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UPPER GREAT LAKES TRANSPORTATION IMPACT FORECASTING SYSTEM

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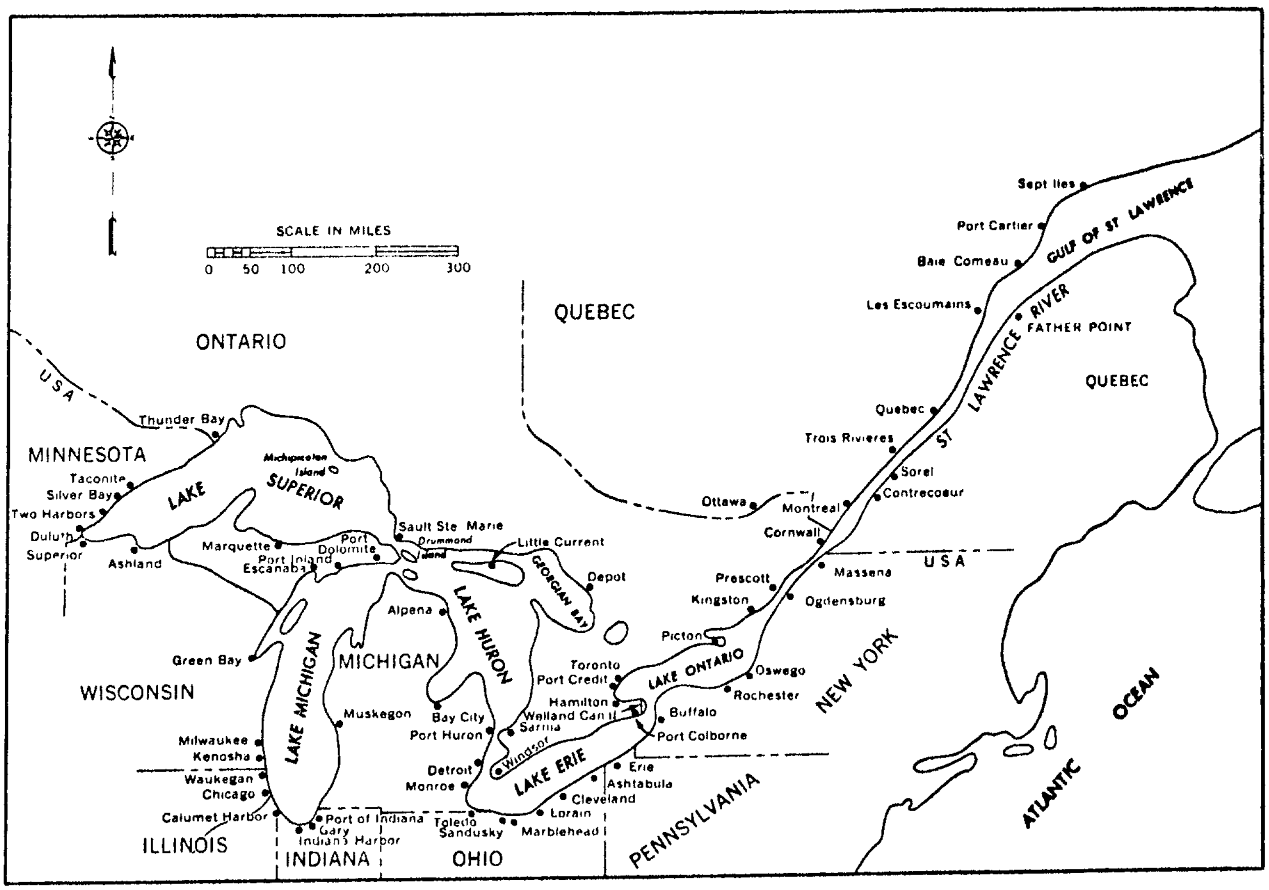
From the perspective of the resource-dependent Upper Great Lakes Region economy, an adequate and efficient lake transportation is an essential condition of regional economic viability. Alternative modes of transportation for a majority of the bulk commodity shipments on Lake Superior are higher cost than existing lake transportation. For some shipments, however, alternate transportation is available which involves very little added costs to either the producer or the consumer. Especially in the shipment of some toxic materials, the alternate transportation may offer a trade-off between low transportation costs and reduced environmental hazards.

U.S. Corp of Engineer studies (7,21), consulting studies on Upper Great Lakes development planning (4,6), university research reports prepared for various regional and state agencies (1,3,5,8,11,16,20), and other regional studies (2,10,22), help support and extend the data and findings on the relationship of lake transportation to other transportation modes and, ultimately, to regional economic well-being. Emerging from all of these efforts is the beginning of a regional systems approach for viewing the role of all transportation in the total economy of the Upper Great Lakes Region.

At least four important dimensions are envisioned in the development of a transportation impact forecasting system. First, the regional setting for assessing the economics of lake transportation must be delineated (Fig. 1). We start with key data on the industry and geographic origins and destinations of particular commodity shipments. Second, the industry and market analysis for determining future transportation needs of regional industries and the related markets, both domestic and foreign, must be implemented.

Figure 1. Principal shipping and receiving ports on the Great Lakes and the St. Lawrence River



Source: U.S. Great Lakes Basin Commission, Great Lakes Basin Framework Study, Appendix C9, Commercial Navigation, prepared by the Commercial Navigation Task Group of the Navigation Work Group, sponsored by the U.S. Department of the Army, Corps of Engineers, published by the Public Information Office, Great Lakes Basin Commission, 3475 Plymouth Road, P.O. Box 999, Ann Arbor, Michigan 48106, 1975.

We seek an overall regional perspective on a total industry and transportation outlook for the Great Lakes Basin Third, facility requirements and costs of alternative transportation modes must be determined. We must be able to determine total facility, and, also, people investment in alternative transportation systems proposals. Fourth, the impact of increasingly severe energy and monetary constraints on regional transportation systems development must be assessed. We face other materials scarcities, too. Yet, we must avoid the massive, irreversible damage to the environment which accompanies certain patterns of resource development and we must achieve this development in the face of growing competition for capital goods and financing.

Regional Setting of Upper Great Lakes Transportation

We now have the beginnings of an economic monitoring capability in the interindustry and inter-area linkage tables prepared by economists and geographers (9,16). These tables include the transportation requirements of each regional industry. Production of toxic materials, including wastes, is indicated, too. Thus, we know roughly the industry sources of all toxic materials and the regional economic importance of these industries. Work underway will refine these data and the subsequent findings, including forecasts (12,14,15,24).

Producing areas for the iron ore, coal, limestone and grain shipped on the Great Lakes are identified along with industries which depend on petroleum products and items of general cargo. The agriculture which uses the fertilizer shipped by lake and the population which buys the regional industry outputs, including petroleum products, are presented, also. We thus have the capability for showing the anatomy of trade and its circulatory system on a regional scale (19).

