Alternatives

1. Selection of Alternatives

During the evaluation process, a number of considerations were raised that required further clarification. Discussions with the GLC/CI on these issues led to the following decisions:

- Currently authorized projects as well as anticipated and emerging projects foreseeable in the future should be included in baseline conditions. These projects are discussed in Part II, Baseline Conditions.
- Constructing barriers that allow one-way passage of water (with additional AIS control measures) and phasing planned infrastructure investments is desired to allow implementation to begin before 2029 when TARP is scheduled to be completed. This phased approach is necessary to prevent increased CSO discharges to Lake Michigan and avoid flooding before TARP is completed and the flood management investments and improvements associated with separation (green infrastructure, sewer separation, floodplain storage, tunnels, etc.) are implemented.
- Only physical barriers should be further analyzed. Although other technologies might exist for ecological separation, this study should consider only physical barriers.

The next step in the study process was to identify the advantages, disadvantages, and required improvements or infrastructure investments for pairings. Several challenging issues and an improvement opportunity came to the forefront regarding flood management, water quality, and transportation, as explained below. The Charrette II Summary Packet documenting all the issues and opportunities is included in Appendix B.

- No increase in the amount or frequency of flooding would be acceptable at any point during implementation of a separation alternative.
- Overflows and daily effluent discharges from WWTPs do not meet Lake Michigan water quality standards. If water were to be rerouted to discharge to Lake Michigan, improvements to WWTPs would be required.
- Barge, commercial, and recreational traffic would be affected, but the degree of interruption would depend on the locations of the barriers.
- Constructing dry dock and maintenance facilities lakeside of the barrier would be required to serve commercial and recreational boats.
- Developing port infrastructure for moving barge materials and commodities was identified as an opportunity to enhance transportation in the Lake Calumet area.

The information was compiled, and three final alternatives were developed that would illustrate a range of challenges and improvement opportunities presented by separation (Figure III-4). The three alternatives were labeled as the Down River Alternative, the Mid-System Alternative, and the Near Lake Alternative, as shown in Figure III-5 and described in further detail in Part IV, Detailed Evaluation of Alternatives. The number of barrier locations ranged from one for the Down River Alternative to five for the Near Lake Alternative (Figure III-5). The barrier locations shown for each alternative are only general representations of where a barrier could be placed. This approach, which was introduced in the September preview meetings for the AC and at the October AC meeting, was recognized as the best way to demonstrate the range of challenges and improvement opportunities that result when barriers are placed at different locations in the CAWS.

Figure III-4. Selection of Three Separation Alternatives

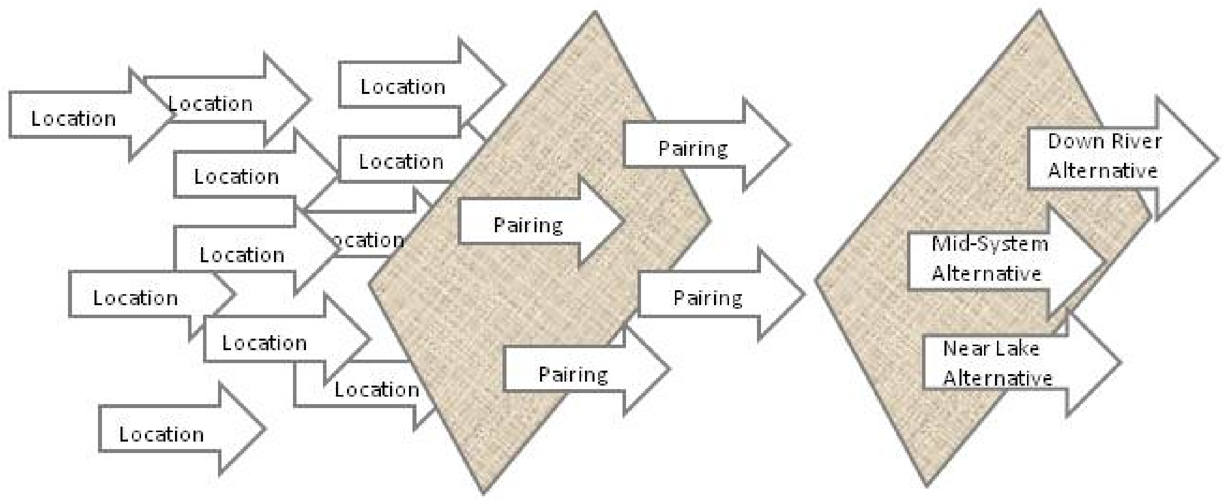

Figure III-5. Three Separation Alternatives

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2. Evaluation of Barrier Types

Although other technologies might exist for ecological separation, this study considers only physical barriers. The barrier would be a physical structure that is water-impermeable, and the barrier type would vary by location. At some locations, a one-way barrier (with additional AIS control measures) was considered as a temporary measure to provide limited separation while improvements are constructed. A one-way barrier would consist of a physical structure within the waterway and some form of water conveyance via pipelines or a pump station.

The following four types of impermeable barrier structures were evaluated: (A) sheet pile, (B) land bridge with no industrial cargo transfer, (C) land bridge with industrial cargo transfer, and (D) constructed barrier with intermodal facility. Ultimately, the size of the waterway, the flow regime, commercial shipping, and recreation were used to determine feasible barrier types for each potential barrier location (Table III-5). The advantages and disadvantages of each barrier type were identified and used as a reference when assessing each location (Table III-6).

Table III-5. Barrier Types by Location

Location	Description	Barrier Type	Notes
5	South Branch	B or C	With limited recreational vessel transfer
9	Upstream of Lockport L&D	C or D	With limited recreational vessel transfer
10	Little Calumet River	A or B	Natural divide east of Hart Ditch
13	Grand Calumet River	A or B	Natural divide east of Whiting WWTP and west of Indiana Harbor Canal
15	Lake Michigan/Calumet River	C or D	With limited recreational vessel transfer
18	Chicago River	B	With limited recreational vessel transfer
19	Upstream of North Side WWTP	A or B	With limited recreational vessel transfer
20	Lake Calumet	C or D	With limited recreational vessel transfer

L&D – Lock and Dam

Table III-6. Evaluation of Barrier Types

Barrier Type	Key Elements	Advantages	Disadvantages
A Sheet pile	• Sheet pile driven to act as a dam • Assumed to be impermeable	• Inexpensive • Fast • Low operational cost	• Potential leaks and damage • Lack of land use opportunities • Limited effectiveness
B Land Bridge without Industrial Cargo Transfer	• Impermeable land bridge (earthen fill, concrete, seawall, etc.) which can be developed or used for other purpose (e.g., transportation crossing, park/residential)	• Standard technology for construction • Flexibility for land use on land bridge and adjacent opportunities • Solid barrier can be as long/large as necessary • Creates land use opportunities • High AIS effectiveness	• Construction could be significant • Transfer of commercial/ recreational boats could become challenging. • Longer planning horizon for implementation
C Land Bridge with Industrial Cargo Transfer	• Impermeable land bridge (earthen fill, concrete, seawall, etc.) with vessel transfer mechanism • Most likely in an industrial area	• Flexibility for land use on land bridge and adjacent opportunities • Solid barrier can be as long/large as necessary • Accommodates navigation • Creates land use opportunities	• Industrial vessel transfer would require non-standard technology • Transfer of commercial/ recreational boats could become challenging. • Longer planning horizon for implementation • Risk of AIS transfer with vessel transfer
D Constructed Barrier with Intermodal Facility	• Impermeable land bridge (earthen fill, concrete, seawall, etc.) • Shape facilitates cargo transfer both across the barrier and to land side. • Would likely require private development and/or political buy-in	• Economic development opportunity • Transfer to multi-modes of transportation possible • Flexibility for land use on land bridge and adjacent opportunities • Solid barrier can be as long/large as necessary • Creates land use opportunities • Improves port efficiency • Accommodates navigation • High AIS effectiveness	• Longer planning horizon for implementation • Construction could be significant • Transfer of commercial/ recreational boats could become challenging • Longer planning horizon for implementation

D. Summary

The development and analysis of separation alternatives consisted of identifying preliminary barrier locations; evaluating barrier locations, types and pairings; formulating three specific separation alternatives; and evaluating the three alternatives. Opportunities for review and comment were offered throughout the study process to allow collaboration with a variety of different stakeholders and groups. In addition, two intensive peer review sessions were included. The result of this process was the development of three possible alternatives for separation based on a preliminary list of 20 barrier locations. The three alternatives were named the Down River Alternative, the Mid-System Alternative, and the Near Lake Alternative.

The alternatives illustrate the range of complexities and improvement opportunities associated with separation that result when physical barriers are placed at different locations in the CAWS. Some of the major considerations are flood conveyance capacity, CSOs, WWTP effluent discharges, waterborne transportation, and intermodal cargo connections. These considerations are further discussed for each alternative in Part IV, Detailed Evaluation of Alternatives.

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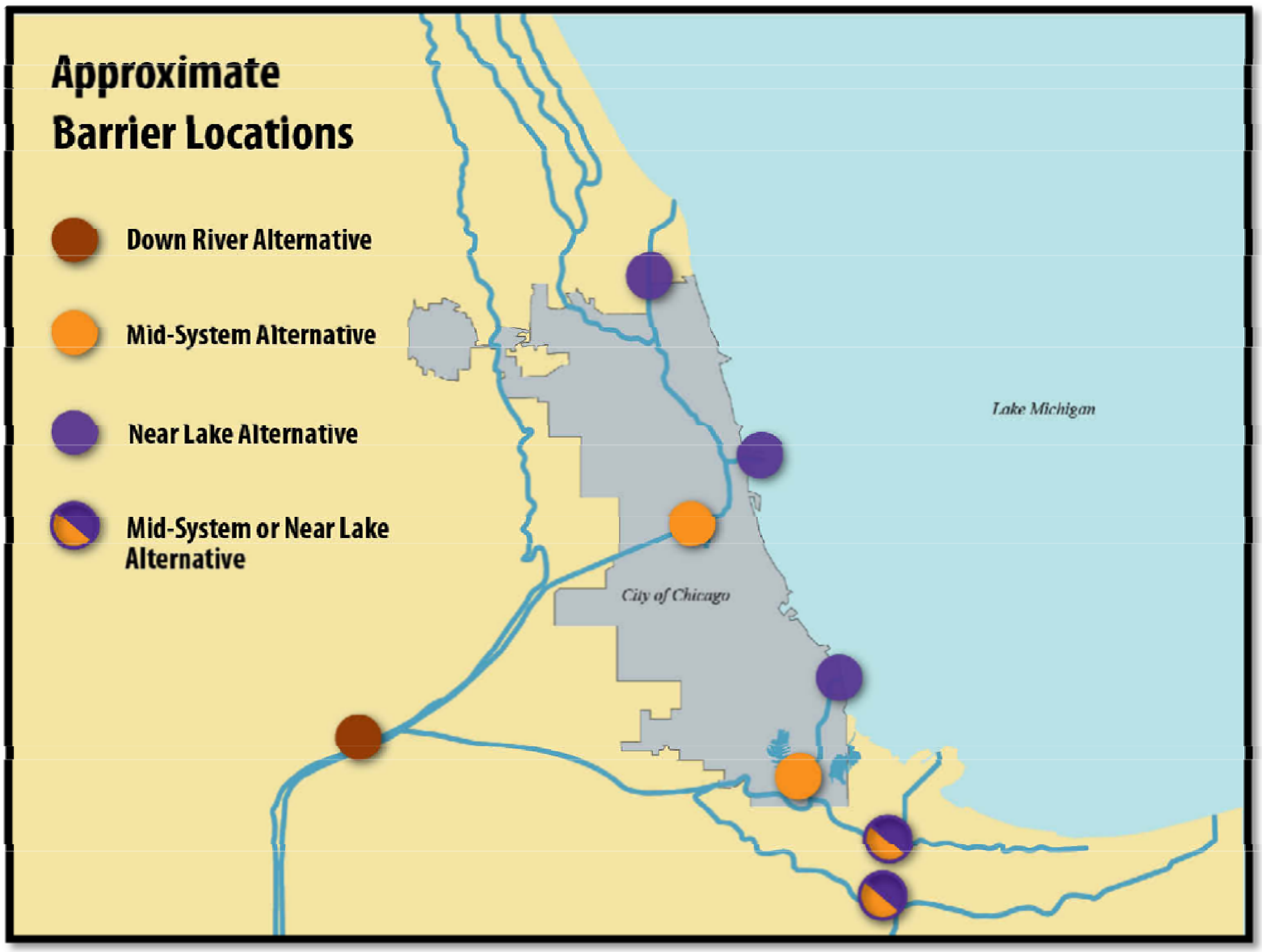
IV. Detailed Evaluation of Alternatives

The three alternatives selected for detailed analysis are a **Down River Alternative**, a **Mid-System Alternative**, and a **Near Lake Alternative,** with the names referring to each alternative's proximity to Lake Michigan (Figure IV-1). The actual barrier locations described in these alternatives are approximate and are intended to illustrate the range of issues that would result from placing barriers at different locations in the CAWS. Further, it is possible that a barrier location for a given alternative could be substituted with a barrier location from a different alternative.

Figure IV-1. Potential Separation Alternatives



The following discussion provides detailed descriptions of each alternative, including potential challenges, opportunities for improvements, required infrastructure investments, future considerations, and implementation timelines. The discussion for each alternative considers flood management, water quality, and transportation issues. Renderings of potential barriers are shown in Figure IV-16 and Figure IV-18 for illustration purposes.

A. Overview of the Alternatives by Function

1. Flood management

A primary consideration for separation is flood management. Each alternative is planned to ensure that flood management is improved or, at least, that flooding is not exacerbated throughout the CAWS system due to separation. The effects of barrier placement on flood management differ based on the locations of individual barriers. The constraints for each alternative are the potential loss of conveyance outlets, reduction in storage capacity, and direct/continual connection of the CAWS to Lake Michigan. Therefore, each of the alternatives considers improvements to improve flood management within the CAWS.

As discussed in Part II, the 100-year flood is based on historical data and published design guidelines for the Chicago area and was used to compare the alternatives with the baseline conditions. It is common practice to conduct a more formal risk analysis to select the appropriate level of flood design for the CAWS. However, it was not within the scope of this study to conduct such an analysis. Statistically, a 100-year flood has a 1% chance of occurring each year, or a 26% chance of occurring over a 30-year period.

The primary flood management factor that influences the implementation timeline for the alternatives is the completion of the TARP system. In addition, as the potential barrier(s) are located farther from the natural drainage divides, such as the Down River and Near Lake Alternatives, flood management issues become more significant. To take full advantage of existing infrastructure, the first step in the proposed flood management strategy is to modify the system to reserve TARP storage for larger floods, thereby enhancing the effectiveness of TARP. Flood management elements for the alternatives consist of a combination of "green" (rain gardens, bioswales, pervious pavements, etc.) and "gray" (traditional pipes, channels, pumps, control structures, etc.) infrastructure that provides inflow reduction, storage, and conveyance.

"Green" flood management elements are envisioned for each alternative as a primary means of reducing flood water inflows into the combined sewage collection system and CAWS. These elements would involve (1) integrating green infrastructure into the existing city of Chicago roadway, water main, and sewer replacement programs along public rights-of-way; and (2) increasing the required capture requirements for flood water runoff for private development through an amendment of the existing city of Chicago flood water management ordinance. Green infrastructure would reduce flood water inflows into the sewage collection system through on-site storage and increased infiltration across the drainage area, thereby reserving TARP storage capacity for larger floods. The green infrastructure improvements also aid in water quality management, as discussed below.

Traditional "gray" infrastructure would augment the effort to provide the required storage and conveyance improvements and would consist of a varying combination of floodplain storage, targeted areas of sewer separation, open channel conveyance modifications, pump stations, conveyance tunnels, and additional reservoir capacity. Storing flood water in the floodplain and conveying flood water directly to the CAWS through partial sewer separation helps reserve TARP capacity for larger floods.

2. Water Quality

Placing barriers would also have varying effects on water quality. The major water quality considerations are the potential for stagnation within the CAWS, WWTP effluent discharges to Lake Michigan, and, depending on the alternative, the ongoing overflow of combined sewage and flood water. In general, the water quality issues become more challenging if the barrier(s) are placed farther from the lake because of the increase in the number of areas requiring augmented flow to prevent stagnation, the additional limitations on the WWTP discharges that would flow toward the lake, and the frequency of combined sewer overflows. The water in the CAWS is constantly moving, so separation of the CAWS would create areas with little or no flow. These areas would become problems for water quality and aesthetics.

Augmenting the flow is proposed to create water movement in areas were stagnation would be a concern in order to maintain or improve water quality. The need for augmenting flow might be reduced or changed over time as the partial sewer separation of the drainage area begins to restore the natural hydrology. The upgrades to WWTPs, flow augmentation, and reductions in combined sewer overflows will protect and improve water quality throughout the CAWS, leading to enhanced recreational opportunities and potentially increased property values.

3. Transportation

Placing barriers would affect waterborne shipping and recreational and commercial travel on Lake Michigan, Des Plaines River, Chicago River, Cal-Sag Channel, Little Calumet River, and Calumet River. The barriers can be developed to minimize the modal shift of bulk cargo that currently ships via water and at the same time to enhance the intermodal connection between barge and rail once the goods reach the Chicago region. All three alternatives would include intermodal connections with the highway and rail systems. Direct access to Lake Michigan for recreational and commercial vessels would be enhanced under the Down River and Mid-System Alternatives, since passing through the Chicago and O'Brien Locks would no longer be required.

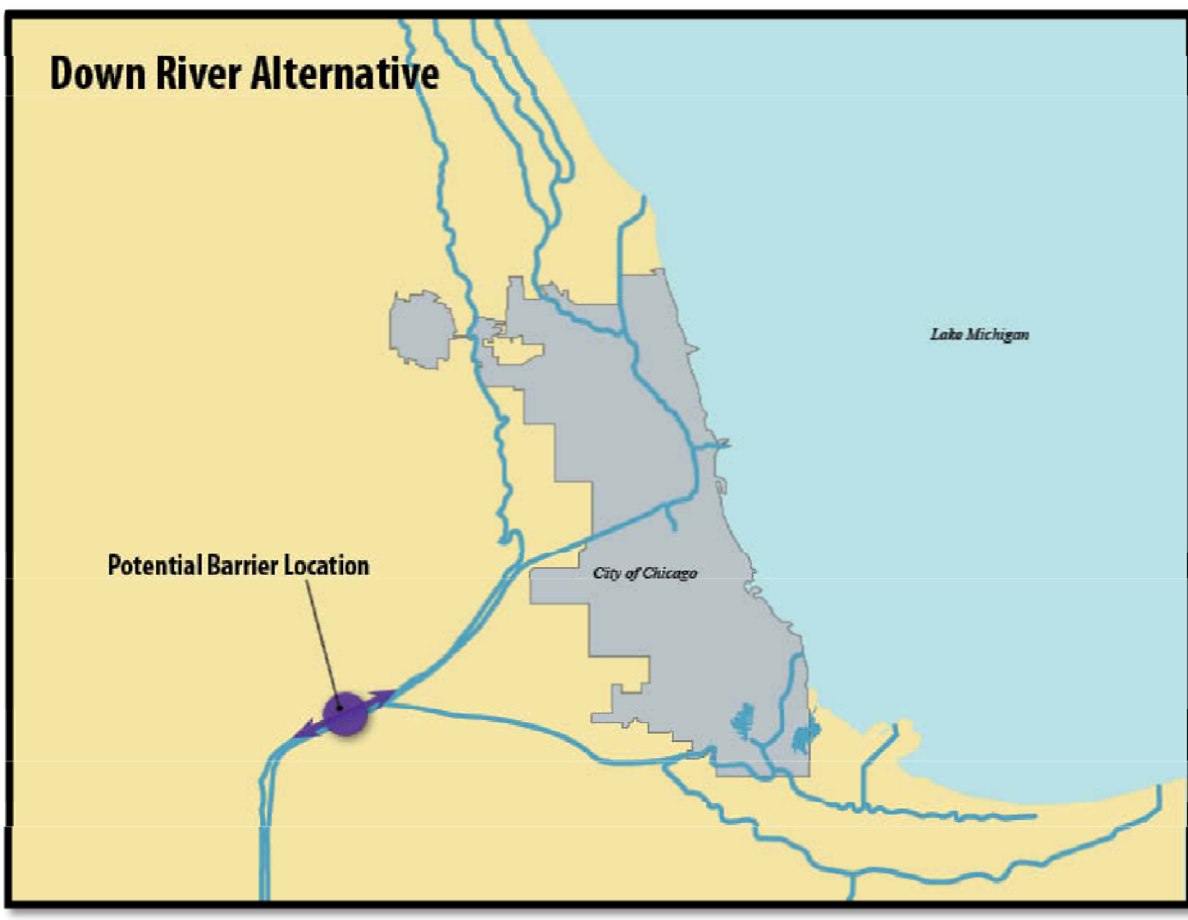
The USDOT's 2011 report to Congress on America's Marine Highways recognizes that infrastructure investments are needed at the nation's inland ports in order to take full advantage of the opportunities that water transport can provide. In addition, "value added" benefits to shippers, such as coordinating and synchronizing container flows between regions; enhancing intermodal connections; and other logistical and shipper support services can increase the reliability and utility of Marine Highway service to shippers.

The proposed transportation improvements associated with the barriers were developed to not only maintain the existing transportation on the CAWS, but to provide opportunities for congestion relief to the highway and rail system, support the marine highway initiative, and capture a share of the emerging container-on-barge market. The types of transportation improvement proposed for the CAWS support the continued industrial investment in Chicago, consistent with the City's *Calumet Area Land Use Plan* (Chicago, 2002), the *Chicago Sustainable Industry Plan* (Chicago, 2011), and the *Millennium Reserve* (State of Illinois, 2011) planning efforts.

B. Down River Alternative

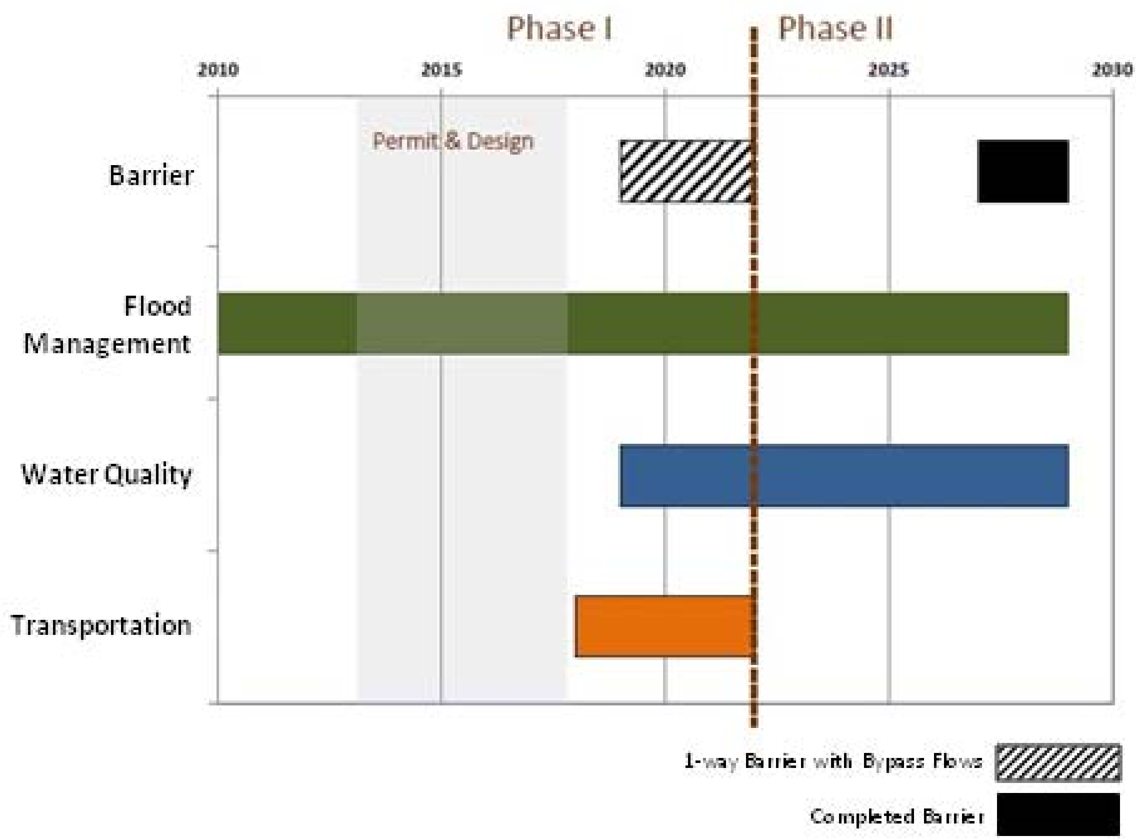
The Down River Alternative consists of placing a physical barrier between the Lockport Lock and Dam and the confluence of the Cal-Sag Channel and the CSSC (Figure IV-2). A single barrier at this location would effectively separate the Mississippi River and Great Lakes basins. As described in Part III, Development and Analysis of Alternatives, this barrier would likely consist of either an impermeable land bridge (that is, earthen fill, concrete, seawall, etc.) with industrial cargo transfer (and limited recreational vessel transfers) or a constructed (that is, concrete, earthen fill, seawall, etc.) barrier with an intermodal facility.

Figure IV-2. Proposed Location of Barrier for Down River Alternative



A potential timeline for implementing the Down River Alternative is shown in Figure IV-3 and is described in more detail in the following sections for each function. This timeline would allow separation to be implemented as quickly as possible. It is anticipated that, upon addressing all permitting and regulatory issues, a one-way AIS barrier could be in place by 2022 and a barrier providing complete separation by 2029. The timeline focuses on planning, design, and construction. Potential legal and regulatory issues must also be addressed and could affect the timeline as presented.

Figure IV-3. Proposed Implementation Timeline for Down River Alternative



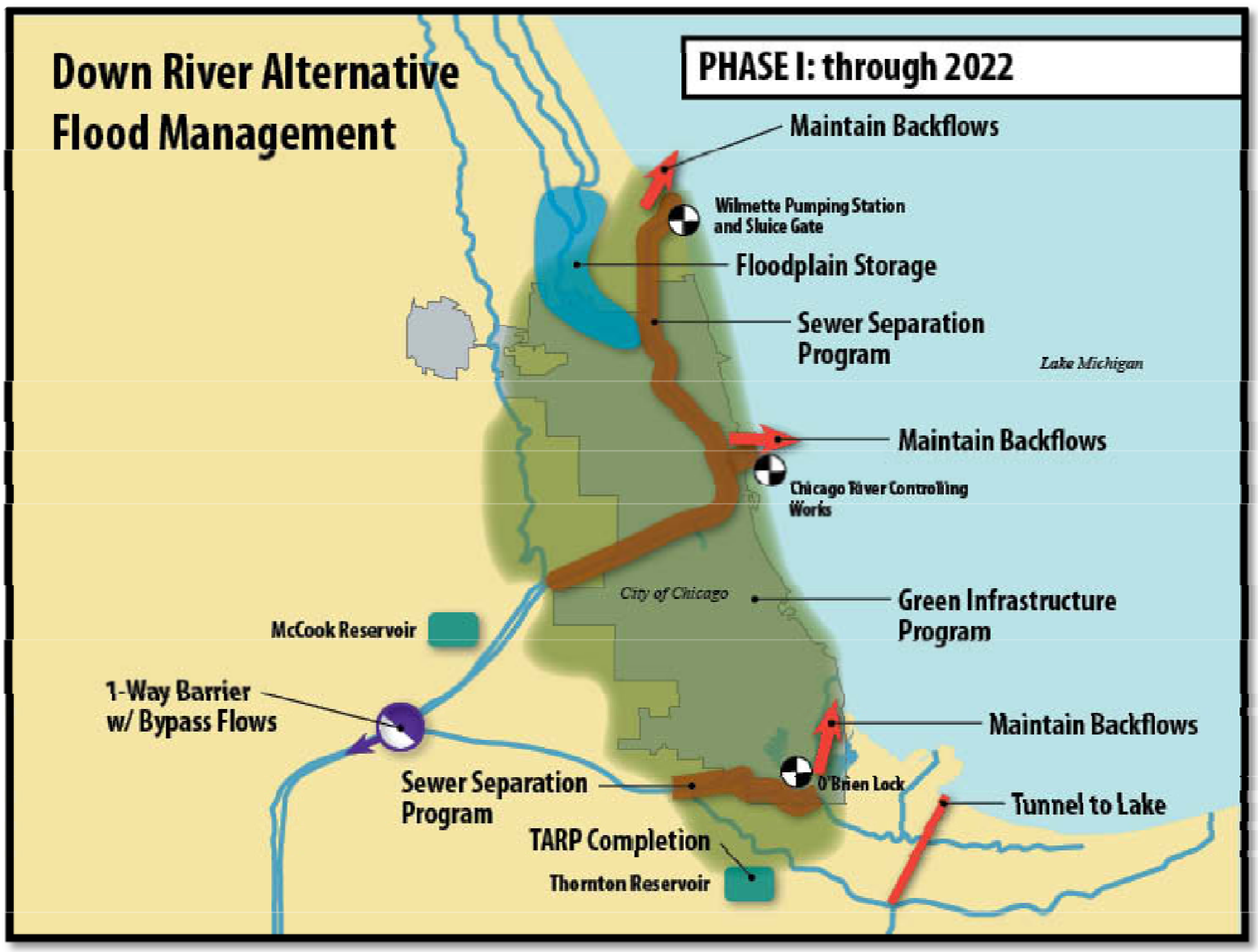
1. FLOOD MANAGEMENT

Implementing the Down River Alternative would effectively cut off the existing downstream flood water conveyance outlet (estimated to be about 20,000 cfs). To prevent additional flooding during implementation, it is anticipated that this alternative would be completed in two phases, and flood water would continue to pass downstream past the barrier location toward Lockport until the end of Phase II. Once Phase II is completed, peak flood water flows up to the 100-year flood would be prevented from bypassing the barrier, thereby separating the Mississippi River and Great Lakes basins within the CAWS up to the a 100-year flood level.

PHASE I: THROUGH 2022

Constructing the Down River Alternative barrier would require improving the flood water management system to reduce flood water inflows and increase flood water storage and conveyance. Flood management would be improved in areas adjacent to the control structures at Wilmette Pump Station, Chicago River Controlling Works (CRCW), and T.J. O'Brien Lock. This is because, with the Down River Alternative, these control structures would be operated "default open," meaning that gates and locks at these facilities would be kept in an open position rather than closed, as is the current practice. However, this operating scenario would likely not be allowed under water quality regulations until the volume of CSOs is reduced by completing TARP, which is not expected to be fully completed until 2029 (portions of TARP will be completed in 2015 and 2017). To reduce as quickly as possible the risk of transferring Asian carp and other AIS, a one-way AIS barrier is proposed that could be implemented before TARP is fully completed in 2029 (Figure IV-4).

Figure IV-4. Flood Management Elements for Down River Alternative – Phase I



Upon addressing all permitting and regulatory issues, the one-way AIS barrier could be in place by 2022. The barrier would consist of a physical barrier in the waterway with the ability to bypass flood flows from the lakeside to the riverside only. The bypass would provide conveyance (gates, pipes, pumps, etc.) designed to allow the continual passage of dry-weather flows (WWTP effluent and surface water base flows) as well as storm flows up to 20,000 cfs through the barrier from lakeside to riverside. The bypass would be equipped with AIS technologies such as screens or filters to prevent AIS from moving from riverside to lakeside, resulting in a one-way AIS barrier.

Before TARP is completed, and while the one-way AIS barrier is in operation, the remaining CAWS control structures (Wilmette, CRCW, T.J. O'Brien) would continue to operate under current conditions; that is, in a "default closed" mode with backflows to the lake only as needed during larger floods to prevent flood damage. It is anticipated that the frequency of these backflows would decrease over time with the implementation of the green infrastructure and partial sewer separation elements that are envisioned as part of this alternative.

Green infrastructure is proposed within the TARP service area (see the green shaded area in Figure IV-4 above) and would be implemented along public rights-of-way based on current City of Chicago reconstruction programs for roads, sewer, and water. In addition, inflow reduction is envisioned for private development by increasing the required capture requirements for flood water runoff through an amendment of the existing City of Chicago flood water management ordinance. Partial sewer separation is envisioned within 1 mile on either side of the CAWS waterways, as shown by the brown shading in Figure IV-4. Green infrastructure elements would reduce flood water inflows into the sewage collection system, thereby reserving storage in TARP, and targeted sewer separation in areas along the CAWS waterways is expected to reduce peak discharges on the CAWS by changing the timing of runoff in the areas of sewer separation. These improvements would reduce the likelihood of flooding and reserve storage in TARP for larger floods. The improvements also have the additional benefit of improving water quality, as discussed in later sections.

This alternative achieves additional flood management by restoring the floodplain functions of particular reaches of the North Branch Chicago River. Phase I flood management elements include implementing additional floodplain storage along the North Branch Chicago River as indicated by the blue shaded area in Figure IV-4. This floodplain storage would be supplementary and in addition to the recommended alternatives identified in the MWRDGC's *Detailed Watershed Plan for the North Branch of the Chicago River*. Potential areas of floodplain storage include those identified in the MWRDGC watershed plans for possible flood water storage but not included as recommended alternatives. Part of the historical flood plain of the North Branch of the Chicago River would be restored through excavation to create flood detention areas at numerous locations along the North Branch Chicago River and its tributaries. The additional floodplain storage would reserve storage in TARP and would reduce peak discharges on the North Branch Chicago River. It is anticipated that floodplain storage would be implemented by the end of Phase I (2022).

A tunnel is included in this alternative that would divert flows from the USACE Little Calumet Flood Control Project (along Little Calumet River between Hart Ditch and Deep River) to Lake Michigan. This diversion is necessary because the separation disrupts the flood management plan of the existing USACE Little Calumet Flood Control project. The tunnel provides the necessary flood conveyance capacity that would be lost due to a separation barrier. This diversion would convey flood flows from the design flood flows currently passing through a control structure west of Hart Ditch (about 2,200 cfs) up to the 200-year flood.

While the general criteria for flood management were focused on the 100-year flood, the USACE Little Calumet Flood Control Project is designed for events up to the 200-year flood. Therefore, flood-management investments proposed for the Little Calumet River (that is, a conveyance tunnel) were specifically denoted to provide means for flows up to the USACE's design event (200-year flood) to maintain the performance of the USACE Little Calumet Flood Control Project and provide additional incremental flood control for events larger than the 200-year design flood.

While the flood-management improvement would be an increment above the 200-year design flood, the diversion would reserve conveyance in the Little Calumet River downstream of Hart Ditch and potentially the Cal-Sag Channel and Calumet River. Although a conveyance tunnel from the Little Calumet River System to Lake Michigan is intended for the completed barrier condition with no bypass flows (end of Phase II in 2029), the tunnel is proposed as part of Phase I to improve flood management in the near term in the Little Calumet River region.

