AN ANALYSIS OF THE ECONOMIC EFFECTS OF TERMINATING OPERATIONS AT THE CHICAGO RIVER CONTROLLING WORKS AND O'BRIEN LOCKS ON THE CHICAGO AREA WATERWAY SYSTEM

April 7, 2010

Joseph P. Schwieterman, Ph.D.*
Professor, School of Public Service, and Director,
Chaddick Institute for Metropolitan Development
DePaul University
Chicago, IL 60604
jschwiet@depaul.edu
312.362/5732

*The author would like to acknowledge the assistance of Alice Bieszczat, Steve Field, Lauren Fischer, Andrew Pizzano and Amy Creyer.

Executive Summary

Concern about the migration of Asian Carp into the Great Lakes system has been the impetus for discussion about terminating operations at three facilities in the Chicago Area Waterway System: the Chicago Controlling Works, the Thomas J. O'Brien Lock and the Wilmette Pumping Station. To foster understanding about the implications of this method of partial ecological separation, this study explores the extent of the economic activity that would be affected by these actions and their potential influence on the region's economic wellbeing.

The findings show that spending by consumers and commercial shippers on the barge and boat operations that would be affected by closure of the locks has an annual financial impact of $1.3 billion. This figure is inclusive of multiplier effects related to waterway use but not inclusive of certain employment-related effects, which can only be measured with further study. The economic value lost from permanent closure is estimated to be $582 million the first year, $531 annually over the subsequent seven years, and $155 million annually thereafter. The net present value of these costs, over a 20-year planning horizon at a four percent discount rate, is $4.7 billion.

For the first year after closures, the lost value consists of added transportation costs ($125 million; inclusive of social costs), losses to recreational boaters ($5 million), consumers of river cruises and tours ($20 million), municipal departments providing public protection ($6 million), property owners ($51 million), and regional agencies needing additional funds for flood-abatement systems ($375 million). A portion of these losses would be shouldered by industries outside the Chicago metropolitan area, particularly certain ports in the Mississippi River basin that serve the barge transportation industry.

Additional research is needed to develop more accurate estimates in a variety of areas, including the effects of closure on assets and activities that derive their value from the aesthetic qualities of the river system, such as riverfront property, boat tours and cruises. This study also does not consider the employment-related effects, which will require separate study. Nonetheless, it offers a framework to illustrate how closure would affect various sectors of the economy, and offers suggestions for a more detailed study that could be conducted in the future.

I. Introduction

The prevalence of two species of Asian Carp in the Chicago Area Waterway System (CAWS) is generating vigorous debate about how to prevent a sustainable population from making its way into the Great Lakes System. A variety of alternatives, including greater use of pesticides, additional "electronic fencing", modified lock operations, and complete hydrologic separation have been proposed to lessen the possibility of this occurring. One method of partial hydrologic separation under review involves the permanent cessation of operations at the Chicago Controlling Works ("Chicago Lock"), the Thomas J. O'Brien Lock, the locks' accompanying sluice gates, and the Wilmette Pumping Station.

This paper focuses on the potential economic effects of the latter alternative. It offers economic and financial estimates of the impact terminating operations at these facilities would have in two areas relevant to the policymaking process. First, it provides estimates of the aggregate spending by consumers and commercial shippers on goods and services directly tied to marine vessels that would be directly and indirectly affected by closing the locks. Second, it estimates the economic value that would be lost from closure, through reductions in consumer surplus, diminished land value, and costs imposed on government agencies. This second section also illustrates how costs are distributed between consumers and institutions, as well as how these losses would be spread out over time.

To formulate these estimates, this study draws primarily on existing data and scholarly research that has been subject to professional review. In areas where little or no published research exists regarding the probable impact closure would have on metropolitan Chicago, it reviews the economic valuation and "benefit transfer" literature to identify measurements made in comparable settings in other parts of the country that can be appropriately applied to this region.

There is a particular dearth of published information about how recreational activities involving use of locks affect the metropolitan economy. Previous studies on recreational boating evaluate the CAWS and the Great Lakes as an integrated unit rather than as distinct resources to be evaluated separately. Similarly, prior studies tend to focus on single aspects of the waterway system, such as recreation, commercial shipment, or flood-abatement. For example, the Illinois Terminal Port District commissioned a study in 2003 that showed more than 8,500 jobs are directly or indirectly linked to the Port of Chicago. Although these studies are useful, they do not provide the U.S. Army Corps of Engineers (USACE) with the full range of analysis needed to evaluate the costs of alternatives related to preventing carp from entering the Great Lakes.

The author and research contributors acknowledge that preparing the estimates for this study required dealing with a great deal of uncertainty. It was not possible to expand the scope of the study to include the collection of extensive primary data, and it was necessary to make informed judgments about variables that have not been accurately quantified in the past, such as

the mix of boats that use the river system. In some areas, we base our estimates on information provided informally by professionals involved with the regional waterway system. Nonetheless, we have attempted to make our assumptions and calculations as transparent as possible, and make available a "computational spreadsheet" on the Chaddick Institute web site to help readers understand the nature of our analysis.

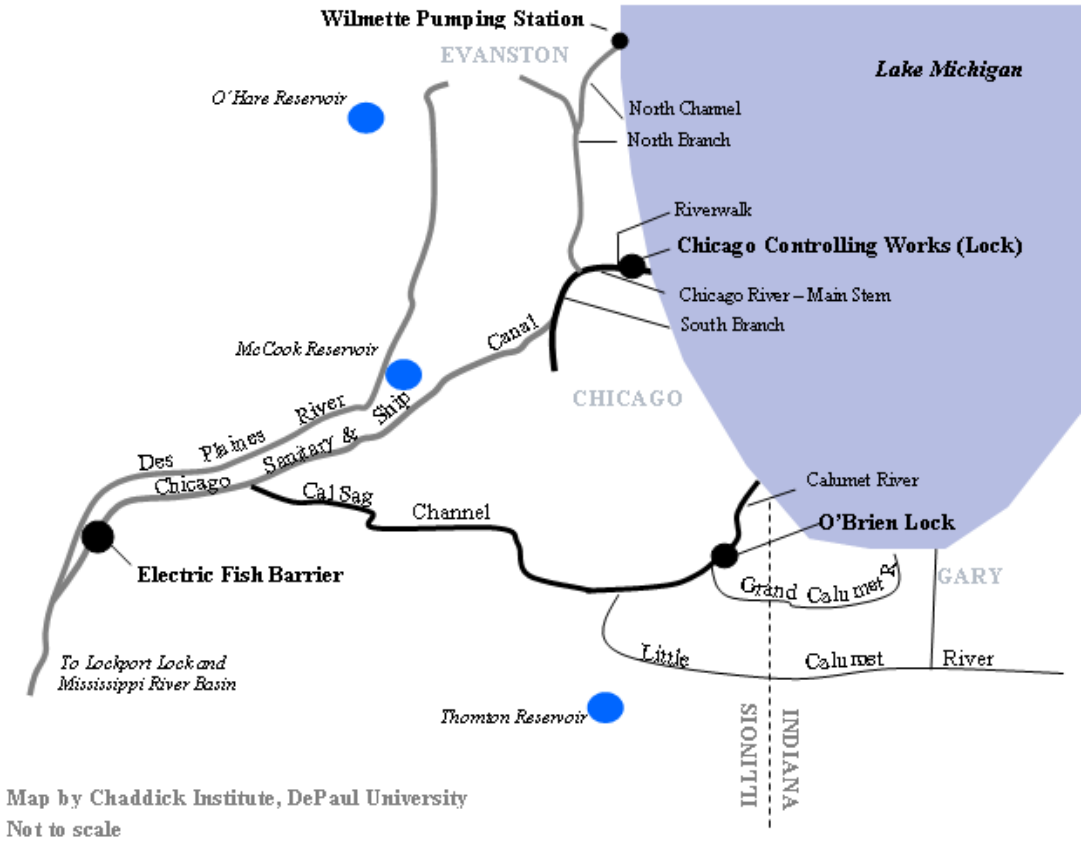
Although we evaluate a broad range of economic activities in this paper, some of the most significant effects of closing the locks are beyond our scope. We do not estimate, for example, the possible declines in the value of specialized transportation equipment and facilities, and the potential induced effects of changing shipping patterns on employment at suppliers of barge services. Nor do we estimate the probable changes in tax revenue to municipal governments or how changing water quality may affect the demand for river-oriented recreation, such as paddling trips and fishing trips. Considering that commodities and products valued at an estimated $16 billion move through CAWS annually, and that river property within 800 feet of the shoreline has a market value of $10.22 billion (see discussion in Section III), more research is needed to understand the full effects of lock closing.

