ENVIRONMENTAL IMPACTS OF A MODAL SHIFT





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PREFACE

Environmental review is a vital step in the deliberations on the development or improvement of any type of project in the nation's water, wetlands and floodplain areas. It is necessary for the continued assurance of the quality of such environments. The majority of the analyses conducted in those areas generally concentrates on the possible impacts in the immediate area. And, those analyses are further concentrated by direction only toward biological functions. That is considered most important because of the delicate natural balances that exist.

For certain project proposals, analysis should be expanded to look at additional elements of the environment and to probable impacts beyond the immediate area. This is especially true for projects in the more developed and populated urban commercial/industrial areas. The extension of the analyses should include not only recognition of biological needs in the area but review of other types of environmental impacts in and beyond the area.

The analysis expansion should be in the direction of a "*no build*" scenario which is standard for such things as airport, highway and other transportation facility construction or expansion. This type of review is especially important for water transportation projects. An environmental analysis of such a project must look at the environmental impacts which will occur, in addition to the biological ones, if the transportation needs of the project are met by other forms of transportation. Most specifically, what will be the increases in such things as fuel use, exhaust emissions, and probable accidents as well as increased traffic congestion if vessels are replaced by trucks or rail cars. Economic considerations, though important, are not as vital to this type of analysis. To demonstrate the types and levels of impacts expanded environmental review would assess, this study reviewed four commodity movements on Minnesota's river and Great Lakes transportation system. The analysis process involved the development of a "*no build*" scenarios by the theoretic shifting of those cargoes from water to land transportation modes. What was determined in the analysis was that a shift to trucks from vessels would cause:

- *a 826% increase in fuel use annually,*
- a 709% increase in exhaust emissions annually
- a 5,967 increase in probable accidents each year,
- the need to annually dispose of 2,746 used truck tires, and
- an additional truck traffic load of 1,333 heavy vehicles each day in the study corridors.

In the two corridors where rail is a possible transportation alternative the annual changes with a vessel to rail shift are:

• *fuel use grows by 331%*

- *emissions jump by 470%*
- probable accidents grow by 290%

Clearly, those major levels of change show great support for including in the environmental study process the analysis of the damage that can be done to the environment by using a land transportation system to replace a viable water system.

INTRODUCTION

Concern for the environmental impacts of any activity on or in Minnesota's waterways has generated a great number of studies and will likely continue to cause study. Commercial navigation is often the focal point of these analyses. Navigation has, in the majority of the studies, been viewed as a major contributor to environmental degradation of the waterways as a precondition to the study.

Historically, environmental assessments have confined their transportation related reviews to the possible impacts from operations of vessels and shore side support activities. The possible environmental impacts of not developing a waterways projects or not maintaining or improving an existing operation are never included in the environmental analysis. Continued concern about the impacts on commercial navigation from such an approach caused the Minnesota Department of Transportation (Mn/DOT) to undertake this study. This analysis will examine the type and extent of environmental impacts which could result from a shift waterborne carriage of certain commodities to other modes of transportation.

Only a few of the many waterborne freight movements from the state's river and Great Lakes terminals are on long term schedules with consistent travel patterns which allow to impact analysis. Specifically, there are three aggregate, three petroleum product and four coal movements on the river and one paper-wood movement on Lake Superior which meet the criteria. The river movements average 3,250,000 tons each year. The Lake Superior movement accounts for 375,000 tons each year. In total, these freight volumes account for about 5% of the state's total waterborne freight movements which average approximately 73,000,000 tons annually. The 3.25 million tons of river carriage account for approximately 20% of the states annual riverine traffic.

It is suggested that the methodology used in this analysis become an integral part of the evaluation process for environmental studies of future development proposals.

METHODOLOGY

There is a demonstrated need for the movement of the study's commodities, therefore total stoppage of the movements was not considered. What is evaluated are the impacts associated with the shift of the cargo from the water to either the rail or highway modes. An analysis of the impacts of a cargo shift from vessel to truck was made for each movement. An analysis of cargo shifts from vessels to truck and from vessel to rail was made for those movements where a rail alternative exists or the construction of a rail link is considered feasible. Table 1 shows the different modal factors used in the analysis.

