



Summary of Technical Evaluations

Prepared for:

CAWS Advisory Committee

Chicago, IL

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Prepared by:



In Association with:



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1.0 Background and Objectives

The Chicago Area Waterway System (CAWS) Advisory Committee (Advisory Committee) was formed in May 2014 with the goal to reach consensus on a set of recommendations to elected and appointed local, state, and federal officials and to the public on short and long-term measures to prevent Asian carp and other aquatic invasive species¹ (AIS) from moving between the Mississippi River and Great Lakes basins through the CAWS.

The 32-member Advisory Committee reached consensus on three letters to the President and members of Congress, two regarding funding for studies at the Brandon Road Lock and Dam. The third recommends that the President's fiscal year 2017 budget request to Congress incorporate sufficient funds for the U.S. Army Corps of Engineers (USACE) to perform additional specific studies under existing authorities and then provide a recommendation to Congress, via a Chief's Report, on the design of a system [of control points] for a comprehensive long-term solution to prevent the two-way inter-basin transfer of aquatic invasive species (AIS) between the Great Lakes and Mississippi River basins via the CAWS.

A list of the CAWS Advisory Committee members and those who participated on an inter-agency resource group can be found in Appendix A.

The work of the CAWS Advisory Committee began with a review of the results from two earlier studies: the *Great Lakes and Mississippi River Interbasin Study* (GLMRIS) conducted by USACE and *Restoring the Natural Divide* sponsored by the Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative.

Based on this review, Advisory Committee members suggested potential elements of a long-term solution, defined a series of questions and information needs, and relied on the technical support of HDR Engineering (HDR) to synthesize existing information relevant to these questions. Advisory Committee members also participated in discussions over a series of ten meetings to evaluate, refine, and improve potential long term solutions based on an identified set of working criteria. These criteria are to:

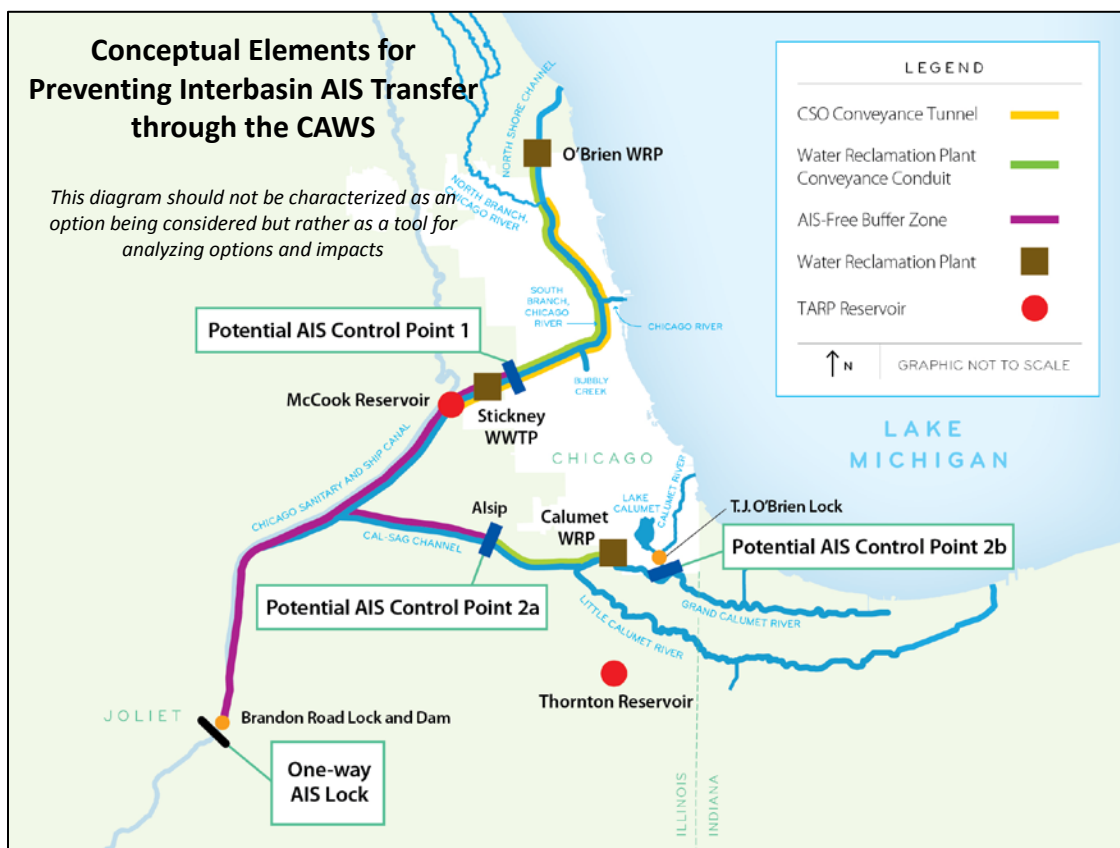
- Prevent two-way inter-basin transfer of invasive species between the Great Lakes and Mississippi River System through the CAWS in Illinois and Indiana.
- Maintain or enhance efficient maritime transportation and commerce through and on the CAWS.
- Reduce flood risk in Illinois and Indiana.
- Reduce impact of Combined Sewer Overflows (CSOs) in Illinois and Indiana.

¹ While the term aquatic invasive species (AIS) is the preferred term of federal and state managers Federal legislation and documentation refers to "aquatic nuisance species" (ANS). Consequently, this document uses the terms AIS and ANS interchangeably.

- Protect or improve water quality in the CAWS, Lake Michigan and the Illinois River Basin and meet federal and Illinois and Indiana environmental regulations.
- Reduce the need for discretionary diversions from Lake Michigan.
- Create local benefits sufficient to facilitate local cost sharing.

Conceptual elements or possible components of a potential long term solution investigated are illustrated in Figure 1. Potential control point locations were informed by previous study results and evolved through CAWS Advisory Committee discussions based on relationship with the working criteria involving AIS risk, flood risk, water quality, and transportation. For example, potential Control Points 1 and 2a were identified as minimizing potential flood risk implications, while Control Point 2b, with possible additional associated structures to prevent movement of AIS, was recognized as lessening potential water quality and transportation effects in exchange for increased flood risk potential relative to Control Point 2a. These conceptual elements and control points were intended to serve as a tool for further evaluation of potential options, and do not necessarily reflect the position of the Advisory Committee or any of its members.

Figure 1: Conceptual Elements of Potential Long Term Solution



Graphic credit: Great Lakes Commission.

Components were combined into a variety of scenarios for purposes of evaluation, which evolved over the course of the Advisory Committee’s work. These components included the

potential design of an AIS “lock system,” three control points designed to create an “AIS free” buffer zone and new conveyance structures to address CSOs and other water quality issues. The Advisory Committee discussed but did not have sufficient information to reach consensus on the type or location of control structures.

An AIS lock system is generally considered to be a lock system to which combinations of AIS control measures (e.g. screening, chemical treatment, electric barrier, etc.) are applied either within or adjacent to the lock that would continue to allow vessel transfer/passage through the lock. A physical barrier is an obstruction placed in the waterway (e.g. earthen berm, sheet pile, concrete, etc.) that creates a physical separation between water bodies and would prevent vessel movement past the location of the barrier. An AIS lock system may include a single lock chamber or two side-by-side lock chambers.

A feasibility assessment for one-way AIS controls at Brandon Lock has been proposed by the CAWS Advisory Committee to Congress as a step toward short-term measures. This effort is under further investigation by USACE. Potential AIS controls at Brandon Lock are assumed to be a part of any long term scenarios evaluated in this document; therefore, because this evaluation is focused on relative differences between scenarios, the Brandon Lock location was not a focus of this investigation. General findings regarding AIS lock control measures and commercial cargo navigation may still apply to Brandon Lock.

This document summarizes technical investigations by HDR assessing the first two criteria and providing a high level summary of background information presented to the Advisory Committee regarding flood risk and water quality criteria, including CSOs and contaminated sediments. While flood risk and water quality criteria were not the primary focus of HDR’s work, it is assumed that the location of control structures will be more significant than the eventual choice of control structure type (i.e. AIS lock system, physical barrier) for these criteria.

As part of the HDR team, Cambridge Systematics provided analysis and support for assessment of commercial cargo navigation.

The information in this summary document draws on previous and ongoing activities by others to address technical questions and concerns from the CAWS Advisory Committee and to inform their efforts to reach consensus on a long-term solution.

2.0 ANS Control Measures

This section provides an overview of potential control methods for Aquatic Nuisance Species (ANS) within the CAWS presented to the CAWS Advisory Committee. It is based on existing information and professional engineering/scientific experience from products complied by the ACRCC, state agencies, federal agencies, the Great Lakes Commission and Great Lakes and St. Lawrence Cities Initiative, other NGO studies and private sector studies. Using this compilation of existing and available information, a qualitative comparison of relative risk reduction was developed for ANS control measures within the CAWS through the following:

- Development of a matrix of ANS control measures by control type, species, species movement, and relative efficiency at preventing movement.
- Identification of one or more conceptual ANS lock system alternatives using combinations of control measures focused on maximizing potential ANS risk reduction.
- Refinement of ANS control measure combination analyses through species specific evaluation.
- Framing of ANS control measure evaluation in the context of the risk assessment developed in GLMRIS.
- Performing a relative comparison of risk reduction between long term scenarios and relative feasibility of control measure implementation.

2.1 Dispersal and ANS of Concern

Dispersal can be defined as the movement of individuals away from an existing population or parent organism. For the purposes of this summary document, dispersal of species was considered between two basins, those species moving away from the Mississippi River Basin and those species moving away from the Great Lakes Basin. Two categories of dispersal were considered for the evaluations, passive and active.









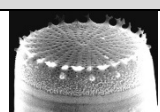
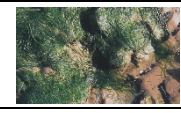
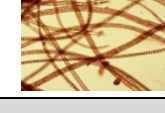

Active: movement of ANS from one location to another by its own means (e.g., swimming)

Passive: movement of ANS from one place to another by means of a stronger force (e.g., floating or hitchhiking), such as water flow, wind, boats, another organism, or object.

It should be noted that species may also move by anthropogenic (human influenced) means, such as bait buckets or intentional introductions. This summary document and all control measures outlined are intended to only address movement by aquatic pathways through the CAWS.

Primary ANS of Concern were adopted from the collection established during the GLMRIS project development managed by the U.S. Army Corps of Engineers (USACE). This process highlighted 39 species of concern between the two basins. Of the 39 species of concern, 13 were labeled as medium to high risk for introduction and establishment within a basin and were therefore considered for the control measures analysis. A summary of the 13 species, potential basin of concern, and the method(s) of movement are listed in Table 1.

Table 1: ANS of Concern Identified in the GLRMIS Document

Common Name	Scientific Name	Risk To Basin	Mode of Dispersal	Image	Image Source
Fish					
Bighead Carp	<i>Hypophthalmichthys nobilis</i>	Great Lakes	Active		USGS
Silver Carp	<i>Hypophthalmichthys molitrix</i>	Great Lakes	Active		USGS
Ruffe	<i>Gymnocephalus cernuus</i>	Mississippi River	Active		USGS
Tube-nose goby	<i>Proterorhinus semilunaris</i>	Mississippi River	Active		USGS
Threespine stickleback	<i>Gasterosteus aculeatus</i>	Mississippi River	Active		USGS
Crustacean					
Scud	<i>Echinogammarus ischmus</i>	Great Lakes	Active/ Passive		USGS
Bloody red shrimp	<i>Hemimysis anomala</i>	Mississippi River	Active/ Passive		NOAA
Fishhook waterflea	<i>Cercopagis pengoi</i>	Mississippi River	Active/ Passive		USGS
Algae					
Diatom	<i>Stephanodiscus binderanus</i>	Mississippi River	Passive		USGS
Grass kelp	<i>Enteromorpha flexuosa</i>	Mississippi River	Passive		USGS
Red algae	<i>Bangia atropurpurea</i>	Mississippi River	Passive		USGS
Plants					
Reed sweetgrass	<i>Glyceria maxima</i>	Mississippi River	Passive		USGS
Diseases					
VHSv	<i>Viral Hemorrhagic Septicemia</i>	Mississippi River	Viral pathogen		

The 13 species identified by GLMRIS is representative for the current state of information and science; however, with the continued evolution of ecosystems, it is acknowledged that additional or different species from the current 13 may be of concern in the future. While the current 13 species of concern provide the primary reference point for this evaluation, consideration was given to the idea that additional species would likely be identified in the future. This was accomplished by focusing on the categories of dispersal (movement), not just species alone.

2.2 Control Measure Risk Reduction Screening

In an effort to narrow the number of potential control measures to a smaller set of viable options for evaluation, a control measure screening process was established. The Control Measure Screening process had two primary steps:

- 1) Combine control measures into one of three major groupings based on the type of control; Physical Controls, Chemical Controls or Biological/Behavioral Controls;
- 2) Rate the relative efficiency of the control measure to produce an intended result. The intended result is defined as preventing movement either upstream or downstream of a control measure location. For the purposes of this summary document, the efficiency of preventing movement is the “reduced risk”.

Control Groupings

Physical Controls - Any control measures that utilize a device, cause manipulation of water flow or make physical contact with a species of concern for the sole purpose of limiting distribution, removing from the water body or in some cases causing injury or mortality, was placed within Physical Controls. Physical Controls include items such as barriers, mechanical filtration/screening, velocity changes, elevation change, water temperature changes, etc.

Chemical Controls - Chemical controls limit ANS dispersal and/or cause injury or mortality to a species through the introduction of chemicals into the water body. Any control measures that include introduction of chemicals either within the existing waterbody or a potential side channel were evaluated as chemical control. Chemical controls include items such as CO₂ introductions, biocides, manipulation of water quality, etc.

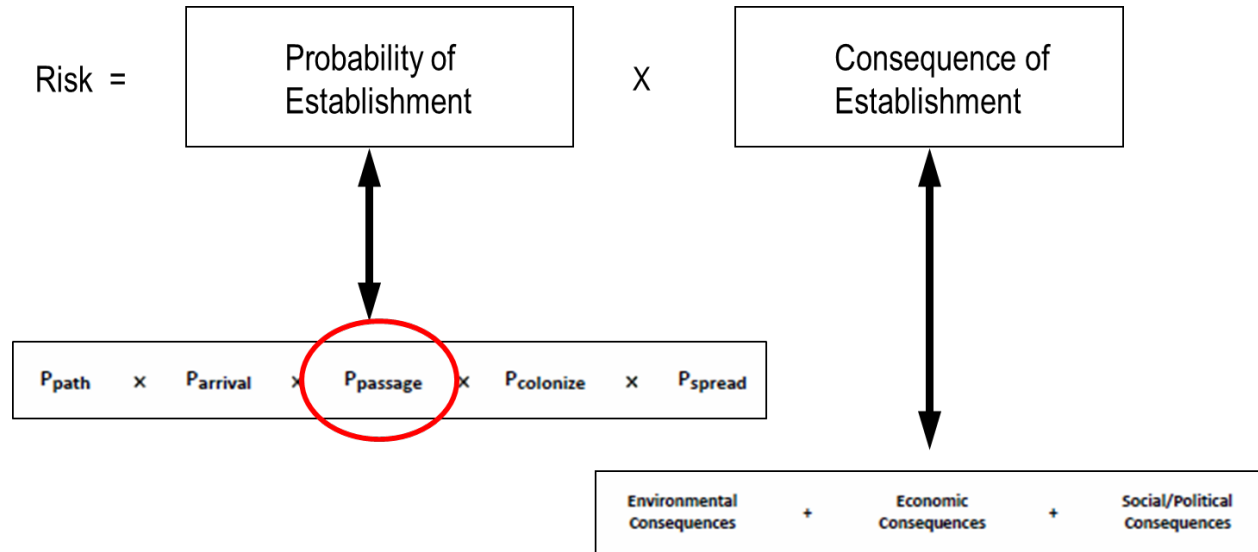
Biological/Behavioral Controls - Biological and behavioral controls include all measures that limit dispersal, injure or cause mortality of ANS through introduction of biological elements (e.g., predators, genetic alterations, etc.) or through modification of behaviors (e.g., pheromones, sensory manipulation, etc.).

Risk Reduction Screening

The GLMRIS project development focused risk assessment on a series of probabilities that when combined, resulted in a ‘probability of establishment’. As illustrated in Figure 2, the GLMRIS probability of establishment included probability of pathway, probability of arrival, probability of passage, probability of colonization, and probability of spread. The risk of adverse impacts occurring as a result of the establishment of an ANS was estimated in GLMRIS through

the multiplicative method which defines risk as the probability that a certain species will establish within a new domain multiplied by the negative consequence once established.

Figure 2: GLMRIS Risk Assessment



Source: GLMRIS Report - USACE

For the purposes of discussion in this summary document, the control combinations will be discussed relative to the probability of passage only as outlined in GLRMIS. This assumes the other probability and consequence elements used for estimating risk outlined in Figure 2 are constant, a reasonable assumption when focusing on the effectiveness of ANS control measures at a distinct location. This geographic representation of probability of establishment elements is demonstrated in Figure 3, as the probability of arrival, spread, and colonization at a particular passing location would each be independently constant for a particular species. That is, regardless of the controls and/or probability of passing at a particular location, the probability of arrival of a species and the subsequent colonization and spread (assuming passage of the point) are each determined independently of the passing probability. Similarly, the consequences of establishment for a particular species are also determined independent of passing probability.

Therefore, for this analysis, risk reduction is synonymous with reducing the probability of passage and was defined as the efficiency in preventing dispersal (either by mortality or preventing movement) through a set of control measures from one point on one side of a control measure (e.g., Point A) to another point past the control measure (e.g., Point B) as illustrated in

Figure 4. Discussions relative to overall risk assessment, and ultimately the consequences of establishment, should be maintained within the context of the GLMRIS document.

Figure 3: Probability of Establishment Elements

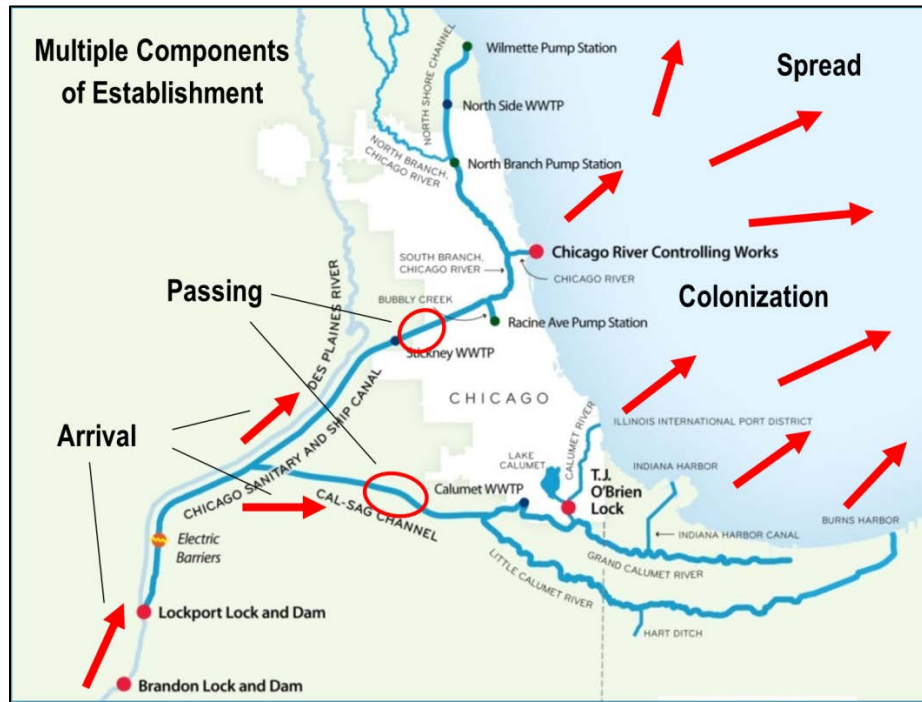
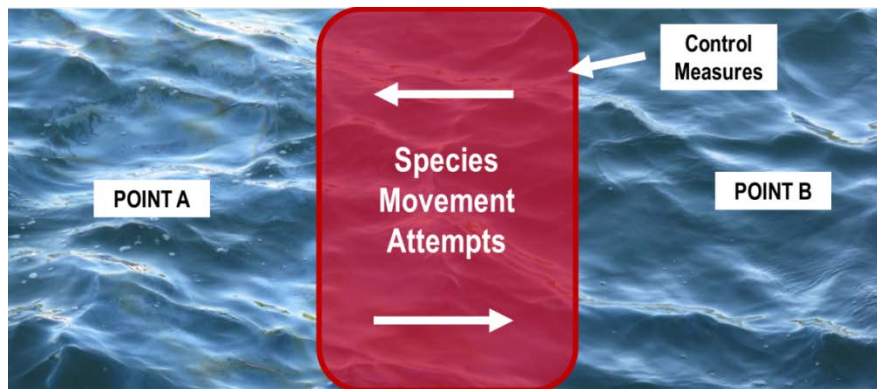


Figure 4: Example Dispersal Points



For assessment of risk reduction efficiency, the following assumptions were made:

- Risk reduction is not related to the risk of a species becoming established in either basin but rather a measure of success for a specific control measure preventing movements at a specific location.
- The risk reduction baseline is assumed to be an “open river” condition where no control measures are employed and species are free to move in any direction.

- For the purposes of this summary document, the open river condition is assumed to be zero percent efficient (baseline = 0% efficiency) at preventing the movement of species (assumes no current control measures in place).
- The control measures were screened on the basis of bi-directional movement only. In other words, control measures that only prevent movement upstream were screened-out as they do not address movement in both directions. This distinction is made to address future ANS of concern that could be moving to or from either basin.
- The term efficiency reflects how well the control measure works under ideal conditions. Where possible, theoretical efficiency was used based on field and laboratory studies of similar control measures. Additionally, efficiency claims made by product manufacturers were considered.
- Some control measures, while technically feasible, have not been employed at the scale necessary for use within the CAWS. For this reason, some efficiency is extrapolated based on similar treatment options or similar species in other aquatic settings.

The risk reduction of each control measure was measured by species category. Potential ANS were placed in one of five biological collections that included Fish, Plants, Crustaceans, Algae, Protozoans and diseases. It should be noted that the biological collections represent a nominal breakdown by dispersal (movement) type. For example, fish swim where as plants float or hitchhike.

Each control measures was given a numerical score (1 to 3) and an associated color code (red to green), with 3 (green) being the highest and 1 (red) being the lowest relative to the efficiency of preventing bi-directional movement of species as defined below:

- Green (3)
 - Control measures that have been shown in literature to be above 75% efficient at preventing the movement of a species past a point of control. Due to uncertainty in the application and/or preliminary development of various control measures, risk reduction efficiency beyond 75% was not assumed.
- Yellow (2)
 - Control measures that have been shown in literature to be between 25%-75% efficient at preventing the movement of a species past a point of control.
- Red (1)
 - Control measures that have been shown in literature or field experiments to be less than 25% efficient at preventing the movement of a species past a point of control.

Table 2 summarizes the control measures evaluated during this document. In some cases, efficiencies are based on professional judgment due to the limited data available.

Table 2: Control Measure Risk Reduction Screening

Control Measure	Description	Purpose	Risk Reduction					Summary	Comments
			Active Dispersal		Passive Dispersal				
			Fish	Crustaceans	Plants	Algae	Disease		
Physical	Accelerated Water Velocity	Creating a water velocity outside of the swimmable range for fish	1	1	1	1	1	5	No downstream control results in less than 25% efficiency. Velocities set above known threshold for burst swimming speeds in fish can achieve above 75% efficiency in limiting upstream movement.
	Controlled Harvest and Overfishing	Physical removal of ANS through harvest	3	1	2	1	1	8	Harvesting fish and sessile plants is feasible. Algae, crustaceans and disease is not
	Physical Barrier	Create a physical separation between water bodies	3	3	3	3	3	15	No movement of water occurs. With near zero exchange of water, efficiencies above 75% can be achieved.
	Lethal Water Temperature	Increasing water temperatures to a lethal point	3	3	2	3	2	13	Assumes lethal temp can be reached and maintained
	Williams Cage	Screen that creates obstacle to movement	2	1	1	1	1	6	Focused on upstream movement. Most conducive to specific points such as a fish ladder. Stuart, I. G., et. al. Document efficiencies above 75% for separating carp
	Vertical Drop Barrier	Change in elevation where downstream section is at a lower elevation than upstream	1	1	1	1	1	5	No downstream control. Barrier is created that is higher than the strongest jumping species. When achieved, greater than 75% efficiency can be achieved.
	Dredging and Diver Dredging	Mechanical removal of unwanted species such as plants	1	1	2	1	1	6	While some substrate can be removed containing ANS such as crustaceans, primary targets would be rooted vegetation. All other species impacts to movement would be less than 25% as many areas to avoid the dredge or diver exist.
	Screening	Water passing through mechanical or static screens for filtration	3	3	3	2	1	12	Efficiencies will vary based on the screen size selected for implementation. With technologies that filter water to sizes smaller than most ANS species, efficiency greater than 75% can be approached
	Ultraviolet Light	Use of UV disinfection technology to kill or disrupt organism	1	2	1	2	3	9	More complex organisms require higher dose. Impacts to ANS above 75% efficiency reported for some species (Huber et. al., 2010-diseases)
	Light Attenuating Dyes	Designed to limit the growth of plants by placing a chemical in the water that disrupts sunlight	1	1	3	3	1	9	Specific to blocking sunlight and disrupting photosynthesis. Assumes exposure time can be met.
	Benthic Barriers	Cover the substrate with undesirable material	1	3	3	1	1	9	limited to few species and variable application results.
	Electron Beam Radiation	Application of electron beam or ray to sterilize	1	2	2	3	1	9	Application needs to be matched to the sterilizing needs of the target species.
	Ultrasound	Sound waves at specific frequency to disrupt algae	1	1	2	3	1	8	Assumes specific frequencies can be maintained.
Chemical	Algaecides	Chemical specific to controlling algae	1	1	2	3	1	8	Specific to algae but may have some residual impact on plants. Assumes contact time can be reached.
	Aquatic Herbicides	General chemicals for controlling plants and algae	1	1	3	3	1	9	Assumes contact time can be reached to induce mortality
	Pesticides	General chemicals for controlling pests	1	2	1	1	1	6	Specific analysis on ANS species is still needed in some cases
	Molluscicides	Chemical specific to controlling mussels	1	1	1	1	1	5	Not effective for ANS species selected.
	General chemicals	Wide range of commonly available chemicals to cause mortality such as hydrogen peroxide.	3	3	3	3	3	15	Assumes required chemical contact time can be reached
	Alteration of Water Quality	Changes to the water quality such as increasing CO2 to deter movement or cause mortality	3	3	3	3	1	13	Assumes alterations can be maintained within the lethal area of species. Hull fouling species need further investigation.
	Irrigation Water Chemicals	Chemicals specifically designed to control algae and plants in irrigation channels	1	1	3	3	1	9	Requires specific contact time.
Biological	Pheromones	Using natural or synthetic chemicals that influence behavior	3	2	1	1	1	8	Trials still underway. Would be specific to individual species.
	Deleterious Gene Spread	Genetic fish released to cause disruption in the population. Examples include daughters genes that only allow for the production of males	3	1	1	1	1	7	Advances in other countries, such as Australia, have shown positive research related to carp.
	Sensory Deterrent Systems - Electrical	Introduction of electrical current to cause undesirable conditions	3	1	1	1	1	7	Assumptions systems are similar in function to the existing CAWS application of electrical barriers.
	Sensory Deterrent Systems - Acoustic, Bubble & Light	Use of items such as strobe lights, hydroguns, bubble curtains or acoustics to deter species from entering a defined area	3	1	1	1	1	7	Solomon (1992) cited fish deflection efficiencies for bubble barriers in laboratory tests of up to 98%, falling to a range of 51% to 80% in darkness or high turbidity levels.

3	75% or greater efficient at disrupting movement
2	25%-75% efficient at disrupting movement
1	Less than 25% efficient at disrupting movement

Notes: See references in Section 2.9

2.3 Control Measure Secondary Screening

The initial control measure screening process narrowed down the list of potential measures viable for locations in the CAWS using risk reduction efficiency. The selected control measures were weighted towards measures that controlled more than one species or movement type. In order to further evaluate the narrowed list, seven additional evaluation criteria categories were developed. These criteria were developed to show a relative order of magnitude difference between control measures. The evaluation criteria included:

- General Safety
- Travel Time
- Facility and Operational Requirements
- Construction Costs
- Feasibility of Implementation
- Recreational Impacts
- Targeting Multiple Species

A brief description of the evaluation criteria follows. Similar to the risk reduction process, a numerical (1 to 3) and color coded (red to green) system, with 3 (green) being the highest and 1 (red) being the lowest, was utilized to qualitatively compare the control measures.

General Safety

Human safety is a top priority and consideration for the implementation of ANS control measures. The following criteria were utilized relative to the safety of workers and/or recreational users of the CAWS:

- Green (3)
 - Control measures that pose no risk to human safety during the course of normal operation.
- Yellow (2)
 - Control measures that introduce some safety risks but risks are able to be mitigated for through training, established safety procedures and introduction of safety equipment at nominal costs.
- Red (1)
 - Control measures that present risk to human safety that is not easily mitigated through training, safety procedures or safety equipment. Additionally, safety equipment that is technically feasible but at a significant cost.

Travel Time

The travel times of commercial traffic utilizing the CAWS was considered in the evaluation and is summarized as:

- Green (3)
 - Control measures that do not impact travel times beyond a nominal timeframe (e.g., two hours or less through a lock).
- Yellow (2)
 - Control measures that cause an increase in travel time above the normal function of the CAWS (e.g., multiple hour delays).
- Red (1)
 - Control measures that significantly restrict or deny access currently available within the CAWS.

Facility and Operational Requirements

This category of criteria considers the requirements for the treatment process and associated building functions. It considers operational items associated with the control such as anticipated man-hour requirements for operations and maintenance plus costs for chemical delivery, utility costs, and/or disposal of waste streams. Elements related to the facility and its operational needs are evaluated within this category. The following guideline was utilized for the facility and operational criteria:

- Green (3)
 - No buildings required for control measure function. Limited man-hours for maintenance and chemical delivery. Site utility needs are minor. No special operational considerations for disposal of waste streams from treatment utilized in control measures.
- Yellow (2)
 - Simple structures or covers for control measures. Utility needs are low to moderate. Staffing is required to maintain functions or manage systems/chemical deliveries. Semi-annual needs for disposal of waste items from control measures.
- Red (1)
 - Full enclosed buildings are required. Staff sizes increase to multiple full-time employees required to maintain function, troubleshoot problems and manage items such as chemical feed and delivery or mechanical systems. Utility costs include building function and control measure operation. Regular (e.g., monthly) requirements for storage and disposal of generated waste streams specific to control measures (e.g., backwash from filters).

Construction Costs

Construction costs include capital expenditures necessary to secure land and implement the solution. These costs do not include any operational considerations. Very broad ranges were utilized because the design criteria and site-specific information needed to fully define costs will require further development and study during the subsequent phases. For example, the amount of land required for a proposed treatment can be realized, however, the actual costs of the land

required to be purchased can not be confirmed. The following guideline was utilized for the construction costs criteria:

- Green (3)
 - Construction costs range to a maximum of less than \$50 million.
- Yellow (2)
 - Construction costs range between \$50 million and \$500 million.
- Red (1)
 - Construction costs exceed \$500.

Feasibility of Implementation

Feasibility relates the potential control measure to the likelihood of being implemented. This includes a relative measure of the permitting complexity, land acquisition hurdles, scalability of the proposed control measure and additional engineering challenges that while possible to overcome, represent a major obstacle:

- Green (3)
 - Elements of the control measure are readily available and present no construction or permitting hurdles to implement.
- Yellow (2)
 - Implementation of control strategies are obtainable but will require some construction innovation and additional permitting clearance before construction could begin.
- Red (1)
 - Implementation of control measures requires special development or major permitting challenges exist.

Recreational Impacts

The impacts to recreation were considered. The likelihood that control measures would alter or impact activities such as fishing, boating, public perception, etc.:

- Green (3)
 - No impacts to current use of the waterbodies.
- Yellow (2)
 - Manageable impacts to current use exists. These impacts are manageable and will allow the continued use of the waterbody with some added complexity.
- Red (1)
 - Major impacts to the current use of the waterbody is expected and would require implementation of strategies to mitigate (e.g., placement of a barrier).

Targets Multiple Types of Dispersal

The ability for a control measure to target more than one species and/or more than one type of dispersal (movement) for a species was considered:

- Green (3)
 - Possibility to control three or more dispersal types or species.
- Yellow (2)
 - Possibility to control up to two species or dispersal type.
- Red (1)
 - Limited to one species or one dispersal type.

Table 3 displays the narrowed list and associated evaluation results. Based strictly on relative efficiency to reduce the risk of a species dispersing, three physical and two chemical control measures were selected for further analysis and are presented. No biological controls advanced beyond the initial risk screening primarily due to their risk reduction being limited to a narrow range of species or dispersal type (typically only one).

Though generally limited to one species or dispersal type, a secondary list of controls was identified including electrical sensory deterrents (i.e. electric barrier) and ultraviolet light. (See section below for more detail.)

Table 3: Control Measures Secondary Screening

Control Measure	Description	Purpose	General Safety	Travel Time	Facility/Operational Requirements	Construction Costs	Feasibility of Implementation	Recreational Impacts	Targets Multiple Dispersal Types	Summary	Comment
Physical	Physical Barrier	Create a physical separation between water bodies	3	1	3	2	1	1	3	14	Physical barrier assumes no water is allowed to transfer
	Lethal Water Temperature	Increasing water temperatures to a lethal point	2	3	1	2	1	2	3	14	Hull fouling species needs further investigation
	Screening	Water passing through mechanical or static screens for filtration	3	3	1	2	2	3	3	17	Assumes ability to manage solids generated by screening process
Chemical	General chemicals	Wide range of commonly available chemicals to cause mortality such as hydrogen peroxide.	2	3	1	2	1	2	3	14	Assumes treatment of a known volume in a lock with mitigated impacts
	Alteration of Water Quality	Changes to the water quality such as increasing CO2 to deter movement or cause mortality	3	3	1	2	1	3	3	16	Assumes treatment of a known volume in a lock with mitigated impacts

Secondary List

Biological	Sensory Deterrent Systems - Electrical	Introduction of electrical current to cause undesirable conditions	2	3	1	2	2	2	1	13	Assumes treatment of a known volume in a lock with mitigated impacts
Physical	Ultraviolet Light	Use of UV disinfection technology to kill or disrupt organism	3	3	1	2	1	3	3	16	Assumes water has been prepped to allow proper transmittance

Notes:

1. See references in Section 2.9
2. Construction costs are conceptual level estimates for relative qualitative comparison; costing of individual components was not performed.