II. Background Perspective

For more than 160 years boat traffic has moved through a system of natural and man-made inland waterways linking the Great Lakes and Mississippi River basins together. Starting in 1849, commerce flowed through an elaborate system of rivers and lakes including the 96-mile Illinois & Michigan Canal. The present day Chicago Lock, located roughly one-half mile east of the Michigan Avenue Bridge, was built in 1898 to replace an older lock in this system and to support the impending reversal of the flow of the Chicago River.

In 1900, the river's reversal was achieved with the opening of major portions of the Chicago Sanitary & Ship Canal (CSSC) on the southwest side of the city, which provided a more expedient passage for boats, better sanitation, and increased flood control in the region. Boats navigating the Chicago River's Main Stem and South Branch, the CSSC, the Des Plaines River, and the Illinois River now traveled downstream the entire distance, from Lake Michigan to the Mississippi River basin, and the original canal was eventually abandoned. Another improvement, the North Shore Channel, was completed between Chicago and Wilmette in 1920 to support flood control around the Chicago River's North Branch. In the process, the ecology of the Great Lakes and Mississippi basin became more interconnected than ever.

Figure 1
Chicago Area Waterway System



More major improvements for waterborne commerce came in 1922 with the opening of the 16-mile Cal Sag Channel, which forged a more southerly route between the CSSC and Lake Michigan. The O'Brien Lock, located several miles from the Illinois-Indiana boundary at the southeastern edge of Chicago, was built as part of these improvements and is situated where the Channel meets the Calumet River, an estuary of Lake Michigan. The overwhelming majority of commercial tonnage (presently more than 98%) shipped over the Illinois waterway system en route to the Great Lakes has used this lock for many decades

Like the older Chicago Lock, the O'Brien Lock and the Lockport Lock (a third lock facility in metropolitan Chicago that is further downstream) serve both navigational and flood-control functions. Today, these locks together with the region's navigable rivers and channels form the Chicago Area Waterway System, which stretches 78 miles. Like most of the other inland waterways in the United States serving commercial navigation, USACE maintains the CAWS.

There are several dozen companies regularly involved in barge movements or maintenance activity services on the CAWS. Vessels carrying approximately 30 million tons of cargo move through the system annually. This commerce predominately involves Chicago-area industries, but a small fraction of the total tonnage is "through traffic" that originates and

terminates outside the metropolitan area (this is primarily tonnage arriving from or destined for Milwaukee, Wisconsin). Barges entering the Great Lakes typically do not travel beyond southern Lake Michigan, leaving most Great Lakes shipping to deep-draft vessels.

As we illustrate below, other stakeholders in the lock closure discussion include commercial tours operators and sightseeing services, public agencies, recreational boaters, marinas, and real-estate developers. In addition, the Metropolitan Water Reclamation District of Greater Chicago (MWRD) manages the sluice gates adjacent to the Chicago Locks and Wilmette Pumping Station, located approximately 15 miles north of downtown Chicago, to control the flow of water in and out of CAWS, thereby facilitating stormwater and flood control for the region.

III. Annual Expenditures on Boat and Barge Service

The approximate scale of economic activity directly tied to the two locks can be estimated by totaling expenditures by consumers as well as shippers and receivers on watercraft that pass through the locks or depend on their availability in other ways. These estimates include expenditures made for boat-related trips, services, and closely related activities that would be affected by the termination of lock operations.

The accounting of expenditures is a useful way to understand the direct and indirect impacts of money flowing through a regional economy. These estimates should not be interpreted as representative of the net economic *costs* associated with terminating operations at the two locks. For example, if commerce in one sector diminishes, some expenditures will likely be redirected to other sectors of the economy. Nevertheless, the estimates offer a perspective on the breadth of the market that would be affected by the unavailability of the locks.

Commercial Shipping. Industrial enterprises spend an estimated $101 million annually on barge transport services that involve shipments through the two locks examined in this study. Our calculation is based on self-reported industry estimates of the average shipping price ($13.50 per ton) and the three-year average of shipping volumes through the locks, which is 7,462,000 tons.[1] More than 98% of this commercial traffic involved use of the more southerly O'Brien Lock.[2]

Others shippers in the CAWS, whose shipments do not use either of these two locks, also have a stake in decisions made regarding the locks, albeit to a lesser extent. This is due to the potentially adverse effects that terminating operations could have on barge utilization, the potential changes in water levels on rivers and canals, and lost access to barge-related services on the Calumet River if the locks cease to be regularly opened. (For a more detailed discussion of this, see Section IV). A particularly large number of services used by barge companies, such as repair and maintenance facilities and barge-tow providers, are located upstream of the O'Brien Lock. This market generates estimated $309 million annually, making total yearly expenditures for all barge services around $412 million.[3]

Recreational Boating. An estimated 2,550 boats pass through the locks every spring and summer to gain access to boat slips and other mooring facilities on Lake Michigan, primarily harbors managed by the Chicago Park District; this represents 45% of the approximate 5,600 boats that moor in Lake Michigan harbors. Other boats are permanently moored or stored downstream from the locks but make regular or occasional trips to the lake. Of these, an estimated 500 are moored during the summer season in marinas that are downstream of the locks

and thus would be unable to reach the lake if lock operations are terminated. Finally, there are boats that access the CAWS system using boat ramps or private facilities. Based on the number of recreational boats reported as operating through the locks annually, and taking into account the number of "marina boats" mentioned above, we estimate that, as a rough approximation, these boats account for about 8,000 – 10,000 roundtrips annually. We use a 9,000 roundtrip estimate in the analysis below.[4]

Estimates of annual spending by owners of watercraft in Illinois can be found in published USACE data that report expenditures for various types of "marina boats" and "non-marina" boats in Illinois. For the purposes of this analysis, we assume the same mix of large and smaller boats reported in these data. We project annual spending by boats at CPD facilities and riverfront marinas is equivalent to the weighted "marina boat" average elsewhere in the state, or $13,700 per boat. This estimate is inclusive of ancillary consumer expenses on boat trips, such as restaurant meals and retail expenditures. It is likely that boats moored on Lake Michigan harbors are larger than those moored on inland rivers and lakes, making this a relatively conservative estimate. For boats not moored at marinas, which tend to be smaller, we use the non-marina figures of $6,435 per boat.

These estimates suggest that recreational boaters using the locks to gain access to the lake cumulatively spend approximately $58.9 million annually on trip-related or craft-related goods and services. (See the computation spreadsheet for more details about these expenses). The total does not include spending by recreational boaters who use the river system but do not use the locks, such as those using canoes and inflatable craft. Nor does it consider the potential revenue impact of recreational boaters who make long excursions between the Mississippi Basin and the Great Lakes.

Commercial Cruises and Tours. An estimated 760,100 passengers purchase tickets for sightseeing and tour boats that pass through the locks annually.[5] These passengers pay an average of $31.00 per trip. Industry representatives estimate that these customers spend $5 - $10 per trip in addition to their fare on food, drink, and other items. (We use the midpoint of $7.50, making total spending of $38.50, in the analysis below).[6] Not included in these estimates (unlike that for recreational boats) is off-boat spending, such as that on parking and restaurant meals. We provide a more detailed summary of this industry in Section IV.

For some consumers, the availability of river tours and excursions is a principal reason for planning a trip to Chicago. As such, tour-boat activity is directly responsible for spending on hotels, restaurants, parking, and other items. There has not been a detailed published study on the buying habits of the boat-riding sector. Nor does the Chicago Tourism Bureau publish data on the importance of tour boat services to tourism, although it does note that more than 30% of consumers consider sightseeing as their primary motive for visiting Chicago.

