THE ECONOMIC VALUE OF BARGE TRANSPORTATION: A CASE STUDY OF THE MINNEAPOLIS UPPER HARBOR

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ABSTRACT

The Minneapolis Upper Harbor is almost 1800 miles upriver from the Gulf of Mexico. To go the last 20 miles from St Paul to the head of navigation at the Minneapolis Upper Harbor, tows are limited to two barges and have to go through 3 small locks to pass the St Anthony Falls. In contrast, below St Paul tows consist of 15 barges and the distances between the 26 large locks on the Upper Mississippi River average over 35 miles.

The Upper Harbor has a small number of private shippers but the largest land parcel is the 42 acres that contains the public barge terminal (Upper Harbor Terminal) owned by the City of Minneapolis.

A number of proposals contemplate closing the Minneapolis Upper Harbor so that the Mississippi River Corridor area above the St. Anthony Fall Locks and Dams can be converted to housing, light industry, and recreational uses, which proponents consider the "highest and best use" for prime waterfront land. Depending on the ultimate mix land of uses, it is assumed that tax revenues and economic activity will dramatically increase. These proposals generally assume that that the barge traffic of relatively low value freight (such as cement, aggregate, construction materials and scrap) is of little economic consequence and can be relocated at little cost to the community.

However, this study demonstrates that displacing many of these movements will cause monetary and environmental costs that previously had not been studied or quantified. There would still be a need to move materials such as sand and gravel, cement, steel products, and other construction materials into Minneapolis; and scrap metals from Minneapolis. Truck movements of grain, fertilizer and other commodities from and to northwest of Minneapolis would need to be rerouted to downstream harbors.

This study estimates the monetary and public externality costs imposed by the 'modal shift', from barge to truck, that would occur if barge traffic to and from above the St. Anthony Dams was eliminated. These include haulage costs, differences in fuel consumption, changes in air emissions, highway congestion impacts, highway accident impacts, and changes in highway maintenance requirements. Coefficients from the FHWA Highway Cost Allocation Study (HCAS) are used to monetize the estimated public costs. Results from the "most likely" scenario indicate an addition of 66,000 truckloads traveling 1.2 million miles in the metro area each year. Increases in transport costs to shippers or customers exceed $4 million annually, while public cost increases, estimated with the HCAS coefficients, exceed $1 million annually

PROBLEM STATEMENT AND BACKGROUND

The primary intent of this case study was to determine the likely economic impacts of the loss of water access to facilities located on the Minneapolis Upper Harbor. The public policy question was: "If the Minneapolis Upper Harbor loses access to barge transport, what changes in truck traffic are expected to result, what are the expected routes of this traffic, and what are the expected private and public costs?" The private costs are the increased costs of transportation that are directly incurred by individuals or businesses. The public costs include highway maintenance costs and public externalities such as emissions, congestion, and accidents.

This study needed to predict which trips would divert to truck (from the water) and how decisions would be made between competing routes for these truck trips. Such prediction requires an understanding of the basic economics of transportation trip costs, which uses a "fixed cost" and "variable cost" construct.

OVERVIEW OF THE MINNEAPOLIS UPPER HARBOR FACILITY

Figure 1 is a map of the study area. The Minneapolis Upper Harbor (the red oval at A in Figure 1) is separated by three river locks and is approximately 20 Mississippi river miles from the ports at St. Paul (the red oval at B), and 25 to 30 river miles from the two aggregate plants at Grey Cloud Island (C). This study found that, if the river was unavailable, most cargo using the Upper Harbor would divert to truck between the two harbors along highway I94 (the dotted line at D), or between northwest of the Metro and the St. Paul ports along highways I694 & I35E (the dotted line at E).

The Minneapolis Upper Harbor contains three facilities that currently handle water (barge) traffic and which would be affected by a loss of access to the river:

i) **Aggregate Industries (AI) Minneapolis Yard** - has only up bound barge traffic, consisting of aggregates (limestone, sand, and gravel) from the AI plants on Gray Cloud Island.

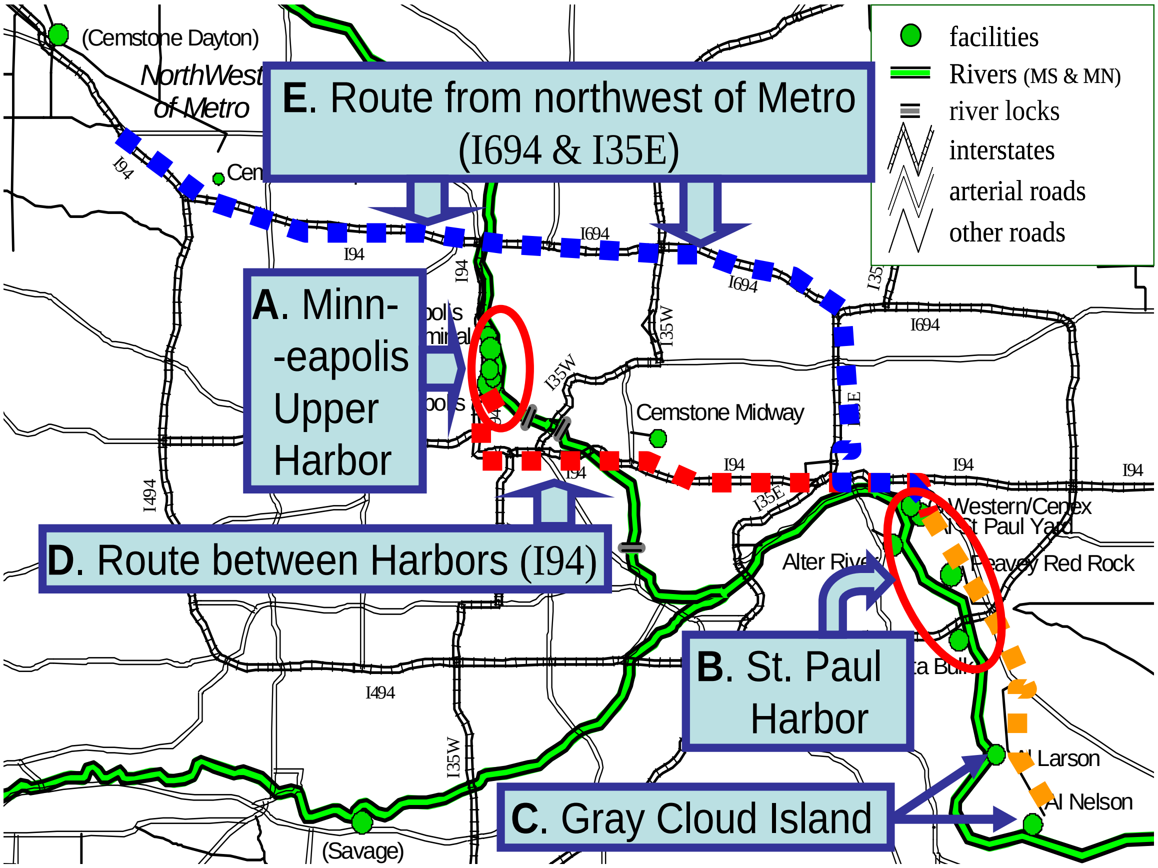
ii) **Upper Harbor Terminal** (River Services, Inc.) – has both down bound and up bound barge traffic, generally consisting of grain and potash down bound, and fertilizer, coal, salt, steel, general cargo, and some specialized aggregates up bound.

