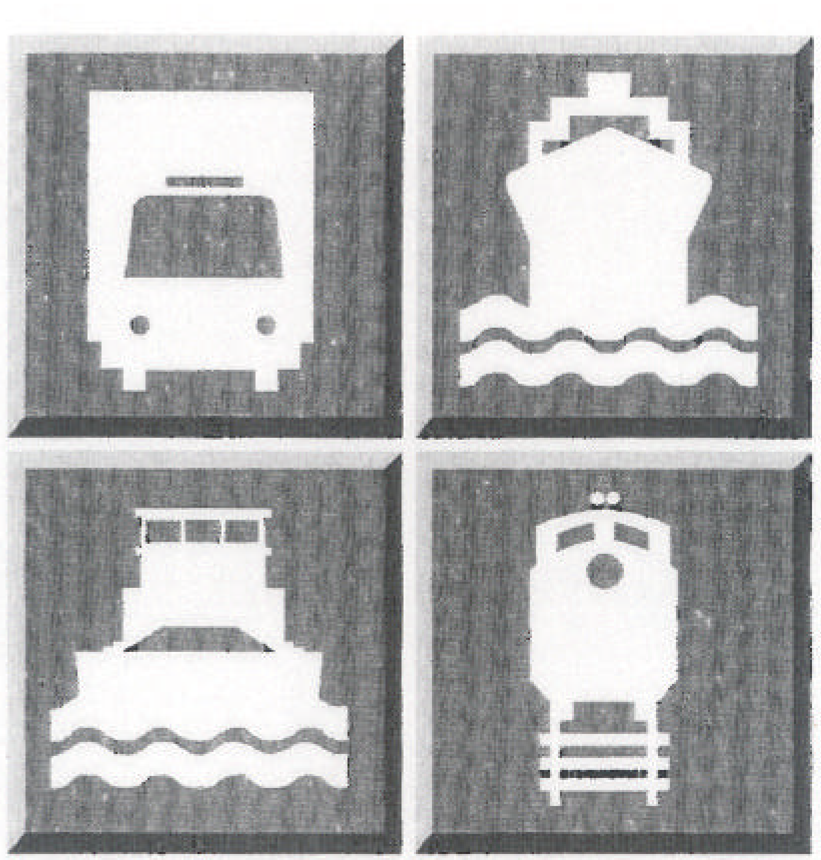
MONETARY COST OF A MODAL SHIFT



MINNESOTA DEPARTMENT OF TRANSPORTATION

PORTS AND WATERWAYS SECTION
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MONETARY COST OF A MODAL SHIFT

SUMMARY

The primary purpose of this report is to place an economic dollar value on the environmental impacts of shifting products from the waterway mode to a land mode. Since the original study, entitled “Environmental Impact of a Modal Shift”, was completed in 1991, two of the three modal shift examples discussed have taken place. This study also looks at what caused the modal shifts to take place and discusses their merits.

The study compares the fuel cost efficiency of the water mode to land modes and the air emission results of burning additional fuel to move the same product tonnage. This study does not discuss freight rate variations between the modes as the focus is on environmental impact cost.

Where comparable, waterborne transportation has an environmental cost impact of one fifth that of rail and one tenth that of truck. The study also discusses accident rates on a per ton mile basis, but no dollar figures are available for comparison purposes at this time.

BACKGROUND

Early in 1991, Bill Newstrand, of the Minnesota Department of Transportation, completed a study on what the environmental effects would be by shifting products normally transported via the waterways onto land based transportation modes. That study demonstrated the hypothetical results to the environment by shifting several waterborne freight movements to land based transportation modes.

In the original analysis, Mr. Newstrand did not try to show a monetary cost due to a modal shift, only the environmental impacts and only the impacts that he felt could be quantified based on earlier independent studies. In the case of a modal shift to railroads, he showed the increase in fuel usage, exhaust emissions, and probable accidents. In the case of a modal shift to trucks, he showed the increase in fuel usage, exhaust emissions, probable accidents, the need to dispose of a number of truck tires each year and the effect of an increase in truck traffic congestion on the roadways.

PURPOSE

In this report, as requested, we will address the monetary cost to the shippers of the products affected by the modal shift away from the water routes. The major cost is due to losing the fuel efficiency advantage of the waterways. We will also expand on the air emissions cost to the environment the additional wear and tear costs to the roadways. The air emission cost studies have not been completed by the Pollution Control Agency (PCA) but there is enough information available to give us a good indication of costs for carbon monoxide and nitrous oxide. We will also discuss situations that removed product from the waterways for both environmental reasons without weighting the impacts, and for sound environmental and economic reasons.