To estimate the extent of "out of water" revenues attributable to sightseeing and tour boats, we considered the percentage of passengers using these boat services who made reservations in advance. Industry representatives estimate that 33% of tourists/travel agencies reserve excursions in advance, often purchasing nonrefundable tickets, which suggests that an appreciable share consider the boat trip important enough to justify making a commitment prior to their arrival at the loading area.[7] As a conservative measure, we assume that only a small fraction of these passengers (30%) are making trips to Chicago on account of these services. This suggests that 76,100 consumers annually come to the city for this reason; this number is equal to about 10% of all customers who use boat tours through the locks, or about three tenths of one percent of all tourists from out of town.

For these customers, whose trips can be directly tied to river cruises, we assign a value for consumer expenditures equal to the average daily spending reported by the Chicago Tourism Bureau—$343 per person—rather than the lower $38.50 amount assigned to the other 90%. Of course, more data collection (involving survey research) is necessary to obtain a more precise estimate, but the analysis suggests the overall spending attributable to scenic cruises and boats tours is in the vicinity of $52.4 million annually.

Public Protection. The Chicago Police Department and the Chicago Fire Department, use the locks for their marine-based public services. We were unable to obtain estimates of annual spending, and have instead used as a proxy figures each provided that represent the labor costs associated with creating stand-alone river operations if lock operations were to be terminated (see discussion in the next section). This total, $5,500,000 annually, provides a sense of the scale of their river operations, and should be interpreted as a lower-bound estimate, as it does not include fuel, supplies, and other costs.

Cumulatively, these estimates indicate that direct impact of boat activity involving vessels using the locks is approximately $529 million annually (Table 1). Using standard multipliers for indirect and induced effects from this spending, we estimate the total impacts to be $1.3 billion. (See Note A for a discussion of the expenditure multipliers we applied.) These totals do not include most spending by land-based consumers, such as those on the Chicago Riverwalk, in marina restaurants, and those using other amenities situated on CAWS. Nor do they include spending by the U.S. Coast Guard, for which no information was available.

Table 1
Estimated Financial Impact of Vessels
Using the Chicago Lock and O'Brien Lock

Category	Annual Direct Spending	Multiplier for Induced and Indirect Effects	Cumulative Economic Impact
Commercial Shipping	$412,000,000	see Note A	$992,920,000
Recreational Boating	$58,885,000	" "	$141,912,850
Commercial Cruises and Tours	$52,409,895	" "	$126,305,437
Municipal Protection	$5,500,000	" "	$13,255,000
Total	$528,686,580	" "	$1,274,393,287

Note A: An expenditure multiplier of 1.41 is used to estimate the induced and indirect impacts. This number was determined to be representative based on previous studies on transportation and recreational activities involving Illinois industry using RIMS. This multiplier is also similar to those used in other studies of Great Lakes shipping and boating activity.

As is evident in Table 1, commercial shipping and recreational boating are the largest categories, followed by commercial cruises and tours. As previously noted, these figures should not be interpreted as indicative of the economic costs of terminating operations at the locks, which we estimate in Section III. Furthermore, the impacts of commercial shipping expenditures will be divided between metropolitan Chicago and other river ports served by the barge industry. A much more extensive analysis will be necessary to consider this issue in greater detail; this analysis should be recognized as providing only an approximation.

IV. Lost Value and Added Costs due to the Termination of Lock Operation

This section offers estimates of the lost economic value and cost escalation that would result from the termination of operations at the locks, the sluice gates, and the Wilmette Pumping Station. These estimates include reductions in consumer surplus, declines in the value of economic assets, and the additional financial burden imposed on government departments to provide the same level of service.

Consumer surplus is a measure of the value a consumer gains from engaging in an economic activity. It is the net benefit to the consumer and is calculated as the total value from consuming a good or service minus the expenditure on that good or service. Consumer surplus is therefore distinct from price, which measures the unit cost to the consumer and not the benefit. This notion is particularly important for measuring recreational activity, as it can be used to measure how the value of an outdoor recreational experience is affected by changes in price, accessibility to the outdoor resource, quality of the resource, distance to a recreation area, and other factors. If the activity itself is no longer available due to changes in environment or accessibility, the expenditure can be recovered and spent on something else while the consumer surplus is lost.

Table 2
Major Categories of Economic Costs Evaluated

1. *Changes in the cost of moving commodities due to the loss of two shipping lanes.*

This category reflects the effects of higher transportation costs associated with the movement of goods. These estimates should also account for changes in the utilization of barge equipment, as well as changes in the speed and reliability of service. They should also include the non-market (external) costs associated with various forms of transportation.

2. *Lost value resulting from the inability of recreational vessels, as well as commercial tour and cruise boats, to access the locks and the lake from the river system.*

This category of costs is indicative of the loss of value to pleasure boaters and consumers of fee-for-service operations that involve use of the locks.

3. *Costs imposed on the city as a result of the loss of public-utility functions using the river system, including flood prevention, stormwater management and emergency response.*

These costs include the value of the locks in reducing water levels related to storm mitigation and flood prevention in the Chicago River, and the need to increase expenditures by various city departments to maintain comparable police and fire services.

4. *The effects of lock closure on the value of the river as a conduit for real-estate development and as a cultural, recreational, and tourism amenity.*

This category includes the loss of economic benefit resulting from the potential fall in property values due to factors such as diminished water quality and aesthetic qualities of the river system, and lack of access to the lake.

Most of the losses in value or cost increases can be assigned to one of four categories described above in Table 2. The first category emphasizes transportation costs, while the final three categories encompass issues of aesthetics, water quality, and consumer preference. Each is evaluated in separate sections below.

a. Costs of Commodity Movement

Barge transportation has consistently been shown to be less expensive for industries on the inland waterway system than rail and truck transportation for the shipment of bulk commodities.[8] The cost difference per ton shipped tends to be less for bulky commodities (such as grain) than for denser ones (such as crushed rock) due to the relative advantages of water transport with respect to the heaviest loads. Nevertheless, the relationship between barge costs and that of other forms of transportation is dynamic. The availability of barges, for example, can be an incentive for railroads to keep their rates low.

Costs of lock closure for existing shippers. A Tennessee Valley Authority study using data from the late 1990s demonstrated that there were significant cost advantages to barge transportation. The Texas Transportation Institute (TTI), adjusting this estimate for inflation, reported that in 2005, the approximate difference was $11/ton. A University of Missouri study

concluded that the cost differences were $6.76 for asphalt projects, $13.05 for cement, $13.16 for fertilizer, and a lesser amount for agricultural commodities. This latter study examines shipping costs from points on the Missouri River, which is also part of the Mississippi River basin and thus has certain geographic similarities to the Illinois Waterway system.

The USACE estimated in its Interbasin Transfer Study, which is slated for completion in 2011, that closing the Chicago and O'Brien locks would cost shippers between $5 and $26 more per ton, depending on the type of commodity involved. This study is not yet complete, however, and the underlying methodology has not yet been formally disclosed. Therefore, we do not use these estimates in the analysis below.

For purposes of this study, we use a composite estimate that uses the midpoint between the TTI and Missouri estimates. (With regard to the Missouri estimate, we tabulated the average cost difference by considering the mix of agricultural and non-agricultural commodities shipping through the two locks.[9]) We then convert all figures into current (2010) dollars. According to this approach, the average cost increase will be roughly $11.96/ton.

An argument can be made that this figure is either too high or too low. As in each of the other studies, we made the simplifying assumption that demand is completely inelastic. Furthermore, the $11.96/ton estimate does not account for the higher cost of truck transportation in congested metropolitan areas. It does not fully account for the prevalence of tanker operations on CAWS, for which shifting to rail and truck transport is relatively difficult. The argument could also be made that Chicago's status as a highly competitive transportation hub would make switching to other modes less costly.

Regardless, this approach provides a reasonable, middle ground estimate. With 7,289,428 tons moving through the Chicago and O'Brien locks annually (this is a three year moving average for 2006 – 2008), the increase in costs for shippers is estimated at approximately $89 million.