The economic monitoring capability can be used in assessing at least two or three levels of regional interdependence. At the local level, we can show the role of lake transportation in terms of total employment and total shipments, by industry (and commodity) group. At the state level, we can show the importance of the local economy, and the related transportation, to each substate region, including its public finances. The same relationships can be shown on a multi-state scale for the total region served by the twin ports of Duluth and Superior and the other Great Lakes ports, both U.S. and Canada. We thus can show quantitatively the importance of lake transportation to those segments of the total economy which, in some measure, are dependent on the lake ports (Tables 1 and 2).

Great Lakes shipping is conditioned by the location of primary resource development and industry concentration in the United States and Canada. The related traffic is dominated by bulk commodities, especially iron ore. With location of two thirds of the total U.S. iron ore and steel production in the Great Lakes Basin, iron ore dominates the freight shipments.

Lake Superior commodity traffic is handled mainly by the ports of Duluth-Superior, Silver Bay, Taconite Harbor, and Thunder Bay in Canada. In 1974, the total freight movement was 117 million tons. Of this total, Duluth accounted for 41 percent, Thunder Bay 20 percent, Taconite Harbor 12 percent, and Silver Bay Harbor 10 percent.

Iron ore

Most of the iron ore traffic on the Great Lakes is domestic lakewise shipments. In 1974, 74.5 million tons was domestic and 15.5 million tons consisted of Canadian imports. To show the origin-destination ports for these shipments, available 1970 data are used in lieu of a similar breakdown for the 1974 data (Table 3).

Table 1 Estimated Total Commodity Traffic on the Great Lakes for U S Ports, by Type of Shipments, 1974

Sector Number	SIC Code	Sector Description	Imports Canadian	Imports Overseas	Exports Canadian	Exports Overseas	Domestic Lakewise	Domestic Internal	Domestic Local	Total
			(1,000 tons)							
		Agriculture								
1	0151-0191	Livestock	-	2	-	1	2	-	-	6
2 1	0102	Barley & rye	235	-	248	355	152	-	-	990
2	0103	Corn	-	-	2,017	1,084	7	3	37	3,148
3	0104	Oats	-	-	234	155	3	-	-	393
4	0107	Wheat	57	-	1,014	739	1,091	2	15	2,918
5	0111	Soybeans	-	-	1,058	451	-	-	19	1,528
6	0119	Other oilseeds	-	-	-	184	-	-	-	184
7	0101,0105,0106 0122,0121-0141	Other crops	-	-	-	9	30	-	-	36
3	0841-0911	Forestry, fish	-	18	-	-	1	-	34	54
		Mining								
4	1011	Iron ore & concentrates	13,467	-	2,001	-	74,572	-	331	90,371
5	1021-1091	Nonferrous ores	1	83	5	1	3	107	-	200
6 1	1121	Coal & lignite	89	-	12,953	73	21,741	225	38	35,119
2	1311	Crude petroleum	24	-	-	-	-	-	-	24
3	1411	Limestone	-	-	2,527	-	33,198	-	13	35,738
4	1442	Sand, gravel	1,723	-	256	1	1,202	3	4,139	7,323
5	1491	Salt	907	-	203	-	-	-	-	1,110
6	1494	Gypsum	-	-	-	-	684	-	-	683
7	1412,1479,1492 1493,1499	Other minerals	-	-	1	1	9	-	-	11
		Manufacturing								
8 1	2012-2031	Livestock prod	-	2	-	221	30	-	-	255
2	2041-2049	Grain products	1	-	25	459	256	-	-	740
3	2034,2039,2061-2099	Other food products	8	38	15	75	112	50	-	297
9	2411-2511	Lumber & furniture	-	24	-	37	272	-	28	364
10	2611-2691	Pulp & paper	218	6	1	3	582	1	1	813
11	2711	Newsprint	-	-	-	-	-	-	-	1
12 1	2810-2819	Basic chemicals	109	65	10	33	406	176	152	952
2	2821-2891	Other chemical products	22	96	-	28	107	15	-	270
13 1	2911,2912	Gasoline & jet fuel	-	-	-	-	1,847	63	112	2,026
2	2913,2914	Distillate fuel oil	152	-	-	-	1,713	113	734	2,711
3	2915	Residual fuel oil	913	-	22	-	1,455	50	645	3,086
4	2916-2991	Other petroleum products	-	-	2	1	305	204	24	592
14 1	3241	Building cement	764	69	25	-	3,339	-	-	4,197
2	3211,3251-3291	Other cement products	2	21	-	2	131	-	-	155
15	3311-3324	Primary metals	300	3,514	500	470	861	1,077	415	7,238
16	3411	Fabricated metals	7	76	-	5	20	6	2	117
17	3511	Machinery, exc elec	4	45	2	37	39	4	-	132
18	3611	Electrical machinery	-	4	-	3	7	-	-	16
19	1911,2111-2311, 3011,3111,3711-3911	Other manufacturing	4	107	1	17	121	-	-	253
---	4011-4999	Scrap1/	20	145	122	331	1,769	666	183	2 793
		Total2/	19,019	4,213	23,221	4,588	144,460	2,836	6,876	204,708

1/ Including miscellaneous products not elsewhere classified and statistical discrepancy (SIC)
2/ Sum of individual items may not equal totals because of rounding
Source U S Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 3, Waterways and Harbors, Great Lakes, Calendar Year 1975 U S Army Engineer District Office, Chicago, Ill , 1975

Table 2 Summary Estimates of Total Commodity Traffic, Lake Superior (U S) Ports, 1974