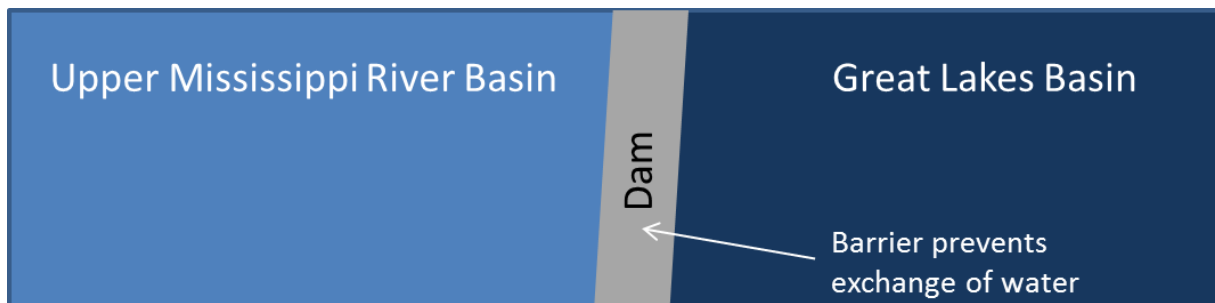
2.4 Control Measure Combinations

Control measures were evaluated within each of the major control types: a) physical, b) chemical, and c) biological. In addition, control measures were evaluated in a combination scenario as an ANS lock system. As outlined in Control Measure Risk Reduction Screening above, control measure concepts were reviewed from a variety of sources that included published papers and reports from various agencies, universities and private companies. It should be noted that extensive work in ballast management programs coordinated by several federal agencies has also generated control measure scenarios specific to treatment of invasive species in ballast tanks (33 CFR Part 151 and 46 CFR Part 162). The following text briefly highlights the control measures relative to long term control.

Physical Measures

Physical Barrier - For the purposes of this summary document, a physical barrier was defined as no exchange of water on either side of a manmade barrier. Figure 5 illustrates a conceptual view of the two isolated basins created by a physical barrier. In the scenario presented, a physical barrier would approach an efficiency of greater than 95% for preventing movement when compared to the open river baseline conditions due to the near zero exchange of water from each basin. For this reason, the physical barrier advanced beyond the initial control measure screening. This scenario, as presented, does not include anthropogenic sources of species movement.

Figure 5: Physical Barrier Separation Concept



From an ANS perspective, the physical barrier provides a very high efficiency for preventing movement, is safe, and, once constructed, would require limited maintenance compared to other more technical control measures. While highly efficient and safe, the physical barrier impedes transportation and recreational uses of the CAWS. In addition, the feasibility of implementation is viewed as low due to numerous permitting, water quality, and flood risk management challenges associated with waterway changes that restrict all current flows and uses.

Lethal Water Temperature - All species are impacted by temperatures that can reach a lethal level. For example, Wijnhoven et al. (2003), showed mortality of scuds above 95°F (35°C) while Jenner and Janssen-Mommen have shown mortality for zebra mussels exposed for 1.5 hours to

91.4°F (33°C). Beyer et al. 2011, has shown that fishhook waterflea can be killed at 109.4°F (43°C) after just 10 min exposure time. For this document, lethal temperatures were considered the high temperature intolerable by a species to the point mortality occurs. In general application, a known volume of water is maintained at a temperature above the most tolerant species' threshold for mortality. Temperature scenarios were outlined in the GLMRIS report and have been documented on a species by species basis in recent literature (USGS 2015). In general, temperatures above 110°F (43.3°C) would need to be maintained for this control measure. Lethal water temperature advanced beyond the risk screening due to the efficiency preventing movement with multiple species and potential to be 75% or greater efficient. While a high efficiency range can be achieved, the amount of exposure time varies with some species requiring a longer time to induce mortality than others. The ability to maintain temperature and administer for the required exposure time to induce mortality needs to be further evaluated at the scale proposed. A greater than 75% efficiency in preventing movement can be realized as all species regardless of movement type have a maximum threshold. For this document, administering lethal temperatures is assumed to be done to a fixed volume via a reservoir or side channel versus continuous treatment of the entire water volume of the waterway.

Screening – Screening was broken into two categories, mechanical screens and static screens. Within this technical document, all screening was assumed to be applied to a known volume, such as the volume of a lock, and not the entire volume of the CAWS. Mechanical screening involves a moving filter with a fixed media mesh size. Water passes through the filter and all organisms larger than the media size are captured. The media is backwashed to remove the trapped debris and organisms. The backwash must be collected and disposed of. Mechanical screens would require an array of multiple screens to match the volume of treatment needed. Example mechanical screens include drum filters, disc filters, stacked discs and strainers. By contract, static screens are non-moving devices that are suspended in a water column. Water is allowed to pass through the static screen trapping debris and organisms larger than the mesh size of the screen. Typically, long surface areas of screen are needed to pass a volume of water.

Modern mechanical screens arranged in an array could treat a fixed volume of water to a range that would eliminate most species of concern based on size of the species. The efficiency of this removal could approach 75% or greater however, further studies on the background water (e.g., total suspended solids) matched to the desired mesh size would need to be researched to ensure that the screens could operate efficiently within a variety of conditions and with a variety of species life history stages (e.g., water flea eggs). Achieving greater than 75% for preventing movement requires considerable facility infrastructure and regular maintenance. An area of concern for screening would be eggs of microscopic species and algae. While technically feasibly to screen to a very small size, the capability of the screens to filter ANS and all associated background parameters would be physically limited if employed as a stand alone strategy.

Ultraviolet light – This control measure was not advanced beyond the initial screening due primarily to the limited number of species and movement types that could be targeted by biological measures. However, a secondary list of controls was identified including ultraviolet light. Though generally limited to one species or dispersal type, this secondary list of controls was identified because these are existing technologies currently in use that have demonstrated some risk reduction efficiency. Furthermore, ultraviolet light is one of the few technologies identified that is expected to have a high risk reduction efficiency for disease species.

Chemical Measures

General chemicals–General chemicals advanced from the initial screening due to the wide variety of available chemicals that could be utilized to control multiple species. In some cases, chemicals can be greater than 75% efficient preventing movement of species by inducing mortality provided the ideal conditions exist for use. While some chemicals can cause mortality in multiple species, some chemicals may be specific to only one species. For this reason, further analysis is needed to select appropriate chemicals for deployment in the CAWS. This limitation would keep chemicals from being a single control measures across multiple species. Safety concerns would need to be thoroughly evaluated for the selected chemicals and ability to mitigate any residual chemical. The feasibility of implementation scored low due to the likely permitting and regulatory issues that would need to be resolved.

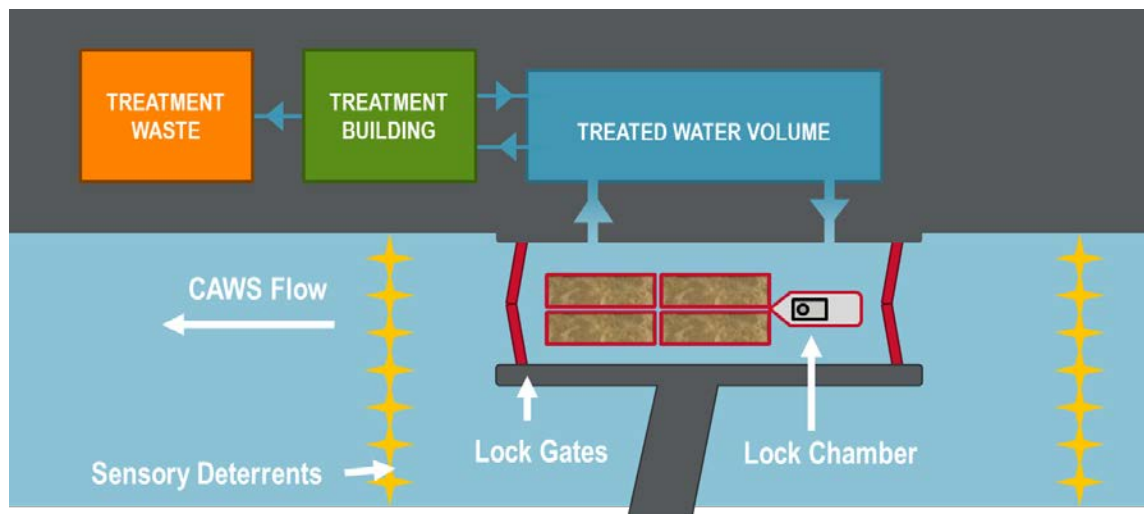
Alteration of Water Quality– The alteration of water quality involves changes in one or more water parameters such as oxygen, carbon dioxide or pH. The undesirable conditions caused by altering water quality in many cases can lead to mortality. In other cases, the undesirable conditions are avoided by actively moving species. Alteration of water quality requires additional research to confirm the undesirable or mortality level of each ANS species of concern matched to the parameter of interest. Similar to the lethal temperature, the exposure time needs to be confirmed at the scale proposed. For example, research is ongoing for preventing movement or causing mortality with the use of carbon dioxide. Additional data will enhance the efficiency of design to implement this control measure.

Biological Measures– No biological measures advanced beyond the initial screening due primarily to the limited number of species and movement types that could be targeted by biological measures. However, a secondary list of controls was identified including electrical sensory deterrents (i.e. electric barrier). Though generally limited to one species or dispersal type, this secondary list of controls was identified because these are existing technologies currently in use that have demonstrated some risk reduction efficiency.

Combination of Measures- It should be noted that with a variety of species and movement types, no single control measure will approach 95% or greater efficiency in preventing movement other than physical separation, which limits the movement of water but also limits transportation. Despite this constraint for a single control measure, combining control measures in a suite of strategies can be utilized to approach efficiencies greater than 75% while still allowing for transportation to occur. In a combination scenario, control measures would be

deployed collectively at an “ANS Lock System”. Building upon the concepts presented in GLMRIS, an ANS Lock System is a location that incorporates physical, chemical and biological strategies into a suite of controls focused on a single point. The ANS Lock System is created by a partial barrier across the waterway and the creation of a lock chamber where treatment of a fixed volume could occur external to the lock chamber. It should be noted that the ANS Lock System scenarios analyzed in this document assume that a fixed volume of water is treated versus the entire CAWS flow past a control point. Figure 6 illustrates an ANS Lock System scenario at a location within the CAWS.

Figure 6: ANS Lock System Concept



In order to approach greater than 75% efficiency in preventing species movement compared to the open river baseline condition, the ANS Lock System assumes the following conditions:

- 1- Lock – Includes a lock chamber and a similar sized sideline chamber or reservoir area for storage of treated water. As a vessel enters the ANS Lock, untreated water is pumped from the lock through treatment process. Treated water is allowed to return to the lock chamber and may be used to continually flush the lock prior to the gates opening. The concept of dual side-by-side locks may augment an ANS treatment system by serving as a temporary storage reservoir.
- 2- Biological Measures -Sensory deterrents may be utilized to limit actively moving species (i.e., fish) from the areas of the lock gates. Limiting or eliminating species in the ANS Lock area could enhance the efficiency of the overall system by limiting the species in the gate areas of the lock. It should be noted that the efficiencies listed in this document relate to the lowest common denominator species for control. This means that efficiencies relate to control of species not impacted by biological measures. The biological measures are therefore considered additional enhancements that may be considered but are not required to achieve the efficiencies noted.
- 3- Physical Measures – Measures that come into contact with the water body within the ANS Lock system and physically remove debris and species will be utilized.

- 4- Chemical Measures – The use of chemicals and/or water quality alterations will be necessary to improve the efficiency of preventing movement by species during the locking process. This addition will also be necessary for addressing ANS that are fouling hulls of boats.

Table 4 lists three potential ANS Lock System Combinations for the CAWS. While three were selected for illustration, it should be noted the multiple combinations are possible. For this reason, no ranking or differences between combination strategies are presented. For overall ratings within the evaluation criteria, the lowest rating of any individual control measures was used to rate the combined scenarios. For example, if three measures are proposed in combination and any of the three are rated 'red' (1) for safety, the evaluation of that category remained 'red' (1) because one of the three had safety concerns.

The pathways and potential control points between the Mississippi River Basin and Great Lakes Basin via the CAWS are well documented. The Corps of Engineers are currently evaluating control measures at the Brandon Road location which would allow for the one way control of species dispersing from the Mississippi River Basin towards the Great Lakes Basin. The one way solution at Brandon Road is viewed as a near-term 1-way solution and additional long term control points and/or bi-direction control at Brandon Road is desirable.

Table 4: Potential Control Measure Combinations for the CAWS

Control Measure Combination	Description	General Safety	Travel Time	Facility/Operational Requirements	Construction Costs	Feasibility of Implementation	Recreational Impacts	Estimated Risk Reduction Efficiency	Comment
ANS Lock System Combination 1	Physical - screening Chemical - general chemicals Biological - electric deterrent	2	3	1	1	1	2	3	Risk Reduction > 75%
ANS Lock System Combination 2	Physical - lethal temperature Chemical - none Biological - electric deterrent	2	3	1	1	1	2	3	Risk Reduction > 75%
ANS Lock System Combination 3	Physical - screening & ultraviolet light Chemical - alteration of water quality Biological - electric deterrent	2	3	1	1	1	2	3	Risk Reduction > 75%
Physical Barrier	Physical - physical barrier Chemical - none Biological - none	3	1	3	2	1	1	3	Risk Reduction > 95%

Notes:

1. See references in Section 2.9
2. Construction costs are conceptual level estimates for relative qualitative comparison; costing of individual components was not performed.
3. Construction costs for all control measures combinations (ANS Lock Systems and Physical Barrier) include only the cost of the control measures and associated infrastructure (i.e. ANS Lock System includes ANS control measures and cost of lock construction) and do not include other mitigation costs (i.e. water quality, transportation, flood risk management).
4. ANS Lock Combinations have higher overall construction costs than the individual control measures because of their cumulative affect and inclusion of lock construction costs to constitute a full system.
5. Water quality and flood risk management assumptions do not measurably differ with respect to the control measure combinations. Transportation costs are assessed in Section 3.0 of this document.

2.5 Enhanced Combination Analysis by Species

Following the initial analysis outlined above, more refinement for efficiencies by species was considered to inform the ranges within the greater than 75% efficiency classification. Similar to the initial screenings, a qualitative system was developed to evaluate control by species. In addition to the qualitative rankings, a level of uncertainty relative to each control measure was added that followed the uncertainty descriptions outlined in GLMRIS including:

- **High Uncertainty** = Little or no data were available, or there was a very broad range in the nature and severity of consequences including extreme consequences, and the probability or consequence ratings (as well as all assumptions used to develop the ratings) were based on professional judgment;
- **Medium Uncertainty** = Good data were available but some major data gaps were still evident, or there was a broad range in the nature and severity of the consequences but no extreme consequences were indicated, such that the probability or consequence rating is based on a mixture of ANS-specific data, data from similar species, anecdotal data, and professional judgment;
- **Low Uncertainty** = Good ANS-specific data were available (e.g., peer-reviewed, ANS specific scientific publications and reports), and no significant data gaps were known, and there was only a limited range of possible consequences; and
- **None** = Adequate data were available to fully support the probability and consequence ratings.

The combined refinement of greater than 75% efficiency with uncertainty levels resulted in the following numerical and color coded ranking system for analysis by species.

95%	95% or greater efficient preventing movement - low uncertainty
85%	85%-95% efficient preventing movement - medium uncertainty
75%	75%-85% efficient preventing movement - high uncertainty

In addition to classification by species and dispersal type, a listing of the GLMRIS establishment time step was included. As outlined in GLMRIS, the time steps were defined as:

- Time 0 (T0) = potential for establishment in the immediate future based on the current distribution of the ANS;
- Time 10 (T10) = potential for establishment within 10 years from present time;
- Time 25 (T25) = potential for establishment within 25 years from present time; and
- Time 50 (T50) = potential for establishment within 50 years from now.

Table 5 outlines the control measure combinations by species analysis.

Table 5: Control Measure Combinations by Species

Control Measure Combination	Description	Estimated Passage Reduction Efficiency												
		Active Dispersal					Active/Passive			Passive Dispersal				
		Fish					Crustaceans			Plants	Algae		Disease	
		Silver Carp	Bighead Carp	Ruffe	Threespine Stickleback	Tubenose Goby	Scud	Bloody Red Shrimp	Fishhook Waterflea	Reed Sweetgrass	Red Algae	Diatom	Grass Kelp	VHSv
T ₂₅	T ₂₅	T ₅₀	T ₀	T ₁₀	T ₀	T ₀	T ₂₅	T ₅₀	T ₀	T ₀	T ₁₀	T ₀		
ANS Lock System Combination 1	Physical - screening Chemical - general chemicals Biological - electric deterrent	85%	85%	85%	85%	85%	75%	75%	75%	85%	75%	75%	85%	75%
ANS Lock System Combination 2	Physical - lethal temperature Chemical - none Biological - electric deterrent	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
ANS Lock System Combination 3	Physical - screening & ultraviolet light Chemical - alteration of water quality Biological - electric deterrent	85%	85%	85%	85%	85%	75%	75%	75%	75%	75%	75%	75%	85%
Physical Barrier	Physical - physical barrier Chemical - none Biological - none	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%

Of the 13 species analyzed, it should be noted the GLMRIS ranked six species at time step zero (T_0) indicating that these species have the potential for establishment in the immediate future based on current distribution information meaning the implementation of control measures may be too late to cause a disruption in dispersal between basins. The remaining species ranged in time from establishment in 10 years to establishment in 50 years indicating that control measures may be put in place in time limit the chance of dispersal from occurring between basins. Of further note in relationship to the time step is that the smallest and likely most difficult species to control are the ones most imminent for establishment.

Similar to the generalized analysis, the by species analysis reflects a high (95%) efficiency and low uncertainty for limiting movement of all species by a physical barrier due to the restricted flow of water from either basin. This efficiency is in contrast to the baseline assumption in this document of zero percent efficiency for the current open river condition.

While the combination of control measures were somewhat similar, the degree of uncertainty was lower for the lethal temperature Combination 2 (85% for all species) compared to Combination 1 and Combination 3 (75% to 85% efficiency). This relates to the fact that all species have an upper temperature threshold that can be quickly realized compared to the variable impacts of screening and use of chemicals. For example, a temperature of 120°C is considered lethal to all the species in the current list (USGS, 2015). The consistent impacts of elevated temperature across species resulted in an assignment of 85% efficiency for all species in Combination 2; however, the uncertainty associated with mixing within a lock chamber and the preliminary development of this technology application prevented any species being assigned an efficiency of 95% for Combination 2. While the impacts of mixing within the lock chamber is unknown, it is believed that lethal temperature could have a residual impact compared to chemicals and screening.

The similarity of efficiencies for Combinations 1 and 3 are notable, in particular, when comparing fish species with other species types. The mass of fish species generally allows for more effective treatment using chemical and screening control measures, and more research and tested applications of these control measures exist for fish species. Consequently, less uncertainty exists for fish species than other species types, and the efficiency of control measures for fish species was generally considered higher (85%) than other species types. Several specific research studies provided additional background allowing several plant species and disease to be assigned an efficiency of 85%. Similar to Combination 2, the uncertainty associated with mixing of chemical or water quality controls within a lock chamber and the preliminary development of these technology applications, prevented any species being assigned an efficiency of 95% for Combination 1 or 3.

Risk Reduction Factors

The relation of passage reduction efficiency to risk reduction within the context of the GLMRIS risk assessment described in Section 2.2 was used for purposes of illustrating the relative risk reduction effects of the potential ANS Lock System Combinations. As illustrated in Table 6, an assumed baseline of 0% efficiency (100% probability of passing) compared with a set of ANS

control measures having 75% passage reduction efficiency (25% probability of passing) would relate to a risk reduction factor of 4 (100% reduced to 25%). Furthermore, ANS control measure combinations with passage reduction efficiencies between 75% and 95% would relate to risk reduction factors between 4 and 20. As previously noted, these relations assume all other probability elements (pathway, arrival, colonization, spread) are constant and independent of passing probability for a species at a distinct location.

Table 6: Relating Passing Probability with Risk Reduction

ANS Controls Passage Reduction Efficiency	Probability of Passing		Risk Reduction Factor ¹
	Baseline	With ANS Controls	
75%	100%	25%	4
85%	100%	15%	7
95%	100%	5%	20

Notes:

1. Assumes all other probability elements are held constant and independent of passing probability

This risk reduction concept is further illustrated using example species for various ANS Lock Combinations and the various probabilities of establishment elements as shown in Table 7. Again assuming the other probability elements are constant and independent of passing probability and using illustrative values for the pathway, arrival, colonization, and spread probability elements, a relative comparison of risk reduction can be determined by species for various ANS Lock Combinations.

Table 7: Relating Passing Probability with Risk Reduction by Species

ANS Control	Example Species	Probability Element					Change in Passage Probability	Risk Reduction Factor
		Pathway	Arrival	Passage	Colonization	Spread		
No control	N/A	100%	80%	100%	50%	50%	N/A	N/A
ANS Lock @ 75% Efficient	Scud	100%	80%	25%	50%	50%	100% to 25%	4 (100% vs 25%)
ANS Lock @ 85% Efficient	Grass Kelp	100%	80%	15%	50%	50%	100% to 15%	7 (100% vs 15%)
ANS Lock @ 95% Efficient	TBD	100%	80%	<5%	50%	50%	100% to <5%	>20 (100% vs <5%)
Physical Barrier	All	100%	80%	<5%	50%	50%	100% to <5%	>20 (100% vs <5%)

Notes:

1. Assumes all other probability elements are held constant and independent of passing probability

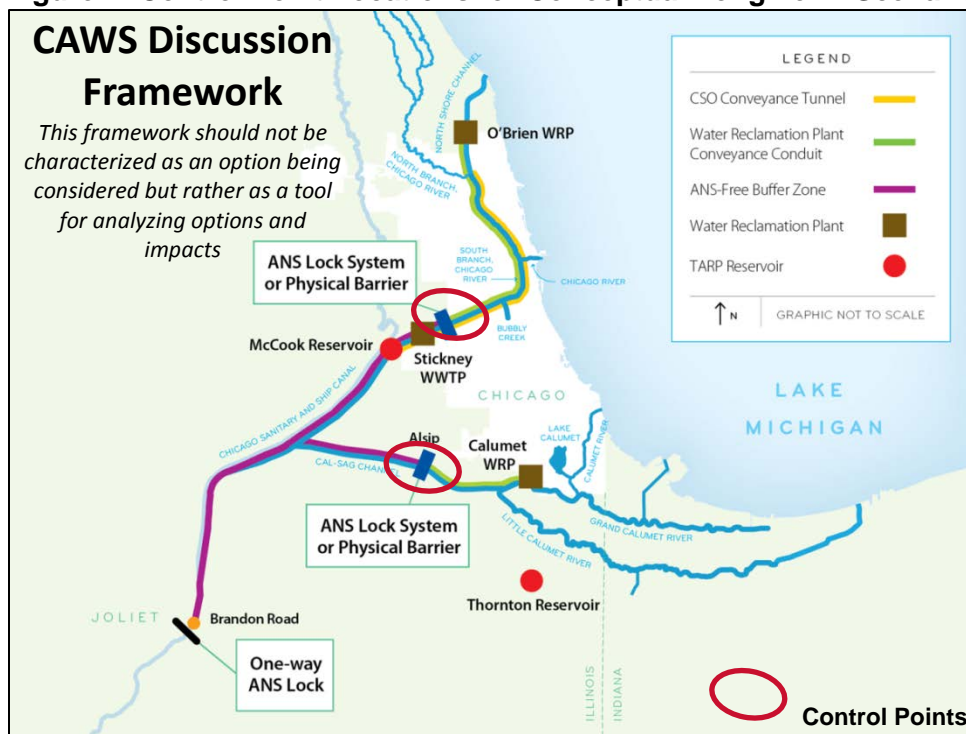
2.6 Comparison of Long Term Scenarios

Three long term scenarios were identified for purposes of the evaluation documented in this summary document. The scenarios consist of ANS lock systems and/or physical barriers located on the Chicago Sanitary and Ship Canal (CSSC) near Stickney, IL (approximately RM 317); and on the Cal-Sag Channel near Alsip, IL (approximately RM 314). The scenarios are described below, and the control points along with pathways, potential buffer zone and potential Brandon Road ANS Lock are shown in Figure 7. Note ANS controls at Brandon Lock are assumed to be a part of all three long term scenarios evaluated in this summary document.

- 1) Two ANS lock systems: one on Chicago Sanitary and Ship Canal (CSSC) near Stickney and one on Cal-Sag Channel (Cal-Sag) near Alsip
- 2) One ANS lock system on Cal-Sag near Alsip and one physical barrier on CSSC near Stickney
- 3) Two physical barriers: one on CSSC near Stickney and one on Cal-Sag near Alsip

It is noted that physical barriers were included in the discussion framework at the time of the initial ANS control measure evaluations; however, more recent Advisory Committee discussions have focused on an ANS Lock System at the Alsip control point. Thus, only two scenarios were compared in some of the following analyses. Furthermore, potential commercial cargo navigation implications related to the long term scenarios were also assessed and are discussed in Section 3 of this document.

Figure 7: Control Point Locations for Conceptual Long Term Scenarios



Graphic credit: Great Lakes Commission.

The following provides a qualitative assessment of relative ANS risk reduction for the three long term scenarios as it relates to the control measure screening and combinations outlined previously:

- 1) Two ANS locks - ANS lock systems on both the Cal-Sag and CSSC for the purposes of ANS control could be greater than 75% in preventing movement under normal flow conditions when compared to the baseline open river condition. These scenarios assume a fixed volume of water is treated versus treatment of the entire river flow. Two ANS locks allow for movement of goods and recreation. The combinations of control measures enhance the ability to prevent movement of multiple species and/or movement types.
- 2) ANS lock and barrier combination - This summary document did not assess the pathways nor the probability of a species entering one pathway over another. It is acknowledged that an incremental increase in overall passage probability would theoretically exist with ANS controls on multiple pathways. With this simple assumption, an ANS lock and physical barrier combination would have a greater efficiency overall compared to two locks simply because one pathway is completely blocked. However, the relative geographic proximity of the CSSC and Cal-Sag control points, suggests that if a particular species is present in one CAWS pathway (CSSC or Cal Sag Channel) it is reasonable to assume that it is present in the other. Therefore, the incremental increase in risk reduction was not able to be quantified in the scope of this evaluation, and the lowest passage reduction efficiency between the two pathways was used for determining the overall rating of a scenario, regardless of how efficient the controls were in the other pathway (i.e. ANS Lock System passage reduction efficiencies governed rating even if a physical barrier was assumed on the other pathway).
- 3) Two Barriers – As stated previously in this document, when the water volumes are not allowed to exchange, the prevention of movement efficiency increases greatly and can be assumed to approach 95% or greater. The prevention of movement can not be considered 100% efficient due to conditions beyond an assumed level of design and transfer through other non-aquatic pathways. This scenario has the largest impact to transportation and recreational uses.

Evaluation Refinement by Species

Following the generalized analysis, further long-term analysis by species was considered to determine the potential passage by species or species type related to Scenario 1, two ANS Lock Systems and Scenario 2, one ANS Lock System and one physical barrier. Table 8 summarizes the potential long term scenarios by species.

The comparison of potential long term scenarios by species assumes the following:

- most efficient ANS Lock System implemented at all lock locations (i.e. ANS Lock System with lethal temperature)
- ANS Lock System controls assumed at Brandon Road that provide 1-way control only (prevent species movement from Mississippi Basin to Great Lakes Basin)

Table 8: Potential Long Term Scenarios by Species

Long Term Scenario	Description	Estimated Passage Reduction Efficiency												
		Active Dispersal					Active/Passive			Passive Dispersal				
		Fish					Crustaceans			Plants	Algae		Disease	
		Silver Carp	Bighead Carp	Ruffe	Threespine Stickleback	Tubenose Goby	Scud	Bloody Red Shrimp	Fishhook Waterflea	Reed Sweetgrass	Red Algae	Diatom	Grass Kelp	VHSv
T ₂₅	T ₂₅	T ₅₀	T ₀	T ₁₀	T ₀	T ₀	T ₂₅	T ₅₀	T ₀	T ₀	T ₁₀	T ₀		
Scenario 1	ANS Lock near Stickney on CSSC ANS Lock near Alsip on Cal-Sag ANS Lock at Brandon Road	95%	95%	85%	85%	85%	95%	85%	85%	85%	85%	85%	85%	85%
Scenario 2	Physical Barrier near Stickney on CSSC ANS Lock near Alsip on Cal-Sag ANS Lock at Brandon Road	95%	95%	85%	85%	85%	95%	85%	85%	85%	85%	85%	85%	85%

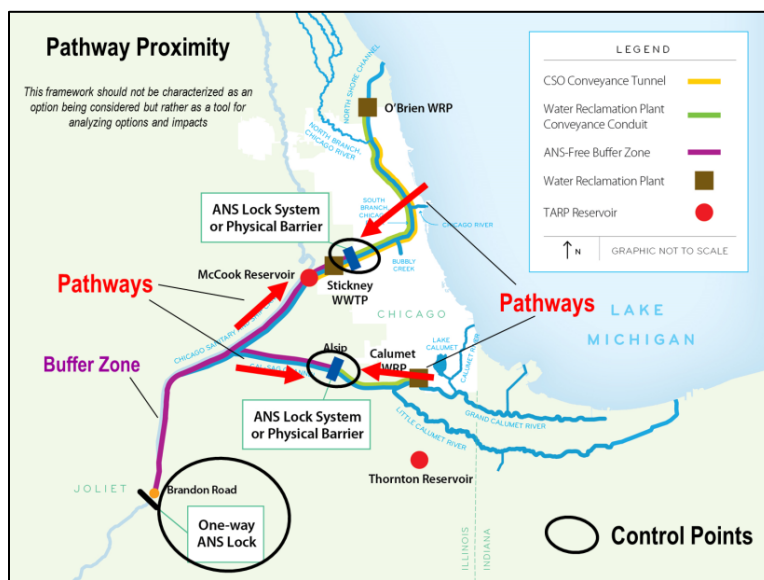
Notes:

1. Assumes most efficient ANS Lock System implemented at all lock locations
2. Assumes Brandon Road provides 1-way control only
3. Assumes multiple ANS Lock treatments for Mississippi to Great Lakes species – cumulative effects
4. Ratings based on pathway with lowest reduction efficiency

- Cumulative effects of multiple ANS Lock treatments (Brandon Road ANS controls and either Stickney or Alsip control point) for Mississippi to Great Lakes species
- Ratings based on pathway with lowest reduction efficiency (i.e. proximity of the two pathways suggests ‘weakest link’ governs)

Unlike the comparison of a CAWS pathway with an aquatic pathway in another state, the close proximity of the two pathways, as illustrated in Figure 8: Pathway Proximity of Control Points, suggested that if a particular species is present in one CAWS pathway (CSSC or Cal Sag Channel) it is reasonable to assume that it is present in the other. Therefore, the lowest passage reduction efficiency between the two pathways was used for determining the overall rating of a scenario; regardless of how efficient the controls were in the other pathway (i.e. ANS Lock System passage reduction efficiencies governed rating even if a physical barrier was assumed on the other pathway). While it is acknowledged that an incremental increase in overall passage probability would theoretically exist with ANS controls on multiple pathways, assessment of this increase was beyond the scope of this evaluation.

Figure 8: Pathway Proximity of Control Points

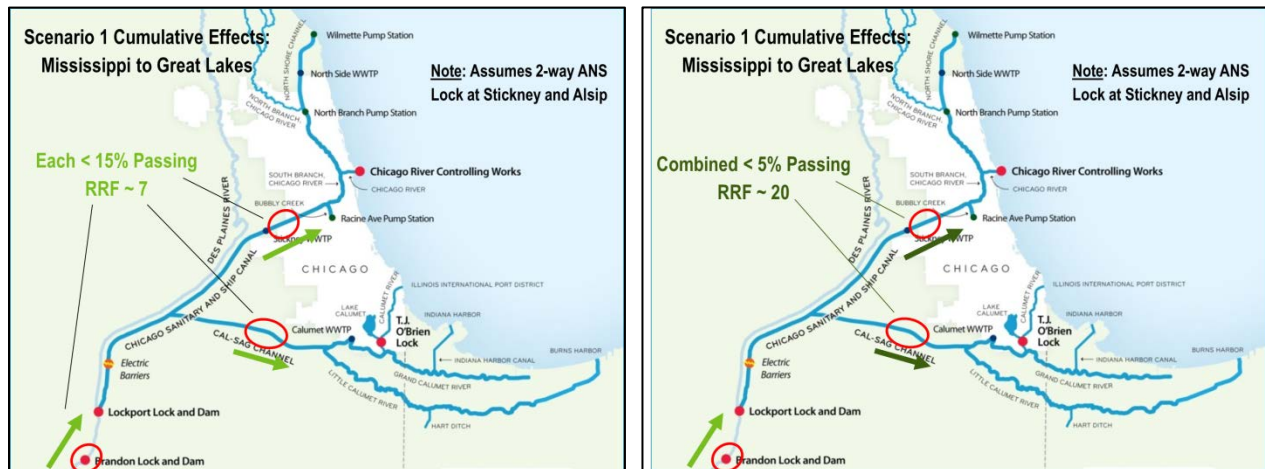


While the incremental effects of implementing ANS control measures on two parallel pathways (i.e. the CSSC and the Cal Sag) were not able to be evaluated, the cumulative effect of multiple control points in series (i.e. 2 control points along the same pathway) were qualitatively estimated. These cumulative effects of multiple control points provided the primary difference between the ANS Lock Combination passage reduction efficiencies of one particular location and the potential long term scenario passage reduction efficiencies of a system of control points and are distinctly different depending on the direction of the controls (Mississippi to Great Lakes or Great Lakes to Mississippi).

This cumulative effect is demonstrated in Figure 9 with the combination of ANS controls at both Brandon Road (1-way) and either of the Stickney or Alsip control points for species traveling from the Mississippi Basin to the Great Lakes Basin and described as follows:

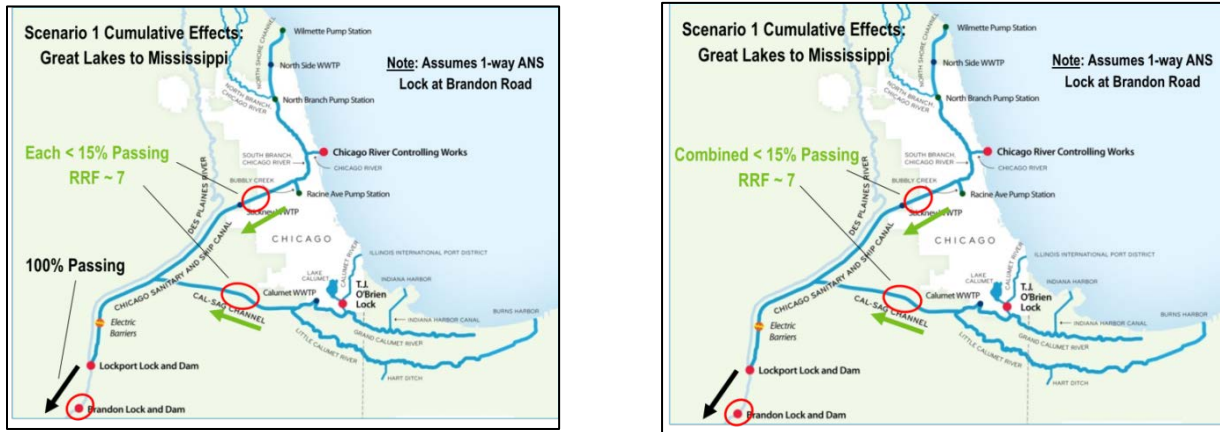
- Each individual control point is estimated to have a passage reduction efficiency of 85% (15% passing) and risk reduction factor (RRF) of: 100% (baseline) to 15% (residual risk) = ~ 7.
- When considering the combined effect of two control points (Brandon Road and either the CSSC or Cal Sag control point) along a pathway, the combined reduction efficiency is estimated at greater than 95% (<5% passing) and RRF of: 100% (baseline) to 5% (residual risk) = ~ 20. This is based on cumulative probability of 2 independent control points with passage reduction efficiencies of 85%: $(100\% - 85\%) \times (100\% - 85\%) = < 5\%$ passing
- It is noted that this is a theoretical cumulative effect assuming independence of control points and does not account for potential factors that may impact the reduction efficiency of one or more control points such as operation and maintenance.