Costs to other Barge Users in Illinois. Although terminating operation of the locks will principally affect customers who ship through the affected locks, it would affect other users on Illinois and Indiana waterway systems as well. Closure could also reduce the level of barge utilization, reduce the density of operations, and separate shippers from businesses operating barge tow and tugboat services as well as repair/maintenance services.

An important factor affecting barge utilization is the extent to which "upstream" and "downstream" traffic can be effectively balanced. At the O'Brien Lock, upstream traffic exceeds downstream traffic by a wide margin.[10] As you move south of the Lockport Lock, conversely, downstream traffic exceeds upstream traffic by an ever-widening margin. The growing imbalance is partially due to the rising volume of grain that is shipped to Mississippi River ports from downstate terminals.

Ending operations at the two locks would most directly affect upstream traffic, aggravating the traffic-imbalance problem. At present, barge companies often "cycle" their equipment through the CAWS system to minimize the costs of moving empties. For example, a company may transport a load from the Mississippi basin through the locks to a manufacturing facility in Gary, Indiana. That same barge might then return as an empty through the O'Brien Lock before picking up a load destined for a downstream destination.

The importance of the O'Brien Lock for such equipment positioning is exemplified by the number of empties that move through it annually. In 2007, 30% of all of its barge movements were empties, an appreciably higher percentage than most other locks on the state's waterway system.[11] If the movement of upstream barges (for reasons noted earlier) is reduced by 40% on account of the closing of the O'Brien Lock due to the diversion of tonnage to rail and truck transport, it is likely that at least 750 fewer empty barges would return to the CAWS for downstream shipments. Several hundred more barges may need to deadhead from New Orleans to customers shipping downstream.

To illustrate the potential this creates for cost escalation, consider the approximate cost of transporting 750 barges an additional 600 miles to support downstream movements.[12] Industry representatives put the transporting and opportunity costs of tying up an unloaded barge for a single day at roughly $750.[13] With barges traveling at roughly 6 m.p.h., and assuming an additional 600 miles of deadheading, each barge would be lost for slightly more than four days—at a total cost of about $3,125/barge. The total annual cost for decreased barge utilization and increased dead-heading cost for 750 barges would be roughly $2.3 million annually. Under a less favorable scenario, in which an appreciable percentage of barges would travel empty the entire 1,400-mile distance from New Orleans, the increased costs would be much greater.

This estimate does not include the costs imposed on downstream shippers resulting from their separation of barge-tow and repair facilities. Nor does it account for the losses that would be incurred by operators who have built specialized barge equipment that cannot be easily utilized elsewhere. A more extensive analysis will be necessary to approximate these costs.

Costs to Intra-Lake Michigan Barge Users. Several shippers rely on barges to move traffic between points on or near the southern part of Lake Michigan. This traffic does not directly use the locks but would be affected nonetheless. If the locks are no longer available, these operations would probably not be sustainable on a stand-alone basis. Moving the affected commodities on deep-draft vessels would be difficult or impossible in many instances, due to the associated terminal costs and the limited depth of the loading areas some of these barges serve.

Without barge traffic moving through the locks, the equipment used for these operations would likely not be effectively utilized, as these movements tend to fluctuate from week to week. It would likely be difficult to justify keeping barges upstream of the locks. Each autumn, barge operators would need to make a complicated equipment transfer to warmer water. This would entail towing barges through the Straits of Mackinac and Lake Erie, through the New York Barge Canal, and down the Intercoastal Waterways. This journey back to the Mississippi Basin is more than 750 miles longer than the present routing through the O'Brien Lock. A reverse trip would be necessary in the spring.

Accurate data on the size of this market is not available. Based on reported shipping patterns noted by industry representatives, a conservative estimate would be that this market encompassed 1 million annual tons (or about 1/7 of the tonnage moving through the O'Brien lock). Due to the short-haul nature of these movements, we assign a value of $5.98 ton—half of the $11.96 estimate used earlier—for the added transportation cost to this market due to the probable discontinuation of barge service. This results in a total additional cost of lock closure of $5.9 million. More research will be needed to develop more accurate measures of the costs as well as a precise estimate of tonnage.

External Costs and Highway Cost Responsibility. All transportation modes generate external costs in the form of pollution, congestion, and safety risks. For some modes, these are

not offset by user fees, creating inefficiency in the use of resources. To develop estimates on changes in these costs, we use widely accepted and frequently cited economic estimates by David Forkenbrock. Forkenbrock's research estimates the external costs to be 0.38 cents/ton for rail service and 1.13 cents/ton for motor carrier (truck) estimate.[14] This study does not measure the external costs of barge traffic. Other studies, however, have suggested the external costs for barge movements are much lower (see Bray, et. al, 1998). Since barge transport has been shown to be more than 33% more fuel efficient than rail service and subject to significantly less accident risk than these other modes, the external costs are almost certainly smaller per ton mile. However, to be conservative, we use a rate for barge transport equal to that of rail transportation.

Shifting traffic to heavy trucks also increases wear and tear on the highway system, most notably in the form of pavement and structural fatigue. Here, too, we use a widely accepted estimate by Forkenbrock, whose research estimates the uncompensated cost of road damage from heavy trucks at $0.31 per ton. Using the traffic figures described above, and estimates on the approximate modal split indicated on our computational spreadsheet, we estimate the additional costs to be $27.5 million annually.[15] (This estimate is based on a scenario of trains and trucks handling 30% and 35%, respectively, of the ton-miles currently moving by barge through the two locks.) This figure does not account for possible offsetting reductions on the cost of maintaining the waterway system as barge traffic declines.

b. Lost value to recreational boaters and consumers of commercial tours and cruises due to the closure of the locks

The implications of terminating operation of the locks differ widely between the various types of boats that use them. We consider separately the various types of recreational boats in the analysis below.

Boats using Chicago Park District facilities and marinas on the Calumet River. Between April and June each year, an estimated 2,600 recreational boats depart marinas, boat ramps, or winter storage facilities on the Chicago River or Cal Sag Channel en route to Chicago Park District (CPD) facilities on Lake Michigan, where they remain for the summer season. The "flotilla" is reversed each autumn, when boat owners return to the rivers for winter storage. Altogether, boats transiting the locks to reach harbors and marinas appear to account for slightly less than half (we use an estimate of 45 percent) of the roughly 5,600 boats using CPD harbors during summer.

The remaining 55% of boats moored on Chicago's harbors tend to be pulled from the water at lakeside boat ramps or brought to marinas or boat ramps in Indiana or southern Wisconsin. These boats do not travel through the locks to access the lake, and we assume they would be completely unaffected. As a general rule, however, boats that use the locks to reach winter storage locations tend to be larger than those that do not.

If the locks were no longer available, it is not clear how the owners of the 2,600 boats would access the lakefront. A small share, about 10%, could be transported to the lakefront on trailers; they are small, light, and narrow enough to be pulled by the owner's car or light truck.[16] The owners of many of these boats would likely drive to a lakefront ramp and face only relatively modest inconvenience. For these boaters, we assign a value of $145 (see Appendix A) for the inconvenience of losing their preferred logistical alternative at the beginning and end of the boating reason.[17] (We assume these boaters already have access to a trailer.)

The remaining 90% of boats would need to divert to distant marinas or storage areas, all of which are a considerable distance from CPD harbors. The owners of these estimated 2,360 boats would likely have difficulties finding marinas or boatyards able to provide winter storage. New capacity would need to be built.

Moreover, these boaters would incur additional monetary and nonmonetary costs, such as added transportation expense, boat wear-and-tear, and lost time. Fuel consumption varies widely by boat, but the overall average for most marina boats is around one mile per gallon. A roundtrip from Chicago to Kenosha, Wisconsin (a distance of 60 miles each way), consequently, would cost the average boater approximately $550 in fuel. Most owners make several trips (typically by car) to their boats to perform preparatory activities before launching their craft during the spring season. These trips would become more costly and time consuming. Considering how marinas are distributed across the southern end of Lake Michigan, our estimates suggest that affected boat owners would incur 18 or more additional hours of travel time per person per year as well as $720 in additional operating costs (boat and highway combined).