Sector Number	SIC Code	Sector Description	Two Harbors	Duluth-Superior	Ashland	Presque Isles Harbor	Marquette	Bayfield	Keewanow Harbor	La Pointe	Silver Bay	Taconite Harbor	Total
						(1,000 tons)							
		Agriculture											
1	0151-0191	Livestock	-	-	-	-	-	-	-	-	-	-	-
2 1	0102	Barley & rye	-	737	-	-	-	-	-	-	-	-	737
2	0103	Corn	-	1,022	-	-	-	-	-	-	-	-	1,022
3	0104	Oats	-	388	-	-	-	-	-	-	-	-	388
4	0107	Wheat	-	2,696	-	-	-	-	-	-	-	-	2,926
5	0111	Soybeans	-	65	-	-	-	-	-	-	-	-	65
6	0119	Other oilseed	-	184	-	-	-	-	-	-	-	-	184
7	0101,0105,0106 0122,0121-0141	Other crops	-	4	-	-	-	-	12	-	-	-	16
3	0841-0911	Forestry, fish	-	1	-	-	-	-		-	-	-	1
		Mining											
4	1011	Iron ore & concentrates	9,789	31,183	-	3,075	-	-	-	-	11,397	11,891	67,335
5	1021-1091	Nonferrous ores	-	-	-	-	-	-	-	-	-	-	2
6 1	1121	Coal & lignite	-	1,713	291	-	910	-	2	5	-	626	3,556
2	1311	Crude petroleum	-	-	-	-	-	-	-	-	1	-	-
3	1411	Limestone	-	810	87	-	-	-	-	-	-	-	897
4	1442	Sand gravel	-	-	-	-	-	2	2	-	-	-	4
5	1491	Salt	-	-	-	-	-	-	-	-	-	-	-
6	1494	Gypsum	-	11	-	-	-	-	-	-	-	-	11
7	1412,1479,1492, 1493,1499	Other minerals	-	66	-	-	-	-	-	59	-	-	59
		Manufacturing											
8 1	2012-2031	Livestock prod	-	15	-	-	-	-	18	-	-	-	33
2	2041-2049	Grain products	-	137	-	-	-	-	73	-	-	-	210
3	2034,2039,2061-2099	Other food prod	-	27	-	-	-	-	39	-	-	-	66
9	2411-2511	Lumber & furniture	-	-	-	-	-	-	224	-	-	-	224
10	2611-2691	Pulp & paper	-	14	-	-	-	-	419	-	-	-	433
11	2711	Newsprint	-	-	-	-	-	-	-	-	-	-	-
12 1	2810-2819	Basic chemicals	-	20	-	-	-	-	112	-	-	-	132
2	2821-2891	Other chemical products	-	54	-	-	-	-	45	-	-	-	99
13 1	2911,2912	Gasoline & jet fuel	-	71	-	19	12	-	5	-	-	-	107
2	2913,2914	Distillate fuel oil	-	178	-	25	15	-	8	-	-	9	235
3	2915	Residual fuel oil	-	19	-	-	-	-	-	-	-	17	36
4	2916-2991	Other petroleum products	-	12	-	-	-	-	3	-	-	-	15
14 1	3241	Building cement	-	603	-	-	-	-	2	-	-	-	605
2	3211,3251-3291	Other cement products	-	-	-	-	-	-	55	-	-	-	55
15	3311-3324	Primary metals	-	268	-	-	100	-	63	-	12	-	441
16	3411	Fabricated metals	-	-	-	-	-	-	18	-	-	-	18
17	3511	Machinery exc elec	-	3	-	-	-	-	6	-	-	-	9
18	3611	Electrical machinery	-	-	-	-	-	-	5	-	-	-	5
19	1911,211-2311, 3011,3111,3711-2911	Other manufacturing	-	15	-	-	-	-	75	-	-	-	90
---	4011-4999	Scrap[1/]	-	29	-	1	1	5	77	4	-	-	284
		Total[2/]	9,789	40,345	378	3,119	1,037	5	1,269	3	11,420	12,543	80,070

1/ Including miscellaneous products not elsewhere classified and statistical discrepancy
2/ Sum of individual items may not equal totals because of rounding
Source U S. Department of the Army, Corps of Engineers. Waterborne Commerce of the United States, Part 3, Waterways and Harbors, Great Lakes, Calendar Year 1975 U S Army Engineer District Office, Chicago, Ill , 1975

Table 3: Estimated iron ore shipments, by origin and destination ports, Great Lakes Basin, 1970.1/

Originating Ports	Destination Ports2/ Michigan	Erie	Totals
	(1,000's tons)		
Superior	19,553	40,610	60,163
Michigan	5,258	4,709	9,967
Huron	-	3,748	3,748
Totals	24,811	49,067	73,878

1/ Based on data in "Appendix C9, Commercial Navigation". U.S. Great Lakes Basin Commission, Michigan, 1975.

2/ No Lake Erie and Lake Ontario originating ports and no Lake Superior, Lake Huron and Lake Ontario destination ports for iron ore shipments are identified for 1970. Estimated U.S. imports from Canada totaled 37,607,000 tons, including 2,734,000 tons for Lake Superior ports and 34,868,000 tons for Lake Ontario ports. Candaian coastwise shipping totaled 6,895,000 tons on Lake Superior and Lake Ontario.

Iron ore moves in both directions on the seaway system--downward bound from Lake Superior, and upward bound from the St. Lawrence River, converging at the south end of Lake Michigan.

Iron ore traffic on Lake Superior originates from ports closest to the taconite processing plants in Northeast Minnesota and the Upper Peninsula of Michigan. The majority of the ore originating in Lake Superior passes through Lake Michigan and Lake Huron to the smelters on Lake Erie and in Pittsburgh Some ore is transported to steel plants in Gary, Indiana. Canadian iron ore, mined in Quebec and Labrador, is shipped from the ports of Sept Iles, Pointe Noire, and Port Cartier on the Lower St. Lawrence River.

Coal and limestone

Coal and limestone together make up the second most important commodity group. Coal traffic totalling 35 million tons was nearly 17 percent of the freight shipments on the Great Lakes in 1974. The shipments originated mostly from the Appalachian coalfields, with smaller amounts coming from Illinois and Kentucky coal mines. Toledo has been the most important originating port Recently, however, increased use of the low sulfur coal from Western mines has reduced demand for shipments from Toledo, which declined from 35 million tons in 1965 to 15 million tons in 1972.

Demand for limestone is tied to steel manufacturing, construction, and the need for lime in industrial chemicals. The State of Michigan has been the principal source of limestone commerce on the Great Lakes. The limestone, which originates from Calcite, Stoneport and Port Inland in Michigan, is shipped to Detroit, Gary, Chicago and Cleveland where the steel mills are located.

In 1974 nearly 36 million tons of limestone were shipped on the Great Lakes. Nearly three million tons were exported to Canada, while 33 million tons consisted of domestic lakewise shipments.

Grain

The six midwest states bordering the Great Lakes produce 37 percent of U.S. grain in 1970. They, combined with nine other states served by the Great Lakes ports, produced 79 percent of the total U.S. grain.

Grain shipments from the Upper Great Lakes Basin are primarily exported to foreign countries. Wheat is shipped from Thunder Bay and Duluth-Superior and corn from Chicago (by drawing its products from Ohio, Indiana, Iowa, and Nebraska). Soybeans, barley, and rye are shipped from Toledo, Chicago, and Milwaukee. Total grain and grain product shipments, mainly to eastern and northern Europe and South Asia, have averaged nine million tons in the past few years.

General cargo

All cargo that is not in bulk is referred to as general cargo. Among the eleven leading states that generate overseas cargo, seven are Great Lakes states, which together generate 45 percent of the total overseas cargo exports. However, the lake ports ship only 20 percent of the commodity exports from the region. Rail and truck shipments account for 80 percent of the total.