The Maritime Administration put it best in their statement, “The strength of a transportation system lies in its diversity, with each mode having its own system-specific advantages. The public’s good is best served by the most efficient use of transport resources, regardless of modes. This efficiency and competitiveness of different transportation systems is essential to both economic growth and productivity, and ensures that the United States will be competitive in the world market.”[1]

DIFFERENCES BETWEEN WATERWAY MODES

When we consider new legislation, there is a tendency to make one law fit the entire mode. There are decided differences in shipping products on the inland waterway system, the Great Lakes St. Lawrence Seaway system and the oceans of the world.

The **Inland Waterway System** is a shallow draft operation (minimum 9 foot deep), usually in a flowing river condition, where the towboat pushes a flotilla (tow) of barges. The Upper Mississippi River, for example, has a series of 29 locks and dams that must be negotiated by each towboat and its tow. The towboat is equipped with a steering rudder behind and two flanking rudders ahead of each propeller. This gives the towboat and its tow controlled maneuverability both ahead and astern. Most towboats have two propellers and engines. This generally eliminates the need for any additional tug assistance. Each engine varies in horsepower from 200 to 3000. Tows on the Upper Mississippi River range up to fifteen barges each. The average barge is 195 feet long, by 35 feet wide and draws 9 feet of water with a payload of 1500 tons of product. The size of a fifteen barge tow on the Upper Mississippi River is 1150 feet long by 105 feet wide including the towboat.

The Great Lakes-St. Lawrence Seaway System basically handles single ships or boats where the cargo is contained within the ship. It is a 26 foot deep system above Montreal with a series of 15 locks that will lift a maximum 78 foot wide by 730 foot long ship from sea to Lake Erie. From Lake Erie through Lakes Huron, Michigan and Superior boats have only one lock to pass through and that lock will accommodate boats up to 105 feet wide and over 1000 feet long with a 28 foot draft. Most of the boats that operate within the Upper Great Lakes are called Lakers. In addition to their main propulsion, diesel engines that range up to 10,000 horsepower, the Lakers have bow engines that assist the boat in entering and exiting locks, ports and terminals. This reduces the need for tug assistance. A 1000 foot Laker, because of its ability to load to 28 feet draft, has a cargo capacity of 68,000 tons which is three times the capacity of a fifteen barge river tow.

Ocean Shipping is unrestricted by length, width and draft, as there are no locks and dams to negotiate, only harbor depths to consider for draft. Most ocean ships will need tug assistance when coming into or exiting a port area because of there size and lack of maneuverability in confined area.

HYPOTHETICAL BECOMES REALITY

At the National Waterway Conference in Tulsa, Oklahoma, I presented an update to Mr. Newstrand's study, "Environmental Impact of a Modal Shift." Since the original study, two of the examples given in his study have become realities. The Lake Superior movement of a railcar ferry from Thunder Bay, Ontario to Duluth, Minnesota shut down. On the Mississippi River, a tank barge operation from Pine Bend, Minnesota to St. Paul, Minnesota also discontinued operations.

In 1992, the increase of the Harbor Maintenance tax on the Great Lakes was the final cost that forced the termination of the Incan Superior Ferry service. The object of the increased Harbor Maintenance Tax was for the Government to recover 100% of the cost of dredging the commercial harbors on the Great Lakes. The Harbor Maintenance tax is actually recovering 125% of the cost to maintain the navigation channel.

In 1993, the river movement that stopped operating was a direct result of the Oil Pollution Act of 1990 (OPA 90). This legislation, directed at single skinned vessels, was designed to protect the environment by making businesses more financially responsible for oil spills on the waterways. The Company concluded it could not justify the risk of an oil spill and the costs of the high limits of financial responsibility placed on it. The Company had, years earlier, invested the additional money in double skinned tank barges to protect the environment and never had a spill resulting from the use of these tank barges.

The concern regarding this legislation is that the transportation of this oil product has been shifted from a double skinned tank barge to a single skinned land mode that may not be as environmentally safe. Why are we moving liquid product transportation off the waterways, to land modes that come in closer contact with our populations? We should weigh both environmental and economic considerations before making these decisions.

