Environmental Impacts of a Modal Shift

M. WILLIAM NEWSTRAND

The need for a no-build alternative in the environmental analysis of water transportation projects and the environmental compatibility of water transportation are demonstrated. To make the demonstration, cargo from four regularly scheduled vessel movements was theoretically transferred to the highway and rail modes. Included in the cargoes studied were coal, aggregate, petroleum products, and wood paper products. All four movements had highway carriage as a feasible alternative, and two had rail service available. For the four movements, in total, the transfer of cargo from vessels to trucks would result in annual increases of 3,774,328 gal of fuel (an 825 percent increase), 573.9 tons of exhaust emissions (a 709 percent increase), 17.9 probable accidents (a 5,812 percent increase), and the need to dispose of 2,746 used truck tires. In addition, such a modal transfer would result in an additional 1,333 large semitrailer trucks in the travel corridors each day. For the two movements that had possible rail service, the annual impacts of a modal shift from water to rail are an increase in fuel use of 899,741 gal (a rise of 259 percent), an increase in exhaust emission of 265.7 tons (up 408 percent), and an increase in probable accidents of 0.35 (a 150 percent increase). In addition, a modal shift of the cargo from vessels to trains would mean the involvement of an additional 75 trains of 100 cars each at 193 highway crossings and 38 at 177 road crossings.

Concern for the environmental impacts of any activity on or in Minnesota's waterways has generated a great number of studies and will probably continue to cause study. Commercial navigation is often the focus of these analyses. In the majority of the studies, navigation has 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 shoreside support activities. The possible environmental impacts of not developing a waterways project 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 examines the type and extent of environmental impacts that could result from a shift from 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 that allow for 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 that 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 percent of the state's total waterborne freight movements, which average approximately 73,000,000 tons annually. The 3.25 million tons of river carriage accounts for approximately 20 percent of the state's 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 impacts associated with the shift of cargo from the water to either 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 vessel to truck and from vessel to rail was made for movements where a rail alternative exists or the construction of a rail link is considered feasible. It is not considered likely that the levels of tonnage carried in the study's movement would justify construction of a rail connection.

Table 1 shows the modal factors used in the analysis. Sources of the factors are described in the following text.

Water travel distances were calculated on the basis of 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 that did not have prohibitive 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 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 industrywide fuel use and commodity carriage. It

TABLE 1 MODAL IMPACT FACTORS

Mode	Fuel Use Ton Miles/ Gallon	Emissions Pounds/ Gallon	Accident 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 ton miles
Great Lakes	607	.37	1/2,590,000,000 ton miles

Minnesota Department of Transportation, Ports and Waterways Section, Suite 925, Kelly Annex, St. Paul, Minn. 55155.

is recognized that certain dedicated rail movements will generate as much as 800 ton-mi/gal; as a balance, Lower Mississippi water movements will reach 1,200 ton-mi/gal. Great Lakes fuel efficiencies at 607 ton-mi/gal reflect the effectiveness of the nation's deep draft fleet.

Modal emission levels were taken from Environmental Protection Agency (EPA) publications and independent studies made by Mn/DOT's Air Quality Office. That office also reviewed the relationship between emission levels and the different engine sizes for each mode. For study purposes emission levels were taken from EPA documents (*2,3*).

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

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 (*4*, Table 4–5). The numbers used represent a weighting of the urban-rural, highway-interstate figures.

In the 5-year period 1986 through 1990, United States Coast Guard records indicate that collisions involving towboats in the St. Paul Marine Safety Detachment's area of control were as follows (*5*):

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

One death and no injuries resulted 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 meets reportability requirements as defined by federal law (46 CFR 4.05-1). None of the towboats used in the scheduled movements in this study were involved in the 29 incidents.

In those 5 years, the towing industry annually averaged 3,478,972,400 ton-mi of carriage in the area. Division of ton miles by accidents indicates approximately one accident per 600,000,000 ton-mi.

The Lake Carriers Association records on U.S. Great Lakes fleet vessels indicate that an accident occurs every 2.6 trillion ton-mi using the same U.S. Coast Guard reporting conditions as river traffic (personal interviews with R. Skelton of the Seaway Port Authority of Duluth, Minnesota, and G. Ryan of the Lake Carriers Association, Cleveland, Ohio, October 1990). 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 its 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 mi of train travel (*6*, Table 2). That is substantially better than the national average of one accident per 41,000 mi of train travel as reported by the Association of American Railroads. Mn/DOT records indicate that the annual average number of accidents is about 130, with more than 50 percent reporting property damage only. This study uses 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 mi with only 40 percent of the carcasses recappable and no second recapping (personal interview with P. Gannaway of J. L. Shiely Company, St. Paul, Minnesota, 1990). In over-the-road traffic, tires have a life expectancy of 100,000 mi and an 80 percent recap rate plus a second recapping of 40 percent of the initial recaps (personal interview with R. Rynda, Kampa Tire Company, St. Paul, Minnesota). This results in average tire lives of 56,000 mi for aggregate hauling and 225,000 mi 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 Grey Cloud Island mines at River Mile (RM) 825.0L and its distribution points at RM 837.2L and RM 843.3R in Pool 2 and RM 853.4R in Minneapolis. 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. Major findings of this analysis are that a shift from barge movement to trucks would annually cause