General cargo items that involve overseas shipping are mainly iron and steel imports from Europe and Japan. Most of these iron and steel imports are unloaded at Detroit and Chicago, mainly for automobile production.

The domestic general cargo moving on the St. Lawrence seaway and the Great Lakes is confined to Canadian and U.S. imports and exports. Downward bound domestic general cargo consists of manufactured goods, newsprint, and chemicals, among other items. The upward traffic consists of salt, crushed rock, clay, peas, beans, and other products. Shipments of general cargo relative to bulk commodities is small, diverse, and volative.

Petroleum products

The major petroleum products traffic on the Great Lakes consists of gasoline distillate and residual fuel oils. The 8.4 million tons of petroleum products shipped in 1974 included 2 million tons of gasoline and jet fuel, 2.7 million tons of distillate oil, and 3.1 million tons of residual oil. Residual oils are frequently shipped by water as they are not well suited to pipelines movement because of high viscosity and contamination danger.

Virtually all lake shipments of petroleum products are domestic and lakewise. Ontario receives fuel oil from western Canada and foreign sources. The western crude is transported by pipeline to Sarnia and Toronto where it is refined. The finished products are then shipped on the Great Lakes to Canadian ports and, thence, for internal use in Canada.

In the United States the transportation sequence begins when crude oil is transported by pipelines from southcentral U.S. areas to refineries in Chicago, Detroit and Toledo, Buffalo, and from Canada to the northern tier refineries (via the Portal and the Lakehead pipelines). In most cases these refineries are located on either the Great Lakes Seaway or tributary bodies of water. From here the refined products are shipped lakewise to demand areas.

Industry and Market Studies

Industry and market studies are available now which complement the Sievright paper and also support the building of a regional economic monitoring capability. A recently completed study of Northeast Minnesota and Douglas County, Wisconsin (the Head-of-the-Lake Region), is used here to illustrate the data inputs and outputs of a regional industry study (13). Special surveys were undertaken on capital expenditure plans and energy utilization among specified industry groups in the region for this study. Additional work is underway to determine the transportation and energy requirements of the existing and alternative projected future industry production levels and to extend the use of the Minnestoa Resource Development Simulation Laboratory (SIMLAB) for use in transportation and energy impact analysis.

National economic projections

Market forecasts to 1985 were prepared for each industry group in the HOTL Region and the regional share of the U.S. output for each industry was projected. Growth of the U.S. economy was manifested by expanding requirements for the industry output originating in the HOTL Region.

For the 1970 - 1980 period, all but two industry groups are projected to expand in total market requirements in the HOTL Region. Projected annual change in national market requirements vary greatly by industry because of differences in both intermediate and final demand requirements Thus, given the regional share of a particular industry market, the national growth can be translated into proportional regional growth. However, the regional share of each industry is likely to vary from its base-year level (Table 4).

Alternative future scenarios

Two alternative futures have been simulated for use in the study The simulated growth alternatives incorporate current perceptions about investment, output and employment levels in the remainder of the 1970 decade. First, increasing levels of industry investment in the HOTL Region triggered an expansion of the construction industry. Secondly, in the alternative growth projection, export-related construction activity was increased, however, at the same time, closure of part of the primary metal industry in the Region reduced employment.

A second stage of market changes was instituted in 1974. First, the annual change in the regional market share of the iron mining industry was

Table 4. Output per worker, annual change in output per worker, annual change in national market, regional share, and annual change in regional share, Head-of-the-Lake Region, 1970-1980.

Industry group	Output per worker 1970 (dol.)	Output per worker 1972 (dol.)	Output per worker 1974 (dol.)	Output per worker 1980 (dol.)	Annual change in output per worker (units)	Annual change in national market[1/] (units)	Reg. share of national market[1/] (units)	Annual change in reg. share (units)
1 LIVESTOCK	22122.	24483.	27095.	36727.	.052	.02116	0	0
2 CROPS	16388.	19171.	20149.	27467.	.053	.00534	0	0
3 OTHER AGRI	29078.	30134.	31229.	34757.	.018	-.04039	.03547	-.00791
4 IRON, FERR	48532.	52492.	56776.	71839.	.040	.03724	5.91390	.07275
5 NON-FERROU	18826.	19973.	21139.	25301.	.030	-.14474	0	0
6 OTHER QUAR	18338.	18818.	19310.	20866.	.013	.04341	0	0
7 CONSTRUCTI	36329.	38317.	40414.	47420.	.027	.00949	.00018	.00052
8 FOOD AND K	78125.	88044.	88272.	106017.	.031	.02741	.00106	.01075
9 LUMBER, FU	33031.	35315.	37759.	46145.	.034	.03995	.00250	.01330
10 PULP AND P	33043.	36113.	38536.	46824.	.033	.03363	.03645	.02460
11 PRINT AND	17785.	19089.	20498.	25331.	.036	.05033	0	0
12 CHEMICAL,	20082.	22979.	25286.	33692.	.049	.07260	0	0
13 PETROL. RE	323732.	189265.	211857.	297137.	.058	.05062	.00049	.01666
14 STONE. CLA	18129.	18935.	19778.	22536.	.022	.04689	0	0
15 PRIMARY ME	31834.	34299.	36956.	46224.	.032	.10069	.01468	.02884
16 FABRIC, ME	22090.	23254.	24479.	28554.	.026	.06113	0	0
17 MACHINERY	27790.	30231.	32887.	42338.	.043	.06648	0	0
18 ELECTRICAL	51176.	55992.	61262.	80239.	.046	.06112	0	0
19 OTHER MANU	21437.	23320.	25369.	32659.	.043	.03911	0	0
20 RAILROAD	14213.	15432.	16755.	21447.	.042	.03873	.00732	.01623
21 TRUCKING	5783.	6005.	6235.	6981.	.019	.03182	0	0
22 OTHER TRAN	60442.	64747.	69359.	85259.	.035	.06799	.00185	.01940
23 COMMUNICAT	22375.	24810.	27509.	37501.	.053	.09074	0	0
24 ELECTRIC U	79891.	86576.	93821.	119400.	.041	.07122	.00315	.01711
25 GAS UTILIT	83475.	87188.	91067.	103768.	.022	.04107	0	0
26 OTHER UTIL	111388.	113852.	116371.	124265.	.011	.02846	.00055	-.03211
27 WHOLESALE	10255.	11371.	12608.	17188.	.053	.0556	0	0
28 RETAIL	5222.	5562.	5923.	7155.	.032	.04455	0	0
29 F.I.R.E.	40604.	42410.	44297.	50475.	.022	.04768	0	0
30 HOTELS, PE	9809.	10346.	10912.	12804.	.027	.02470	0	0
31 BUSINESS S	9489.	9911.	10352.	11796.	.022	.04555	0	0
32 MEDICAL,	8332.	8857.	9414.	11307.	.031	.05048	0	0
33 OTHER SERV	26853.	1674.	1738.	1946.	.019	.02004	0	0
34 FED. GOVT.	3329.	3573.	3835.	4741.	.036	.05038	.00032	.03065
35 STATE-LOCA	6711.	7203.	7731.	9558.	.036	.03423	0	0

1/ National market share is U.S. final demand, which is changed in later simulation runs to U.S. gross output increased by 50 percent (to 10.9 percent). During this period, output per worker increased 4 percent annually, which again worked counter to the market expansion by reducing total employment requirements nearly 30 percent for the given 1974 level of industry output. This labor productivity gains, thus, will significantly temper the total employment impacts of the large projected capacity expansion in the iron mining industry.