iii) **American Iron and Steel (AIS) –** has only down bound traffic, of scrap metals.

As in many other urban areas, industrial use at the Upper Harbor is coming into conflict with residential and recreational use as the waterfront becomes a desirable location. There have been several proposals to discontinue barging in the Upper Harbor, most notably *Above the Falls: A Master Plan for the Upper River in Minneapolis* (BRW Inc. Undated).

Above the Falls assumes that the elimination of freight facilities or their loss of access to water would lead to the disappearance of any truck traffic associated with these facilities. This study investigates whether that assumption is correct by forecasting the net change in traffic that would occur if water access was no longer available at the Minneapolis Upper Harbor.

FIGURE 1. MAP OF STUDY AREA



RELEVANT LITERATURE

The 1997 study *Monetary Costs of a Modal Shift* (Lambert 1997) established the basic methodology for this study: forecast net changes in traffic by mode, and multiply these by the best available “coefficients” to establish total impacts of these changes by mode. For the net overall impact, subtract the impacts “saved” in the replaced mode from the impacts incurred by use of the new mode.

A significant resource that was unavailable to Lambert is the “Highway Cost Allocation Study” (FHWA 1997), and the “Addendum to the Highway Cost Allocation Study (HCAS)” (FHWA, 2000). The HCAS Addendum developed national coefficients specific to heavy trucks, based upon vehicle miles traveled (VMT), versus the ton-miles used in Lambert 1997. The “Comprehensive Truck Size and Weight Study” (USDOT 2000a) and “Truck Size and Weight” (USDOT 2000b) assisted in understanding the economics of the modal choice between truck and rail, and the operations and impacts of heavy trucks.

The primary published data sources for this study are: *Minnesota’s River Terminals* (Lambert 2001) for information about Mississippi and Minnesota river facilities and river mileages; the “Lock Performance Monitoring System (LPMS)” (USACE, 2003) dataset, for information about cargo types and volumes on the river; the “Overview of Highway Performance Monitoring System (HPMS)” and supplementary documents (FHWA 2003a and FNWA 1989, FHWA 2003b), for information about highway types, and the associated “National Highway Planning Network (NHPN)” (FHWA 2003c) for highway routing and mapping. All other data is from original sources (i.e. interviews conducted as part of this study).

This complete results of this study, which was conducted for the Minnesota Department of Transportation (Mn/DOT), are reported in *Modal Shifts from the Mississippi River & Duluth/Superior to Land Transportation*, (Fruin, Fortowsky 2004).

METHODOLOGY

The fundamental economic methodology applied to this problem is "with and without" analysis: cargo movement, and associated costs, with access to the river at the Upper Harbor are compared to the cargo movement, and associated costs, that would occur without access to the river.

Removing river access would have several follow-on effects, each of which must be explicitly understood to properly model the "without" scenarios:

a) Facilities which exist wholly to provide access to the river would disappear, and traffic using those facilities would relocate to alternative facilities.

b) Facilities which exist for another purpose, but use the river, would either relocate or simply switch modes, depending upon the underlying economic rationale for the location and the relative importance of transportation costs in this rationale.

c) For all traffic using these facilities, the choice of replacement mode and the route of the replacement trip depend upon the economics of the remaining transportation choices.

A crucial factor in the nature of the movement is whether it is arriving at or leaving the facility as part of another trip which can be rerouted, or whether an entirely new trip is generated. This distinguishes whether a trip is an "incremental" trip or a "whole-move" trip. An incremental trip means that the "without" scenario only needs to consider the cost of additional distance; whereas a whole-move trip means the "without" scenario also needs to consider the cost of an additional load/unload step.

Computation Of Expected Costs

To determine expected costs, cargo modal choices, volumes, and distances must be estimated. Distances depend upon routes, which depend upon facility locations (and relocations, as discussed above) and the origins/destinations of cargo to/from the affected facilities. Cargo volumes were estimated through available statistics and interviews. Routes and modal choice are determined from the economics of modal choice, local geography, and facility location.

There are two major types of cost analysis available to then turn volumes and distances, by mode, into predicted costs:

1) costs by ton-mile; and

2) for heavy trucks, costs by vehicle-mile traveled (VMT).

Costs by VMT require the additional step of determining vehicle "load factors" to convert tonnage volumes into vehicle trips. These load factors are based on information from the cited sources and interviews with representatives of facilities on the Upper Harbor.