- An increase in fuel use from 72,300 to 690,000 gal,
- An increase in exhaust emission from 13.4 to 106.9 tons,
- An increase in probable accidents from 0.06 to 2.45, and
- The need to dispose of 1,108 used truck tires.

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

On the basis of an 11-hr workday and a 250-workday year, the mine would load 34.5 trucks per hour. Existing operational loading rates are 1.5 min per truck. Local ordinances prohibit truck movements at certain hours, which limited the working day to a maximum of 11 hr. 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 Movements in Pool 2

Movements of refined petroleum products in Pool 2 occur throughout the year. Tank barges are moved between the Pine Bend refinery in lower Pool 2 to several distribution terminals in the upper pool. During the last 5 years these movements have averaged 278 loaded and 278 empty barge trips annually, with an annual average volume of 232,796,400 gal 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.

Major findings of this analysis are that a shift of this movement from barges to trucks would cause

- An annual increase in fuel consumption from 19,400 to 178,900 gal,
- An exhaust emission increase from 3.6 to 27.7 tons each year,
- An increase in probable accidents from 0.02 to 0.48 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-hr working day for such movements, the shift would mean 31 additional tank trucks each hour. Major portions of the areas that the trucks would traverse are residential.

Coal Movements from St. Paul

Power plants at Alma, Genoa, and Cassville, Wisconsin, and Lansing, Iowa, receive regular barge shipments of coal from Pool 2 in St. Paul. These cargo movements average about 0.75 million tons each year.

In this analysis both rail and highway modal alternatives were considered, although rail connections do not 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 movement 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. An analysis was included to demonstrate the impacts of a shift to trucks.

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

Major impacts of modal shifts to truck for these coal movements include

- An increase in annual fuel use from 249,900 to 2,136,850 gal,
- An annual increase in exhaust emissions from 46.2 to 331.2 tons,
- An increase of truck traffic in the corridor of 35,407 trucks annually,
- An increase in probable accidents from 0.2 to 10.0 per year, and
- The need to dispose of 1,043 used truck tires each year.

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

- An increase in annual fuel use from 249,900 to 541,400 gal,
- An annual increase in exhaust emission from 46.2 to 186.9 tons,
- An annual increase of train traffic in the corridor of 75 trains of 100 cars each,
- The involvement of automobile traffic with those 75 trains at 193 grade crossings, and
- An increase in probable accidents from 0.2 to 0.48 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 products between the ports of Thunder Bay, Ontario, and Duluth-Superior. Most 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 each year. Major impacts of a modal shift to rail for this cargo movement include

- An annual increase in fuel use from 113,674 to 661,765 gal,
- Annual increases in exhaust emission from 21.0 to 129.0 tons,
- An annual increase in rail traffic of 38 trains each of 100 cars,
- Automobile involvement with those trains at 177 grade crossings, and
- An increase in probable accidents from 0.02 to 0.16 per year.

Rail traffic for this movement must follow a circuitous 360-mi route west from Thunder Bay for 200 mi and then southeast for 160 mi to Duluth. Water movement distance for this trip is 184 mi. 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 113,674 to 1,212,500 gal,
- An annual increase in exhaust emission from 21.0 to 188.9 tons,
- An increase in probable accidents from 0.02 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 automobile and truck traffic. In the summer, traffic on that stretch of 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 five-axle semis. Addition of 35,714 truck trips each year, or 120 per day of a 300-workday year, would be a substantial increase. That increase would occur along with the continuing growth in automobile traffic, exacerbating the automobile-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 gal,
- 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 feasible alternative, the cumulative impacts would be

- An annual increase in fuel use of 839,600 gal,
- Annual increases in exhaust emissions of 248.9 tons,
- An increase of 75 trains (each of 100 cars) at 193 highway crossings and 38 more at 177 crossings, and
- An annual increase in probable accidents from 0.22 to 0.64.

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 the need for the inclusion of a similar type of analysis in environmental studies of water project proposals.

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.

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