Finally, the regional share and the annual change in regional share for the construction industry were increased again to account for increased construction activity in iron mining industry. Thus, for the 1975 - 1980 period, the projected market share was increased 100 percent and the projected change in market share was increased 300 percent.

Projected industry investment

Industry expansion to increase market shares is a function of investment. Most industry is involved in investment to maintain and to expand production. In the current simulation, however, the two types of investment are not differentiated, nor is the total level of investment, in terms of production capacity and its utilization, included in the data base. Rather, the increase in gross output is related directly to the equivalent facilities and related capital stock required for production. In short, existing capacity is viewed as being fully utilized, which, of course, is the case for only a few industries, such as iron mining in 1974.

Projected output levels for 1974 and 1980 under the growth scenario provide the base-year and target-year comparisons with the survey findings on capital expenditures cited earlier (Table 5). Except for iron mining, pulp and paper products manufacturing, and electric utilities, projected capital requirements for the 1975 - 1980 period greatly exceed anticipated capital expenditures. Most businesses are unlikely to expand facilities

Table 5. Projected increases in gross output, capital expenditures and employment in selected industries, Head-of-the-Lake Region, 1975-1980. 1/

Sector No.	Title	Gross Output	Capital Expenditures 2/	Employment
		(thou. dol.)	(thou. dol.)	(no.)
1.	Livestock	13343	14669	-129
2.	Crops	6962	8702	-67
3.	Other agriculture	2028	1602	-5
4.	Mining: ferrous	351476	527179	2635
5.	Non-ferrous	972	1652	24
6.	Quarrying	1198	1411	45
7.	Construction	125770	35379	1902
	Manufacturing:			
8.	Food and kindred	76649	33894	158
9.	Lumber, furn.	25019	10398	153
10.	Pulp, paper	43173	33697	1
11.	Printing, publ.	12968	8300	252
12.	Chemical	1817	1520	4
13.	Petro. refining	21300	17040	-13
14.	Stone, clay, glass	4027	2879	129
15.	Primary metal	49490	31139	495
16.	Fabr. metal	8784	3848	177
17.	Machinery, exc. elect.	9042	4180	25
18.	Electrical machinery	4375	1316	-10
19.	Other manufacturing	16696	5698	22
	Regulated industries:			
20.	Railroad	17356	56407	-67
21.	Trucking	2205	771	202
22.	Other transportation	40504	56199	197
23.	Communications	12579	28293	6
24.	Electric utilities	34267	181615	66
25.	Gas utilities	6071	14873	37
26.	Other utilities	2717	4510	18
	Trade and service:			
27.	Wholesale	29020	31899	50
28.	Retail	57113	62778	3819
29.	Finance, ins., real estate	94697	18200	1270
30.	Hotels, personal	26077	36507	1378
31.	Business, repair	8843	4244	488
32.	Medical, educ.	57274	100229	2935
33.	Other services	6838	14650	1242
34.	Federal gov't. enter.	5762	3/	443
35.	State-local enter.	6117	3/	208
	TOTALS	1182529	1355878	18090

1/ Based on Growth Projection II

2/ Based on Battelle Memorial Institute Research Report, "on *Ex Ante* Capital Matrix for the United States, 1970-75", March 31, 1971.

3/ Data not available

until warranted by a substained high level of market demand.

Expected increases in capital outlays--based on the survey (rather than the scenario) findings--in several basic industries are sufficiently large to severely tax existing facilities as a result of the expansion in construction and related population. Especially vulnerable are the energy-producing and distributing facilities as well as public facilities, such as schools and hospitals.

Projected industry output and employment

In both the baseline and growth projection series, industry output in 1980 is substantially larger than in 1970. For some industries, output is projected to double or nearly double; e.g., iron mining, construction, and services

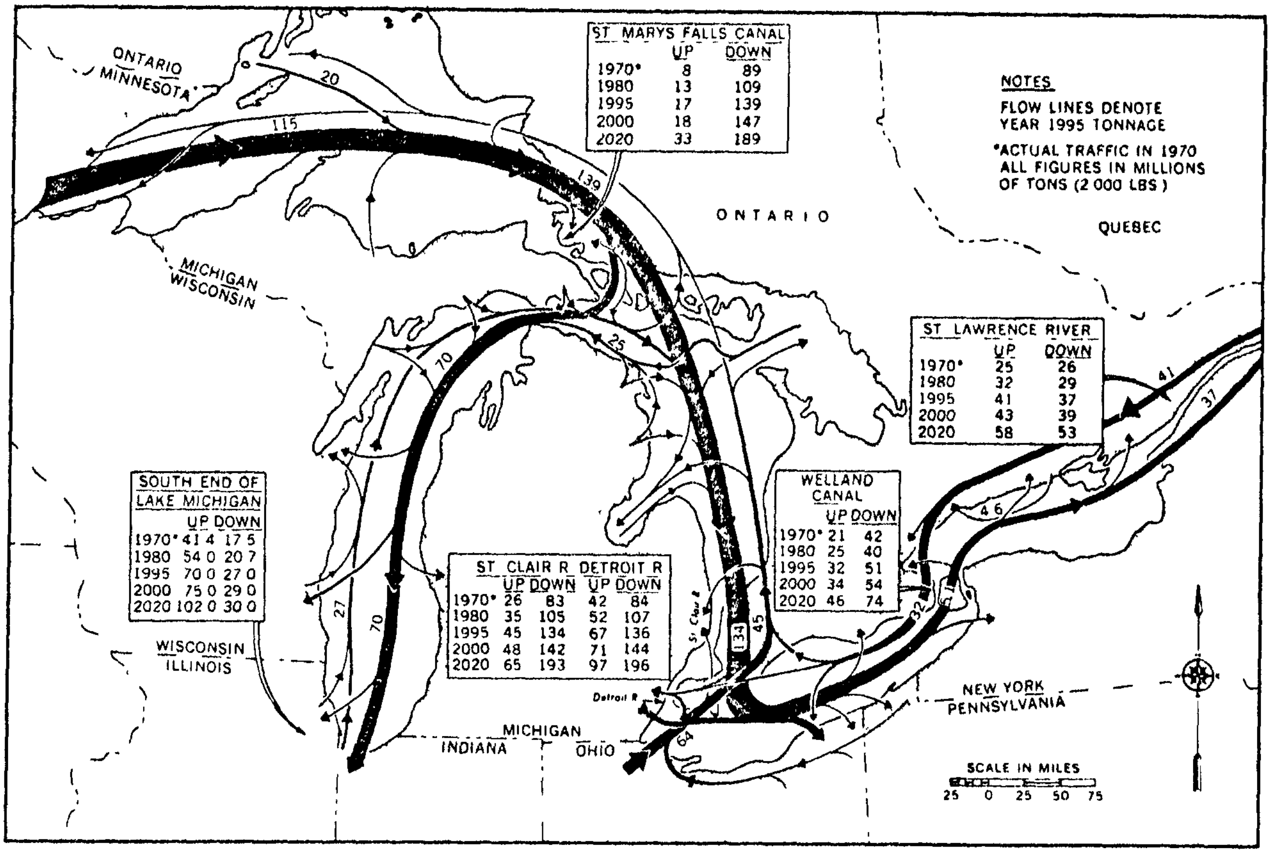
Employment shows markedly different patterns of change from output. In the baseline projection, total employment grows by seven percent while in several industries employment declines; for example, agriculture, construction, and manufacturing.