Dr. Samuel E. Eastman, in his study, "Fuel Efficiency in Freight Transportation", noted that rail track beds prefer low flat terrain, as along side river valleys. Should a spill occur, the product has immediate access to the river. Should a truck transport have a spill in metropolitan area, the product has access to the storm sewers which flow to the river.

From a government perspective, we are concerned with the economics of transportation including cost, timing, care of the product, ease of arranging and tracking product movement. These are factors shippers consider when choosing a mode or combination of modes to move their product. Now, in addition to the above economics, we added the environmental concerns of air, land and water pollution, noise, and social impacts which affect our daily lives. People who have a good environmental understanding will be able to weigh and compare the use of the waterway to other modes in transporting those same products.

In our efforts to clean up the rivers and lakes and keep them clean, it may have been forgotten that goods still must get to a destination by some mode of transportation. Statistically, water transportation is more fuel efficient, has less air emission contaminants and a better safety record than land based modes. From an environmental viewpoint, moving many products by water routes, especially hazardous materials, may be the better way to transport goods. The U.S. Coast Guard, who investigates all accidents on the waterways, has no record of any single hull tank barge spills for the past six years on the Upper Mississippi River.

On the other hand, it is not correct or practical to draw the conclusion “that all goods should be moved by water because it is environmentally safer”. The waterways transport bulk products very efficiently, but it may not be the mode of choice to move all commodities. Perishables, time sensitive, and high value products may want to use other modes of transportation. Additional handling costs of a product and logistics may also negate the economic advantages of waterborne transportation.

TON/MILE EFFICIENCY OF THE WATERWAYS

Dr. Eastman further brought out the fuel efficiency of water transportation over land based modes. One gallon of fuel on the Inland Waterway will move one ton of freight 514 miles. The same gallon of fuel will move one ton of freight 202 miles by rail, 59.2 miles by truck transport, and 492 miles by pipeline.

AIR POLLUTION THROUGH EXHAUST EMISSIONS

Environmental studies show that air pollution is caused by burning diesel fuel. The following table shows the relative air emissions (in pounds) produced by the different modes each burning one gallon of fuel.

	Hydrocarbons	Carbon Monoxide	Nitrous Oxide	Total
TRUCK	.0373	.1125	.6021	.7519
RAIL	.0929	.1293	.3697	.5919
BARGE	.0462	.1026	.2718	.4206

* Source: EPA Emissions Control Lab[4].

Putting a dollar cost on the environmental impact of emissions from diesel fuel is relatively new. The Minnesota Pollution Control Agency[5], the Public Utilities Control Commission, Department of Public Safety, the Environmental Coalition, Northern States Power Co., and Triangle Economic Research have discussed the environmental costs of coal burning emissions. Carbon monoxide and nitrous oxide emissions are common to diesel fuel and coal burning, but in different amounts. The agencies are trying to put an environmental cost on the emissions in three different areas based on different population densities.

Although agreement may not have been reached, I wanted to give the reader an idea of what cost impacts are being discussed. Being that there are three population groups and a cost range in each area, I choose the middle in both population and cost range of the Minnesota Pollution Control Agency's recommendation. This is close to middle ground. Regarding carbon monoxide, the agency's environmental coverage would be $1.00 per ton. Regarding nitrous oxide the agency's environmental cost average is about $200.00 per ton.

This study applied the air emission cost estimates to both the Rail Ferry example on Lake Superior and the petroleum movement on the river.

MODAL SHIFT: RAIL FERRY ON LAKE SUPERIOR

The two freight movements, mentioned earlier, that were moved off the waterways were examples of a modal shift for questionable reasons. The first movement to stop operating was in Lake Superior between Thunder Bay, Ontario and Duluth, Minnesota. A ferry operation moved loaded railcars of wood and paper products. Increased taxes was the final cost that stopped this waterborne movement. With the stoppage of this transportation option, the railroads were forced to move via their own routes through International Falls into the United States and then on to destination, adding hundreds of miles to the trip.

The Lake Superior movement represented 375,000 tons per year. Most of this movement is now going by rail route and some by truck down Highway 61 paralleling the old water route. Assuming all is going by rail and truck, following are the environmental and economic impacts:

1) An annual increase in fuel use from 134,241 gallons by ship to 668,317 gallons by rail, or 1,228,885 gallons by truck. At approximately $.93 per gallon for fuel, this amounts to an additional fuel cost of from $534,076. by rail and $1,018,019. by truck. This adds an additional fuel cost to the shipper of $1.42 per ton by rail and $2.71 per ton by truck.