"Most Likely" Flows of Diverted Traffic

The origins, destinations, and volumes of cargo flows were determined over the "most likely" routes for these cargo flows. The length of these routes, multiplied by volumes in tons or truck trips, produced ton-mile and VMT estimates (respectively). Appropriate coefficients are then applied to the ton-miles and VMT, to develop costs.

A key point in this analysis flows from a simple observation of the location of the Minneapolis Upper Harbor ports, which is northwest of the alternative ports in the St. Paul area. Cargo will only currently use the Minneapolis ports if these ports are closer to the cargo's origin or destination. Otherwise, the cargo would already be using the St. Paul ports, and saving the costs of the additional river miles (and three locks) between St. Paul and Minneapolis. Thus, the Minneapolis ports capture cargo moving to Minneapolis itself, western suburbs, and to/from northwest of Minneapolis. If the river mode to Minneapolis is unavailable, cargo will move to and from Minneapolis, and northwest of Minneapolis, by the most direct possible route to/from the St. Paul ports. Most of these routes will be directly through St. Paul and Minneapolis via I94, with the rest close to the northern and western boundaries of Minneapolis (on I694 and I494).

Based upon this fundamental observation, the economics of truck movements (described below) and interviews with the facility operators, a "most likely" scenario of the changed traffic patterns (following a loss of water access to the Upper Harbor) was developed.

Availability of Data

Normally, information on commercial transportation costs and volumes is difficult to obtain, particularly for transportation industries where it is a key part of a firm's pricing strategies and competitiveness. However, the Upper Harbor is a unique situation in several respects:

i) The Upper Harbor is the only harbor above the last set of locks on the Mississippi. Because of this, exact volumes can be obtained through the Lock Performance Monitoring System dataset (USACE 2003). Statistics for all other Mississippi locks include through traffic.

ii) There are a limited number of facilities in the Upper Harbor, so the operators could be identified and interviewed. The facility operators also had an interest in cooperating with this study, to make the case that there would be significant impacts of a loss of water access.

A primary goal of the methodology was to provide credibility for policy purposes. It was anticipated that the results of this study would show that there would be substantial private and public economic impacts if water access to the Upper Harbor were lost. Therefore this analysis has been biased towards underestimating these impacts. Conservative assumptions of truck volumes, distances, and costs are used throughout.

OVERVIEW OF THE ECONOMICS OF MODAL CHOICE

In this study, "modal choice" refers to which freight transport "mode", truck or rail, would be used to replace the water mode for Upper Harbor cargo. This study needed to predict which trips would divert to truck (from the water) and also how decisions would be made between competing routes for these truck trips. Both predictions require an understanding of the basic economics of transportation trip costs, which uses a "fixed cost and variable cost", construct.

Loading and unloading are a significant cost for most freight transportation trips. These costs are fixed costs: they happen regardless of the time or distance required for the trip (variable costs are those that vary by time or distance of the trip). Fixed costs represent a 'hurdle'. Once this hurdle is crossed trip distance can be increased for a small percentage of the overall cost.

The relationship between fixed and variable costs varies greatly between modes. Rail costs less per ton mile than truck but load and unload costs are higher. Fixed costs of rail are increased by fees for "switching" and costs of delays. A relatively long rail trip is required before the fixed cost disadvantage with trucks is offset by variable cost savings. This required trip distance is generally far greater than the distances involved in this study. For example, the USDOT 2000a study used a cutoff of 200 miles before the use of the rail mode would even be considered. A similar decision was made in this study to set short haul [truck only] limits at 200 miles.

River costs are even lower per ton mile than rail. River load and unload costs are also low, on a per ton basis. But the river is only available in limited locations and at limited seasons of the year. Generally, truck or rail transport is required either to or from the river, or both.

In short trips, such as urban movements, the distance cost portion of a truck trip cost is often roughly similar to, or less than, the loading/unloading costs. In fact, urban truck services are generally charged based upon time (longer, non-urban, trips are generally charged based upon shipment weight and distance). Thus, as compared to a "long-haul" trip, changes in distance of a short-haul urban trip are a relatively small component of the overall cost, and will have limited effect once it has been decided to make the trip (i.e. to incur the load/unload costs). The impact of these effects for this analysis means that the diversion to rail will be very limited (the distances are simply too short to justify the fixed costs) and that differences in distance will not have a large impact on route choices.

Since fixed and variable truck costs are of similar magnitude, and we need to know how these costs will change if the river is not available, it is important to distinguish between:

i) "incremental" trips, which are only extensions to trips which would already occur – thus only increased variable costs should be added to the "without" scenarios; and

ii) "whole-move" trips, which are entirely new trips resulting from the "without" scenarios – thus incurring both fixed (load/unload) costs and increased variable costs.

In the Upper Harbor modal shift, "incremental" trips occurred for all the trips involving the Upper Harbor Terminal, and about half the trips involving Aggregate Industries. "Whole-move" trips occurred for all the trips involving American Iron and half of the trips involving Aggregate Industries.

Truck "backhaul" refers to the return trip portion of a truck trip (i.e. after it unloads). A backhaul can either be empty backhaul, where no cargo is hauled in the return trip, or paid backhaul, where a cargo is moved on the return trip as well. Backhauls generally represent a quarter, or less, of the cost of urban movements, as the savings of a paid backhaul can be easily offset by the repositioning (time) costs of moving the truck to the other customer's location.

Private, Public Sector, and Public Externality Costs

In accord with standard economic practice, the costs estimated in this study are divided into three major categories based on "who pays":

i) "Private costs" are incurred as direct expenses to individuals or corporations. In this study these costs occur as haulage costs charged by a barge or trucking company to move the traffic. Net private costs will consist of new truck haulage costs incurred minus barge haulage costs saved.

ii) "Public sector costs" represent direct costs to public road authorities, for road maintenance due to wear from increased truck volumes.

iii) "Public externality costs" represent "hidden" costs to the public as a whole, including emissions, congestion, crash, and noise costs arising from increased truck volumes.