Fuel Use Ton Miles/Gallon		Emissions	Accident
		Pounds/Gallon	Rate/Incidents
Truck	60	.31	76.6/100,000,000 miles
Rail	204	.69	1/51,310 miles
River	514	.37	1/600,000,000 miles
Great Lake	s 607	.37	1/2,590,000,000 miles

TABLE 1 – Modal Impact Factors

Water travel distances were calculated based on navigation charts with support through interviews with navigation industry representatives. Highway distances were taken from Mn/DOT records, or in the case of urban movements from field measurement. Highway trip lengths were measured on either the shortest, most direct route or the most time efficient route which did not have prohibiting load restrictions. Rail distances were taken from Mn/DOT records with support from the involved railroads. Rail grade crossing numbers were obtained in the same manner.

Modal Fuel efficiencies were taken from a study done by Professor S.E. Eastman.¹ It is assumed that modal fuel use improvements for each mode have advanced at the same relative pace since that study was made. Fuel efficiencies used here represent industry-wide fuel use and commodity carriage. It is recognized that certain dedicated rail movements will generate as much as 800 ton miles to the gallon; as a balance, Lower Mississippi water movements will reach 1,200 ton miles per gallon. Great Lakes fuel efficiencies at 607 ton miles to the gallon reflect the effectiveness of the nation's deep draft fleet.

Modal emission levels were taken from EPA publications and independent studies made by Mn/DOT's Air Quality Office. That office also reviewed the relationship of emission levels with the different engine sizes for each mode. For study purposes emission levels were taken from the EPA documents "Compilation of Air Pollutant Emission Factors, Second Edition" and "Mobile Four".²

The only emissions considered in this study are exhaust emissions. Since it is impossible to determine the size or duration of the queues of autos at rail crossings and signalized intersections caused by additional heavy train and truck movements, the amount of non exhaust emissions from those autos cannot be determined.

¹ EASTMAN, SAMUEL, EWER, "Fuel Efficiencies in Freight Transportation. June, 1980.

² "Compilation of Air Pollutant Factors", Volume 2, USEPA, 1973, "Mobile Four", USEPA 1989.

Safety data for the modes came from several sources.

Highway accident rates were taken from the Transportation Research Board's study on twin trailer trucks.³ The numbers used represent a weighting of their urban-rural, highway-interstate figures.

In the five year period 1986 through 1990, United States Coast Guard records show that collisions involving towboats in the St. Paul Marine Safety Detachment's area of control were:⁴

- *3 collisions between towboats,*
- 5 collisions between towboats, and pleasure craft,
 - 21 collisions by towboats with fixed objects.

There was one death and no injuries resulting from the 29 accidents. The death resulted from a pleasure boat running into a barge-tow. The fixed object collisions involved towboat contacts with bridge piers, sheer fences, gorge ice, the channel bottom, or lock walls. Each of these incidents meet reportability requirements as defined by Federal Law 46 CFR4.05-1. None of the towboats used in the scheduled movements in this study were involved in the 29 incidents.

In those five years, the towing industry annually averaged 3,478,972,400 ton miles of carriage in the area. Ton miles divided by accidents equals approximately 1 accident per 600,00,000 ton miles.

The Lake Carriers Association records on U.S. Great Lakes fleet vessels show that an accident occurs every 2.6 trillion ton miles using the same U.S. Coast Guard reporting conditions as river traffic.⁵ The vessel involved in the study's movement between Thunder Bay and Duluth has not had a reportable accident in its 26 years of operation. The probability of it ever being involved in an accident is small, however, an accident probability factor has been incorporated in this study.

The Minnesota Department of Public Safety records for the past decade indicate that there is one highway vehicle-train collision for every 51,310 miles of train travel.⁶

³ TRANSPORTATION RESEARCH BOARD, NATIONAL RESEARCH COUNCIL, *"Special Report, #211,"* Table 4.5.

⁴ LCDR PAXTON, DAVID, U.S. Coast Guard – Marine Safety Detachment, St. Paul, Minnesota.

⁵ Personal Interviews with Captain Ray Skelton, Seaway Port Authority of Duluth, Minnesota and Mr. George Ryan, President, Lake Carriers Association, Cleveland, Ohio October, 1990.