For purposes of this study, we use these estimates and the standard microeconomic assumption that travelers disvalue additional travel time at about one-half of their wage rate. We assume no additional costs for boat storage or necessary capital outlays (despite the apparent lack of existing capacity) beyond what these boaters already spend. We also assume that the added travel time would affect two people for each boat. This suggests additional costs for these vessel owners of $1,638 per boat.[18]

The lost value to boat users from losing their preferred option would, as a rough approximation, be about $5.1 million annually. (As a simplification, we assume that the demand for boat slips is inelastic with respect to cost of accessing the lake.)

Boaters Storing their Equipment Downstream of the Locks. An estimated 600 recreational boat owners use commercial boat slips at one of several marinas on the Chicago River or Cal Sag Channel. These boaters would be even more acutely affected by the lock closures. To understand their approximate economic losses, we reviewed the economic literature measuring value that consumers place on having access to a wide variety of water-related recreational amenities. This extensive body of work, summarized in the Appendix A, suggests an average loss of $47 - $87 per boat trip from the loss of a recreational alternative. We use the midpoint of this range, $67 per boat, in our analysis.

To develop an annual cost per boat, we applied the $67 estimate to USACE's estimates of the number of trips taken annually by boats moored in marinas. This suggests that closing the locks result in a $1,005 loss in value for each affected boat. This appears to be a lower bound, considering that, as previously noted, the total annual spending for marina boats is more than $13,000 annually.

Our analysis also considers the lost value for recreational boaters who do not operate out of marinas; instead, these boats launch their vessels through other means, such as by using public boat ramps or private boat slips. These boaters account for (as previously noted) an estimated 9,000 roundtrips to the lake annually. Altogether, using the above coefficient, this suggests that a cumulative estimate of the economic losses to recreational boaters is $5.1 million annually (See computational spreadsheet for details).

Commercial Tours and Cruises. Approximately 75% of all tour and cruise activity in Chicago that uses the river system involves use of the locks. A recent survey by the Passenger

Vessel Association elicited responses from five of the seven tour operators. This survey showed that the river-cruise industry has a total boat capacity for 4,500 to 5,100 passengers. The five companies responding to the survey employ 604 workers and have an approximately $7 million payroll. In 2009, their boats used the Chicago Lock 7,790 times.[19]

Accounting for the fact that several operators did not respond to the survey, we estimate that 760,000 paid customers pass through the locks each year. This represents about half of the total Chicago boat-cruise market, with the other half primarily operating off of Navy Pier. The Pier's operations tend to focus more heavily on dinner cruises and special-event outings, which are longer in duration and less educationally focused. These cruises generally do not use the locks.

Although tour operators could specialize in lake-only or river-only cruises as lock operations cease, the evidence suggests that the value of river-oriented operations would be diminished. The absence of through-boat activity, such as the passage of recreational boats and yachts, as well as a diminution of water quality, would likely hamper the appeal of river cruises. Moreover, the locks are a major tourist attraction themselves—many groups, for example, take cruises primarily to pass through them—and the separation of the lake and river system would hamper the utilization of boat equipment. Some boats primarily navigate the river by day and Lake Michigan by night, often in response to heavy demand for watching the sunset and fireworks (scheduled twice weekly) around Navy Pier. The nature of these markets suggest that most of the river market would be lost if tourists needed to travel via cab or bus to the pier for a different type of cruise.

For purpose of this analysis, we assume that the existing lake-only and river-only cruises would be completely unaffected—despite potential changes in water quality on the river system—while those using the locks would experience lost value roughly equivalent to the typical value observed in economic-valuation studies involving water-related excursion activities. These prior studies, which we summarize in Appendix A, suggest that people derive approximately $18 – 34 consumer surplus from expenditures on these activities For purposes of analysis, we use the midpoint value of $26 per trip. The cumulative effect of this lost value is $19.6 million/year.

c. Public Service, Public Protection and Stormwater

These costs can be divided into two categories: public protection and flood control.

Public protection: Police and Fire. The Chicago Police Department and Chicago Fire Department both maintain facilities designed to jointly support operations on the lake and river system. The Chicago Fire Department's Air Sea Rescue Division facility, located near the mouth of the Chicago River on Lake Michigan, is equipped with two fireboats, one 96-foot boat and one 33-foot boat. This facility allows the Department to respond to emergency locations on the inland Waterway System in 15 to 40 minutes and more quickly to those on the lake.

The Fire Department considers maintaining a marine presence on both sides of the locks to be essential to its mission. If lock operations cease, this would require adding a fireboat and personnel at a new location on the Chicago River. The CFD estimates that adding additional 33-foot and 96-foot vessels would cost $350,000 and $2.76 million, respectively, and that added personnel would cost another $2.75 million annually. The department would also need to make capital investments to handle these boats and the associated personnel.[20]

The Chicago Police Department's Marine & Helicopter Unit uses eight watercraft for search, rescue, and recovery operations as well as for law enforcement and homeland security patrols and inspections. These boats, housed on the South Branch of the Chicago River, are frequently users of the locks. In 2009, the boats used the locks, on average, several times daily and made 7,314 site inspections. If lock operations cease, the department would need to purchase an ice-breaking watercraft at a cost of approximately $1 million and to budget for the addition of between 16 and 24 personnel, at a cost of between $1.8 million and $2.7 million annually. (We use $2.3 million, which is near the midpoint of this range, in our analysis). Although appreciable capital costs to prepare facilities for the changes would also be incurred, there is uncertainty about their magnitude, so we assigned only a nominal value for these costs of $150,000 each to both the CPD and CFD. The actual costs will likely be much higher.

We amortize the costs of the boats and facilities over an eight-year period, which suggests the total costs would be approximately $5.7 million annually over this initial period and $5.1 million thereafter. This is a lower-count estimate as it does not include the cost of additional fuel, supplies, and other necessary expenditures.

Stormwater, Flooding and Water Reclamation. Stormwater management and flooding has been a problem in metropolitan Chicago for more than a century. Due to the flat topography and the limited capacity of existing waterways to handle runoff, heavy emphasis has been placed on reducing the costs of flooded basements, flash floods, and the pollution attributable to excessive water runoff. A great deal of investment has been made to modify the river system to alleviate these problems. The decision to reverse the flow of the Chicago River and build the CSSC, for example, was motivated by these concerns. Moreover, the locks must be periodically opened to allow rising waters of the river to flow into the lake to compensate for the inadequacy of stormwater systems.

The efforts to control flooding crossed an important milestone in the late 1980s when the Metropolitan Water Reclamation District of Greater Chicago (MWRD) completed extensive portions of its Tunnel and Reservoir Plan (TARP). This system of tunnels and reservoirs, popularly called the "Deep Tunnel Project", channels stormwater over a 375 square-mile area into reservoirs so that it can be gradually discharged in the river system. MWRD has spent about $3 billion on this initiative, and recent estimates suggest these improvements are providing $41 million in annual benefits. The first of the two construction stages is slated for completion in 2014.[21] For a variety of reasons, including funding concerns, however, the construction timetable will likely drag on more than 40 years longer than anticipated, and the second phase is not slated for completion until 2023.

The principal constraint on the system remains the limited capacity of the waterway system between Sag Junction to Lockport, which is capable of handling only 20,000 cubic feet of water per second, which is grossly insufficient after heavy rain. As the region's development footprint expands, consequently, the TARP system is strained. Basement flooding from sewer backup remains a problem, and has been estimated by USACE to cost $150 million annually.[22]

MWRD has reported to the Rapid Response Work Group that it would be necessary to bore a tunnel between the North Branch of the river from the facility at Foster Avenue to the McCook Reservoir, a distance of more than 10 miles, if operations at the locks, sluice gates, and pump station are halted. This proposed tunnel, which would provide protection for 1.2 million structures, was part of the original TARP package; construction, however, was cancelled when it was deemed unnecessary for controlling flooding. Other investments would also likely be

necessary due to the termination of operations at the O'Brien Lock, including expansion of the McCook Reservoir to provide protection to 182,000 structures.