PHASE II: THROUGH 2029

At the completion of Phase I (2022), a one-way AIS barrier would be in operation and the following flood management elements would be operational:

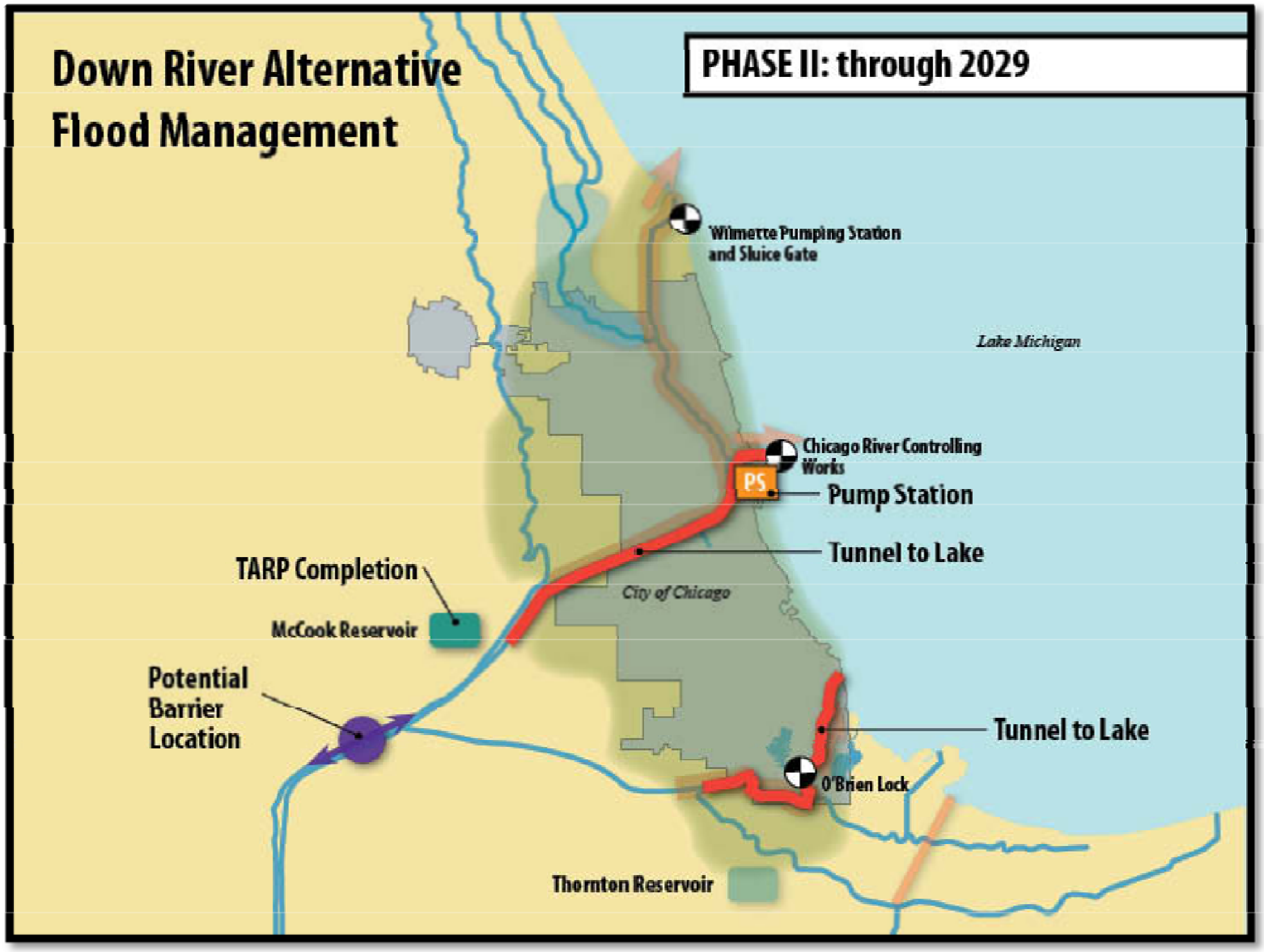
- One-way AIS barrier with bypass for flows lakeside to riverside
- Green infrastructure and sewer separation programs (ongoing through Phase II)
- Floodplain storage on North Branch Chicago River
- Little Calumet River tunnel to Lake Michigan

Phase II would ultimately end the lakeside to riverside bypass flows through the barrier, thereby providing a completed barrier and separation in both directions. Before ending the flow bypass, the following critical-path elements must be completed:

- TARP completion for managing CSOs (considered part of the baseline condition)
- Water quality elements in the Phase II separation project
    - Upgrades to WWTPs to discharge to Lake Michigan
    - Management of contaminated sediments (completed as part of the baseline condition)
    - Flow augmentation lakeside and riverside of the barrier
- Flood management elements in the Phase II separation project to address loss of flow conveyance

While green infrastructure and partial sewer separation programs would continue throughout Phase II, the primary flood management element for Phase II would be constructing conveyance tunnels and pump stations that would direct flows from both the CSSC/Chicago River and Cal-Sag/Calumet Systems to Lake Michigan (Figure IV-5). For the Chicago River System, about 15 miles of large-diameter tunnel would parallel the CSSC, South Branch Chicago River, and Chicago River from near McCook Reservoir to the CRCW. Given the length of the tunnel and the potential elevation difference between Lake Michigan and CAWS water levels along the CSSC, it is anticipated that a large pump station would be required to discharge flows from the tunnel system to Lake Michigan. In the Calumet River System, about 15 miles of additional tunnel would parallel the Little Calumet and Calumet rivers from near the Cal-Sag/Little Calumet River confluence to Lake Calumet and then to Lake Michigan at the mouth of the Calumet River. This Calumet tunnel system is anticipated to operate by gravity flow (no pump station).

Figure IV-5. Flood Management Elements for Down River Alternative – Phase II



Once the critical-path elements listed above are completed, including the flood water conveyance tunnels and pump stations, bypass flows would stop at the barrier location, thereby separating the Great Lakes and Mississippi River basins during storms up to the 100-year storm. The flow bypass elements of the initial one-way barrier would be kept in place to allow for emergency bypass of flows lakeside to riverside during floods that exceed the 100-year storm. The control structures at Wilmette Pump Station, CRCW, and T.J. O'Brien Lock would also be operated "default open," thereby providing additional outlet conveyance for the CAWS.

Contingency plans would be in place to prevent basement flooding when Lake Michigan water levels are well above normal. These plans could include (1) closing Wilmette, CRCW, and T.J. O'Brien gates/locks and using pumping capacity to lower CAWS water levels before larger storms (similar to current CAWS operations) and/or (2) allowing emergency bypass of flows lakeside to riverside through the barrier (the barrier becomes a one-way barrier) before or during larger floods.

The net effect of the improvements described above would be a flood management system that is more resilient to larger floods and can provide flood management for the Chicago area that is as good as or better than what currently exists.

2. Water Quality

The Down River Alternative would ultimately prevent water from the Great Lakes from flowing into the Illinois River System. This could create a stagnant stretch of the CSSC, since there would be no source water for flow. This elimination of source water would shut down the hydropower operation at the Lockport L&D. To maintain flows in this river reach, this alternative would route water from the Stickney WWTP to both sides of the barrier. Although this would meet water quality requirements, it would not produce the equivalent hydropower at Lockport. Another option to address stagnation lakeside of the barrier is to construct an in-stream circulation system that uses either air or water to maintain mixing and water movement.

Since water quality standards are anticipated to remain more stringent for Lake Michigan than for the CAWS, it is expected that upgrades will be required for the three WWTPs (North Side, Stickney, and Calumet), since all wastewater would be returned to the lake with this alternative. Under current operations and regulations, all three plants meet their permit standards for river discharge. After separation, flows will be directed to Lake Michigan, and the discharge standards are expected to become more stringent relative to anticipated river discharge standards, as described in Part II, Baseline Conditions. At a minimum, nutrient-treatment improvements for removing phosphorous and nitrogen will be required at some level.

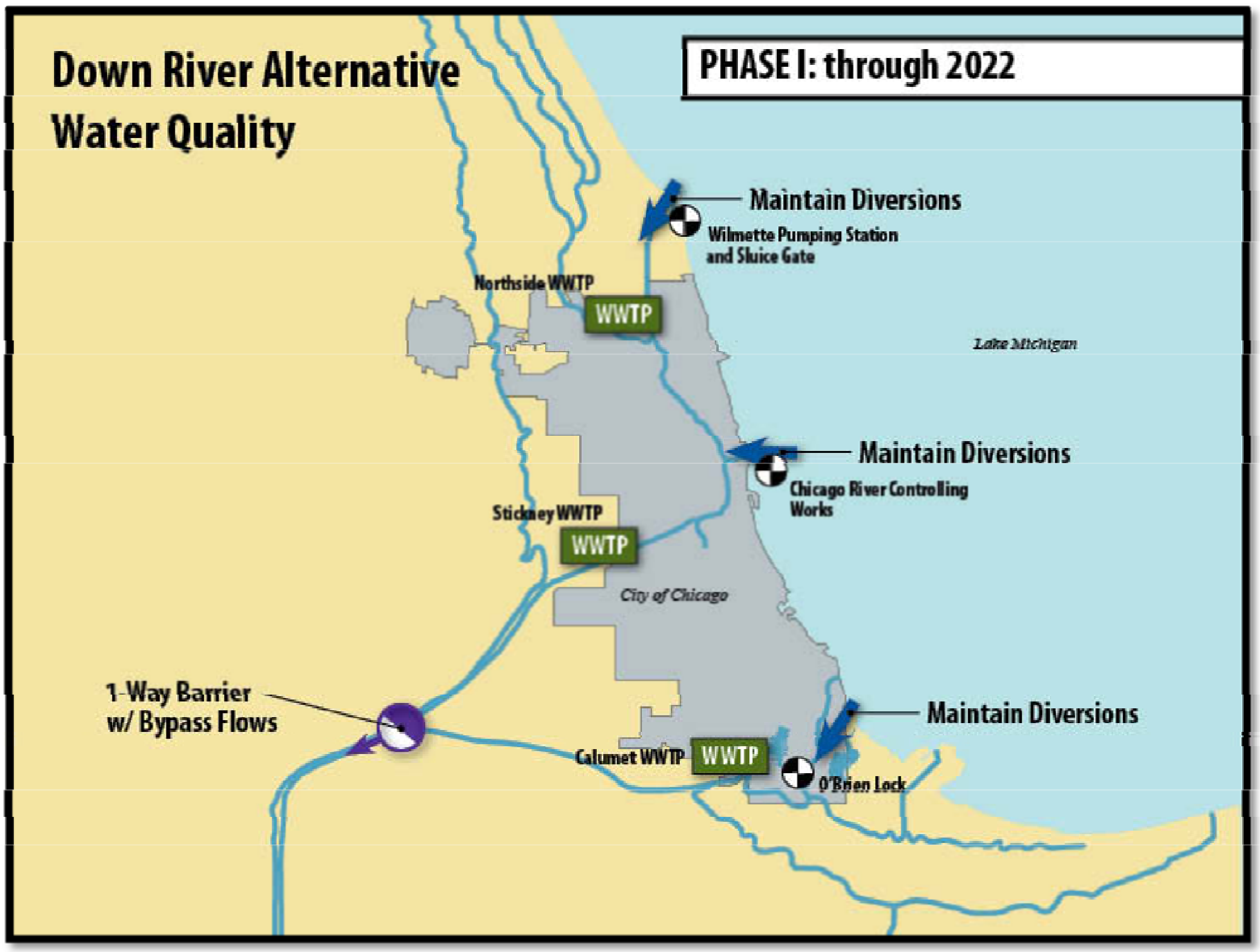
However, “anti-degradation” issues could also emerge from such a large flow of water returning to Lake Michigan in the form of highly treated wastewater effluent. Water quality regulations are based on an anti-degradation philosophy that even if discharge standards are met or achievable, a reduction in the beneficial use of a water body is not allowed, as described in further detail below.

Pursuant to Clean Water Act requirements and associated U.S. EPA regulations, all states must include an anti-degradation provision in their state water quality standards. While use classification and water quality standards are enacted to protect specific beneficial uses and functions of a water body, the anti-degradation provision is intended to protect high-quality water resources from degrading below their existing high quality. The essence of this provision is that new and expanding pollutant sources are allowable only if they are determined to be necessary to support important social or economic community purposes. If allowable, such new or expanded loading is subject to higher performance standards, not merely compliance with traditional standards. Any diversion option that redirects discharges currently flowing downstream to the Des Plaines and Mississippi Rivers instead of to Lake Michigan would constitute a new load to Lake Michigan and therefore would be subject to the Illinois anti-degradation provisions. Given the sensitivity of the Lake Michigan ecosystem, anti-degradation requirements will most likely be applied to nutrients as well as to bio-accumulative and toxic pollutants, such as mercury, that are discharged with the treated effluent.

Phase I: Through 2022

A one-way AIS barrier would be constructed by 2022 that would consist of a physical barrier in the waterway with the ability to bypass flows from the lakeside to the riverside only. The discharges of the three WWTPs would continue to be directed riverside through the barrier (Figure IV-6). During Phase I, upgrades to the three WWTPs would be initiated to meet the lakeside water quality standards. Until the completion of Phase II in 2029, when the barrier becomes fully functional and all discharges are directed lakeside, the WWTPs would continue to operate and meet requirements for discharge to the river. These requirements would likely become more stringent over time.

Figure IV-6. Water Quality Elements for Down River Alternative – Phase I

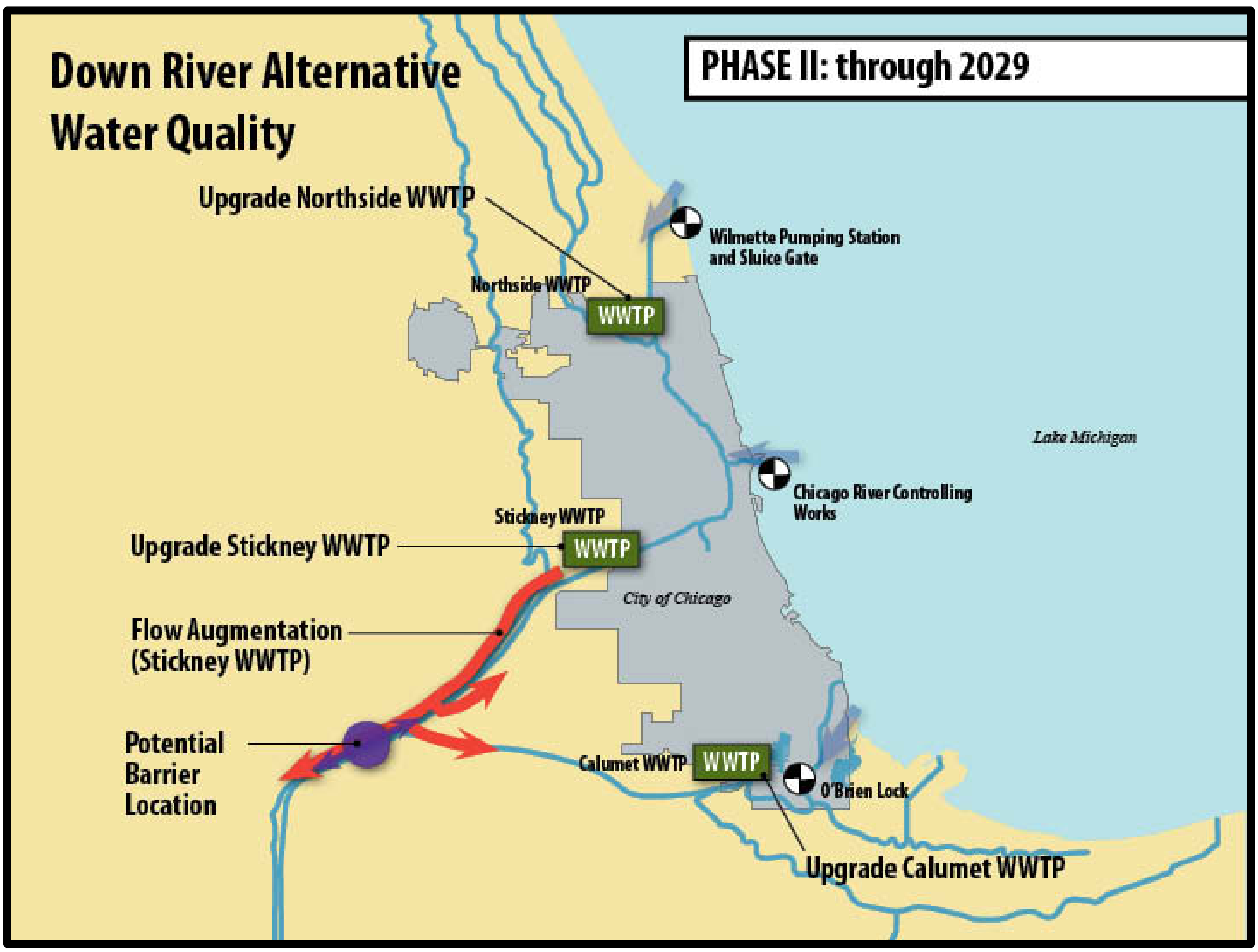


PHASE II: THROUGH 2029

Phase II would eliminate the lakeside to riverside bypass flows through the barrier, thereby providing a completed barrier and separation (Figure IV-7). Before ending the flow bypass, the following would be required:

- TARP would be completed for managing combined sewer overflow volumes (considered part of the baseline condition).
- Upgrades to WWTPs would be completed to address discharges to the lake and meet water quality standards.
- Management of contaminated sediments (completed as part of the baseline condition).
- Flow augmentation riverside and lakeside of the barrier would be required to prevent stagnation.

Figure IV-7. Water Quality Elements for Down River Alternative – Phase II

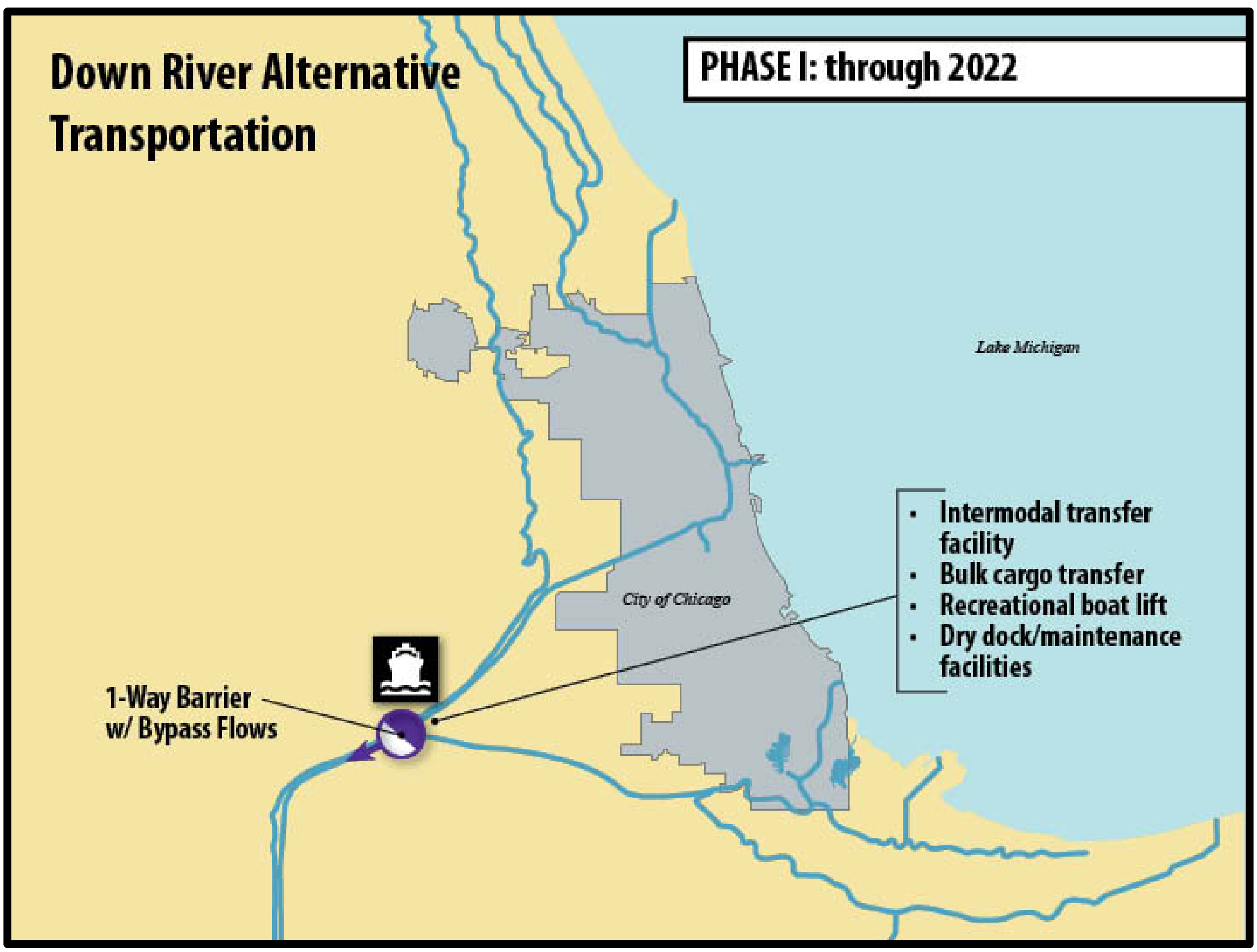


The overall improvements in water quality would be such that the water quality vision and recreational use of the CAWS would be maintained or improved. The improvements in combined sewer overflow management, flow augmentation, and wastewater treatment would protect and improve water quality throughout the CAWS, leading to enhanced water usage opportunities such as recreation. The Down River Alternative would also significantly reduce exports of Lake Michigan water to the Mississippi River basin.

3. Transportation

All water traffic between the Mississippi River basin and the CAWS, including recreational and barge traffic, would be affected at the Down River Alternative barrier location. As a result, improvements to the existing transportation system and new infrastructure investments would be necessary, as described below. These transportation improvements would need to be in place before the barrier is built in order to avoid interrupting recreational and barge traffic. Thus, all improvements would be completed by 2022 during Phase I (Figure IV-8).

Figure IV-8. Transportation Elements for Down River Alternative



The proposed improvements and investments include a port and materials transfer station, an offloading and storage site, new rail and roadway service for shipping barge-delivered commodities, a small recreational boat lift and disinfection station, and a new dry dock. Developing a port and materials transfer station, including barge-to-barge and barge-to-rail and truck capabilities, would facilitate offloading or transferring commodities over or around the barrier.

Although few recreational boats use this stretch of the river, a recreational boat transfer and disinfection station would be installed to minimize the transfer of AIS via recreational boats so that recreational boats can move between the lake and river sides of the barrier. Small recreational boats that currently traverse the basins could be lifted and disinfected year-round, while larger recreational boats could also pass over the barrier and be disinfected on a seasonal basis. Except for blocking access to some off-season dry docking and maintenance facilities downstream of the barrier, the commercial boat services (taxi and tour boats) would not be negatively affected. The commercial boats traveling from the CAWS to the Mississippi River basin via the Des Plaines River for dry docking would be improved by constructing a new dry dock within the CAWS system. Recreational and commercial direct access to Lake Michigan would be improved with this alternative, since the Chicago and T.J. O'Brien Locks would remain open.

This alternative could enhance intermodal connections. The BNSF and UPRR logistics parks are near the Des Plaines River, but there is currently no interface between barges and these rail facilities. Developing a new transfer station at the barrier could include an intermodal facility that would connect to these centers and therefore enhance the intermodal connection. There are no CREATE projects in the immediate vicinity of the Down River Alternative; however, the State of Illinois and UPRR are currently improving trackage between St. Louis and Chicago to support high-speed passenger rail. These improvements will include an additional mainline track as well as signal and crossing improvements, which will increase capacity and operations on this line and enhance the potential intermodal opportunities at the new port.

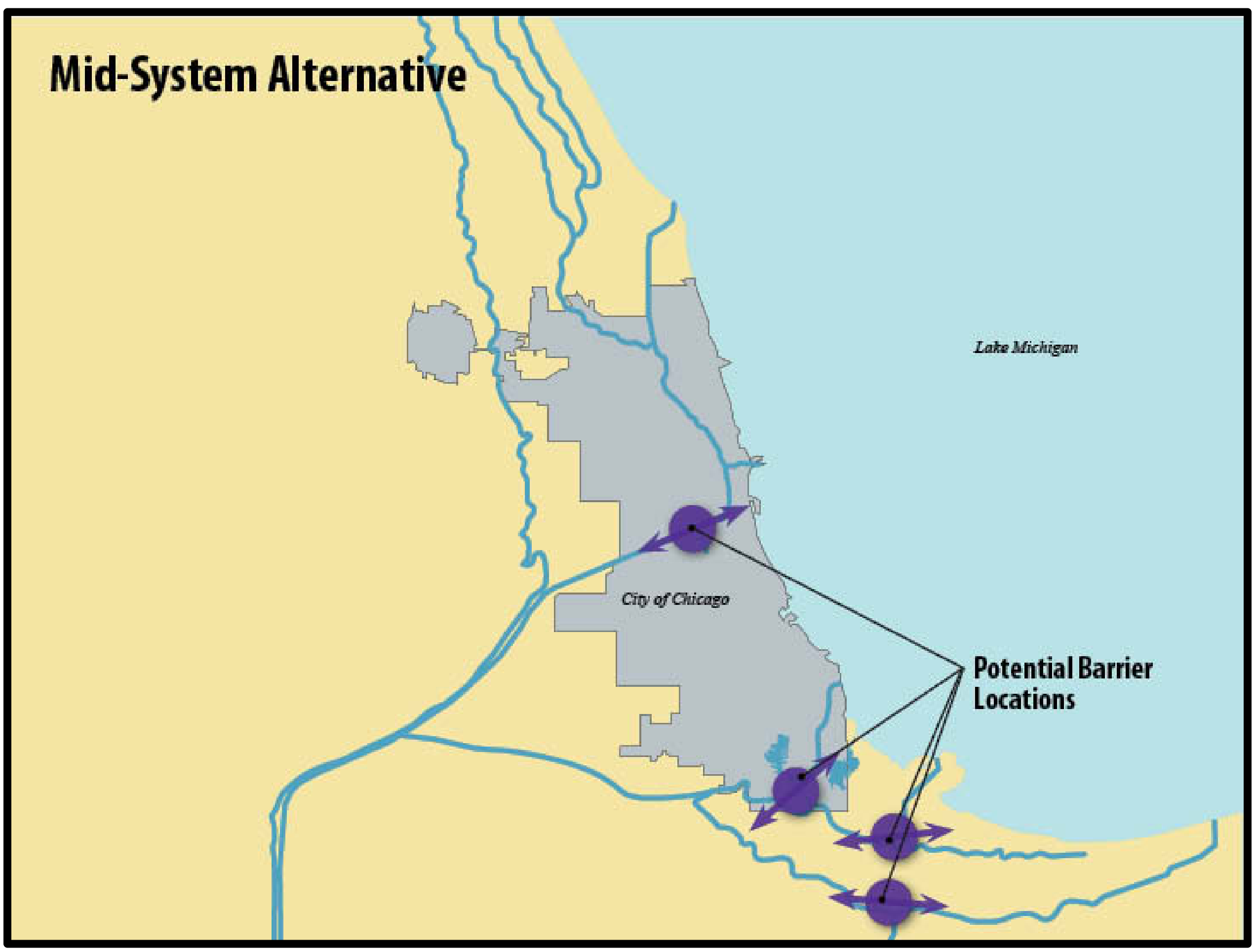
In summary, the proposed improvements would maintain the existing uses of the CAWS for transportation while at the same time creating the potential for new improvements to the regional transportation system. Improving transportation on the currently underused CAWS could help reduce congestion on the roadway and rails, increase container cargo traffic in the region, and improve intermodal efficiency of the freight system. Finally, with the opening of the Chicago and T.J. O'Brien Locks providing direct access to Lake Michigan, travel by recreational and commercial vessels would also be enhanced.

C. Mid-System Alternative

The Mid-System Alternative would require four barriers to separate the two basins (Figure IV-9). A barrier on the South Branch Chicago River upstream of Bubbly Creek would separate the South Branch from the CSSC. The south section of the CAWS would be separated by three barriers: (1) on Little Calumet River near the USACE flood-control project at Hart Ditch, (2) on Grand Calumet River near the historic natural divide, and (3) on Calumet River immediately south of the connection with Lake Calumet (north of the T.J. O'Brien Lock and Dam and the existing railway and vehicle traffic bridge).

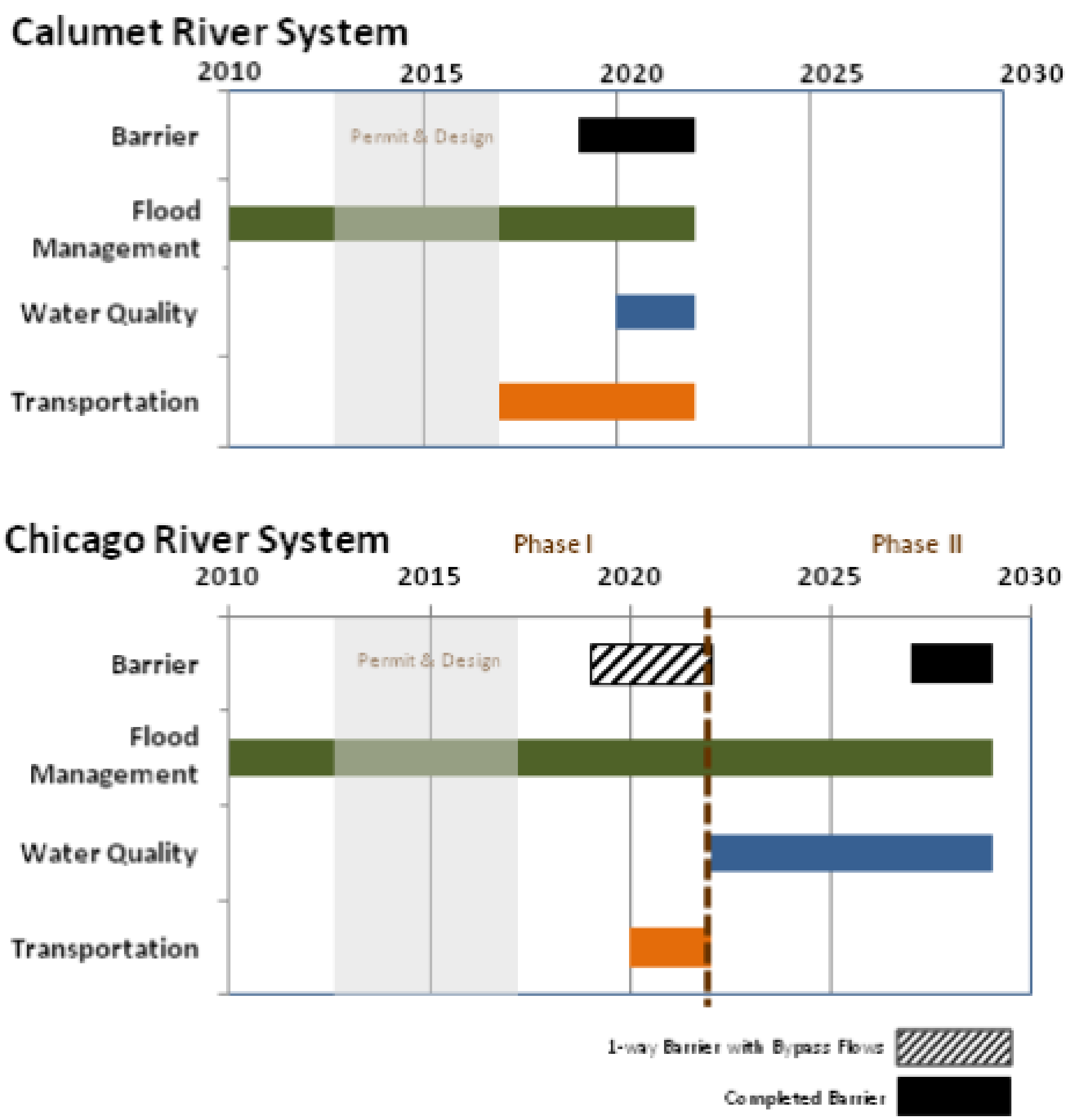
As described in Part III, Development and Analysis of Alternatives, the barrier type would vary by barrier location and would likely range from a sheet pile or impermeable land bridge (that is, earthen fill, concrete, seawall, etc.) without industrial cargo transfer (with limited recreational vessel transfers) for the Little and Grand Calumet River Barriers to an impermeable land bridge (that is, concrete, earthen fill, seawall, etc.) with industrial cargo transfer (and limited recreational vessel transfers) or a constructed (that is, concrete, earthen fill, seawall, etc.) barrier with an intermodal facility for the Calumet River/Lake Calumet barrier. The South Branch Chicago River barrier would likely consist of an impermeable land bridge (that is, earthen fill, concrete, seawall, etc.) either with or without industrial cargo transfer (with limited recreational vessel transfers).

Figure IV-9. Proposed Location of Barriers for Mid-System Alternative



A proposed timeline for implementing the Mid-System Alternative is presented in Figure IV-10 and is described in more detail in the following sections for each area. This timeline would allow separation to be implemented as quickly as possible. It is anticipated that, upon addressing all permitting and regulatory issues, a one-way AIS barrier could be in place by 2022 on the Chicago River System, and a barrier providing complete separation could be in place by 2022 and 2029 on the Calumet River and Chicago River Systems, respectively. The timeline is focused on planning, design, and construction. Potential legal, regulatory, and permitting issues must also be addressed and could affect the timeline as presented.

Figure IV-10. Proposed Implementation Timeline for Mid-System Alternative



1. Flood Management

Placing the four barriers for this alternative would affect flood management by different degrees at each barrier location:

- South Branch – flows from Racine Avenue Pump Station (RAPS) redirected riverside (about 6,000 cfs), and North and South Branch Chicago River flows (about 14,000 cfs) redirected to Lake Michigan at Chicago River
- Lake Calumet – barrier would effectively cut off backflow discharge capacity to Lake Michigan at T.J. O'Brien L&D (about 15,000 cfs)
- Little Calumet River – barrier would effectively cut off outlet discharge from the USACE flood-control structure west of Hart Ditch (about 2,200 cfs)
- Grand Calumet River – limited effect since barrier would be located near natural drainage divide (storm flows are currently directed in both directions)

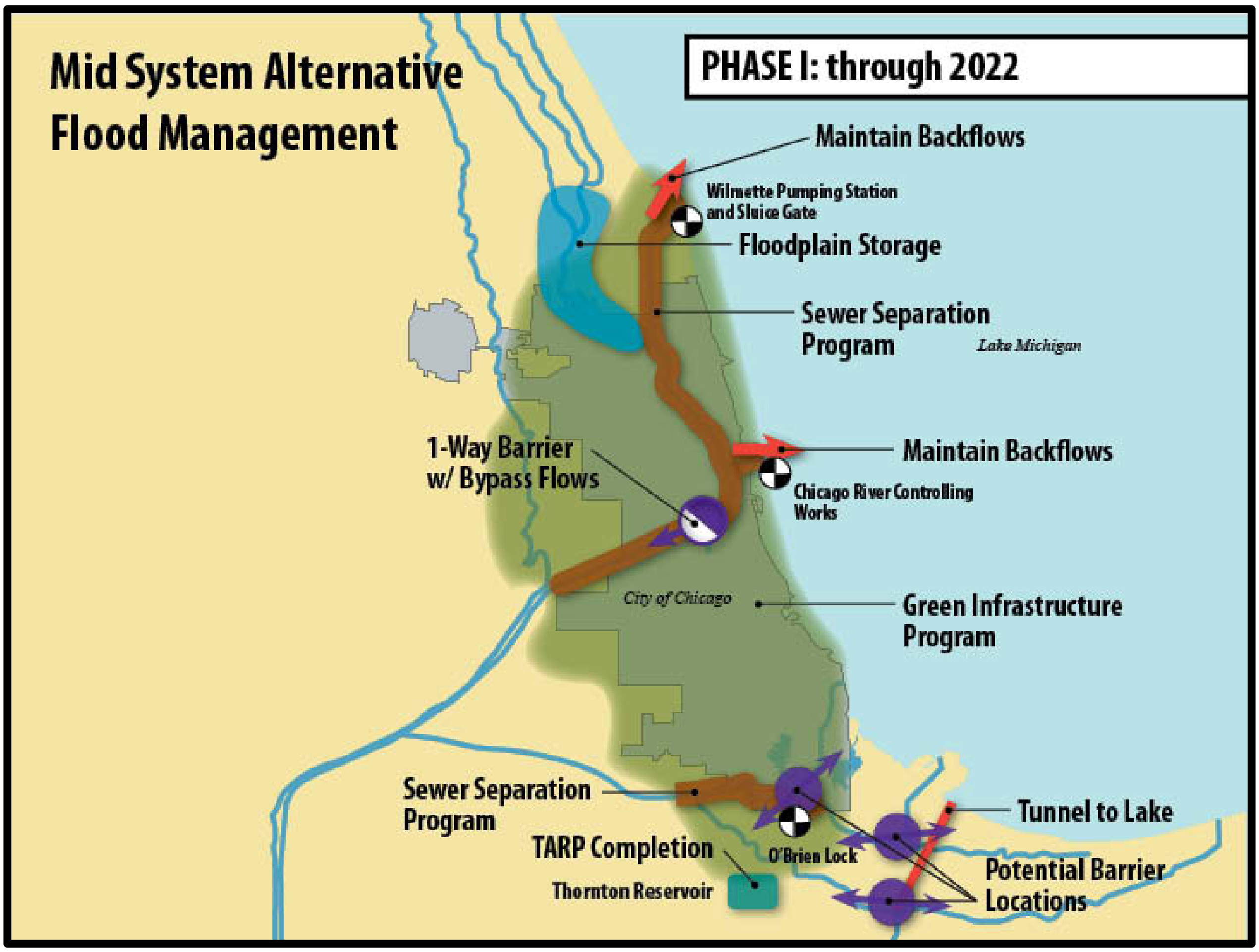
Implementing the three barriers in the Calumet System would be completed in Phase I. However, to prevent additional flooding, it is anticipated that implementing the South Branch barrier would be completed in two phases. Flood water would continue to pass downstream past the barrier location toward Lockport until the end of Phase II. Once Phase II is completed, flood water flows up to the 100-year storm would be prevented from bypassing the barrier, thereby separating the Mississippi River and Great Lakes basins during storms up to the 100-year storm.