In the growth projection, the total employment change is more than twice the baseline projection. Agriculture employment again is projected to decline but substantial increases are projected, not only in mining and construction, but also in the service industries. Growth in the economic base thus triggers a "ripple" effect through the output multiplier which is felt subsequently throughout the regional economy and, especially, in its service industries.

Importance of transportation constraint

Future restriction of low-cost lake transportation could reduce industry output below projected future levels (fig. 2). Specific industry impacts would depend on the transportation-dependency of particular industry

Figure 2. Projected total commodity traffic on Great Lakes-St. Lawrence River System, 1995.



Source: U.S. Great Lakes Basin Commission, Great Lakes Basin Framework Study, Appendix C9, Commercial Navigation, prepared by the Commercial Navigation Task Group of the Navigation Work Group, sponsored by the U.S. Department of the Army, Corps of Engineers, published by the Public Information Office, Great Lakes Basin Commission, 3475 Plymouth Road, P.O. Box 999, Ann Arbor, Michigan 48106, 1975.

in the HOTL Region.

Estimated transportation sector purchases and sales of goods and services (for a composite transportation sector which includes lake transportation) are available for the HOTL region from the HOTL Region study. These data show the varying degree of transportation dependency of regional industry and the effects of demand for particular transportation services on the total economy (Table 6). The regional impacts from the loss of an essential transportation service for a given industry are not included, however.

Assessment of the local impacts of lake transportation depends on availability data on commodity shipments for individual lake ports. For example, bulk commodities account for the major cargo handled by Duluth-Superior port facilities (Table 7). In the 1973-75 period, the bulk commodities consisting of iron ore and taconite, bulk grains, coal, limestone, petroleum products, and scrap iron accounted for 97 percent of total volume handled Other bulk traffic including salt, gypsum, slay, calcium chloride potash is very small and undergoes large annual fluctuations.

Duluth-Superior iron ore shipments are tied to the highly cyclical steel industry and hence, the quantity of iron ore shipped fluctuates a great deal, e.g., from a high tonnage of 34 million tons in 1973 to 23 million tons in 1975. However, the average tonnage for the period 1970 to 1975 was nearly 30 million tons--only slightly less than in the 1960's. Virtually all the iron ore shipped in from Lake Superior is lakewise exports, originating on Lake Superior, mainly from Duluth-Superior, Two Harbors, Silver Bay, and Taconite Harbor

In the Great Lakes Basin Framework Study, iron ore shipments from Duluth-Superior are projected to increase only slightly to 32 million tons

Table 6 Estimated purchases, sales, and inter-industry effects of water and pipeline transportation and transportation services sectors, Northeast Minnesota and Douglas County, Wisconsin, 1972

Sector No	Industry	Direct Effects of Specified Transportation[1] Purchases ($1,000)	Direct Effects of Specified Transportation[1] Sales ($1,000)	Total Inter-industry Effects Per $1 million Final Sales Output (dol.)	Total Inter-industry Effects Per $1 million Final Sales Employment (number)	Total Inter-industry Effects Per $1 million Final Sales Payroll (dol)
	Agriculture					
1	Livestock & livestock prod	0	67	258	0101	13
2	Other agric products	0	68	203	0108	20
3	Agri services, for , fish	0	12	60	0023	17
	Mining and construction					
4	Iron & ferro alloy ores	0	32,076	644	0123	118
5	Nonferrous metal ores	0	46	7	0003	2
6.	Other mining, quarrying	0	10	65	0033	26
7	Construction	223	198	3,444	3285	2,214
	Manufacturing					
8	Food & kindred prod	32	741	778	0104	159
9	Lumber & furniture	4	1,101	1,515	0414	447
10	Pulp & paper products	154	570	3,980	.1034	223
11	Printing & publishing	36	4	1,681	0874	750
12	Chemicals & allied prod	75	12	1,203	0233	331
13	Petroleum refining	1,545	2,341	23,186	.1146	2,430
14	Stone, clay and glass	31	26	550	0229	223
15	Primary metals	515	550	13,586	04082	4,862
16	Fabricated metals	0	3	186	.0076	62
17	Machinery exc electrical	35	17	1,071	0473	502
18	Electrical manufactures	10	17	197	0053	80
19	Other manufacturing	89	51	1,347	0371	417
	Transportation					
20	Railroad transportation	0	0	0	0	0
21	Trucking & warehousing	236	88	3,468	5753	1,830
22	Other transportation	9,148	9,191	1,125,020	30 4882	344,790
	Communication & utilities					
23	Communication	396	4	6,293	2442	2,703
24	Electric utilities	697	288	10,923	1219	1,827
25	Gas utilities	-1	0	898	0105	101
26	Other utilities	43	1	752	0068	51
	Trade, finance, and services					
27	Wholesale trade	478	34	7,966	7336	3,997
28	Retail trade	75	41	1,509	2783	869
29	Finance, ins , real estate	1,786	193	28,911	1 0171	8,398
30	Hotels, pers & repair serv	185	91	2,819	2817	1,225
31	Business services	249	3	4,056	4156	1,450
32	Medical, educational	73	25	1,281	1495	793
33	Other services	0	0	0	0	0
34	Federal govt enterprise	0	0	0	0	0
35	State & local govt ent	0	0	0	0	0
Total		17,956	47,891	1,273,835	36.7273	391,062