This study derives private costs from predicted truck VMT using estimated haulage rates derived in the interviews. Both public sector costs and public externality costs will be derived from predicted truck VMT using the HCAS Addendum (FHWA 2000) for each cost. Net costs for all scenarios are then derived by subtracting barge costs saved, using the best available estimates of rates and coefficients (generally, interviews and Lambert 1997).

CALCULATION OF FREIGHT VOLUMES

A typical semi-trailer truck has a maximum gross vehicle weight (GVW) of 80,000 pounds, the maximum GVW allowable on Interstate highways. After the weight of the truck and trailer are subtracted, there is a remaining maximum cargo capacity. Based upon the interviews, the "truck payload" weights were developed for each major shipper. These weights of 23 or 24 tons per truckload were used to convert cargo-tons to truck-loads.

Actual barge movements through the Upper St. Anthony Falls Lock at river mile 853.9 for the years 1995 through 1999 were used to derive five-year averages from the LPMS database (USACE 2003). In general, the interviews and data analysis found that commodities can be clearly assigned to specific facilities, and reasonable diversion scenarios are known for each facility/commodity pair. "Diversion scenarios" are the broadly predicted route and mode that would be used, by traffic currently moving through the Upper Harbor by water, if the river mode (barge) is not available.

American Iron (AIS)

American Iron (AIS) collects and resells scrap metals. AIS processes this scrap by sorting it and reducing its volume. Primary customers are steel mills, many of whom have receiving facilities on the river system. AIS collects scrap metals primarily from Minneapolis and to the west and north, from as far as North Dakota and beyond. AIS currently loads approximately 70 barges per year, which accounts for about 65 percent of their outbound product. Truck movement to St. Paul is expected to cost $5-$6 per ton (versus $0.50 by barge), This truck rate assumes one half hour to load and another half hour to unload, plus a half hour for the loaded trip, at rate of $55 to $70 per hour.

AIS has commenced a multi-million dollar investment in a large state of the art scrap "shredder". The shredder will allow a significant increase in AIS processing capacity. They expect their outbound barge tonnage to at least double. We used a conservative forecast of the increased tonnages processed by the shredder (twice the current USACE average of barge shipments). It should be noted that, in addition to the beneficial transportation impacts found in this study, AIS recycling activities have obvious environmental benefits. They reduce the volumes that are land filled and the need for raw material mining and processing to produce steel and metal products.For example, AIS disposes of all discarded appliances in the City of Minneapolis, and processes 4 to 5 trucks per day from the Hennepin County Incinerator.

Upper Harbor Terminal (River Services, Inc.)

The Upper Harbor Terminal (UHT) is owned by the City of Minneapolis and operated by River Services Inc. The UHT both loads and unloads barges. Up bound cargo unloaded from barges is moved exclusively by truck. This cargo's destination is Minneapolis and its western suburbs, or the west and north-west of the Twin Cities.

Down bound cargo arrives by both truck and rail. Rail cargo is primarily grain and, sometimes, potash from Canada. All rail cargo would simply divert to alternative ports. The rail diversion cost are not costed in this study (they are, comparatively to the truck costs, very small). UHT estimates that shippers save $3 per ton per truck trip to UHT versus to/from St. Paul ports, while the barge movement costs only 50 cents per ton. If a backhaul is available at St. Paul the trip savings at UHT may only be $2 per ton. Some of the traffic currently using the UHT is to/from points significantly to the northwest of the Metro area, and backhaul would thus be a more attractive proposition than it is for the purely urban routes.

Diversion routes were developed for each major type of traffic. A weighted average, by road type, was then developed from these routes. This average was subsequently used to represent the entirety of the UHT truck diversion traffic.

Aggregate Industries Minneapolis Yard and Cemstone

Aggregate Industries (AI) moves 800,000 tons/year of aggregate by barge into the AI Minneapolis Yard (formerly called AI Yard D) in the Upper Harbor. AI mines aggregate and mines and crushes limestone at two sites on Grey Cloud Island on the Mississippi (river miles 825.0 & 826.6), and moves these products by barge. One of the sites is much smaller than the other and, again, a weighted average of routes was developed to represent both sites in subsequent steps of the analysis.

The river shipping season is approximately 160 working days (32 weeks at 5 days per week), during which there are typically two tows to AI Minneapolis per day with two barges per tow, for a total of four barges per day.

Sixty percent of the AI Minneapolis product is used by an adjacent Cemstone concrete ready-mix facility which serves the nearby urban core of the City of Minneapolis area. The rest (40 per cent) is trucked to other area facilities. The Cemstone plant uses 1.6 tons of aggregate (1,750 lbs of gravel, 1,500 lbs of sand) in a cubic yard of concrete. Cemstone must maintain a facility close to downtown Minneapolis (a major market) as ready-mix concrete cannot travel more than half an hour in the delivery truck. There are only two major ready-mix competitors in the area. Because of the industry structure increases in cost due to increased aggregate transportation costs (using truck rather than barge) can be expected to result in similar increases in the price of the final product, which will negatively impact construction costs.

Summary of Upper Harbor Tonnages Diverting To Truck

The interviews, data, and diversion scenarios were used to create Table 1, which predicts the annual tonnages that will divert to truck if the barge mode is not available at the Minneapolis Upper Harbor facilities. Table 1 excludes the tonnages that arrive at the UHT by rail and are forecast to divert by rail rather than truck. Table 1 has also included the increased AIS tonnages that will result when the installation of a “shredder” is completed (using a conservative estimate of a doubling of the tons handled). Table 1 represents the forecasted total volumes of one-way loaded truck trips that would result if the water mode (barge) was unavailable to facilities at the Minneapolis Upper Harbor.