Our assessment suggests that MWRD's estimate that it would cost approximately $2.5 billion to build the tunnel (the equivalent of about $1,500 per household served) to be credible. Another $56 million would be needed to support improvements to the Little Calumet River. These improvements (which are in addition to the estimated $726 million needed to finish the second phase of TARP) would require a lengthy construction timetable after planning and design. Although the expected costs of flood damage without the improvements aren't presently known, testimony by Dr. Yu-Chun Su suggests the costs could exceed $1 billion annually.[23]

For purposes of this study, we estimate the amortized cost of making these improvements deemed necessary by MWRD over an eight year construction period and assume no additional costs beyond that period. This suggests (with an allowance for 4% annual cost escalation) that the costs would be $375 million/year over these eight years. Heavy investments could likely be necessary even if allowances were made to open the locks only during moments of rare flooding. The routine opening of locks serves to lower water levels on the Chicago River and Cal-Sag Channels after periods of heavy precipitation. Although our cost estimates are speculative (construction could not likely begin for several years) amortizing the costs over eight years illustrates the extent of the funding commitment that would be necessary to see the project through to completion.

d. Value of Property Along the River System and Other Issues Related to Proximity

There has been extensive analysis in recent years about the economic value of a "healthy" river system to the Chicago economy. Little of it, however, has been formally published in peer-reviewed journals. A report commissioned by local nonprofit organizations postulates that the vitality of the river system has resulted in property value increases of more than $400 million in the early 2000s. It notes that the river's value as a recreational amenity has risen due to regulatory changes made in the 1980s that dramatically improved water quality. It also notes that there is data suggesting water quality has improved as a result.[24]

This body of work also notes that effluent from reclamation plants operated by MWRD currently makes up about 30% of the Chicago River's annual flow—a percentage that would likely rise significantly if Lake Michigan water no longer passed through opened locks. Water from the lake tends to be cleaner than effluent from MWRD, suggesting that there would be a material reduction in water quality if the locks were closed.

Based on the Supreme Court testimony by Kevin Boyle of Virginia Polytechnic University, the loss of discretionary water diversion from Lake Michigan into the CAWS may lead to noxious conditions and fish kills which can only be partially overcome via existing alternative measures in the short term. Further, in his testimony, Colonel Vincent V. Quarles states that the lack of lake flows could lead to low water levels and stagnant conditions potentially affecting CAWS users.

The City of Chicago, after tabulating the Equalized Assessed Value (EAV) of property along the river system, postulated that property values rose by more than $400 million due to the river's expanding role as a recreational and aesthetic amenity during the early 2000s. Nevertheless, this study did not control for exogenous factors, such as the proximity of many of the studied properties to the central business district. Recent expansion of residential housing along the Chicago River, however, lends credence to the view that the inland waterways have

been an important factor in real-estate development, particularly in the Central Area and along the North Branch. In addition to the established marinas such as Marina City and River City, several new ones on more outlying river segments, including the Chinatown Area, as well as the Trump Tower, Lake Shore East, and new condominium towers provide support for the notion that property along the river increasingly sells at a premium.

The city has invested approximately $22 million and leveraged additional private investment for the Chicago Riverwalk, which extends from Lake Shore Drive to Franklin Street. This system of public walkways and seating areas along the water's edge is designed to showcase the "canyon of skyscrapers" while watching the boats go by. The Riverwalk presently has six cafes and is a jumping off point for boat cruises, water taxis, bike rentals and tours. The McCormick Tribune Bridgehouse and Chicago River Museum on Michigan Avenue also are illustrative of the river's role in tourism.

Many industrial properties along the river and canal system, however, do not appear to have benefitted from this effect. The demand for industrial property along the river system remains relatively weak, in part due to the economic downtown and the county's tax structure. Moreover, recreational activity that involves direct contact with the river, such as swimming and tubing, remains quite limited, partially due to variability in the level of water quality.

An informed estimate of the decline in property value that would occur as a result of the lock closures can be made by reviewing several different methodological approaches. Boyle's research indicates that even relatively modest *improvements* in water quality could generate $1.05 billion in value for the region in the form of improved health, recreation, and tourism opportunities. This equates to a benefit of about $47 per resident of the city. A Friends of the Chicago River report suggests that improved water quality could generate more than $500 million in new economic activity over 20 year period, primarily in the form of increased recreation. The Brookings Institution maintains that improved water quality could increase property values in the Great Lakes by 1% to 2% percent in densely populated urban areas and a greater amount in other areas. (See the reference section for full citations on these studies.)

Economic analysis exploring changes in property values in other regions that are the result of changes in the quality of waterways are also useful to consider. As we note in Appendix B, there is a particularly extensive literature on the elasticity of property values with respect to water quality (as measured by the percent change in contaminants in the water). Using an estimate near the median of the elasticity estimates made in these studies (.05), and assuming a hypothetical 10% reduction in water quality, we estimate that property values would fall by 0.5%.

Data from the City of Chicago indicates that the market value of property within an 800-foot buffer of the river system was $10.22 billion in 2006. This suggests a decline in property value of $51 million dollars. This estimate should be recognized as being speculative, but it is also conservative, as it does not account for the effects that lost access to the lake and the diminishment of the other qualities of the river system (such as a decline in the recreational value and tourism role of the system) would likely have on property values. The decline in value is less than half the effect suggested by Austin, et.al, in the Brookings Institution study (2007) and only a small fraction of the estimate made by Sulski of the benefits of improved water quality. The costs to property owners could take the form of smaller increases in land value. Regardless, more research in this area is clearly needed.

V. Conclusions

The findings of this study about the implications of terminating operations at the lock facilities and the Wilmette Pumping Station suggest that the decision should not be made lightly. A summary of the economic losses from the termination of lock operations appears in Table 3.

Table 3

Summary of Economic Loss from Termination of Lock Operations

	Year 1	Years 2 - 8	Years 9 - 20
Commercial Shipping	$95,230,082	$95,230,082	$95,230,082
External & Highway Costs	$29,828,326	$29,828,326	$29,828,326
Recreational boating	$5,077,920	$5,077,920	$5,077,920
River Cruises and Tours	$19,762,600	$19,762,600	$19,762,600
Flood prevention	$375,478,436	$375,478,436	
Municipal protection	$5,643,913	$5,643,913	$5,050,000
Property value loss	$51,000,000		
Total	$582,021,277	$531,021,277	$154,948,928

The economic value lost from permanent closure is estimated (as a lower bound estimate) to be $582 million the first year, $531 annually over the subsequent seven years, and $153 million annually thereafter. The net present value of these costs, over a 20-year planning horizon at a four percent discount rate, is $4.7 billion.

Additional research is needed for policymakers to understand the full effects of this policy alternative. The decision-making process could benefit from a careful consideration of other economic issues not included in this study, such as the investments that industries have made in specialized equipment and facilities, the effects of changing shipping patterns on employment at suppliers of barge services, and the effects that changes in barge transportation will have on the rates charged by competing transportation modes. Furthermore, the analysis should be expanded to consider changes in tax revenue and the effects of changing water quality on the demand for river-oriented recreation, such as paddling trips and fishing.

There is a particular need for more research on the value of recreational boating and tour-boat operations on urban waterways. Survey data could help reveal how local consumers make decisions regarding tour boat trips relative to other local activities, as well as how tour boat trips contribute to Chicago tourism from out-of-town visitors. This data could then be used to assess how various trip characteristics, such as lock passage, views and river water quality affect the overall economic value of the boat trips. Such a study could utilize some of the same techniques that researchers at the University of Chicago and RCF Economic and Financial Consulting used to measure the value of area beaches.

The computation spreadsheet prepared as part of this study allows for evaluation of different scenarios and testing different assumptions. This provides a tool that can be used to deal with some of the uncertainty about the long-range effects of lock closure.

VI. Appendix

A. Methods to Value Recreational Boating

The most common method used to measure the economic value associated with water-based recreation is the travel cost model. It is based on the travel costs and travel time required to engage in a recreational activity, while accounting for the next best use of an individual's time and the other available recreational alternatives. Since this methods is survey based, it is often time and labor intensive to employ, and a commonly-utilized alternative to measuring recreation value relies on a case-specific and well-informed transfer of benefits from existing travel cost literature.