Figure 9: Cumulative Effect of Control Points – Mississippi to Great Lakes



Conversely, the assumed 1-way nature of the ANS controls at Brandon Road allows 100% passage of Great Lakes species to the Mississippi River basin. Therefore, no cumulative effects are estimated along a pathway with multiple control points for species moving from the Great Lakes to the Mississippi River basin as illustrated in Figure 10. Rather the overall passage reduction efficiency of the scenario is determined by a single control point with the lowest passage reduction efficiency between the two pathways (15% passing and RRF ~ 7).

Figure 10: Cumulative Effect of Control Points – Great Lakes to Mississippi



Risk Reduction Factors

Similar to the previously presented example of relating passage efficiency to risk reduction using example species, Table 9 illustrates the probability of establishment elements and relation to risk reduction for the potential long term scenarios. Cumulative effects of multiple control points are assumed (Mississippi species to Great Lakes), which demonstrates that both long term scenarios have similar expected risk reduction effects. Table 9 provides the estimated risk reduction by species for the potential long term scenarios. Again it is noted that both long term scenarios have similar results, the cumulative effects of multiple control points provide the difference of expected risk reduction between species.

Table 9: Relating Passing Probability to Risk Reduction by Potential Long Term Scenario

Long Term Scenario	Example Species	Probability Element					Cumulative Change in Passage Probability	Risk Reduction Factor
		Pathway	Arrival	Passage	Colonization	Spread		
No control	N/A	100%	80%	100%	50%	50%	N/A	N/A
Scenario 1	Mississippi	100%	80%	<5%	50%	50%	100% to <5%	>20 (100% vs <5%)
Scenario 1	Great Lakes	100%	80%	15%	50%	50%	100% to 15%	7 (100% vs 15%)
Scenario 2	Mississippi	100%	80%	<5%	50%	50%	100% to <5%	>20 (100% vs <5%)
Scenario 2	Great Lakes	100%	80%	15%	50%	50%	100% to 15%	7 (100% vs 15%)

Notes:

1. Assumes all other probability elements are held constant and independent of passing probability
2. Assumes ANS Lock controls applied at multiple control points – Brandon Road and Stickney/Alsip

Table 10: Risk Reduction by Species for Potential Long Term Scenarios

Movement Type	Classification	Species	Time Period (years)	Basin at Risk	Estimated Risk Reduction of ANS Controls						
					GLMRIS Alts w/ ANS Lock Controls	Scenario 1: 2 ANS Locks			Scenario 2: 1 ANS Lock & 1 Physical Barrier		
						Risk Reduction ¹	Estimated Passage Reduction Efficiency	Cumulative Change in Passage Probability	Risk Reduction Factor ²	Estimated Passage Reduction Efficiency	Cumulative Change in Passage Probability
Active Dispersal	Fish	Silver Carp	25	Great Lakes	Yes	95%	100% to <5%	>20	95%	100% to <5%	>20
		Bighead Carp	25	Great Lakes	Yes	95%	100% to <5%	>20	95%	100% to <5%	>20
		Ruffe	50	Mississippi	Yes	85%	100% to 15%	7	85%	100% to 15%	7
		Threespine Stickleback	0	Mississippi	Yes	85%	100% to 15%	7	85%	100% to 15%	7
		Tubenose Goby	10	Mississippi	Yes	85%	100% to 15%	7	85%	100% to 15%	7
Active/ Passive	Crustaceans	Scud	0	Great Lakes	No	95%	100% to <5%	>20	95%	100% to <5%	>20
		Bloody Red Shrimp	0	Mississippi	Yes	85%	100% to 15%	7	85%	100% to 15%	7
		Fishhook Waterflea	25	Mississippi	No	85%	100% to 15%	7	85%	100% to 15%	7
Passive Dispersal	Plants	Reed Sweetgrass	50	Mississippi	Yes	85%	100% to 15%	7	85%	100% to 15%	7
		Red Algae	0	Mississippi	No	85%	100% to 15%	7	85%	100% to 15%	7
	Algae	Diatom	0	Mississippi	No	85%	100% to 15%	7	85%	100% to 15%	7
		Grass Kelp	10	Mississippi	Yes	85%	100% to 15%	7	85%	100% to 15%	7
	Disease	VHSV	0	Mississippi	No	85%	100% to 15%	7	85%	100% to 15%	7

Notes:

1. Risk is reduced provided no establishment occurs before plan implementation
2. Assumes baseline passing probability is 100% and all other probability elements are held constant and independent of passing probability
3. Assumes ANS Lock controls applied at multiple control points – Brandon Road and Stickney/Alsip

2.7 Summary

Potential ANS Lock System Combination concepts for Scenarios 1 & 2 are estimated to provide similar > 85% to > 95% risk reduction depending upon species. The evaluations presented in this document were also framed within the context of the GLMRIS Risk Assessment including the following background:

- Evaluations were refined by 13 GLMRIS species, several of which may establish at any time (T0)
- Probability of passage drives Probability of Establishment which governs Risk Reduction estimates
- Uncertainty of control measure application, weakest pathway link, and potential cumulative effects of multiple control points drives overall risk reduction estimates
- Further research and development combined with adaptive management is expected to improve efficiencies and reduce uncertainty

The overall findings were determined through a series of analyses including:

- Development of a matrix of Individual ANS Control Measures
- ANS Lock System Control Measure Combination Evaluation

- Refinement of ANS Lock Systems Control Measure Combination Evaluation by Species
- Potential Long Term Scenarios
- Refinement of Long Term Scenario Evaluation by Species

The following provides a more detailed summary of these ANS control measures evaluations:

- Matrix of Individual ANS Control Measures - A matrix of individual ANS control measures was developed and organized by control type, species, species movement, and relative efficiency at preventing movement with the objective to identify control measures that would maximize risk reduction across a range of species. These control measures were screened for further analysis as follows:
 - Control measures with estimated risk reduction efficiencies of >75% were identified for all species and dispersal (movement) types. Only those control measures with > 75% risk reduction efficiencies were further considered.
 - Control measures that controlled three or species or multiple movement types at an estimated > 75% risk reduction efficiency (3 physical and 2 chemical control measures) were further evaluated using additional criteria for relative comparison.
 - While not estimated to provide > 75% risk reduction efficiency for multiple species types, additional screened controls including sensory deterrents (i.e. electric barrier) and ultraviolet light were included for further evaluation because these are existing technologies currently in use that have demonstrated some risk reduction efficiency. Furthermore, ultraviolet light is one of the few technologies identified that is expected to have a high risk reduction efficiency for disease species.
- ANS Lock System Control Measure Combination Evaluation – Three (3) ANS Lock System concepts were identified using combinations of screened control measures focused on maximizing potential ANS risk reduction.
 - As a system of control measures, each ANS Lock System combination was estimated to provide >75% risk reduction efficiency
 - Using additional criteria, qualitative comparisons were made between the 3 ANS Lock System combinations and a physical barrier
- Refinement of ANS Lock Systems Control Measure Combination Evaluation by Species – Refinement of the ANS Lock System combination evaluation was provided through a qualitative assessment of relative risk reduction by species based on uncertainty descriptions consistent with GLMRIS.
 - Uncertainty associated with mixing within a lock chamber and the preliminary nature of engineering design and testing of various technologies provided the

basis for the range in risk reduction efficiencies and prevented estimates for control of any species being assigned an efficiency of 95%

- Current information suggests lethal temperature is estimated to provide the most consistent and highest risk reduction efficiency across all species (~85% in combination with screening and electric barrier controls)
- ANS Lock System combinations were estimated to provided risk reduction efficiencies > 75% to > 85% depending upon species and technology
 - Higher risk reduction efficiencies were estimated for non-fish species with lethal temperature than chemical treatment
 - Higher risk reduction efficiencies were estimated for fish species with chemical treatment than for other species
- Passage reduction efficiency was related to risk reduction factors within the context of the GLMRIS risk assessment assuming other probability elements are constant and independent of passing probability for a species at a distinct location
 - ANS control measure combinations with passage reduction efficiencies between 75% and 95% would equate to risk reduction factors between 4 and 20 times what it would have been without the controls
- Potential Long Term Scenarios – A qualitative assessment of relative risk reduction for the three potential long term scenarios was provided as related to the control measure screening and combinations outlined
 - Scenarios 1 and 2 (those containing ANS Lock Systems) are estimated to provide risk reduction efficiency of > 75%
 - Scenario 3 is estimated to provide risk reduction efficiency of > 95%
 - Due to uncertainty in the application and/or preliminary development of various control measures, risk reduction efficiency up to 95% was not assumed for ANS Lock System combinations
 - It is expected that the risk reduction efficiency of ANS Lock Systems could be improved with further research and development and adaptive management strategies
 - Some level of residual risk is always expected between an ANS Lock System and a physical barrier due to the difference in water exchange assumptions
- Refinement of Long Term Scenario Evaluation by Species – Following the generalized analysis of the three potential long term scenarios, additional investigation of potential

long-term Scenarios 1 & 2 was considered regarding species and potential cumulative effects of multiple control points.

- Ratings based on pathway with lowest reduction efficiency or ‘weakest link’
- Similar risk reduction estimated for Scenarios 1 & 2 due to proximity of pathways
- Potential for > 85% passage reduction efficiency or RRF ~ 7 for the 13 GLMRIS species
- Potential for > 95% passage reduction efficiency or RRF ~ 20 for Mississippi to Great Lakes species based on cumulative effects
- Combination with Brandon Road drives cumulative effects in one direction only

While a consensus level of ‘successful’ risk reduction efficiency has not generally been quantified by the ANS community, the brief evaluation provided in this document was designed to advance the discussion of what control measures could be utilized and what relative efficiency range the measures could provide in preventing the movement of ANS from either basin. Statements and efficiency ranges presented in this assessment were based on current science, professional opinion, available data in research and other known installations of control measures utilized in settings other than the CAWS. The broad ranges of risk reduction efficiencies presented were not further quantified because of the uncertainty in this current knowledge base. As such, formal documentation of the overall risk is difficult to quantify. Despite these limitations, advances in the concepts were made and future analysis will continue to advance the current state of science. It is anticipated that specific research on control measures designs matched to the conditions within the CAWS may lead to improvements in technology that attain a higher risk reduction threshold. While 75% to 95% risk reduction can be theorized, actual rates will be dependent upon the specific control measures selected and the targeted species.

2.8 Next Steps

A concept which introduces a combination of control measures in a safe, efficient manner yet still allows for transportation and recreational uses appears feasible and will require additional development, validation, and testing. Initial thoughts for these additional ANS lock system evaluations include:

- Identifying a focused set of control measures and combinations (e.g. physical - screening, chemical – lethal temperature, biological – electric barrier) for investigation
- Analyses aimed at reducing uncertainty in ANS risk reduction
 - Evaluation of interactions of control measures working in combination (e.g. lethal temperature combined with chemicals)
 - Evaluating mixing effects in lock chambers for control measures

- Temperature/chemical applications in lock chamber
- Range of species and species types beyond 13 GLMRIS species
- Detailed assessment of additional criteria beyond ANS risk reduction, in particular related to maritime transportation and operations
 - General safety of waterway users (maritime transportation, recreation, etc.)
 - Travel time implications of ANS controls for maritime transportation
 - Facility and operational requirements, construction and O&M costs, and feasibility of implementation of ANS control measures
 - Water quality and recreational implications of ANS controls
- Adaptive Management Strategies
 - Efficacy studies in the lab and field applications for validation of risk reduction and assessment of maritime transportation and operational implications
 - Demonstration projects of technologies validated from efficacy studies

2.9 References

- 1 Bailey, S.A., I.C Duggan, P.T. Jenkins, and H.J. MacIsaac. 2005. Invertebrate resting stages in residual ballast sediment of transoceanic ships. *Canadian Journal of Fisheries and Aquatic Sciences* 62: 1090–1103.
- 2 Boelman, S. F., F. M. Neilson, E. A. Dardeau, Jr., and T. Cross. 1997. Zebra Mussel (*Dreissena polymorpha*) Control Handbook for Facility Operators. **First Edition**.
- 3 Code of Federal Regulations. "Subpart C—Ballast Water Management for Control of Nonindigenous Species in the Great Lakes and Hudson River." Title 33: Navigation and Navigable Waters. <http://www.ecfr.gov/cgi-bin/text-idx?node=33:2.0.1.5.21#sp33.2.151.c>. Accessed September 2015.
- 4 Cope, W. G., M. R. Bartsch, and L. L. Marking. 1997. Efficacy of Candidate Chemicals for Preventing Attachment of Zebra Mussels (*Dreissena polymorpha*). *Environmental Toxicology and Chemistry* 16.
- 5 DeStasio, B. and J. Beyer. 2009. Tests of lethal temperature limits for invasive species in the Lower Fox River. Final Project Report to the Fox River Navigational System Authority Aquatic Invasive Species Committee. Biology Department, Lawrence University Appleton, WI, 54912.
- 6 *Environ Manage.* 2011 Jan;47(1):67-76. doi: 10.1007/s00267-010-9573-4. Epub 2010 Oct 9. Acute upper thermal limits of three aquatic invasive invertebrates: hot water treatment to prevent upstream transport of invasive species.
- 7 Huber P, Petri B, Allen S, Lumsden JS (2010) Viral haemorrhagic septicaemia virus IVb inactivation by ultraviolet light, and storage viability at 4 and 20°C. *J Fish Dis* 33: 377-380.
- 8 MacNeill, D., M. Snyder, K. Schultz, and J. Makarevicz (eds). 2004. Guidelines for Reducing the Spread of 'Fishhook Waterfleas' (*Cercopagis pengoi*). Fact Sheet, New York Sea Grant Communications, Stony Brook University, Stony Brook, NY, 4 pp.
- 9 Maguire, B. 1963. The passive dispersal of small aquatic organisms and their colonization of isolated bodies of water. *Ecological Monographs* 33: 161-185.
- 10 Michels, E., K. Cottenie, L. Neys, and L. De Meester. 2001. Zooplankton on the move: first results on the quantification of dispersal of zooplankton in a set of interconnected ponds. *Hydrobiologia* 442: 117-126.
- 11 Molloy, D. P. 1998. The Potential for Using Biological Control Technologies in the Management of *Dreissena* Spp. *Journal of Shellfish Research* 17:177-183.
- 12 Lau-Tuttle, M.T., Philips, K.A. and Gaikowski, M.P. Evaluation of the Efficacy of Iodophor Disinfection of Walleye and Northern Pike Eggs to Eliminate Viral Hemorrhagic Septicemia Virus <http://pubs.usgs.gov/fs/2009/3107/pdf/fs20093107.pdf>
- 13 Wijnhoven, S., M.C. van Riel, and G. van der Velde. 2003. Exotic and indigenous freshwater gammarid species: physiological tolerance to water temperature in relation to ionic content of the water. *Aquatic Ecology* 37: 151-158.

- 14 U.S. Army Corps of Engineers. 2014, Great Lakes and Mississippi River Interbasin Study (GLMRIS), Appendix C, Part 1.
- 15 U.S. Geological Survey. 2015. Administrative Report: Identify Potential Lock Treatment Options to Prevent Movement of Aquatic Invasive Species through the Chicago Area Waterway System (CAWS)
- 16 Wright, D. A. M., John A.; Setzler-Hamilton, Eileen M.; Chalker-Scott, Linda; Gary L. Morgan. 1995. Use of High Energy Monochromatic UV Light to Kill Dreissenid Larvae.

3.0 Commercial Cargo Navigation

Information about implications for commercial cargo navigation was compiled and analyzed for three combinations of the conceptual elements for a long term solution described in Section 1 above. This was achieved by:

- Presenting a synopsis of the existing conditions of the CAWS, including infrastructure, commodities, and industries
- Analyzing trends in commodity usage and travel characteristics
- Examining the potential for goods to be re-routed or shifted to another mode
- Identifying and refining existing and projected future commercial cargo navigation volumes and movements
- Performing a relative comparison between long term scenarios of commercial cargo navigation implications

3.1 Background of CAWS Commercial Cargo Navigation

For purposes of this document, the CAWS segments have been broken down by the Upper CAWS (Chicago Sanitary and Ship Canal from Lockport Lock and Dam to the Chicago River; Chicago River North Branch; and Chicago River South Branch); and the Lower CAWS (Cal-Sag Channel; Lake Calumet; and Calumet River/Harbor.) A map depicting these waterway segments is shown in Figure 11.

UPPER CAWS WATERWAY SEGMENTS

- **Chicago Sanitary and Ship Canal (CSSC):** From Damen Avenue, Chicago to Lockport, IL. Maintained Depth: 9 feet at low water stages.
- **Chicago River (Main and North Branch):** Main River from Rush Street to the junction of the North and South Branch; North Branch to North Avenue. Project Depth: 21 feet from Rush Street in the Main River to North Avenue in the North Branch, including the North Branch Canal and the North Turning Branch Basin. Several roadway bridges span the River and the North Branch. On the North Branch, tows must be light-loaded to navigate because of reduced channel depth, due to shoaling. The City of Chicago also limits tow sizes to two barges on all segments of the Chicago River, and many areas are speed restricted (no wake zones).
- **Chicago River (South Branch):** From Damen Avenue to Lake Street. Maintained Depth: 9 feet at low water stages. Several bridges span the South Branch.

LOWER CAWS WATERWAY SEGMENTS

- Calumet-Sag Channel :** From the junction with the Chicago Sanitary and Ship Canal to Blue Island, Little Calumet and Calumet Rivers to Turning Basin No. 5 (130th Street Bridge). Maintained Depth: 9 feet.

Figure 11: CAWS Segments



- Lake Calumet:** Entrance channel from the Calumet River to a harbor area at the south end of the lake with a channel extending northward for a distance of 3,000 feet and a width of 1,000 feet. Project Depth: 27 feet. The deep draft of Lake Calumet can accommodate laker vessels (bulk freighters that can traverse Lake Michigan and the Great Lakes).
- Calumet Harbor and River:** Calumet Harbor and River to Turning Basin No. 5 (130th Street Bridge). Project Depth: 29 feet in approach channel, 28 feet in outer harbor anchorage area, 27 feet in river entrance channel to former EJ&E rail bridge, and 27 feet in river to and including Turning Basin No. 5. The deep draft of the Harbor, River and turning basin can accommodate laker vessels. Channel circuitry is a limiting factor on tow size and tow configuration.

3.1.1 Waterway Infrastructure and Identified Capital Needs

Infrastructure conditions are a driving factor in whether or not the CAWS is used, and how efficiently it serves its users. Existing and potential impediments and barriers to efficient goods movement, such as lock delays, lock size, overhead clearances, and others, are discussed in this section. In addition, needs identified by the USACE to mitigate current conditions and improve barge transport efficiencies in the future are also noted.

LOCK INFRASTRUCTURE

There are presently four locks on the CAWS system between Brandon Road and Lake Michigan. One of these locks, the Chicago Lock, is generally not open to barge traffic, except during closures at T.J. O'Brien Lock.

- **Chicago Lock:** The Chicago Lock is located at the entrance to Lake Michigan in Chicago, on the Chicago River. It primarily handles recreational vessels and tour boats. The lock chamber is 600 feet long x 80 feet wide x 22 feet deep. It takes about 12-15 minutes to cycle through the lock. On a busy day, 50-100 vessels can be locked simultaneously. On average, the lock cycles 12,000 times annually.
- **T.J. O'Brien Lock:** The O'Brien Lock is located approximately 7 miles from Lake Michigan, on the Calumet River. O'Brien Lock is a low lift sector gate lock. It provides a maximum lift of 5.0 feet for traffic passing from Lake Michigan to the Little Calumet River. The lock chamber is 1000 feet long by 110 feet wide. The adjacent dam is 257 feet in length and comprised of two sections. It takes approximately 15 minutes to cycle through the lock. The lock handles both non-cargo and cargo vessels.
- **Lockport Lock:** The Lockport Lock is located on the Chicago and Sanitary and Ship Canal. Lockport Lock and Dam are 291 miles above the confluence of the Illinois River with the Mississippi River at Grafton, Illinois. The complex is two miles southwest of the city of Lockport, Illinois. The lock is 110 feet wide by 600 feet long. It averages 22.5 minutes to fill the lock chamber; 15 minutes to empty. The majority of vessels using this lock are barge, with limited non-cargo vessels.
- **Brandon Road Lock:** This is the located south of the CAWS study area. It is included here for reference purpose, since all alternatives will involve modifications to this Lock. It is 2 miles southwest of Joliet, IL. The lock is 110 feet wide by 600 feet long. It averages 19 minutes to fill the lock chamber; 15 minutes to empty. The majority of vessels using this lock are barge, with limited non-cargo vessels.

The locks on the CAWS have significant infrastructure challenges, including length of chamber, usable length of chamber, width of chamber, and usable width of chamber. Chamber length is an issue for all of the CAWS locks – none have the ability to accommodate a typical 3-barge by 5-barge configuration powered by a single tow that is 105 feet wide and 1,200 feet long. Width is also important, both in the lock and waterway, as sufficient width is needed to ensure that

barges can safely pass each other. At most locations the canal widens in the vicinity of the locks to accommodate traffic entering and exiting. However, the Brandon Road Lock, downstream of the CAWS has a 160-foot channel width that makes it extremely difficult to operate vessels in two-directions, thus limiting the practical barge configuration that may operate on the CAWS.

Over one-third of the barges traversing these locks currently experience delay due to a combination of factors. As presented in detailed 2013 statistics by lock, the delays are related to vessel processing time, number of barges and vessels, number of lockages, unavailable time, and tons locked are shown in Table 11 and described, below. Note, since this document is focused on cargo-related transportation impacts, discussion of the Chicago Lock is not included, since there is very limited barge traffic at that location.

- Delay Time:** This is considered the time spent by a vessel waiting to navigate a lock. Each of the CAWS locks experiences an average delay of nearly an hour or more per tow. The most significant delays are seen at the Lockport Lock with an average wait of 2.41 hours and with 44 percent of all vessels experiencing delays. Note that this delay time is only reported for tows. In many incidences, recreational vessel operators have precedence over commercial vessels. In addition, recreational vessels may be able to lock with commercial craft, pending permission of the lockmaster, resulting in fewer delays for recreational vessels. This is especially true at T.J. O'Brien Lock, with over 9800 recreational vessels.

Vessel processing time is considered the amount of time it takes to traverse a lock and does not include the time spent waiting to be processed. This processing time includes approach time, entry time, chambering time, and exit time, and also includes turnback times and any time between cuts for multiple-cut lockages. In addition to delay, the average processing time for these locks was up to an hour, with the highest average processing time occurring at the Lockport Lock. As most locks are only 600 feet in length (the T.J. O'Brien Lock is 1,000 feet), each passage requires a double-lockage for barges over 600 feet long.

- Lock Travel Time:** This is the amount of average delay plus average processing time.
- Number of Lockages:** Lockages are considered the movement through a lock. Oftentimes, multiple recreational vessels can be locked in a single lockage resulting in a ratio of vessels to lockages of nearly 3:1 in the case of T.J. O'Brien. Tows do not have this advantage and have almost a 1:1 ratio. Theoretically, the Chicago area locks are currently handling only one-third or less of their designed tonnage capacity; however, unavailable time and limitations of the waterway significantly contribute to reducing the amount of lockages that can be achieved.
- Unavailable Time:** Unavailable time is the total amount of time the lock is not operational in a given year. A lock could be unavailable due to scheduled or unscheduled maintenance, weather, etc. The 2013 statistics for unavailable time are a marked decline over previous years with each lock recording unavailable time in 2013. The T.J. O'Brien Lock is the only lock which experienced a decrease in overall unavailable time due to a large reduction in scheduled unavailability.

Table 11: CAWS Lock Usage (2013)

	T.J. O'Brien Lock	Lockport Lock	Brandon Road Lock
Tons Locked	5,257,864	9,889,403	10,427,098
Lock Travel Time			
Average Delay (Tows) (Hrs.)	0.04	2.41	0.88
Average Processing Time (Hrs.)	0.21	1.02	0.81
Average Delay + Processing Time (Hrs.)	0.25	3.43	1.69
Percent Vessels Delayed (%)	1	44	36
Number of Barges and Vessels			
Barges Empty (#)	1,716	3,689	3,870
Barges Loaded (#)	3,195	5,845	6,193
Total Barges (#)	4,911	9,534	10,063
Commercial Vessels (#)	1,732	2,772	3,066
Non-Commercial Vessels (#)	55	8	12
Recreational Vessels (#)	9,822	422	555
Total Non-Barge Vessels (#)	11,609	3,202	3,633
Number of Lockages			
Commercial Lockages (#)	1,648	2,775	2,976
Non-Commercial Lockages (#)	53	8	11
Recreational Lockages (#)	3,300	302	321
Non-Vessel Lockages (#)	0	0	1
Total Lockages (#)	5,001	3,085	3,633
Unavailable Time (annual hours)			
Scheduled Unavailability (#)	36	17	72
Scheduled Unavailable Time (Hrs.)	12.22	8.32	63.17
Unscheduled Unavailability (#)	3	39	71
Unscheduled Unavailable Time (Hrs.)	74.65	23.27	59.45
Unavailability (#)	39	56	143
Unavailable Time (Hrs.)	86.87	31.58	122.62

Source: U.S. Army Corps of Engineers Note: The Chicago Lock is not included in this table since it no longer serves as a primary barge lock.

Overhead structures, weather, and waterway levels are also key barriers to commercial navigation along the CAWS. These are described below.²

- **Overhead structures:** There are a number of low clearance railroad bridges along the CAWS. The most noteworthy is the Lemont rail bridge, owned by BNSF, over the Chicago Sanitary and Ship Canal. This bridge is effectively fixed with a vertical clearance of 19.1 feet and can be a barrier to barge traffic. Due to this severe vertical clearance, large tows can only pass if they have telescoping pilothouses, and other types of barges must be reconfigured in order to clear the bridge and travel between the Illinois River and the CAWS. Tow height is important as pilots must be able to see the front of their barge configuration. The six-barge tows seen on the waterways of Chicago are able to suffice with a pilothouse of 28 feet. Larger configurations on the Mississippi River, in contrast, have pilothouses upwards of 54 feet. It is noted that on a number of occasions each year, commercial vessels such as USACE heavy crane barges and large passenger vessels (e.g., tour boats) are prevented passage between the MRS and the Great Lakes. In some cases, where it is possible, large equipment is rerouted along next best watercourse or transit options. The BNSF is currently considering the replacement of this bridge, which would include a greater vertical clearance.

Several of the roadway and rail bridges over the Chicago River, between Monroe Street and Addison Street, provide only 18-19 feet of clearance.

Additional low structures found on the Chicago Sanitary and Ship Canal and the Cal-Sag Channel are also barriers to navigation. Some of the bridges with the lowest vertical clearances include³:

- Belt Railway Chicago Railroad Bridge, RM 317. Vertical clearance is 17.8 feet. Does not open for navigation.
 - South California Avenue Bridge, RM 320. Vertical clearance is 17.7 feet. Does not open for navigation.
 - CSX Chessie System/Conrail Railroad Bridge, RM 320. Vertical clearance is 17.0 feet. Does not open for navigation.
- **Weather and Waterway Levels:** In recent years the entire inland waterway system has struggled with both record high and low water levels. These levels cause significant problems for business and navigation. Navigation may cease temporarily as the USACE must remove critical lock operating equipment. Low water levels can also put barges at risk for running aground. In the case of both high and low water levels, it is difficult to develop reliable forecasts for returning waterways back to transportation use, as weather is ever changing and unpredictable.

² USACE, "Appendix D-Chicago Sanitary and Ship Canal," *Great Lakes Navigation System Review Study*, 2002

³ USACE, *Illinois Waterway Navigation Charts*, 2013.

The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) has some control over the Chicago Sanitary and Ship Canal water levels in order to prevent catastrophic flooding in downtown Chicago. Approximately 15 times each year, the Lockport pool is drawn down in anticipation of heavy rains in order to provide additional floodwater storage within the waterway banks. During these drawdowns, river navigation is slowed or halted, depending on how near the tow is located to the open gates or operating controlling works.

CAWS CAPITAL PROGRAM

The USACE has developed a prioritized plan for investment at locks along the CAWS; unfortunately, few of these projects are actually funded, and the list does not fully address the scope of the needs along the CAWS noted in the previous subsection. Maintenance projects and needs are described below:

- Chicago Lock:** The Chicago Lock is one of two locks located at the entrance to Lake Michigan in Chicago; however is generally closed to barge traffic. The Chicago Lock Sector Gate Replacement was completed in April 2011, up until which point there were several infrastructure failures and shutdowns during the last twenty years that closed the lock for up to 6 months at a time.⁴ The Chicago Lock serves barge traffic during the O'Brien Lock maintenance closures which occurred in late 2014 – early 2015.
- T.J. O'Brien Lock:** The T.J. O'Brien Lock is the only commercial access from the Illinois Waterway to Lake Michigan. The USACE estimates that investment of over \$48.4 million is required for major rehabilitation at this location. High usage at this lock, combined with frequent flooding and temperature extremes, has significantly deteriorated the lock concrete, as well as the mechanical and electrical systems. Sections of the lock wall have periodically been removed, but hazards still remain to lock personnel, barges, and their personnel due to the condition of the concrete.

Some maintenance on the lower and upper sector gates occurred in late 2014 and early 2015. This consisted of two separate lock closures of 47 days each: November 3, 2014 through December 19, 2014 and January 5, 2015 to February 20, 2015.⁵ The dewatering of this lock not only allowed for critical maintenance to be performed but also for an inspection of the infrastructure for the first time in nearly 35 years.⁶

⁴ USACE, *Chicago Harbor Lock Sector Gate Replacement – 01 November 2001 – 15 April, 2011*. Presentation on June 15, 2011.

⁵ <http://www.futuresmag.com/2014/10/30/tj-obrien-lock-dam-closure>

⁶ <http://www.mvr.usace.army.mil/Media/NewsReleases/tabid/6637/Article/502064/corps-of-engineers-to-close-tj-obrien-lock-for-critical-maintenance.aspx>

- Lockport Lock:** The Lockport Lock is located two miles southwest of the city of Lockport, Illinois and has a significant 6-stage rehabilitation project underway.⁷ In 2005, the Lockport Pool Approach Dike and Walls were ranked as a Category DSAC II⁸, which is defined as a dam that has confirmed (unsafe) or unconfirmed (potentially unsafe) dam safety issues.
- Brandon Road Lock:** The Brandon Road Lock is located near Rockdale, Illinois and the integrity of the concrete walls on the surrounding portion of the Illinois Waterway is essential to prevent flooding in Joliet. A USACE study⁹ found that a major rehabilitation of this lock and dam, separate from the repair and reinforcement of the concrete walls, could cost \$60 million (\$40 million for lock and \$20 million for dam).
- WRRDA P3 Pilot Program Improvements:** The Water Resources Reform and Development Act of 2014 (WRRDA creates a pilot program to improve the nation's water infrastructure through public-private partnerships. The pilot program is intended to help expedite necessary repairs and upgrades across the waterway transportation network – including lock and dam modernization along the Mississippi and Illinois Rivers. 15 pilot projects will be selected. The T.J. O'Brien, Lockport and Brandon locks are part of the pilot program application submitted by the State of Illinois. No decision has been made yet regarding the status of this pilot program.
- M5 Maritime Corridor:** The Maritime Administration has designated 11 Marine Highway Corridors. These corridors identify routes where water transportation presents an opportunity to offer relief to landside corridors that suffer from traffic congestion, excessive air emissions or other environmental concerns and other challenges. One such corridor is the M-55 Corridor, which serves to relieve congestion on I-55. The CAWS is part of the M-55 Maritime Corridor.

3.1.2 Maritime Transportation Operation Considerations

The existing operational requirements and considerations regarding waterway elevations are another key factor influencing maritime transportation usage of the CAWS. These considerations include requirements related to navigation and flood risk management that are influenced by CAWS waterway elevations as well as Lake Michigan elevations. Consequently, the variance in these waterway elevations impacts the vertical clearance for maritime vessels

⁷ USACE, *Project Factsheet for: Lockport Dam, Illinois Waterway Locks and Dams*, 2012. <http://www.mvr.usace.army.mil/Media/FactSheets.aspx>

⁸ Dam Safety Action Classification ratings include: DSAC I – URGENT AND COMPELLING (Unsafe), DSAC II – URGENT (Unsafe or Potentially Unsafe), DSAC III – HIGH PRIORITY (Conditionally Unsafe), DSAC IV – PRIORITY (Marginally Safe), and DSAC V – NORMAL (Safe)

⁹ USACE, *Inland Marine Transportation Systems (IMTS) Capital Projects Business Model Final Report*, April 2011

beneath numerous bridges spanning the CAWS, ultimately determining the ability and frequency of movements for various maritime vessels.

CAWS ELEVATION REQUIREMENTS

For maritime navigation on the CAWS, the Code of Federal Regulation (CFR) includes sections specific to the Chicago (33 CFR 207.420) and Calumet (33 CFR 207.425) Rivers that require the following:

- Chicago and Calumet Rivers riverside of the Chicago River and T.J. O'Brien Locks be maintained between -0.5 ft and -2.0 ft Chicago City Datum (CCD) [Note: 0.0 ft CCD = 579.5 ft NGVD]
- Chicago and Calumet Rivers be maintained at levels lower than Lake Michigan except when Lake Michigan water levels are less than -2.0 ft CCD or during excessive storm runoff

The CAWS waterways and control structures that provide for maritime transportation also provide a flood risk management function for the City of Chicago and the MWRDGC. Therefore, CAWS operational guidelines related to flood risk management also exist which include:

- Opening of Chicago River Controlling Works and T.J. O'Brien Controlling Works sluice gates when Chicago and Calumet River levels riverside of the locks reach +3.0 ft CCD (582.5 ft NGVD) and indication exists that river levels will continue to rise with the possibility of exceeding +3.5 ft CCD
- Opening of Chicago Lock and T.J. O'Brien Lock sector gates opened as emergency measure if possibility exists for river levels to exceed +3.5 ft CCD with sluice gates already opened

The combination of federal navigation requirements and the local flood risk management operations of the CAWS also provide for the following general navigation operation guidelines:

- Navigation is halted at the Chicago River and T.J. O'Brien locks during excessive storm events when river levels exceed Lake Michigan elevations (Lake Michigan elevations above -2.0 ft CCD); typically this is accompanied by opening of sluice and/or sector gates at Chicago River and T.J. O'Brien Controlling Works
- Navigation is halted at Lockport Lock when flows in this segment of the CAWS \geq 7,200 cfs due to velocity and safety concerns of maneuvering through bridge openings

HISTORICAL LAKE MICHIGAN AND CAWS ELEVATIONS

Given the interdependence of the CAWS water levels and Lake Michigan elevations, an understanding of the variability in Lake Michigan elevations provides further context for maritime transportation operations. The monthly average Lake Michigan elevation has generally varied between +3.0 ft and -3.0 ft CCD over the past 100 years (Figure 12), with an overall period of record average of 0.0 ft CCD. Furthermore, this indicates Lake Michigan has cycled through

lower and higher lake level periods during this time based on near term weather and climate patterns. Lake Michigan is, on average, approximately 0.5 ft higher than the typical maximum CAWS water level of -0.5 ft CCD. A closer look the frequency of Lake Michigan elevations relative to the CAWS indicates the probability of Lake Michigan elevations exceeding the typical maximum CAWS water level of -0.5 ft CCD is approximately 60% (Figure 13), i.e. Lake Michigan elevations exceed -0.5 ft CCD (typical maximum CAWS water level) approximately 60% of the time. While more recent data records of the past 17 years (daily stage from USGS Gage 04087440 – Lake Michigan at Chicago Lock) indicate Lake Michigan elevations exceeded -0.5 ft CCD approximately 25-30% of the time, this is likely a temporary low lake level period similar to other cycles during the nearly 100 year period of record of monthly average stages.