Table 1. Estimates of Upper Harbor Tonnages Diverting to Truck

Facility/ Commodity	Comments	AVG_TONS downbnd	AVG_TONS upbound	tons/ truck	truckload equivalent Dnbnd	truckload equivalent Upbnd	truckload equivalent total
Aggregate Industries/Cemstone							
Aggregate	90% of upbound volumes	-	801,225	23	-	34,836	**34,836**
American Iron (AIS)							
Iron/Scrap	forecast doubling with shredder	197,200	-	23	8,574	-	**8,574**
Upper Harbor Terminal (UHT)							
Aggregate	10% of upbound , all downbnd	4,230	89,025	24	176	3,709	**3,886**
Cement	all downbound volumes	3,000	-	24	125	-	**125**
Iron/Scrap	all upbound volumes	-	52,574	24	0	2,191	**2,191**
Grain	all upbnd, reported Metro downbnd	18,000	9,000	24	750	375	**1,125**
Grain	downbnd from NW of Metro	60,000	-	24	2,500	-	**2,500**
Fertilizer	all upbound volumes	-	55,200	24	-	2,300	**2,300**
Coal	all volumes (both directions)	5,020	123,932	24	209	5,164	**5,373**
Salt	all volumes (both directions)	4,500	74,100	24	188	3,088	**3,275**
General	all volumes (both directions)	8,524	38,015	24	355	1,584	**1,939**
total	total - all UHT truck movements	103,274	441,845	24	4,303	18,410	**22,713**
Forecast Total diversion to truck:		300,474	1,243,070		12,877	53,246	**66,123**

based upon USACE 5 year LPMS average tonnages (1995-99) and interviews with Upper Harbor shippers

CALCULATION OF ROUTES AND DISTANCES

Loaded Truck Vehicle Miles Traveled (LT_VMT)

Vehicle Miles Traveled (VMT) has become the standard denominator of measurement for most highway-related cost and environmental factors. For example, if air pollution costs are estimated at 4.4 cents per VMT, this coefficient can simply be multiplied by the forecast change in VMT to produce a forecast of the air pollution cost. In this study, the abbreviation LT_VMT is used to specify that the VMT under discussion are for Loaded Trucks, based upon one-way truck-load trips that would be required to move the commodity tonnages shifted from water (barge) to truck.

In the types of truck traffic that would result from the modal shifts under study (particularly the short, intensive, urban movements in the Minneapolis Upper Harbor modal shift), it is expected that most loaded truck trips will also have an empty "backhaul" trip. However, if backhauls are available they would obviously reduce the expected total truck impacts. Thus very generous estimates of backhaul potential were used (c.f. Table 5). For example, since American Iron traffic has complementary flows to Aggregate Industry traffic (i.e. similar routes in opposite directions) and uses similar equipment, it was estimated that 100% of the American Iron traffic would have a paid backhaul of Aggregate Industry traffic (which corresponds, in turn, to a paid backhaul for 25% of Aggregate Industry traffic since it is four times the tonnage of American Iron traffic).

HPMS, Routing, and Road Types

The routings were based on calculation of "shortest time" routes (a function of posted speed limit and distance) between origins and destinations that were identified in the interview process. The Road Types used in this analysis are based upon the HPMS (Highway Performance Monitoring System) (FHWA 2003a and 2003b) functional class classification. This allows matching with the most current road environmental cost figures, which are calculated for road types based upon functional classes. The functional class of a given road is ultimately derived from its speed limit and capacity, and is thus implicitly related to its traffic volumes. Within a given area like the Twin Cities roads of similar functional classes can be expected to have broadly similar traffic volumes.

Road Type Categories

For this analysis, we grouped HPMS Functional Classes into three categories:

i) CAT1: urban Interstate and controlled access Expressways

ii) CAT2: urban Major and Minor Arterials

iii) CAT3: All other urban road types (collector, local, and unclassified)

The HPMS functional classification system distinguishes between urban and rural roads. No rural road type categories were used for this analysis since our analysis of the underlying data determined that all Metro-area roads can be treated as urban.

"Most Likely" Scenario Results

As discussed previously, a "most likely" scenario of the changed traffic patterns (following a loss of water access to the Upper Harbor) was developed, based upon all the information and analytic tools described thus far. The scenario was also validated with the facility operators and a steering committee of local industry experts.

A key part of the "most likely" scenario is Aggregate Industries continuing to move the aggregates, destined for the Upper Harbor, partly by water, with a transload-to-truck step occurring at their St. Paul port facility. A strong alternative scenario is movement entirely by truck. However, this would entail huge public and externality costs on the primarily local roads between Grey Cloud Island and the St. Paul port (roughly paralleling the river). Use of St. Paul port as a transloading facility will likely require major investments by Aggregate Industries, which are not costed in this study.

Table 2 illustrates the forecast new truckload trips through the Metro area. For example: trips from northwest of the Metro that now stop at the Upper Harbor Terminal are counted as "new" trips if they are extended through the Metro (to/from St. Paul ports). Note that "new" trips should not be confused with the distinction between "incremental" and "whole-move" trips – both types can result in new trips <u>through</u> the Metro area. Also note that this count includes empty backhaul trips.

The first part of Table 2 represents the forecast annual count of these new trips: 103,607 new truck trips through the Metro area, of which 81,980 would use I94 between St. Paul and Minneapolis, which is the busiest connector in the state. A daily count would properly use the shipping season as a denominator to convert form annual for most of the traffic types (some of the movements could occur year round, but most still link with the River mode and are thus dependant upon the shipping season). There are 160 season-days in a year (5 weekdays times the 32 week barge season). The second part of Table 2 represents the forecast daily count of new trips during the shipping season: 648 new truck trips per day, with 512 of these on the aforementioned portion of I94.