Numerous studies have provided estimates on the value of a recreational boating day either through primary valuation or through a benefit transfer or meta-analysis of existing estimates. Estimates of the consumer surplus of recreational boating are fairly consistent across locations and range from $47 to $87 per boat trip in 2009 dollars[25]. We used the midpoint ($67/day) in our analysis. Other estimates of water-related recreation include the value of a day at the beach, which are also consistent across locations and range from $34-$44 in 2009 dollars.[26]

No estimates of the consumer surplus of a tour boat trip were found through an extensive literature search. While limited literature exists for luxury cruises, this is distinct from an urban boat tour which only lasts a couple of hours at most. In this case, the consumer surplus of a tour boat cruise is assumed to be proportion of the value of a recreational boat trip, based on the relative time difference of the trip. Wendella Boat Tours in Chicago offers three different tours ranging in length from 75 minutes to 2 hours and averaging 95 minutes in length. Assuming a recreational boating trip lasts an average of 4 hours, the average consumer surplus per hour is approximately $11.75 to $21.75[27]. The implied consumer surplus per 95 minute tour boat excursion is then approximately $18 - $34. For purposes of analysis, we use the midpoint of $26 per affected consumer.

B. Changes in Water Quality

Methods to Value Changes in Water Quality

A commonly-used approach to measuring the economic value associated with changes in water quality is the hedonic property method, which observes the impact of changes in water quality on the value of properties near the water body. This approach has been used extensively for measuring the economic value of various types of environmental quality changes. An alternative approach relies less on market prices and instead directly engages individuals to state their willingness to pay for environmental quality improvements. This technique called the contingent valuation method relies on surveys and interviews to simulate a referendum vote, although in a hypothetical setting. Again, because primary valuation is costly and time-intensive, the transfer of benefit estimates using these methods from the existing literature are a commonly applied technique.

Changes in Property Value Associated with Water Quality

Numerous studies have observed the changes in water-proximate property given changes in water quality from fecal coliform, pollutants from run off and water clarity. The range of imputed home price elasticities from the economic literature using the property value approach is -0.0002 to -0.07 for water quality degradation and +0.04 for an improvement in water clarity[28].

In 2006, the estimated market value of properties within 800 feet of the Chicago River was $10.22 billion. Using the range of -0.0002 to -0.07 for a 1% degradation in water quality, we use an elasticity of -0.05.

Willingness to Pay for Water Quality Changes

A common metric for measuring the willingness to pay for recreational water quality is a water quality ladder (WQL) scale which ranks recreational designation from 1 to 10, where 2.5 is "boatable", 5.1 is "fishable" and 7.0 is "swimmable"[29]. In a seminal study on the Clean Water Act, Carson and Mitchell estimated the mean household willingness to pay to improve water from "Non-boatable" to "Boatable" to range from $106 - $141 in 1983 dollars.

In testimony before the Illinois Pollution Control Board, Kevin Boyle reported an estimate of the willingness to pay for Cook County residents for an improvement in the CAWS water-quality index from 6.1 to 6.8 on the 10-point scale[30]. Using results of a meta-analysis of 18 water quality studies by Van Houtven, et al, he estimated the willingness to pay for the water quality improvement to be $47 per household per year in Cook County for a present value of $1.05 billion over 20 years for the improvement in water quality.

In a 1986 survey about Chicago waterways, Croke, et al. determine the mean household willingness to pay in Cook County for improved water quality to range from $33-$46. The range of willingness to pay is for varying levels of water quality in the Chicago waterways from improving water for outings ($33.49), outings and boating ($37.76) and outings, boating and fishing ($46.05).

V. References

General Sources Used

Austin, John C., Soren Anderson, Paul N. Courant, Robert E. Litan, *Healthy Waters, Strong Economy: The Benefits of Restoring the Great Lakes Ecosystem*. The Brookings Institution, Metropolitan Policy Program, Great Lake Initiative, 2007.

Boyle, Kevin J. Testimony before the Illinois Pollution Control Board in the Matter of: Water Quality Standards and Effluent Limitations for the Chicago Area Waterway System and the Lower Des Plaines River, August 4, 2008.

Brammeier, Joel, Irwin Polls, Scudder Mackey, "Preliminary Feasibility of Ecological Separation of the Mississippi River and the Great Lakes to Prevent the Transfer of Aquatic Invasive Species," 2008 Project Completion Report, Great Lakes Fishery Commission, November 2008.

Bray, Larry; Burton, Mark; Dager, Chris; Henry, Ron; Koroa, M. The undervalued Benefits of Water Transportation. Tennessee Valley Authority, September 1998.

Compton, John L. The Proximate Principle: the impact of parks, open space and water features on residential property values and the property tax base. 2nd edition. Ashburn, Va: National Recreational and Pak Association.

Chicago Park Disrict. 2002. Chicago River Master Plan: Connecting People to the river.

Friends of the Chicago River, "Strategies for a Cleaner, Healthier, More Vibrant Chicago River: A Roadmap and Recommendations," Research paper provided courtesy of Friends of Chicago River. n.d.

Forkenbrock, David J. "Comparison of External Costs of Rail and Truck Freight Transportation," *Transportation Research Part A* 35 (2001), 321-337.

Gorman, Michael F, Evaluating the Public Investment Mix in U.S. Freight Transportation Infrastructure. Transportation Research Part A: Policy and Practice, Volume 42, Issue 1, January 2008, 1 – 14.

Illinois Environmental Protection Agency, Chicago Area Waterway System Use Attainability Analysis, August 2007.

Solzman, David.. *The Chicago River: An Illustrated History and Guide to the River and its Waterways*. Chicago: Loyola Press, 2009.

Sulski, Robert and Ronald French, Illinois Environmental Protection Agency. *Use Attainability Analysis of the Chicago Area Waterway System*, National TMDL Science and Policy 2003 Specialty Conference, 2003

Taylor, John C. and James Roach, "Chicago Waterway System Ecological Separation: The Logistics and Transportation Related Cost Impact of Waterway Barriers," For State of Michigan Department of Attorney General, February 2, 2010.

Texas Transportation Institute, "A Modal Comparison of Domestic Freight Transportation Effects on the General Public," Center for Ports and Waterways, December 2007. Amended March 2009

University of Missouri Food and Agricultural Policy Research Institute, "Estimated Value of Barge Freight Rates for Commodities Shipped on the Missouri River and Implied Freight Savings," Report #05-04. April 23, 2004.

U.S. Army Corps of Engineers, Aquatic Nuisance Species Interbasin Study, Chicago Sanitary and Ship Canal, IL: Ecosystem Restoration Feasibility Study Review Plan, May 2009.

U.S. Army Corps of Engineers, 2008. *Great Lakes Recreational Boating*. In response to Public Law 106-53, Water Resources Development Act of 1999, Section 455(c), John Glenn Great Lakes Basin Program

U.S. Army Corps of Engineers, Data Navigation Center.

Vachal, Kim, Jill Hough, and Gene Griffin, U.S. Waterways: A Barge Sector Industrial Organization Analysis, March 15, 2005

Studies on Consumer Valuation of Water-Related Amenities

Ara, S**.**, E. Irwin, and T. Haab. 2006. "The Influence of Water Quality on the Housing Price Around Lake Erie." In Proceedings of American Agricultural Economics Association Annual Meeting, Long Beach, CA.

Austin, J.C. S. Anderson, P.N. Courant and R.E. Litan, 2007. *America's North Coast: A Benefit-Cost Analysis of a Program to Protect and Restore the Great Lakes*.

Boyle, Kevin. 2008. Testimony before the Illinois Pollution Control Board in the matter of Water Quality Standards and the Effluent Limitations for the Chicago Area Waterway System and the Lower Des Plaines River. August 4, 2008.

Carson, R. T. and R. C. Mitchell. 1993. "The Value of Clean Water: The Public's Willingness to Pay for Boatable, Fishable and Swimmable Quality Water" *Water Resources Research*, 29(7): 2445-2545.

Croke, K. R. Fabian and G. Brenniman, 1986. "Estimating the Value of Improved Water Quality in an Urban River System." *Journal of Environmental Systems*, 16: 13-24.