Figure 12: Historical Lake Michigan Elevations

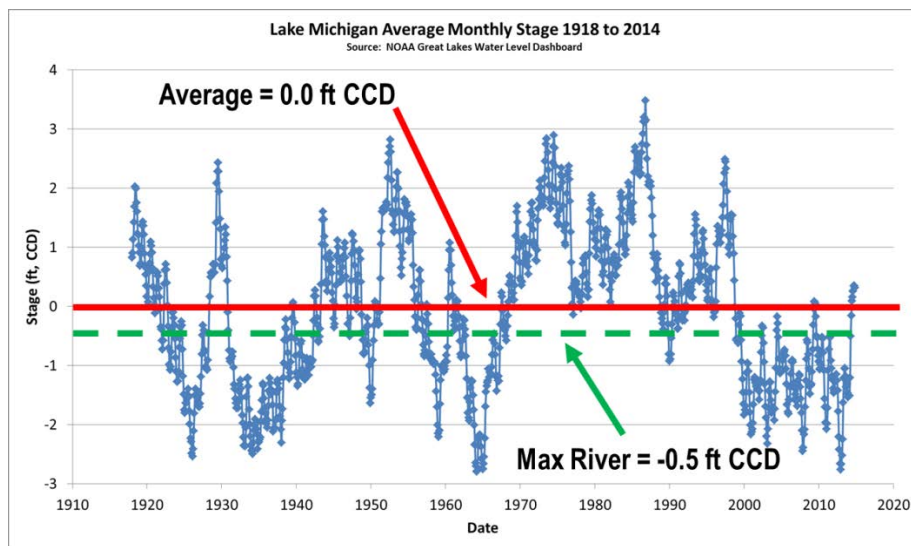
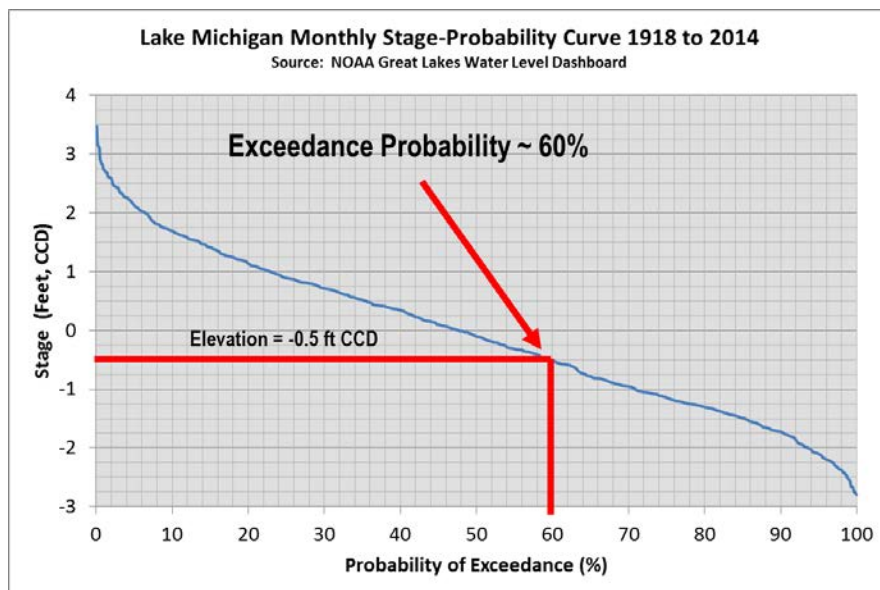


Figure 13: Frequency of Lake Michigan Elevations Exceeding CAWS Water Level



CAWS VESSEL SIZES AND CLEARANCES

Variations in the CAWS water levels are critical to maritime transportation on the CAWS because maritime vessel clearance above the waterway is limited by extensive infrastructure, primarily highway and rail bridges. While many highway and rail bridges over the CAWS are moveable in some capacity (i.e. lift, bascule, swing), these movements are generally limited in frequency because of high levels of highway and rail traffic, and avoided by maritime vessels to limit transit times. Consequently, the typical maximum 'air draft' (vessel height above the water) for commercial cargo vessels on the CAWS is between 17 ft. and 19 ft. to provide vertical clearance for most bridges identified in the USACE 2013 Illinois Waterway Navigation Charts. Discussions with commercial cargo operators and review of CAWS water level information and USACE 2013 Navigation charts provide the following understanding of commercial cargo vessel sizes, clearances, and operations on the CAWS:

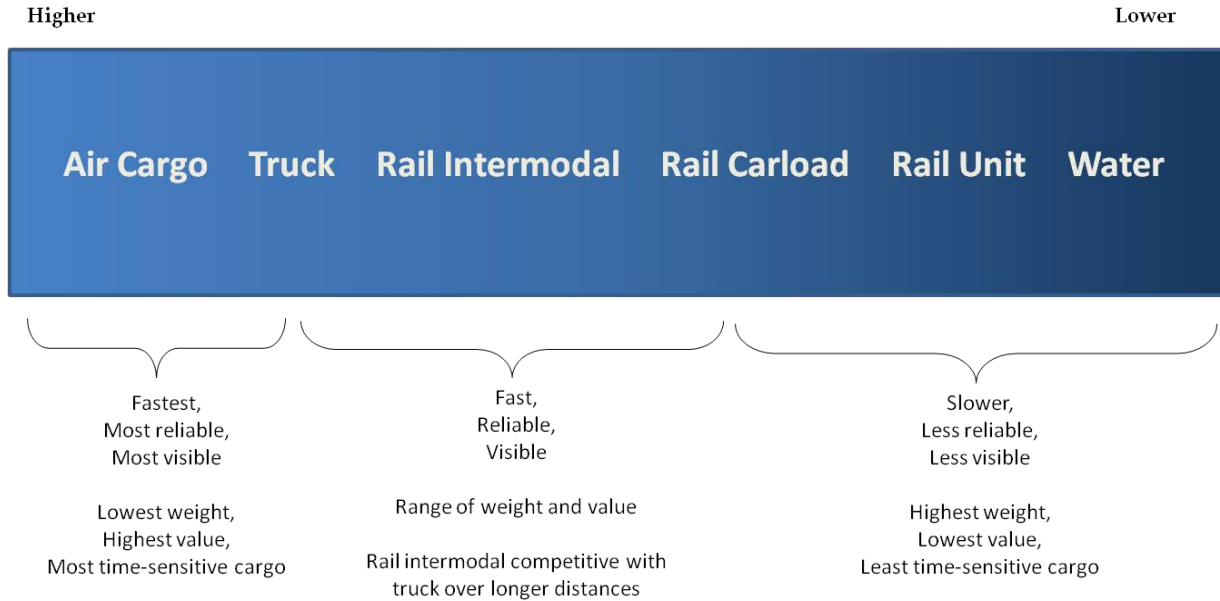
- Chicago River System
 - Typical maximum 'air draft' is 17 ft.
 - Michigan Avenue bridge is the critical pinch point on Chicago River → 17.2 ft. clearance @ -0.5 ft CCD
 - During high water levels (i.e. excessive storms events) traffic may stop due to bridge clearances, or smaller vessels are used
- Calumet River System
 - Typical maximum 'air draft' estimated between 17 and 19 ft. (including retractable pilot houses)
 - Lowest clearance bridges are located on Calumet River lakeside of T.J. O'Brien Lock and are subject to Lake Michigan elevations, though all are lift bridges that typically require opening
 - Bridges riverside of T.J. O'Brien Lock are all fixed (non-movable) with lowest clearance of 23.5 ft @ -0.5 ft CCD
 - Typical clearance/freeboard of 4.5 ft. may allow for slight increase in river elevation above -0.5 ft CCD while maintaining navigation operations

3.1.3 Transportation Usage, Commodities and Industries

Each freight mode offers certain advantages and disadvantages in terms of cost, speed, reliability, visibility, and security, with shippers buying freight services that best fit their specific shipping needs. These factors are important when evaluating if certain commodities that are currently shipped by water would realistically switch to another mode. One way to visualize these advantages and disadvantages is as a spectrum of freight transportation services, shown in Figure 14. On one end of the spectrum is water transportation, which tends to be the lowest-cost carrier, but also provides the slowest service. At the other end of the spectrum is air freight services, which offer fast and reliable shipment, but at much higher prices. Between these extremes are truck, intermodal, and rail services. And within each mode, there are different types and levels of service available (e.g., single-customer truckload versus multi-customer less-than-truckload common carrier service, and container- or trailer-on- flatcar rail service versus carload rail service). As a general rule of thumb, higher-value, lower-weight and more

time-sensitive freight is shipped by truck and air, while lower-value, heavier weight and less time-sensitive freight moves by rail and water.

Figure 14: Freight Transportation “Service Spectrum”



COMMODITIES

The inland waterway system plays an important role in regional, national and international commerce, but typically handles high weight, low value commodities. These commodities serve industries that transport large quantities of goods without restrictive delivery windows, like mining, agriculture, and construction. Table 12 illustrates types of commodities typically traveling on the inland waterway system. Since 1971, total demand on the U.S. Inland Waterway System has been relatively flat, and the 2007-2009 recession added to this decreasing trend, although there has been some recovery of domestic tonnage from the 2009 lows.¹⁰ Demand on the Chicago Area Waterway System (CAWS) is consistent with these national trends.

Table 12: Inland Waterway System Primary Industries and Commodities

Primary Industry	Commodities*
Agriculture	Fertilizers, Chemical Products
Construction	Natural Sands, Gravel and Crushed Stone, Nonmetallic Minerals-n.e.c., Logs and Other Wood in the Rough, Wood Products, Nonmetal Mineral Products
Food Processing	Cereal Grains, Other Agricultural Products, Animal Feed, Milled Grain Products and Preparations, and Bakery Products, Other Prepared Foodstuffs, and Fats and Oils

¹⁰ AASHTO Water Bottom Line Report, 2011

Primary Industry	Commodities*
Manufacturing	Other Prepared Foodstuffs, and Fats and Oils, Chemical Products, Nonmetal Mineral Products, Base Metals, Metallic Ores , Waste/Scrap
Power Generation	Coal, Gasoline, Coal and Petroleum Products- n.e.c.
Printing	Pulp, Newsprint, Paper, and Paperboard
Recycling	Waste/Scrap
Retail	Alcoholic Beverages, Wood Products, Furniture
Various	Basic Chemicals

*n.e.c. = not elsewhere classified

Figures 16 and 17 show the marine flows by commodity for the Greater Chicago region as reported in 2011. This includes the Chicago, T.J. O’Brien, Lockport, Brandon Road and Dresden Island Locks, as well as portions of the Greater Chicago area that touch Indiana, as shown in Figure 15. Gravel and coal products dominate flows by tonnage, comprising more tons than all other commodities combined in 2011. Gravel can be associated with the construction industry. Chemicals and coal dominated the movements by value in 2011. Chemicals can be associated with several industries including agriculture, manufacturing and other various industries. Coal is most often linked to power generation.

Figure 15: Chicago Region as Defined in FHWA Freight Analysis Framework (FAF)

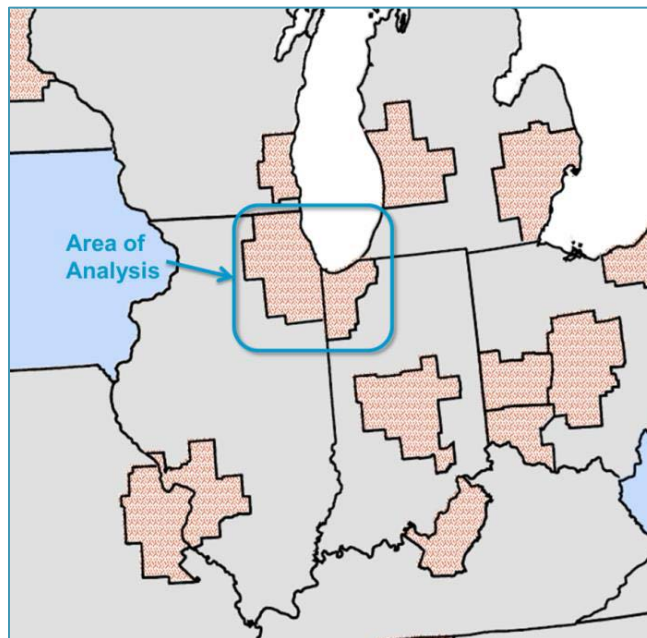
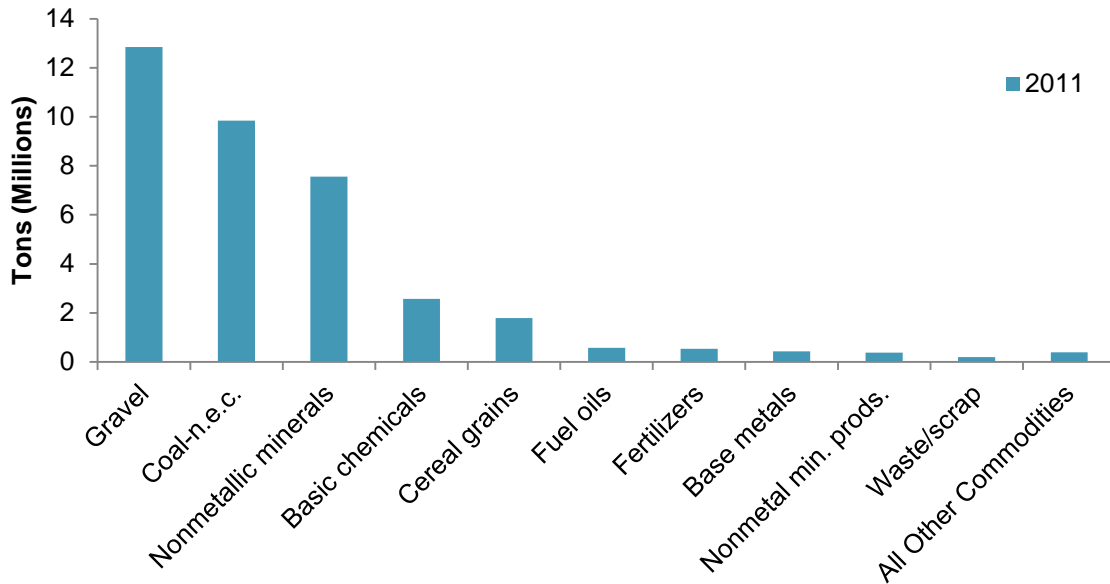
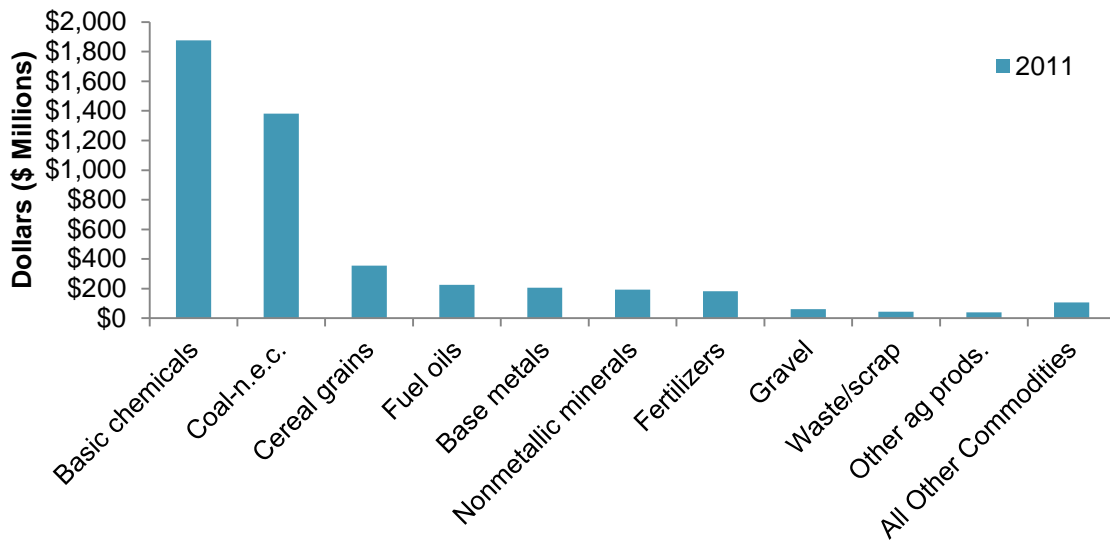


Figure 16: Greater Chicago Region Marine Flows by Commodity, Tons (2011)¹¹



Source: FAF3.4, Greater Chicago Region – IL and IN portions. Inland waterway freight only.

Figure 17: Greater Chicago Region Marine Flows by Commodity, Value (2011)



Source: FAF3.4, Greater Chicago Region – IL and IN portions. Inland waterway freight only.

¹¹ N.e.c. stands for not elsewhere classified.

Figures 16 and 17 reveal that although gravel is the leading commodity in terms of tonnage, it is one of the lowest in terms of value. Coal is one of the highest in both tonnage and value.

INDUSTRIES

The CAWS serves a variety of businesses and industries. The 2013 U.S. Navigation Charts were reviewed to determine the locations and types of currently operating barge facilities that are located on the CAWS. 80 existing and functioning cargo docks or barge facilities are located lakeside of the proposed alternative scenario locations at Stickney and Alsip. See Table 13, Figure 18, and Figure 19.

Upper CAWS: There are a total of 67 existing and functioning cargo docks or barge facilities located on the water segments that make up the Upper CAWS from the Lockport Lock up to and including the North Branch of the Chicago River. Of these, 24 (or 36%) are located lakeside of the proposed scenario near Stickney (RM 317).

Lower CAWS: Between the confluence of the Des Plaines River/Cal Sag Channel and the Calumet Port, there are total of 59 existing and functioning cargo docks or barge facilities on the lower CAWS segments. Nearly all of them are located lakeside of the proposed scenario at Alsip (RM 314). The majority of these are located at Lake Calumet or on the Calumet River/Harbor. The majority of the barge facilities are marine cargo handling, warehousing and storage facilities; and construction and building related.

The 80 currently operating barge facilities and docks, and their geographic relation to the proposed alternative scenario locations, are shown in Table 13 (Upper CAWS and Lower CAWS). In Figure 18, it is noted that 14 industries are located between the Stickney Wastewater Treatment Plant and Bubbly Creek. Depending on the actual location of the lock/barrier, some or all of these industries could be impacted.

In Figure 19, it is noted that most of the industries are located in the deep draft area of Lake Calumet and Calumet River/ Harbor, and upstream of the T.J. O'Brien Lock. Only four industries are located in the shallow draft of the Cal Sag Channel and the Calumet River.

Table 13: Facilities Lakeside of Proposed Scenarios

Upper Caws			
	Name	Waterway	Commodity
1	Ameropan Oil Corp., Bell Oil Terminal Wharf	CSSC	Petroleum and Petroleum Products
2	Citgo Petroleum Corp., Cicero Compound Plant Wharf	CSSC	Petroleum and Petroleum Products
3	Mobil Oil Corp., Cicero Avenue Dock	CSSC	Petroleum and Petroleum Products
4	Koppers Industries, Stickney Terminal Wharf	CSSC	Coal Lignite and Coal Coke
5	Olympic Oil Wharf	CSSC	Petroleum and Petroleum Products
6	Koch Fuels, Marine Oil Terminal, Chicago Wharf	CSSC	Petroleum and Petroleum
7	Reliable Asphalt Corp. Wharf	CSSC	Petroleum and Petroleum Products
8	Prairie Material Yard 33	CSSC	Primary Manufactured Goods
9	Ameropan Oil Corp., 33rd St. Terminal Dock	CSSC	Petroleum and Petroleum Products
10	Prolerized Chicago Corp. Wharf	CSSC	Unknown or Not Elsewhere Classified
11	Domino Sugar Corp., Chicago Wharf	CSSC	Food and Farm Products
12	Hanson Material Service, Damen Ave Mooring	CSSC	Crude Materials Inedible Except Fuels
13	Tri-River Docks, Damen Ave Terminal Wharf	CSSC	Crude Materials Inedible Except Fuels
14	Sims Metal Management South Paulina St Yard Wharf	CSSC	Primary Manufactured Goods
15	E.A. Cox Construction Co. Wharf	South Branch Chicago River	Crude Materials Inedible Except Fuels
16	Commonwealth Edison Co., Loomis St Coal Storage Terminal	South Branch Chicago River	Coal Lignite and Coal Coke
17	Ozinga Chicago RMC Inc.	South Branch Chicago River	Primary Manufactured Goods
18	City of Chicago Recycling Wharf	South Branch Chicago River	Unknown or Not Elsewhere Classified
19	Morton Salt, Elston Ave Wharf	South Branch Chicago River	Chemicals and Related Products
20	Prairie Material Yard 32	South Branch Chicago River	Primary Manufactured Goods
21	Ogden Ave Materials Wharf	South Branch Chicago River	Petroleum and Petroleum Products
22	Sims Metal Management Cortland Wharf	South Branch Chicago River	Primary Manufactured Goods
23	Ozinga Chicago Ready Mix Concrete Inc.	South Branch Chicago River	Primary Manufactured Goods
24	General Iron Industries Recycling Center	South Branch Chicago River	Primary Manufactured Goods



Lower Caws			
	Name	Waterway	Commodity
1	Valero L.P., Blue Island Terminal	Cal-Sag Channel	Petroleum and Petroleum Products
2	Prestone Products Co	Cal-Sag Channel	Chemicals and Related Products
3	Nustar Blue Island Terminal Wharf	Cal-Sag Channel	Petroleum and Petroleum Products
4	Sims Metal Management Ewing Wharf	Calumet River	Primary Manufactured Goods
5	North American Salt Co., Chicago Plant Wharf	Calumet River	Chemicals and Related Products
6	Great Lakes Towing Co., Calumet River Dock	Calumet River	Unknown or Not Elsewhere Classified
7	The Brown 95th St Wharf	Calumet River	Unknown or Not Elsewhere Classified
8	Holcim Chicago South Terminal, 95th St	Calumet River	Primary Manufactured Goods
9	Cozzi Calumet River Wharf	Calumet River	Crude Materials Inedible Except Fuels
10	Kindra Lake Towing Slip	Calumet River	Unknown or Not Elsewhere Classified
11	Morton Salt, Calumet River Wharf	Calumet River	Chemicals and Related Products
12	S. H. Bell Co., Chicago Terminal, North Slip	Calumet River	Terminal
13	S. H. Bell Co., Chicago Terminal, Middle Slip	Calumet River	Terminal
14	S. H. Bell Co., Chicago Terminal, South Slip	Calumet River	Terminal
15	S. H. Bell Co., Chicago Terminal, Barge Wharves	Calumet River	Terminal
16	KCBX Terminals Co., Loading Wharf	Calumet River	Coal Lignite and Coal Coke
17	Calumet River Terminal	Calumet River	Terminal
18	Arcelormittal Long Carbon North America, Calumet Depot	Calumet River	Primary Manufactured Goods
19	Carmeuse Lime, North Wharf	Calumet River	Crude Materials Inedible Except Fuels
20	Carmeuse Lime, South Wharf	Calumet River	Crude Materials Inedible Except Fuels
21	Specialty Steel Products Wharf	Calumet River	Primary Manufactured Goods
22	Beemsterboer Slag and Ballast Wharves	Calumet River	Crude Materials Inedible Except Fuels
23	Midwest Marine Terminals	Calumet River	Terminal
24	Hanson Material Service, Yard No. 20 Wharf	Calumet River	Crude Materials Inedible Except Fuels
25	E L G Metals Inc.	Calumet River	Primary Manufactured Goods
26	Holcim Chicago South Terminal, 103rd St	Calumet River	Primary Manufactured Goods
27	KCBX Terminals Co., Barge-Unloading Slip	Calumet River	Coal Lignite and Coal Coke
28	Omni Materials Inc., Calumet River Wharf	Calumet River	Primary Manufactured Goods



Lower Caws			
	Name	Waterway	Commodity
29	Arro Corporation, Calumet River Wharf	Calumet River	Unknown or Not Elsewhere Classified
30	Asphalt Operating Services of Chicago, LLC (AOSC)	Calumet River	Petroleum and Petroleum Products
31	DTE Chicago Fuels Terminal	Calumet River	Coal Lignite and Coal Coke
32	Walsh Construction	Calumet River	Primary Manufactured Goods
33	Horsehead Resource Development Co., Chicago Wharf	Calumet River	Primary Manufactured Goods
34	Nidera - Chicago & IL River Marketing	Calumet River	Unknown or Not Elsewhere Classified
35	Midwest Marine Terminals	Calumet River	Terminal
36	Reserve Marine Terminals, Calumet River Dock #2	Calumet River	Terminal
37	Cargill, Chicago Grain Wharf	Calumet River	Food and Farm Products
38	PVS Chemical Solutions Wharf	Calumet River	Chemicals and Related Products
39	Cargill, Chicago Salt Wharf	Calumet River	Food and Farm Products
40	Kinder Morgan Ferro Operation Wharf	Calumet River	Primary Manufactured Goods
41	S.E.E. Terminal Wharf	Calumet River	Terminal
42	Domino Sugar Dock	Calumet River	Food and Farm Products
43	Kinder Morgan Chicago Terminal, Docks, A&B Wharves	Calumet River	Unknown or Not Elsewhere Classified
44	S.H. Bell Co, Lake Calumet Terminal	Calumet River	Terminal
45	First Choice Logistics, Inc. Wharf	Calumet River	Unknown or Not Elsewhere Classified
46	Scrap Corp. of America, Butler Wharf	Calumet River	Primary Manufactured Goods
47	Lafarge North America, Inc.	Calumet River	Primary Manufactured Goods
48	PM AG Products	Calumet River	Food and Farm Products
49	Continental Grain Company, Lake Calumet Terminal	Calumet River	Food and Farm Products
50	IL Intl Port District, Grain and Liquid Bulk Storage Terminal	Calumet River	Terminal
51	St. Mary's Cement, Lake Calumet Plant Dock	Calumet River	Primary Manufactured Goods
52	Sims Metal Management, Lake Calumet, Harbor Wharf	Calumet River	Primary Manufactured Goods
53	Town and County Landscaping	Calumet River	Manufactured Equipment and Machinery
54	Emesco Marine Term, Lake Calumet Slip	Lake Calumet	Crude Materials Inedible Except Fuels
55	Interstate Steel Processing	Lake Calumet	Primary Manufactured Goods
56	Steel Coils, Inc. Dockside Processing Center	Lake Calumet	Primary Manufactured Goods

Figure 18: Lakeside Cargo Docks and Barge Facilities: Upper CAWS (not to scale)

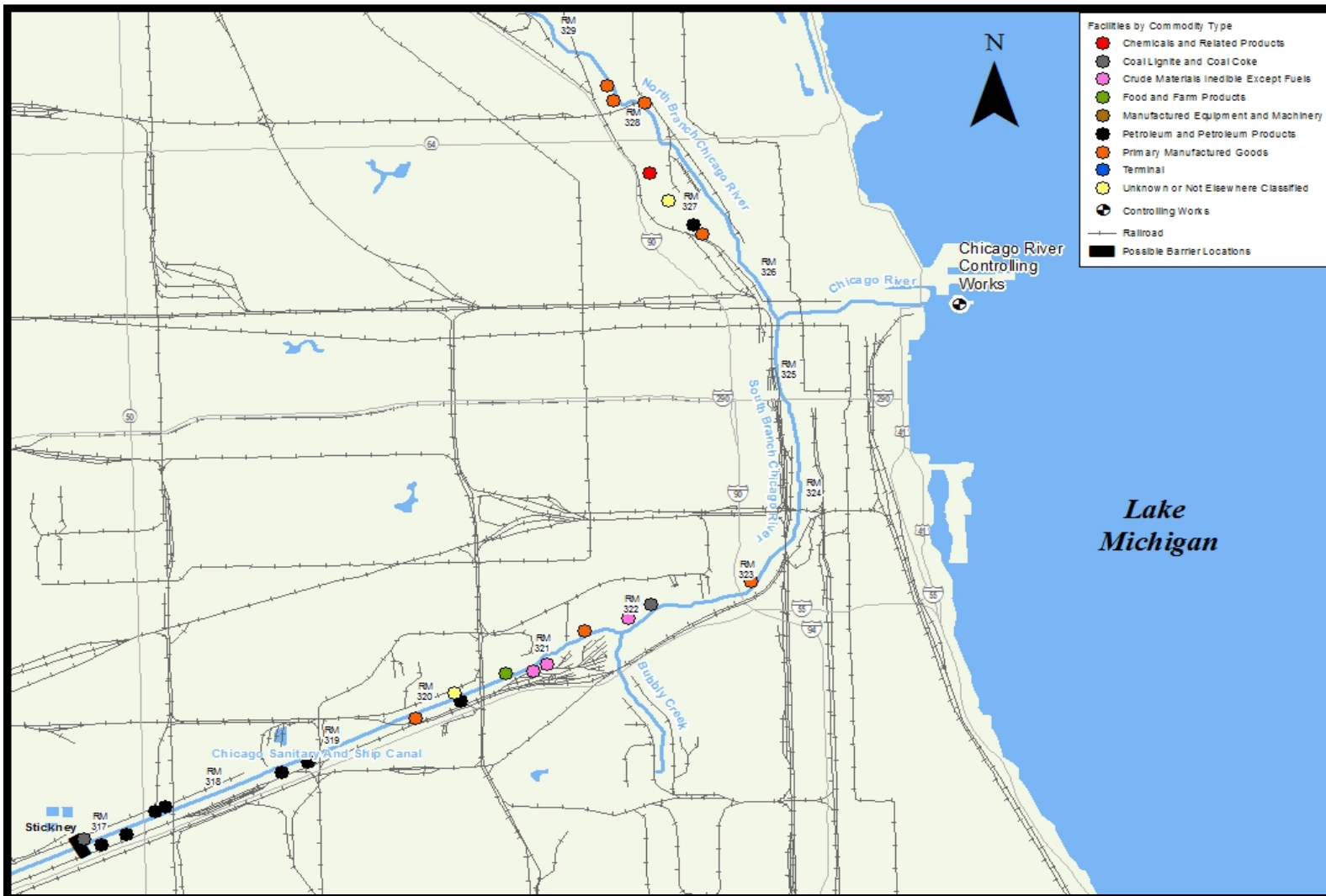
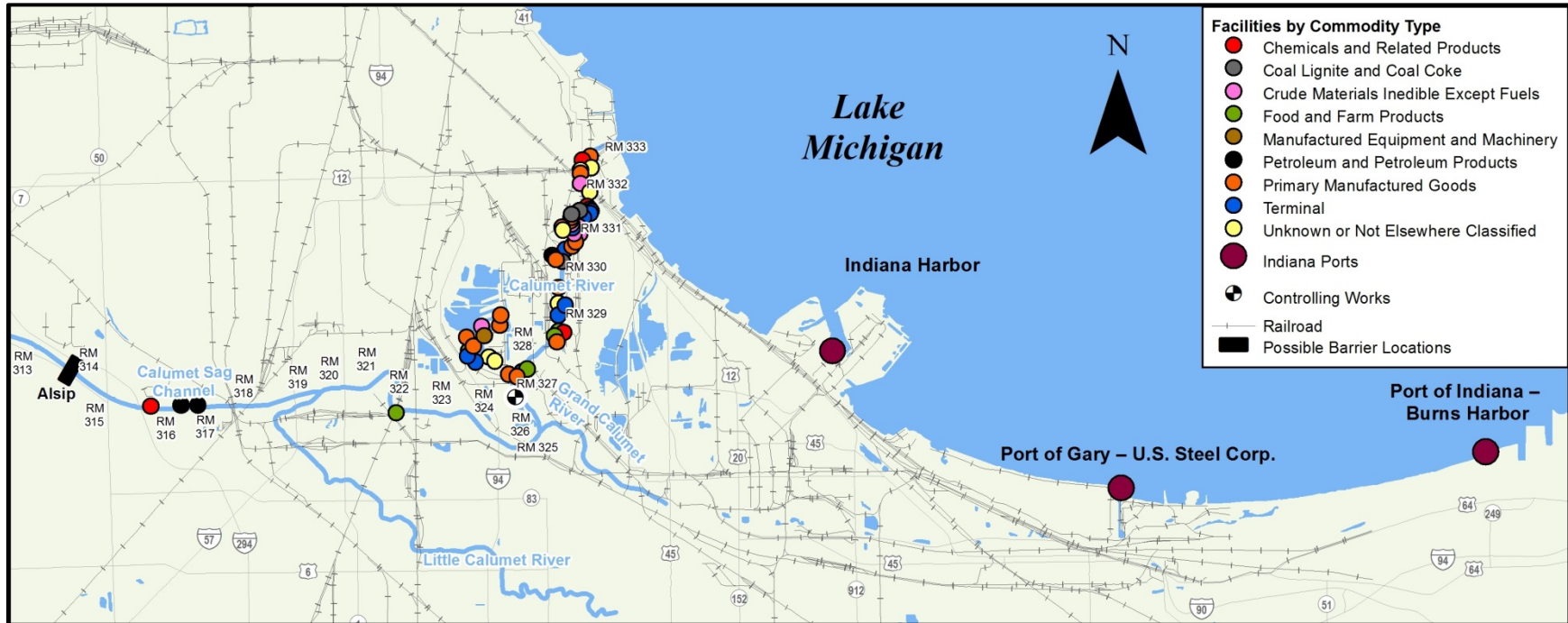


Figure 19: Lakeside Cargo Docks and Barge Facilities: Lower CAWS (not to scale)



3.2 Trends Analysis

The maritime demand in the Greater Chicago region is dominated by gravel, coal, and non-metallic minerals, with basic chemicals and cereal grains making up most of the remaining demand (by weight). However, there are several trends that will influence demand for these commodities moving forward, as described below:

- Coal:** Recent trends suggest that coal trade will decrease significantly over the next several years. A report by the Lake Carriers Association shows significant decreases in coal moved on the Great Lakes over the past 6 years, with an 8.2 percent decrease between 2011 and 2012, resulting in a 2012 value that was 25 percent less than the prior five-year average.¹² This trend is expected to continue into the future. For example, Ontario Power Generation, one of the largest power companies in North America which used the Great Lakes to transport coal to power plants, stopped using coal as fuel in 2014.¹³ In greater Chicago, a reduction in coal transport is seen both on Lake Michigan and on the CAWS. In March 2012 the State Line Power Station on Lake Michigan closed, and later that year the Fisk and Crawford coal-fired power plants, serviced by the CAWS, were closed.¹⁴
- Gravel and non-metallic minerals:** It is likely that demand for gravel and non-metallic minerals will increase over the next several years. These commodities typically move upbound on the CAWS and supply construction and ready-mix yards in the City of Chicago. The commercial and residential construction markets in the Chicago area are continuing to recover from the 2007-2009 recession, and new construction contracts are at their highest level since 2008.¹⁵ As the construction markets continue to recover, demand for concrete (and associated sand, gravel, and aggregate) will grow apace.
- Cereal grains:** Increasing demand for agricultural exports through Gulf Coast and Pacific Northwest ports will create increases in demand for cereal grains. However, most of this bulk traffic will remain outside of the CAWS – traveling from the Illinois River System, where producers are located, south towards the Gulf of Mexico for export. Recent studies of new Container-on-Barge (COB) markets for agricultural products focus on movements from the Joliet and Peoria regions to the Mississippi River system downstream, which do not utilize the portion of the CAWS near Lake Michigan.¹⁶ In recent years the Port of Muskegon

¹² Lake Carriers' Association, *2012 Statistical Annual Report*

¹³ Ontario Power Generation, <http://www.opg.com/generating-power/thermal/stations/thunder-bay-station/Pages/thunder-bay-station.aspx>

¹⁴ Wernau, Julie, "Closure of Chicago's Crawford, Fisk electrical plants ends coal era," *Chicago Tribune*, August 2012

¹⁵ Dodge Data & Analytics, December 2014

¹⁶ Illinois Soybean Association, "ISA Study: COB Shuttle Program is Feasible, Offers Biodiesel Opportunities." April 2012

Michigan has expressed interest in establishing a bulk grain barge terminal to transport goods from Michigan to Gulf Coast ports via the CAWS.¹⁷ In order to make these movements the U.S. Coast Guard must establish a special load line-exempted route on Lake Michigan between Chicago (Calumet Harbor), IL, and Muskegon, MI. Comments were accepted on this rulemaking through August 2014; no decision regarding the service has been made.¹⁸

- Petcoke:** Petroleum coke, or “petcoke,” is a solid, carbon material derived as a byproduct of the oil refining process and is typically used as a fuel source in power plants abroad. The petcoke piles along the Calumet River have grown considerably in recent years. The BP Whiting, Indiana Refinery is in high production of petcoke as it is processing heavier crude oil from the oil sands region in Canada. In fact, the Whiting facility is the world’s second-largest source of petcoke. In the fall and winter of 2013, there were several news reports about the petcoke storage piles on the southeast side of Chicago, and the city’s crackdown to ensure that facilities that store and handle this material take measures to prevent the offsite dispersion of dust. As a result of this one company, Beemsterboer Slag Corp., closed down its petcoke storage operation in Chicago and sold its Calumet Transload Facility.¹⁹ Two additional sites on the Calumet River, both operated by KCBX Terminals, are still operational, however in February 2015 BP, KCBX Terminals largest customer, announced that it would no longer ship its petcoke to Chicago.²⁰ KCBX has indicated that their long-term plan is to consolidate the two terminals to a single site, and it will no longer function as a staging area for petcoke, and instead will only transfer petcoke directly from rail cars to barges or other shipping vessels. This will be a temporary solution while the company determines if they will be able to remain in business.²¹

¹⁷ Muskegon port development could mean a river barge terminal linking farmers to Gulf Coast, *mLive*, August 29, 2013, http://www.mlive.com/news/muskegon/index.ssf/2013/08/muskegon_port_development_coul.html

¹⁸ Petition for Rulemaking: Special Load Line Exemption for Lake Michigan (Federal Register Publication), <http://www.regulations.gov/#!documentDetail;D=USCG-2013-0954-0049>

¹⁹ Beemsterboer shuts down petcoke storage terminal in Chicago, *nwTimes*, September 25, 2014, http://www.nwTimes.com/business/local/beemsterboer-shuts-down-petcoke-storage-terminal-in-chicago/article_9cc07f97-d18b-5cd4-b54b-aff3c80967b.html

²⁰ BP to stop sending petcoke to Chicago, *Chicago Tribune*, February 18, 2015, <http://www.chicagotribune.com/news/ct-bp-petcoke-met-20150218-story.html>

²¹ Chicago petcoke announcement raises more questions, *Midwest Energy News*, February 24, 2015, <http://www.midwestenergynews.com/2015/02/24/chicago-petcoke-announcement-raises-more-questions/>

3.3 Mode Shift Potential

The evaluation of impacts from placement of new locks or barriers on the CAWS must take into consideration the potential for existing and future cargo to shift to other modes. Freight transportation is a service purchased by public and private shippers and receivers, and hence the freight transportation market operates in response to shippers’ needs. Shippers and receivers, and their “third-party logistics providers,” typically make their purchasing decisions based on multiple factors, including modal characteristics, commodity characteristics, shipper/ receiver characteristics, total costs, and other factors. The critical factors are listed in Table 14, but the importance of these and other factors is highly dependent on the individual agents making the decisions. The service that a particular shipper chooses depends on the commodity, trade lane, and competitive advantage offered by the different modes.