⁶ MINNESOTA DEPARTMENT OF PUBLIC SAFETY, "1980 Motor Vehicle/Train Crashes", Table 2, June 1990.

That is substantially better than the national average of one accident per 41,000 miles of train travel as reported by the American Association of Railroads. Minnesota Department of Transportation records show that the annual average number of accidents is about 130, with over 50% reporting property damage only. This study will use the Minnesota Department of Public Safety's travel-collision ratio.

Tire use was determined through interviews with industry representatives. There is a significant difference for tire life expectancy between aggregate movements and over the road commodity carriage. In aggregate hauling, truck tires last an average of 40,000 miles with only 40% of the carcasses recappable and no second recapping.⁷ In over-the-road traffic, tires have a life expectancy of 100,000 miles and an 80% recap rate plus a second recapping of 40% of the initial recaps.⁸ This results in average tire lives of 56,000 miles for aggregate hauling and 225,000 miles for highway movements.

ANALYSIS OF CARGO MOVEMENTS

AGGREGATE MOVEMENTS POOLS 2 AND 1

The J.L. Shiely Company of St. Paul annually moves in excess of 2 million tons of aggregate from its mines at River Mile (RM) 825.0L and its distribution points at RM837.2L, RM843.3R, and RM 853.4R. There is no existing rail connection between the mines and the distribution yards. Topographic, environmental, regulatory, and economic influences prohibit construction of rail connections. Therefore, only a shift from barge to truck movements was considered for this segment of the study. Appendix A gives full details of the aggregate movement analysis. Major findings are that a shift from barge movement to trucks would annually cause:

- an increase in fuel use from 72,300 gallons to 690,000 gallons,
- an increase in exhaust emission from 13.4 tons to 106.9 tons
- an increase in accident probability from .06 to 2.45, and
- *the need to dispose of 1,108 used truck tires.*

⁷ Personal Interviews with Mr. Pat Gannaway, Vice President, J. L. Shiely Company, St. Paul, Minnesota. Fall, 1990.

⁸ Personal Interviews with Mr. Robert Rynda, Kampa Tire Company, St. Paul, Minnesota.



A major impact of the modal shift would be a near doubling of the heavy truck traffic through the City of Newport, Minnesota. As shown on Map 1, access to the Grey Cloud mines is limited. All truck traffic would enter Trunk Highway 61 at the main signalized intersection, shown in Figure 1, of the city's business district. Mn/DOT traffic records show that at that intersection the current average daily traffic load consists of 35,500 autos and 2,450 commercial vehicles including 1,125 heavy semi trailer trucks. Peak hour traffic loads include 115 heavy semi trailer trucks. The analysis shows that the modal shift would add 759 six axle semi trailer trucks each day to the traffic load and 69 during the peak hours. This section of highway is already close to capacity.



Figure 1 Off Peak Traffic TH 61 in Newport, Minnesota

Based on an 11 hour work day and a 250 work day year, the mine would load 34.5 trucks per hour. Existing operational loading rates are 1.5 minutes per truck. Local ordinances prohibit truck movements at certain hours which limited the working day to 11 hours maximum. Even if the work year is expanded to 300 days the average added hourly truck movement through the area would be 57 heavy vehicles.

PETROLEUM PRODUCT MOVEMENT IN POOL 2

Movements or refined petroleum products in Pool 2 occur throughout the year. Tank barges are moved between the Pine Bend refinery at RM824.2R to several distribution terminals. Map 2 shows the locations. Over the last five years these movements have annually averaged 278 loaded and 278 empty barge trips with an annual average volume of 232,796,400 gallons of product or 814,509 tons.



The only feasible modal transfer is from barges to truck. Rail distances between the points are too short and the necessary interchanges too many to make rail an acceptable substitute. Pipelines could not be built on the required routes because of local, state, and national governmental safety and environmental regulations.