Phase I: Through 2022

With the completion of the TARP Thornton Reservoir expected by 2015, it is anticipated that flood water improvements could be implemented for the three Calumet System barriers in Phase I (Figure IV-11). Conversely, fully implementing the South Branch barrier would not be possible until the overall volume of overflows is reduced through completion of the TARP McCook Reservoir in 2029. To reduce risk of AIS transfer as quickly as possible, a one-way AIS barrier would be implemented on the South Branch barrier in Phase I before TARP is completed. Upon addressing all permitting and regulatory issues, this one-way AIS barrier could be in place by 2022 (Figure IV-11).

Green infrastructure and sewer separation are common elements for both the South Branch and Calumet System barriers. Green infrastructure is proposed within the TARP service area (the green shaded area in Figure IV-11) and would be implemented along public rights-of-way based on current City of Chicago reconstruction programs for roads, sewer, and water. In addition, inflow reduction is envisioned for private development by increasing the capture requirements for flood water runoff through an amendment of the existing City of Chicago flood water management ordinance. Partial sewer separation is envisioned within 1 mile on either side of the CAWS waterways, as shown by the brown shading in Figure IV-11. Green infrastructure elements will reduce flood water inflows in the sewage collection system, thereby reserving storage in TARP, and targeted sewer separation in areas along the CAWS waterways is intended to reduce peak discharges on the CAWS by changing the timing of runoff in the areas of sewer separation.

Figure IV-11. Flood Management Elements for Mid-System Alternative – Phase I



Before TARP is completed and while the one-way AIS barrier is in operation, the remaining CAWS control structures (Wilmette, CRCW, T.J. O'Brien) would continue to operate under current conditions; that is, in a "default closed" mode with backflows to the lake as needed during larger floods. It is anticipated that the frequency of these backflows would decrease over time with the implementation of the green infrastructure and sewer separation elements envisioned as part of this alternative. The net benefit of these improvements is that more of TARP is reserved for larger floods, thereby improving both flood management and water quality.

SOUTH BRANCH BARRIER

This alternative includes a one-way AIS barrier for the South Branch that could be implemented before TARP is completed (Figure IV-11). The conveyance lost on the South Branch with the barrier would require improvements to the flood management system to reduce inflows and increase flood water conveyance. While conveyance would be gained by operating the control structures at Wilmette Pump Station, CRCW, and T.J. O'Brien Lock "default open," this operating scenario is not likely due to water quality regulations until the volumes of combined sewer overflows are reduced through the completion of TARP in 2029.

The one-way AIS barrier would consist of a physical barrier in the waterway with the ability to bypass flows from the lakeside to the riverside only. The bypass would provide conveyance (gates, pipes, pumps, etc.) designed to allow continual passage of dry-weather flows (WWTP effluent and surface water base flows) as well as storm flows up to 10,000 cfs through the barrier from lakeside to riverside. The bypass would be equipped with AIS technologies such as screens or filters to prevent AIS from moving from riverside to lakeside, resulting in a one-way AIS barrier. Screens and filters are necessary given the flat topography of the Chicago area. There is not enough difference in elevation to create adequate head and resulting flow for the barrier to be reliable using elevation alone.

This alternative achieves additional flood management by restoring the floodplain functions of particular reaches of the North Branch Chicago River. Phase I flood management elements would include additional floodplain storage along the North Branch Chicago River as indicated by the blue shaded area in Figure IV-11. This floodplain storage would be supplementary and in addition to the recommended alternatives identified in MWRDGC's *Detailed Watershed Plan for the North Branch of the Chicago River*. Potential areas of floodplain storage include those identified in the MWRDGC watershed plans for possible flood water storage but not included as recommended alternatives. Part of the historical floodplain of the North Branch of the Chicago River would be restored through excavation to create flood detention areas at numerous locations along the North Branch Chicago River and its tributaries. The additional floodplain storage would reserve potential storage in TARP and would reduce peak discharges on the North Branch Chicago River. It is anticipated that floodplain storage would be implemented by the end of Phase I (2022).

CALUMET SYSTEM BARRIERS

A conveyance tunnel from the Little Calumet River System to Lake Michigan is proposed as part of Phase I to improve flood management for the Little Calumet region. The tunnel would divert flows from the USACE Little Calumet Flood Control project along Little Calumet River between Hart Ditch and Deep River to Lake Michigan. This diversion would convey flood flows from the design flows currently passing through a control structure west of Hart Ditch (about 2,200 cfs) up to the 200-year flood.

While the general criteria for flood management were focused on the 100-year flood, the USACE Little Calumet Flood Control Project is designed for events up to the 200-year flood. Therefore, flood-management investments proposed for the Little Calumet River (that is, a conveyance tunnel) were specifically denoted to provide means for flows up to the USACE's design event (200-year flood) to maintain the performance of the USACE Little Calumet Flood Control Project and provide additional incremental flood control for events larger than the 200-year design flood.

While the flood management improvement would be an increment above the 200-year design flood, the diversion would reserve conveyance in the Little Calumet River downstream of Hart Ditch and the Cal-Sag Channel and Calumet River. Limited effect is anticipated for the Grand Calumet River; however, if additional detailed analysis reveals the need for additional conveyance, diverting flows from the Grand Calumet River to the Little Calumet conveyance tunnel would be an option.

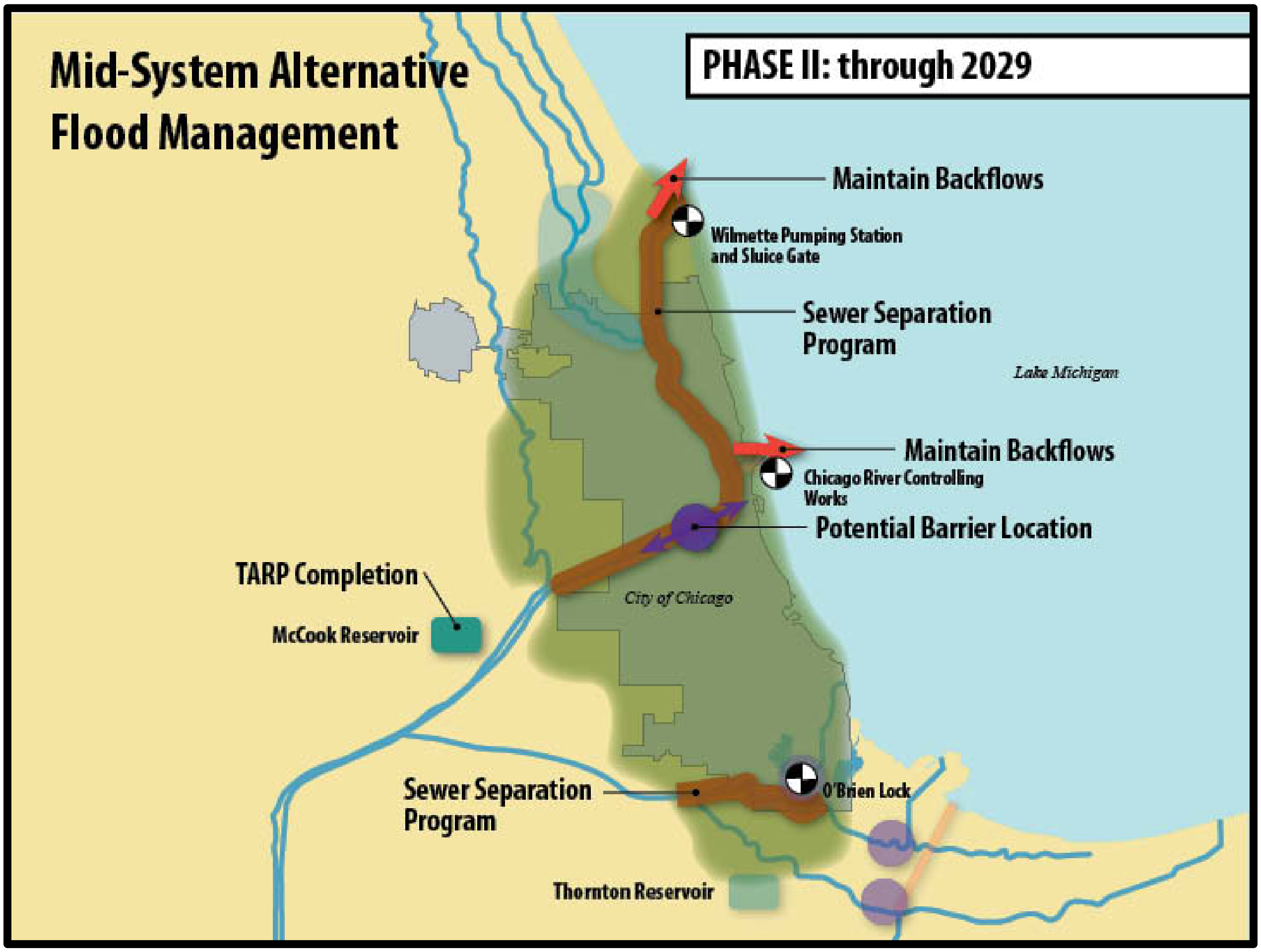
PHASE II: THROUGH 2029

At the completion of Phase I, the three Calumet System barriers would be fully implemented and the one-way AIS barrier would be in operation at the South Branch location. Completing Phase II will end the lakeside to riverside bypass flows through the South Branch barrier, thereby providing a completed barrier and separation. Before terminating the flow bypass, the following critical-path elements must be completed:

- TARP McCook Reservoir completion for managing combined sewer overflows (considered part of the baseline condition)
- Water quality elements in the Phase II separation project
    - Upgrades to North Side WWTP for discharge to Lake Michigan
    - Management of contaminated sediments (completed as part of the baseline condition)
    - Flow augmentation lakeside and riverside of the barrier

Green infrastructure and sewer separation programs would continue throughout Phase II in both the Calumet System and South Branch barrier locations. With the anticipated outlet conveyance that would be provided at Wilmette Pump Station and CRCW once Phase II is completed, the need for construction of conveyance tunnels and/or reservoirs is not anticipated in Phase II (Figure IV-12).

Figure IV-12. Flood Management Elements for Mid-System Alternative – Phase II



Once the critical-path elements listed above are completed, bypass flows would stop at the South Branch barrier location, thereby providing a separation up to the 100-year storm. The flow bypass elements of the initial one-way barrier would be kept in place to allow emergency bypass of flows lakeside to riverside during floods exceeding the 100-year storm. The control structures at Wilmette Pump Station and CRCW would also be operated “default open,” thereby providing the primary outlet conveyance for the Chicago River portion of the CAWS.

Contingency plans would be in place to prevent basement flooding when Lake Michigan water levels are well above normal. These plans could include (1) closing Wilmette, CRCW, and T.J. O’Brien gates/locks and using pumping capacity to lower CAWS water levels before larger storms (similar to current CAWS operations) and/or (2) allowing emergency bypass of flows lakeside to riverside through the barrier (the barrier becomes a one-way barrier) before or during larger floods.

The net effect of the improvements described above would be a flood management system that is more resilient to larger floods and can provide flood management for the Chicago area that is as good as or better than what currently exists.

2. Water Quality

With full implementation of the Mid-System Alternative, the North Side WWTP would require treatment upgrades beyond those identified in Part II, Baseline Conditions, to meet anticipated standards for water quality. The barriers would prevent treated effluent and augmented flows from traveling from Lake Michigan downstream toward Lockport. Therefore, stagnation is likely to occur on either side of the barrier. Flow could be augmented on both sides of the South Branch barrier by rerouting Stickney WWTP effluent and/or by providing Lake Michigan water to supply a headwater on either side of the barrier. Similarly, Calumet WWTP flow could be rerouted riverside of the Lake Calumet barrier to augment flow.

Since water quality standards are more stringent for Lake Michigan than for the CAWS, it is expected that some level of WWTP upgrades would be required for the North Side WWTP, since its effluent would be discharged to the lake with this alternative. Upgrades to the Stickney and Calumet WWTPs are not anticipated as part of the Mid-System Alternative separation, since their effluent would continue to be directed riverside of the barriers (other anticipated baseline improvements would occur without any separation alternative). Under baseline operating requirements, the North Side plant meets permit levels for river discharge. After separation, effluent will be diverted to Lake Michigan, and the discharge standards are expected to become more stringent. At a minimum, nutrient treatment improvements for removing phosphorous and nitrogen will be required. However, anti-degradation issues could emerge from such a large flow of water returning to Lake Michigan in the form of highly treated wastewater effluent. Water quality regulations are based upon an anti-degradation philosophy that even if discharge standards are met or achievable, a reduction in the beneficial use of a water body is not allowed, as described in further detail below.

Pursuant to Clean Water Act requirements and associated U.S. EPA regulations, all states must include an anti-degradation provision in their state water quality standards. While use classification and water quality standards are enacted to protect specific beneficial uses and functions of a water body, the anti-degradation provision is intended to protect high-quality water resources from degrading below their existing high quality. The substance of this provision is that new and expanding pollutant sources are allowable only if they are determined to be necessary to support important social or economic community purposes. If allowable, such new or expanded loading is subject to higher performance standards, not merely compliance with traditional standards. Any diversion option that redirects discharges currently flowing downstream to the Des Plaines and Mississippi Rivers and then to Lake Michigan would constitute a new load to Lake Michigan and therefore would be subject to the Illinois anti-degradation standards. Given the sensitivity of the Lake Michigan ecosystem, anti-degradation requirements will most likely be applied to nutrients as well as to bio-accumulative and toxic pollutants, such as mercury, that are discharged with the treated effluent.

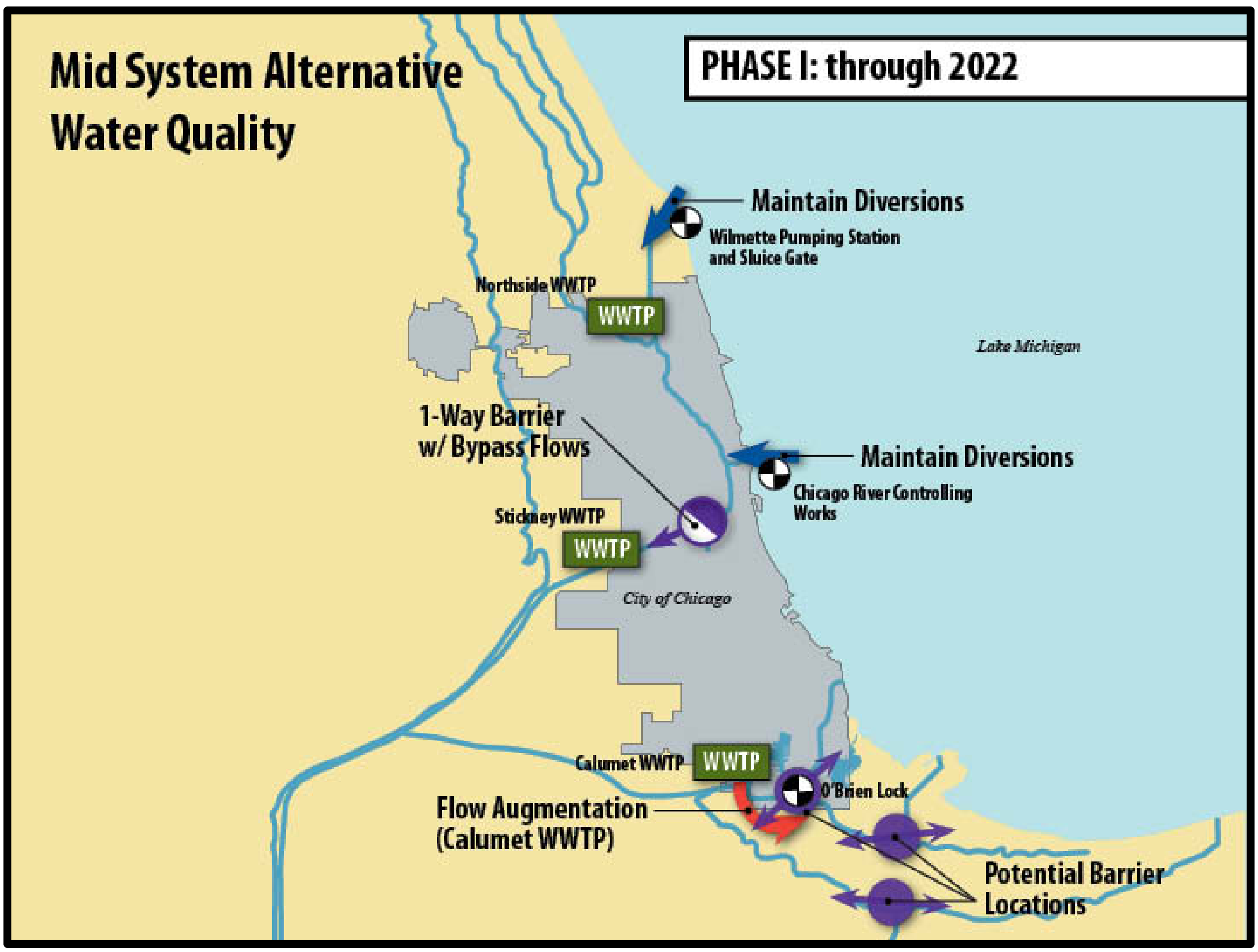
PHASE I: THROUGH 2022

The barrier near Bubbly Creek, on the South Branch of the Chicago River, would initially be constructed as a one-way barrier to address flood management and water quality requirements. The barrier would be able to bypass flows from the lakeside to the riverside only. The North Side WWTP discharge would continue to be directed riverside through the barrier (Figure IV-13) while improvements to the plant are being constructed. Once the improvements to the plant are constructed, green infrastructure is installed, and TARP improvements are completed, the barrier would be completed, and all flows north of the barrier would be directed toward Lake Michigan.

Phase I of this alternative would include a one-way barrier that is anticipated to be operational by 2022, resulting in:

- Water diversion through Wilmette Pump Station and CRCW for flow augmentation, as needed
- Flow augmentation from Calumet WWTP riverside of the barrier as needed

Figure IV-13. Water Quality Elements for Mid-System Alternative – Phase I

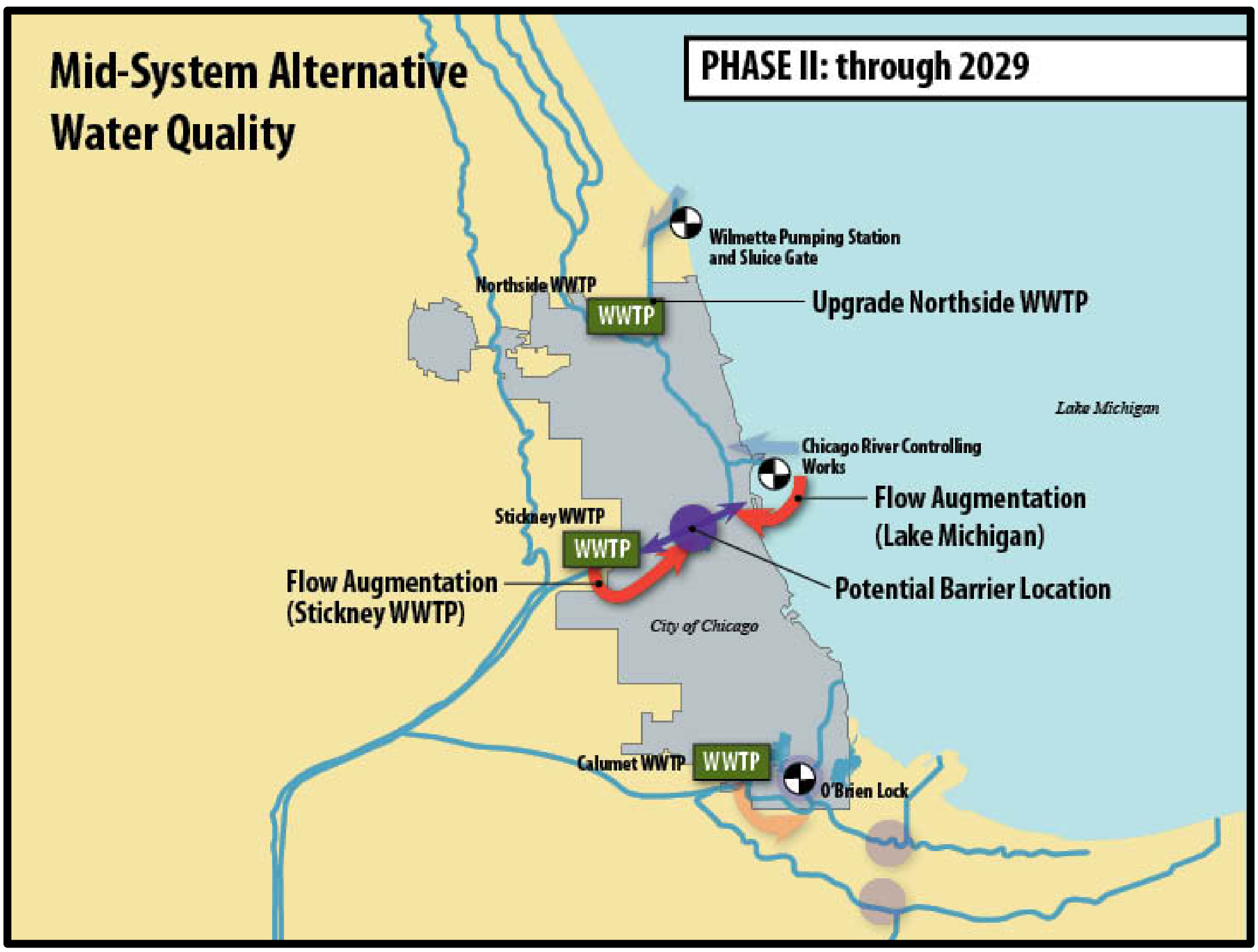


PHASE II: THROUGH 2029

Phase II would ultimately eliminate the lakeside to riverside bypass flow through the South Branch barrier, thereby providing a completed barrier and separation (Figure IV-14). Before ending the flow bypass, the following will be required:

- TARP will be completed for managing CSOs (considered as part of the baseline condition).
- Upgrades to North Side WWTP will be completed to address discharge to Lake Michigan and meet water quality standards.
- Management of contaminated sediments (completed as part of the baseline condition).
- Flow will be augmented riverside and lakeside of the South Branch barrier from the Stickney WWTP and Lake Michigan.

Figure IV-14. Water Quality Elements for Mid-System Alternative – Phase II

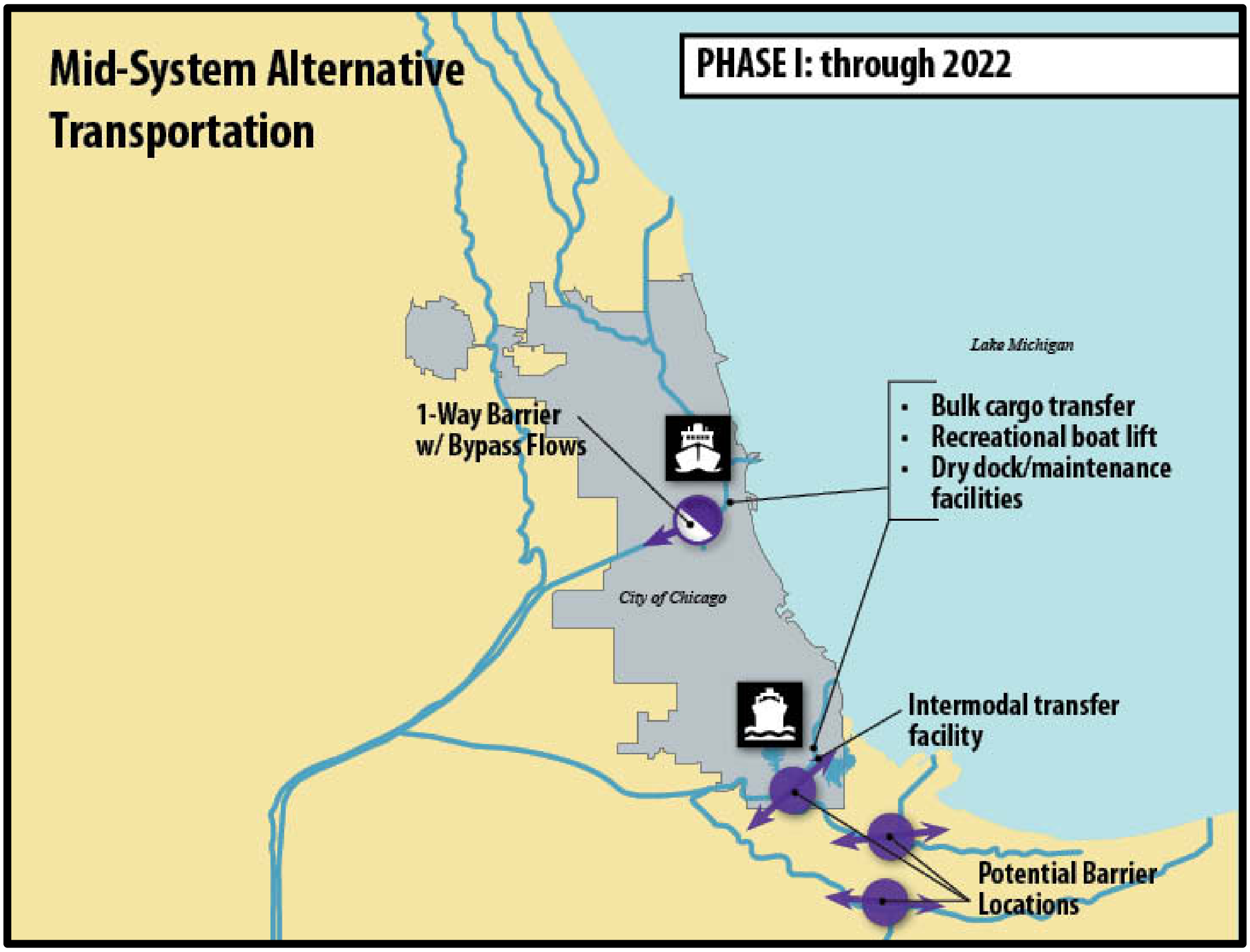


In summary, the overall improvements in water quality with the Mid-System Alternative would be such that water quality, recreational use of the CAWS, and potentially property values along the waterways would be maintained or improved. The proposed improvements would return portions of the water currently diverted from Lake Michigan to the lake, and water quality and flood management would be improved through using green infrastructure, restoring the floodplain, and preserving the capacity of TARP for larger floods. In addition, the improvements in combined sewer overflow management, flow augmentation, and wastewater treatment would protect and improve water quality throughout the CAWS, leading to enhanced water usage opportunities, such as recreation, and potentially increased property values.

3. TRANSPORTATION

For the Mid-System Alternative, placing barriers on the Grand Calumet and Little Calumet Rivers would not affect transportation. However, some traffic would be interrupted on the South Branch, and all traffic between the CAWS and Lake Michigan, including recreational, commercial, and barge, would be interrupted at the Lake Calumet barrier location. As a result, improvements to the existing transportation system and new infrastructure investments would be necessary, as described below. The transportation improvements would need to be in place before placing the barrier in order to avoid interrupting recreational and barge traffic. Thus, all improvements would be completed by 2022, defined as Phase I (Figure IV-15).

Figure IV-15. Transportation Elements for Mid-System Alternative



South Branch Chicago River Barrier

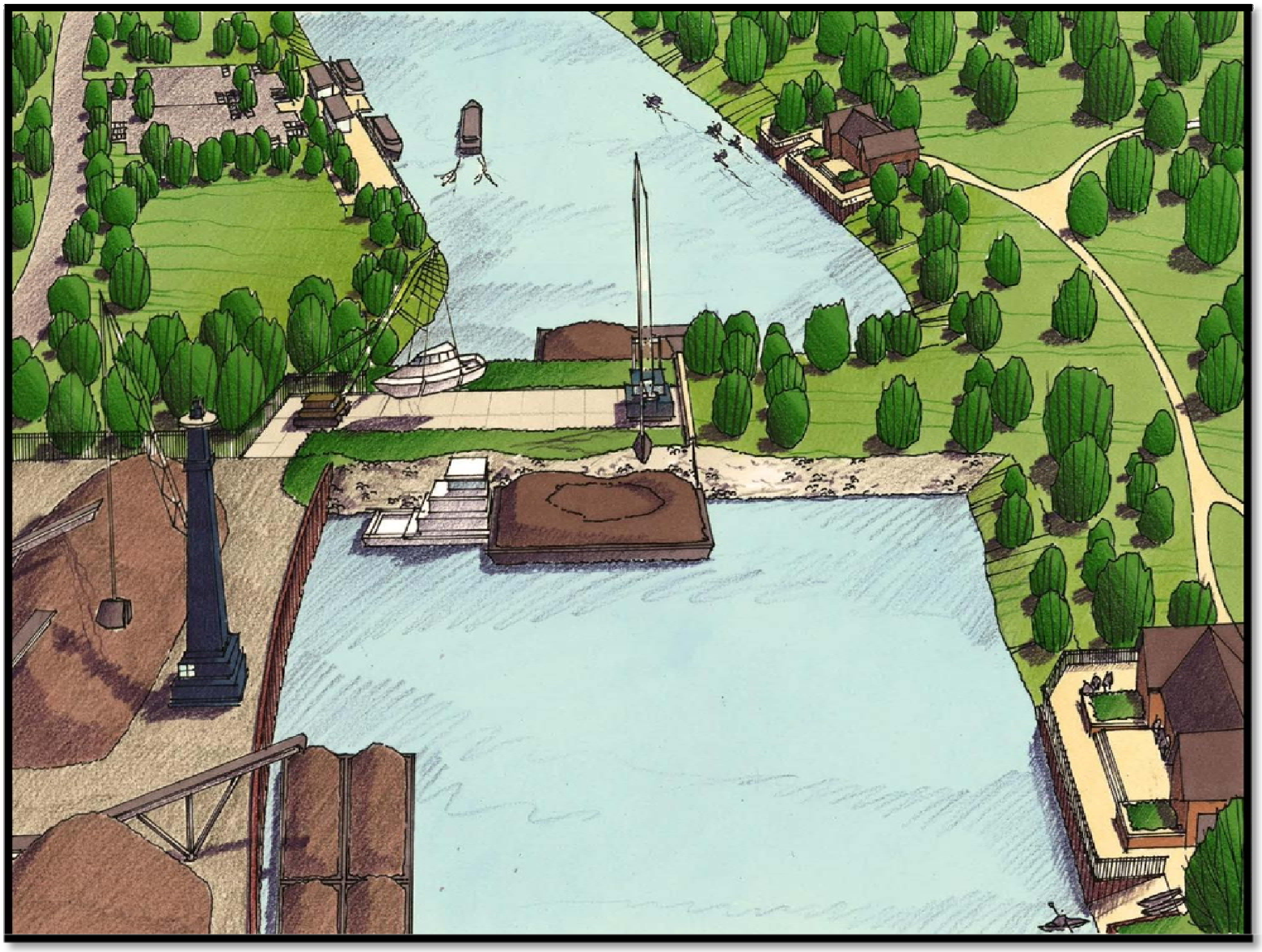
Cargo traveling by barge on the South Branch Chicago River would need to be transferred over the barrier, as would recreational vessels. Depending on the final location of the barrier, recreational vessels associated with the Chicago River boathouses proposed at Ping Tom Park and 28th and Eleanor Streets might need to be lifted over the barrier. The daily operations of commercial tour boats and water taxis would not be affected, but some of their occasional trips downriver for maintenance and dry docking, which currently occur on the CSSC, would need to be accommodated.

Improvements would include loading/unloading equipment and transfer alternatives for dry bulk barge materials. A recreational boat lift and disinfection station would be installed for the smaller boats to prevent the transfer of AIS via recreational boats. The proposed Chicago Park District lakeside marinas and harbors are baseline elements that could reduce much of the recreational boat traffic in this area. A rendering of a potential South Branch barrier is shown in

Figure IV-16. New dry dock facilities would also be constructed lakeside of the barrier so that commercial tour boats would not be affected.

The barrier could be developed in conjunction with the City of Chicago's boathouse plan; it could include green space, landscaping, and pedestrian-friendly elements to tie into the boathouse and park system. Transferring recreational boats could also allow time for passengers to visit the park properties and amenities, thereby furthering the City's vision of enhancing the river system.

Figure IV-16. Conceptual Rendering of South Branch Barrier



Calumet River Barrier

The Calumet River's deep draft navigational channel extends from Calumet Harbor to just north of the T.J. O'Brien L&D. Placing a barrier where the deep draft channel and Little Calumet River intersect would restrict the movement of barge and recreational traffic. It would not affect the movement of large "lakers" that currently enter the Calumet River, but it would affect any interface between barges and lakers. Currently, there is not much commercial tour boat traffic, other than to access dry dock and maintenance facilities south of the proposed barrier locations.

Improvements for this area would include developing a new OMNI modular grid overlay system port to accommodate the movement of various barge materials and commodities, including movement to and from new truck and rail connections. The OMNI port concept starts with a base module and can be adapted with successive layers for different commodities as demand warrants (see Figure IV-19). Loading and unloading equipment, transfer alternatives, and liquid bulk conveyance would be necessary. New dry dock maintenance and storage facilities to serve commercial and recreational boats would be constructed, and a recreational boat lift and disinfection station would be installed to prevent the transfer of AIS via recreational boats.

The proposed Chicago Park District Lake Michigan marinas and harbors would reduce much of the recreational boat traffic that would need to be transferred over the barrier; however, the seasonal movements from dry dock to lake would need to be accommodated. The Chicago Park District is now accommodating outdoor winter storage at one harbor and is considering additional storage spaces at other harbors. New dry dock and boat storage/maintenance area adjacent to the barrier on the lakeside, additional lift cranes during peak times, or other methods could also be implemented. A conceptual plan for a new Calumet River port is shown in Figure IV-17, and a rendering is shown in Figure IV-18.

The OMNI port concept would accommodate various types of cargo, including dry bulk, liquid bulk, and container-on-barge using technologies currently in use in Europe (Figure IV-19). The equipment used to transfer materials and goods over the barrier would allow a seamless integration between lakers, barges, trucks, and rail.

Recreational and commercial direct access to Lake Michigan at the Chicago River would be improved with this alternative, since the Chicago Lock would remain open.