Table 14: Factors that Affect Freight Modal Choice

Factor Category	Factor
<i>Modal Characteristics</i>	Capacity Trip Time Reliability Equipment Availability Customer Service and Handling Quality
<i>Commodity Characteristics</i>	Shipment Size Package Characteristics Shipment Shelf Life Shipment Value Shipment Density
<i>Shipper and Receiver Characteristics</i>	Access to modes
<i>Logistics Costs</i>	Order and Handling Costs Transportation Charges Capital Carrying Cost in Transit Intangible Service Costs, i.e., Billing Processes Inventory Costs Loss and Damage Costs Service Reliability Costs
<i>Additional Factors</i>	Length of Haul Shipment Frequency Environmental/Sustainability

Sources: NCFRP Report 8, *Freight Demand Modeling to Support Public Sector Decision-Making*, Table 3.6, and Center for Urban Transportation Research, *Analysis of Freight Movement Mode Choice Factors*, Table 4.1.

Although there is significant interest at the federal, state, and local levels in making better use of inland waterway shipping services, affecting a meaningful shift from other modes has proven

challenging. For example, the Port Inland Distribution Network (PIDN) program, which operated between the Port of New York and New Jersey and the Ports of Albany and Boston, was recently canceled due to lack of sufficient volume. An initial testing of a multimodal regional routing model on a scenario increasing annual wheat flows from the Pacific Northwest region through the Columbia-Snake river system showed that even a 20 percent increase in wheat production only produced a 1 percent increase in barge traffic. There are many issues and challenges that impact the viability of inland shipping services to effectively compete for additional traffic, including:

- **Existing infrastructure may not be capable of handling large volumes of inland traffic:** The U.S. inland and coastal waterway systems have not been maintained effectively. In many locations, the waterway infrastructure (locks/dams, channel depths, bridge clearances) is not robust enough to handle commercial traffic. In 2007, the U.S. Army Corps of Engineers found that delays caused by undersized locks and bottlenecks on the Mississippi waterway system added an average of \$72.6 million annually to the cost of shipping. It is unlikely that major investments to maintain or improve the inland waterway infrastructure will be made until there is sufficient commercial traffic; and commercial users are not likely to consider inland shipping as a viable option until the system is improved (and can provide some degree of transit-time reliability).
- **Frequency and flexibility of service does not meet shipper requirements:** In order to compete effectively with trucks, inland operations must offer regularly scheduled service. Service flexibility – a key component of trucking operations – is something that these services must attempt to offer, as well, in order to attract traffic.
- **Cost:** Total trip costs for inland shipping can include multiple drayage, loading, and unloading fees, which tend to make these movements less cost-competitive versus truck movements.
- **Reasons for shippers to switch modes/operations have not been effectively demonstrated or communicated:** The largest challenge to increasing the use of inland waterway services is encouraging shippers to adapt their operations. As an example, studies by the I-95 Corridor Coalition²² and Transport Canada²³ have shown that many shippers and carriers feel that this kind of change in operational strategy can only happen through high-visibility demonstration projects and studies that prove that inland shipping concepts can work in practice. Until inland shipping can demonstrate that it can compete with other modes in cost, speed, and/or reliability, there may be only incremental increases in the use of these services.

The GLMRIS report generally concluded that shippers who currently use the waterway will use the least costly mode if in fact a separation alternative is chosen. Factors that influence the cost

²² I-95 Corridor Coalition, *Short-Sea and Coastal Shipping Options Study*, November 2005.

²³ Transport Canada, *Cross-Border Short Sea Shipping Study*, March 2004.

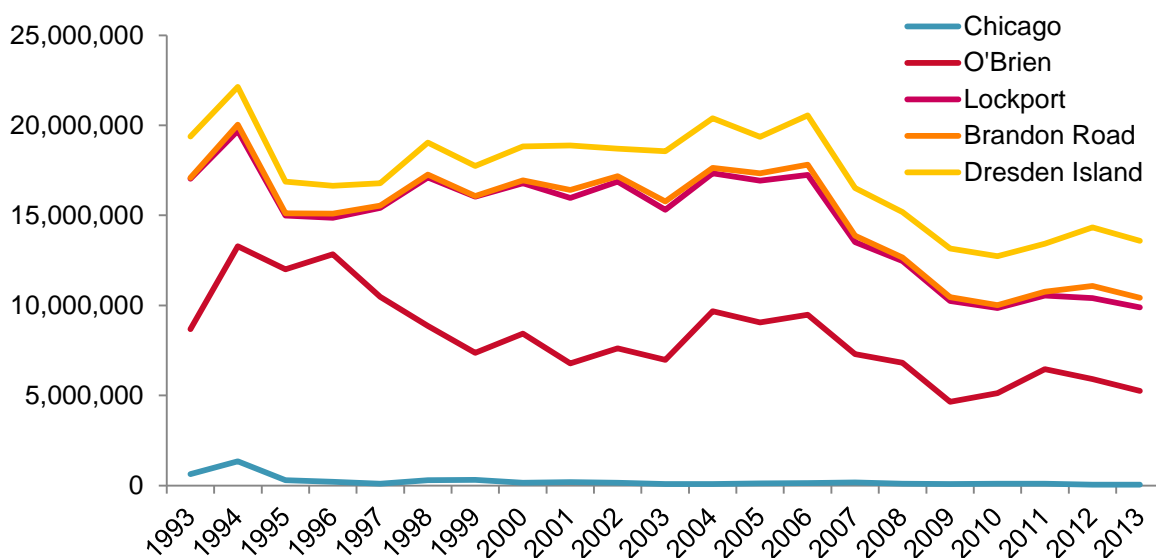
are discussed in Table 14, above. For these trips, GLMRIS assumed that 97% of the existing cargo and trips will re-route; that is, stay on the waterway while avoiding the separation barrier. The three major commodities currently shipped on the CAWS include coal, petcoke and aggregates. The GLMRIS study identified the Centerpoint intermodal and logistics center in the Joliet area as a likely location where these commodities could be shipped to Chicago via rail instead of barge, if the cost to do so was less than using the waterway with a separation alternative. However, the GLMRIS study also indicated that most current CAWS industries do not have the necessary infrastructure in place to switch to rail. Costs of constructing the necessary infrastructure (e.g. rail leads) are in addition to the typically higher costs of transporting by rail or truck.

An evaluation of the transportation impact costs of re-routing versus shifting modes is included in section 3.5 of this document.

3.4 Current and Forecasted CAWS Demand

Maritime tonnage along the CAWS varies significantly by segment due to the locations of the industries along the waterway. In the Chicago region, the Dresden Island Lock to the southwest has the highest volumes of any lock at 13.6 million tons. As one travels northeast on the CAWS towards Lake Michigan, these lock tonnages decrease. The T.J. O'Brien Lock has the lowest tonnage on the CAWS at 5.3 million tons. While the Chicago Lock shows some minimal tonnage each year, this lock is not in active use for barge traffic. As shown in Figure 20, lock usage has dropped off significantly in the last 10 years. While traffic has rebounded some from the lows seen in 2009 and 2010, volumes have yet to fully recover to the pre-recession quantities and have in fact rescinded some the recent high seen in 2011.

Figure 20: Historical Tonnage for Locks on the CAWS, 1993 – 2013

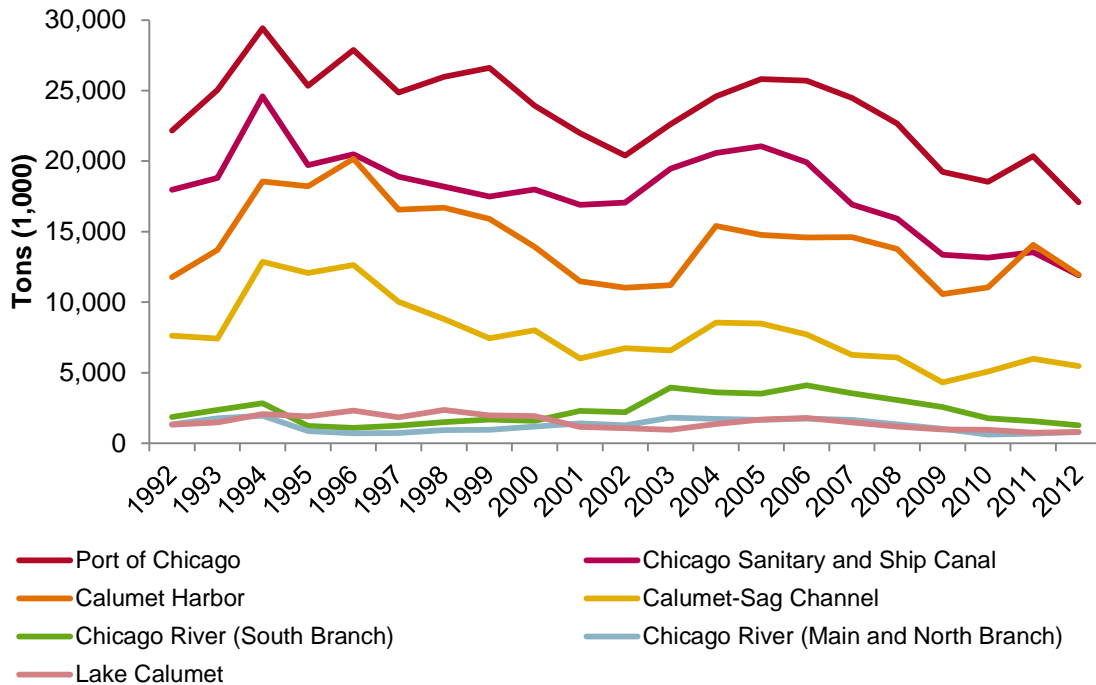


Source: US Army Corps of Engineers Lock Performance Monitoring System.

Similar to the data seen at the locks, reported tonnages on the CAWS have decreased from historic highs due to the recent economic recession. Figure 21 shows the historic tonnage on these segments over the last 20 years. Note that this data is only reported through 2012, unlike the lock data that goes through 2013, due to the timing of the release of the WCUS. In addition, this data includes some intra-CAWS traffic which may not traverse any of the locks. While the lock data showed a relatively steady usage between 1995 and 2006, this data shows that there was a significant drop off in usage in 2002, before rebounding to the highs seen in 2005. Use of the CAWS is currently at its lowest level since 1992. The historical tonnage for the individual waterway segments, as well as the “whole” Port of Chicago, is shown in Figure 21 and are defined as follows:

- Chicago Sanitary and Ship Canal – From Damen Avenue, Chicago to Lockport, IL. Maintained Depth: 9 feet at low water stages.
- Chicago River (Main and North Branch) - Main River from Rush Street to the junction of the North and South Branch; North Branch to North Avenue. Project Depth: 21 feet from Rush Street in the Main River to North Avenue in the North Branch, including the North Branch Canal and the North Turning Branch Basin.
- Chicago River (South Branch) – From Damen Avenue to Lake Street. Maintained Depth: 9 feet at low water stages.
- Lake Calumet - Entrance channel from the Calumet River to a harbor area at the south end of the lake with a channel extending northward for a distance of 3,000 feet and a width of 1,000 feet. Project Depth: 27 feet.
- Calumet Harbor and River - Calumet Harbor and River to Turning Basin No. 5 (130th Street Bridge). Project Depth: 29 feet in approach channel, 28 feet in outer harbor anchorage area, 27 feet in river entrance channel to E. J. & E. R. R. Bridge, and 27 feet in river to and including Basin No. 5.
- Calumet-Sag Channel - From the junction with the Chicago Sanitary and Ship Canal to Blue Island, Little Calumet and Calumet Rivers to Turning Basin No. 5 (130th Street Bridge). Maintained Depth: 9 feet.
- Port of Chicago – Includes the Chicago Harbor, Chicago River, Main and North Branch, Chicago River, South Branch, Chicago Sanitary and Ship Canal, Calumet-Sag Channel and Lake Calumet, and the Calumet Harbor and River.

Figure 21: Historical Tonnage for Waterway Segments of the CAWS, 1992 – 2012



Source: US Army Corps of Engineers Waterborne Commerce of the United States.

*Note that the “Port of Chicago” in this figure represents the entire CAWS, not the Port located in Lake Calumet. Tonnages include inbound, outbound, through, and internal traffic on each segment, as applicable.

3.4.1 Overall Commodity Forecasts, by Commodity

Summaries of current, short term (2020) and longer term (2040) forecasts of future CAWS demand by commodity, and by commodity and waterway segment have been developed. These are based on the publicly available USACE data sources described below.

- Waterborne Commerce of the United States (WCUS):** Waterborne Commerce of the United States, maintained by the U.S. Army Corps of Engineers (USACE), is a series of publications which provide statistics on the foreign and domestic waterborne commerce moved on the United States waterway system. Data is provided on a segmented basis allowing the user to analyze specific portions of the waterway system and details flows by direction and commodity. For the Chicago Area Waterway System (CAWS), data is provided for each of the following segments: Chicago River (Main and North Branches), Chicago River (South Branch), Lake Calumet, Calumet Harbor, Calumet-Sag Channel, Chicago Sanitary and Ship Canal, and the CAWS which combines the statistics of the six waterway segments.
- Lock Performance Monitoring System (LPMS):** The Lock Performance Monitoring System provides data on vessels, both foreign and domestic, which operate on U.S.

waterways and which transited a Corps-owned or operated lock structure. This contains information on the types of vessels transiting the locks, barge tonnages, and delay times. While both the WCUS and the LPMS are maintained by the USACE, data collection efforts are dissimilar and the tonnage estimates from these two sources rarely match.

- Great Lakes and Mississippi River Interbasin Study (GLMRIS):** The Great Lakes and Mississippi River Interbasin Study is a 2012 USACE study which presents a range of options and technologies to prevent aquatic nuisance species (ANS) movement between the Great Lakes and Mississippi River basins. As part of this summary document, baseline and future cargo assessments were conducted. The methodology and projections determined from GLMRIS were consulted to help guide the development of projections presented here, along with input from more recent industry trends and developments. Data from the LPMS and WCUS are summarized into eight main commodity groupings: Coal, Lignite, & Coal Coke; Petroleum & Petroleum Products; Chemicals & Related Products; Crude Materials, Inedible, Except Fuels; Primary Manufactured Goods; Food & Farm Products; Manufactured Equipment & Machinery; and Unknown or Not Elsewhere Classified. The LPMS also provides a ninth category of “Waste Material”; however, this is not found in the WCUS and represents less than one percent of the total traffic at each lock. As such, this category is not discussed here.

Forecasts were developed using a “high” and “low” approach. For each commodity, a number of scenarios were examined for the overall CAWS (also referred to in the data sources as “Port of Chicago”) and trend assessments and best professional judgment was used to determine the most likely range of future demand. Scenarios considered included using a historical average, linear trend analysis, constant percentage growth/decline, or a percentage of commodity movement. These assumptions were influenced by but do not necessarily align with those in the GLMRIS study. In that study, total annual growth was estimated at roughly 4 percent, for a total growth of 37 percent between 2011 and 2020. However, 2011 represents a peak in usage since volumes had decreased during the recession. Both the LPMS and WCUS show a decrease in usage in 2012. With the exception of the Chicago River (Main and North Branches) and Lake Calumet, which have the lowest volumes on the system to begin with, every segment along the CAWS reported a decrease in traffic from 2011 to 2012 ranging from a 9 to 19 percent reduction. As 2013 data is available from the LPMS, this trend is also shown to continue with reductions in traffic reported at all locks on the CAWS between 2011 and 2013.

Looking forward, both local and global market conditions will have an impact on how frequently these commodities utilize the CAWS. The following details the assumptions made for each commodity type in order to determine future volumes along the CAWS.

Group 1: Coal, Lignite, & Coal Coke

Major commodities in this group which are shipped on the CAWS include Coal & Lignite and Coal Coke. As previously discussed coal shipments make up one of the single largest commodity shipments on the CAWS. However, several power plants which used the CAWS to receive coal have shut in recent years, including the Fisk and Crawford plants, the State Line Power Plant, Ontario Power Generation, among others. The Fisk and Crawford plants alone accounted for 55 percent of total coal and coke moving on the CAWS in 2010. Additionally, on March 13, 2014, the City of Chicago passed an ordinance that prohibits the establishment of any new petcoke and coal facilities or the expansion of any existing facilities. Due to these developments, a significant decrease in coal usage along the CAWS is anticipated. Some discussions have arisen regarding the location of a coal gasification plant in or near the city of Chicago which would boost coal shipments; however, plans have stalled and a new plant is not anticipated in the near future.

Group 2: Petroleum & Petroleum Products

Major commodities in this group which are shipped on the CAWS include Asphalt, Tar & Pitch, Petroleum Coke, and Distillate Fuel Oil. The majority of crude oil for the two major crude oil refineries located along the CAWS is received by pipeline. However, the plants are dependent upon barge for the movement of bulk outputs, such as petcoke, asphalt, and high sulfur residuals. Increases in production at these facilities will result in only a modest increase in CAWS usage due to the dependency on pipeline. This is evident in the relatively steady historic volumes seen in the LPMS data. Also, as described previously, the City of Chicago now prohibits the establishment of any new or expanded petcoke and coal facilities.

Group 3: Chemicals & Related Products

Major commodities in this group which are shipped on the CAWS include Sodium Hydroxide and Alcohols however a significant variety of chemicals are distributed utilizing the CAWS. This includes chemicals which are used to deice planes and runways at Chicago's O'Hare International Airport, antifreeze for automobiles, mineral oils, and salts. The GLMRIS report highlights the steady decline in usage of the CAWS for chemical shipments and mentions that proposed storage tank facilities would not be located along the waterway. The forecast trends determined by GLMRIS were adapted for this commodity and growth is anticipated to be relatively flat.

Group 4: Crude Materials, Inedible, Except Fuels

Crude materials include gravel and non-metallic minerals which are another high-volume commodity moving on the CAWS. The decline in volumes of this commodity in recent years can be attributed to the recent economic decline and reduction in construction. As the economy continues to recover, the demand for these products will grow significantly. Conversations with local industry suggest that some construction-related companies are anticipating a growth of

nearly 10 percent annually. This is evidenced by the fact that City of Chicago building permits are up by 46% since 2012.

Group 5: Primary Manufactured Goods

In terms of primary manufactured goods, the most significant goods by volume that move on the CAWS in this category are Cement & Concrete and Primary Iron & Steel Products. Similar to trends in aggregate products, growth of cement & concrete commodities are tied to the rebounding of the construction industry. For iron & steel products, it is more closely tied to the automotive industry as well as the fastener and piping and tubing industries. The use of the CAWS for these products is anticipated to grow as the automobile and construction industries rebound.

Group 6: Food & Farm Products

Food and farm products have seen one of the most significant declines in CAWS usage over the years. Currently the highest volume commodity in this group moving on the CAWS is soybeans. As highlighted previously, most of the bulk traffic remains outside of the CAWS – traveling from the Illinois River System, where producers are located, south towards the Gulf of Mexico for export. With USDA crop forecasts projecting a flat production rate of the major crop groups through 2025,²⁴ significant changes in the usage of the CAWS for this commodity are not anticipated.

Group 7: Manufactured Equipment and Machinery

Commodities in this group include things such as Electrical Machinery, however, Manufactured Equipment and Machinery does not commonly use the CAWS as a mode of transport and typically has very low reported volumes along all segments of the waterway. Considering this, forecasted volumes are in line with historic trends and averages.

Group 8: Unknown or Not Elsewhere Classified

Unknown or Not Elsewhere Classified commodities do not commonly use the CAWS as a mode of transport and typically has very low reported volumes along all segments of the waterway. Considering this, forecasted volumes are in line with historic trends and averages.

Additional commodities descriptions encompassed by each of these eight groups are detailed in Table 15 below.

²⁴ USDA Long-Term Projections, February 2015.

Table 15: Commodities in Each Commodity Group

Commodity Group	Commodities
Coal	Coal & Lignite; Coal Coke
Petroleum and Petroleum Products	Crude Petroleum; Gasoline; Distillate Fuel Oil; Residual Fuel Oil; Lube Oil & Greases; Naphtha & Solvents; Asphalt, Tar & Pitch; Petroleum Coke
Chemicals and Related Products	Nitrogenous Fertilizer; Potassic Fertilizer; Benzene & Toulene; Other Hydrocarbons; Alcohols; Organic Compounds not elsewhere classified; Sodium Hydroxide; Inorganic Elements, Oxides, & Halogen Salts; Metallic Salts; Inorganic Chemicals not elsewhere classified; Chemical Products not elsewhere classified
Crude Materials, Inedible Except Fuels	Wood Chips; Limestone; Sand & Gravel; Waterway Improvement Material; Iron Ore; Iron & Steel Scrap; Aluminum Ore; Manganese Ore; Clay & Refractory Material; Slag; Non-Metallic Minerals not elsewhere classified
Primary Manufactured Goods	Cement & Concrete; Paper Products; Miscellaneous Mineral Products; Pig Iron; Ferro Alloys; i&s Plates and Sheets; i&s Bars & Shapes; i&s Pipe & Tube; Primary i&s not elsewhere classified; Fabricated Metal Products
Food and Farm Products	Wheat; Corn; Soybeans; Vegetable Oils; Animal Feed, Preparations; Sugar
Manufactured Equipment, Machinery, and Products	Machinery (not electric); Electrical Machinery; Vehicles & Parts; Manufactured Products not elsewhere classified

Source: US Army Corps of Engineers Waterborne Commerce of the United States.

Table 16 summarizes the assumptions made for future tonnages of each of these commodity groups for this document. Note that the “Historic Trend Line” assumes that a particularly commodity will continue to illustrate a similar annual increase or decrease based on historic volumes whereas the “Historic Average” assumes that the commodity will maintain its volumes near recent presented volumes.

Table 16: Summary of 2020 Forecast Assumptions

	Commodity Group	Minimum	Maximum	Short-term Forecasted Trend	Rationale
1	Coal, Lignite, & Coal Coke	45% of 2010 Volumes	45% of 2010 Volumes	Declining	Fisk and Crawford plants used 55% of coal/coke shipments moving on the CAWS in 2010; with the closure of these 2 plants, new prohibitive coal facility ordinance, and without new gasification plants, future volumes are unlikely to grow.
2	Petroleum & Petroleum Products	Historic Trend Line	Historic Average	Slightly declining to Increasing	Most petroleum moved by pipeline; plants are dependent upon barge for bulk outputs, such as petcoke, and asphalt; new prohibitive petcoke facility ordinance,
3	Chemicals & Related Products	Historic Trend Line	Historic Average	Variable	Adopted GLMRIS forecasts
4	Crude Materials, Inedible, Except Fuels	Historic Average	5% Annual Growth except for the Chicago River (10%)	Increasing	High volume goods; industries experiencing growth
5	Primary Manufactured Goods	Historic Trend Line	2.5% Annual Growth	Variable	Growth or decline will be tied to automotive and construction industries
6	Food & Farm Products	Zero	Historic Ranges	Minimal use of the CAWS	Although historically significant; recent use of the CAWS for agricultural products is minimal
7	Manufactured Equipment & Machinery	Historic Average	Historic Trend Line	Minimal use of the CAWS	Industry typically uses other modes
8	Unknown or Not Elsewhere Classified	Historic Average	Historic Trend Line	Minimal use of the CAWS	Industry typically uses other modes

For comparison, the assumptions made in the GLMRIS report are shown in Table 17 with a comparison of how the different assumptions impacted the anticipated future volumes and annual growth rates by commodity in Table 18. Of note, the GLMRIS forecasting efforts were based on historic data through 2011. Annual growth was estimated at roughly 4 percent for a total growth of 37 percent between 2011 and 2020. These commodity groups identified in the GLMRIS report are different than those detailed above from the WCUS. Many of these are a subcategory of the larger commodity groupings, such as Grains are a part of Food & Farm

Products. This does not allow for a direct comparison of the methodologies, however, it can give some sense of how the assumptions vary from the GLMRIS forecast to the ones made here.

Table 17: Forecast Summary of Industry Specific Actions and Trends by Commodity Group (GLMRIS)

Commodity Group	Near Term Trend Determined By	Long Term Trend	WCUS Category
Coal	Industry Interviews, new reports	Held Flat	Coal, Coal Lignite, and Coal Coke
Petroleum Fuels	Industry Interviews	Held Flat	Petroleum & Petroleum Products
Aggregates	Industry Interviews	Held Flat	Crude Materials, Inedible, Except Fuels
Grains	USDA Forecast Report	Held Flat	Food & Farm Products
Chemicals	Industry Interviews	Held Flat	Chemicals & Related Products
Ores and Minerals	10 Year Rolling Average	Held Flat	Crude Materials, Inedible, Except Fuels
Iron Ore and Steel	U.S. Federal Reserve Growth report combined with historic WCUS percentages	Held Flat	Crude Materials, Inedible, Except Fuels and/or Primary Manufactured Goods
All Others	10 Year Rolling Average	Held Flat	

Source: USACE Planning Center of Expertise for Inland Navigation

Table 18: 2020 GLMRIS Future Without Project Forecasts, by Commodity

Year	2011	2020	Annual Change
Coal	8,239	7,902	-0.5%
Petroleum Fuels	1,697*	1,987	2%
Aggregates	2,398	3,808	5%
Grains	127	657	20%
Chemicals	1,332	1,332	0%
Ores	799*	2,190	12%
Iron & Steel	2,104*	4,013	7%
All Others	2,581	4,513	6%
Total	19,277	26,402	4%

*Deep Draft Tonnage withheld to protect confidential business information

The biggest discrepancies between the GLMRIS forecasts and the forecasts created for this document relate to the expected changes in aggregates and grains. As discussed in previous sections, aggregates are expected to grow as the Chicago construction industry continues to rebound from recessionary levels. The GLMRIS projections indicate only a modest increase (5%), while the projections prepared for this document assume at least a 30% increase by 2020.

For grains, GLMRIS assumes a 20% increase by 2020, based on historical trends and USDA Forecasts. However, more recent use of the CAWS for agricultural products has been minimal, and the projections prepared for this document assume zero to very little growth by 2020.

Table 19 shows current volumes (average of 2011-12) by commodity and segment. Tables 20 and 21 show 2020 low and 2020 high forecasts, respectively, based on the assumed growth rates prepared and shown in Table 16. These assumptions result in a decline in traffic of just over 3 percent annually in the “2020 Low” scenario from present volumes. The “2020 High” scenario, however, shows a growth of nearly 3 percent per year through 2020. This growth rate is lower than the forecasted growth rate on the CAWS in the GLMRIS report.

This difference is based on a few considerations. The first is that GLMRIS forecasts were based on 2011 volumes. These volumes are higher than 2012 volumes and would have shown the waterway system rebounding from the recession at a much faster pace than the 2012 data suggests. Secondly, the GLMRIS report held coal volumes relatively flat based on the assumption that a coal gasification plant would be built in the area and served by the CAWS by 2020. Since the coal gasification plans have been put on hold, the forecasts presented in this summary document anticipate a much more significant decline in coal volumes. GLMRIS noted only a -0.5 percent annual change in this commodity while the “2020 Low” forecast in this document suggests an 11 percent annual decline and the “2020 High” forecast suggests a 4 percent annual decline.

Table 19: Current¹ Volumes by Commodity and Segment (2011-12 average, ktons)

Commodity	TOTAL CAWS ²⁵	Upper CAWS			Lower CAWS		
		Chicago River (Main and North Branch)	Chicago River (South Branch)	Chicago Sanitary and Ship Canal	Lake Calumet	Calumet Harbor	Calumet-Sag Channel
Coal	5,495	0	193	2,824	0	3,982	1,228
Petroleum	3,336	4	0	2,449	39	2,171	857
Chemicals	1,247	1	1	1,286	8	263	328
Crude Materials	4,881	689	1,122	3,278	73	3,239	1,222
Manufactured Goods	3,465	40	93	2,476	625	2,989	1,711
Food and Farm	262	4	4	300	31	254	275
Manufactured Equipment	24	1	1	124	0	114	109
Unknown or Not Elsewhere Classified	13	0	0	0	0	13	0
Total	18,721	737	1,416	12,734	776	13,020	5,727

Notes: ¹“Current” is defined as the average of 2011 and 2012 volumes.

Source: US Army Corps of Engineers Waterborne Commerce of the United States.

²⁵ The Total CAWS volumes are not a sum of the individual segments. As some traffic goes through multiple segments, simply summing the individual segments would result in double counting some of the traffic. The Total CAWS numbers presented here are as they are reported by the U.S. Army Corps of Engineers.

Table 20: 2020 “Low Forecast” Volumes by Commodity and Segment (ktons)

Commodity	TOTAL CAWS	Upper CAWS			Lower CAWS		
		Chicago River (Main and North Branch)	Chicago River (South Branch)	Chicago Sanitary and Ship Canal	Lake Calumet	Calumet Harbor	Calumet-Sag Channel
Coal	2,000	0	400	1,200	0	1,000	550
Petroleum	3,000	0	0	2,000	0	2,000	800
Chemicals	500	0	0	900	0	100	50
Crude Materials	7,000	900	1,500	4,600	100	4,100	1,300
Manufactured Goods	1,600	0	100	2,000	400	1,400	500
Food and Farm	0	0	0	0	0	0	0
Manufactured Equipment	0	0	0	0	0	0	0
Unknown or Not Elsewhere Classified	0	0	0	0	0	100	0
Total	14,100	900	2,000	10,700	500	8,600	3,200

Table 21: 2020 “High Forecast” Volumes by Commodity and Segment (ktons)

Commodity	TOTAL CAWS	Upper CAWS			Lower CAWS		
		Chicago River (Main and North Branch)	Chicago River (South Branch)	Chicago Sanitary and Ship Canal	Lake Calumet	Calumet Harbor	Calumet-Sag Channel
Coal	4,000	0	600	1,600	0	2,200	1,100
Petroleum	4,000	0	0	3,300	50	2,500	1,350
Chemicals	1,500	0	0	1,300	50	300	300
Crude Materials	8,200	1,500	2,400	5,500	150	4,800	1,800
Manufactured Goods	4,300	100	200	3,200	800	3,800	2,250
Food and Farm	1,000	0	0	1,000	100	1,000	1,000
Manufactured Equipment	200	0	0	200	0	200	200
Unknown or Not Elsewhere Classified	200	0	0	0	0	200	0
Total	23,400	1,600	3,200	16,100	1,150	15,000	8,000

3.4.2 Long Term (2040) CAWS Demand

Long term forecasts were developed to project “high” or “low” use of the CAWS in 2040. Due to uncertainty in future trends, projections were only developed for the CAWS as a whole on a commodity level basis and not for individual segments. The “2040 Low” growth scenario is that the waterway movements in 2040 resemble those during the most recent economic recession, when barge movements were at their 20 year low. The “2040 High” growth scenario predicts continued growth in all commodity movements, except coal.