Table 2. Additional Truck Trips by Road Category, Most Likely" Scenario

C. Total for ALL trips (fronthaul and empty backhaul)

I. "Most Likely" Summary Scenario								
Table 2: Annual truck TRIPS and trip VMT TOTAL TRIPS by Road Type	truck-trip VMT by road type category thousand annual VMT				annual truck-trips I94 and		annual truck-trips
	CAT1	CAT2	CAT3	total	I35W	I35E	
TOTAL HAUL annual increase:	1,453	270	97	**1,820**	81,980	81,980	103,607

D. TOTAL TRIPS per SEASON-DAY

I. "Most Likely" Summary Scenario							
Table 2: DAILY truck TRIPS and trip VMT SEASON-DAY TRIPS by Road Type	truck-trip VMT by road type category thousand daily VMT				daily truck-trips I94 and		daily truck-trips
	CAT1	CAT2	CAT3	total	I35W	I35E	
all-trip increase per SEASON-DAY:	9.1	1.7	0.6	11.4	**512**	**512**	**648**

Table 3. Additional VMT and Ton-miles "Most Likely" Scenario

Table B: (ml)	Annual truck loads and LT_VMT by Road Type			truckload VMT by road type category thousand annual VMT				annual truckloads I94 and		annual truck-loads
scenario	route	origin	destination	CAT1	CAT2	CAT3	total	I35W	I35E	
i) American Iron at minimum forecast volumes with shredder, to Dakota Bulk										
AIS-3	R3A	Am Iron	Dakota	136	48	12	**196**	8,574	8,574	8,574
ii) Upper Harbor Terminal, weighted average of routes										
UHT_avg	A&C	UHT cargo traffic	port/route average	321	78	9	**407**	8,296	8,296	22,713
iii) Aggregate Industries trucking current AI Minneapolis volumes from AI ST. Paul										
Total		AI St Paul	AI Minn	477	60	41	**579**	34,836	34,836	34,836
		total forecast annual increase:		934	186	62	**1,182**	51,706	51,706	66,123

Table C: (ml)	Ton-Miles (Thousand Annual) by Road Type			truck by road type category thousand annual ton miles				WATER		cargo thous tons
scenario	route	origin	destination	CAT1	CAT2	CAT3	total	river miles	ton miles	
i) American Iron at minimum forecast volumes with shredder, to Dakota Bulk										
AIS-3	R3A	Am Iron	Dakota	3,136	1,113	267	**4,515**	-24.7	-4,871	197.2
ii) Upper Harbor Terminal, weighted average of routes										
UHT_avg	A&C	UHT cargo traffic	port/route average	7,694	1,863	208	**9,760**	-19.7	-10,740	545.1
iii) Aggregate Industries trucking current AI Minneapolis volumes from AI ST. Paul										
Total	0	AI St Paul	AI Minn	10,979	1,389	951	**13,319**	-18.8	-15,063	801.2
		total forecast annual increase:		21,809	4,364	1,427	**27,595**		-30,674	1,543.5

Table 3 shows the same "most likely" new truck traffic (and the water traffic which it replaces) in terms of Vehicle Miles Travelled (VMT) and ton-miles. (Note that the final "annual truck-loads" column now excludes the empty backhaul trips included in Table 2). The forecast total annual change is **1.182 million annual loaded truck miles** (LT_VMT) of traffic **from 66,123 loaded truck trips** through the Metro area. This is equivalent to 27.60 million truck ton miles, which is offset by a reduction of 30.67 million ton-miles in river barge traffic (note that river ton-miles are larger because the river route is longer; tonnages are the same).

Table 4 summarizes the forecast results that will be need in the cost estimation: the net changes in VMT and ton-miles reported above; the (generous) proportion of paid backhauls; and the proportion of "incremental" versus "whole trip" movements.

Table 4. Summary of Truck Trips by Type

I. "Most Likely" Summary Scenario		WATER		ROAD							
	cargo		thous	annual			thous	truck trip type			
	thous	water	ton	truck-	thous	road	ton	backhaul		incr	whole
scenario	tons	miles	miles	loads	TL_VMT	miles	miles	empty	paid	trip	move
Am. Iron with shredder	197	-24.7	-4,871	8,574	196	22.9	4,515	0%	100%	0%	100%
UHT weighted average	545	-19.7	-10,740	22,713	407	17.9	9,760	50%	50%	100%	0%
AI Minn from AI St Paul	801	-18.8	-15,063	34,836	579	16.6	13,319	75%	25%	38%	63%
	1,544		**-30,674**	**66,123**	**1,182**		**27,595**				

COST ESTIMATION

Two types of cost analysis are used in this study:

1) costs per ton-mile, consisting of private haulage costs; and,

2) costs per heavy-truck VMT, using the HCAS coefficients to produce public sector (road maintenance) costs and public externality (emission, congestion, crash and noise) costs.

Cost per Ton-Mile

Interviews revealed that for trips between the Upper Harbor and St. Paul ports, the truck times can be roughly divided into one-quarter for each step: half-hour load; half-hour front haul; half-hour unload; and half-hour return trip. UHT estimates a cost for the incremental portion only of $3 per ton (i.e. extending a trip that would normally be to/from the UHT, to/from St. Paul instead, thus excluding costs for the load and unload steps). UHT also estimates that a paid backhaul would reduce this rate by about one-third, or $1 per ton. These rates are used as the cost of an incremental truck trip for all movements to St. Paul ports in the “truck rate $/ton” columns in Table 5. Also, one dollar per ton is deducted as an estimated saving for every paid backhaul trip (in the “paid backhaul” column). Note that no “whole-moves” occur for the UHT.

American Iron estimates $5-$6 per ton for a full move due to half-hour load and half-hour unload, so $5 per ton is used for their whole-moves. An intensive gravel haul should be able to cut load/unload times in half, so $4 is used for the Aggregate Industries incremental trips to St. Paul ports. As noted, in the “most likely” scenario part of the Aggregate Industries movement continues on water, with transload-to-truck at their St. Paul port facility.