Figure IV-17. Conceptual Lake Calumet Port Terminal

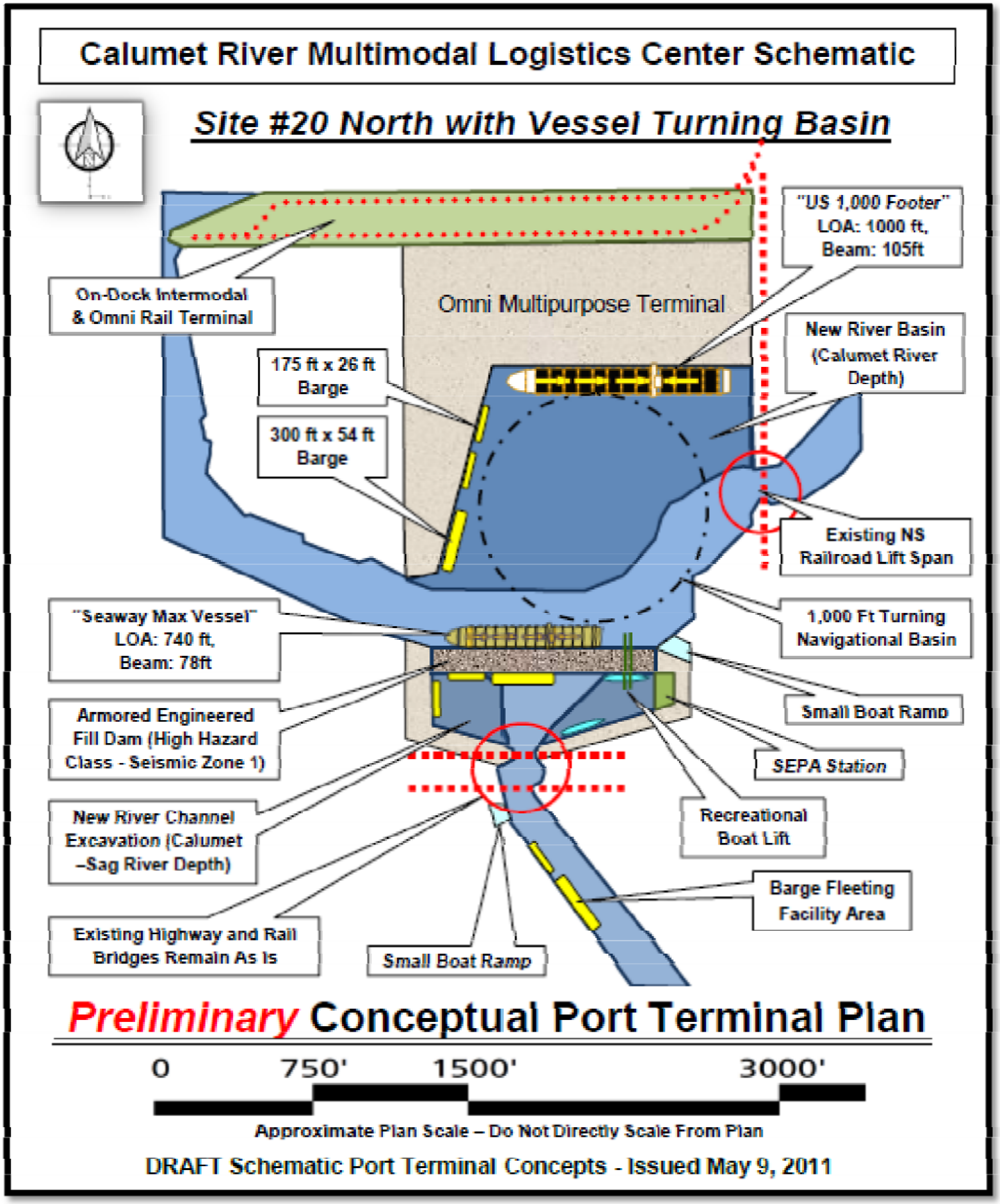
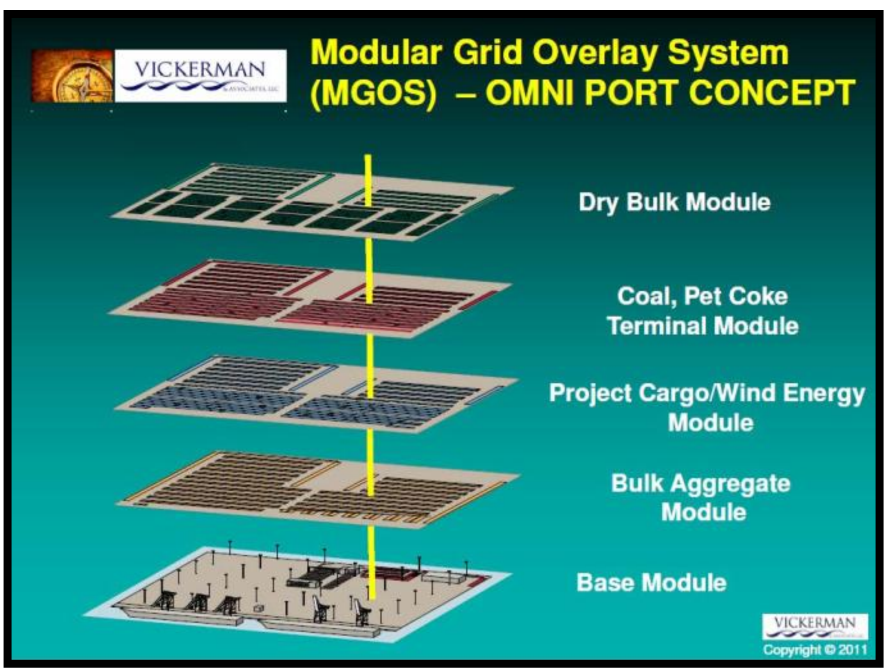


Figure IV-18. Conceptual Rendering of Lake Calumet Port Terminal

Figure IV-19. OMNI Port Concept



The Mid-System Alternative could accommodate the deep draft vessels and barges, and there would be an extensive network of existing rail facilities nearby. The proposed port's direct access to the NS, UPRR, and CN (former EJ&E) railways, as well as to Interstates 90, 94, 80, and 57, would make it a major intermodal trucking and rail nexus.

Several NS mainlines and branches extend into the Lake Calumet industrial area and serve terminals that line both sides of the Calumet River. NS has direct connections to Calumet Harbor, which provides intermodal transfer opportunities with rail, barges, vessels, and trucks. NS's Fort Wayne Main and Calumet Yard are just north of Lake Calumet; Burnham Yard is southeast of Lake Calumet near the state line; and Colehour Yard is just south of the Calumet River, between the Indiana Skyway and Lake Michigan shoreline in Indiana.

The BRC, IHB, CSS, and CRL also serve this area. These railroads provide vital connections and links between the terminals and ports in the Illinois and Indiana rail yards and with Class I railroads. Major facilities in the study area include the BRC South Chicago Yard and the IHB Blue Island Yard.

The UPRR Villa Grove Subdivision is just west of the Lake Calumet area. This rail line connects the Lake Calumet Area to Logistics Park Calumet North, where numerous intermodal yards are located. The CN Intermodal Terminal in Harvey, UP Intermodal Terminal in Dolton, Indiana Harbor Belt Terminal in Riverdale, CSX Intermodal Terminal in Riverdale, and IAIS Intermodal Terminal in Blue Island are all located in this area. The direct connection between the Lake Calumet area and these intermodal terminals would enhance the viability of intermodal connections for this alternative.

The CREATE program will have positive effects on transportation in the entire Chicago region, including several improvements adjacent to the CAWS system that can contribute to the integration of rail with the new proposed port near Lake Calumet. The CREATE program has two corridors in the vicinity of the South Chicago Branch and Calumet River barrier locations. The CREATE East-West Corridor is located along the NS and BRC mains, north of Lake Calumet and near the mouth of the Calumet River. The CREATE Western Avenue Corridor is located to the west of both barriers, using trackage from most of the major carriers. Implementing four CREATE projects in the vicinity of the barriers would further strengthen the intermodal connectivity between barge and rail. These include (1) improved train operations from the Rock Island Junction and 80th Street through the Pullman Junction (EW3-NS); (2) improved train speeds from the NS Mainline to the BRC Mainline (EW4-NS); (3) increased train speeds, capacity, and reliability at Dolton Interlocking, south of the Little Calumet River (WA11-BRC); and (4) new access near the crossing of the Cal-Sag Channel in Blue Island, Illinois, to allow better use of the Western Avenue, East/West, and Beltway rail corridors (WA10-BRC).

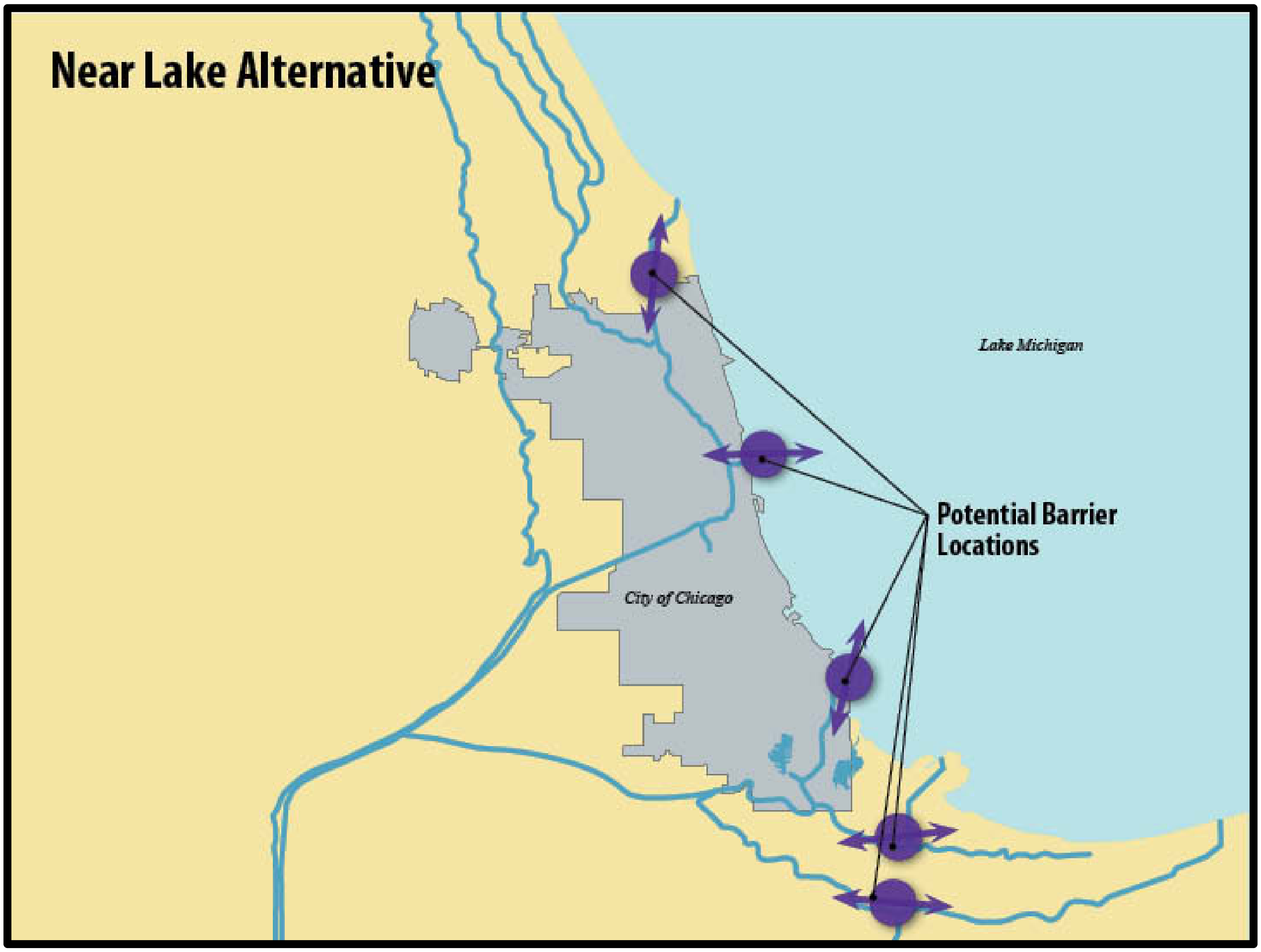
In summary, the proposed improvements would maintain the existing uses of the CAWS for transportation while at the same time creating the potential for new improvements to the regional transportation system. Improving transportation on the currently underused CAWS could help reduce congestion on the roadway and rails, increase container cargo traffic in the region, and improve intermodal efficiency of the freight system. Finally, with direct access to Lake Michigan due to the opening of the CRCW and T.J. O'Brien locks, travel by recreational and commercial vessels could also be enhanced.

D. Near Lake Alternative

The Near Lake Alternative would place five barriers in the following locations: (1) north of the North Side WWTP on the North Shore Channel, (2) at the Chicago River Controlling Works on the Chicago River, (3) at the mouth of the Calumet River, (4) near the natural divide of the Grand Calumet River, and (5) on the Little Calumet River near the USACE flood-control project at Hart Ditch (Figure IV-20).

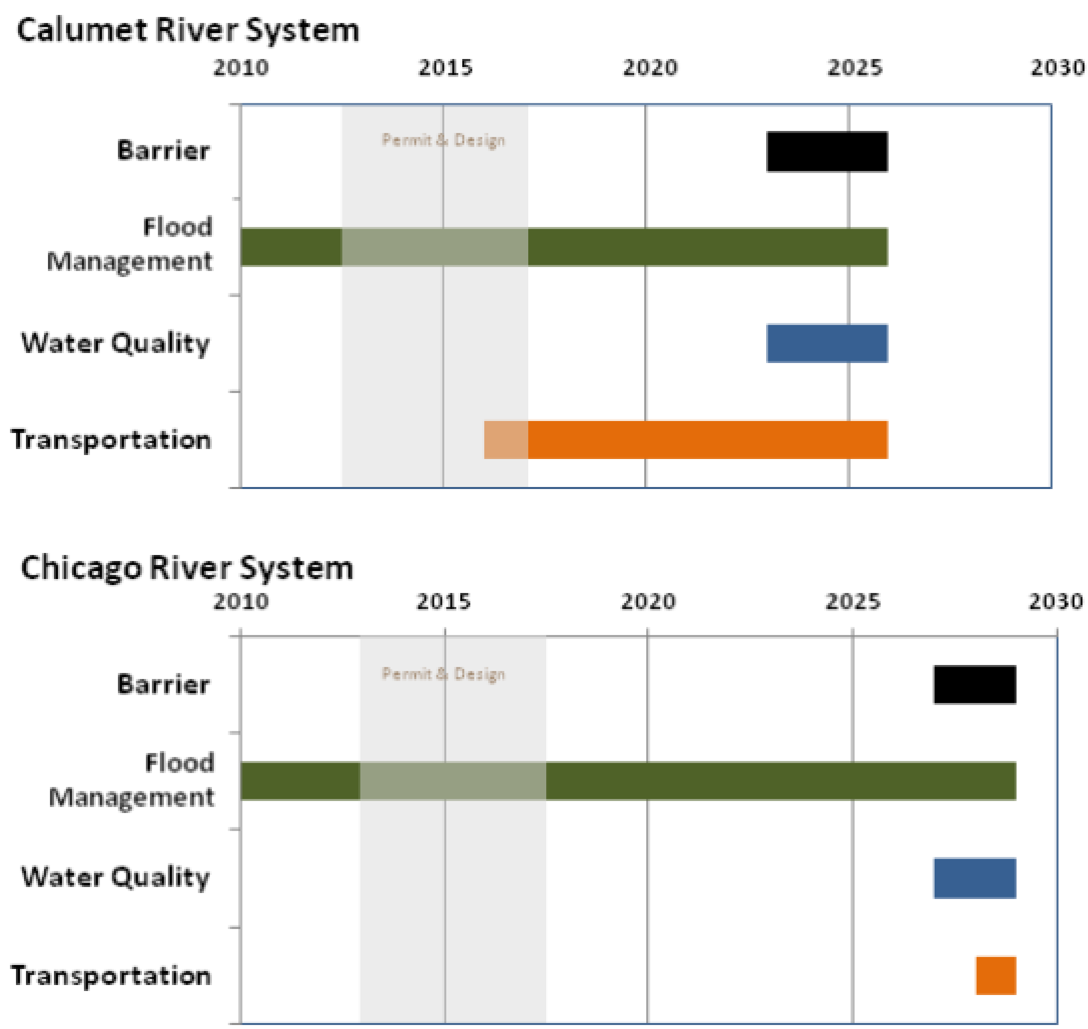
As described in Part III, Development and Analysis of Alternatives, the barrier type would vary by barrier location and would likely range from a sheet pile or impermeable land bridge (that is, earthen fill, concrete, seawall, etc.) without industrial cargo transfer (with limited recreational vessel transfers) for the Little Calumet River, Grand Calumet River, and North Shore Channel barriers to an impermeable land bridge (that is, concrete, earthen fill, seawall, etc.) with industrial cargo transfer (and limited recreational vessel transfers) or a constructed (that is, concrete, earthen fill, seawall, etc.) barrier with an intermodal facility for the Calumet River barrier. The Chicago River Controlling Works barrier would likely consist of an impermeable land bridge (that is, earthen fill, concrete, seawall, etc.) without industrial cargo transfer (with limited recreational vessel transfers).

Figure IV-20. Proposed Location of Barriers for Near Lake Alternative



A potential timeline for implementing the Near Lake Alternative is shown in Figure IV-21 and is described in more detail in the following sections for each area. This timeline would implement a separation barrier as quickly as possible. Unlike the Down River and Mid-System Alternatives, the Near Lake Alternative is proposed to be implemented in a single phase because of the anticipated needs for improvements to flood management (Chicago River System) and transportation (Calumet River System). It is anticipated that, upon addressing all permitting and regulatory issues, separation barriers could be in place by 2026 on the Calumet River System and 2029 on the Chicago River System. The timeline is focused on planning, design, and construction. Legal and regulatory issues must also be addressed and could affect the timeline as presented.

Figure IV-21. Proposed Implementation Timeline for Near Lake Alternative



1. Flood Management

Placing the five barriers for the Near Lake Alternative would eliminate the discharge of flood water and sewage into Lake Michigan. This requires a staged implementation to prevent additional flooding. Each barrier location affects flood management by different degrees at each barrier location:

- North Shore Channel – barrier would effectively cut off backflow discharge capacity to Lake Michigan at Wilmette Pump Station (about 5,000 cfs)
- Chicago River – barrier would effectively cut off backflow discharge capacity to Lake Michigan at CRCW (about 18,000 cfs)
- Lake Calumet – barrier would effectively cut off backflow discharge capacity to Lake Michigan at T.J. O'Brien L&D (about 15,000 cfs)
- Little Calumet River – barrier would effectively cut off outlet discharge from USACE flood-control structure west of Hart Ditch (about 2,200 cfs)
- Grand Calumet River – limited effect since barrier would be located near natural drainage divide (storm flows are currently directed in both directions)

With the completion of the TARP Thornton Reservoir expected by 2015, it is anticipated that flood management improvements could be implemented for the three Calumet System barriers and the barriers constructed by 2026, since they are driven by the Lake Calumet barrier transportation improvements (Figure IV-22). Conversely, the two Chicago River System barriers could not be fully implemented until the volumes of combined sewer overflows are reduced through completing the TARP McCook Reservoir in 2029. One-way barriers that would continue to pass peak flood water downstream past the barrier location toward Lockport are proposed as part of this alternative. Once the two Chicago River System barriers are completed, flood water flows up to the 100-year storm would be separated by the barrier, thereby separating the Mississippi River and Great Lakes basins up to a 100-year flood event.

Green infrastructure and partial sewer separation are proposed for both the Chicago River and Calumet System barriers. Green infrastructure elements would reduce flood water inflows, thereby reserving storage in TARP, and targeted sewer separation in areas along the CAWS waterways would reduce peak discharges on the CAWS by changing the timing of runoff in the areas of sewer separation. Green infrastructure is proposed within the TARP service area (green shaded area in Figure IV-22) and would be implemented along public rights-of-way based on current City of Chicago reconstruction programs for roads, sewer, and water. In addition, inflow reduction is proposed for private development by increasing the required flood water runoff capture requirements through an amendment of the existing City of Chicago flood water management ordinance. Sewer separation is proposed within 1 mile either side of the CAWS waterways, as shown by the red shading in Figure IV-22.

Figure IV-22. Flood Management Elements for Near Lake Alternative

Before TARP is completed and while the flood management elements are being implemented, the remaining CAWS control structures (Wilmette, CRCW, T.J. O'Brien) would continue to operate under current conditions; that is, in a "default closed" mode with backflows to the lake as needed during larger floods. It is anticipated that the frequency of these backflows would decrease over time with the implementation of the green infrastructure and sewer separation elements proposed as part of this alternative.

CALUMET SYSTEM BARRIERS: THROUGH 2026

The primary flood management element for the Calumet River System barriers is constructing conveyance tunnels to direct flows from the Cal-Sag/Calumet away from Lake Michigan and from the Little Calumet River System to Lake Michigan (Figure IV-22).

A conveyance tunnel from the Little Calumet River System to Lake Michigan is proposed to potentially improve flood management for the Little Calumet region. The tunnel would divert flows from the USACE Little Calumet Flood Control project along Little Calumet River between

Hart Ditch and Deep River to Lake Michigan. This diversion is anticipated to convey design flows that currently pass through a control structure west of Hart Ditch (about 2,200 cfs) up to the 200-year flood. While the general criteria for flood management were focused on the 100-year flood, the USACE Little Calumet Flood Control Project is designed for events up to the 200-year flood. Therefore, flood management investments proposed for the Little Calumet River (that is, a conveyance tunnel) were specifically denoted to provide means for flows up to the USACE's design event (200-year flood) to maintain the performance of the USACE Little Calumet Flood Control Project and provide additional incremental flood control for events larger than the 200-year design flood. While the flood management improvement would be an increment above the 200-year design flood, the diversion would reserve conveyance in the Little Calumet River downstream of Hart Ditch and potentially the Cal-Sag Channel and Calumet River. Limited effect is anticipated for the Grand Calumet River; however, if additional detailed analysis reveals the need for additional conveyance, diverting flows from the Grand Calumet River to the Little Calumet conveyance tunnel would be an option.

An additional conveyance tunnel riverside of the Calumet River barrier is proposed to convey flood water flows to additional proposed reservoir storage near Thornton Reservoir. About 20 miles of tunnel would parallel the Little Calumet and Calumet Rivers from near the Cal-Sag/Little Calumet River confluence to Lake Calumet and then to Lake Michigan at the mouth of the Calumet River. Part of the additional 20 miles of tunnel would include a tunnel from near Lake Calumet to Thornton Reservoir, and this tunnel would connect the tunnel paralleling the Little Calumet and Calumet Rivers to Thornton Reservoir. This Calumet tunnel system is anticipated to operate by gravity flow (no pump station). While the apportionment of about 6.9 billion gallons of cumulative storage volume required between the Calumet River and Chicago River Systems would be determined during design, it is anticipated that additional reservoir capacity would be added near the existing Thornton Reservoir to accommodate the additional tunnel discharge.

When complete, the three Calumet River System barriers, as conceived, would provide separation up to a 100-year flood event. A flow bypass element would be integrated into each barrier to allow emergency bypass of flows during floods that exceed the 100-year flood. The Little Calumet River barrier is one exception in that separation would be provided up to a 200-year flood in order to maintain and enhance the current design (200-year design flood) of the USACE Little Calumet River Flood Control Project.

Chicago River System Barriers: Through 2029

The primary stormwater element for the Chicago River System barriers is constructing conveyance tunnels to direct flows from the Chicago River System and Little Calumet River System to new reservoir capacity in the vicinity of the TARP McCook Reservoir (Figure IV-22).

About 25 miles of large-diameter tunnel would parallel the North Branch Chicago River, South Branch Chicago River, and CSSC from near the North Branch/North Shore Channel confluence to additional proposed reservoir storage near McCook Reservoir. This tunnel system is anticipated to operate by gravity flow (no pump station). While the apportionment of about 6.9 billion gallons of cumulative storage volume required between the Calumet River and Chicago River Systems would be determined during design, it is anticipated that additional reservoir capacity would be added near the existing McCook Reservoir to accommodate the additional tunnel discharge.

The flood management elements of the Chicago River System barrier would also include implementing additional floodplain storage along the North Branch Chicago River, as indicated by the blue shaded area in Figure IV-22. This floodplain storage would be supplementary and in addition to the recommended alternatives identified in MWRDGC's *Detailed Watershed Plan for the North Branch of the Chicago River*. Potential areas of floodplain storage include those identified in the MWRDGC watershed plans for possible flood water storage but not included as recommended alternatives. Part of the historical floodplain of the North Branch of the Chicago River would be restored through excavation to create flood detention areas at numerous locations along the North Branch Chicago River and its tributaries. The additional floodplain storage would reserve potential storage in TARP and would reduce peak discharges on the North Branch Chicago River.

When completed, the two Chicago River System barriers would provide separation up to a 100-year flood event. A flow bypass element would be integrated into each barrier to allow emergency bypass of flows during larger floods that exceed the 100-year flood.

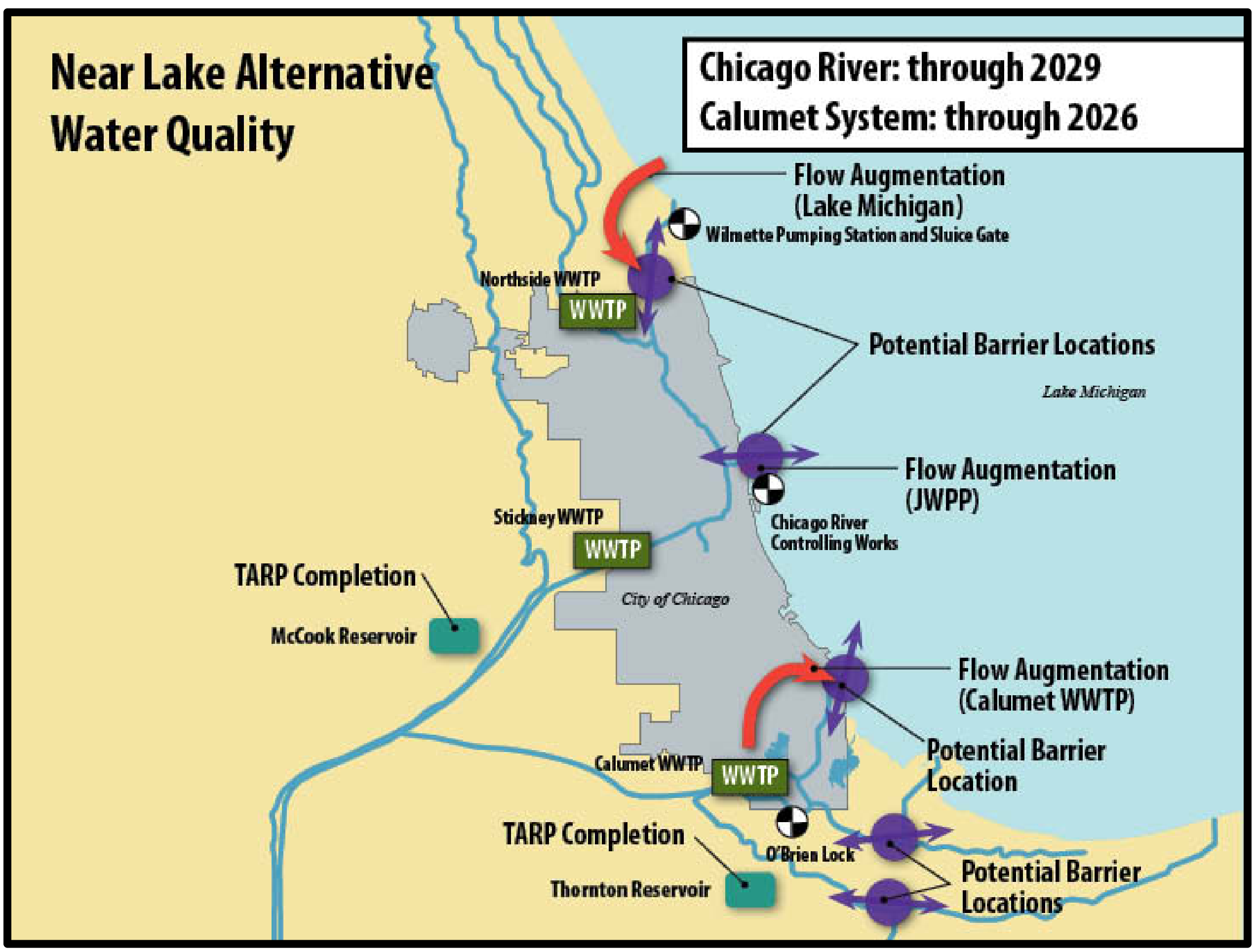
The net effect of the improvements described above would be a flood management system that is more resilient to larger floods and can provide flood management for the Chicago area that is as good as or better than what currently exists.

2. Water Quality

With the Near Lake Alternative, none of the three major WWTPs would require treatment upgrades beyond those identified in Part II, Baseline Conditions, to meet anticipated standards for water quality (that is, Lake Michigan standards or Illinois anti-degradation requirements). However, stagnation would occur on the lakeside of the barrier located north of the North Side WWTP. Removing the oxygen-consuming sediments and adding flood water through partial sewer separation could help address these stagnation issues. Additional improvements include augmenting flow by diverting Lake Michigan water to the lakeside of the barrier. Similarly, this alternative would avoid stagnated waters riverside of the Calumet River barrier by diverting treated effluent from the Calumet WWTP. Flow from the JWPP is proposed to address stagnation riverside of the Chicago Lock barrier. Once oxygen-consuming sediments are removed as anticipated as part of emerging baseline conditions, water quality will improve and the need for flow augmentation and aeration will be greatly reduced, with only intermittent aeration required. Separation barriers could be in place by 2026 on the Calumet River System and 2029 on the Chicago River System, as shown in Figure IV-23, with implementation of the following water quality improvement elements:

- Completion of TARP to manage CSO discharges (considered as part of the baseline condition)
- Flow augmentation from Lake Michigan lakeside of North Branch barrier
- Flow augmentation from Calumet WWTP riverside of Calumet River barrier
- Flow augmentation from JWPP riverside of Chicago River barrier
- Management of contaminated sediments lakeside of North Branch barrier (considered as part of the baseline condition)

Figure IV-23. Water Quality Elements for Near Lake Alternative



In summary, the overall improvements in water quality with the Near Lake Alternative would be such that the water quality vision and recreational use of the CAWS would be maintained or improved. The proposed improvements would return small portions of the water diverted from Lake Michigan to the lake, and water quality and flood management would be improved through using green infrastructure, restoring the floodplain, and preserving the capacity of TARP for larger floods. In addition, while less significant than the Down River and Mid-System Alternatives, the improvements in combined sewer overflow management, flow augmentation, and wastewater treatment (baseline condition) would protect and improve water quality throughout the CAWS, leading to enhanced water usage opportunities, such as recreation, and potentially increased property values.

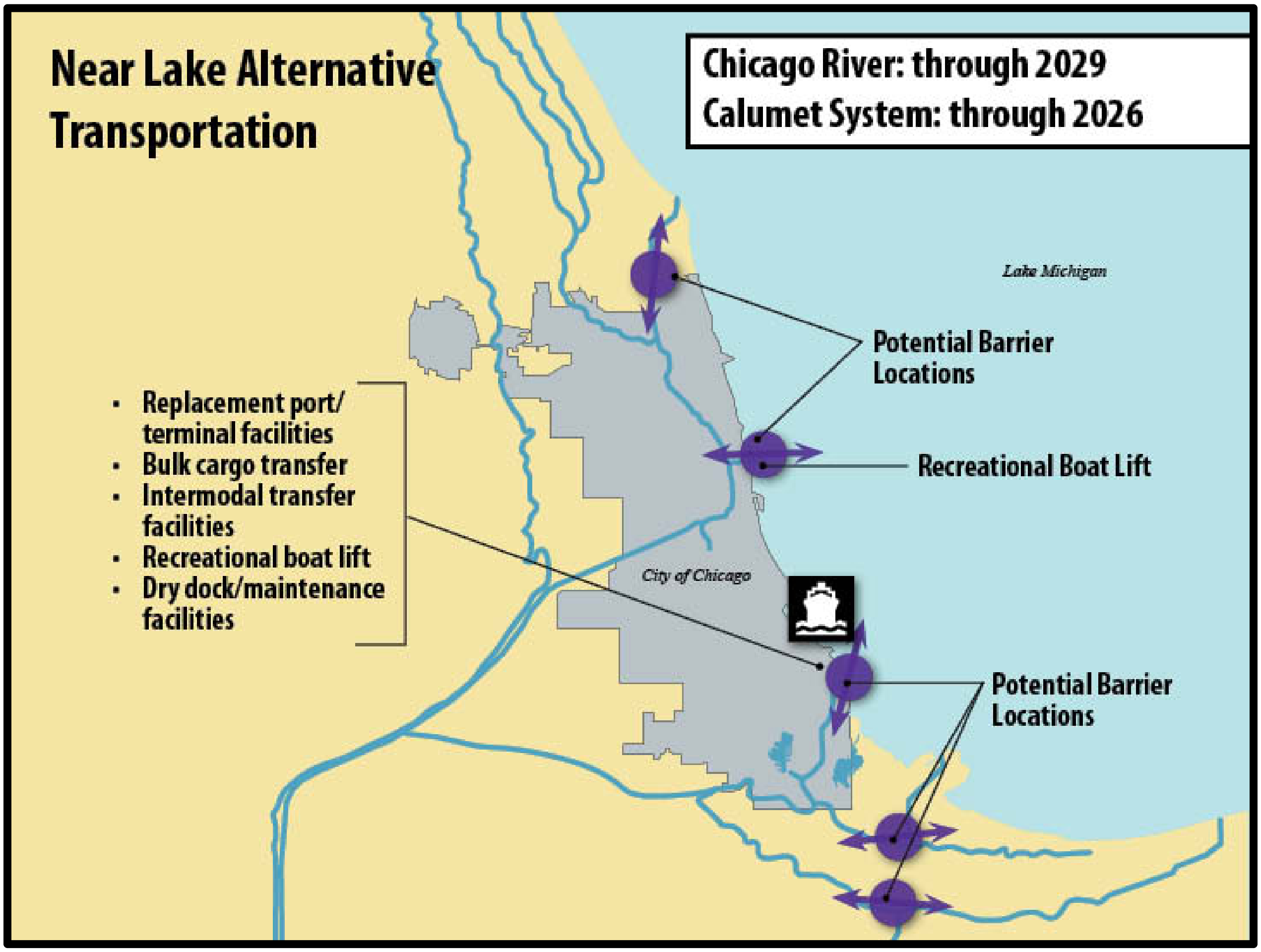
3. Transportation

Placing barriers on the North Shore Channel, the Grand Calumet, and the Little Calumet would not affect transportation. However, all traffic between the CAWS and Lake Michigan, including recreational, commercial, and barge, would be interrupted at the Chicago River and Calumet River barrier locations. As a result, improvements to the existing system and new infrastructure investments would be necessary at both locations, as described below. The transportation improvements would need to be in place before placing the barrier in order to avoid interrupting recreational and barge traffic. Improvements on the Calumet River would be completed by 2026, and improvements on the Chicago River by 2029 (Figure IV-24).

Chicago Lock Barrier

The barrier at the Chicago Lock would be located on Lake Michigan at the mouth of the Chicago River in downtown Chicago. This location is adjacent to Navy Pier and the Chicago Harbor and handles mostly recreational and commercial tour boat traffic. With the placement of a barrier in this location, the existing lock would no longer be functional. Commercial tour operators that traverse between the river and the lake (700,000 passengers per year) would need to relocate some of their operations lakeside of the barrier, while those that operate only within the river could remain. Commercial tour boats and water taxis would no longer be able to traverse Lake Michigan to reach their current dry dock/winter locations and would instead need to travel through the CAWS. The limited barge traffic that currently uses this lock would be diverted to the Calumet River. The 23,000 recreational vessels that travel between the Chicago River and Lake Michigan would no longer be able to traverse between the lake and the river at this location without additional investments.