2) An annual increase in exhaust emissions of carbon monoxide and nitrous oxide go from 25 tons by water to 167 tons by rail and 439 ton by truck. The calculations appear in Appendix A. The emission cost by water transport is $3,656., by rail it is $24,751., and by truck is $74,069. There are other emissions, but we do not have a well defined dollar cost at this time.
3) An annual increase in rail traffic of 38/100 car trains, or 17,795 truck loads per year. The social impact is at 177 railroad crossing or an additional 51 daily truck loads on the roadways.
4) The disposal problem of an additional 554 truck tires. The estimated cost of disposing of a truck tire is $5.00. This totals an additional $2,770.
5) The additional dollar cost regarding wear and tear on highways due to increased truck traffic is another factor to be considered. In 1990, the Minnesota Department of Transportation completed a user cost allocation study on Minnesota highways[6]. This study determined that five axle vehicles fell 2.4 cents per mile short in covering their estimated user cost of the roadways. This does not reflect an additional cost to the shipper. It does reflect an estimated additional cost to those responsible for building and maintaining the highways. According to Mr. Newstrand's original study, the truck must travel 194 miles from Thunder Bay to Duluth and can carry a payload of 21 tons. To move the annual 375,000 tons of freight would take 17,857 trips by truck. This times 194 miles per loaded trip equals 3,464,286 miles of travel. This figure times 2.4 cents per mile allocated short fall equals $83,142. of additional wear on the highways.
6) The probability of an accident increases from .03 per year for water to .1 for rail and 5.4 for trucks. We don't have statistics as yet on the monetary value comparing modal cost of accidents, unless there was a fatality. In these examples we will assume there are no fatalities. (See Appendix D, on Page 16)

The annual increased economic cost of this single product movement by rail is estimated at $517,878. and by truck at 41,174,318. (See Appendix A, on Page 13)

MODAL SHIFT: PETROLEUM MOVEMENT ON THE RIVER

The river movement represented an average of 814,509 tons of petroleum products moved annually from the Pine Bend Refinery to St. Paul. Being that there is no rail service from the refinery to the oil terminal, the only mode capable to move this product is by truck. The following will be the economic and environmental impacts:

1) An annual increase in fuel use of 159,594 gallons @ $.93 per gallon. Fuel costs would escalate from $18,002. by waterways transport to $166,424. by truck.
2) An exhaust emission increase from 3.6 tons to 64 tons annually by truck. Carbon monoxide and nitrous oxide emissions amount to $527. by water transport and $10,795. by truck.
3) The need to dispose of an additional 41 used truck tires each year. The estimated cost to dispose of truck tires is $5.00. In this situation, the cost would add another $205.
4) The social impact of an additional 312 truck trips per day, amounting to 31 truck trips per hour during the working day. A major portion of the truck route is through populated areas.
5) Using the same highway user cost allocation study as in the above example, to move 814,509 tons of petroleum will take 40,725 loaded trips of 13.2 miles moving 20 tons per trip. This will amount to an additional highway cost of $12,884. in additional wear. Our study did not incorporate an empty return trip on any of the examples. If there were no options to avoid an empty backhaul, then the cost differential would be higher.
6) An increase in probable accidents from .12 a year to .48. (See Appendix D, on Page 16)

The economic or monetary cost increase of moving this product by truck is $171,779. per year.
(See Appendix B, on Page 14).

We hesitated to develop the above additional costs of moving this petroleum product by truck because it was found that one Oil Terminal in this scenario shut its operation down because it was dependent on oil from the water route. The terminal employed 32 people with an estimated annual payroll of $1,600,000. This resulted in the petroleum being transported to other distribution points.

It was found that some of this petroleum is now delivered by pipeline to other distribution points. Trucking moves the balance of the petroleum from the refinery. I could not estimate the additional fuel cost differentials without getting into great detail and using several scenarios.

It is interesting to see the economic results of a law that was intended to make water transportation more financially responsible. The law, OPA 90 was the result of an ocean tanker spill in Alaska, having nothing to do with the shallow draft inland river transportation industry, but having a significant impact on it nevertheless.

RIVER AGGREGATE MOVEMENT

(Still in Operation)

A third example of a modal shift was discussed by Mr. Newstrand, and is still in operation on the River. The J. L. Shiely Co. mines and gravel on Grey Cloud Island next to the river and transports the product by barge directly to several distribution and blending yards in the Twin Cities.