Costs for the eliminated barge trips between the Upper Harbor and St. Paul are commonly estimated at 50 cents per ton. This is higher than ton-mile costs elsewhere on the river due to the short tow (only two barges) that must be used and the time costs of traversing multiple locks in a short distance.

Table 5 illustrates truck trips and barge ton-miles, and the corresponding estimated truck and barge rates. These were used to compute the private costs that would be incurred for new trucking and saved on the eliminated barge movements.

Table 5. “Most Likely” Scenario Haulage Costs

I. "Most Likely" Summary Scenario									
Trip Type Tonnages	ROAD	WATER	**cargo**	truck trip type		paid			
	road	river	**thous**	incr	whole	back-			
scenario	miles	miles	**tons**	trip	move	haul		Barge	
Am. Iron with shredder	22.9	-24.7	**197**	0%	100%	100%		100%	
UHT weighted average	17.9	-19.7	**545**	100%	0%	50%		100%	
AI Minn from AI St Paul	16.6	-18.8	**801**	38%	63%	25%		100%	

I. "Most Likely" Summary Scenario				**truck rate $/ton**					
Rates/Ton by Trip Type	ROAD	WATER	**cargo**	truck trip type		paid		Barge	
	road	river	**thous**	incr	whole	back-		Rate	
scenario	miles	miles	**tons**	trip	move	haul		$/ton	
Am. Iron with shredder	22.9	-24.7	**197**		$5.00	-$1.00		$0.50	
UHT weighted average	17.9	-19.7	**545**	$3.00		-$1.00		$0.50	
AI Minn from AI St Paul	16.6	-18.8	**801**	$3.00	$4.00	-$1.00		$0.50	

Table 6 shows that in the “most likely” scenario, the increase in private trucking costs is $4.856 million per year. This would be offset by saved private barge costs of $0.772 million, for a net cost increase of $4.084 million per year in private costs to move the cargo to/from the Upper Harbor by truck rather than by barge.

Table 6. Change in Truck & Barge Haulage Costs – "Most Likely" Scenario

I. "Most Likely" Summary Scenario				truck cost $thousands					
Haulage Costs by mode	ROAD	WATER	cargo	truck trip type		paid	net	Barge	NET
	road	river	thous	incr	whole	back-	truck	Cost	cost
scenario	miles	miles	tons	trip	move	haul	cost	$ thous	$ thous
Am. Iron with shredder	22.9	-24.7	**197**	$0	$986	-$197	$789	-$99	**$690**
UHT weighted average	17.9	-19.7	**545**	$1,635	$0	-$273	$1,363	-$273	**$1,090**
AI Minn from AI St Paul	16.6	-18.8	**801**	$901	$2,003	-$200	$2,704	-$401	**$2,304**
			1,544	$2,537	$2,989	-$670	$4,856	-$772	**$4,084**

COMPUTATION OF PUBLIC COSTS FROM HCAS COEFFICIENTS

This study uses "marginal costs of highway use" developed by the Federal Highway Administration in their Highway Cost Allocation studies (FHWA 1997 and 2000). These are nationally comparable cost coefficients, which the FHWA has committed to update and refine on a regular basis.

> "Table 13 shows estimates of marginal pavement, congestion, crash, air pollution, and noise costs in 2000 for selected vehicles operating under different conditions. Costs reflect typical or average conditions; in certain locations, costs could be expected to vary from values shown. The relative costs of pavement damage, congestion, crashes, air pollution, and noise for different vehicle classes operating in rural and urban areas are as important as the individual costs themselves." (FHWA 2000)

Table 7 reproduces the specific coefficients, for both rural and urban Interstates, that have been developed in the HCAS Addendum. The coefficients for the fully-loaded 5 axle trucks (80,000 lb. GVW) which move the cargo under study are found in the line "80 kip 5-axle Comb/Urban Interstate". Note that "80 kip" means a fully-loaded 80,000 pound GVW vehicle. As stated previously, the roads in the Metro area are all "urban" in the FHWA categorization. Only "Interstate" coefficients are currently available, but Interstate travel both represents the majority of the modeled VMT, and can be expected to represent conditions close to the other major roads used by truck traffic.

Table 7. HCAS Coefficients

2000 Addendum to 1997 FHWA Highway Cost Allocation Study (HCAS)
Table 13. 2000 Pavement, Congestion, Crash, Air Pollution, and Noise Costs
for Illustrative Vehicles Under Specific Conditions

	$ per thousand VMT					
Vehicle Class/Highway Class	Pavement	Congestion	Crash	Air Pollution	Noise	Total
Autos/Rural Interstate	$0.0	$7.8	$9.8	$11.4	$0.1	$29.1
Autos/Urban Interstate	$1.0	$77.0	$11.9	$13.3	$0.9	$104.1
40 kip 4-axle S.U. Truck/Rural Interstate	$10.0	$24.5	$4.7	$38.5	$0.9	$78.6
40 kip 4-axle S.U. Truck/Urban Interstate	$31.0	$244.8	$8.6	$44.9	$15.0	$344.3
60 kip 4-axle S.U. Truck/Rural Interstate	$56.0	$32.7	$4.7	$38.5	$1.1	$133.0
60 kip 4-axle S.U. Truck/Urban Interstate	$181.0	$326.4	$8.6	$44.9	$16.8	$577.7
60 kip 5-axle Comb/Rural Interstate	$33.0	$18.8	$8.8	$38.5	$1.7	$100.8
60 kip 5-axle Comb/Urban Interstate	$105.0	$183.9	$11.5	$44.9	$27.5	$372.8
80 kip 5-axle Comb/Rural Interstate	$127.0	$22.3	$8.8	$38.5	$1.9	$198.5
80 kip 5-axle Comb/Urban Interstate	$409.0	$200.6	$11.5	$44.9	$30.4	$696.4

Scaling of HCAS Coefficients for non-Interstate Roads

To more closely match the other road types (CAT2 and CAT3 roads) to the Interstates (CAT1 roads), this analysis also uses “road category cost factors” to conservatively scale up the coefficients used for CAT2 and CAT3 VMT (relative to CAT1 VMT) where there are widely known and accepted differences in impacts (such as pavement maintenance costs). Also, since the vehicle type represents a fully-loaded truck, a “backhaul cost factor” is used to scale down coefficients used for empty backhaul VMT, relative to loaded front haul VMT, where there are widely known and accepted differences in impacts (again, such as in pavement maintenance costs). A summary of the factors used is presented in Table 8 “HCAS Road Category and Backhaul Cost Factors”.