1/ Water transportation (SIC 44), pipeline transportation (SIC 46) and transportation services (SIC 47, except 473 and 474) are included

2/ Other transportation includes local sub-urban and inter-urban highway passenger transportation (SIC 41), air transportation (SIC 45), and the transportation sectors in the "specified" transportation sector (i e , SIC 44, 46, and 47, except 473 and 474)

Source Based on E C Venegas, W R Maki, J E Carter "A 1972 Structural Model of the Minnesota Economy Towards a Source Oriented Tool " Research Division, Minnesota Energy Agency, April 1975

Table 7 Estimated Total Commodity Traffic for Duluth-Superior, by Type of Shipments, 1974

Sector Number	SIC Code	Sector Description	Foreign: Overseas Imports	Foreign: Overseas Exports	Foreign: Canadian Imports	Foreign: Canadian Exports	Domestic: Receipts	Domestic: Lakewise Shipments	Domestic: Local	Total
			(1,000 tons)							
		Agriculture								
1	0151-0191	Livestock	-	-	-	-	-	-	-	-
2 1	0102	Barley, rye	-	355	2	248	-	131	-	737
2	0103	Corn	-	413	-	609	-	-	-	1,022
3	0104	Oats	-	155	-	232	-	-	-	388
4	0107	Wheat	-	722	-	925	-	1,049	-	2,696
5	0111	Soybeans	-	4	-	61	-	-	-	65
6	0119	Other oilseed	-	184	-	-	-	-	-	184
7	0101,0105,0106, 0122,0121-0141	Other crops	-	4	-	-	-	-	-	4
3	0841-0911	Forestry, fish	-	-	-	-	-	-	1	1
		Mining								
4	1011	Iron ore & concentrates	-	-	21	628	-	30,534	-	31,183
5	1021-1091	Nonferrous metal ores	-	-	-	-	-	-	-	-
6 1	1121	Coal & lignite	-	12	-	13	892	796	-	1,713
2	1311	Crude petroleum	-	-	-	-	-	-	-	-
3	1411	Limestone	-	-	-	-	810	-	-	810
4	1442	Sand, gravel	-	-	-	-	-	-	-	-
5	1491	Salt	-	-	-	-	-	-	-	-
6	1494	Gypsum	-	-	-	-	11	-	-	11
7	1412,1479,1492, 1493,1499	Other minerals	-	-	46	-	19	-	-	66
		Manufacturing								
8 1	2012-2031	Livestock prod	-	15	-	-	-	-	-	15
2	2041-2049	Grain prod	-	128	-	9	-	-	-	137
3	2034,2039,2099	Other food prod	-	27	-	-	-	-	-	27
9	2411-2511	Lumber & furniture	-	-	-	-	-	-	-	-
10	2611-2691	Pulp & paper	-	-	14	-	-	-	-	14
11	2711	Newsprint	-	-	-	-	-	-	-	-
12 1	2810-2819	Basic chemicals	-	-	-	4	5	10	-	20
2	2821-2891	Other chemical prod	44	-	-	-	-	10	-	54
13 1	2911,2912	Gasoline & jet fuel	-	-	-	-	14	57	-	71
2	2913,2914	Distillate fuel oil	-	-	-	-	139	39	-	178
3	2915	Residual fuel oil	-	-	-	-	-	19	-	19
4	2916-2991	Other petroleum prod	-	-	-	-	-	12	-	12
14 1	3241	Building cement	-	-	78	20	505	-	-	603
2	3211,3251-3291	Other cement prod	-	-	-	-	-	-	-	-
15	3311-3324	Primary metals	48	13	-	-	206	-	-	268
16	3411	Fabricated metals	-	-	-	-	-	-	-	-
17	3511	Machinery, exc elec	1	2	-	-	1	-	-	3
18	3611	Elec machinery	-	-	-	-	-	-	-	-
19	1911,2111-2311, 3011,2111,2711- 3911	Other manufacturing	15	-	-	-	-	-	-	15
---	4011-4999	Scrap 1/	1	17	2	-	-	14	-	29
		Total 2/	108	2,050	161	2,749	2,602	32,671	1	40,345

1/ Including miscellaneous products not elsewhere classified and statistical discrepancy

2/ Sum of individual items may not equal totals because of rounding

Source U S Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 3, Waterways and Harbors, Great Lakes, Calendar Year 1975 U S. Army Engineer District Office, Chicago, Ill , 1975 per year by 1995 (23). The local economic impacts of the projected increases in iron ore shipments from Duluth-Superior are projected, also, using the origin-destination in the Framework Study A methodology has been developed for allocating projected shipments which is illustrated for iron ore, because of its importance in the HOTL economy. Table 8 presents the number of trips required if shipments were made on vessels averaging 30,000 tons capacity

The second largest bulk commodity shipped through Duluth-Superior is coal. Historically, all shipments of coal originated from the Eastern regions, via Lake Michigan and Lake Erie, the main recipients being the steel manufacturing industry and households. Since 1965 the shipments of coal declined, firstly due to the decline in steel production and secondly due to increasing costs of utilizing high-sulfur coal. In 1972, coal traffic through Duluth-Superior declined to 0.8 million tons, the lowest level in 12 years. By 1985, however, shipments of western coal are expected to reach levels that will more than double 1970 totals.

Declining supplies of gas and increased demand for electricity have augmented the demand for coal, both as a primary fuel and for electricity generation. Pollution control restrictions have made western low sulphur coal (from Wyoming, North Dakota and Montana) competitive with eastern coal, thus increasing its production to 36 million tons in 1973. A large proportion of the coal shipments has been secured by a Detroit utility company--a total of 27 million tons from 1975 to 1980 and 8 million tons per year from 1980 to 2000. If the shipping costs of coal are similar to the shipping costs of grain, a significant amount of coal shipments to Michigan will be handled by the Duluth-Superior ports. Unit trains will haul the coal from mines in North Dakota to the Superior terminal and, then, via vessel from Superior to Detroit

Table 8. Projected Iron Ore Shipments from Duluth-Superior to Great Lakes Ports, 1995 1/

Lake Michigan Ports 2/	Shipments	No. Trips 2/	Lake Erie Ports 2/	Shipments	No. Trips 3/
	(1,000 tons)	(no.)		(1,000 tons)	(no.)
Gary	3,652	122	Cleveland	5,508	184
Chicago	3,131	104	Detroit	4,025	134
Indiana Harbor	2,713	90	Buffalo	2,966	99
Burns Waterway	626	21	Conneaut	2,119	71
			Toledo	2,330	78
			Ashtabula	1,695	57
			Lorain	1,271	42
			Huron	1,059	35

1/ Based on 20 one-way trips per season, e.g., between Duluth and Buffalo, 5 ships are required as follows:

$$\frac{2.966 \times 10^6 \text{ tons}}{20 \frac{\text{trips}}{\text{ship}} \times 30{,}000 \frac{\text{tons}}{\text{trip}}} = 5 \text{ ships}$$

The Origin/Destination total requiring less than one ship is:

$$1 \times 20 \times 30{,}000 = 600{,}000 \text{ tons/year}$$

i.e., when shipments between any O/D pair are less than 600,000 tons/year, less than one ship is required for its movement.