Leggett, C. G. and N. E. Bockstael, 2000. "Evidence of the Effects of Water Quality on Residential Land Prices." *Journal of Environmental Economics and Management*, 29, 121-144.

Hushak, L. and M. Bielen. 2000. "Valuing the Ottawa River: The Economic Values and Impacts of Recreational Boating." Ohio Sea Grant Publication OHSU-TB-042.

Leggett, C.G. and N. E. Bockstael. 2000. "Evidence of the Effects of Water Quality on Residential Land Prices." *Journal of Environmental Economics and Management*. 39(2):121-44.

Lew, D. K. and D. M. Larson. 2005. "Valuing Recreation and Amenities at San Diego County Beaches." *Coastal Management*, 33: 71-86.

Poor, P. J., K. L. Pessagno and R. W. Paul. 2007. "Exploring the Hedonic Value of Ambient Water Quality: A Local Watershed-based Study." *Ecological Economics*, 60, 797-806.

Rosenberger, R. S. and J. B. Loomis. 2000. "Using Meta-analysis for Benefits Transfer: In-Sample Convergent Validity Tests of an Outdoor Recreation Database." *Water Resources Research* 36, 1097 -1107.

Shaikh, S. L. 2007. "Valuing Swim Bans and Beach Closures with Truncation and Overdispersion Corrections in Count Data Models." Economics of Beach Management and Coastal Hazard Mitigation. American Agricultural Economics Association Annual Meeting, Portland, OR.

Sohngen, B.L., F. Lichtokoppler and M. Bielen. 1999. "The Value of Lake Erie Beaches." Ohio Sea Grant FS-078.

Van Houtven, G., J. Powers and S. Pattanayak. 2007. "Valuing Water Quality Improvements in the United States using Meta-analysis: Is the Glass Half-full or Half-empty for National Policy Analysis. 29, 206-228.

Walsh, R.G., D. M. Johnson and J. R. McKean. 1992. "Benefit Transfer of Outdoor Recreation Demand Studies." *Water Resources Research*, 28, 707-713.

Wiggin J.J., D. Hellin K. Uiterwyk, D. Bordner, P. Kubilis, E. Mahoney, D. Stynes, M. Thomas, F. Lupi, M. Kaplowitz, Y. Cui, T. Herbowicz, T. Stock, L. Alpert and M. Mathews. 2009. "Florida Boating Access Facilities Inventory and Economic Study including a Pilot Study for Lee County." Prepared for the Florida Fish and Wildlife Conservation Commission.

Court documents

Fox, Michael W. City of Chicago Fire Department, Declarations in the Supreme Court of the United Stations, State of Wisconsin, Minnesota, Ohio and Pennsylvania, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, State of Michigan v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, . State of New York v. State of Illinois and Metropolitan Sanitary District of Greater Chicago,

Georgas, Steve E., City of Chicago Police Department, Declarations in the Supreme Court of the United Stations, State of Wisconsin, Minnesota, Ohio and Pennsylvania, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, State of Michigan v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, . State of New York v. State of Illinois and Metropolitan Sanitary District of Greater Chicago.

Groundwater, John, Passenger Vessel Association, Declarations in the Supreme Court of the United Stations, State of Wisconsin, Minnesota, Ohio and Pennsylvania, v. State of Illinois and Metropolitan

Sanitary District of Greater Chicago, State of Michigan v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, . State of New York v. State of Illinois and Metropolitan Sanitary District of Greater Chicago.

Motion for Preliminary Injunction, States of Wisconsin, Minnesota, Ohio and Pennsylvania, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, State of Michigan v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, . State of New York v. State of Illinois and Metropolitan Sanitary District of Greater Chicago.

Moyer, Rebecca J., U.S. Army Corps of Engineers, Declarations in the Supreme Court of the United Stations, State of Wisconsin, Et. Al, Plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al., State of Michigan, plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al., State of New York, plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al.

Peabody, John W., U.S. Army Corps of Engineers, Declarations in the Supreme Court of the United Stations, State of Wisconsin, Et. Al, Plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al., State of Michigan, plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al., State of New York, plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al.

Quarles, Charles, U.S. Army Corps of Engineers, Declarations in the Supreme Court of the United Stations, State of Wisconsin, Et. Al, Plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al., State of Michigan, plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al., State of New York, plaintiffs, v. State of Illinois and Metropolitan Sanitary District of Greater Chicago, Et. Al.

ENDNOTES

[1] No published information is available on the average cost of barge shipments per ton or ton-miles. This is a consensus based estimate provided by several shippers who do business in metropolitan Chicago.
[2] Based on average tonnage between 2006 and 2008 reported by the U.S. Army Corps of Engineers Data Navigation Center.
[3] Included in this estimate are expenditures on Intra-Great Lake operation. See Section III for details.
[4] This estimate was made in part by looking the approximate distribution of recreational boat trips in other previously mentioned categories and then determining how many more were taken so that the total is consistent with USACE estimates. These estimates suggest that the two locks serve slightly more than 40,000 recreational-vessel movements per year .
[5] This estimate was determined by using the estimate provided in Passenger Vessel Association survey and account for non-responses, which was conservatively assumed to be 10% of the total.
[6] Information on ticket prices and ancillary spending was provided by the Wendella Boat Company.
[7] Information on advance bookings was provided by the Wendella Boat Company.
[8] See especially studies by Texas Transportation Institute (2007) and University of Missouri (2004), listed in the reference section, to a discussion of differential costs of various modes of transportation.
[9] The estimate from the Missouri study is based on the follow assumed mix of barge commodities: 7% agricultural (based on USACE data for the two locks being studied) and the remaining 93% split equally between cement, asphalt, and fertilizer.
[10] Based on lock usage data from USACE Data Navigation Center.
[11] See computational spreadsheet on the Chaddick Institute web site for a summary of this calculation
[12] The estimate of 450 miles is based on a mix of shipments from various Mississippi River ports.
[13] This estimate is used by a major barge service provider about the opportunity cost of tying up a barge. It should be recognized as an approximation.
[14] David Forkenbrock (2001)
[15] This assumes a 800 mile average trip distance. See computational spreadsheet.

[16] These estimates are based on estimates made with assistance with area boat specialists, including Grant Crowley and other individuals affiliated with the Friends of the Chicago River.
[17] This estimate is based on the economic value recreational boats placed on proximity to water amenities in previous research. Boaters are affected twice annually by the loss of their preferred alternative ($72.50 per trip, once to launch their boat in spring and again to remove it in late summer or autumn).
[18] This is based on a wage rate among owners of marina boats of $40/hr. This likely understates the actual hourly earnings of the affected population.
[19] See the U.S. Army Corps of Engineers 2008 study, "*Great Lakes Recreational Boating".*
[20] See testimony by Michael W. Fox, Chicago Police Department, and Steve E. Georgas, Chicago Fire Department. Citations provided in reference section.
[21] Information about capital costs provided to the author by MDRD in March 2010..
[22] See "Strategies for a Cleaner, Healthier, More Vibrant Chicago River," Friends of the Chicago River (2006).
[23] For reference to the Charles Quarles testimony, see reference list,
[24] Citation from Strategies document, 5.
[25] See Hushak and Bielen (2000), Wiggin, et al. (2009), Walsh, et al. (1992), Rosenberger and Loomis (2000).
[26] See Sohngen, et al. (1998), Shaikh (2006), Lew and Larson (2005).
[27] Consumer surplus may not necessarily be determined on an hourly basis and the marginal consumer surplus will likely be decreasing per hour. Given the limited information on the consumer surplus for boat tours, an average hourly consumer surplus is assumed to be the most appropriate method of calculation.
[28] See Poor, Pessango and Paul (2007), Leggett and Bockstael (2000), Ara, et al (2006)
[29] The Water Quality Ladder (WQL) was developed by Resources for the Future in 1986 and has been used by many researchers to assess recreational users' willingness to pay for steps up the WQL. See van Houtven, et al (2007) and Carson and Mitchell (1993) for more information on the WQL.
[30] Boyle's testimony before the Illinois Pollution Control Board focused on the economic benefits from improved CAWS water quality from recreation use designations by the Illinois EPA, which would be achieved with the implementation of additional wastewater disinfection.