Figure IV-24. Transportation Elements for Near Lake Alternative



The Chicago Lock is not currently served by freight rail, and no additional freight rail improvements are proposed after the barrier is placed; however, some new facilities and modifications to existing waterborne operations would be necessary. A recreational boat lift and disinfection station would be constructed to clean and carry vessels over the barrier to prevent the transfer of AIS via recreational vessels. Transferring commercial tour boats is not practical, so operators would likely need to provide vessels to operate on either side of the barrier. Commercial tour operators would likely offer separate river and lake tours; however, there is the possibility of modifying the traditional river/lake tour by requiring passengers to disembark and re-board on either side of the barrier. Although the traditional tour would be modified, it could be an interesting and educational addition to the tour that highlights the unique aspects of the barrier, its critical need, and its value (much like the current lock system is discussed). The barrier and transfer facility could even become a tourist attraction, given its unique status and function.

Downriver dry dock and maintenance facilities would be developed to service commercial tour boats and taxis on the riverside of the barrier. Those tour boats located lakeside of the barrier would need to travel farther south to the new port at the Calumet River, as discussed below.

CALUMET RIVER BARRIER

The proposed barrier located near the mouth of the Calumet River would affect current transportation activities. The 570-acre abandoned U.S. Steel site and the 190-acre Port of Chicago–Iroquois Landing are located north and south of the river, respectively. Several terminals are located on the Calumet River between Lake Calumet and Lake Michigan. All types of waterborne traffic pass this location, including lakers, barges, commercial tour boats (for dry docking), and fishing, governmental, and recreational vessels.

With a barrier near the mouth of the Calumet River, the downstream T.J. O'Brien Lock would not remain functional. It would not be possible for vessels to pass between the river and the lake. Access to all Calumet River terminals would be affected by loss of direct laker service. River-only barge service to and from these terminals could still continue, but barge access to Lake Michigan would be severed. All laker traffic to and from Lake Calumet would be affected. The USACE "past the point" data indicates that between 10 million and 13 million tons of commodities travel on the Calumet River between Lake Calumet and Lake Michigan each year. Additionally, the estimated 12,000 recreational vessels that pass this location each year would no longer be able to traverse between the lake and the river.

To address these issues and improve existing infrastructure and operations, the Port of Chicago would be improved with a new, modern port that handles all commodity types, including the emerging COB market. The barrier would be developed as part of this port and would allow barge traffic to access the port from riverside and laker traffic from lakeside. It would also allow the transfer of recreational boat traffic. The possible functional elements of the new port are listed below.

With this alternative, the port would consolidate terminals based on size and commodity types, as described below (Figure IV-25).

- 18 large terminal configurations, consolidated as follows:
    - Common commodities (such as steel, coal, liquid bulk, pet coke)
    - Common areas for barges and vessels of any "remaining" cargo
    - One main terminal for containers only
    - One major public terminal with shared use
    - Centralized rail operations
- New lakeside harbor, mooring, launching, dry dock, and disinfection facilities for recreational and commercial tour boats
- Transfer amenities for recreational vessel passengers

Figure IV-25. Potential Container Terminal Operations

From a transportation perspective, the Near Lake Alternative at the Calumet River could accommodate the deep draft vessels and barges, and there would be an extensive network of existing rail facilities nearby. The proposed port's direct access to the NS, UPRR, and CN (former EJ&E) railways, as well as to Interstates 90, 94, 80, and 57, would make it a major intermodal trucking and rail nexus. The existing railroads and proposed improvements described for the Mid-System Alternative also apply for the Near Lake Alternative.

In summary, the proposed investments would maintain the existing uses of the CAWS for transportation while at the same time creating the potential for new improvements to the regional transportation system. Improving transportation on the currently underused CAWS could help reduce congestion on the roadway and rails, increase container cargo traffic in the region, and improve intermodal efficiency of the freight system.

4. Other Considerations

Since much of the barge commodities traveling up the Cal-Sag Channel and Calumet River are headed to Indiana ports, an additional transportation element was considered that would provide a direct connection from the Calumet River to Indiana Harbor. Dubbed the "back door" option, it would include creating a new navigational channel between the Calumet River and Indiana Harbor via the Grand Calumet River. In addition, a barrier would be required at Indiana Harbor, likely similar in size and function to the Mid-System Calumet River barrier.

With the "back door" option, barriers would still be required on the Calumet River (either at Mid-System or Near Lake). However, this option would reduce some of the bulk commodity transfer that would take place on the Calumet River by redirecting cargo bound for the Indiana Harbor. (Gary and Burns Harbor cargo would still require commodity transfer.)

This option was not further analyzed for several reasons. First, developing a new navigational channel would require modifying numerous bridges in Illinois and Indiana. Second, dredging the Grand Calumet River would likely require disposing of large quantities of potentially hazardous material. Third, right-of-way and environmental permitting issues might be associated with this option. And, finally, an additional barrier with commodity transfer equipment would be required. The investments associated with these issues would likely be roughly $1 billion over and above the investments associated with either the Mid-System or Near Lake Alternative.

E. Summary

The three alternatives discussed in Part IV illustrate the varying complexities, challenges, and improvement opportunities that would result from placing barriers at different locations in the CAWS. The descriptions of these alternatives address the effects of constructing barriers within reasonable proximity of the locations that have been described for each alternative. Part V, Economic Analysis, discusses the cost and benefit analysis of each alternative.

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V. Economic Analysis

A. Introduction

Infrastructure investments, by their very nature, can be expensive. Re-engineering an entire waterway system such as the CAWS, which has been reworked over more than a century, is a substantial task. At the same time, investments in new infrastructure can lead to significant economic returns and job creation. A number of studies have found significant gains in private-sector productivity from public infrastructure investments. In many cases, returns on public investment are greater than returns on private investment (USDOT and CEA, 2010). The research record indicates that infrastructure investment can raise economic growth, productivity, and land values while also providing significant positive spillovers to areas such as economic development, environmental protection, energy efficiency, public health, manufacturing, and overall living standards.

The focus of this study is on the costs and benefits of creating physical barriers in portions of the CAWS to prevent the passage of AIS in both directions. In order to look at the entire system in an integrated way, the flood management, water quality, and transportation aspects are essential elements of this study.

A vision of the CAWS has been put forth that addresses current water quality problems, improves ongoing flood-management issues, and creates a transportation system that supports existing and future industries. Constructing physical barriers supports a vision in which the CAWS no longer serves as a direct conduit for the transfer of AIS between the Great Lakes and Mississippi River basins. Constructing the separation barrier would spur much larger investments to improve flood management, water quality, and transportation and would bring the waterway up to a level to support a clean and healthy CAWS, with managed flood risks and a transportation system that supports the growing economy of the Chicago region and beyond.

Part V presents an economic analysis of each separation alternative. Preliminary economic estimates and analyses resulting from separating the Great Lakes and Mississippi River basins on the CAWS are documented in this part, while detailed logic models, assumptions, and a sensitivity analysis are included in supporting appendices. It is not possible to quantify the economic value for all of the benefits of the alternatives under consideration with the data and modeling available for this study. To provide a specific monetized value for the benefits of reducing the risk of AIS transfer, the confidence band associated with any individual estimate would be so large that it would not be useful to present the estimate. Therefore, no specific estimate is provided for some of these benefits.

The economic analysis that follows is not a quantitative cost and benefit analysis in which the value of all the benefits are compared to the value of all the costs to determine whether the net value is positive and therefore good for society. Rather, the economic analysis presents the range of potential types of costs and benefits and quantifies these various impacts where possible. Where quantification is not specifically feasible in some instances with any degree of certainty with existing data sources, alternative approaches are used to provide some perspective on the potential scale of the impact. The economic analysis that follows is a cost and benefit analysis in which quantification is completed where feasible; and where not feasible, the potential effects are identified and treated qualitatively.

The magnitude of potentially the largest benefit of separation—reduced AIS risk and damage—is not directly quantifiable based on the currently available data, but a "case study" analysis demonstrates that these benefits, even for a single AIS, can be as much as $5 billion over 30 years. These estimates are derived from historical data on the impact of AIS such as sea lamprey, zebra mussel, and transportation-borne AIS in the Great Lakes. These numbers, while large, must be viewed in comparison to the existing Great Lakes fishing industry. The physical separation barriers would help protect this $7-billion industry. It is also important to recognize that a physical barrier could reduce the risk of multiple AIS over time. Once AIS transfer occurs, it would be infeasible and most likely impossible to reverse, resulting in continual damages.

The economic analysis has identified what appears to be the most cost-effective option for separation. The Mid-System Alternative appears to be the most cost-effective alternative with median costs of about $3.3 billion to $4.3 billion over the project lifecycle, which spans almost 50 years. A mid-system alternative is also the most logical location for a new port development to facilitate laker-to-barge and intermodal transfers.

The cost of constructing the separation barriers themselves would be a relatively small component of the overall project investments[1]: $143 million for the Near Lake Alternative, $144 million for the Mid-System Alternative, and $109 million for the Down River Alternative. The direct investments required to implement any separation alternative would be localized in the Chicago area, while the benefits of reduced economic damage due to AIS would be broad-based and would span the Great Lakes and Mississippi River basins. This lack of symmetry between costs and benefits suggests a justification for supplementary regional, national, and/or international (Canadian) funding sources.

Given the data and model challenges, what perspective does this study give on the question "Would the economic benefits of physical separation outweigh the costs of the investments?" The total estimated investment costs for the least-cost alternative are $3.3 billion to

[1] On a present value basis using a 3% discount rate.

$4.3 billion. What is the likelihood that avoiding AIS-related environmental damage alone would lead to similar or greater economic benefits? The evidence needed to give a definitive answer to this question is not currently available. However, an analysis of the available data provides some perspective (see page V-12).

For example, analysis indicates that the economic benefits of averting the invasion of one species could be as much as $5 billion (in present-day value over 30 years). This is enough to justify the economic cost of the alternative ($3.3 billion to $4.3 billion). Moreover, since a physical barrier could prevent the transfer of more than one species, the economic benefits might significantly outweigh the costs. However, this conclusion is based on limited evidence, so scientific and economic research into the economic value of avoiding AIS transfer should continue in order to determine whether $3.3 billion to $4.3 billion in investments for physical separation would be justified by the associated economic benefits.

All alternatives would require significant capital expenditures and would therefore generate new economic output in the region and across the United States from constructing and operating the new infrastructure. Employment impacts would range from 140,000 to 360,000 person-years over the full project lifecycle, or on average about 2,900 to 7,500 person-years annually, depending on the alternative. A person-year represents 1 year of employment for one person.

In addition to the overall project costs, each alternative would produce economic impacts across all areas of analysis, but the biggest impact would be on the cost to move cargo that is currently moved on the CAWS via barge. Separation would require extra handling of cargo and would likely shift some cargo to other modes of transportation, with resulting economic costs of $1.3 billion to $1.5 billion over the full project lifecycle (30+ years). Even with a small modal shift, the economic impact can be large due to the large cost advantage that barge transportation has compared to other modes. Other impacts, such as recreational boating, commercial tour boats, and public safety, are relevant to the various stakeholders. However, the scale of these impacts—both costs and benefits—is small *relative* to the major impacts described above.

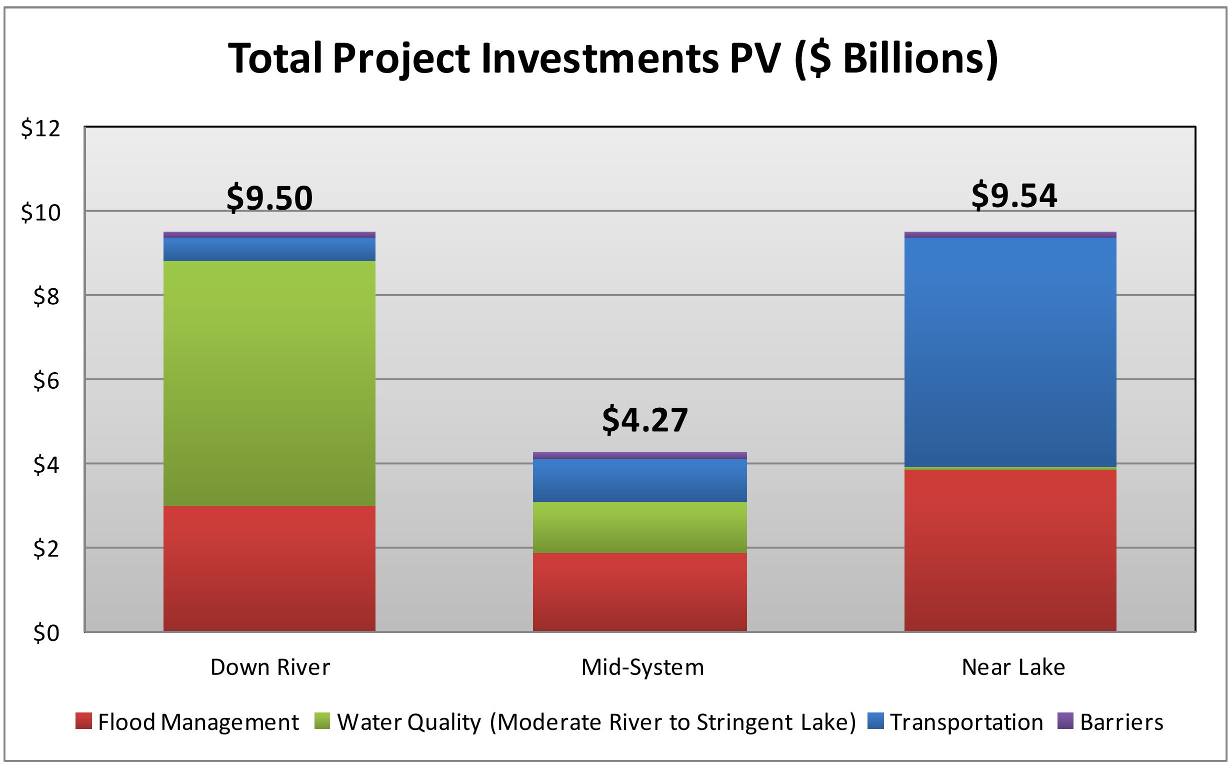
Figure V-1 summarizes the estimated investments for each of the alternatives that are separate from those associated with baseline conditions (baseline conditions includes costs that will be incurred even if separation is not implemented). The estimates represent the present value of lifecycle impacts discounted at a 3% discount rate.[2] Flood management costs include investments associated with sewer separation, floodplain storage, tunnels, conveyance, and green infrastructure; water quality costs include all investments associated with the upgrades

2 Costs that occur in the future are discounted to current-day dollars using a 3% discount rate.

of the Calumet, North Side, and Stickney WWTPs and flow augmentation; and transportation costs include all investments associated with new port development, facilitating cargo transfer over the barrier, lifting and disinfecting recreational boats, new dry dock facilities, and intermodal facilities.

There is high degree of uncertainty about the future effluent standards in the CAWS and Lake Michigan. This leads to uncertainty about the costs of WWTP upgrades. The costs presented in Figure V-1 are based on a Moderate River (standards) to Stringent Lake (standards) scenario. which is assumed to be the most likely scenario based on the best available information at the time of this study regarding future wastewater water quality standards and regulatory requirements for nutrient removal and the anti-degradation process. Other scenarios examined result in lower costs for the Mid-System and Down River Alternatives.

Figure V-1. Total Project Investments, Present Value (PV) in Billions of Dollars



B. Methodological Framework

The role of the current economic analysis is to guide the discussion of the impacts that separation will have on various segments of the economy and to provide a monetary estimate of those impacts, where possible. At this stage of the analysis, some legitimate impacts are not quantifiable in monetary terms due to the lack of supporting information. These impacts, while not quantifiable, can be important.

A sustainable return on investment (SROI) process for assessing the economics (for example, cost and benefit analysis, or CBA) of the alternatives for separation was used to quantify, in monetary terms, as many of the costs and benefits of separation as possible. *Benefits* are broadly defined. They represent the extent to which people are made better off, as measured by their own willingness to pay to prevent AIS transfer.

Central to CBA is the idea that people are best able to judge what is good for them and what improves their well-being. CBA also adopts the view that a net increase in well-being (as measured by the summation of individual welfare changes) is a good thing, even if some groups within society are made worse off. A project or proposal would be rated positively if the benefits to some are large enough to compensate the losses of others. Finally, CBA is typically a forward-looking exercise that seeks to anticipate the welfare impacts of a project or proposal over its entire lifecycle. Future welfare changes are weighted against today's changes through discounting, which is meant to reflect society's general preference for the present as well as broader inter-generational concerns.

The specific methodology developed for this study incorporates the above CBA principles. However, it also recognizes the limitations of the available data and detailed modeling for this study. Therefore, impacts are identified, but not all are quantifiable (especially benefits). In particular, the methodology involves:

- Establishing existing and future conditions under the separation and no-separation alternatives and considering three alternate separation scenarios (alternatives).
- Measuring incremental impacts.
- Measuring impacts in dollar terms whenever possible, expressing benefits and costs in a common unit of measurement, and qualifying the impacts where it is not possible to quantify impacts due to insufficient data or evidence. In some instances, examples or case studies are developed to demonstrate the potential scale of impacts.
- Not providing an estimate of the difference between total costs and total benefits, or net present value, because the largest benefits of the alternatives are not quantifiable using the data available for this study. However, some perspective is provided on the question.

- Relying on the existing sources of data only, including data that was made available by various stakeholders and literature reviews. Primary research such as "willingness to pay" (WTP) surveys, cargo origin-destination surveys, etc., was not a part of the scope of this study.
- Discounting future benefits and costs with the real discount rates that comply with USACE and federal guidelines.
- Conducting risk/sensitivity analysis and scenario analysis to assess the impacts of changes in key estimating assumptions.

C. Project Overview

The economic assessment compares each alternative to a "baseline conditions" option and identifies the relevant impacts.

1. Baseline Conditions

As described in Part II, Baseline Conditions, the baseline conditions include current and planned infrastructure investments. The baseline conditions include key elements by area as listed in detail in Table II-1 in Part II. Additional details about elements of the baseline conditions that are related to the economic analysis are described in Appendix B.

2. Separation Alternatives

Three separation alternatives are considered in the economic analysis:

- **Down River Alternative** with a barrier near the confluence of CSSC and the Cal-Sag Channel
- **Mid-System Alternative** with four barriers: upstream of Racine Avenue Pump Station, near Lake Calumet, and on the Grand and Little Calumet Rivers
- **Near Lake Alternative** with five barriers: upstream of the North Side WWTP, at the Chicago River Controlling Works, at the Lake Michigan–Calumet River interface, and on the Grand and Little Calumet Rivers

D. General Assumptions

The following general assumptions were made for the economic analysis:

- The analysis identifies impacts and measures benefits and costs, where feasible, through a period beginning at present and including 30 years of operations from barrier completion and including all investments. The period of analysis begins in 2011 and ends in 2059. It includes project development and construction years (2011–2028) and 30 years of operation (2029–2059).
- Input prices and monetized benefits and costs are estimated in 2010 dollars with future dollars discounted in compliance with USACE and federal guidelines. A 3% real discount rate[3] is used, plus a sensitivity analysis is performed with a 7% real rate (OMB, 1992). The economic evaluation does not make any explicit assumption about how the capital and operation and maintenance (O&M) costs associated with the infrastructure required for separation would be funded. The evaluation captures these project costs and assumes an appropriate opportunity cost for the use of these funds (for example, through the discount rates noted above) but does not speculate on a specific funding source. Speculating on user fees, etc., to help fund the infrastructure would influence user behavior and is not normally assumed in economic analysis unless rates are predetermined.

[3] The discount rate for federal water resources planning for fiscal year 2011 is 4.125%. www.federalregister.gov/articles/2010/12/29/2010-32801/change-in-discount-rate-for-water-resources-planning#p-3. This has been adjusted by the gross domestic product (GDP) deflator, and the result is a real discount rate of about 3%.

E. COST AND BENEFIT MATRIX

The cost and benefit matrix in Table V-1 lists and discusses the impacts of the separation alternatives. The final list of impacts considered in the cost and benefit analysis is provided in Table V-25.

Table V-1. Cost and Benefit Matrix

Area	Impact Category	Potential Impact	Description	Stakeholder
General Infrastructure	Infrastructure Investments	Cost	Cost to construct, maintain, and operate the separation barriers (including lifts, ports, etc.) plus all incremental costs associated with infrastructure investments including mitigating transportation, stormwater, flow augmentation, ecological health, and WWTP upgrades relative to the baseline condition.	Public
Reduce Risk of AIS Transfer	AIS Risk Reduction	Benefit	Separation would reduce the risk of future transfers of AIS in the Great Lakes and Mississippi River basins through the CAWS, thereby avoiding the economic costs and ecosystem damage of AIS. This is a multifaceted impact that includes (1) reduction in cost of prevention and eradication (post-separation), (2) use value—reduction in recreational use, (3) commercial value, (4) ecosystem value, and (5) option use.	Public
Transportation	Shipping Costs – Cargo Handling	Cost	For cargo that continues to use the CAWS after separation, additional costs for shippers associated with handling cargo over the separation barrier from barge to barge. Included in these additional costs is the cost to barge operators of less-efficient use of barge resources; separation would result in less-efficient use of barge resources since barges would not be able to cross the separation barrier and operators might need additional barges.	Shippers
Transportation	Shipping Costs – Higher Shipping Rates after Modal Shift	Cost	Diverting some traditional cargoes from barge to other modes after separation would result in increased shipping costs.	Shippers
Transportation	Emissions (after Modal Shift)	Cost	Diverting some traditional cargoes from barge to other modes after separation would result in increased emission levels. Emissions are a mode-specific externality and are based on the net ton-miles diverted from barge to other modes and the change in emissions by mode on a grams-per-ton-mile basis.	Public
Transportation	Accidents (after Modal Shift)	Cost	Diverting some traditional cargoes from barge to other modes would result in additional accident-related costs. Accident costs are a mode-specific externality and are calculated based on net ton-miles diverted and industry data on accident cost per ton-mile.	Public

Area	Impact Category	Potential Impact	Description	Stakeholder
Transportation	Infrastructure Operating and Maintenance Costs (after Modal Shift)	Cost	Diverting some traditional cargoes from barge to other modes would increase O&M costs on other transportation facilities (such as highway and rail).	Public
Transportation	Congestion (after Modal Shift)	Cost	Diverting some traditional cargoes from barge to other modes would increase levels of truck traffic congestion. Traffic congestion is a mode-specific externality and is a function of the capacity of the facility and the total volume of traffic. Only incremental truck congestion is monetized as an externality in this study, since highways are public. Incremental rail congestion is internal to the private rail companies and would be reflected in the rail shipping rates.	Public
Transportation	New Cargo Potential (NCP) – Reduced Shipping Costs	Benefit	The new port development at Calumet or Lake Michigan would facilitate the diversion of some cargo (for example, container) to barge that otherwise would have traveled on overland modes. This would decrease transportation costs associated with non-traditional (historically) container cargoes moving through the CAWS facilitated by the new port at the separation barrier.	Shippers
Transportation	Emissions (NCP)	Benefit	Diverting new cargoes from other modes to barge would decrease emission levels. Change in emission costs is calculated in the same manner as regular cargo.	Public
Transportation	Accidents (NCP)	Benefit	Diverting new cargoes from other modes to barge would decrease accident-related costs. Change in accident costs is calculated in the same manner as for regular cargo.	Public
Transportation	Infrastructure Operating and Maintenance Costs (NCP)	Benefit	Diverting new cargoes from other modes to barge would decrease O&M costs on other transportation facilities (such as highway and rail). Change in operating and maintenance costs is calculated in the same manner as for regular cargo.	Public
Transportation	Congestion (NCP)	Benefit	Diverting new cargoes from other modes to barge would decrease levels of traffic congestion. Change in traffic congestion is calculated in the same manner as for regular cargo.	Public
Transportation	Recreational Boat Barrier Crossing	Cost	For recreational boaters who would use the lifts to cross the separation barrier and have the boat disinfected, there would be additional time costs for each transit (relative to the time to get through the locks).	Recreational Boaters
Transportation	Recreational Boat Time Savings	Benefit	The Mid-System Alternative ensemble would allow the Chicago Lock to remain permanently open. This would reduce the annual time that recreational boaters spend waiting to pass through the locks.	Recreational Boaters

Area	Impact Category	Potential Impact	Description	Stakeholder
Transportation	Marina Relocation	Cost	Post-separation, some boaters might relocate to marinas lakeside since the lifts would accommodate fewer crossings than the locks. In addition, this could result in additional travel time costs and vehicle operating costs since boaters might tow and launch rather than use marinas for mooring.	Recreational Boaters
Transportation	Enhanced Access to Lake	Benefit	Some barrier location options would enhance lake access, thereby providing an opportunity to develop new harbors, marinas, and recreational fishing opportunities.	Public
Transportation	Boat Servicing and Storage	Cost	Separation could impede access for recreational boaters, commercial tours, and water taxis to dry docks for servicing and storage. Additional costs have been assumed for investments for new dry dock facilities.	Recreational Boaters, Water Taxis, and Commercial Tour Operators
Transportation	Additional Commercial Tour Vessels	Cost	The Near Lake Alternative would disrupt service for tour operators who traverse both the river and lake, and they might require additional vessels to maintain the current level of service.	Commercial Tour Operators
Transportation	Additional Public Safety Vessels	Cost	The Mid-System and Near Lake Alternatives would restrict the operation of emergency vessels and would require one additional emergency vessel on each side of the separation barriers for the Chicago police and fire departments. The additional vessels might also result in additional mooring and staffing costs.	Public Agencies
Transportation	Reduced Train Delay	Benefit	Reduction in rail delays associated with lift bridges spanning the Calumet River (pertains to Near Lake Alternative only).	Shippers/Rail Operators
Ecological Health	Water Quality Improvement	Cost / Benefit	Water quality and ecological health could be reduced as a result of barriers. Measures and associated cost estimates have been developed to ensure that water quality is no worse off than under the baseline condition. The Mid-System and Down River Alternatives would improve water quality for those stretches of the CAWS that would have an open connection to Lake Michigan. For some of the scenarios considered, the improved water quality in the CAWS would increase species diversification, recreational use, and aesthetic value.	Public
Flood Management	Flood Management	Cost	Without investments, flooding and the number of CSOs would increase as a result of the barriers. Strategies and associated cost estimates have been developed to ensure that flood management is no worse off than under the baseline condition. These investments could provide local flood-reduction benefits.	Public, Property Owners
General Infrastructure	Infrastructure Cost Avoidance	Benefit	Cost savings from not having to maintain and operate the displaced locks. Cost savings from not having to deploy alternate AIS technologies.	USACE
Other	Lockport Powerhouse	Cost	Power generation at the Lockport Powerhouse would be reduced.	Public

F. Benefits

Each of the separation alternatives would provide economic benefits, with the largest being the reduced risk of AIS transfer via the CAWS. The economic analysis identified a number of distinct benefits. Some of these benefits, while significant, are not directly quantifiable based on available data. The benefits are discussed below.

1. Reduced Risk of AIS Transfer

Each of the separation alternatives would reduce the risk of future transfers of AIS in the Great Lakes and Mississippi River basins through the CAWS, thereby avoiding economic costs and ecosystem damage. Separation would reduce the risk of AIS transfer in two directions: from the Mississippi River to the Great Lakes and from the Great Lakes to the Mississippi River. The potential economic losses associated with AIS are multifaceted and include the following (Emerton and Howard, 2008):

- **Management Costs:**
    - Cost of prevention—the costs associated with working to reduce risk of AIS transfer
    - Cost of control and eradication (after transfer)
- **Direct Values:** Reduction in recreational use; reduction in commercial value (for example, fish).
- **Indirect Values:** The ecological functions that maintain and protect natural and human systems and provide essential life support (for example, watershed protection).
- **Option Values:** The premium placed on maintaining ecosystems, landscapes, species, and genetic resources for future possible uses that have economic value.
- **Existence Values:** The value of ecosystem attributes and their component parts, regardless of current or future possibilities to use them. Ecosystems provide sites and landscapes, and contain a range of plant and animal species, that people value simply because they exist—not just because of the products and services they generate.

Monetizing the economic benefits associated with reducing the risk of AIS transfer requires several data elements for which data do not currently exist. To derive a specific estimate of the benefits of AIS risk reduction would require, at a minimum, forecasts by year of the following elements without separation:

- Number of species that would transfer between basins over time
- The likelihood that species that do transfer would become established
- The likelihood of species becoming invasive once established
- The economic damage if the species is invasive

While data do not exist at this time to allow the derivation of a reliable estimate of the potential benefits of separation related to AIS risk reduction, there is information available that provides some perspective.

There are a number of high-risk species in both basins that could transfer between basins and become invasive.

In its *Non-native Species of Concern and Dispersal Risk for the Great Lakes and Mississippi River Interbasin Study*, the USACE identified 254 alien aquatic species that are present in one or both basins or that are threatening to infiltrate a basin (USACE, 2011d). From this initial list, the USACE assessed a total of 119 alien and native species for their potential adverse effects on ecosystems and the methods they use for dispersal. In turn, 39 species were identified as having a high level of risk according to two criteria: they have a high level of risk for transferring from one basin to another, and they have a high risk of moderately to severely affecting the invaded ecosystem type if they do disperse and colonize the ecosystem.

The economic impact of individual or groups of AIS has been estimated for some species historically.

Existing literature provides some estimates of the economic damage from AIS. The available economic literature on AIS in the Great Lakes and Mississippi River basins was reviewed. From this review and discussions with experts in this field, it is apparent that this body of literature is still relatively small and the study domain is in its infancy. Very few empirical studies estimate the economic costs of AIS. The studies use a variety of methods to create the available estimates, resulting in a large variation in cost estimates from several hundred thousand to several billion dollars. Within the literature, it is broadly recognized that the economic impact of AIS is usually understated. For example, studies often ignore the value that society places on maintaining ecosystems for potential future uses.

The harm caused by a single AIS can be substantial.

Measuring the economic costs of AIS involves determining rates of biological propagation as well as assessing the risks of AIS. While few AIS have a high risk of becoming invasive, and even fewer of those would cause significant harm, the harm caused by these few can be substantial. Estimating the benefits associated with controlling the spread of AIS is difficult (Lovell and Stone, 2005).

While this area of study is in its infancy and existing economic impact estimates are based on varying approaches and degrees of rigor, the available studies can still provide some useful context for exploring the potential benefits of reducing the risk of AIS transfer.

CASE STUDY ANALYSES

To help put the potential benefits into context, a series of case studies have been constructed using a reasonable range of assumptions. The case studies are based on existing estimates of the economic damage caused by some individual species or group of species. Alternate studies could have been used with smaller or larger annual estimates of damage. These examples help demonstrate that preventing the transfer of even one AIS *could* have substantial benefits. The case studies or experiments are described using only the following three variables, which still result in many different permutations.

- Potential annual benefit from AIS prevention, or damage from AIS if transfer does occur:
    - $12 million to $18 million per year (based on sea lamprey) (Corn et al., 2002)[4]
    - $150 million per year (based on all ballast-mediated invasives in the Great Lakes, excluding producer impacts) (Lodge, 2008)
    - $300 million to $500 million per year (based on zebra mussel) (Cole, 2006)
- Start date of benefits (2030, 2040, or 2050):
    - The year in which AIS prevention benefits start accruing. The alternatives would be fully completed by 2029, but benefits would not necessarily start accruing immediately, so different start dates are used.
- End date of benefits (2059 or perpetuity):
    - Once damage is done by an AIS, the impacts are generally ongoing and forever. In recognition of this, the time period for which benefits are measured is varied to reflect (1) the study period only or (2) to perpetuity.

These case studies are not intended to provide definite evidence about the benefits of separation. Rather, they illustrate and provide perspective on the magnitude of possible damage from AIS if transfer between basins is not addressed.

The case studies illustrate that stopping even a single AIS from transferring between basins could avoid billions of dollars in economic loss. Table V-2 estimates the potential benefits, or potential costs avoided, from preventing a single AIS transfer, measured as present value in billions of 2010 dollars, that were derived from these case studies using a discount rate of 3% real.

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[4] This is consistent with feedback from the Great Lakes Fishery Commission, which quotes costs for controlling sea lamprey to be about $20 million per year (Gaden, 2012)

Table V-2. Potential Costs Avoided from Preventing a Single AIS Transfer, Present Value in Billions of 2010 Dollars

Annual Costs Avoided	Start: 2030 End: 2059	Start: 2040 End: 2059	Start: 2050 End: 2059	Start: 2030 End: Perpetuity	Start: 2040 End: Perpetuity	Start: 2050 End: Perpetuity
$12 million	$0.14	$0.08	$0.03	$0.23	$0.17	$0.13
$18 million	$0.21	$0.12	$0.05	$0.34	$0.26	$0.19
$150 million	$1.73	$0.98	$0.42	$2.85	$2.12	$1.58
$300 million	$3.45	$1.95	$0.83	$5.70	$4.24	$3.16
$500 million	$5.76	$3.25	$1.39	$9.51	$7.07	$5.26

While there is no way to definitively project the damage an AIS could do in the absence of separation, this analysis shows that the long-term benefits of preventing even a single AIS transfer can be significant.

2. Transportation (New Cargo Potential)

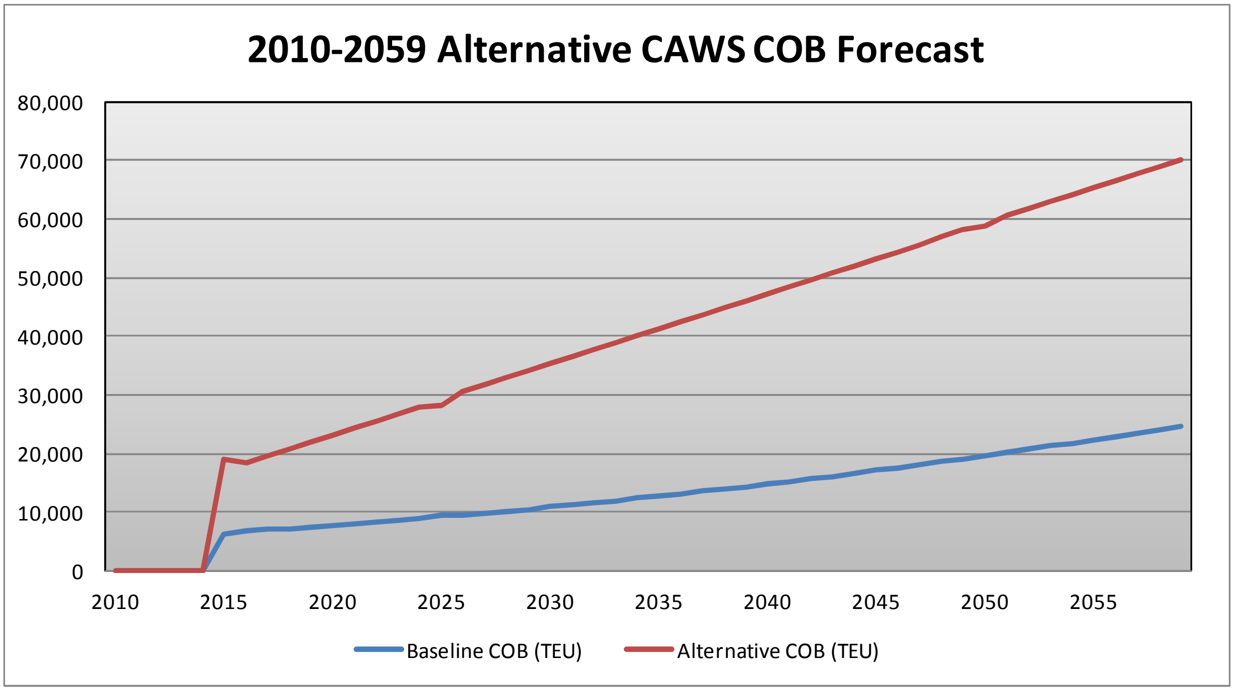
The transportation investments and the development of the new port facilities with the Near Lake and Mid-System Alternatives could facilitate the movement of new cargoes through the CAWS in the form of shipping containers on barges (COB). Through the study process, there has been some debate about whether these new cargoes would actually cause the new investments in port facilities or whether these movements would have occurred anyway in the baseline condition. Regardless, the potential benefits of increased COB movements through the CAWS based on alternative demand projections in the USACE NETS cargo forecast report mentioned earlier have been estimated (USACE, 2007c).