Here again, if the river movement were discontinued, trucking of the product would be the only alternative. The following would be the economic and environmental impacts:

1) An annual increase in fuel use of 619,766 gallons @ .93 per gallon. Fuel costs would increase from $65,317. by waterway transportation to $641,699. by truck.
2) An exhaust emission increase from 13 tons to 247 tons annually. Carbon monoxide and nitrous oxide cost amount to $1,904. by water transport to $41,584. by truck.
3) The need to dispose of 1108 truck tires each year, at $5.00 each. The total is $5,540.
4) The social impact of an additional 759 five axle trailers each day on traffic lanes that already handle 1125 trucks.

5) Using the same highway user cost allocation study as in the previous examples, to move the 2 million tons of aggregate will add 2,070,000 truck miles to metro roads. At 2.4 cents per mile, this will add $41,400. in additional road wear.
6) An increase in probable accidents from .06 to 2.3. (See Appendix D, on Page 16)

The annual increase to move this aggregate by truck is $663,012. (See Appendix C, on Page 15)

MODAL SHIFT BASED ON SOUND REASONS

Until 1986, Northern States Power Co. received its western coal needs for two of its large coal plants in the Twin Cities area by a combination of rail and barge. The approximate rail mileage from the western coal source in Montana to the Twin Cities is 850 miles. The coal was then transferred to barges at several water terminals, based on competitive bids, and delivered to two or three Northern States Power Co. sites.

Until 1986, the power plant sites did not have trackage to receive unit train loads. By 1986 trackage was installed so that NSP could receive unit train loads of coal directly to their unloading sites, thus eliminating the transfer to barges. This was an economic decision that did not impact the environment. In fact, NSP did not have to carry as large an inventory of coal through the winter when the barging operation was suspended because of the weather. (Phone interview with Robert Kermes of Northern States Power Co.)[7]

Further down river in Wisconsin, Dairyland Power Co. also received its western coal supply via train to the Twin Cities and then by barge to their Alma and Genoa, Wisconsin power plants. Also in the 1980's a coal transfer terminal was developed in East Dubuque, Illinois where this coal supply could be transferred to barge. This saved the railroads over one hundred miles in their trip from Wyoming to the river as East Dubuque is 936 miles from the western coal source. East Dubuque is about the same distance to Genoa and Alma as St. Paul is via the river route. These are examples of a modal shift for sound economic and environmental reasons. (Interview with Doug Peterson of Dairyland Power Cooperative)[8].

CONCLUSION

It is not the intent of this study to promote one mode of transportation over another. We must use each mode to its fullest advantage economically and environmentally so the United States can compete well in the world market today and into the future. We are blessed with efficient land, water and air modes of transportation to move our freight. The shipper has a choice of one or a combination of modes depending on the nature of his product, where it is going and how fast it must get there. Many competing countries do not have this advantage of a multi modal system. We must use ours wisely.

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APPENDIX A
RAIL FERRY ON LAKE SUPERIOR

Mode	Water	Cost	Rail	Cost	Truck	Cost
Tons	375,000		375,000		375,000	
Av. Miles	184		360		194	
Ton Miles	69,000,000		135,000,000		72,750,000	
Fuel @ .93/gal.	134,241	$124,844	668,317	$621,535	$1,228,885	$1,142,863
Emissions						
Carbon Monoxide	6.9 tons @ $1.00	$7.	43 tons	$43.	69 tons	$69.
Nitrous Oxide	1 & 2 tons @ $200.	$3,649.	124 tons	$24,800..	370 tons	$74,000.
Tires @ $5.00/ea					554	$2,770
Road wear miles @ $.024/mi.					3,464,286	$83,142
Accidents	.02		.16			5.4
Tons		**$128,500**		**$646,378**		**$1,302,818**
Cost/Ton		**$.34**		**$1.72**		**$3.47**
Cost/Ton mile		$.0019		$.0048		$.0179

1) There are still some emissions that we have not been able to put a cost factor on.
2) We have not been able to put a dollar cost on “accidents” for this study.
3) We did not calculate any back haul miles for this study, only the one way loaded tonnage.