Appendix B gives details on the full impact of modal shift from barge to truck. Major findings are that such a shift would cause:

- an annual increase in fuel consumption from 19,400 gallons to 178,900 gallons,
- an exhaust emission increase from 3.6 tons to 27.7 tons each year,
- an increase in probable accidents from .02 a year to .48 a year, and
- *the need to dispose of 41 used truck tires each year.*

In this shift, increased truck traffic also creates a significant local traffic impact. With a cargo shift from barges to trucks, there would be an increase of 156 loaded and 156 empty tanker trucks moving through the area each working day, for a total additional truck traffic load of 312 five axle semis. Assuming a standard 10-hour working day for such movements, it would mean 31 additional tank trucks each hour. Major portions of the areas which the trucks would traverse are residential in character.

COAL MOVEMENTS FROM ST. PAUL

Power plants at Alma, Genoa, and Cassville, Wisconsin and Lansing, Iowa receive regular barge shipments of coal from St. Paul. Map 3 show the locations of the loading terminal and the 4 cities. These cargo movements average about three quarters of a million tons each year.

In this analysis both rail and highway modal alternatives were considered; although, rail connections do no currently exist at these plants. Steep hills and wetland use restrictions would make it difficult, although not impossible, to build rail unloading facilities at the four power plant sites. At Alma, it would be possible to build an extensive overland conveyor system to transfer coal between the two generating plants. Rail movements to these sites is considered in this analysis in spite of these difficulties.

By the same token, movement of these huge quantities of coal by truck would be extremely difficult. Analysis of a shift to trucks was included to demonstrate the impacts that would occur should such a shift be made.

The most probable transportation change would be to north bound barges from the lower part of the Upper Mississippi River, which would have a significant economic impact on the Twin Cities community.



Appendix C gives full details of this analysis of the study. Major impacts of modal shifts to truck for these coal movements include:

- an increase in annual fuel use from 249,900 gallons to 2,136,850 gallons,
- an annual increase in exhaust emission from 46.2 tons to 331.2 tons,
- an increase of truck traffic in the corridor of 35,407 trucks annually,
- an increase in the probability of an accident from .2 per year to 10.0 per year,
- the need to dispose of 1,043 used truck tires each year.

With a modal shift to rail using 100 car (100 tons each) trains, the major impact would include:

- an increase in annual fuel use from 249,900 gallons to 541,400 gallons,
- an annual increase in exhaust emission from 46.2 tons to 186.9 tons,
- an annual increase of train traffic in the corridor of 75 trains of 100 cars each,
- the involvement of auto traffic with those 75 trains at 193 grade crossings, an increase in probable accidents from .2 to .48 each year.

PAPER-WOOD PRODUCT, LAKE SUPERIOR MOVEMENTS FROM THUNDER BAY, ONTARIO TO DULUTH-SUPERIOR

One consistent Minnesota Great Lakes ship movement is dedicated to the carriage of wood and paper produces between the ports of Thunder Bay, Ontario and Duluth-Superior. The majority of the cargo carried in these shipments is not ultimately destined for the Duluth-Superior area but for other points in the Midwest. Since the final destinations of the cargoes are mainly to the south and west of Duluth, movement on corridors other than between Thunder Bay and Duluth-Superior would be unlikely. It is assumed that all products carried on the vessel would remain captive to the corridor.

The average volume of this movement is 375,900 tons of cargo. Appendix D gives full details of the impacts of a modal shift from ship to rail or highway for this carriage. Major impacts of a modal shift to rail include:

- an annual increase in fuel use from 113,674 gallons to 661,765 gallons,
- annual increases in exhaust emission from 21.0 tons to 129.0 tons,
- \cdot an annual increase in rail traffic of 38 100 car unit trains,
- auto involvement with those trains at 177 grade crossings,
- the probability of an accident rate increase from .02 per year to .16 per year.



Paper / Wood Products from Thunder Bay to Duluth



Rail traffic for this movement must follow a circuitous 360 mile route as shown on Map 4. There are no rail facilities paralleling the Lake Superior shoreline between the two ports. Construction of such a line would be prohibitively expensive both in dollars and in environmental impacts.

The major impacts of a modal shift to trucks, for this movement, include:

- an increase in annual fuel use from 113,764 gallons to 1,212,500 gallons,
- an annual increase in exhaust emission from 21.0 tons to 188.9 tons,
- *an increase in the accident probability from .02 per year to 5.4 per year, and,*
- the need to dispose of 554 used truck tires each year.