These long-term forecasts, shown in Table 22, were developed primarily from CAWS-related historic trends and averages, as these offer the most comprehensive look at the CAWS, rather than the individual segments. In order to determine volumes in 2040, the annual growth rates determined between the base year of 2011/2012 and 2020 were used as a starting point. However, these annual growth rates may be significantly skewed, as volumes are still recovering from the recent economic recession. For instance, the annual growth rate of “Manufactured Equipment” from 24,000 tons in 2011/2012 to 200,000 tons in the 2020 High scenario is over 28 percent. Extending this trend to 2040 would result in volumes over 20 million tons, which is unlikely for this commodity group. With this in mind, annual declines in volumes were capped at -3 percent while annual growth was capped at +3 percent. Calculated annual growth rates which were already within this range were kept as they were, while those outside of this range were adjusted to either -3 percent or 3 percent, depending on the commodity’s trend. The exception was for Crude Materials. These were capped at a 2.5% annual growth due to the significant increase already anticipated through 2020.

Table 22: 2040 Forecast Volumes by Commodity (ktons)

Commodity	Current	2020		2040	
	2011/2012 Average	2020 Low	2020 High	2040 Low	2040 High
Coal	5,495	2,000	4,000	1,000	2,200
Petroleum	3,336	3,000	4,000	2,500	6,100
Chemicals	1,247	500	1,500	250	2,300
Crude Materials	4,881	7,000	8,200	11,500	13,500
Manufactured Goods	3,465	1,600	4,300	900	7,200
Food and Farm	262	0	1,000	0	1,800
Manufactured Equipment	24	0	200	0	200
Unknown NEC	13	0	200	0	900
Total	18,721	14,100	23,400	16,150	34,200

Compared to the GLMRIS report, this methodology for longer term forecasts was notably different. While the trends for these commodities were extended out to 2040 for the forecast presented here, GLMRIS suggests a steady annual CAWS volume of 26,402 from 2020 through 2065.

Long term forecasts were also developed at the segment level by utilizing the forecasts by commodity and allocating the traffic along segments of the CAWS based on the current distributions. As seen in Table 23, the “2040 Low” growth scenario shows minimal growth across the waterway system. Volumes are still expected to increase slightly on all segments between 2020 and 2040, with the exception of Lake Calumet, but will remain near the low usage seen during the most recent recession. The “2040 High” scenario presented in this table predicts continued growth of nearly every commodity with the exception of coal, resulting in higher growth. This predicted growth would put tonnage volumes moved on the CAWS near the highs seen over the last 20 years.

Table 23: 2040 Forecast Volumes by Segment (ktons)

River Segment	Current	2020		2040	
	2011/2012 Average	2020 Low	2020 High	2040 Low	2040 High
CAWS	18,721	14,100	23,600	16,150	34,200
Chicago River (Main and North Branch)	737	900	1,600	1,500	2,700
Chicago River (South Branch)	1,412	2,000	3,200	2,900	4,750
Chicago Sanitary and Ship Canal	12,736	10,700	16,100	11,100	25,250
Lake Calumet	775	500	1,150	350	2,050
Calumet Harbor	13,022	8,600	15,000	10,000	22,200
Calumet-Sag Channel	5,728	3,200	8,000	3,550	12,950

3.5 Scenario Evaluation

3.5.1 Description of Scenarios

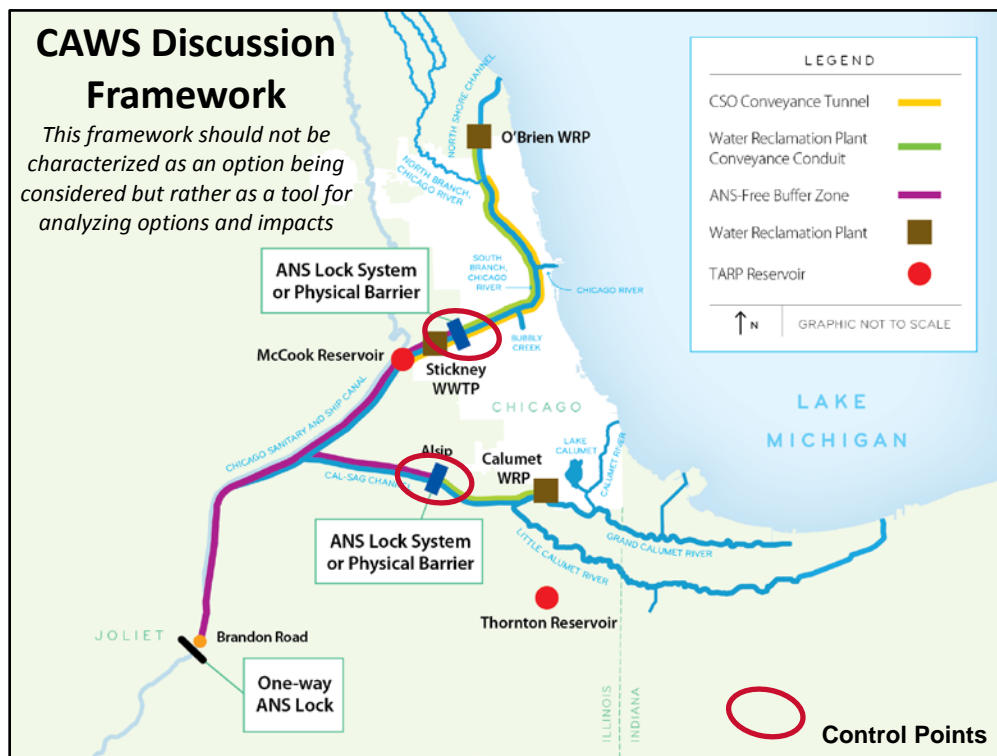
Three long term scenarios were assessed using control points located on the Chicago Sanitary and Ship Canal (CSSC) near Stickney, IL (approximately RM 317); and on the Cal-Sag Channel near Alsip, IL (approximately RM 314). The scenarios are described below, and the control points are shown in Figure 22. Note ANS controls at Brandon Lock are assumed to be a part of all three long term scenarios evaluated.

- 1) Two ANS lock systems: one on Chicago Sanitary and Ship Canal (CSSC) near Stickney and one on Cal-Sag Channel (Cal-Sag) near Alsip

- 2) One ANS lock system on Cal-Sag near Alsip and one physical barrier on CSSC near Stickney, with two assumptions concerning commercial cargo navigation:
 - a. assumes re-routing on the waterway
 - b. assumes a full modal shift from the waterway
- 3) Two physical barriers: one on CSSC near Stickney and one on Cal-Sag near Alsip

It is noted that two physical barriers as described in Scenario 3 were included in the discussion framework at the time of the commercial cargo navigation evaluation; however, more recent Advisory Committee discussions have focused on an ANS Lock System at the Alsip control point. Thus, only two scenarios were compared in the following analyses.

Figure 22: Control Point Locations for Conceptual Long Term Scenarios



Graphic credit: Great Lakes Commission.

3.5.2 Assumptions and Evaluation Criteria

Several sources were used to determine assumptions and evaluation criteria. The USACE Planning Guidance Notebook, April 2000, was consulted first for guidance. Additionally, the evaluation measures and other assumptions contained in the GLMRIS report and “Restoring the Natural Divide” was reviewed. Other movement assumptions were made based on the locations of the origins and destinations of the commodities on the various waterway segments. Table 24 shows the cost impact/ton assumptions:

Assumptions:

- All scenarios include a one-way ANS lock system at Brandon Lock and Dam.
- All scenarios assume that the T.J. O’Brien Lock will be functional and operations maintained (note: an initial investigation of existing maritime transportation operations, Section 3.1.2, indicated navigation operations may be able to be maintained with increases in river elevations above -0.5 ft CCD, potentially allowing for the closure of T.J. O’Brien Lock with these scenarios).
- Delays during construction and operations and maintenance are not accounted for in this analysis, as they are beyond the scope of this document. However, it is anticipated that waterway movements would continue during construction of an ANS Lock System without significant delay.
- While water compelled rates are not directly accounted for in this analysis, costs associated with modal shift were estimated, some of which would be attributed to higher rates that other modes could charge because one mode (water) is no longer available.
- Changes in water compelled rates, and any associated delays, are not accounted for in this analysis, as they are beyond the scope of this document
- Potential economic impacts associated with business closures as a result, or independent of, potential modal shift were not included, as it is beyond the scope of this document.
- Estimating the opportunity cost of potential future development along the waterway, or of business expansion, is not included in this analysis, as it is beyond the scope of this document. However, the City of Chicago and south suburban communities have explored the economic development potential of the water access provided by the Cal Sag Channel; if a physical barrier is placed in the Cal Sag Channel, this could affect business decisions on whether or not to locate in these areas.
- Estimates for the additional O&M costs on other transportation facilities (i.e. road and rail) due to modal shift are included; however, costs associated with new infrastructure due to modal shift were not included.
- The proposed ANS lock system or physical barrier on the CSSC would be constructed upstream of the Stickney Wastewater Treatment Plant (approximately RM 317). The exact location of the control point would affect the number of industries and cargo volumes that are impacted.
- Up to two hours (120 minutes)/lockage are assumed for the decontamination process at the new ANS lock(s), approximately twice that of typical lock processing times on the CAWS.

- Since both waterways remain open in Scenario 1, the number of industries considered impacted is not quantifiable. No re-routing is assumed, and limited modal shift is anticipated to occur.
- Scenario 2a: re-routes 97% of impacted CSSC cargo (based on GLMRIS assumption).
- All alternative scenarios prevent further ANS transfer between basins.
- None of the alternative scenarios increase flooding or negatively impact water quality.
- The development of dual side-by-side chambers of a proposed ANS lock would have a minor effect on processing travel time through the lock. It may reduce delay time at lock compared to what is currently experienced, allow for redundancy should one chamber be down for maintenance or other reasons, and provide means for implementing ANS control measures (serving as a temporary storage reservoir).

Evaluation Criteria:

For assessment of potential commercial cargo navigation impacts of the long term scenarios and how well they meet the Advisory Committee’s criterion of maintaining or enhancing efficient maritime transportation and commerce through and on the CAWS, specific evaluation criteria were developed as follows:

- Number of impacted existing facilities along the CAWS
- Tonnage of cargo impacted (ktons)
- Delay to waterborne cargo transport
- Cost impacts to commercial cargo industry
 - Additional Costs of Re-Routing
 - Additional Costs of Mode Shift
 - Externality Costs of Mode Shift (accidents, emissions, congestion, etc.)
 - Total Cost Impact

Table 25 shows the current and forecasted volumes that are impacted by implementing the various alternatives. Forecasts for both 2020 and 2040 are given for the “Low” and “High” growth scenarios, as described previously.

Table 24: Cost Impact Assumptions

		Description	Cost Impact
	Shipping Costs – Cargo Handling	For cargo that continues to use the CAWS after separation (i.e. re-routes and stays on the waterway), additional costs for shippers associated with re-routing and re-handling cargo. Included in these additional costs is the cost to barge operators of less-efficient use of barge resources	\$1.36/ton ¹
	Shipping Costs – Lock Delay time	For cargo that traverses the CSSC, a new lock will be added under Scenario 1, and a new lock will be added under Scenarios 1 and 2 for cargo that traverses the Cal-Sag Channel (assumes T.J. O’Brien lock will remain in operation). Included in this cost is the additional time delay associated with the ANS decontamination.	\$0.08/ton ¹
	Shipping Costs – Higher Shipping Rates (after Modal Shift)	Diverting some traditional cargoes from barge to other modes would result in increased shipping costs. The cost is the loss of transportation rate savings.	\$25/ton ¹
Externalities (only in Modal Shift)	Emissions (after Modal Shift)	Diverting some traditional cargoes from barge to other modes 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.	\$12.50/ton ²
	Accidents (after Modal Shift)	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.	
	Infrastructure Operating and Maintenance Costs (after Modal Shift)	Diverting some traditional cargoes from barge to other modes would increase O&M costs on other transportation facilities (such as highway and rail).	
	Congestion (after Modal Shift)	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 document, since highways are public. Incremental rail congestion is internal to the private rail companies and would be reflected in the rail shipping rates.	

¹ Based on assumptions in GLMRIS.

² Based on assumptions in “Restoring the Natural Divide.”

Upper CAWS Considerations:

At present, no intra-waterway traffic exists on either the Chicago River South Branch or the Chicago River Main and North Branches. In addition, the current directionality of the traffic suggests there is no traffic moving in either direction *solely between* the South Branch and the Main and North Branches. As such, all traffic on the Chicago River (Main, North, and South

Branches) must traverse CSSC in order to reach its final destination, particularly as the Chicago Lock and Dam is closed to commercial traffic. The minimum amount of traffic impacted by a separation on the CSSC would be the amount moving into, out of, or through the South Branch, and is indicated by the “Low” forecast in Table 25. Available data, including point and segment volume estimates and location of industries on the CSSC, Chicago River, and Cal-Sag Channel were reviewed to determine an estimate of the maximum traffic potentially impacted by the scenarios. It was determined that about 1/3 of the industrial sites located on the CSSC and Chicago River were located lakeside of separation, thus a “high” estimate was developed corresponding to one-third of the total traffic on the CSSC.

Further, the ‘low’ and ‘high’ volumes reported for the CSSC could essentially represent a shifting of the barrier location; that is, a barrier near Stickney (RM 317) is represented by ‘high’ estimate and a barrier near Bubbly Creek (RM 321.5) is represented by ‘low’ estimates.

Lower CAWS Considerations:

Nearly 100% of all movements on the Cal-Sag Channel portion of the CAWS are through movements (i.e., they travel from one end of the Cal Sag Channel to the other, from at least the Lockport Lock to at least the T.J. O’Brien Lock). According to the GLMRIS Report, in 2011, 53% of cargo that started at Brandon Road Lock traveled upstream and passed through T.J. O’Brien Lock; conversely, 86% of cargo that started at T.J. O’Brien Lock travelled downstream and passed through Brandon Road Lock. Any separation alternatives along the length of this channel would impact all traffic traveling on this waterway. Further, the City of Chicago and south suburban communities have explored the economic development potential of the water access provided by the Cal Sag Channel. If a physical barrier is placed in the Cal Sag Channel, this could affect business decisions on whether or not to locate in these areas.

Most of the industries in the Lower CAWS are located lakeside of the T.J. O’Brien Lock, in the deep draft channel of the Calumet River/Harbor and Lake Calumet., The industries in the deep draft areas will be less impacted by a Cal-Sag Channel separation due to their location and directionality and travel patterns that are observed in the segment data (majority of volumes are shipped to/from Lake Michigan).

Considerations of both Upper and Lower CAWS:

The analysis of impacted traffic on the Cal-Sag Channel and the CSSC does not separate out any potential traffic traversing both waterway segments, and thus there may be some double counting; however it is likely that the percentage of traffic affected by both locks is small. Industry interviews of users of the North Branch did not indicate a high demand for goods traveling along the Cal-Sag channel; it is assumed that this also applies to at least some industry along the CSSC.

Table 25: Current and Forecast Volumes Impacted by Separation (ktons)

Impacted Traffic	2011/2012 Average	2020 Low	2020 High	2040 Low	2040 High
Upper CAWS: CSSC					
Low	1,412	2,000	3,200	2,900	4,800
High	4,245	3,600	5,400	3,700	8,500
Lower CAWS: Calumet Sag Channel	5,728	3,300	8,000	3,600	13,000

These volumes were used to generate impact costs associated with implementation of each scenario, using the assumptions described previously.

3.5.3 Comparison of Scenarios

Comparison of the scenarios is shown in Table 26. Generally speaking, implementation of Scenario 1 (two ANS locks) would have lower transportation cost impacts since the waterways remain open. The principal measurable cost associated with this alternative is the delay associated with a new lock on both the CSSC and the Cal-Sag Channel. The new lock on the Cal Sag channel would be in addition to maintaining current operations at T.J. O'Brien lock, resulting in an increase in overall travel time.

Fewer impacts would occur to industries and cargo that use the Calumet River and Harbor and Lake Calumet under any scenario, since most of their traffic is coming or going to Lake Michigan. This is evidenced by the fact that there are higher tonnage volumes on these water segments (>13m tons) than pass through the T.J. O'Brien Lock (5.3m tons). However, upstream and downstream shipments using the Cal Sag Channel would be affected.

The cost associated with implementation of Scenario 2a, (CSSC barrier and Cal-Sag lock with re-route) is lower (worst case scenario is \$13M in 2040) than other scenarios involving a physical barrier. However, the additional costs of specialized equipment to operate on Lake Michigan, coupled with additional transit time and handling charges to/from Lake Michigan make it appear unlikely that 97% of the cargo would re-route on the waterway, as suggested by GLMRIS.

The implementation of Scenario 2b (CSSC barrier and Cal-Sag lock assuming a full modal shift) could result in hundreds of million dollars in impact.

Scenario 3, which places barriers on both the CSSC and Cal-Sag Channel, also could result in hundreds of millions of dollars in impact since all traffic on these waterway segments would be forced to shift modes. Some of the costs would be attributed to higher rates that other modes could charge because one mode (water) is no longer available.

3.6 Summary

This document has examined current waterway usage and commodity trends in an effort to determine the types and quantities of cargo that might be impacted by three long term scenarios. To do this, historic and industry trends were analyzed, and short term and long term

forecast ranges were developed by commodity and by water segment. Economic values were then assigned to determine a range of monetary impacts that might be observed under the various scenarios. These ranges could be used to make order-of-magnitude comparisons between the scenarios. The following provides a summary of this commercial cargo navigation assessment:

- Commodity trends
 - While coal has been a leading commodity on the CAWS in the past, it is projected to decline substantially due to the recent closure of power generation plants.
 - Crude materials, including aggregates and other building materials, has been steadily rising and is projected to continue increasing.
- Scenario 1
 - Places two locks and no physical barriers, would have the least amount of impact, since the entire waterway remains open.
 - Some costs would be associated with the travel time delay posed by a new lock on the CSSC and on the Cal-Sag Channel (assumes T.J. O'Brien Lock remains in operation).
- Scenario 2
 - Places a physical barrier on the CSSC and an ANS lock on the Cal Sag Channel, is significantly affected by future decisions by shippers.
 - Several existing industries located on the CSSC. The exact number of industry impacts on the CSSC will depend on where exactly a physical barrier is placed, should such a scenario be chosen. The number of impacted businesses could range from 10-24.
 - The decision to shift commercial cargo to another mode would have substantially more impact in terms of dollars (up to 30 times more) than if the cargo stays on the waterway and is re-routed. The “external” costs of switching modes (congestion, accidents, emissions, etc.) may not be enough to outweigh the lost transportation rate savings of staying on the water. However, because of the high costs and coordination associated with additional travel time, additional equipment, and additional handling, many shippers may not choose to use this method.
- Scenario 3
 - Places two physical barriers (one in CSSC and one in Cal Sag Channel), would be the most costly option.
 - Virtually all of the traffic on the CAWS, with the exception of that traveling solely within the deep draft segment to/from Lake Michigan, would be forced to use a different mode, or change their supply location to the Great Lakes.

- Although there are several industries located in the Lower CAWS, virtually all of them are located in the deep draft area of Lake Calumet and Calumet River/Harbor. These water segments also account for the most tonnage in the Lower CAWS, and a large share of the traffic is going to/from Lake Michigan.
- The industries most affected by this scenario would likely be those located on the CSSC.

Table 26: Comparison of Scenarios

Evaluation Criteria	Scenario 1: Two ANS locks	Scenario 2a: CSSC Barrier/Cal Sag Lock with Re-route				Scenario 2b: CSSC Barrier/Cal Sag Lock with Modal Shift @ Barrier				Scenario 3: Two Barriers			
	2020 to 2040	2020 Low	2020 High	2040 Low	2040 High	2020 Low	2020 High	2040 Low	2040 High	2020 Low	2020 High	2040 Low	2040 High
Cargo Volume Impacted/Year (ktons)													
Upper CAWS (CSSC)	2,000-8,500	2,000-3,600	3,200-5,400	2,900-3,700	4,800-8,500	2,000-3,600	3,200-5,400	2,900-3,700	4,800-8,500	2,000-3,600	3,200-5,400	2,900-3,700	4,800-8,500
Lower CAWS (Cal Sag)	3,300-13,000	3,300	8,000	3,600	13,000	3,300	8,000	3,600	13,000	3,300	8,000	3,600	13,000
# of Industries Impacted													
Upper CAWS (CSSC)	Not quantifiable	10-24	10-24	10-24	10-24	10-24	10-24	10-24	10-24	10-24	10-24	10-24	10-24
Lower CAWS (Cal Sag)	Not quantifiable	Not quantifiable	Not quantifiable	Not quantifiable	Not quantifiable	Not quantifiable	Not quantifiable	Not quantifiable	Not quantifiable	Up to 59	Up to 59	Up to 59	Up to 59
Travel Delay Additional costs													
Upper CAWS (CSSC)	<\$1	<\$1	<\$1	<\$1	<\$1	N/A				N/A			
Lower CAWS (Cal Sag)	<\$1	<\$1	<\$1	<\$1	\$1	<\$1	<\$1	<\$1	\$1				
RE-ROUTE Additional costs													
Upper CAWS (CSSC)	No re-route	\$3-\$5	\$4-\$7	\$4-\$5	\$6-\$11	N/A				N/A			
Lower CAWS (Cal Sag)	No re-route	No re-route	No re-route	No re-route	No re-route								
MODE SHIFT Additional costs													
Upper CAWS (CSSC)	Limited	N/A				\$50-\$100	\$80-\$150	\$70-\$100	\$120-\$210	\$50-\$100	\$80-\$150	\$70-\$100	\$120-\$210
Lower CAWS (Cal Sag)	Limited					Limited	Limited	Limited	\$90	\$200	\$90	\$330	
MODE SHIFT Externalities													
Upper CAWS (CSSC)	Limited	N/A				\$25-\$50	\$40-\$70	\$40-\$50	\$60-\$110	\$25-\$50	\$40-\$70	\$40-\$50	\$60-\$110
Lower CAWS (Cal Sag)	Limited					Limited	Limited	Limited	\$40	\$100	\$50	\$170	
Total Cost Impact/Year													
Upper CAWS (CSSC)	<\$1	\$4-\$6	\$5-\$8	\$5-\$6	\$7-\$12	\$75-\$150	\$120-\$220	\$110-\$150	\$180-\$320	\$75-\$150	\$120-\$220	\$110-\$150	\$180-\$320
Lower CAWS (Cal Sag)	<\$1	<\$1	<\$1	<\$1	\$1	<\$1	<\$1	<\$1	\$1	\$130	\$300	\$140	\$500
TOTAL COSTS/YEAR UPPER AND LOWER CAWS	<\$2	\$5-\$7	\$6-\$9	\$6-\$7	\$8-\$13	\$75-\$150	\$120-\$220	\$110-\$150	\$180-\$320	\$200-\$280	\$420-\$520	\$250-\$290	\$680-\$820

Note: All costs in millions of dollars per year

3.7 References

1. USACE, “Appendix D-Chicago Sanitary and Ship Canal,” Great Lakes Navigation System Review Study, 2002
2. USACE, Illinois Waterway Navigation Charts, 1998.
3. USACE, Chicago Harbor Lock Sector Gate Replacement – 01 November 2001 – 15 April, 2011. Presentation on June 15, 2011.
4. <http://www.futuresmag.com/2014/10/30/tj-obrien-lock-dam-closure>
5. <http://www.mvr.usace.army.mil/Media/NewsReleases/tabid/6637/Article/502064/corps-of-engineers-to-close-tj-obrien-lock-for-critical-maintenance.aspx>
6. USACE, Project Factsheet for: Lockport Dam, Illinois Waterway Locks and Dams, 2012. <http://www.mvr.usace.army.mil/Media/FactSheets.aspx>
7. USACE, Project Factsheet for: Lockport Dam, Illinois Waterway Locks and Dams, 2012. <http://www.mvr.usace.army.mil/Media/FactSheets.aspx>
8. Dam Safety Action Classification ratings include: DSAC I – URGENT AND COMPELLING (Unsafe), DSAC II – URGENT (Unsafe or Potentially Unsafe), DSAC III – HIGH PRIORITY (Conditionally Unsafe), DSAC IV – PRIORITY (Marginally Safe), and DSAC V – NORMAL (Safe)
9. USACE, Inland Marine Transportation Systems (IMTS) Capital Projects Business Model Final Report, April 2011
10. AASHTO Water Bottom Line Report, 2011
11. N.e.c. stands for not elsewhere classified.
12. Lake Carriers’ Association, 2012 Statistical Annual Report
13. Ontario Power Generation, <http://www.opg.com/generating-power/thermal/stations/thunder-bay-station/Pages/thunder-bay-station.aspx>
14. Wernau, Julie, “Closure of Chicago’s Crawford, Fisk electrical plants ends coal era,” Chicago Tribune, August 2012
15. Dodge Data & Analytics, December 2014
16. Illinois Soybean Association, “ISA Study: COB Shuttle Program is Feasible, Offers Biodiesel Opportunities.” April 2012
17. Muskegon port development could mean a river barge terminal linking farmers to Gulf Coast, mlive, August 29, 2013, http://www.mlive.com/news/muskegon/index.ssf/2013/08/muskegon_port_development_coul.html
18. Petition for Rulemaking: Special Load Line Exemption for Lake Michigan (Federal Register Publication), <http://www.regulations.gov/#!documentDetail;D=USCG-2013-0954-0049>
19. Beemsterboer shuts down petcoke storage terminal in Chicago, nwitimes, September 25, 2014, http://www.nwitimes.com/business/local/beemsterboer-shuts-down-petcoke-storage-terminal-in-chicago/article_9cc07f97-d18b-5cd4-b54b-aff3c80967b.html

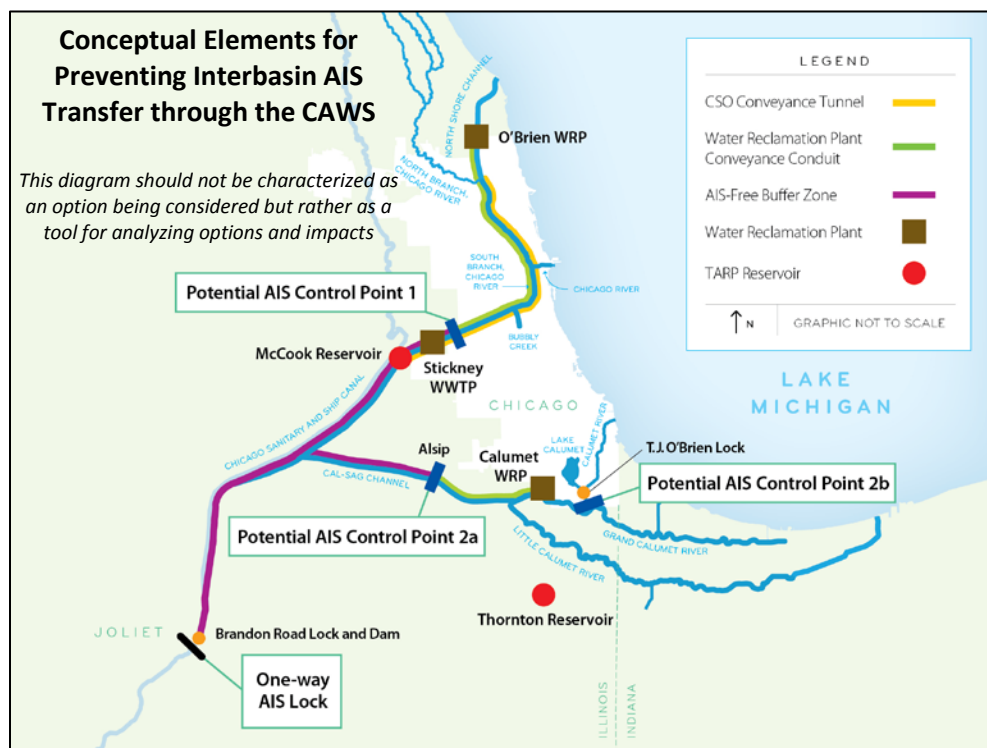
20. BP to stop sending petcoke to Chicago, Chicago Tribune, February 18, 2015, <http://www.chicagotribune.com/news/ct-bp-petcoke-met-20150218-story.html>
21. Chicago petcoke announcement raises more questions, Midwest Energy News, February 24, 2015, <http://www.midwestenergynews.com/2015/02/24/chicago-petcoke-announcement-raises-more-questions/>
22. I-95 Corridor Coalition, Short-Sea and Coastal Shipping Options Study, November 2005.
23. Transport Canada, Cross-Border Short Sea Shipping Study, March 2004.
24. USDA Long-Term Projections, February 2015.
25. U.S. Army Corps of Engineers. 2014. Great Lakes and Mississippi River Interbasin Study (GLMRIS), Appendix D.

4.0 Flood Risk Management and Water Quality Conveyance

Implications for flood risk management and water quality was presented to the CAWS Advisory Committee regarding conceptual elements or possible components of a potential long term solution, as illustrated in Figure 23. These elements and the Advisory Committee’s questions were informed by previous study results and evolved through CAWS Advisory Committee discussions based on relationship with the working criteria involving AIS risk, flood risk, water quality, and transportation. For example, Control Points 1 and 2a were identified as minimizing potential flood risk implications, while Control Point 2b, with possible additional associated structures to prevent movement of AIS, was recognized as lessening potential water quality and transportation effects in exchange for increased flood risk potential relative to Control Point 2a.

While no new flood risk or water quality analyses were performed, key implications of and comparisons between potential AIS control point combinations drew on previous study results (e.g. GLMRIS and *Restoring the Natural Divide*) and CAWS Advisory Committee discussions. Variances in water quality implications associated with potential AIS control point 2b are directly related to balances in flood risk management (water quality implications for the Calumet System would be eliminated), and, therefore, are also discussed.

Figure 23: Conceptual Elements of Potential Long Term Solution

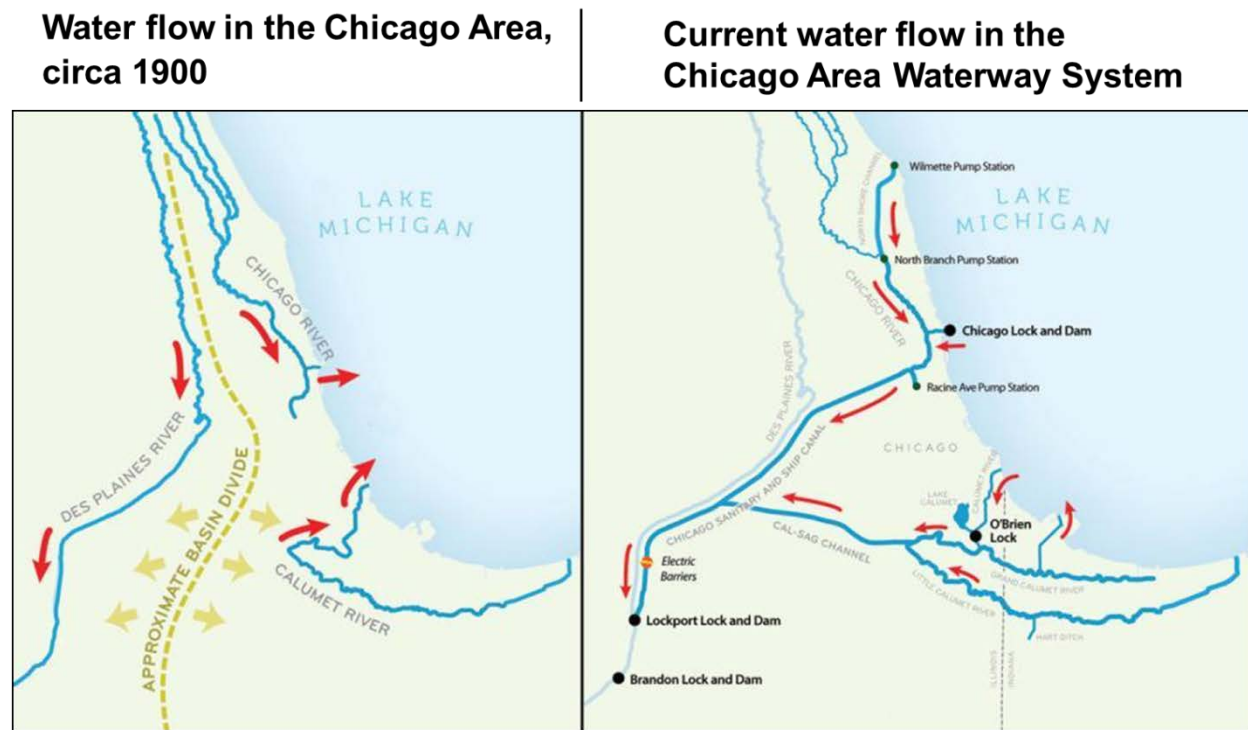


Graphic credit: Great Lakes Commission.

4.1 Background and Existing Conditions

Prior to construction of the CAWS waterways in the early 1900s, the natural sub-continental drainage basin divide directed the Chicago and Calumet River flows toward Lake Michigan (Figure 24). For purposes of water quality protection and maritime transportation, construction of the Chicago Sanitary and Ship Canal (CSSC), North Shore Channel (NSC), and the Cal-Sag Channel in 1900, 1910, and 1922, respectively, reversed the flow of the Chicago and Calumet River systems away from Lake Michigan and diverted flows downstream into the Illinois and Mississippi Rivers providing for the current CAWS flow regimes (Figure 24). This history of the CAWS and natural drainage divides provides the context for discussion of flood risk management implications of the potential long term solution and associated control point locations. Furthermore, through the physical connection of the CAWS waterways, water quality and flood risk in the CAWS are intricately linked.

Figure 24: Pre- and Post-CAWS Flow Regimes



Graphics courtesy of the Great Lakes Commission

4.2 Potential Long Term Strategy

4.2.1 System Components

The conceptual components of a long term solution are directly affected by the combination of control points included in a particular scenario. As previously noted, potential control point locations were informed by prior study results and evolved through CAWS Advisory Committee discussions. For purposes of comparing potential flood risk implications, two combinations of control point locations were identified. The combinations are outlined below, and the control points along with pathways, potential system components, and potential Brandon Road ANS Lock are shown in Figure 23. Together with the potential Brandon Road ANS Lock, the combination of ANS control points would provide a system of three control points designed to create a buffer zone.

- ANS Control Point 1 (Stickney) and Control Point 2a (Alsip)
- ANS Control Point 1 (Stickney) and Control Point 2b (T.J. O'Brien Lock)

The potential one-way AIS controls at Brandon Lock are assumed to be a part of any long term scenario considered by the CAWS Advisory Committee and to not alter flood risk operations. Therefore, comparison of potential flood risk implications is focused on the relative differences between potential combinations of ANS Control Points 1 (Stickney), 2a (Alsip), and 2b (T.J. O'Brien Lock).

The long term scenarios identified for ANS and commercial cargo evaluations and involving different structural ANS control elements (i.e. ANS Lock System or physical barrier) at AIS Control Points 1 and 2a have similar flood risk and water quality implications, and, therefore, were not further investigated. While the specific ANS control measures applied at the potential control points may vary, for purposes of investigation, the control measures were assumed to limit the exchange of surface water at these locations to either navigation purposes only (ANS Lock System) or none at all (physical barrier). Either of these structural elements would provide means for water control and involve reversal of flows back to Lake Michigan lakeside of the respective control point location. As a result, the flood risk and water quality implications of a particular control point are similar irrespective of whether the control point consists of an ANS Lock System or a physical barrier. Rather, it is the location of a control point that most directly affects the associated flood risk and water quality implications.