Table 8: HCAS Road Category and Backhaul Cost Factors

Road Category and Empty Backhaul Cost Factors applied to HCAS, by Cost Type					
	Pavement	**Congestion**	**Crash**	**Air Pollution**	**Noise**
road category cost factor: ratio of CAT2 & CAT3 to CAT1 VMT	**200%**	100%	**200%**	100%	100%
backhaul cost factor: ratio of empty backhaul VMT to loaded truck VMT	**5%**	**75%**	100%	**75%**	100%

Rationales for Cost Factors

Pavement (Maintenance) Costs: Heavy Trucks create much less pavement damage when empty (though still much more than normal traffic, since the unit can still weigh as much as 15 tons). Thus a factor of 5% was applied for empty backhaul trips. CAT2 and CAT3 type roads cost much more to maintain, per mile of heavy vehicle travel, than CAT1 (interstate-class) roads (which are specifically constructed to accommodate such travel at relatively low maintenance rates, though at an initial construction cost, excluding land costs, that is in turn much higher than CAT1/CAT2 roads). Thus a very conservative factor of 200% was applied for CAT2 and CAT3 roads.

Congestion Costs: Heavy vehicles are much better able to match traffic flows when empty, particularly in stop/start (i.e. congested) traffic and at ramps and merges. Thus a factor of 75% was applied for empty backhaul trips.

Crash Costs: The divided highway and controlled access formation of CAT1 roads produces significantly lower crash rates (and associated costs) than CAT2 and CAT3 roads. Thus a conservative factor of 200% was applied for CAT2 and CAT3 roads.

Air Pollution Costs: Heavy vehicles can be expected to use less fuel (which is the source of air pollution) and be less affected by congestion (a major factor in air pollution rates for a given amount of travel) when empty. Thus a factor of 75% was applied for empty backhaul trips.

Noise Costs: No scaling was used for noise costs.

Calculation Steps

The adjusted HCAS coefficients are simply multiplied by the forecast change in truck VMT, to produce estimated annual cost increases However, both the “loaded truck VMT” (“LT_VMT”) and associated empty backhaul trips must be accounted for. This is done by applying the estimates of percentage of empty backhaul (see Table 4) to the loaded truck VMT. Note that “empty backhaul” is equal to 100% minus “paid backhaul”, i.e. all trips have either an empty or paid backhaul. The backhaul VMTs are maintained separately to allow use of the “backhaul scaled” HCAS coefficients.

Total HCAS Costs

As illustrated in Table 9, the calculated total net public costs are $1.088 million per year. These costs are a summation of all the costs that can be calculated using the HCAS cost coefficients for pavement maintenance, congestion, crash, air pollution, and noise. These costs are sub-totaled into "Public Sector Costs" (road maintenance), amounting to $601 thousand per year and "Public Externality Costs" (congestion, emission, crash, and noise), amounting to $488 thousand per year.

Table 9. HCAS Cost Analysis Summary

HCAS COST ANALYSIS SUMMARY IN YEAR 2000 DOLLARS				
Congestion Costs	CAT1	CAT2	CAT3	TOTAL
Loaded Fronthaul Cost Annual Increase	$187.4	$37.4	$12.4	$237.2
Empty Backhaul Cost Annual Increase	$78.0	$12.7	$5.3	$96.0
Total Congestion Cost Annual Increase	$265.4	$50.0	$17.7	$333.1
Crash Economic Impacts				
Loaded Fronthaul Cost Annual Increase	$10.7	$4.3	$1.4	$16.4
Empty Backhaul Cost Annual Increase	$6.0	$1.9	$0.8	$8.7
Total Crash Economic Cost Annual Increase	$16.7	$6.2	$2.2	$25.2
Air Pollution Costs				
Loaded Fronthaul Cost Annual Increase	$41.9	$8.4	$2.8	$53.1
Empty Backhaul Cost Annual Increase	$17.5	$2.8	$1.2	$21.5
Total Air Pollution Cost Annual Increase	$59.4	$11.2	$4.0	$74.6
Noise Costs				
Loaded Fronthaul Cost Annual Increase	$28.4	$5.7	$1.9	$35.9
Empty Backhaul Cost Annual Increase	$15.8	$2.6	$1.1	$19.4
Total Noise Cost Annual Increase	$44.2	$8.2	$2.9	$55.3
SUBTOTAL Externality Costs				
Loaded Fronthaul Cost Annual Increase	$268.5	$55.7	$18.4	$342.6
Empty Backhaul Cost Annual Increase	$117.2	$20.0	$8.4	$145.5
Total Externalities Cost Annual Increase	$385.7	$75.7	$26.8	$488.2
Pavement Maintenance Costs	CAT1	CAT2	CAT3	TOTAL
Loaded Fronthaul Cost Annual Increase	$382.1	$152.4	$50.4	$585.0
Empty Backhaul Cost Annual Increase	$10.6	$3.4	$1.4	$15.5
Total Pavement Annual Cost Increase	$392.7	$155.9	$51.9	$600.5
TOTAL Public and Externality Costs	CAT1	CAT2	CAT3	TOTAL
Loaded Fronthaul Cost Annual Increase	$650.6	$208.2	$68.9	$927.7
Empty Backhaul Cost Annual Increase	$127.8	$23.4	$9.8	$161.0
Total Cost Annual Increase	$778.4	$231.6	$78.7	$1,088.7

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