The most significant impact of a transfer from vessels to trucks on this movement would be the increased truck traffic on TH 61 along the North Shore. During the summer tourist season this highly traveled road already has a serious conflict between auto and truck traffic. In the summer, traffic on that stretch of a scenic highway grows, from an average off season daily level of 2,800 to 5,500, with a constant heavy truck traffic level of 402, of which 223 are 5 axle semis. Adding 35,714 truck trips each year, or 120 per day of a 300 work day year, would be a substantial increase. That truck traffic increase would occur along with the continuing growth in auto traffic, further exacerbating the auto-truck conflict.

TOTAL IMPACTS OF MODAL SHIFTS

The shift of all cargo in the study's movements from vessels to trucks, would result in:

- an annual increase in fuel use of 3,763,000 gallons,
- an increase in exhaust emission of 570.5 tons each year
- the need to dispose of 2,746 used truck tires each year, and
- an annual increase in probable accidents of 18.

For those two movements where rail is a viable alternative, the cumulative impacts would be:

- an annual increase in fuel use of 839,600 gallons,
- annual increases in exhaust emissions of 248.9 tons,
- an increase of 75-100 car unit trains at 193 highway crossings and 38 more at 177 crossings.
- an annual increase in probable accidents from .22 to .64.

These environmental impacts would be accompanied by an increase in transportation costs to the shippers as well as increased highway maintenance costs. Increases in costs for highway maintenance would be partially offset by increased fuel taxes.

CONCLUSION

It was the intention of this analysis to demonstrate some of the potential environmental costs of a modal shift from water and to further demonstrate the need for the inclusion of a similar types of analysis in environmental studies of water project proposals.

To the support that, this study's results show that a modal shift in four transportation corridors would result in annual increases in:

- Fuel use of 826%, from 455,274 to 4,218,250 gallons,
- Exhaust emission of 709%, from 80.9 tons to 654.8 tons,
- Probable accidents of 5,967%, from .3 to 18.2, and
- Daily truck, traffic increases of 1,333 vehicles in the corridors, and
- The need to dispose of 2,746 truck tires each year.

Two of the movements could possibly have rail service. If it were available there would still be increases in fuel use of 331.%, in exhaust emissions of 470%, and in accidents of 290% each year.

The commodity volumes studied here represent only a fraction of the total waterborne commerce in Minnesota. A similar analysis of all commercial navigation in the State would further demonstrate the environmental compatibility of this transportation mode. It would add even more support for a similar review for all new water transportation projects.

Since a proposal for a water transportation project demonstrates a need for transportation service, an environmental review of the project should not be considered complete without the inclusion of an analysis of the impacts of not building the project. Such an analysis, using the methods in this study or similar techniques, should be part of all future environmental assessments of water transportation projects.

MINNESOTA DEPARTMENT OF TRANSPORTATION PORTS AND WATERWAYS SECTION M. WILLIAM NEWSTRAND, DIRECTOR JANUARY 1991

APPENDIX A

AGGREGATE MOVEMENTS, MINES TO DISTRIBUTION YARDS

RIVER

<u>YARD</u>	<u>TONS</u>	<u>MILES</u>	TON MILES (TM)	Gallons Fuel Use (G) (TM ÷ 514)	Emissions (Tons) (Gx, 37 ÷ 2000)	Accidents (TM ÷ 600,000,000)
А	1,000,000	11.8	11,800,000	22,958	4.2	.02
В	500,000	17.7	8,850,900	18,385	3.4	.01
С	500,000	30.9	15,450,000	30,958	5.7	.03

TRUCK

<u>YARD</u>	<u>TONS</u>	MILES	TON MILES (TM)	Gallons Fuel Use (G) (TM ÷ 60)	Emissions Tons (Gx, 31 ÷ 2000)	(Truck Miles tm) (Miles x 2)	Tire Use (m x 20 ÷ 56,000)	Accidents tm (100,000,000 x 76.6
А	1,000,000	15.7	15,700,000	261,666	40.6	1,495,237	534	1.1
В	500,000	18.9	9.450,000	157,500	24.4	590,625	211	.4
С	500,000	32.5	16,250,000	270,833	41.9	1,015,625	363	.8