It is also noted that physical barriers were included in the discussion framework at the time of the initial ANS control measure and commercial cargo evaluations; however, more recent CAWS Advisory Committee discussions have focused more broadly on ANS control points, the form of which is yet to be determined.

Drawing upon previous study results (e.g. GLMRIS and *Restoring the Natural Divide*) and CAWS Advisory Committee discussions regarding potential flood risk and water quality implications, key flood risk and water quality system elements were identified for the two combinations of ANS control points as described below and illustrated in Figure 23.

ANS Control Point 1 (Stickney) and Control Point 2a (Alsip)

- Flood Risk Management
 - reconfiguration of existing and planned Tunnel and Reservoir Plan (TARP) infrastructure and/or operations at McCook and Thornton reservoirs to accommodate additional volumes without increasing reservoir sizes
 - management of localized flooding through additional mitigation measures as needed in Chicago and Calumet River systems and northwest Indiana
- Water Reclamation Plant (WRP) Conveyance Conduits
 - Reroute O'Brien WRP outfall to discharge riverside of ANS Control Point 1 (Stickney)
 - Reroute Calumet WRP outfall to discharge riverside of ANS Control Point 2a (Alsip)
- Combined Sewer Overflow (CSO) Conveyance Tunnel and Treatment
 - Use of tunnel for capturing and conveying the existing CSO outfalls for the Chicago River System along the North Shore Channel, North/South/Main Branch Chicago River, and CSSC to McCook Reservoir
 - Treatment of CSO conveyance tunnel flows through a high volume pump station with disinfection at McCook Reservoir
- Modifications to existing WRP facilities and stormwater systems in both the Chicago and Calumet River systems to meet anti-degradation regulations and Great Lakes Initiative (GLI) water quality standards (further discussed in Section 5.0 – Water Quality)
- Flow augmentation/circulation systems for water quality purposes in potential areas of stagnation (i.e. riverside and/or lakeside of ANS control points)
- Management of extreme (high or low) Lake Michigan water levels for flood risk, water quality, and maritime transportation purposes (i.e. maintaining and/or modifying current CAWS lock and gate operations)
- Sediment Remediation for areas of CAWS lakeside of ANS Control Points 1 and 2a in both Chicago and Calumet River systems (further discussed in Section 6.0 – Contaminated Sediments)

ANS Control Point 1 (Stickney) and Control Point 2b (T.J. O'Brien Lock) [*differences in system elements relative to Control Point 2a noted in **bold italics** below*]

- Flood Risk Management
 - ***additional flood storage (i.e. expansion of Thornton reservoir or new reservoir similar to Thornton) and/or conveyance would be required in the Calumet River system as backflows to Lake Michigan through T.J. O'Brien lock would be eliminated and structural ANS control measures (i.e. physical barriers) would be required to address ANS risk on the Grand and Little Calumet River pathway connections to Lake Michigan***

- reconfiguration of existing and planned Tunnel and Reservoir Plan (TARP) infrastructure and/or operations at McCook and Thornton reservoirs to accommodate additional volumes without increasing reservoir sizes
- management of localized flooding through additional mitigation measures as needed in Chicago and Calumet River systems and northwest Indiana
- Water Reclamation Plant (WRP) Conveyance Conduits
 - Reroute O'Brien WRP outfall to discharge riverside of ANS Control Point 1 (Stickney)
 - **No rerouting of Calumet WRP outfall would be required**
- Combined Sewer Overflow (CSO) Conveyance Tunnel and Treatment
 - Use of tunnel for capturing and conveying the existing CSO outfalls for the Chicago River System along the North Shore Channel, North/South/Main Branch Chicago River, and CSSC to McCook Reservoir
 - Treatment of CSO conveyance tunnel flows through a high volume pump station with disinfection at McCook Reservoir
- Modifications to existing WRP facilities and stormwater systems in **only the Chicago River system** to meet anti-degradation regulations and Great Lakes Initiative (GLI) water quality standards (further discussed in Section 5.0 – Water Quality)
- Flow augmentation/circulation systems for water quality purposes in potential areas of stagnation (i.e. riverside and/or lakeside of ANS control points)
- Management of extreme (high or low) Lake Michigan water levels for flood risk, water quality, and maritime transportation purposes (i.e. maintaining and/or modifying current CAWS lock and gate operations)
- Sediment Remediation for areas of CAWS **lakeside of only ANS Control Point 1 in the Chicago River system** (further discussed in Section 6.0 – Contaminated Sediments)

4.2.2 Assumptions

The key flood risk and water quality system elements described above for the two combinations of ANS control points were based on the following assumptions:

- Potential long term solution system components are conceptual level only
 - Detailed feasibility and/or design was not performed of conceptual system components
 - Additional analyses/investigations are required to further define and validate the assumptions for these system components
- Flood risk design event
 - 100- to 500-yr storm event for estimating need of additional storage volumes and localized flood mitigation measures

- Optimization/reconfiguration of completed and planned McCook and Thornton reservoirs limits the need for additional reservoir storage
- Need for additional tunnel/reservoir infrastructure to mitigate localized flood risk in the 100- to 500-yr storm event requires further evaluation
- CSO design storm event
 - completed TARP system + additional CSO conveyance/treatment provides CSO control for approximately 10- to 50-yr storm event
 - intended to limit CSO discharges lakeside of ANS control points to Lake Michigan to same or less frequency than the completed TARP system under existing CAWS flow regimes
- High volume pump station with disinfection treatment of CSO flows from additional tunnel at McCook
 - No additional volumes treated at Stickney WRP (existing TARP volumes still sent to Stickney WRP)
 - Eliminates the need for additional reservoir storage for CSO control
 - Reservoir occupancy (back-to-back storms) would be addressed via existing/planned TARP operations
- Water quality
 - Non-MWRD WRPs and stormwater facility modifications may be required related to antidegradation and GLI standards
 - No additional treatment of discretionary flows would be required to address potential stagnation issues; therefore, reduction of discretionary diversion occurs through recirculation of flows on either side of the ANS control points
 - Rerouting of O'Brien and Calumet WRPs mitigates potential low flow issues riverside of ANS control points
 - Contaminated sediment remediation would occur for the Chicago and Calumet River systems lakeside of the ANS control points

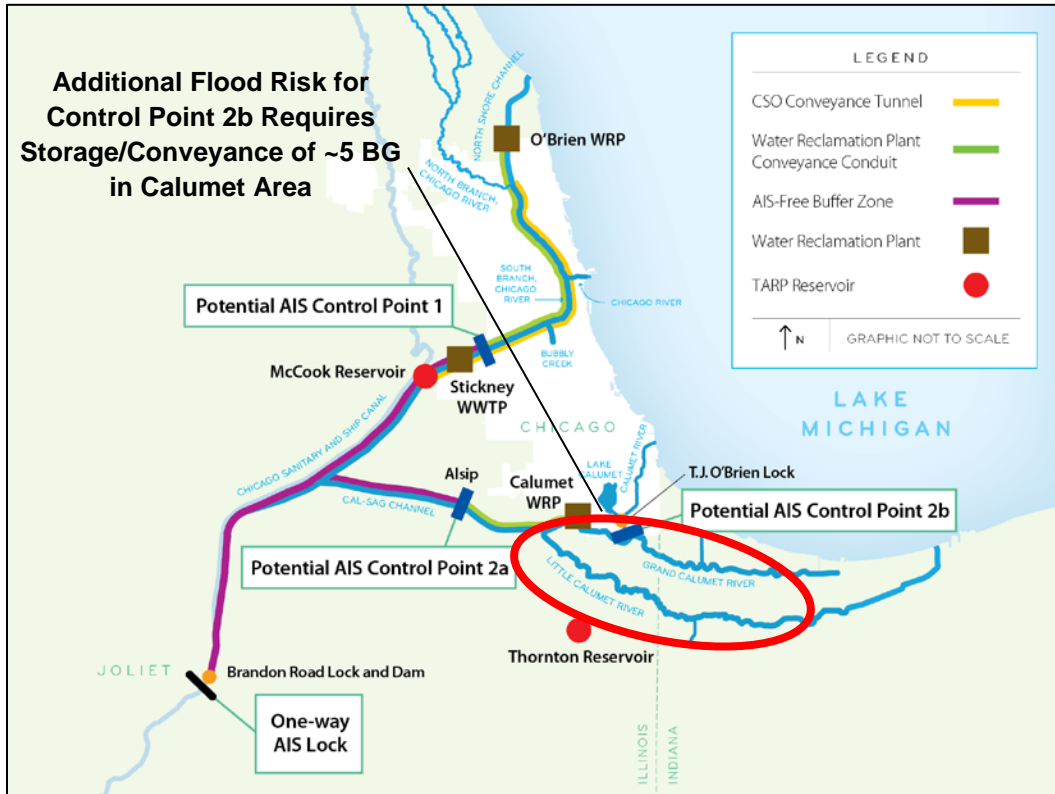
4.2.3 Implications and Comparison of Potential AIS Control Points

While no new flood risk or water quality analyses were performed relative to the potential elements of a long term solution, previous study results (e.g. GLMRIS and *Restoring the Natural Divide*) and CAWS Advisory Committee discussions provided the context for identifying some key implications and comparisons of potential AIS control point combinations, in particular the variances in flood risk and water quality associated with ANS Control Points 2a and 2b. Additional analyses/investigations are required to further define and validate these implications and comparisons.

The combination of ANS Control Points 1 and 2a are considered to result in limited induced flood risk in either the Chicago or Calumet River systems lakeside of the control points that would be mitigated through either localized measures or reconfiguration of existing and planned TARP infrastructure and/or operations. When shifting ANS Control Point 2a (Alsip) to ANS Control Point 2b (T.J. O'Brien lock), additional flood storage (i.e. expansion of Thornton

reservoir or new reservoir similar to Thornton) and/or conveyance of approximately 5 billion gallons is estimated to be required in the Calumet River system as backflows to Lake Michigan through T.J. O'Brien lock would be eliminated and structural ANS control measures (i.e. physical barriers) would be required to address risk of ANS transfer on the Grand and Little Calumet River pathway connections to Lake Michigan (Figure 25).

Figure 25: Flood Risk Implication Comparison – Control Points 2a and 2b

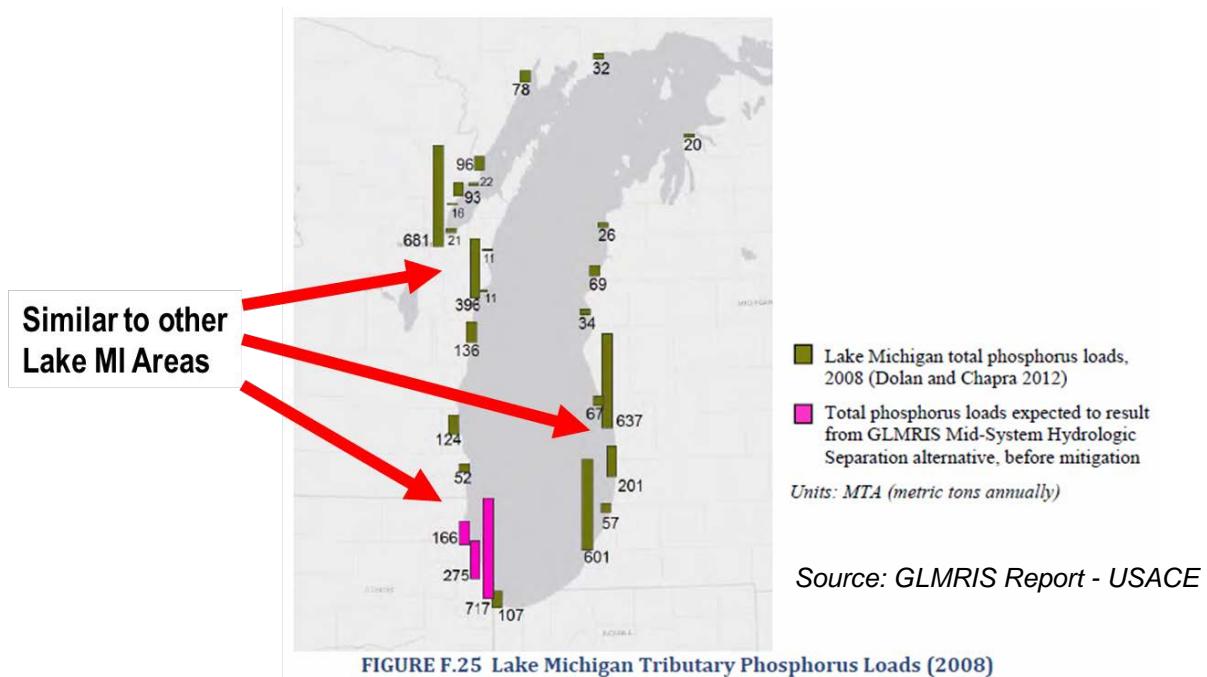


Graphic credit: Great Lakes Commission.

Water Quality Conveyance

Drawing upon analyses performed in GLMRIS for alternatives (GLMRIS, Appendix F) involving similar ANS control point locations that limit the exchange of surface water (i.e. ANS lock system or physical barrier), some parallels exist to the combination of ANS control points reviewed by the CAWS Advisory Committee as part of a potential long term solution. Approximately 80-90% of the potential unmitigated flow and associated contaminant loadings related to ANS Control Points 1 and 2a (Stickney and Alsip) are from two point sources, O'Brien and Calumet WRPs, resulting in phosphorus loadings similar to other Lake Michigan tributary sources with significant urban/industrial development (Figure 26).

Figure 26: Estimated Phosphorus Loadings for GLMRIS Mid-System Separation Alternative with No Mitigation (Comparable to ANS Control Points 1 and 2A with No Mitigation)



Notes:

1. With project condition assumes no mitigation measures

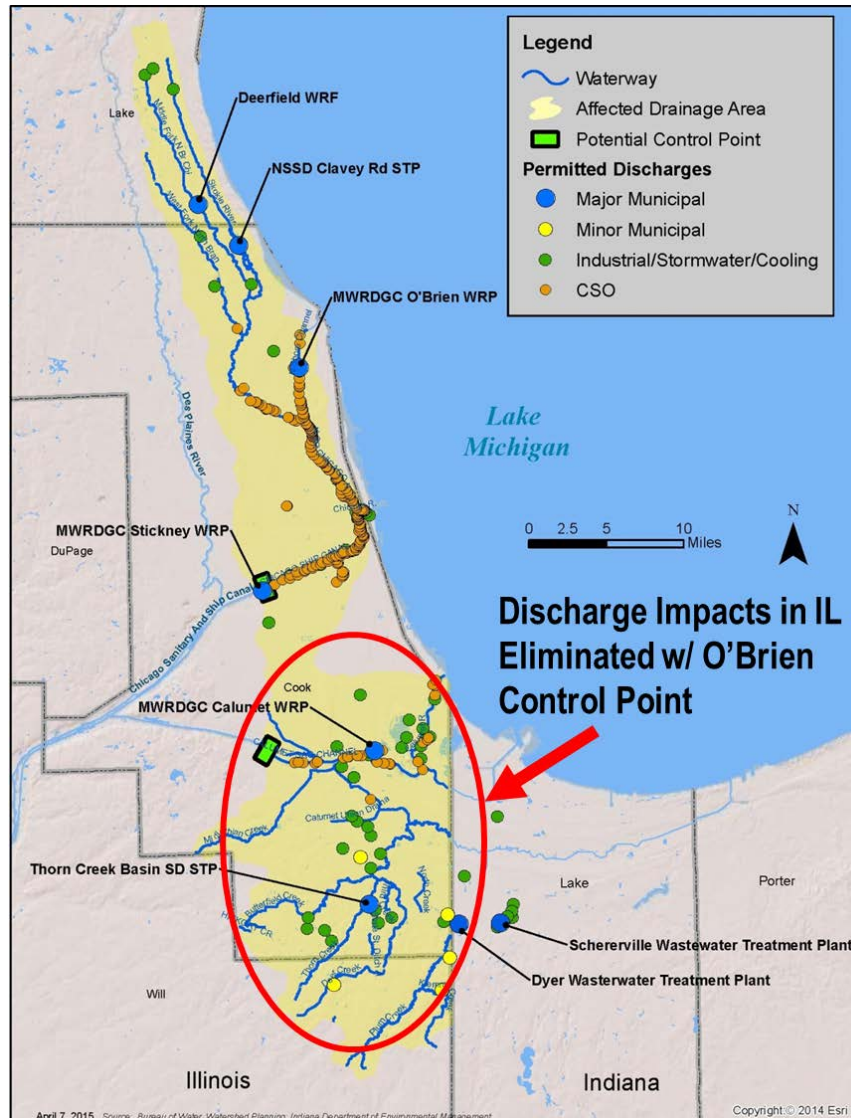
Variances in water quality implications associated with potential ANS Control Point 2b are directly related to balances in flood risk management. While flood risk implications are increased, the water quality implications of ANS Control Point 2b (T.J. O’Brien Lock) are diminished relative to ANS Control Point 2a (Alsip).

Aside from eliminating the occasional CSO backflow to Lake Michigan and withdrawal of Lake Michigan discretionary diversion flows through T.J. O’Brien Lock and sluice gates, ANS Control Point 2b would maintain the existing water quality functions and flow regimes of the Calumet River System. Relative to ANS Control Point 2a, this would avoid the potential impacts and associated mitigation in the Calumet River system of Calumet WRP effluent, CSO and stormwater flows, and contaminated sediments being directed toward Lake Michigan. Consequently, the potential annual contaminant loadings to Lake Michigan from a combination of ANS Control Points 1 and 2b (Stickney and T.J. O’Brien Lock) are estimated to be approximately half of those for ANS Control Points 1 and 2A (Stickney and Alsip).

Examination of potentially affected National Pollution Discharge Elimination System (NPDES) permitted discharges (Figure 27) is one illustration of the differences in potential water quality impacts between ANS Control Point 2a (Alsip) and ANS Control Point 2b (T.J. O’Brien Lock). While all permitted discharges in the affected Chicago and Calumet River drainage areas would be affected by ANS Control Points 1 (Stickney) and 2a (Alsip) and require some form of mitigation (i.e. CSO conveyance tunnel, rerouted WRP conveyance conduit, modifications to

WRP facilities and stormwater systems), ANS Control Point 2b (T.J. O'Brien Lock) would eliminate potential impacts to NPDES permitted discharges in the Illinois portion of the Calumet River System (Figure 27).

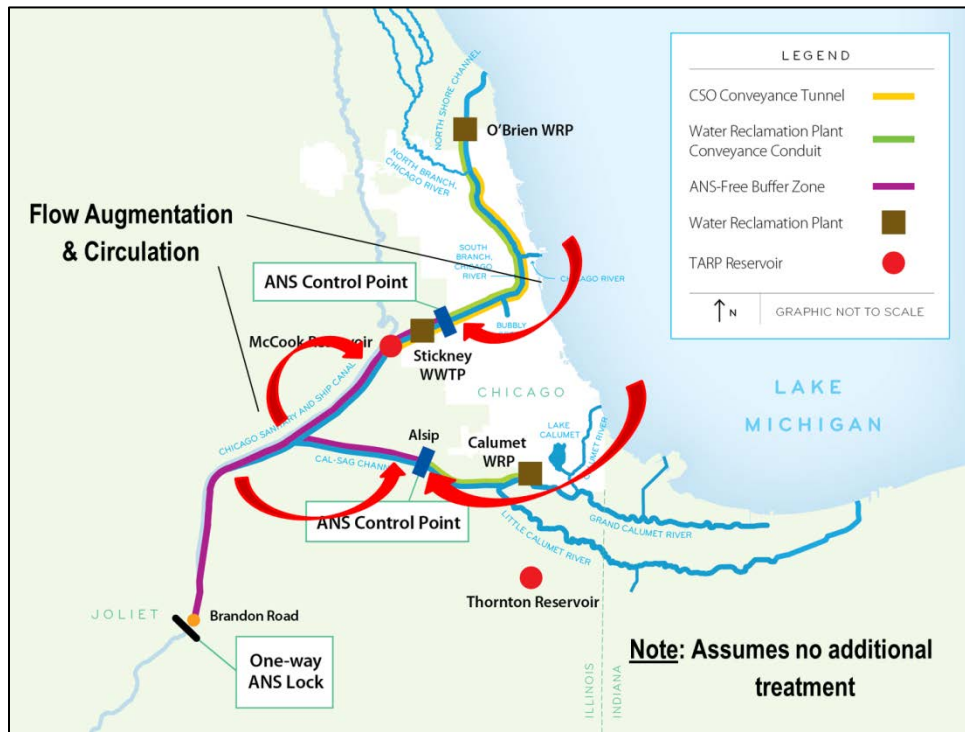
Figure 27: Example of Flow Augmentation & Circulation Near Potential ANS Control Points



Stagnation riverside and lakeside of all control point locations would potentially create compliance issues with the current dissolved oxygen (DO) standards in the CAWS that would require flow augmentation and/or recirculation. It is conceived that flow augmentation and/or recirculation could be accomplished through rerouting of flows with higher DO levels and/or aeration using water on the same side a particular control point (Figure 28) rather than additional ANS treatment of water from the opposite side a control point. Stagnation issues for ANS Control Point 2b are anticipated to be considerably less than ANS Control Point 2a given

the close proximity of the higher DO effluent of the Calumet WRP to the control point (T.J. O'Brien Lock).

Figure 28: Example of Flow Augmentation & Circulation Near Potential ANS Control Points



4.3 Summary

While no new flood risk or water quality analyses were performed relative to the potential elements of a long term solution, previous study results (e.g. GLMRIS and *Restoring the Natural Divide*) and CAWS Advisory Committee discussions provided the context for identifying some key implications and comparisons of potential AIS control point combinations. Though specific ANS control measures applied at the potential control points may vary, such structural elements were assumed to provide means for water control and, thus, would involve reversal of flows back to Lake Michigan lakeside of the respective control point location. As a result, the flood risk and water quality implications of a particular control point were considered similar irrespective of whether the control point consists of an ANS Lock System or a physical barrier. Rather, it is the location of a control point that most directly affects the associated flood risk and water quality implications as follows:

- Mitigation measures exist for flood risk and water quality impacts and provided the basis for conceptual elements of a potential long term solution
- Control Points 1 and 2a were identified as minimizing potential flood risk implications, while Control Point 2b, with possible additional associated structures to prevent movement of AIS, was recognized as lessening potential water quality and

transportation effects in exchange for increased flood risk potential relative to Control Point 2a.

- ANS Control Point 2b (T.J. O'Brien Lock) relative to Control Point 2a (Alsip)
 - Increased flood risk requires approximately 5 BG of additional conveyance and/or storage
 - Water quality impacts (contaminant loadings, permitted NPDES discharges, contaminated sediment) nearly eliminated in Calumet River system for CAWS and Lake Michigan

Additional analyses/investigations are required to further define and validate the assumptions for system components and the associated implications and comparisons. In particular, additional hydrologic and hydraulic modeling is necessary for refinement of flood risk mitigation elements (i.e. tunnels, reservoirs, infrastructure operations) to address both CSO and localized flood risk.

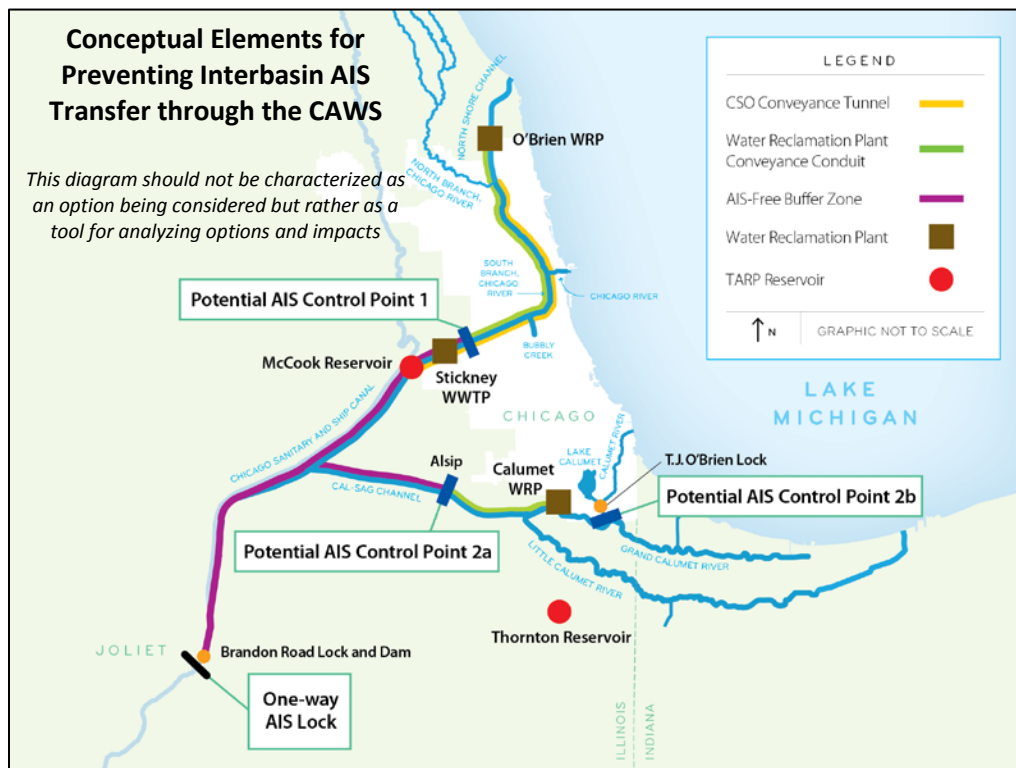
4.4 References

- 1 Great Lakes Commission and Great Lakes and St. Lawrence Cities Initiative. 2012. Restoring the Natural Divide: Separating the Great Lakes and the Mississippi River Basins in the Chicago Area Waterway System.
- 2 HDR Engineering. 2012. Technical Report to the Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative: Evaluation of Physical Separation Alternatives for the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System.
- 3 U.S. Army Corps of Engineers. 2014. Great Lakes and Mississippi River Interbasin Study (GLMRIS), Main Report, Appendix E, and Appendix F.

5.0 Water Quality

The working criteria established by the CAWS Advisory Committee suggests that potential long term solutions should protect or improve water quality in the CAWS, Lake Michigan and the Illinois River Basin, and meet federal, Illinois, and Indiana environmental regulations. While no new water quality analyses were performed relative to the potential elements of a long term solution, the purpose of this section is to discuss the implications of the potential elements of a long term solution as it relates to water quality conditions and Clean Water Act (CWA) requirements. More specifically, this section addresses water quality standards, antidegradation, Total Maximum Daily Loads (TMDLs), and potential National Pollutant Discharge Elimination System (NPDES) permitting implications of redirecting flows to Lake Michigan. Regarding the potential elements of a long term solution, the water quality issues described below are focused on scenarios involving Potential AIS Control Points 1 (Stickney) and 2a (Alsip), as illustrated in Figure 29 and assumes these control points limit the exchange of surface water at these locations to navigation purposes only. Variances in these water quality implications associated with potential AIS control point 2b are directly related to tradeoffs in flood risk management (water quality impacts for the Calumet System would be nearly eliminated with AIS Control Point 2b), and, therefore, were previously discussed in Section 4.

Figure 29: Conceptual Elements of Potential Long Term Solution



Graphic credit: Great Lakes Commission.

5.1 Background

Prior to construction of the CAWS in the early 1900s, the Chicago River and untreated sewage flowed directly into Lake Michigan resulting in unsanitary conditions throughout the city. Construction of the CAWS largely resolved this issue by reversing the direction of flow to the Illinois River and diverting “flush water” from Lake Michigan. Although this resulted in significant water quality improvements, contaminants remained in the rivers, canals, and Lake Michigan. The persistence of the problem was due to variety of factors including wastewater effluent, stormwater runoff, and combined sewer overflows (CSOs), which contain both stormwater and sanitary waste. Continued development exacerbated the issue as it led to increased runoff entering the sewer and waterway system. During particularly heavy rains, the flow direction of the CAWS is forced to reverse direction, releasing sewage and urban stormwater into Lake Michigan.

In 1972, the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) adopted the Tunnel and Reservoir Plan (TARP) with the primary intent of pollution control. Phase I of TARP was completed in 2006, which consisted of four distinct tunnel systems designed to capture CSOs. Phase II of the TARP, scheduled for completion in 2029, will provide further water quality improvements through additional storage volume including the construction of two large reservoirs, Thornton (completion in 2015) and McCook (completion in two phases – 2017 and 2029). Completion of the TARP, and the associated water quality and flood management improvements, are assumed to occur independently of potential activities associated with the discussion framework and would be necessary to protect or improve water quality in the CAWS, Lake Michigan, and the Illinois River Basin in the context of the discuss framework.

The potential redirection of flows to Lake Michigan associated with the discussion framework has potential water quality and regulatory implications. The following sections synthesize previous and ongoing efforts to address these items, including meetings with MWRDGC, the Indiana Department of Environmental Management (IDEM) and the Illinois Environmental Protection Agency (IEPA).

5.2 Water Quality Standards

As established under the Clean Water Act (CWA), water quality standards define the goals of a waterbody by designating its beneficial uses (e.g., recreation and aquatic life protection), setting narrative and numeric criteria to protect those uses, and establishing and implementing an antidegradation policy. Waterbody specific goals help determine what controls are necessary for individual point sources of pollution (e.g., municipal wastewater treatment facilities) as established through the through National Pollutant Discharge Elimination System (NPDES) permits.

The Illinois Pollution Control Board (IPCB), which is responsible for setting water quality standards (WQS) in Illinois, has established four primary categories of narrative and numeric water quality standards designed to protect the beneficial uses of Illinois waters:

- General Use;
- Public and Food Processing;
- Secondary Contact and Indigenous Aquatic Life; and
- Lake Michigan Basin standards.

Each category is intended to help protect various designated uses established for each category.

Most of the state waters fall within a General Use class, a classification intended to protect aquatic-life, wildlife, agriculture, primary contact, secondary contact, and most industrial uses. The Upper North Branch Chicago River Watershed, which is tributary to the CAWS, falls within this use class. The CAWS, however, falls within the Secondary Contact and Indigenous Aquatic Life use class which has associated standards intended to recognize the unique character and limitations of the system. These waters are not required to meet the General Use standards or the Public and Food Processing water supply standards, except for those waters designated as primary contact recreation, which must meet applicable bacteria criteria. Waters in the CAWS designated as primary contact recreation waters include:

- Lower North Shore Channel from North Side Water Reclamation Plant to confluence with North Branch of the Chicago River;
- North Branch of the Chicago River from its confluence with North Shore Channel to its confluence with South Branch of the Chicago River and Chicago River;
- Chicago River;
- South Branch of the Chicago River;
- Little Calumet River from its confluence with Calumet River and Grand Calumet River to its confluence with Cal-Sag Channel; and
- Cal-Sag Channel.

Waters in the CAWS designated as incidental contact recreational waters include:

- Upper North Shore Channel from Wilmette Pumping Station to North Side Reclamation Plant;
- South Fork of the South Branch of the Chicago River (Bubbly Creek);
- Chicago Sanitary and Ship Canal from its confluence with South Branch of the Chicago River to its confluence with Calumet-Sag Channel;
- Calumet River from Torrence Avenue to its confluence with Grand Calumet River and Little Calumet River;
- Lake Calumet;
- Lake Calumet Connecting Channel; and
- Grand Calumet River.

The Calumet River from Lake Michigan to Torrence Avenue is designated as a non-contact recreation water. The Chicago Sanitary and Ship Canal has the lesser designation of non-recreational water. Recreational use designations of the CAWS reflect recent rule updates

based on a use attainability analysis filed in 2007. Some aspects of this rulemaking are still pending.

The highest use class in Illinois' regulations applies to Lake Michigan and its tributaries, which is subject to the Final Water Quality Guidance for the Great Lakes System, also known as the Great Lakes Initiative (GLI). The GLI includes criteria for 29 pollutants, including bioaccumulative chemicals of concern (BCCs), and prohibits the use of mixing zones for these toxic chemicals. 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.

5.3 Antidegradation

Antidegradation policies and regulations provide protections that are critical to the fulfillment of the Clean Water Act (CWA) objective to restore and *maintain* the chemical, physical, and biological integrity of the nation's waters. The intent of antidegradation regulations is to prohibit any significant degradation without a demonstration that lowering water quality is necessary and important. Necessity is typically demonstrated with an assessment of alternatives that result in less of a load increase, no load increase or minimal degradation. A demonstration of importance must also be made with respect to economic or social development.

The antidegradation water quality standard is evoked when any new CWA Section 401 Water Quality Certification or any new, expanded or relocated NPDES discharge is proposed. Therefore, the discussion framework would trigger antidegradation as it would require a CWA Section 404 permit and 401 Certification and involves redirecting some flows to Lake Michigan. Based on initial conversations with IEPA and the Indiana Department of Environment Management (IDEM), the alternatives analysis required as part of the 401 Certification could be used to partially satisfy antidegradation requirements. An antidegradation review would not likely be required for individual NPDES permittees located on the CAWS unless changes are made to the individual discharge point locations; however, the entity or agency sponsoring potential implementation of the discussion framework would need to address antidegradation requirements for the redirection of flows to Lake Michigan. A demonstration of the importance could potentially be made based on the potential savings from avoided AIS control costs and damages, improved water quality, strengthened flood protection, and modernized shipping facilities.

"Supplemental Antidegradation Provisions for BCCs" found in Section 302.521 of the Illinois Administrative Code presents a potential regulatory hurdle to aspects of the discussion framework that would redirect water flows to Lake Michigan. This section prohibits any increased loading of BCCs to Lake Michigan that result in exceedance of applicable water quality criteria or concentrations exceeding the level of water quality necessary to protect existing uses. BCCs are defined in Section 302.501 as including a variety of substances including mercury and PCBs, which are identified on IEPA's 2014 303d List as causing impairments on several segments of the CAWS. While the presence of BCCs in the CAWS

does not necessarily preclude implementation of the discussion framework, it will likely require further analysis.

5.4 Total Maximum Daily Loads

Under Section 303(d) of the CWA, U.S. Environmental Protection Agency (USEPA) and IEPA (through state primacy) are required to identify and list all state waters that fail to meet water quality standards. Commonly referred to as the 303d List, this list identifies waters in need of a Total Maximum Daily Load (TMDL). A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. This allocation is assigned to both point and nonpoint sources and serves as a basis for NPDES permitting requirements and increased management responsibilities amongst sources in the watershed.

Based on IEPA's 2014 303d List, multiple waterbodies within the CAWS are impaired for a variety of designated use impairments and causes. Few, if any, of these waterbodies are currently classified as tributary to Lake Michigan. Should flows be redirected back to Lake Michigan as part of the separation project, 303d impairment status would likely remain unchanged. However, TMDL allocations for both point and nonpoint sources may become more stringent than what are currently required to provide adequate protections for Lake Michigan, depending on the use impairment and pollutant cause. TMDL status reports from IEPA's website are summarized below.

LAKE MICHIGAN BEACHES

In 2013, USEPA approved IEPA's TMDL for Lake Michigan beaches in Lake and Cook Counties. The TMDL addresses primary contact use recreation impairments due to excess bacteria. A variety of pollutant sources including wastewater treatment plants, urban stormwater, and CSOs were targeted within the TMDL. However, wastewater treatment facilities within the CAWS were not specifically targeted as flow reversals into Lake Michigan were considered infrequent and not significant in the bacteria model. Additionally, the TMDL notes that IEPA is working on TMDLs for portions of the CAWS, which will be completed at a future date.