The USACE report forecasts a Radical Change COB scenario based on future use of specialized COB systems, which are currently used in other countries. The specialized COB systems would use deck barges instead of standard open hoppers, dedicated tows instead of general tows, and specialized terminals with container-lifting equipment and ship-to-barge capability.

The specialized terminals with container-lifting equipment and ship-to-barge capability are similar to what is being proposed at the Near Lake and Mid-System Alternative terminals. The specialized system at these terminals would allow greater COB traffic than what has been forecasted in the baseline condition. This Radical Change COB forecast has been used for the purposes of the economic model.

The baseline condition and Alternative Case COB forecasts are shown in Figure V-2. It is assumed that these new COB movements would otherwise have been handled within the region by rail transportation. The forecasts spike upward in 2015 with the opening of the expanded Panama Canal.

Figure V-2. COB Forecast for Mid-System and Near Lake Alternatives, 2010–2059



Similar to the modal shift discussion above, several impacts would occur with the cargoes diverted from other modes:

- Decreased shipping/transportation costs via COB
- Decreased emission levels
- Decreased accidents
- Decreased O&M costs

The magnitude of the benefits associated with new COB traffic potential through the CAWS is driven by two major factors: the level of incremental traffic and the rate of savings associated with shipping cargo via barge as opposed to rail. For this analysis, it was assumed that the percentage rate savings for barge over other transportation modes also applies to COB.

The potential benefit of new COB traffic moving through the CAWS is estimated to be about $416 million over the study lifecycle for the Mid-System Alternative. The primary economic benefit is the savings in transportation costs (for example, shipping rate) of almost $300 million for the Mid-System Alternative.

Table V-3. New COB Cargo-Related Benefits, Mid-System and Down River Alternatives, Millions of 2010 Dollars

Benefit	First-Year Impact (2023)	Present Value of Impact ($ millions)	
		3% Discount Rate	7% Discount Rate
Shipping rate (from modal shift)	$12	$296	$100
Emissions	$1	$29	$10
Accidents	$2	$55	$19
O&M	$1	$36	$12
Total	**$16**	**$416**	**$141**

Table V-4. New COB Cargo-Related Benefits, Near Lake Alternative, Millions of 2010 Dollars

Benefit	First-Year Impact (2027)	Present Value of Impact ($ millions)	
		3% Discount Rate	7% Discount Rate
Shipping rate (from modal shift)	$14	$265	$82
Emissions	$1	$26	$8
Accidents	$3	$49	$15
O&M	$2	$32	$9
Total	**$16**	**$372**	**$115**

3. Reduced Train and Automobile Delay

The Near Lake Alternative barrier ensemble would eliminate rail delays associated with lift bridges spanning the Calumet River that are raised when vessels from Lake Michigan traverse the river. Also, the Near Lake Alternative would seasonally eliminate automobile, pedestrian, and bicycle delays associated with the lift bridges spanning the Chicago River. These benefits are recognized but not monetized.

4. Water Quality

The Mid-System and Down River Alternatives would improve water quality for those stretches of the CAWS with an open connection to Lake Michigan. The improved water quality, for some of the scenarios considered, in the CAWS would increase species diversification, recreational use, aesthetic value, and potentially property values.

It is broadly recognized in the economic literature that improved water quality provides significant economic benefits and that people have demonstrated a strong willingness to pay for such improvements. Numerous studies have demonstrated the economic benefits of water quality improvements, and the most frequently used methodology in these studies is "willingness to pay" using contingent valuation techniques. U.S. EPA used this technique to determine the economic benefits of the Clean Water Act (CWA) in 2000, which were about $11 billion per year.

> The measure of value employed in this study is households' maximum willingness to pay (WTP) for the estimated improvements in water quality under the CWA. WTP is usually regarded as the best observable measure of the value that people place on the benefits of environmental quality improvements, and its use is consistent with governmental directives for conducting benefits analyses. Use of WTP implies a human-oriented perspective on the benefits of water quality improvements. For decision makers who believe that a more expanded view of the value of ecosystems should be the basis of public policy, WTP would, presumably, represent a lower bound on the value of the water quality improvements under the CWA (U.S. EPA, 2000).

Other studies have also provided useful context of willingness to pay for water quality improvements in the Chicago region.

- Boyle (2008): The value of disinfection at all three WWTPs in the CAWS was found to be about $47 per household per year, or about $1 billion over 20 years.
- Croke et al. (1986): The willingness to pay in Cook County for improving water for recreational use was found to range from $33 to $46 per year per household.
- The Brookings Institute (2007): The economic benefits of the federal-state Great Lakes Regional Collaboration (GLRC) Strategy were estimated to be about $50 billion, or about two times the cost (Austin et al., 2007).

The economic valuation of water quality improvements is usually measured in terms of a "water quality ladder," which represents the degree to which people perceive that water is boatable, fishable, or swimmable. These steps in the ladder (for example, fishable) are tied to several specific water quality indicators such as levels of dissolved oxygen, fecal coliforms, etc., to derive an estimate of the economic benefits of improved water quality. While it is recognized that the Mid-System and Down River Alternatives would have water quality benefits with an economic value, specific measurements of water quality indicators are not available in the baseline condition and for each alternative. Therefore, an estimate for the water quality benefits for these two alternatives cannot be provided with the data and modeling available for this study.

5. Flood Management

Each alternative includes significant investments related to flood management including sewer separation, floodplain storage, tunnels, conveyance, and green infrastructure for stormwater. While it is expected that these investments could provide some local flooding benefits relative to the baseline condition, the level of modeling analysis did not provide specific measures to allow the team to quantify the flood-control benefits. The potential benefit for each alternative is recognized but is not quantified or monetized.

The alternatives also provide significant investments in green infrastructure that provide benefits over and above their primary objective of flood management. While it is recognized that investments in green infrastructure provide benefits related to reduced energy consumption and emissions, biological diversity, etc., these benefits have not been quantified.

6. Cost Avoidance

There would be some cost avoidance benefits from each of the alternatives. Cost avoidance refers to costs that are expected to be incurred in the baseline condition that would not be incurred with each of the separation alternatives. The two sources of cost avoidance are:

- **Operation of the T.J. O'Brien and Chicago Locks:** After separation, neither lock would be operated by USACE, with a cost avoidance of about $3 million annually.
- **AIS-Related Research and Prevention:** After separation, activities related to monitoring, research, and preventing the transfer of AIS through the CAWS would no longer be required, with a cost avoidance of about $5 million annually. It is noteworthy, however, that if future expenditures for initiatives like Asian carp management are maintained in the long term at the level of appropriations in the last two fiscal years, the cost avoidance estimates could increase tenfold. The level of these future appropriations is not known at this time.

Table V-5. Cost-Avoidance Impacts, Mid-System and Down River Alternatives, Millions of 2010 Dollars

Benefit	First-Year Impact (2023)	Present Value of Impact ($M)	
		3% Discount Rate	7% Discount Rate
Annual Lock O&M Costs	$3.0	$46.6	$17.4
AIS-Related Research/Prevention Costs	$5.0	$77.7	$29.1
Total	**$8.0**	**$124.3**	**$46.5**

Table V-6. Cost-Avoidance Impacts, Near Lake Alternative, Millions of 2010 Dollars

Benefit	First-Year Impact (2027)	Present Value of Impact ($M)	
		3% Discount Rate	7% Discount Rate
Annual Lock O&M Costs	$3.0	$38.8	$13.0
AIS-Related Research/Prevention Costs	$5.0	$64.7	$21.6
Total	**$8.0**	**$103.5**	**$34.6**

G. Capital and Operation & Maintenance Costs

This part of the report summarizes the capital and operation and maintenance (O&M) costs associated with separation in the CAWS. Costs are summarized for each separation alternative. For each alternative, capital and O&M costs are summarized into three cost categories—flood management, water quality, and transportation—but each of these categories has layers of detail for various investment components.

Determining the future investments required for WWTPs is extremely difficult because there is significant uncertainty about future effluent standards. It is anticipated that the effluent standards for both Lake Michigan and the Mississippi River are likely to become more stringent over the study period, but the exact degree is unknown. The economic analysis is based on consideration of baseline condition scenarios and improvements that are required due to placing separation barriers.

A major cost factor is determining the baseline condition cost for upgraded treatment at the regional WWTPs. The baseline condition for WWTP effluent is to continue to assume that it discharges into the Mississippi River basin. It is anticipated that, within the study period for the separation project, nutrients will need to be reduced by some level. Two different levels of treatment for removing nutrients from effluent discharged to the CAWS were assumed for the baseline condition: a moderate level of treatment and a more stringent level of treatment.

These two baseline condition assumptions were then used to calculate the incremental costs of additional treatment required when discharging effluent to Lake Michigan due to placing separation barriers. Moderate and stringent levels of effluent treatment were assumed for Lake Michigan to account for uncertainty in water quality permitting for discharges that reach the lake. Therefore, the most expensive option is to modify a WWTP that is currently designed to treat effluent to a moderate river standard to instead treat effluent to a stringent lake standard. The least expensive option would be if a plant will be mandated to meet a stringent river standard and now must upgrade to meet a moderate lake standard.

Therefore, cost estimates for three different scenarios were examined for WWTPs:

- The first and most likely scenario is the **Moderate River to Stringent Lake Scenario**. This scenario assumes that the effluent quality standards required for discharges to the CAWS/Mississippi River are moderate, while those standards for discharges to Lake Michigan are stringent. Therefore, the improvements in effluent quality required when a WWTP discharges to the lake instead of the river would be the most costly because the difference in standards would be the greatest. This scenario was assumed to be the most likely based on the best available information at the time of this study regarding potential wastewater quality standards and regulatory requirements for nutrient removal and the anti-degradation process. This scenario would also be the most costly.
- The second scenario, the **Moderate River to Moderate Lake Scenario**, assumes that both bodies of water require moderate effluent quality improvements. The resulting costs are due to the difference between the moderate river standard and the moderate

lake standard; that is, the moderate lake standard is higher than the moderate river standard. This scenario would have costs that fall in between those of the other two scenarios.

- The third scenario, the **Stringent River to Stringent Lake Scenario**, assumes that both bodies of water require a similar stringent level of effluent quality improvement. This scenario would be the least costly.

1. Presentation of Data

All capital and O&M costs in this cost analysis are median cost values in billions of dollars. In the tables and graphs that follow, the estimated investments required for the project represent the sum of the median cost estimates for flood management, water quality, and transportation investments. The graphs and summary tables show the investments in present value format and reflect the capital and O&M costs over the project lifecycle. Capital cost components such as engineering design, permitting, sewer separation, green infrastructure, and National Environmental Policy Act (NEPA) analyses start occurring as early as 2012. Major construction capital costs end in 2029, in line with the barrier completion date. However, O&M costs for several project components extend to the study end date of 2059.

All values in the cost analysis are presented in constant 2010 dollars. Since all cost values are in constant dollars, a real discount rate has been applied to calculate the present value of the project's capital and O&M costs. Project cost inputs have been developed based on a preliminary assessment of the requirements for each separation alternative.

- Flood-management costs include all costs associated with investments related to sewer separation, floodplain storage, tunnels, conveyance, and green infrastructure.
- Water quality costs include all costs associated with investments related to the upgrades of the Calumet, North Side, and Stickney WWTPs plus costs associated with flow augmentation.
- Transportation costs include all costs associated with investments related to new port development, facilitating cargo transfer over the barrier, lifting and disinfecting recreational boats, new dry dock facilities, and intermodal facilities.

The costs associated with the actual dam or barrier structures are identified separately.

2. Down River Alternative

Future effluent standards have a significant impact on the project costs for the Down River Alternative due to the costs associated with upgrades at the Stickney WWTP. The total investment for this alternative ranges from $3.94 billion to $9.50 billion depending on the scenario. Water quality investments are $5.85 billion for the Moderate River to Stringent Lake

Scenario, $1.57 billion for the Moderate River to Moderate Lake Scenario, and $0.29 billion for the Stringent River to Stringent Lake Scenario.

The Down River Alternative also requires significant flood-management investments of $2.98 billion related to tunnels to the lake, green infrastructure, and other elements. At $0.56 billion, transportation investments for this alternative are less than for the other alternatives since only one cargo transfer location is required. Barrier costs are $0.11 billion.

Figure V-3. Investments by Category, Down River Alternative (Moderate River to Stringent Lake Scenario)

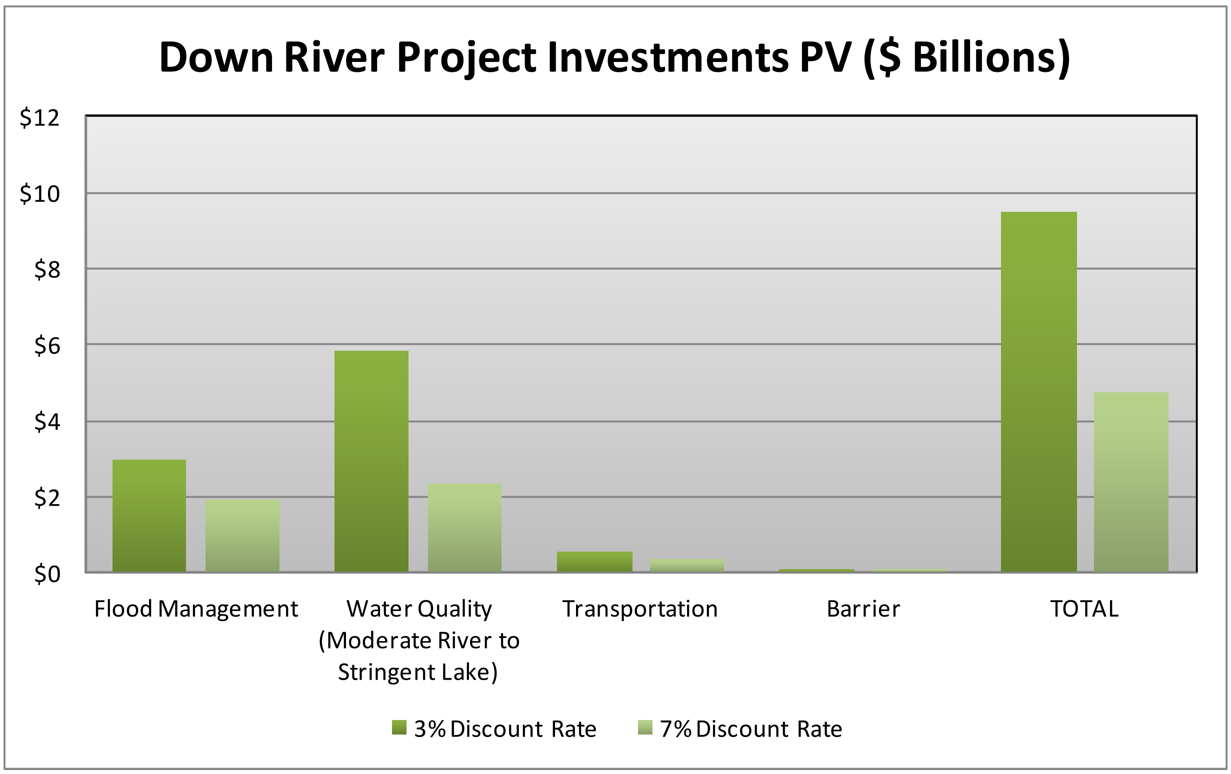


Table V-7. Investments by Category, Down River Alternative (Moderate River to Stringent Lake Scenario), Present Value in Billions of 2010 Dollars

	3%	7%
Flood Management	$2.98	$1.94
Water Quality	$5.85	$2.35
Transportation	$0.56	$0.38
Barrier	$0.11	$0.07
Total	$9.50	$4.74

Figure V-4. Investments by Category, Down River Alternative (Moderate River to Moderate Lake Scenario)

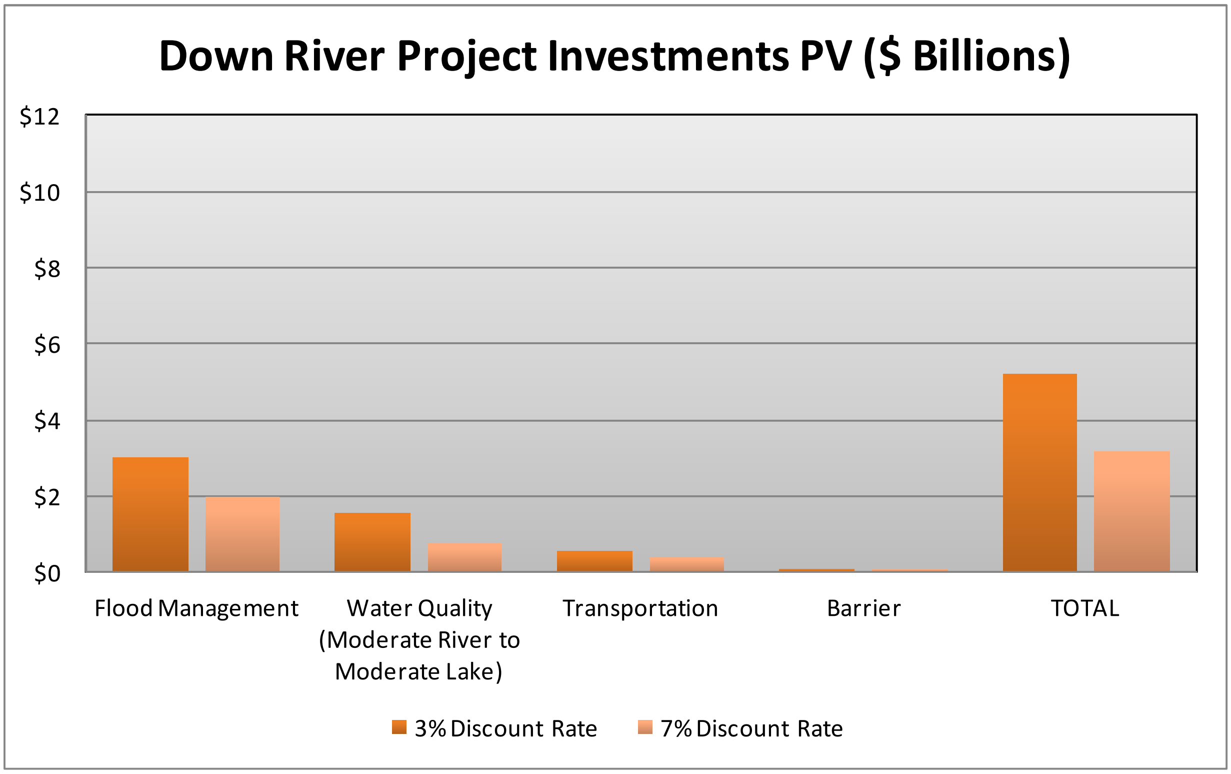


Table V-8. Investments by Category, Down River Alternative (Moderate River to Moderate Lake Scenario), Present Value in Billions of 2010 Dollars

	3%	**7%**
Flood Management	$2.98	$1.94
Water Quality	$1.57	$0.78
Transportation	$0.56	$0.38
Barrier	$0.11	$0.07
Total	$5.22	$3.17

Figure V-5. Investments by Category, Down River Alternative (Stringent River to Stringent Lake Scenario)

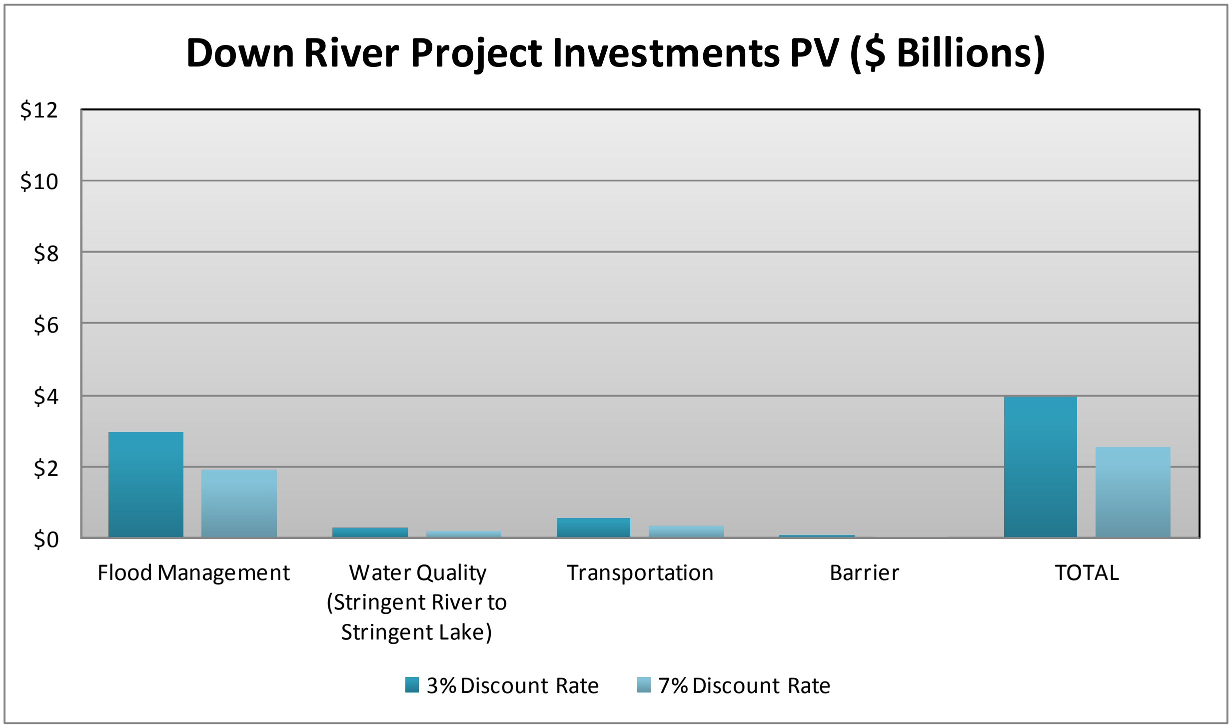
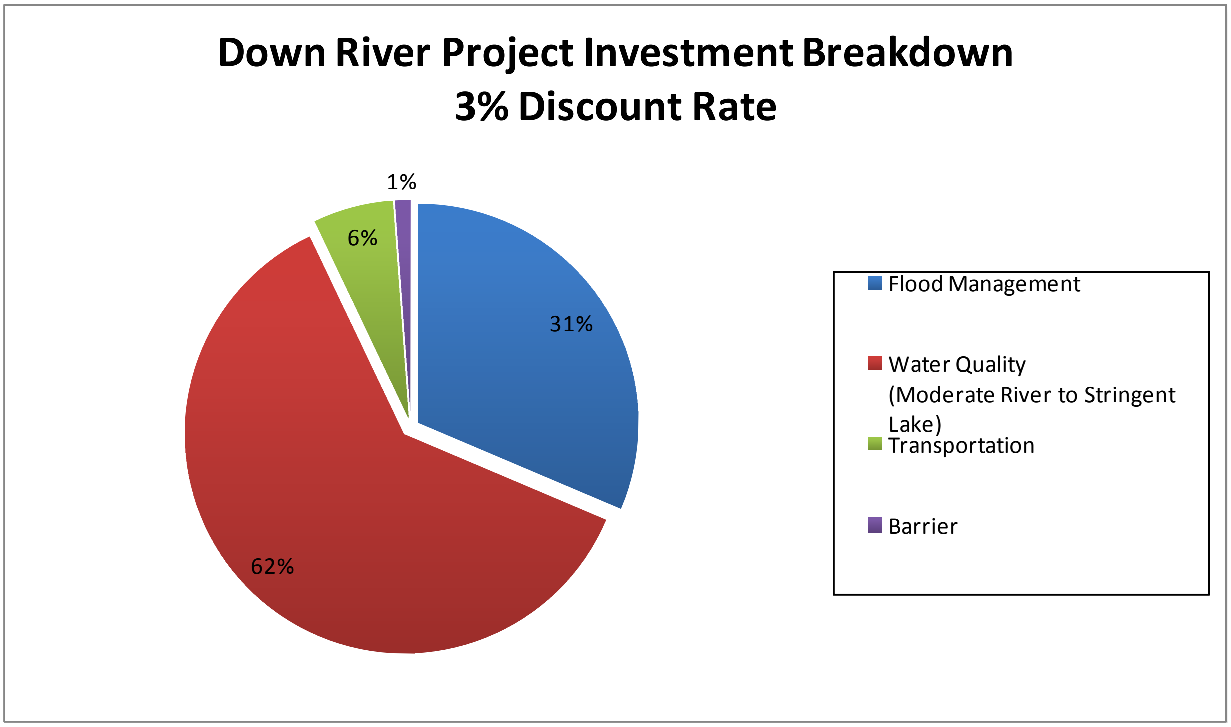


Table V-9. Investments by Category, Down River Alternative (Stringent River to Stringent Lake Scenario), Present Value in Billions of 2010 Dollars

	3%	**7%**
Flood Management	$2.98	$1.94
Water Quality	$0.29	$0.19
Transportation	$0.56	$0.38
Barrier	$0.11	$0.07
Total	$3.94	$2.58

Figure V-6. Investment Breakdown, Down River Alternative, 3% Discount Rate (Moderate River to Stringent Lake Scenario)



3. Mid-System Alternative

The total investments for the Mid-System Alternative over the project lifecycle range from $3.26 billion to $4.27 billion, depending on what is assumed for the future effluent standards. The Mid-System Alternative has significant investments for stormwater management, water quality, and transportation. Flood-management investments are $1.89 billion, and transportation investments are $1.04 billion. Water quality investments range from $0.18 billion to $1.20 billion and primarily relate to WWTP upgrades at the North Side WWTP. Barrier costs are $0.14 billion.

The figures that follow summarize these expenditure profiles. Additional details by specific investments and year are provided in the supporting appendices.

Figure V-7. Investments by Category, Mid-System Alternative (Moderate River to Stringent Lake Scenario)

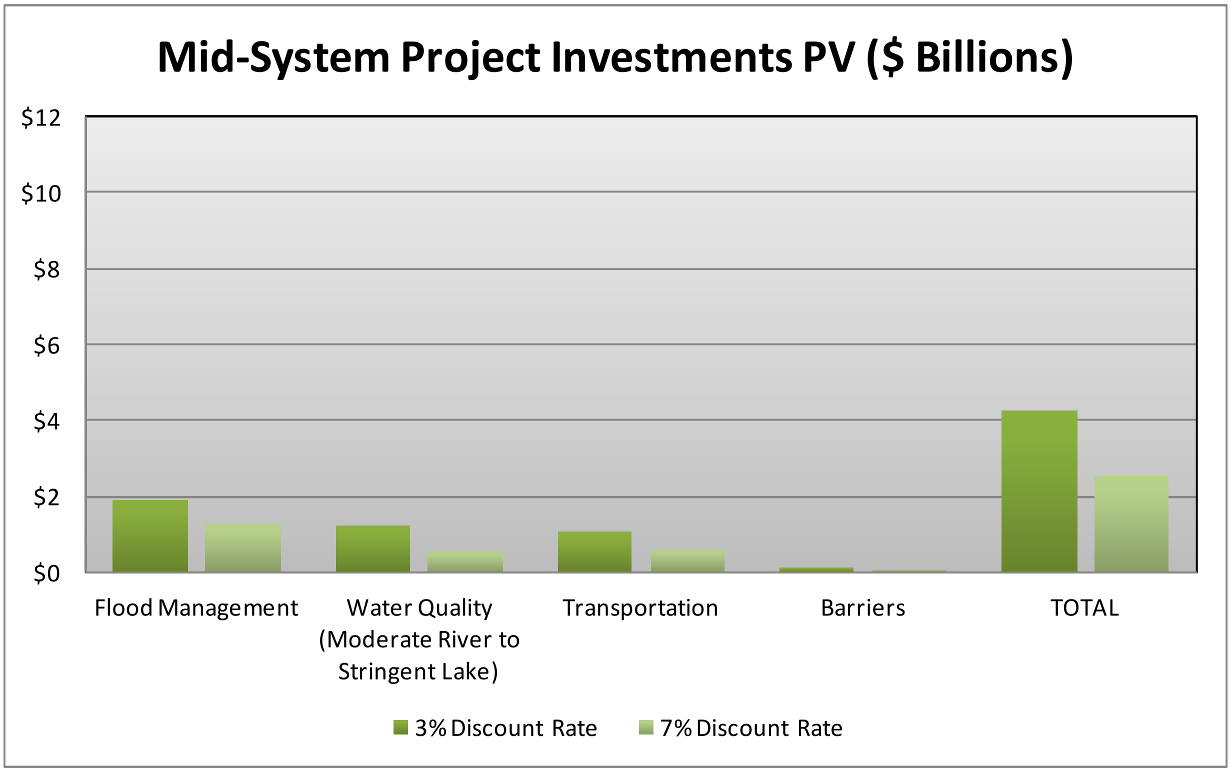


Table V-10. Investments by Category, Mid-System Alternative (Moderate River to Stringent Lake Scenario), Present Value in Billions of 2010 Dollars

	3%	7%
Flood Management	$1.89	$1.29
Water Quality	$1.20	$0.52
Transportation	$1.04	$0.60
Barrier	$0.14	$0.09
Total	$4.27	$2.52

Figure V-8. Investments by Category, Mid-System Alternative (Moderate River to Moderate Lake Scenario)

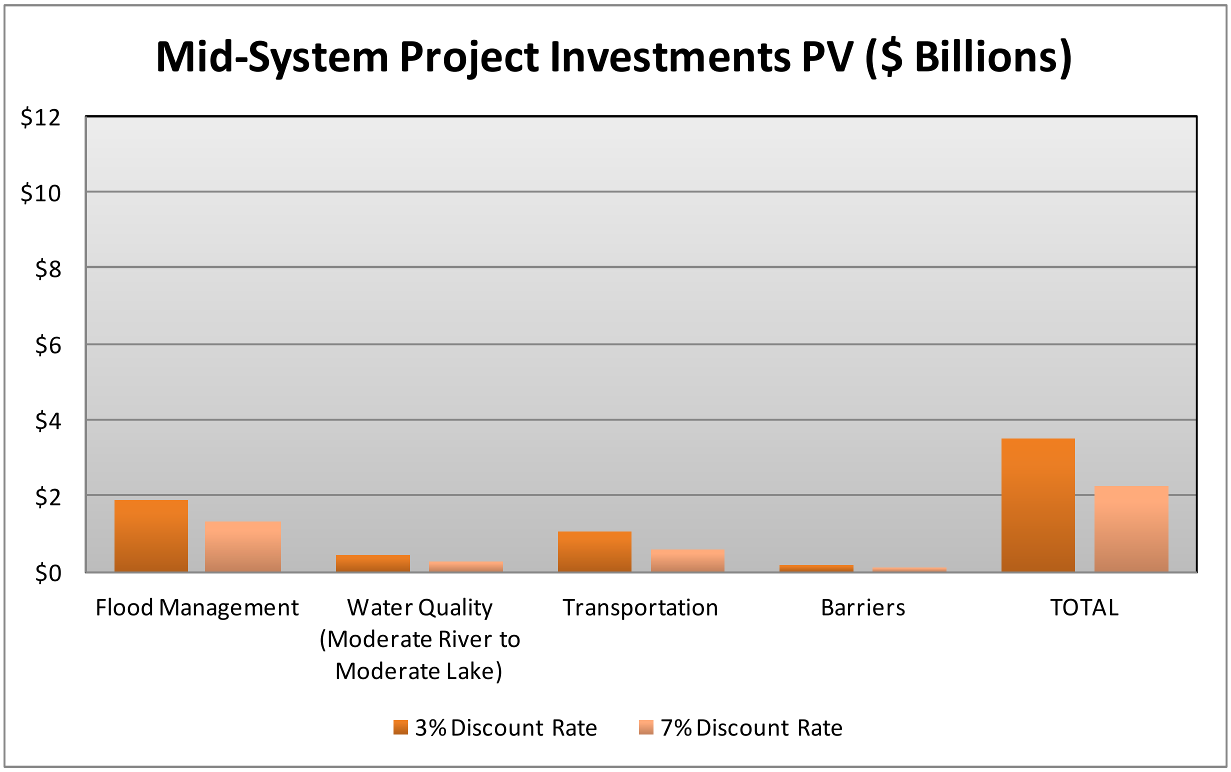


Table V-11. Investments by Category, Mid-System Alternative (Moderate River to Moderate Lake Scenario), Present Value in Billions of 2010 Dollars

	3%	7%
Flood Management	$1.89	$1.29
Water Quality	$0.45	$0.25
Transportation	$1.04	$0.60
Barrier	$0.14	$0.09
Total	$3.52	$2.24

Figure V-9. Investments by Category, Mid-System Alternative (Stringent River to Stringent Lake Scenario)

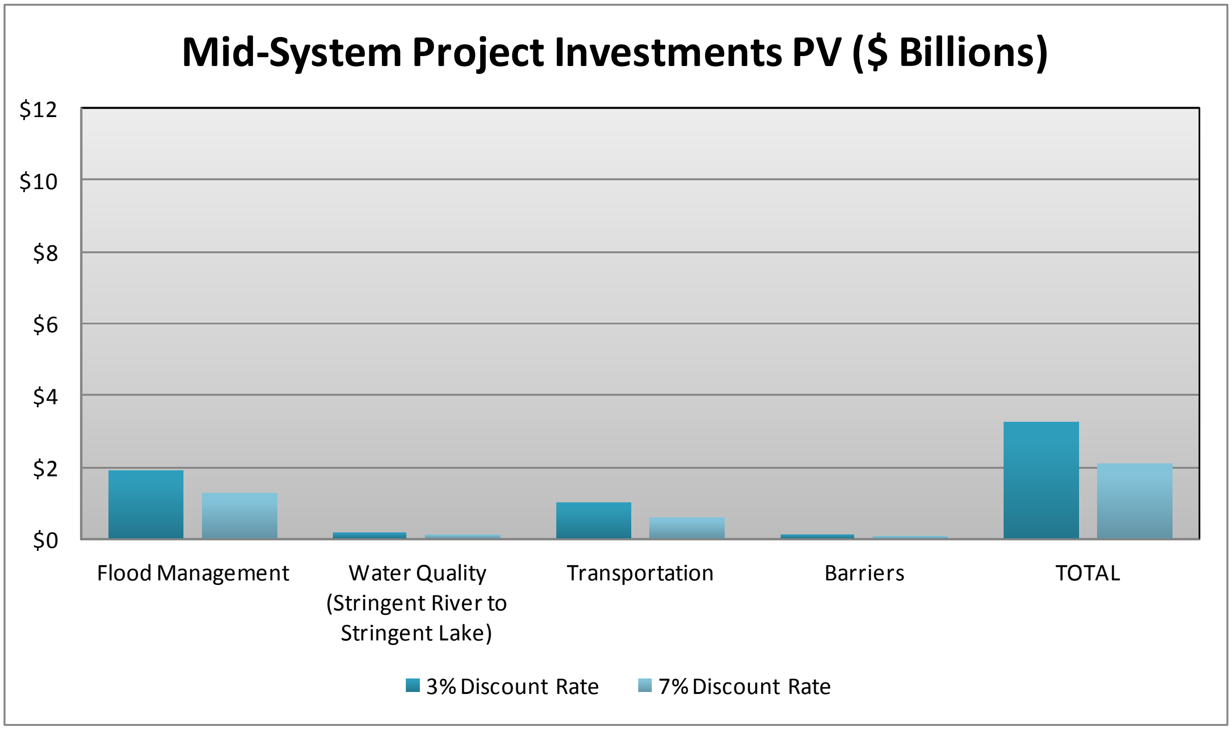
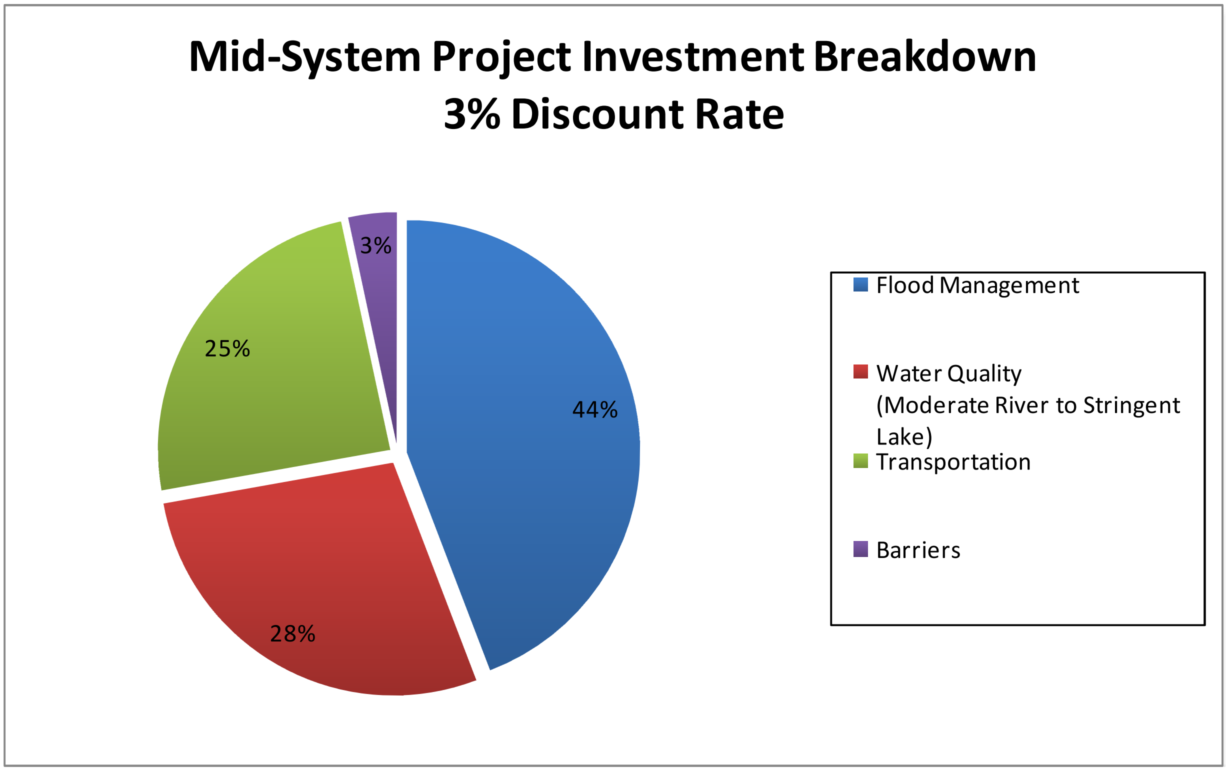


Table V-12. Investments by Category, Mid-System Alternative (Stringent River to Stringent Lake Scenario), Present Value in Billions of 2010 Dollars

	3%	**7%**
Flood Management	$1.89	$1.29
Water Quality	$0.18	$0.12
Transportation	$1.04	$0.60
Barrier	$0.14	$0.09
Total	$3.26	$2.11

Figure V-10. Investment Breakdown, Mid-System Alternative, 3% Discount Rate (Moderate River to Stringent Lake Scenario)



4. Near Lake Alternative

Because there would be no WWTP investments required, the total investments for the Near Lake Alternative are $9.54 billion over the project lifecycle (for all scenarios involving possible changes to future effluent standards). For the Near Lake Alternative, transportation investments are the most significant investments at $5.45 billion, primarily related to the development and operation of 18 shipping terminals that previously were on the Calumet River. There are also significant flood-management investments of $3.82 billion for tunnel and reservoirs, green infrastructure, and other investments. There are minor water quality expenditures of $0.12 billion required for flow augmentation, and barrier costs are $0.14 billion.