APPENDIX B
PETROLEUM PRODUCTS MOVEMENT IN POOL 2

Mode	Water	Cost	Truck	Cost
Tons	814,509		814,509	
Av. Miles	122		13.2	
Ton Miles	9,949,681		10,737,096	
Fuel @ .93/gal.	19,357	$18,002.	178,951	$166,424.
Emissions				
Carbon Monoxide	.99 tons @ $1.00/ton	$1.	10 tons	$10.
Nitrous Oxide	2.63 tons @ $200./ton	$526.	53.87 tons	$10,785
Tires @ $5.00/ea			4	$205.
Road wear miles @ $.024/mi.			536,854	$12,884
Accidents	.0155		.48	
Tons		**$18,529.**		**$190,308.**
Cost/Ton		**$.0227**		**$.2336**
Cost/Ton mile		$.0019		$.0177

We did not use a rail comparison because there are no access tracks between the Refinery and the terminals.

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APPENDIX C
AGGREGATE MOVEMENTS IN RIVER

Mode	Water	Cost	Truck	Cost
Tons	2,000,000		2,000,000	
Av. Miles	18.05		20.7	
Ton Miles	36,100,000		41,400,000	
Fuel @ .93/gal.	70,233	$65,317.	689,999	$641,699.00
Emissions				
Carbon Monoxide	.3.6 tons @ $1.00/ton	$3.60.	39 tons	$39.
Nitrous Oxide	9.5 tons @ $200./ton	$1,900.	208 tons	$41,545.00
Tires @ $5.00/ea			1108	$5,540.00
Road wear miles @ $.024/mi.			2,070,000	$41,400.00
Accidents	0.6		2.3	
Tons		**$67,221.**		**$730,233.**
Cost/Ton		**$.0336**		**$.365**
Cost/Ton mile		$.0019		$.0176

We again did not use a rail comparison because there are no access tracks between the Refinery and the terminals.

1) There are still some emissions that we have not been able to put a cost factor on.
2) We have not been able to put a dollar cost on “accidents” for this study.
3) We did not calculate any back haul miles for this study, only the one way loaded tonnage.

APPENDIX D
OTHER MODAL IMPACT COMPARISON FACTORS
ACCIDENT RATES PER MILES TRAVELED BY RAIL & TRUCK AND PER TON MILES BY TOWBOAT AND GREAT LAKES SHIP:

Rail	**1/51,310 miles**
Truck	**76.6/100,000,000 miles**
Barge	**1/600,000,000 ton miles**
Great Lakes	**1/2,590,000,000 ton miles**

Source: Minn. Dept. of Public Safety, Transportation Research Board, U.S. Coast Guard, and Lake Carriers Association.

The problem with the above table is that we are comparing ton miles of two water modes to miles traveled by two land modes. In the following table, I have attempted to compare all modes on a ton mile basis. I have made the following assumptions to draw the comparisons. Each mode has an approximate maximum load capacity:

Rail: 100 cars times 100 times tons per car	=	10,000 tons ÷ 2 = 5,000 tons*
Truck:	=	25 tons ÷ 2 = 1.5 tons*
Barge: 30 barges times 1500 times tons per barge	=	45,000 tons ÷ 2 = 22,500 tons*
Great Lakes:	=	68,000 tons ÷ 2 = 34,000 tons*

* The modes don't run at full capacity all the time and many times run empty or with empties. For demonstration purposes I have chosen the average trip to represent 50 percent of total capacity.

In the case of rail, multiply the average trip tonnage by the miles traveled per accident to get ton miles per accident. For truck, multiply 12.5 tons times 100 million miles divided by 76.6 which is the number of accidents in 100 million miles. This results in the number of ton miles traveled per accident. The results are as follows:

Great Lakes:	**=**	**1 accident every 2,590,000,000 ton miles**.
Barge:	**=**	**1 accident every 600,000,000 ton miles**.
Rail:	**=**	**1 accident every 256,550,000 ton miles**.
Truck:	**=**	**1 accident every 16,318,538 ton miles**.

REFERENCES

1) Page 3, Environmental Advantages of Inland Barge Transportation, Maritime Administration, August 1994.

2) Page 4, Environmental Impact of a Modal Shift, Minn. Dept. of Transportation, 1991.

3) Page 5, Fuel Efficiencies in Freight Transportation, Dr. Samuel Eastman, 1980.

4) Page 7, Compilation of Air Pollutant Factors, EPA, Emissions Control Lab, 1992.

5) Page 7, Minn. Pollution control Agency, Robert J. McCarron, 1996.

6) Page 8, Highway Cost Allocation Study, Cambridge Systematics, Inc., 1990.

7) Page 12, Northern States Power, Robert Kermes, 1996.

8) Page 12, Dairyland Power Cooperative, Douglas Peterson, 1996.