The TMDL assigned an *E. coli* wasteload allocation (WLA) of 126 cfu/100 mL for the following 7 municipal separate storm sewer systems (MS4s) in Chicago and Cook County:

- City of Chicago,
- Union Drainage District No. 1 Middle Fork
- City of Evanston,
- Village of Glencoe,
- Village of Wilmette,
- Village of Winnetka,
- Village of Kenilworth.

An exception to this allocation was provided for the Cook County Highway Department, which received a WLA of 0 cfu/100 mL. This allocation is a result of the stormwater management from roadways, which was designed to be fully intercepted by the CAWS. Should Chicago and Calumet River flows be redirected to Lake Michigan, additional MS4 communities may be impacted by this TMDL.

UPPER NORTH BRANCH CHICAGO RIVER WATERSHED

Nine impaired waterbodies were identified for the Upper North Branch Chicago River Watershed, which drains approximately 87,000 acres, including the North Shore Channel, into the CAWS. The only waterbody classification to the Upper North Branch Chicago River Watershed is the General Use classification. The designated uses for these waterbodies are primarily aquatic life and primary contact recreation with some aesthetic quality and fish consumption issues. The identified causes for impairments include total phosphorus, fecal coliform, pH, dissolved oxygen, temperature, manganese, and chloride.

IEPA uses a three-stage approach to develop TMDLs for a watershed: 1) watershed characterization, 2) data collection, and 3) model calibration, TMDL scenarios, and implementation plans. At this time, IEPA has completed the Stage 1 report for the Upper North Branch Chicago River Watershed. A total of 10 potential NPDES point sources are identified in the Stage 1 report including 3 major wastewater treatment plants (i.e., greater than 1 MGD) and 4 CSO communities. Additionally, the Stage 1 report identified 27 municipal separate storm sewer systems (MS4) within the Upper North Branch Chicago River Watershed that will potentially be impacted by this TMDL. The Stage 1 report targets water quality standards commensurate with the General Use classification. Should Chicago River flows be redirected to Lake Michigan, Lake Michigan Basin standards would likely apply, potentially resulting in more stringent permitting conditions.

LAKE MICHIGAN NEARSHORE (NEARSHORE)

As part of the TMDL development process, IEPA completed a scoping report for 51 beach segments and 4 harbors along the Illinois Lake Michigan shoreline that are included on IEPA's impaired waters listing for mercury and polychlorinated biphenyl (PCBs). Potential pollutant sources identified in the scoping report include, among others, MS4 stormwater loading, other NPDES permitted sources, and flow reversals from the CAWS. Redirecting Chicago and Calumet River flows to Lake Michigan would significantly enlarge the contributing drainage area to the nearshore resulting in increased pollutant loading. It is unclear if the additional loading would be allowed once the TMDL is finalized. At a minimum, however, the TMDL would likely necessitate more stringent permitting conditions for MS4s and other NPDES sources within the enlarged drainage area.

5.5 NPDES Permitting Implications

For facilities and communities located riverside of possible ANS control points, effluent and stormwater runoff would continue to drain towards the Illinois River. Although water quality

standards would remain the same for riverside facilities, without flow augmentation or other mitigation reduced flow conditions could negatively impact dissolved oxygen levels potentially resulting in more stringent effluent limitations (e.g., lower carbonaceous biological oxygen demand). Facilities and communities located lakeside of the ANS control points that currently discharge to the CAWS (i.e., affected drainage area) would likely be subject to more stringent water quality standards and additional TMDL requirements. The potential permitting and regulatory implications for wastewater treatment plants (WWTPs), MS4 and CSO communities located in the affected drainage area of the CAWS are discussed below.

5.5.1 Wastewater Treatment Plants

AFFECTED WWTPS

Numerous WWTPs, including major municipals minor municipals, and industrial facilities, are located within the affected drainage area of the CAWS (Figure 30). Major municipal WWTPs located within the affected drainage area in Illinois are listed below:

Figure 30: CAWS Drainage Area and NPDES Permitted Discharges Potentially Affected



- **MWRDGC O'Brien WRP** (Design average flow (DAF) = 330 MGD) – Located on the North Shore Channel, this plant currently discharges lakeside of the ANS control points. However, the discussion framework includes a conveyance conduit terminating riverside of the ANS control points. Therefore, it is not anticipated that treatment operations would be impacted by the discussion framework concepts.
- **MWRDGC Stickney WRP** (DAF = 1,200 MGD) – The largest of all the MWRDGC plants, this WWTP is located on the Chicago Sanitary and Ship Canal in close proximity to the ANS framework control point. This plant would discharge riverside of the ANS control point; therefore, it is not anticipated that treatment operations would be impacted by the discussion framework concepts.
- **MWRDGC Calumet WRP** (DAF = 350 MGD) – Located on the Little Calumet River, this facility currently discharges lakeside of the ANS control points. However, the discussion framework includes a conveyance conduit terminating riverside of the ANS control points. Therefore, it is not anticipated that treatment operations would be impacted by the discussion framework concepts.
- **NSSD-Clavey Road SD STP** (DAF = 17.8 MGD) – This plant is located in the Upper North Branch Chicago River Watershed, which is tributary to the CAWS. Discharge from this facility could potentially be rerouted to the Des Plaines River Watershed, where General Use criteria apply. Without such a reroute, Lake Michigan Basin criteria (Table 27) would apply to this plant if Chicago River flows were redirected to Lake Michigan.
- **Deerfield Wastewater Reclamation Facility** (DAF = 3.5 MGD) – This plant is located in the Upper North Branch Chicago River Watershed, which is tributary to the CAWS. Discharge from this facility could potentially be rerouted to the Des Plaines River Watershed, where General Use criteria apply. Without such a reroute, Lake Michigan Basin criteria would apply to this plant if Chicago River flows were redirected to Lake Michigan.
- **Thorn Creek Basin SD STP** (DAF = 15.94 MGD) – This plant currently discharges to Thorn Creek which is tributary to the Little Calumet River. This plant discharges lakeside of the ANS control point; therefore, Lake Michigan Basin criteria would apply to this plant if Calumet River flows were redirected to Lake Michigan.

In addition to these facilities, five major municipal WWTPs are located in Indiana in the affected drainage area. Three of these WWTPs (Hammond Sanitary District WWTP, East Chicago Municipal Sewage Treatment Plant, and Gary WWTP) discharge to Lake Michigan via the Grand Calumet River. Although the Hammond plant also discharges to the CAWS via the Grand Calumet River, all three of these facilities have treatment processes and NPDES permits to meet Great Lakes Initiative (GLI) standards, which allows them to discharge to Lake Michigan. Two of the five facilities (Schererville WWTP and Dyer WWTP) discharge to the Hart Ditch drainage basin, which represents the drainage divide between the CAWS and the Lake Michigan. Therefore, it is not anticipated that any of the WWTPs located in Indiana would be significantly impacted if Calumet River flows were redirected to Lake Michigan.

ANTICIPATED PERMIT LIMITS AND CONDITIONS

Effluent limitations for discharges both to the Lake Michigan Basin (i.e., lakeside of the ANS control points) and the Illinois River Basin (i.e., riverside of the ANS control points) are likely to become more stringent over time. Predicting the standards and their timing is a challenging undertaking that was beyond the scope of this document. However, it is anticipated that discharges to the Lake Michigan Basin would require more stringent effluent limitations than that currently expected for treated effluent discharged to the Illinois River Basin.

Anticipated potential limits and permitting conditions representative of both sides of the drainage divide were estimated for planning level purposes (Table 27). Estimations are based on potential regulatory requirements that may occur within the planning horizon of the discussion framework. Actual NPDES permit limits and conditions are site-specific and will likely vary between facilities. Additional considerations of estimated limits and conditions follow.

Bacteria

As previously discussed, waterways in the CAWS are designated for a variety of recreational uses ranging from non-recreational waters to primary contact recreation. Currently no bacteria criteria exist for waters not designated as primary contact recreation. Additionally, IEPA is currently in the process of changing the Illinois General Use water quality criteria for fecal coliform bacteria to *E. coli*. At this time it is unclear what, if any, *E. coli* criteria will ultimately apply to those waterways not designated for primary contact recreation. However, as disinfection is planned and has been authorized by MWRDGC for the Calumet and North Side WWTPs, disinfection commensurate with primary contact recreation is assumed here for all facilities located in the CAWS. It is further assumed that an *E. coli* limit of 126 cfu/100 mL, expressed as a geometric mean, will be required regardless of discharge location based on USEPA's Final National Recreational Criteria released in 2012.

Nutrients

Due to the national attention on nutrient loading 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 planning horizon, nutrient reduction will be required at some level, whether wastewater effluent is discharged to the Illinois River Basin or Lake Michigan. It is anticipated that discharges to the Lake Michigan Basin would likely require more stringent nutrient removal, potentially ranging from enhanced nutrient removal to the limits of technology.

Emerging Contaminants

Although potentially dependent on discharge location (Illinois River versus Lake Michigan), regulatory requirements for constituents not currently regulated are expected to emerge within a 50-year planning period for the discussion framework and may apply with or without redirection of flows to Lake Michigan. While these emerging contaminants are a concern to all Great Lakes dischargers, affordable treatment technologies are not currently available, and this level of treatment is generally not required at this point for other wastewater plants that discharge to the

Great Lakes. Additionally, potential performance standards are not fully understood. Most municipalities are addressing these concerns through point source control and aggressive industrial pretreatment enforcement.

Table 27: Potential Ranges of Future Regulatory Requirements

Parameter	Lake Michigan Basin		Illinois River Basin		
	Stringent	Moderate	Stringent	Moderate	Current
CBOD (mg/L)	4 ^a	4 ^a	10	10	10
TSS (mg/L)	5 ^a	5 ^a	12	12	12
Ammonia N (mg/L)					
Apr-Oct	0.2 ^b	1.5 ^c	0.2 ^b	1.5 ^c	2.5
Nov-Mar	0.8 ^b	4 ^c	0.8 ^b	4 ^c	4
Total Phosphorus (mg/L)	0.1 ^d	0.1 to 1 ^e	0.5 to 1 ^e	1 ^e	--
Total Nitrogen (mg/L)	3 ^d	6 ^f	3 ^d	6 ^e	--
<i>E. coli</i> (cfu/100mL)	126 ^g	126 ^g	126 ^g	126 ^g	--
Mercury (ng/L)	1.3 ^h	12 ⁱ	12 ⁱ	--	500 ^j
Other BCC ^k 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 standards for un-ionized ammonia.

^d Current practical limit of technology. Treatment includes nitrification/denitrification and biological phosphorus removal via activated sludge, chemical addition, enhanced 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 USEPA 2012 Final Recreational Criteria expressed as a geometric mean.

^h Current Lake Michigan ambient water quality standard.

ⁱ Current water quality standard for General Use Water.

^j Current Chicago Waterway System ambient water quality standard

^k Bioaccumulative chemicals of concern.

5.5.2 Stormwater and MS4 Permittees

Numerous industries and MS4 communities are currently authorized to discharge stormwater to the CAWS under both general and individual permits. Conditions within these permits hold industries and MS4 communities responsible if their discharge, alone or in combination with other sources, causes or contributes to a violation of any applicable water quality standard. The

redirection of flows to Lake Michigan associated with the discussion framework would effectively hold these permittees to a higher water quality standard as well as TMDL pollutant loading limitations associated with the Lake Michigan beaches and nearshore. This will likely necessitate revisions to stormwater management programs and stormwater pollution prevention plans (SWPPPs). Additionally, MS4 communities may be required to retrofit existing stormwater management systems for water quality improvements. Based on existing Lake Michigan TMDLs, parameters that will likely drive additional stormwater requirements include bacteria, PCBs and mercury.

5.5.3 Combined Sewer Overflows

In the CAWS drainage areas, there are 245 active CSOs owned by the City of Chicago, MWRDGC and surrounding municipalities (MWRDGC Website, 2015). The CSOs drain away from Lake Michigan to the Mississippi River Basin under most wet weather conditions. However, during major storms it is necessary to release combined flood water and sewage into Lake Michigan. Phase II of the TARP is designed to significantly reduce the number of CSO discharges and minimize the possibility of back flows during these storm events. At the scheduled completion of two large reservoirs for TARP in 2015 and 2029, about 14.8 billion gallons of reservoir storage will be added to the combined flood water and sewer conveyance system. Previous estimates indicate that, with the completion of these TARP reservoirs, up to 10 overflow events per year could still occur from several existing overflow discharge locations in 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.

While the Chicago-area is not currently considered a Lake Michigan CSO community, implementation of the discussion framework would alter this assumption (USEPA, 2007). It is unclear what, if any, ramification this would have on CSO controls. The Great Lakes Strategy 2002, which was developed by the U.S. Policy Committee to advance the restoration of the Great Lakes Basin Ecosystem, established the following specific target with respect to CSO control:

“By 2005 100% of all CSO permits in the Great Lakes basin will be consistent with the national CSO Policy. All issued/reissued permits for CSO discharges will contain conditions that conform to the National CSO policy, and States will prioritize the reissuance of CSO permits under their backlog strategies (USPC, 2002).”

Based on these conditions, the TARP, which was approved as the Long-Term Control Plan (LTCP) for the MWRDGC and surrounding communities, may meet this target. However, the TARP was not developed with the intent of providing a level of service necessary to attain water quality standards in Lake Michigan. Additional hydraulic and water quality modeling may be needed to determine if a higher level of service would be required.

5.6 Summary

The potential elements of a long term solution have wide ranging implications with respect to water quality conditions and Clean Water Act (CWA) requirements as it could involve rerouting flow from the CAWS to Lake Michigan. Water quality standards applicable to Lake Michigan are generally more stringent than for the CAWS. Additionally, multiple segments of the CAWS have been identified as impaired for a variety of pollutants. Rerouting flow to Lake Michigan, therefore, has implications for antidegradation, Total Maximum Daily Loads (TMDLs), and NPDES permitting. Of particular note is the fact that segments of the CAWS are impaired for BCCs including mercury and PCBs, which have special restrictions under the GLI. Rerouting flows could also have significant implications with regards to MWRDGC and surrounding communities, which are implementing LTCPs for CSO control. In addition, stormwater utilities may also be impacted through their MS4 permits and programs. While various mitigation measures for these water quality impacts have been conceived as potential elements of a long term solution, additional detailed analysis including hydraulic and water quality modeling are needed for reducing uncertainty related to flow augmentation, antidegradation, GLI standards, and stormwater. These analyses should be coupled with more detailed economic evaluations to accurately weigh costs and benefits of alternatives.

5.7 References

1. MWRDGC. <https://www.mwrd.org/irj/portal/anonymous/tarp>. Accessed 9/8/2015.
2. 35 Ill. Adm. Code Sections 301-303
3. IEPA. Illinois Water Monitoring Strategy 2015-2020. September 2014. <http://www.epa.state.il.us/water/water-quality/monitoring-strategy/monitoring-strategy-2015-2020.pdf>
4. Illinois 2014 303d List. <http://www.epa.illinois.gov/topics/water-quality/watershed-management/tmdls/303d-list/> Accessed 8/30/2015.
5. Lake Michigan Beaches TMDL Status Reports. <http://www.epa.illinois.gov/topics/water-quality/watershed-management/tmdls/reports/index> Accessed 8/30/2015.
6. Lake Michigan (Nearshore) TMDL Status Reports. <http://www.epa.illinois.gov/topics/water-quality/watershed-management/tmdls/reports/index> Accessed 8/30/2015.
7. Upper North Branch Chicago River Watershed TMDL Status Reports. <http://www.epa.illinois.gov/topics/water-quality/watershed-management/tmdls/reports/index> Accessed 8/30/2015.
8. USEPA, Report to Congress – Combined Sewer Overflows to the Lake Michigan Basin. EPA-833-R-07-007, September 2007.
9. Lanyon, 2011 (*citation taken from HDR 2013 report: Briefing on the Water Quality Elements for the Mid-System Alternative from the Evaluation of Physical Separation Alternatives in the CAWS Technical Report*)
10. Durgunoglu et al., 1992 (*citation taken from HDR 2013 report: Briefing on the Water Quality Elements for the Mid-System Alternative from the Evaluation of Physical Separation Alternatives in the CAWS Technical Report*)
11. MWRDGC. Combined Sewer Overflows – Outfalls Along Waterways. November 2014. [https://www.mwrd.org/pv_obj_cache/pv_obj_id_37D32E1D73E700E880C3EFF32BC41B1840840000/filename/Outfalls Along Waterways.pdf](https://www.mwrd.org/pv_obj_cache/pv_obj_id_37D32E1D73E700E880C3EFF32BC41B1840840000/filename/Outfalls_Alone_Waterways.pdf). Accessed 9/8/2015.

6.0 Contaminated Sediment

The CAWS has historically been used for commerce and the banks of the rivers have been lined with commercial and industrial land uses for many decades. Over time, these uses have resulted in the accumulation of known contaminants to the environment and aquatic species in the river from run-off, discharges, and spills into the CAWS. The potential long term solutions involving Potential AIS Control Points 1 (Stickney) and 2a (Alsip) are the focus of this discussion of CAWS contaminated sediment as they would result in a reversal of flow (currently away from Lake Michigan) that could potentially carry previously undisturbed contaminated sediment in the river bed into Lake Michigan. Contaminated sediment implications for the Calumet System would be eliminated with potential AIS control point 2b, but are directly related to tradeoffs in flood risk management; therefore, these were previously discussed in Section 4. Many studies have been conducted to collect and analyze sediments in the river bed for potential disposal, human health and aquatic species impacts. The U.S. Environmental Protection Agency (USEPA) has provided an unofficial summary of results of sampling and analysis conducted by the USEPA and other agencies (USACE, Bureau of Mines, Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), and Great Lakes National Program Office) within the CAWS¹. Contaminants of concern identified and analyzed for the studies varied, but generally included: Polychlorinated Biphenyls (PCB), Polycyclic Aromatic Hydrocarbons (PAHs), oil and grease, volatile organic compounds (VOCs), dioxin and furans, and heavy metals (lead, cadmium, chromium, nickel, copper, zinc and mercury).

6.1 Chicago River System Upstream of Stickney

The discussion of the Chicago River has been divided into the following reaches, from upstream to downstream, and illustrated in Figure 31, in order to improve the discussion of contaminated areas along the river.

6.1.1 North Shore Channel

The North Shore Channel extends from the Wilmette Pumping Station to the confluence with the North Branch of the Chicago River (NBCR). Sample locations (side and center channel) were selected along the North Shore Channel (NSC) for analysis for heavy metals, PAHs, total volatile solids (TVS), total phosphorus, and ammonia.

Analysis indicated that PAHs were highest at Touhy Avenue just downstream of the NS STP at 122 ppm. The highest levels of TVS, ammonia, and most metals were found at Oakton Street. The entire North Shore Channel exhibits elevated to extremely elevated levels of certain heavy metals.

6.1.2 Upper North Branch of the Chicago River above Albany Avenue

This section of the NBCR is mostly un-channelized and follows a path similar to the way it was before the area became heavily urbanized. The stream splits into three upstream branches: the Skokie River, the West Fork (WFNBCR), and the Middle Fork (MFNBCR).

Heavy metal contamination along this reach is similar to that found in the NSC above, however the chromium, mercury and zinc levels were higher in the upper NBCR streams. Maximum values were scattered among the sample locations, but the main (semi-natural) channel of the NBCR had the highest levels of most metals.

6.1.3 North Branch of the Chicago River (NBCR) below Albany Avenue

The NBCR downstream of the junction with the North Shore Channel is wider and channelized completely downstream to the Chicago River at Wolf Point (downtown loop Chicago) where the South Branch of the Chicago River (SBCR) joins. This reach, which contains the Federal Navigation Channel, is heavily contaminated with metals, PCBs, PAHs, and nutrients and it has been problematic for the USACE. No suitable dredged material disposal site has been found to date and maintenance dredging has not been performed for many decades due to PCBs concentrations above the Toxic Substance Control Act (TSCA) level in the deeper strata. Sediment in the turning basin and NBCR channels around Goose Island are 20 or more feet thick.

The highest PCB level in the surface grabs during 1980-1992 (9.1 ppm) was found between Ohio Street and Grand Avenue about midway downstream of Goose Island and the junction with the Chicago River at Wolf Point. The 110 ppm maximum Total PCB concentration was found in 1980 in the North Branch Canal on the east side of Goose Island at about 18 feet below low water depth.

6.1.4 Chicago River Main Channel

From the Chicago River junction at Wolf Point to the Chicago Locks, the main channel of the Chicago River is anticipated to be relatively less polluted than other areas because of the USACE maintenance dredging.

Total PCBs as sum of Arochlors ranged from < 0.2 to 3.8 ppm with an average of 1.6 ppm. The total sum of PAHs ranged from 10 to 4,776 ppm with an average of 517 ppm. The maximum value was collected in the center channel near North La Salle Drive during 2002. The total PAHs are usually the sum of 15-17 specific PAH compounds under current practice. In 1980 the USACE analyzed 2 surface grab samples for only 5 PAH compounds (Acenaphthene, Acenaphthylene, Benzo (a) pyrene, Naphthalene and Pyrene). The sum of these five PAHs ranged from 1.3 ppm to 10.4 ppm in these two samples.

6.1.5 South Branch of the Chicago River, Bubbly Creek, and nearby slips

This reach has been extensively sampled by the USEPA and the USACE. It includes Bubbly Creek and nearby slips in the area where the South Branch begins to be called the San-Ship. Bubbly Creek (sampled by Superfund and the subject of recent City of Chicago and USACE engineering studies) has similar metals contamination found in other parts of the river, but has higher organic matter from historical animal slaughterhouse waste. This 1.25 mile tributary's flow is controlled since the headwater is a sewage overflow pumping station managed by the MWRDGC. Sediment samples all showed elevated levels PAHs and heavy metals. Other detected contaminants included some low part per billion level semi-volatile organic compounds (SVOCs) and VOCs.

The Superfund Program of the USEPA is currently working with a Potentially Responsible Party (PRP) as a part of an alternative approach agreement to investigate and remove contaminated sediments in the river resulting from manufactured gas plants (MGP). The defined operable unit (OU) includes the northern portion of Bubbly Creek, Turning Basin, and approximately three-quarters of a mile of the South Branch lake side of the confluence with Bubbly Creek. Sediment within this area with elevated PAHs, heavy metals, VOCs, and other constituents resulting from manufactured gas may be targeted for clean-up under this agreement with the PRP. Investigation is currently underway in the OU, with clean-up a possibility within the next several years.

Figure 31: Chicago River System Areas of Contaminated Sediment



6.2 Calumet River System Upstream of Alsip

The discussion of the Calumet River has been divided into the following reaches, from upstream to downstream, and illustrated in Figure 32 below, in order to improve the discussion of contaminated areas along the river.

6.2.1 Cal-Sag Channel / Little Calumet River / Thorn Creek / Grand Cal River

This channel system has heavy metal, mercury, and nutrient contamination throughout and downstream to its junction with the San-Ship. The Little Calumet River starts at RM 319.5, and the Calumet WRP main outfall is located on the Little Calumet River at about RM 321.3 in Chicago across from Riverdale. Alsip is about 6.5 miles downstream along the Cal-Sag Channel at about 127th Street (RM314.9). The name of the river changes to the Calumet River on the upstream side of O'Brien Lock and Control Works. All of the Calumet River proper can be considered part of existing conditions for the purpose of the discussion framework evaluation. The Grand Calumet River (Grand Cal) flows into the Little Calumet near Torrence Avenue from the drainage divide at the Hammond WWTP in Indiana. The system up to the state line has not been dredged or capped while the Indiana side of the system is either being remediated or will be soon.

The highest mercury levels occurred at Indiana Avenue (WW56) on the Little Calumet River. The highest levels of silver, cadmium, chromium, copper, nickel, lead, zinc, PAHs, and TVS occurred on the Grand Cal at Burnham Avenue (WW86). The highest levels of iron and manganese occurred at Halsted Street (WW76) on the Little Calumet River.

The highest PAHs occurred at the Cal-Sag at Cicero (WW59). The Total DDT averaged 0.09 ppm (n=13) including MWRDGC samples. The maximum was 0.65 ppm at 1D5S7 just downstream the Alsip boat ramp. A few of the other 19 pesticides were detected: Delta-BHC, gamma-chlordane, alpha-chlordane, endrin aldehyde, and endosulfan sulfate at low levels.

The highest ammonia levels occurred at 1D5S7 at Alsip in the Cal-Sag, while the highest Total Potassium and Nitrogen (TKN) and Total Phosphorus was found at Burnham Avenue in the Grand Cal.

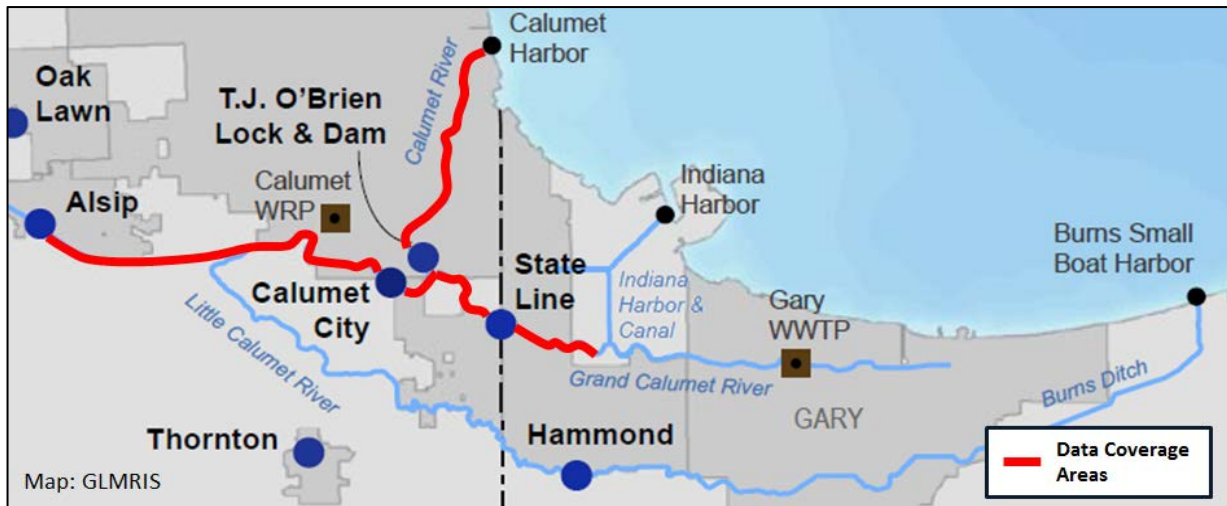
The Grand Cal area, especially near the mouth has deep (up to 16 ft. thick) deposits of historic sediments with elevated organic content. The Grand Cal mouth area bubbles gases in a manner similar to Bubbly Creek having received large quantities of waste from slaughter houses and gelatin factories back before 1900. Two locations on the Illinois side, Torrence Avenue and State-Line Road, were sampled in 1993 as part of a lawsuit against Hammond Indiana and others. The portion of the river further east on the Grand Cal, upstream of State-Line have been or will be remediated soon.

6.2.2 Calumet River, O'Brien Locks to Lake Michigan

This reach is part of the existing conditions as it is already connected directly to Lake Michigan. It is likely fairly clear of heavy sediment deposits because of maintenance dredging. It is also connected to Lake Calumet. It is possible that some near shore and slip areas still contain heavily contaminated materials left over from the industrial period. There were two sampling locations by the MWRDGC at Ewing Avenue and 130th Street collected from side and center channel during 2003 and 2007.

The highest TKN and Total Phosphorus were found at 130th Street while the highest ammonia levels were found at Ewing Avenue. The highest TVS, iron, manganese, and silver were found at Ewing Avenue while the other metals had their maximums at 130th Street.

Figure 32: Calumet River System Areas of Contaminated Sediment



6.3 Summary

Based on the referenced studies, extensive contamination (specifically heavy metals, PAHs, and PCB) have been identified along both the Chicago River System and the Calumet River System. Maintenance dredging and remediation has helped to alleviate higher contaminant concentrations along portions of the river; however, contaminated sediments still remain. In addition to the general waterway reaches of the CAWS lakeside of the ANS control points, the following areas have been identified as contaminated areas of concern that could potentially impact Lake Michigan if flows were to reverse towards the lake:

- Goose Island
- Bubbly Creek
- Turning Basins (Goose Island and Bubbly Creek)
- Grand Calumet at Torrence Ave (sunken barge)
- Grand Calumet (Stateline to Hohman Ave)

Anticipated remediation of contaminated sediments through a Superfund settlement with a PRP may eliminate the Bubbly Creek Turning Basin and the northern end of Bubbly Creek as an area of concern. Remedial activity would likely take place before the proposed flow reversals would occur.

Though sediments in both river systems have been identified as polluted, action levels need to be established to determine areas of elevated contamination. Initially, it should be determined which threshold levels, whether specific to aquatic life, human health, or clean-up standards, should be applied for this document. Next a model of sediment transport would need to be conducted to determine which areas of the river system and to what depths, are likely to impact Lake Michigan. Identification of targeted clean-up areas could then be conducted using these assessments.

6.4 References

USACE 1981. “Draft Environmental Impact Statement; Chicago Area Confined Disposal Facility and Maintenance Dredging in Cook County, Illinois”, Chicago District Corps of Engineers.

USACE 1981. “Summary Report: Chicago Sites Sediment Quality Analysis”, Chicago District Corps of Engineers.

USACE 1983. “Chicago River – North Branch: Analysis of Sediment Samples Collected in August 1983”, Chicago District Corps of Engineers.

USACE 1984. “North Branch of the Chicago River – An Analysis of Alternatives for Disposal of Maintenance Dredgings”, Chicago District Corps of Engineers.

USACE 1987. “Sediment and Pore Water Studies of Chicago River – North Branch Sediment”, James M. Brannon, Environmental Laboratory, Waterways Experiment Station, Corps of Engineers, Vicksburg, Mississippi.

Harrison, PM, Aznavoorian, D Kullen, MD Erickson, JF Schneider, and C. Tome, 1988. Draft report titled “Chemistry of Bottom Sediments from the North Branch of the Chicago River and North Branch Canal, Lake Street to North Avenue, Chicago, Illinois” prepared for USACE by Argonne National Laboratory.

USACE 1990. “Chemistry of Bottom Sediments from the North Branch of the Chicago River and North Branch Canal, Lake Street to North Avenue, Chicago, Illinois.”

Allen, James P and Irwin Polls 1992. “Heavy Metals in Sediments From the North Branch Chicago River” in Assessment and Treatment of Contaminated Sediments in the North Branch Chicago River a model approach for an urban waterway, Chicago Botanic Garden, Glencoe, IL Oct 19 & 20, 1992.

USEPA 1994. Unpublished sediment collection associated with Hammond et al enforcement case.

USEPA 1999-2002. Unpublished sediment collections: Chicago River, Sanitary and Ship Canal, Cal-Sag Channel, Illinois River, USEPA, Region 5, the Water Division, the Great Lakes National Program Office and the Superfund Division.

USEPA 2003. “October 2000 and August 2002 Survey of Sediment Contamination in the Chicago River, Chicago, Illinois” prepared by Demaree Collier and Scott Cieniawski of the Great Lakes National Program Office.

Unpublished Presentation to the Friends of the River (Power Point). “North & South Branch Chicago River Sediments, George Azevedo & John Dorkin, 2004”

7.0 Summary

The document summarizes technical investigations and background information compiled by HDR to address technical questions and concerns from the CAWS Advisory Committee and to inform their efforts to reach consensus on a long-term solution.

Information about and implications for various combinations of conceptual elements for a potential long term solution to prevent ANS transfer via the CAWS were informed by previous study results and evolved through CAWS Advisory Committee discussions based on relationship with the working criteria involving AIS risk, flood risk, water quality, and transportation. These conceptual elements and control points served as a tool for further evaluation of potential options regarding:

- ANS control measures
- Commercial cargo navigation

A high level summary of background information and potential implications of a potential long term solution also was focused on the following areas:

- Flood Risk and Water Quality Conveyance
- Water Quality
- Contaminated Sediments

A concept which introduces a combination of control measures in a safe, efficient manner yet still allows for transportation and recreational uses appears feasible and will require additional development, validation, and testing. Potential ANS Lock System Combination concepts for Scenarios 1 & 2 are estimated to provide similar > 85% to > 95% risk reduction depending upon species. While 75% to 95% risk reduction can be theorized, actual rates will be dependent upon the specific control measures selected and the targeted species. The uncertainty of control measure application, weakest pathway link, and potential cumulative effects of multiple control points drives overall risk reduction estimates. Further research and development combined with adaptive management is expected to improve efficiencies and reduce uncertainty, including investigation of a focused set of control measures and combinations, evaluation of mixing effects in lock chambers and interactions of control measure combinations, and assessment of criteria related to maritime safety and operations.

While volumes of coal shipments on the CAWS are projected to decline substantially due to the recent closure of power generation plants, crude materials, including aggregates and other building materials, have been steadily rising and are projected to continue increasing. Since the waterways remain open, potential Scenario 1 (two ANS locks) would have transportation cost impacts limited to a few million dollars, with the principal measurable cost being the delay associated with a new lock on both the CSSC and the Cal-Sag Channel. Potential Scenarios 2 & 3 could result in transportation cost impacts ranging from tens of million dollars (assuming re-routing of cargo) to hundreds of million dollars (either full modal shift and/or physical barrier) if all traffic on these waterway segments is forced to shift modes.

Relative to potential flood risk and water quality implications, the location of a potential ANS control point is expected to be more significant than the eventual choice of control structure type (i.e. ANS lock system or physical barrier). Potential ANS Control Points 1 and 2a were identified as minimizing potential flood risk implications, while Control Point 2b, with possible additional associated structures to prevent movement of AIS, was recognized as lessening potential water quality and transportation effects in exchange for increased flood risk potential relative to Control Point 2a. Additional hydrologic and hydraulic modeling is necessary for refinement of flood risk mitigation elements (i.e. tunnels, reservoirs, infrastructure operations) to address both CSO and localized flood risk.

The potential elements of a long term solution have wide ranging implications with respect to water quality conditions and Clean Water Act (CWA) requirements as it could involve rerouting flow from the CAWS to Lake Michigan, which has implications for antidegradation, Total Maximum Daily Loads (TMDLs), and NPDES permitting. Of particular note is the fact that segments of the CAWS are impaired for BCCs including mercury and PCBs, which have special restrictions under the GLI. Rerouting flows could also have significant implications with regards to CSO communities, and stormwater utilities may also be impacted through their MS4 permits and programs. While various mitigation measures for these water quality impacts have been conceived as potential elements of a long term solution, additional detailed analysis including hydraulic and water quality modeling are needed for reducing uncertainty related to flow augmentation, antidegradation, GLI standards, and stormwater. These analyses should be coupled with more detailed economic evaluations to accurately weigh costs and benefits of alternatives.

Based on the referenced studies, extensive contamination (specifically heavy metals, PAHs, and PCB) have been identified along both the Chicago River System and the Calumet River System. Though sediments in both river systems have been identified as polluted, action levels need to be established to determine areas of elevated contamination. Initially, it should be determined which threshold levels, whether specific to aquatic life, human health, or clean-up standards, should be applied for this document. Next a model of sediment transport would need to be conducted to determine which areas of the river system and to what depths, are likely to impact Lake Michigan. Identification of targeted clean-up areas could then be conducted using these assessments.



Appendix A

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