Figure V-11. Investments by Category, Near Lake Alternative

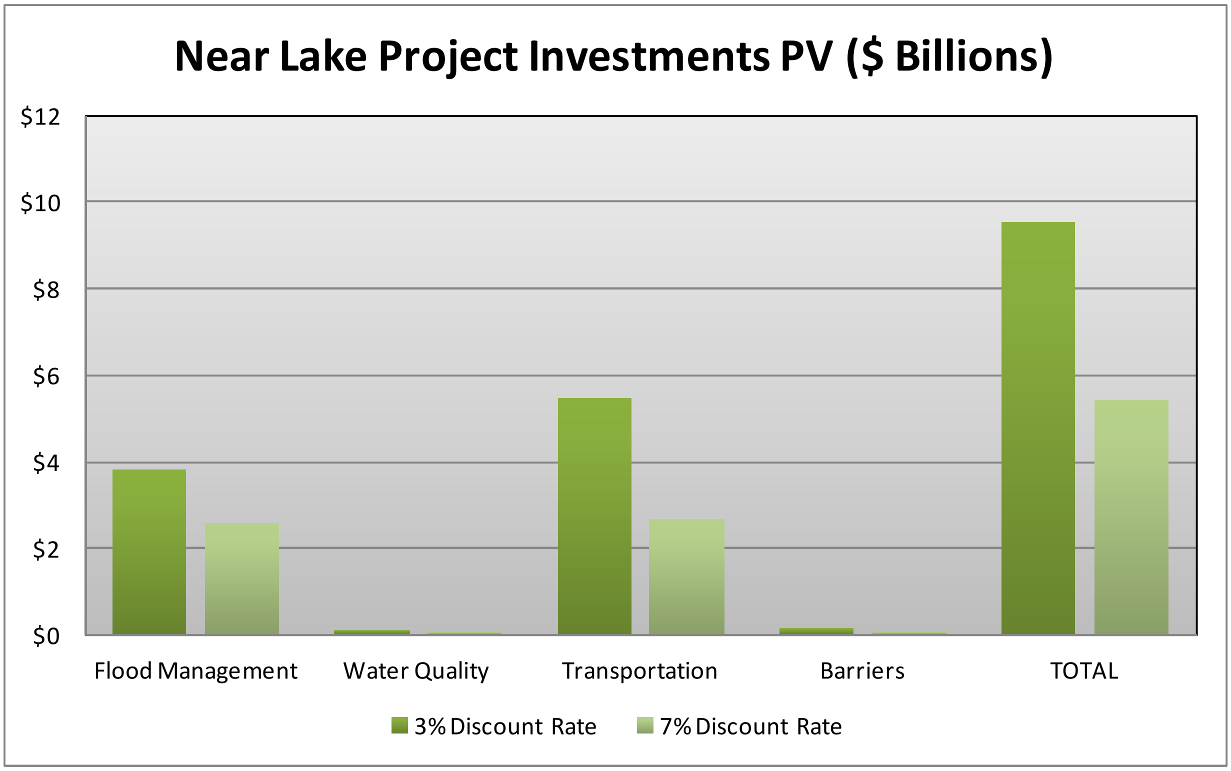
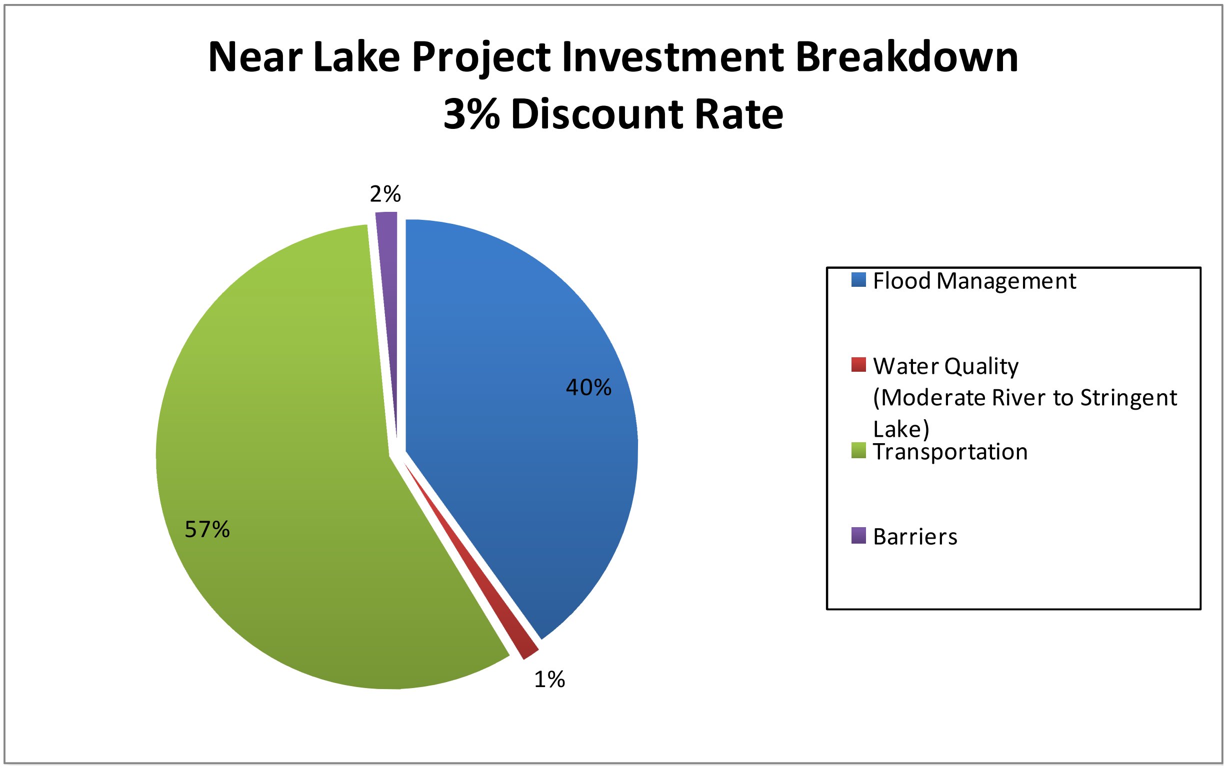


Table V-13. Investments by Category, Near Lake Alternative, Present Value in Billions of 2010 Dollars

	3%	7%
Flood Management	$3.82	$2.58
Water Quality	$0.12	$0.07
Transportation	$5.45	$2.68
Barrier	$0.14	$0.08
Total	$9.54	$5.40

Figure V-12. Investment Breakdown, Near Lake Alternative, 3% Discount Rate



5. Summary of Cost Analysis

The estimated total project investment varies greatly depending on what is assumed for future WWTP effluent standards. Varying these assumptions can affect which separation alternative is determined to be the most cost-effective.

The determination of the most cost-effective alternative appears to be relatively straightforward under the Moderate River to Stringent Lake Scenario. The total project investments for the Mid-System Alternative of $4.27 billion are less than half that of the other alternatives. However, under other scenarios, the difference in estimated investment levels between the Mid-System and Down River Alternatives is less significant. Still, the Mid-System Alternative's estimated investments remain lower.

The Near Lake Alternative, with significant transportation investments to accommodate displaced Calumet River terminals, is expected to cost $9.54 billion regardless of the water quality scenario.

The cost of the physical barriers is a small proportion of the total project investments and represents at most 3% of costs for all of the alternatives.

Figure V-13. Total Project Investments, Present Value (PV) in Billions of Dollars

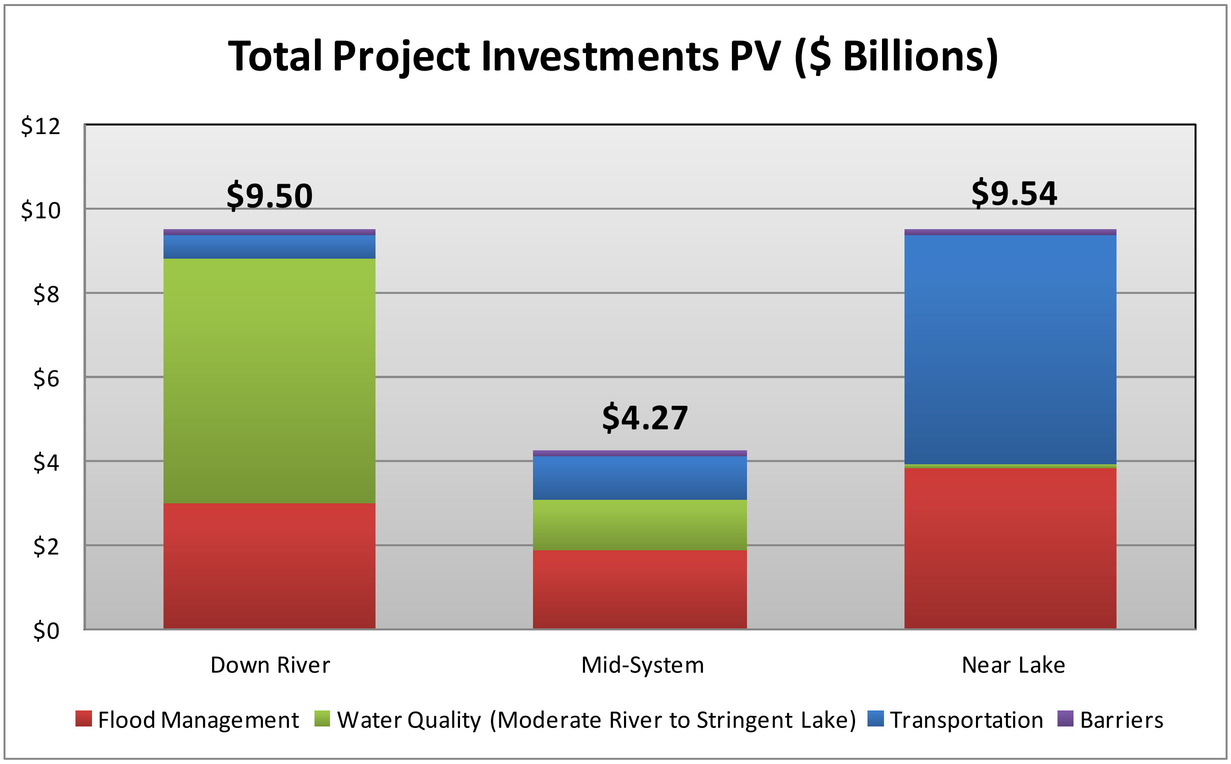
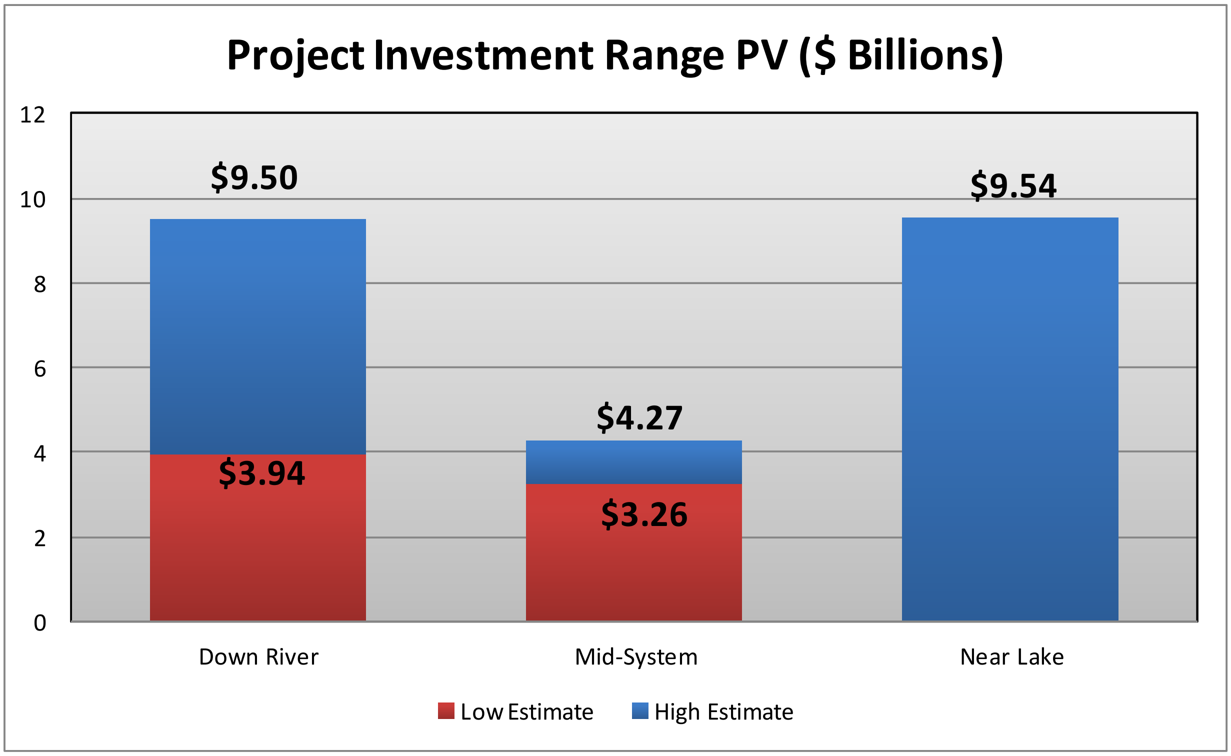


Figure V-14 illustrates the range of project investments costs for the alternatives depending on the WWTP scenario. For the Down River Alternative, the required project investments range from $3.94 billion (for the Stringent River to Stringent Lake Scenario) to $9.50 billion (for the Moderate River to Stringent Lake Scenario). Similarly, Mid-System Alternative investments range from $3.26 billion to $4.27 billion.

Figure V-14. Project Investment Range, Present Value (PV) in Billions of Dollars



6. Precision of Project Cost Estimates

The precision of the estimates should be considered when reviewing the overall project investments by alternative. The following list gives a general guide for the level of precision in these estimates for each area.

- Flood management: -50% to +100%
- Water quality: -50% to +100%
- Transportation: -25% to +50% for Mid-System and Down River
- Transportation: -50% to +100% for Near Lake

That is, for *total* water quality costs, the actual cost is expected to fall within -50% to +100% of the median estimate provided. For example, for a $1-billion cost estimate, the potential range of estimates is $500 million to $2 billion.

H. Other Impacts

This part describes the measurement approach used for each cost impact category identified and provides an overview of the associated methodology, assumptions, and estimates.

1. Presentation of Data

All impacts in this section are presented in millions of dollars. Unless otherwise stated, all cost impacts are presented as a negative value and all benefit impacts as a positive value.

2. Transportation (Cargo Movement)

All of the separation alternatives being considered would affect the movement of cargo through the CAWS. In the baseline condition, cargo moves through the system and locks. With each of the separation alternatives, there are barriers in place that limit the physical movements of barges; it is not feasible to move barges over or around the barriers. However, the transportation investments provide the capability to move cargo over the barriers from barge to barge. In this way, the ability to use the CAWS for cargo movement via barge is maintained. Maintaining cargo movement through the system is important because the USACE estimates that *on average* it costs about $24 per ton, or almost 60% less, to move cargo via barge than via other modes (USACE, 2007c). Note that other studies that have examined the impact of separation on cargo movements have not assumed that cargo could be transferred over the proposed barrier.

While the transportation movements provide the ability to move cargo on the CAWS, the cost of barge transportation would increase due to additional time required for transferring cargo over the barrier to another barge, new logistical relationships with other barge operators for transferring cargo over the barrier, and the requirement for additional barges on each side of the barrier. Based on financial statement data from inland waterway operators and operational data from the USACE, the cost of barge operators and the rate for shippers could increase by about 10% and transit times by about 5%.

Using this cost data and demand elasticity with respect to price and transit time from USACE studies (USACE, 2007c), an order-of-magnitude estimate of the proportion of cargo that would remain on the waterway (although at a higher cost of transport) and the amount of cargo that would switch to other modes can be determined. The rate and transit time demand elasticity are approximately -1 each, so the rate and transit time increases above would result in about a 15% modal shift. The simplifying assumption was made that all cargo would continue to move one way or another and that shippers would not stop movements altogether because of the increased transportation costs.

Given these assumptions, the following impacts would occur:

- For cargo that continues to move through the CAWS on barge, there would be increased transportation/shipping costs.
- For cargo movements that change modes, there would be several different impacts:
  - Increased shipping/transportation costs via the other modes
  - Increased emission levels from other modes (relative to barge)
  - Increased accidents from other modes (relative to barge)
  - Increased roadway congestion due to truck traffic
  - Increased accidents (relative to barge)

In general, the approach to deriving the impact of each of the alternatives is similar, with the only difference being the amount of cargo that is affected by the various barrier locations.

Overall, the change in cargo transportation over the study lifecycle is estimated to have a range of additional economic costs between $1.3 billion and $1.5 billion for the various alternatives over the almost 50-year project lifecycle. The largest impact would occur with the Near Lake Alternative, since more cargo would be affected. The vast majority of this impact is related to additional transportation cost for any cargoes that change modes and the cost associated with the additional handling of cargo over the barrier for cargo that remains on the CAWS. The other impacts or externalities are also quantified, but these account for only about one-quarter of the overall impact.

The overall intent of this analysis is to provide an order-of-magnitude impact of the potential impacts. It is recognized that these overall results are sensitive to the assumptions used in the analysis, and varying these inputs can result in much smaller or much larger impacts. The estimates can be considered an upper bound of the impact for the following reasons: it is based on the assumption of forecasted growth of cargo movements through the CAWS, which is counter to the trend over the last several years; it does not reflect the potential for shutting down coal-fired power plants serviced by the CAWS in the future, which would lower the cost impact of cargo movements for the Down River Alternative; and it assumes that cargo that shifts modes reflects the average barge savings of $24 per ton, while the cargo that switches modes might have lower-than-average rate savings by barge. Sensitivity analysis is provided in an economics appendix to illustrate this further.

Table V-14. Cargo-Related Impacts (Costs), Down River Alternative, Millions of 2010 Dollars

Cost	First-Year Impact (2023)	Present Value of Impact ($ millions)	
		3% Discount Rate	7% Discount Rate
Cargo Handling	-$14	-$274	-$91
Shipping Rate (from Modal Shift)	-$37	-$750	-$248
Emissions	-$2	-$35	-$12
Accidents	-$11	-$223	-$74
O&M	-$3	-$67	-$22
Congestion	-$2	-$29	-$10
Total	**-$68**	**-$1,269**	**-$455**

Table V-15. Cargo-Related Impacts (Costs), Mid-System Alternative, Millions of 2010 Dollars

Cost	First-Year Impact (2023)	Present Value of Impact ($ millions)	
		3% Discount Rate	7% Discount Rate
Cargo Handling	-$20	-$274	-$98
Shipping Rate (from Modal Shift)	-$56	-$750	-$269
Emissions	-$3	-$35	-$13
Accidents	-$17	-$223	-$80
O&M	-$5	-$67	-$24
Congestion	-$2	-$29	-$11
Total	**-$74**	**-$1,379**	**-$495**

Table V-16. Cargo-Related Impacts (Costs), Near Lake Alternative, Millions of 2010 Dollars

Cost	First-Year Impact (2027)	Present Value of Impact ($ millions)	
		3% Discount Rate	7% Discount Rate
Cargo Handling	-$20	-$308	-$99
Shipping Rate (from Modal Shift)	-$56	-$843	-$272
Emissions	-$3	-$39	-$13
Accidents	-$17	-$250	-$81
O&M	-$5	-$75	-$24
Congestion	-$2	-$33	-$11
Total	**-$103**	**-$1,549**	**-$499**

3. TRANSPORTATION (RECREATIONAL BOATING)

All three separation alternatives would affect recreational boating on the CAWS. The three impact categories are:

- Additional time for recreational boats to cross the barriers
- Time savings for recreational boaters after the locks are removed (Down River and Mid-System Alternatives) plus induced recreational boat trips due to open access between the Chicago River and Lake Michigan (Down River and Mid-System Alternatives)
- Marina relocation costs for recreational boaters who move to lakeside marinas to avoid lifts over the barriers

Under the baseline condition with new marina developments lakeside, it is expected that most recreational boats would move to new marinas lakeside in the future, and therefore fewer recreational boats would cross separation barriers in the future. In some instances as well, once the barriers are in place, some recreational boats that would not have moved to lakeside marinas in the baseline condition would instead switch to a lakeside marina to avoid the boat lifts and disinfection process.

For those recreational boats that do cross the barriers, there would be additional time-related cost impacts with the Mid-System and Near Lake Alternatives due to additional delay from the increased time to cross barriers using boat lifts versus the baseline condition of passing through the locks. The GLMRIS non-cargo assessment report estimates the average time to pass through the Chicago and T.J. O'Brien Locks to be 15 minutes (USACE, 2011b). It is estimated that the boat lifts would take an additional 30 minutes beyond the current lockage time and would have the capacity to transfer about 3,000 boats per year.

The time savings benefit for recreational boats monetizes the reduction in recreational travel time due to eliminating the current lockage times at the Chicago and T.J. O'Brien Locks. After separation, these locks would remain permanently open, thereby allowing quicker access to Lake Michigan and the CAWS. There would be no time savings benefit for recreational boats with the Near Lake Alternative, since these barriers would impede access to the lake.

The open access between the Chicago River and Lake Michigan would induce some recreational boats to go into the Chicago River from Lake Michigan (and vice versa), thereby providing additional economic value. If the open access decreases recreational travel time by 30 minutes, and the average recreational boat trip time is 4 hours, this decreases trip time by 12.5%. Reduction in trip time can be taken as a cost saving to recreational boaters. Assuming a unitary price elasticity of demand for recreational activity, there would be an induced 12.5% increase in recreational boating trips on the CAWS. The induced economic benefit has been included in the time savings impact for recreational boats.

While the gates at the Wilmette Pump Station would remain open under the separation alternatives, the gates would not allow recreational boats to move between the river and the lake. Removing this structure would allow enhanced lake access and would potentially provide an opportunity to develop new harbors, marinas, and recreational fishing opportunities.

The cost impact for relocating the marina assumes that recreational boaters who are not willing or able to use the boat lifts would be required to relocate to marinas if they wish to continue to have access to Lake Michigan. It was assumed that the number of boaters affected would be equal to the total annual lockages through the Chicago and T.J. O'Brien Locks minus the total annual capacity of the boat lifts after separation. It was assumed that there would be no CAWS marinas downstream of the Lockport Lock, and, as a result, there would be no marina relocation impact with the Down River Alternative.

In Table V-17, Table V-18, and Table V-19, negative values represent a cost and positive values represent a benefit.

Table V-17. Recreational Boating Impacts, Down River Alternative, Millions of 2010 Dollars

Impact	First-Year Impact (2023)	Present Value of Impact ($ millions)	
		3% Discount Rate	7% Discount Rate
Recreational Boat Barrier Crossing	$0.0	$0.0	$0.0
Recreational Boat Time Savings	$0.8	$11.8	$4.4
Marina Relocation	$0.0	$0.0	$0.0
Total	**$0.7**	**$11.8**	**$4.4**

Table V-18. Recreational Boating Impacts, Mid-System Alternative, Millions of 2010 Dollars

Impact	First-Year Impact (2023)	Present Value of Impact ($ millions)	
		3% Discount Rate	7% Discount Rate
Recreational Boat Barrier Crossing	-$0.2	-$3.2	-$1.2
Recreational Boat Time Savings	$0.5	$7.2	$2.7
Marina Relocation	-$1.7	-$27.1	-$10.2
Total	**-$1.5**	**-$23.9**	**-$11.4**

Table V-19. Recreational Boating Impacts, Near Lake Alternative, Millions of 2010 Dollars

Impact	First-Year Impact (2027)	Present Value of Impact ($ millions)	
		3% Discount Rate	7% Discount Rate
Recreational Boat Barrier Crossing	-$0.2	-$2.7	-$0.9
Recreational Boat Time Savings	$0.0	$0.0	$0.0
Marina Relocation	-$1.7	-$22.6	-$7.5
Total	**-$1.9**	**-$25.3**	**-$8.4**

4. Transportation (Commercial Tours)

The Down River and Mid-System Alternatives would improve access to the lake for commercial tours, since the locks at the lakefront would no longer be necessary and the large amount of traffic could flow freely between the two bodies of water. There are also possible increases in traffic and revenues for the tour boat operators.

The Near Lake Alternative would disrupt service for tour operators that traverse both the river and the lake, and they might need additional vessels to maintain their current level of service. The locations of barriers with the Down River and Mid-System Alternatives are not expected to affect the routes of water taxis or commercial tour operators.

For the Near Lake Alternative, people taking tours of both the lake and the river would have to transfer from a riverside tour boat to a lakeside tour boat, but it is expected that the time involved would be similar to that of a lockage in the baseline condition. There might still be an inconvenience factor for people taking the tours. Water taxis should not be affected, since they do not go onto Lake Michigan.

The impact of the Near Lake Alternative has been monetized (Table V-20) to provide an order-of-magnitude estimate of the potential impact on commercial tour operators. The first-year impact on tour operators is significantly higher than for subsequent years, since it accounts for purchasing new tour vessels and additional mooring infrastructure. The following years until 2059 have only staffing costs for providing the tour service.

Table V-20. Commercial Tour Impacts (Costs), Near Lake Alternative, Millions of 2010 Dollars

Cost	First-Year Impact (2027)	Present Value of Impact ($M)	
		3% Discount Rate	7% Discount Rate
Annual Tour Operator Costs	-$16.3	-$13.2	-$6.2
Total	**-$16.3**	**-$13.2**	**-$6.2**

5. Transportation (Public Safety and Security)

The Mid-System and Near Lake Alternatives would restrict the operation of emergency vessels and would require one additional emergency vessel on each side of the separation barriers for the Chicago police and fire departments. However, with additional vessels on each side, the travel time to reach emergencies would decrease and more coverage would be provided for the area.

Table V-21. Impacts Related to Public Safety and Security (Costs), Mid-System Alternative, Millions of 2010 Dollars

Cost	First-Year Impact (2023)	Present Value of Impact ($M)	
		3% Discount Rate	7% Discount Rate
Annual Public Safety and Response Operation Cost	-$4.4	-$3.0	-$1.8
Total	**-$4.4**	**-$3.0**	**-$1.8**

Table V-22. Impacts Related to Public Safety and Security (Costs), Near Lake Alternative, Millions of 2010 Dollars

Cost	First-Year Impact (2027)	Present Value of Impact ($M)	
		3% Discount Rate	7% Discount Rate
Annual Public Safety and Response Operation Cost	-$4.4	-$2.7	-$1.4
Total	**-$4.4**	**-$2.7**	**-$1.4**

6. Lockport Power Impacts

The power-generation potential at the Lockport Powerhouse would be reduced with each of the alternatives, since there would be reduced flow downstream. The loss of power generation is monetized at $3.75 million per year.

Table V-23. Lockport Power Generation Impacts (Costs), Mid-System and Down River Alternatives, Millions of 2010 Dollars

Impact	First-Year Impact (2027)	Present Value of Impact ($M)	
		3% Discount Rate	7% Discount Rate
Impact on Lockport Power	-$3.8	-$58.3	-$21.8
Total	**-$3.8**	**-$58.3**	**-$21.8**

Table V-24. Lockport Power Generation Impacts (Costs), Near Lake Alternative, Millions of 2010 Dollars

Impact	First-Year Impact (2027)	Present Value of Impact ($M)	
		3% Discount Rate	7% Discount Rate
Impact on Lockport Power	-$3.8	-$48.5	-$16.2
Total	**-$3.8**	**-$48.5**	**-$16.2**

I. Summary of Findings and CBA Outcomes

Given the grouping of quantifiable and unquantifiable benefits, these benefits have been summarized in a *multiple accounts economics framework* (Defined as an evaluation framework where the effects of a project are divided into "accounts" to show different perspectives. This may include qualitative and quantitative criteria. The relative importance of each criteria, and account, may be determined by decision makers.

The following are the *key* highlights of the economic analysis:

- The cost of constructing the physical barriers is a small portion (less than or equal to 3%) of the total project investments of the alternatives.
- In general, it appears that the Mid-System Alternative is the most cost-effective alternative for separation, with median costs of about $3.3 billion to $4.3 billion.
- Future effluent standards and regulations for WWTPs are uncertain and add considerable uncertainty to the actual investment levels required for implementing an alternative.
- The magnitude of potentially the largest expected benefit, reduced AIS risk and damage, is not quantifiable based on the data that is currently available. That being said, a basic case study analysis demonstrates that these benefits can be significant.
- Other potential benefits, such as reduced flood risk and water quality improvements, are also not quantifiable based on the available data and modeling available at this time, but they are important potential benefits.
- There are cost-avoidance benefits for each of the separation alternatives of more than $100 million over the study lifecycle from closing locks and stopping AIS-related research and prevention once the barrier(s) is (are) in place.
- While there would be many different impacts from each alternative, the biggest impact would be on cargo that is currently moved on the CAWS via barge. Separation would result in extra handling of cargo and would likely shift some cargo to other modes of transportation at an economic cost of $1.3 billion to $1.5 billion over the life of the project, or about $35 million to $50 million per year. Even with a small modal shift, the economic impact can be large because barge transportation is much cheaper than other modes.
- The new port facilities could help facilitate economic benefits for the Chicago area in the future. The potential for container-on-barge benefits alone has been valued at $400 million.
- Other impacts, such as recreational boating, commercial tour boats, and public safety, are relevant to the various stakeholders. However, the scale of these impacts is small *relative* to the major impacts identified above. The Near Lake Alternative would likely pose the greatest challenges for these stakeholders.
- In general, the investments required to implement any separation alternative would be localized in the Chicago area, while the benefits of reduced economic damage due to AIS would be broad-based and would span the Great Lakes and Mississippi River basins. This lack of symmetry between costs and benefits suggests a justification for supplementary regional, national, and/or international (Canadian) funding sources.

Table V-25 summarizes the results of the cost and benefit analysis for each of the separation alternatives. Quoted estimates represent lifecycle impacts discounted at a 3% discount rate.

Table V-25. Summary of Cost and Benefit Impacts, Present Value over the Study Lifecycle Using a 3% Discount Rate

Impact	Monetized or Qualified	Cost or Benefit	Down River	Mid-System	Near Lake
Benefits of reducing the risk of AIS transfer between both basins.	Q	B	The reduction of a single AIS transfer can potentially result in significant economic benefits of billions of dollars over the project lifecycle.		
Economic benefits associated with new COB potential associated with the new port developments.	M	B	$0.4 billion	$0.4 billion	$0.4 billion
Benefits of eliminating the requirement for lift bridges to be raised, thereby reducing delay for trains, cars, and pedestrians.	Q	B	No impact	No impact	Reduced delay from lift bridges
For the areas of the CAWS that are opened to Lake Michigan, water quality would be improved (for the Moderate River to Stringent Lake Scenario and the Moderate River to Moderate Lake Scenario).	Q	B	Improved water quality	Improved water quality	No impact
Flood-management investments would provide local flooding benefits and green infrastructure–related benefits.	Q	B	Potential for local flood reduction and green infrastructure benefits.		
Cost avoidance associated with AIS monitoring and lock operations.	M	B	$125 million	$125 million	$105 million
Project costs associated with all investments.	M	C	$3.9 billion – $9.5 billion	$3.3 billion – $4.3 billion	$9.5 billion
Additional costs associated with modal shift from barge to other modes, and additional cargo handling for cargo that stays on the CAWS.	M	C	$1.3 billion	$1.4 billion	$1.5 billion
Net additional costs associated with recreational boating: movements over the barrier, relocation of marinas to lakeside, time savings, and induced recreational boating trips.	M	C	$10 million	$25 million	$25 million
The barriers for the Near Lake Alternative would disrupt commercial tours and cruises that provide tours that go on both the Chicago River and Lake Michigan.	M	C	No impact	No impact	$15 million
The barriers for the Near Lake and Mid-System Alternatives would restrict access for public safety and security vessels, thereby requiring additional vessels.	M	C	No impact	$5 million	$5 million
Reduced power generation at Lockport Powerhouse.	M	C	$60 million	$60 million	$50 million

Note: Estimates in millions are rounded to the nearest $5-million increment.

J. Other Economic Considerations

Other considerations are relevant to the discussion of the separation alternatives outside the context of the impacts discussed in the cost and benefit analysis. These are addressed below.

1. Direct, Indirect, and Induced Economic Impact of Project Investments

While not considered in the CBA, separation would require significant investments in new infrastructure and a stimulus that would have impacts throughout the local, state, and national economies. The project investments would add jobs locally and throughout the United States related to the construction and ongoing operation and maintenance of the infrastructure investments. These jobs would reflect the impact of the direct investments plus the related economic spinoff and would represent full-time and part-time jobs created for a full year.