<u>APPENDIX B</u> <u>PETROLEUM PRODUCTS MOVEMENTS IN POOL</u> (Refinery to Distribution Terminals A, B, C and Between Terminals D)

RIVER

				Fuel Use (G)	Emission (Tons)	Accidents
<u>TERMINAL</u>	TONS	MILES	TON MILES (TM)	$(TM \div 514) = G$	<u>(G X .37 ÷ 2000)</u>	<u>(TM ÷ 600,000,000)</u>
А	396,992	8.0	3,175,935	6,179	1.1	.005
В	265,639	16.8	4,462,735	8,682	1.6	.007
С	110,830	18.0	1,994,940	3,881	.7	.003
D	41,048	7.7*	316,070	615	.1	.0005

TRUCK

<u>TERMINAL</u>	<u>TONS</u>	<u>MILES</u>	TON MILES (TM)	FUEL USE	EMISSIONS	TRUCK MILES TM	Tire Use (tm x 18 ÷ 225,000)	ACCIDENTS
А	396,992	10.2	4,049,319	67,489	10.5	192,821	15	.2
В	265,639	17.3	4,595,555	71,593	11.9	218,845	18	.2
С	110,830	15.1	1,673,533	27,892	4.3	79,698	6	.07
D	41,048	10.2*	418,690	6,978	1.1	19,828	2	.01

* Average of trips/distances

<u>APPENDIX C</u> COAL MOVEMENTS FROM POOL 2

RIVER

POWER PLANT SITE	<u>TONS</u>	<u>MILES</u>	TON MILES (TM)	FUEL USE	EMISSIONS	ACCIDENTS
Alma, Wisconsin	113,258	84.5	970,030	1,862	.3	.002
Genoa, Wisconsin	323,739	157.6	51,021,266	99,263	18.4	.08
Lansing, Iowa	58,544	176.0	10,303,744	20,046	3.7	.02
Cassville, Wisconsin	250,000	230.2	57,550,000	111,965	20.7	.1

TRUCK

							TIRE USE	
<u>SITE</u>	TONS	MILES	TON MILES (TM)	FUEL USE	EMISSION	TRUCK MILES (tm)	<u>(tm x 18 ÷ 225,000)</u>	ACCIDENTS
Alma	113,258	88.3	1,000,068	16,668	2.6	952,446	76	.7
Genoa	323,739	166.0	53,740,674	895,678	138.8	5,118,112	409	3.8
Lansing	58,544	168.0	895,678	207,831	32.2	1,147,035	92	1.1
Cassville	250,000	244.0	61,000,000	1,016,667	157.6	5,809,523	465	4.4

RAIL

<u>SITE</u>	<u>TONS</u>	<u>MILES</u>	TON MILES	FUEL USE	EMISSIONS	TRAIN <u>MILES (rm)</u>	Accidents (rm ÷ 51,310)
Alma	113,258	82.0	928,716	4,553	1.6	2,022	.04
Genona	323,739	153.0	49,532,067	242,804	83.8	10,220	.2
Lansing	58,544	168.0	9,835,392	48,213	16.6	2,318	.04
Cassville	250,000	236.0	59,000,000	289,216	99.8	11,800	.2

APPENDIX D

WOOD-PAPER PRODUCT MOVEMENTS Thunder Bay to Duluth-Superior

SHIP							
	<u>TONS</u> 357,000	<u>MILES</u> 184	<u>TON MILES</u> 69,000,000	<u>FUEL USE</u> 113,674	EMISSIONS 21.0	<u>ACC</u>	<u>IDENTS</u> .03
TRUC	K						
TONS	MILES	TON MILES	FUEL USE	EMISSIONS	TRUCK MILES	<u>TIRE USE</u>	ACCIDENTS
375,00	0 194	72,750,000	1,212,000	188.9	6,928,571	554	5.4
RAIL							
	<u>TONS</u> 357,000	<u>MILES</u> <u>TON</u> 360 135.0	<u>MILES</u> <u>FUEL</u> 00.000 661.	<u>USE</u> <u>EMI</u> 765 129	SSIONS TRAIN	<u>1 MILES</u> 768	<u>ACCIDENTS</u> .1