2/ 30 percent and 67 percent, respectively, of 31,620,000 tons for the two lakes.

3/ Assume 30,000 ton ships.

Finally, the availability of services to shippers from Duluth-Superior is limited by the annual closing of the port, the long distance to the sea lanes and the restricted size of port accomodations. In addition, other transportation options and competing shipping points in the six states of Montana, North and South Dakota, Minnesota, Iowa, and Wisconsin have affected the export volume for Duluth-Superior ports. Nevertheless, the grain shipments that averaged 4.9 million tons in the 1960 - 70 period increased by nearly two million tons in the 1970 - 75 period--an increase primarily due to exports.

Petroleum product shipments during the last ten years have consisted of distillate oil, residual oil, gasoline, lubricating oils and asphalt. The average tonnage shipped during 1970 - 75 was 289,000 (1.7 million barrels), about 2 percent of Minnesota's requirements. Lake shipments of petroleum products to Canada will increase with the completion of the petroleum pipeline dock in Superior. Lake transportation of petroleum products also is expected to double during the 1970 - 85 period.

The preceding discussion again illustrates the need to include a total transportation system component in the regional economic monitoring capability. Such a component would show the principal origin and destination points for commodity shipments in the given study region. Both investment and energy requirements of each alternative transportation mode and the corresponding fiscal and resource constraints on these requirements must be specified. We then can assess systemically and quickly the employment and income effects of proposed changes in lake transportation. We are moving towards this expanded capability, but a lot more thought and effort is needed to achieve a fully operational transportation impact monitoring capability.

Facility Requirements and Costs of Alternative Transportation Systems

The projected expansion of transportation on Lake Superior implies a certain level of new investment in lake transportation facilities, both public and private. Who ultimately pays for these facilities, including the public investments, and who benefits from them, is not clear to most of us. Nor is the "true" or "full" cost of shipping known for each mode of transportation. However, rough estimates of certain costs of transportation have been prepared for additional comparison of lake with rail transportation (Table 9). These estimates are comparable to those prepared by Sievright (18), except that costs compared in the Sievright report are line costs only, which do not include transfer, maintenance and capital requirements.

Itemization and costing of specific transportation facilities to meet projected transportation requirements of the regional economy implies availability of information on planned new construction or facility renovation. If additional petroleum products were carried with other commodities, it is not entirely clear as to the extent of individual bulkhead modification, if any, to accomplish the change in shipment mix. Alternatively, is there a possibility of using small oil tankers on Lake Superior, which would reduce oil expenditures but, perhaps, increase total oil shipments through a given lake port? Questions occur, also, with respect to petroleum pipeline transportation and the impact of proposed pipeline construction on Great Lakes crude petroleum and petroleum product shipments in the future (14).

Transportation Implications of Energy and Capital Constraints

The energy and capital efficiencies of lake shipping were cited in a panel presentation of the International Conference of Lake Superior held recently in Duluth, Minnesota (18). But data on energy and capital intensities of projected transportation facility construction and corresponding expansion

Table 9. Derivation of Comparative Transportation Costs for Grain Shipments Between Duluth-Superior and Buffalo, New York, 1970.

Item	Unit	Lake Shipping	Rail Transportation 1/
Total shipments	tons 2/	1.935×10^6	1.935×10^6
Distance	miles	200 3/ + 1,000	1,200
Average speed	miles/hr 4/	7.5	15
Trip time	hours	160	80
Shipping season	hrs/yr	6,400	8,640
Number of trips	two-way	20	54
Capacity	tons	20,000	3,500
Number of ships/unit trains required	number	5	10
Investment requirement	mil. dol.	30.00	3.50
Interest @ 8%	mil. dol.	2.40	0.28
Investment cost	dol./ton	1.24	0.14
Estimated rate charges 5/	dol./ton	.0024	.0125
Total operating cost	dol./ton	6.86 6/	15.00
Total cost	dol./ton	8.10	15.14
Total cost	dol./year	15.67×10^6	29.30×10^6

1/ Unit trains of 50 cars of 70 ton capacity
2/ 1970 shipments
3/ Rail portion of trip
4/ Includes turn-around time
5/ Average dry bulk cargo rates
6/ Includes $2.50 for rail transportation, $4.90 for water transportation, $1.13 for maintenance of harbors and waterways, and $0.83 for rail/ship terminal transfer costs at Duluth-Superior

Source: Braslau, D., "Grain Shipments between Duluth-Superior and Buffalo, New York: An Intermodal Scenario - Rail/Ship versus Rail", Private Communication, March 17, 1976.

in commodity shipments for each alternative mode of transportation, is lacking. Under increasingly severe energy, capital, and environmental constraints, certain trade-offs are likely to occur which cannot be anticipated clearly at this time because of existing data deficiencies

Energy efficiency, economic growth and environmental protection are important concerns in assessing transportation alternatives. In comparing only the propulsive (direct) energy required for the shipment of one ton-mile by various modes, water transportation is the lowest of the five principal modes of transportation While waterborne carriers used from 250 to 500 BTU per ton-mile, railways used 750 BTU Inland waterway carriers require 16% more energy than lake or open water carriers. Not included, however are the effects of commodity density, circuity, or the other direct and indirect energy costs associated with the movement of one ton-mile by any given mode. While the apparent rate for shipment by water is only one-fifth that for rail, this figure falls to one-half when total costs are included. Similar arguments could be also applied to associated energy requirements. Even though water transportation still may be more energy efficient than rail, adverse environmental consequences would increase total social costs, thus reducing the energy and cost gaps between these two transportation modes.

Most, if not all, of the data and knowledge deficiencies cited will remain for the very simple reason: lack of institutional responsibility The recent effort by the Minnesota Pollution Control Agency is, indeed, an exceptional event for it brings to public attention the practical importance of viewing the use of Lake Superior in its totality. Lake Superior is strategic in both a regional economic and a regional environmental setting Trade-offs between economics and environment are inevitable Their direction and magnitude will depend on many isolated and unrelated decisions, which increasingly, however, must take into account their effects on the total regional system.

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