Over the project lifecycle, the Down River Alternative is estimated to generate about 360,000 person-years of employment, the Mid-System Alternative about 140,000 person-years of employment, and the Near Lake Alternative about 310,000 person-years of employment.[5] A person-year represents 1 year of employment for one person. These estimates, which should be considered order-of-magnitude estimates, are meant to provide a macro-level assessment of potential employment as a result of construction and ongoing operation and maintenance activities.

2. Willingness to Pay for Separation

Two key observations of this economic analysis of separation alternatives in the CAWS are:

- The investments required for any of the separation alternatives and expenditures related to improving flood management, water quality, and transportation are easier to quantify than the benefits, even at an order-of-magnitude level of analysis. Quantifying benefits for major areas such as AIS risk reduction, flood management, and water quality require a level of primary research and detailed modeling that was not possible.
- The investments required for any of the separation alternatives and expenditures related to improving flood management, water quality, and transportation are local to the Chicago area. However, the largest expected benefit, AIS risk reduction, would occur primarily outside the Chicago area.

These two factors make it a challenge to assess the value to society of separation and the related improvements. A useful way of putting the overall investments in perspective or providing a "reasonableness" test is examining the project investments from the perspective of what society would have to be willing to pay to reduce the risk of AIS transfer between the basins. If society is willing to pay an amount, in aggregate, that exceeds the cost of separation,

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5 The Minnesota IMPLAN Group's input-output model was used to estimate the direct, indirect, and induced effects.

then there is a net economic benefit based on how individuals value this reduced risk of AIS transfer.

Based on the estimate of project investments for each alternative, this analysis estimates what society (households) would have to be willing to pay annually to at least cover the investments associated with separation and the related improvements (Table V-26). The annual willingness-to-pay figures for the regions that would receive project benefits, namely the Great Lakes and Mississippi River basins, are estimated. These figures provide an estimate of how much households would have to be willing to pay annually starting in 2012 in order to cover the project investments for each alternative.

Table V-26. Annual Willingness-to-Pay Estimates

	Down River	**Mid-System**	**Near Lake**
Project Investments (*Moderate River to Stringent Lake* WWTP scenarios, which are highest cost)	$9.50 billion	$4.27 billion	$9.54 billion
***Annual* Willingness to Pay Required by:**			
Great Lakes Basin Households Only to 2059	$24.50	$11.01	$24.60
Great Lakes Basin Households to Perpetuity	$18.57	$8.35	$18.65
Great Lakes and Mississippi River Basin Households to 2059	$8.74	$3.93	$8.77
Great Lakes and Mississippi River Basin Households to Perpetuity	$6.62	$2.98	$6.65

The analysis reveals that households in the Great Lakes basin (U.S. and Canada) would have to be willing to pay, on average, about $1 a month or about $11 annually from now through 2059 for the Mid-System Alternative. If the Mississippi River basin is included as well, households would have to be willing to pay about $0.33 a month (or $3.93 annually) in order for the alternative to provide net economic benefits. While it is not known at this time whether households are, in fact, willing to pay these amounts for AIS risk reduction, these estimates provide a reference point for discussion, and future studies can determine whether society is actually willing to pay these amounts.

Similarly, for the Near Lake and Down River Alternatives, households in the Great Lakes and Mississippi River basins would have to be willing to pay, on average, almost $9 per year or about $0.75 per month.

Conducting a study to determine how much society is willing to pay for separation to reduce the risk of AIS transfer between basins is a logical next step for decision-makers to consider.

K. Summary

This part examined the economic impact of three separation alternatives using a cost and benefit analysis approach. The analysis has identified what appears to be the most cost-effective alternative for separation. The Mid-System Alternative appears to be the most cost-effective alternative, with total investments in the range of $3.3 billion to $4.3 billion over a project lifecycle of almost 50 years, depending on the degree to which WWTPs would have to upgrade their treatment. The costs reflect significant investments in flood management, water quality, and transportation throughout the CAWS.

The benefits of separation are also expected to be quite large, but estimating the scale of these benefits is not feasible with the data available for this study. The largest expected potential benefit, reducing the risk of AIS transfer and related economic damage, is demonstrated to be in the range of billions of dollars using reasonable assumptions based on anecdotal evidence. Other benefits such as water quality improvements are also unquantifiable at this point but are expected to be significant over the project lifecycle. Future detailed modeling analysis is required to develop estimates of benefits in the future.

Given the lack of detailed empirical data to assess the full tradeoff between costs and benefits, one way of putting the project investments in context is an assessment of society's willingness to pay for the reduced risk of AIS transfer between basins that these alternatives provide. For the most cost-effective alternative, households would have to be willing to pay less than a dollar per month for the reduced risk of transfer alone in order for the most cost-effective alternative to provide net economic benefits.

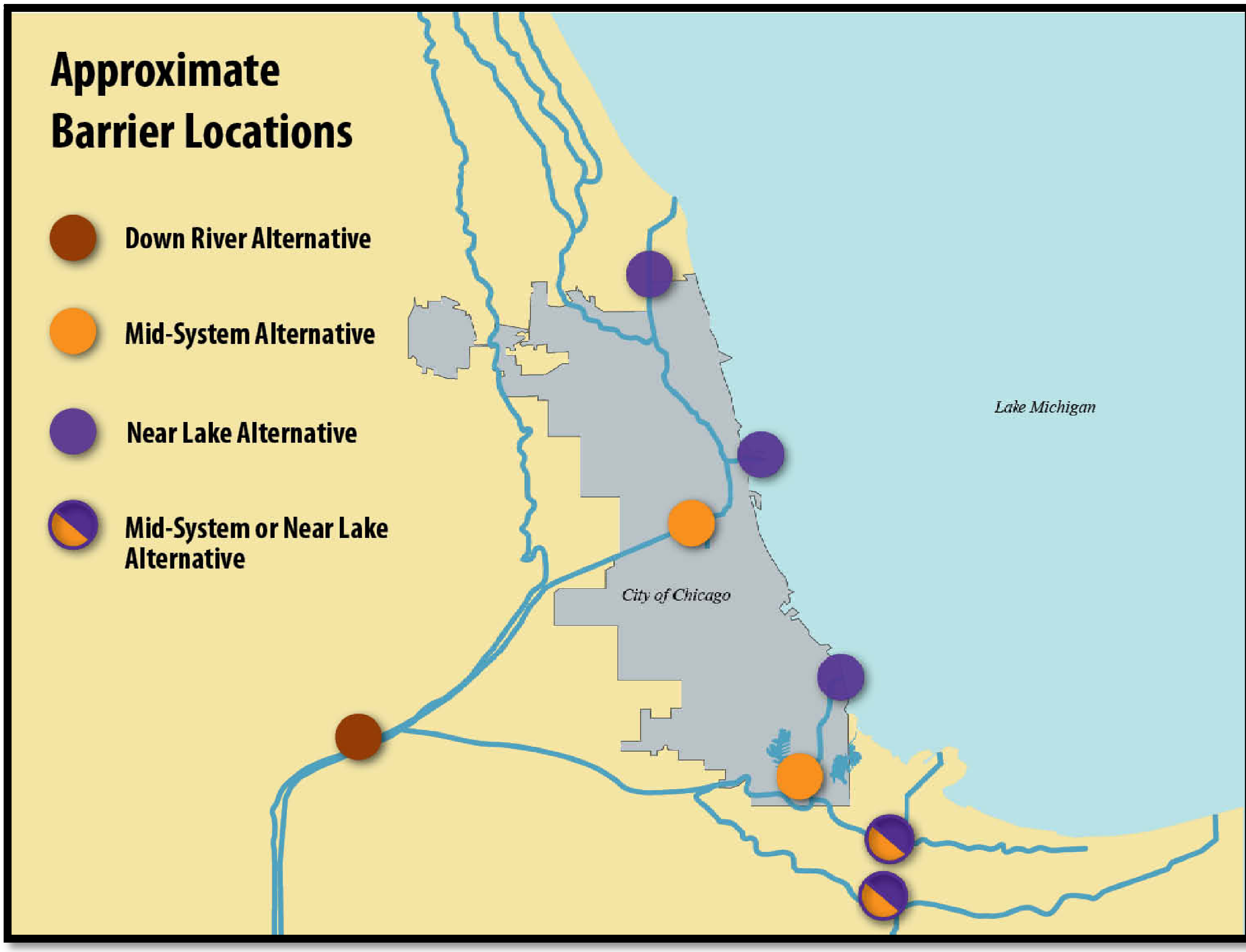
VI. Study Findings

The vision associated with this study foresees a future for the CAWS with less flooding, cleaner water, and an improved transportation system along with a separation that prevents the free-water transfer of AIS between the Great Lakes and Mississippi River basins. Achieving this vision will require significant investments (some of which are already planned or anticipated), but the actual physical separation barriers are one of the least-costly investments of this complex, long-term endeavor.

This study was initiated to investigate the feasibility of separating the Great Lakes and Mississippi River basins in the Chicago area while also maintaining or enhancing other functions of the CAWS. The study presents a detailed evaluation of three potential alternatives for placing of physical barrier(s) that would sever the connection of free-flowing water between the CAWS and Lake Michigan. The alternatives were named the Down River Alternative, the Mid-System Alternative, and the Near Lake Alternative and are shown in Figure VI-1. Together, these alternatives illustrate the wide range of considerations for placing barrier(s) related to flood management, water quality, and transportation. As alternatives were developed, opportunities for improving the CAWS and related systems were identified, and the costs and benefits that would result from these improvements were examined.

All told, the study findings indicate that separation is achievable. Political will and societal support for investing the resources needed are essential to moving forward. Further, it is possible to begin implementation in the near term, following a phased approach that largely corresponds to the schedule for completing the flood management infrastructure planned with MWRDGC's TARP. Among the three alternatives, the Mid-System Alternative emerges as the least-challenging and most cost-effective option, with an estimated investment that is substantially less than that of the other two alternatives. The collective findings for each alternative are presented within this section.

Figure VI-1. Potential Separation Alternatives



A. Down River Alternative

As described in Part IV, Detailed Evaluation of Alternatives, the Down River Alternative would place a single physical barrier between the Lockport Lock and Dam and the confluence of the Cal-Sag Channel and the CSSC. A two-phase approach to implementation would be necessary to continue passing dry-weather base flows and flood water flows downriver while new infrastructure is completed. Before implementing the completed barrier, an initial one-way barrier would block movement of AIS from the riverside to Lake Michigan and would provide flood management while allowing combined sewer overflow discharges to be reduced with the completion of TARP.

This alternative proposes a phased implementation that would allow construction of the barrier to begin in the near term and investments in the CAWS to occur over a longer period. It is anticipated that, upon addressing all permitting and regulatory issues, a one-way AIS barrier could be in place by 2022 (Phase I) and a barrier providing complete separation by 2029

(Phase II). The Phase I barrier (one-way bypass flows), estimated for completion by 2022, would maintain current CAWS operations riverside of the barrier and would not require water quality improvements to be completed before Phase II is initiated. It is anticipated that the Phase II barrier, estimated for completion in 2029, would be constructed after WWTP upgrades, contaminated sediment remediation, flow augmentation, and TARP are completed. These phased timelines are focused on planning, design, and construction. Potential legal, regulatory, and permitting issues must also be addressed and could affect the timeline as discussed.

The estimated cost of the separation barrier is $109 million, and the total investment for this alternative are estimated to range from $3.94 billion to $9.50 billion, depending on the scenario for WWTP upgrades. The Down River Alternative investments by area are estimated to be $2.98 billion for flood management, between $0.29 billion to $5.85 billion for water quality depending on the scenario for WWTP upgrades, and $560 million for transportation. Based on the best available information at the time of this study, the most likely scenario for WWTP upgrades was assumed to be the Moderate River to Stringent Lake Scenario which was estimated to require $5.85 billion in water quality investments. Consequently, the most likely total investment for this alternative was estimated to be about $9.5 billion, which is similar to the estimated investment for the Near Lake Alternative but about twice as much as the estimated investment for the Mid-System Alternative. Of the three alternatives, this alternative requires the largest investment, especially with respect to water quality. A summary of the Down River Alternative is included in Table VI-1.

1. Opportunities

Flood management would be improved in the immediate vicinity of Lake Michigan because the locks and gates to the lake would be open, thereby providing significant flood-management capacity. This alternative has three advantages for transportation: (1) commercial tour boats, water taxis, and most recreational travel would be minimally affected; (2) daily recreational movements, particularly close to the lake, would be improved because the Chicago and T.J. O’Brien Locks would be open full time; and (3) laker access to and from the Calumet River terminals would be maintained.

2. Challenges

With this alternative, all stormwater and WWTP effluents would be directed to Lake Michigan. The CSSC would no longer provide a downstream outlet to the Des Plaines River. Areas that currently rely more on the downstream outlet through the CSSC would require additional flood conveyance and storage investments to prevent additional flooding. CSOs and wastewater effluent would have a direct route to the lake. U.S. EPA water quality standards for Lake Michigan would likely have significant implications for this alternative.

Without flow augmentation, portions of the river would "run dry," with dewatered stretches from the barrier location to Lockport Lock and Dam. Stagnant reaches of the CAWS lakeside of the barrier would also exist from the confluence of the CSSC and the Cal-Sag Channel up to the Stickney and Calumet WWTPs. These dewatered and stagnant reaches would be remediated by augmenting flows with effluent discharge from Stickney WWTP to riverside of the barrier and from Stickney and Calumet WWTPs lakeside of the barrier. Hydropower generation at the Lockport Lock and Dam would be reduced unless flow is augmented. A large coal-fired power plant on the potentially dewatered section of river (near Romeoville) would be affected, since its source of cooling water would no longer be available.

In addition, all barge, commercial, and recreational traffic between the Illinois River and the CAWS would require an intermodal and transfer system to move vessels from one side to the other to maintain the movement of goods between the Illinois River and the CAWS.

3. Improvements and Investments

Proposed solutions to these challenges, including green infrastructure, sewer separation, WWTP upgrades, and intermodal facilities, would result in overall improvements to the CAWS. The infrastructure investments required to address the challenges presented by placing a downriver barrier also include an emergency peak flow bypass, flow augmentation, bulk and liquid cargo transfer, recreational boat lifts with disinfection equipment, and dry dock facilities.

Flood management for the Down River Alternative relies on both the completion of TARP and additional storage and conveyance capacity in the form of floodplain storage and conveyance tunnels. Green infrastructure and sewer separation programs, along with an enhanced stormwater management ordinance, would also provide added storage volume and water quality benefits. Additionally, an emergency bypass would be incorporated into the barrier structure to allow emergency bypass of flows lakeside to riverside during storms exceeding the 100-year flood.

Once Phase II of this alternative is completed, flood management would be improved in the immediate vicinity of Lake Michigan because the locks and gates to the lake would be open, thereby providing significant flood-management capacity. However, areas that currently rely more on the downriver outlet through the CSSC would be maintained through additional flood conveyance, storage, and green infrastructure investments. The net effect of the Down River Alternative improvements would be a flood-management system that is more resilient to larger floods and that can provide flood management for the Chicago area that is as good as or better than what currently exists.

Water quality would be improved within the CAWS due to upgrades in WWTPs, management of CSOs, flow augmentation, and green infrastructure. Water quality improvements for effluent discharges are likely to be required at all three major WWTPs once the treated effluents are directed to Lake Michigan, since lake standards are currently more stringent than river standards. Flow augmentation would be required in certain locations to prevent stagnation and associated water quality problems. A portion of the Stickney WWTP's discharge would be routed to the river side of the barrier and discharged to the CSSC to maintain flows for water quality and transportation purposes. The Down River Alternative would also significantly reduce exports of Lake Michigan water to the Mississippi River basin. The overall improvements in water quality would be such that the water quality vision and recreational use of the CAWS would be maintained or improved.

While the Down River Alternative would block all barge movements between the Illinois River and the CAWS, the opportunity exists for improved intermodal connections between water, truck, and rail. The ability to capture a share of the emerging COB market is another prospect. Thus, transportation investments including intermodal and bulk and liquid cargo transfer facilities would be constructed coincident with and/or prior to construction of the Phase I barrier in 2022.

B. Mid-System Alternative

The Mid-System Alternative requires four barriers in the CAWS to separate the two basins. One barrier on the South Branch of the Chicago River upstream of Bubbly Creek would separate the South Branch from the CSSC. The Calumet River System would be separated by three barriers: (1) on the Little Calumet River near the USACE flood-control project at Hart Ditch, (2) on the Grand Calumet River near the natural divide, and (3) on the Calumet River immediately south of the connection with Lake Calumet (north of the T.J. O'Brien Lock and Dam and the existing railway and vehicle traffic bridge).

Similar to the Down River Alternative, a two-phased implementation approach is proposed to allow the South Branch barrier to continue passing dry-weather base flows and flood water flows downriver while new infrastructure is completed. Before the completed barrier is implemented, this initial one-way barrier would block AIS movement from riverside to lakeside and maintain flood management while allowing overflow discharges to be reduced through completion of TARP.

It is anticipated that, upon addressing all permitting and regulatory issues, a one-way AIS barrier could be in place by 2022 on the Chicago River System, and a barrier providing complete separation could be in place by 2022 and 2029 on the Calumet River and Chicago River Systems, respectively. Phase I, to be completed by 2022, would include construction of a one-way barrier and transportation infrastructure on the South Branch as well as three Calumet System barriers (Calumet River, Little Calumet River, and Grand Calumet River). Phase II would include additional conveyance and WWTP upgrades and would be completed by 2029. These phased timelines are focused on planning, design, and construction. Potential legal, regulatory, and permitting issues must also be addressed and could affect the timeline as discussed.

The estimated cost for the separation barriers is $144 million, and the total investments for this alternative are estimated to range from $3.26 billion to $4.27 billion, depending on the scenario for WWTP upgrades. The Mid-System Alternative investments by area are estimated to be $1.89 billion for flood management, between $0.18 billion and $1.20 billion for water quality depending on the scenario assumed for WWTP upgrades, and $1.04 billion for transportation. Based on the best available information at the time of this study, the most likely scenario for WWTP upgrades was assumed to be the Moderate River to Stringent Lake Scenario which was estimated to require $1.20 billion in water quality investments for the Mid-System Alternative. Consequently, the most likely total investment for this alternative was estimated to be about $4.27 billion, making it the most cost-effective of the alternatives. A summary of the Mid-System Alternative is included in Table VI-1.

1. Opportunities

Flood management would be improved because increases in outlet capacity with the opening of Wilmette Pump Station and the Chicago Controlling Works would reduce flooding lakeside of the barrier. Waterborne traffic would be least affected by this alternative because commercial water taxis and tour boats could maintain daily activities, and the movement of large lake vessels into the Calumet River and terminal sites would not be impeded and would be enhanced with the completion of a new intermodal terminal at the barrier.

2. Challenges

This alternative presents some challenges for flood management, water quality, and transportation. The portions of the CAWS lakeside of the barriers would be controlled by the lake elevation. Thus, if the lake elevation rose, it could exacerbate basement flooding unless additional investments for local flood protection are made. Similarly, the lack of water flow would cause stagnation on the riverside of the South Branch and Lake Calumet barriers without additional investments.

The stability of the existing sediment in the CAWS is unknown, and it is possible that removing and/or encapsulating the contaminated portions of the sediments on the lakeside of the barrier would be necessary. Access to winter dry dock and maintenance facilities would be impeded for water taxis, tour boats, and recreational boats. Barge traffic at the South Branch and Calumet River barriers would also be impeded. Recreational boat traffic would be impeded at the Calumet River barrier and minimally affected at the South Branch barrier.

3. Improvements and Investments

Investments such as green infrastructure, sewer separation, WWTP upgrades, and intermodal facilities would provide improvements and opportunities to the CAWS. Other infrastructure investments would be required to address the challenges presented by placing Mid-System barriers, including an emergency bypass, flow augmentation, bulk cargo transfer, recreational boat lifts with disinfection equipment, and dry dock facilities.

Flood management in the Chicago River System would be improved by maintaining open access to the lake through the Wilmette Pump Station and the open lock at the Chicago Controlling Works. An additional tunnel to convey stormwater from the Little Calumet and Grand Calumet Rivers would also maintain or improve flood protection for these systems. The net effect of the improvements described above would be a flood-management system that is more resilient to larger floods and can provide flood management for the Chicago area that is as good as or better than what currently exists.

The overall improvements in water quality with the Mid-System Alternative would be such that the water quality vision and recreational use of the CAWS would be maintained or improved. The proposed improvements would return portions of the water diverted from Lake Michigan to the lake, and water quality and flood management would be improved by using green infrastructure, restoring the floodplain, and preserving the capacity of TARP for larger floods. In addition, the improvements in wastewater treatment at the North Side WWTP, combined sewer overflow management, and flow augmentation would protect and improve water quality throughout the CAWS, thereby leading to enhanced water usage opportunities such as recreation and potentially increased property values.

Transportation investments including intermodal and bulk and liquid cargo transfer facilities, new lakeside dry dock facilities, and recreational boat lifts with disinfection equipment would be completed at the same time as and/or before construction of the Phase I barrier in 2022, since the Mid-System Alternative would block all barge movements between the CAWS and Lake Michigan. However, the opportunity exists for improved intermodal connections between water, truck, and rail as well. The ability to capture a share of the emerging COB market, due to expansion of the Panama Canal, is another prospect. By enhancing the existing transportation infrastructure with a modern intermodal transfer facility, this alternative furthers the goals of the State of Illinois, the City of Chicago, and local governments in the south Chicago area for open space reclamation and industrial revitalization. Recreational and commercial direct access to Lake Michigan at the Chicago River would also be improved with this alternative, since the Chicago Lock would remain open.

C. Near Lake Alternative

The Near Lake Alternative consists of placing five barriers in the following locations: (1) north of the North Side WWTP on the North Shore Channel, (2) at the Chicago Controlling Works on the Chicago River, (3) at the mouth of the Calumet River, (4) near the natural divide of the Grand Calumet River, and (5) on the Little Calumet River near the USACE flood-control project at Hart Ditch. Unlike the Down River and Mid-System Alternatives, the Near Lake Alternative barriers for both the Chicago River System and the Calumet River System would be constructed in one phase, with completion of the Chicago River System barriers anticipated by 2029 (driven by TARP completion and flood-management elements) and completion of the Calumet System barriers anticipated by 2026 (driven by port and intermodal facility completion) upon addressing all permitting and regulatory issues.

These timelines are focused on planning, design, and construction. Potential legal, regulatory, and permitting issues must also be addressed and could affect the timeline as discussed.

The estimated cost of the separation barriers for this alternative is $143 million, and the total investments are estimated to be $9.54 billion, which is similar to the upper range of investments for the Down River Alternative but about twice as much as the investments for the Mid-System Alternative. The Near Lake Alternative investments by area are estimated to be $3.82 billion for flood management, $120 million for water quality, and $5.45 billion for transportation. Because none of the three major WWTPs would require treatment upgrades beyond those identified in Part II, Baseline Conditions, a range in the estimates for water quality investments was not required. While this alternative has benefits for water quality, it poses significant challenges for flood management and transportation. A summary of the Near Lake Alternative is provided in Table VI-1.

1. Opportunities

The major advantage of this alternative is improved water quality for Lake Michigan since CAWS water, including WWTP effluent discharges and CSOs, would flow only to the river.

2. Challenges

This alternative would cause significant challenges for flood management and transportation. The flooding impacts on the North and South Branches of the Chicago River and the Calumet River System would be significant, even with full implementation of TARP, since backflows to Lake Michigan would be effectively eliminated. Commercial tour and recreational boat traffic would be disrupted at both the Chicago Lock and Calumet River barrier. Large laker vessels would not be able to access the Calumet River terminals. Direct barge traffic to and from northwest Indiana would be severed at the Calumet River barrier.

3. Improvements and Investments

Infrastructure investments for flood management and transportation would be required to address the challenges presented by placing the Near Lake barriers, including an emergency bypass for flood water to Lake Michigan, low-flow augmentation, bulk and liquid cargo transfer, recreational boat lifts with disinfection equipment, and dry dock facilities. However, investments such as green infrastructure, sewer separation, and modern shipping and intermodal facilities would provide improvements and opportunities to the CAWS.

Flood-management investments would include additional conveyance tunnels and reservoir storage to relieve high water levels in the Chicago River and Calumet River Systems. A tunnel from the Grand Calumet and Little Calumet Rivers to the lake would also be necessary to address flooding. The net effect of the Near Lake Alternative improvements would be a flood-management system that is more resilient to larger floods and can provide flood management for the Chicago area that is as good as or better than what currently exists.

The overall improvements in water quality with the Near Lake Alternative would be such that the water quality vision and recreational use of the CAWS would be maintained or improved. Water quality would be improved through flood management by using green infrastructure, restoring the floodplain, and preserving the capacity of TARP for larger floods. In addition, while less significant than the Down River and Mid-System Alternatives, the improvements in CSO management, flow augmentation, and wastewater treatment (baseline condition) would protect and improve water quality throughout the CAWS, thereby leading to enhanced water usage opportunities such as recreation.

One of the major improvements included in this alternative is developing a modernized port to be located in Lake Michigan at the mouth of the Calumet River. The new port would provide an opportunity for improved intermodal connections between water, truck, and rail. It would also provide the ability to capture a share of the emerging COB market. This new port would feature consolidated terminals, a container terminal, and integrated intermodal facilities, which would improve handling capabilities and efficiency. New recreational launching areas with disinfection equipment would also be developed. By enhancing the existing transportation infrastructure with a modern intermodal port facility, this alternative also furthers the goals of the State of Illinois, the City of Chicago, and local governments in the south Chicago area for open space reclamation and industrial revitalization.

D. Economics Summary

Part V, Economic Analysis, presented a detailed analysis of technical information on the economic costs and benefits associated with physically separating the Great Lakes and Mississippi River basins in the CAWS. The investments varied with each alternative due to the wide-ranging costs of infrastructure proposed as opportunities to improve the CAWS or elements to address challenges that result from placing barriers. The Down River Alternative was the most expensive ($3.94 billion to $9.54 billion) due largely to WWTP upgrades, followed by the Near Lake Alternative ($9.5 billion), which includes major investments for constructing a new in-lake harbor and port. The Mid-System Alternative was the most cost-effective alternative ($3.26 billion to $4.27 billion) in terms of infrastructure investments.

The magnitude of potential benefits is not quantified due to the limitations of this study. However, while the benefit of reduced AIS risk and damage is not easily quantifiable based on the data that is currently available, basic scenario or “case study” analysis demonstrates that these benefits, even for prevention of a single AIS transfer, could be as much as $5 billion over 30 years. These estimates are derived from historical data on the impact of AIS such as sea lamprey, zebra mussels, and transportation-borne AIS in the Great Lakes. Furthermore, the level of analysis and modeling associated with this study did not provide specific measures to allow the team to quantify the benefits of improved water quality conditions and a more resilient flood management system.

While there are many different challenges and investments for each alternative, perhaps the most significant is related to cargo currently moved on the CAWS via barge. Separation would require extra handling of cargo and would likely shift some cargo to other modes, thereby incurring economic costs of up to $1.5 billion over the nearly 50-year project lifecycle. Even with a small modal shift, the economic impact can be large due to the substantial cost advantage that barge transportation has compared to other modes. While there are clearly other advantages and disadvantages relevant to recreational boating, commercial tour boats, public safety, and other stakeholder uses, the scale of these impacts is small relative to the major impacts identified in this study.

The analysis concludes that, in general, the investments needed to implement any separation alternative would be made in the Chicago area, but the benefits of reduced economic damage due to AIS are broad-based and would span the Great Lakes and Mississippi River basins. This lack of symmetry between the investments needed and the benefits achieved points to the potential need for a broader reach of funding beyond local sources.

Based on the estimated project investments for each alternative, projections were made for what society (households) would have to be willing to pay annually to at least cover the investments associated with separation. The analysis reveals that households in the Great Lakes basin in the United States and Canada would have to be willing to pay, on average, about $1 a month or $11.14 annually from now through 2059 for the Mid-System Alternative (assuming the most likely WWTP upgrade scenario of Moderate River to Stringent Lake). This includes a 30-year operation period after construction. If the Mississippi River basin is included as well, households would have to be willing to pay about $0.33 a month (or $3.97 annually). While it is not known at this time whether households are willing to pay these amounts for AIS risk reduction, these estimates provide a reference point for future discussion, for public education and outreach, and for additional studies to quantify the impacts of AIS if they become established.

E. Study Summary

A vision of the CAWS with improved flood management, water quality, and transportation systems that prevents the free-water transfer of AIS between the Great Lakes and Mississippi River basins is possible. Investments to improve the function of the CAWS will require a concerted and cooperative effort between stakeholders in the Chicago area and in the Great Lakes region to address political, financial, and legal authorities to implement the vision and create a CAWS that supports the needs of residents of Chicago and the region well into the 21st century.

By identifying opportunities and challenges, proposing improvements and investments, and estimating the resulting costs and benefits, this study has focused on what would be required to achieve separation. Support for continued stakeholder engagement exists, as this study has provided a valuable forum for collaboration and cooperation. Priorities for future work could include (1) stakeholder engagement and public outreach and (2) technical support and evaluation of land use, freight logistics, financing elements, and additional economic analysis of benefits, among other issues.

Building on the successful and productive stakeholder engagement of the current study can advance the adoption and implementation of an effective separation alternative by those institutions responsible for the region’s infrastructure. Public outreach and education would inform the public and gauge the political and social will to re-engineer the CAWS for improved flood management, water quality, and transportation functions.

Land-use planning would be required to assess the viability of implementing alternative plans and to illustrate place-specific changes and effects on stakeholders. Site-specific land-use plans can stimulate creative thinking and inspire leadership and project support, and an analysis of how site-specific land-use patterns will shift from existing uses would clarify the full economic impacts such that a suite of financial tools and funding sources could be properly identified. A deeper assessment of economic benefits and costs associated with proposed changes, and identification of the recipients and bearers of those benefits and costs, could help inform potential funding vehicles and create market-based solutions. Potential financial investigations could include the community's "willingness to pay," the availability of innovative financing options (such as public-private partnerships, TIF, etc.), and the anticipated cash flow of individual project elements.

This study has shown that separation can be accomplished and that it can be done in a way that maintains or improves other uses of the CAWS. It can be done using a phased approach, such that it fits in with existing and anticipated infrastructure improvements. A robust land-use planning process, continued stakeholder and agency engagement, and financing evaluations can advance the current work toward realizing the vision of separating the Mississippi River and Great Lakes basins while maintaining or improving flood management, water quality, and transportation in the CAWS over the 21st century.

Table VI-1. Summary of Findings for the Down River, Mid-System, and Near Lake Alternatives

Down River Alternative			Mid-System Alternative			Near Lake Alternative		
Flood Management	**Water Quality**	**Transportation**	**Flood Management**	**Water Quality**	**Transportation**	**Flood Management**	**Water Quality**	**Transportation**
Opportunities			**Opportunities**			**Opportunities**		
• Continual connection between the CAWS and Lake Michigan	• Provides impetus for improving CAWS water quality	• Maintains movements *within* the CAWS • Maintains laker access to CAWS terminals • No disruption to commercial tour boats, water taxis, and most recreational travel • Improved river-to-lake travel for commercial tour and recreational vessels	• Continual connection between the CAWS and Lake Michigan	• Provides impetus for improving CAWS water quality	• Minimal interruption to commercial tours and water taxis • Minimal interruption to recreational vessels using Chicago Lock • Maintains laker access to Lake Calumet and Calumet River terminals	• Reduces backflows to Lake Michigan	• CSOs and WWTP discharges remain riverside • Eliminates diversions from Lake Michigan	• Maintains barge, commercial tour, water taxi, and recreational vessel movement *within* the CAWS
Challenges			**Challenges**			**Challenges**		
• Lose downstream conveyance outlet for flood water	• More-stringent WWTP discharge standards • Flow stagnation along CSSC and Cal-Sag Channel • Reduction in flows downstream of barrier (water supply, habitat, and hydropower impacts) • Flood water (and potential pollutants) directed to Lake Michigan	• Prevents movement of barges into and out of CSSC • Interrupts all traffic between the CAWS and the Illinois River	• Lose downstream conveyance outlet for flood water at Bubbly Creek	• More-stringent WWTP discharge standards • Flow stagnation near South Branch and Lake Calumet barriers • Flood water (and potential pollutants) directed to Lake Michigan	• Prevents movement of barges and recreational vessels directly to Lake Michigan	• Lose multiple conveyance outlets to Lake Michigan for flood water	• Flow stagnation in NSC and Calumet River	• Interrupts all barge and laker traffic to and from the lake • Interrupts all commercial tour and recreational vessels to and from the lake

Down River Alternative			Mid-System Alternative			Near Lake Alternative		
Flood Management	**Water Quality**	**Transportation**	**Flood Management**	**Water Quality**	**Transportation**	**Flood Management**	**Water Quality**	**Transportation**
Improvements			**Improvements**			**Improvements**		
• Green infrastructure and sewer separations • Additional conveyance (lake outlets and tunnels) and storage (floodplain)	• WWTP upgrades (North Side, Calumet, and Stickney)	• Enhanced intermodal facilities and connections • New COB market potential	• Green infrastructure and sewer separations • Additional conveyance (lake outlets) and storage (floodplain)	• WWTP upgrades (North Side)	• Enhanced intermodal facilities and connections • New COB market potential • Furthers community goals of open space and industrial revitalization	• Green infrastructure and sewer separations • Additional conveyance (tunnels) and storage (floodplain and reservoir)	• Not applicable	• Modern, full-service port facility with consolidated terminals, intermodal facilities, and recreational vessel facilities • New COB market potential • Furthers community goals of open space and industrial revitalization
Investments			**Investments**			**Investments**		
• Emergency barrier bypass	• Flow augmentation	• Bulk and liquid cargo transfer • Recreational boat lift with disinfection • New dry dock	• Emergency barrier bypass	• Flow augmentation	• Bulk and liquid cargo transfer • Recreational boat lift with disinfection • Dry dock facilities	• Emergency barrier bypass	• Flow augmentation	• Consolidated terminals • New container terminal • Recreational boat transfer with disinfection • Dry dock facilities
Timeline			**Timeline**			**Timeline**		
Chicago and Calumet River Systems: • Overall timeline driven by TARP completion • Phase I – One-way barrier with bypass by 2022 • Phase II – Completed barrier by 2029			**Chicago River System:** • Overall timeline driven by TARP completion • Phase I – One-way barrier with bypass by 2022 • Phase II – Completed barrier by 2029 **Calumet River System:** • Overall timeline driven by port and intermodal facility construction • Phase I – Completed barrier by 2022 (only one phase)			**Chicago River System:** • Overall timeline driven by TARP completion and stormwater elements • Phase I – Completed barriers by 2029 (only one phase) **Calumet River System:** • Overall timeline driven by port and intermodal facility construction • Phase I – Completed barrier by 2026 (only one phase)		
Barrier Costs [a]			**Barrier Costs [a]**			**Barrier Costs [a]**		
$109 million			$144 million			$143 million		
Investments by Area [a]			**Investments by Area [a]**			**Investments by Area [a]**		
Flood Management	**Water Quality [b]**	**Transportation**	**Flood Management**	**Water Quality [b]**	**Transportation**	**Flood Management**	**Water Quality**	**Transportation**
$2.98 billion	$0.29–$5.85 billion	$0.56 billion	$1.89 billion	$0.18–$1.20 billion	$1.04 billion	$3.82 billion	$120 million	$5.45 billion
TOTAL INVESTMENT [a,b]			**TOTAL INVESTMENT [a,b]**			**TOTAL INVESTMENT [a]**		
$3.94–$9.50 billion			**$3.26–$4.27 billion**			**$9.54 billion**		

Notes:
[a] All costs represent median present values with a 3% discount rate.
[b] Based on the range in assumed WWTP upgrades between "Stringent River to Stringent Lake" and "Moderate River to Stringent Lake." Based on the best available information at the time of this study, the "Moderate River to Stringent Lake Scenario" was assumed to be most likely (that is, the upper bound of water quality investments presented).

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